

# PENNSYLVANIA JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES STRATEGIC PLAN



Final Report

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By

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<b>16. Abstract</b> Connected and automated vehicles (CAV) technologies are rapidly advancing, and while the promise for safety benefits is substantial, states have a critical role to play in shepherding this forward. The Pennsylvania Joint Statewide Connected and Automated Vehicles Strategic Plan serves as a roadmap for organizational change as CAV technology advances. In collaboration with internal and external stakeholders, the CAV Strategic Plan focuses on several key business areas and culminates in 45 implementable objectives with identified short- and long-term benefits. Each objective is captured on a single page and is tied to the business areas, gaps, and six strategic goals formulated during plan development. The CAV Strategic Plan is designed around business motivations and intended to be action oriented. The objectives include identification of stakeholders, investment needed, and next steps. The document concludes with selected pilot projects that Pennsylvania can pursue today.					
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# LIST OF ACRONYMS AND ABBREVIATIONS

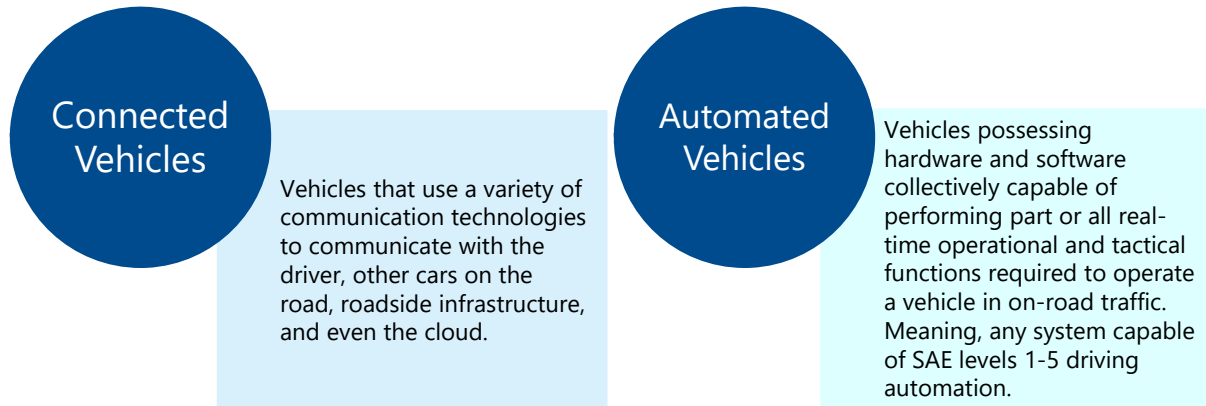
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AAA	American Automobile Association
AAMVA	American Association of Motor Vehicle Administrators
AASHTO	American Association of State Highway and Transportation Officials
ADS	Automated Driving System
ATA	American Trucking Associations
AV	Automated Vehicle
CAV	Connected and Automated Vehicles
CIS	Center for Internet Security
CMM	Capability Maturity Model Evaluation
CMU	Carnegie Mellon University
ConOps	Concept of Operations
CSC	Critical Security Controls for Effective Cyber Defense
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
DCED	Department of Community and Economic Development
DMV	Department of Motor Vehicle
DSRC	Dedicated Short-Range Communications
DVS	Driver and Vehicle Services
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
IPV6	Internet Protocol Version 6
IT	Information Technology
ITS	Intelligent Transportation Systems
ITSPA	Intelligent Transportation Society of Pennsylvania
KSAs	Knowledge, Skills, and Abilities
L RTP	Long-Range Transportation Plan
MASITE	Mid-Atlantic Section of the Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act
MPO	Metropolitan Planning Organization
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
OEM	Original Equipment Manufacturer
PA	Pennsylvania
PIP	Public Involvement Plan
PMTA	Pennsylvania Motor Truck Association
PennDOT	Pennsylvania Department of Transportation



PennSTART .....	Pennsylvania Safety, Transportation and Research Track
PSP .....	Pennsylvania State Police
P3 .....	Public-Private-Partnerships
PTC .....	Pennsylvania Turnpike Commission
RPO .....	Regional Planning Organization
SAE .....	Society of Automobile Engineers
SOP .....	Standard Operating Procedures
SPaT .....	Signal Phase and Timing
SPC .....	Southwestern Pennsylvania Commission
STIP .....	State Transportation Improvement Plan
TIP .....	Transportation Improvement Plan
TMC .....	Traffic Management Centers
TSAMS .....	Traffic Signal Asset Management System
TRB .....	Transportation Research Board
TSMO .....	Transportation Systems Management and Operations
USDOT .....	United States Department of Transportation

## TERMINOLOGY



The term **connected and automated vehicles (CAV)** can refer to a variety of implemented vehicle technologies to improve travel. These technologies may work at the level of the vehicle, the transportation system, or both. Some conflate both connected and automated systems with intelligent transportation systems (ITS). ITS may include connected and automated vehicles systems, but is a much broader concept involving a variety of advanced applications that go beyond vehicle systems. For example, connected and automated vehicles technologies may or may not be integrated into ITS, depending on the specific application [1].

**Automated vehicles (AV)** will integrate onto United States roadways by progressing through six levels of automation advancements. Figure 1 presents the automation levels as defined by the Society of Automotive Engineers (SAE). Appendix A provides additional CAV technical definitions.

### SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) AUTOMATION LEVELS

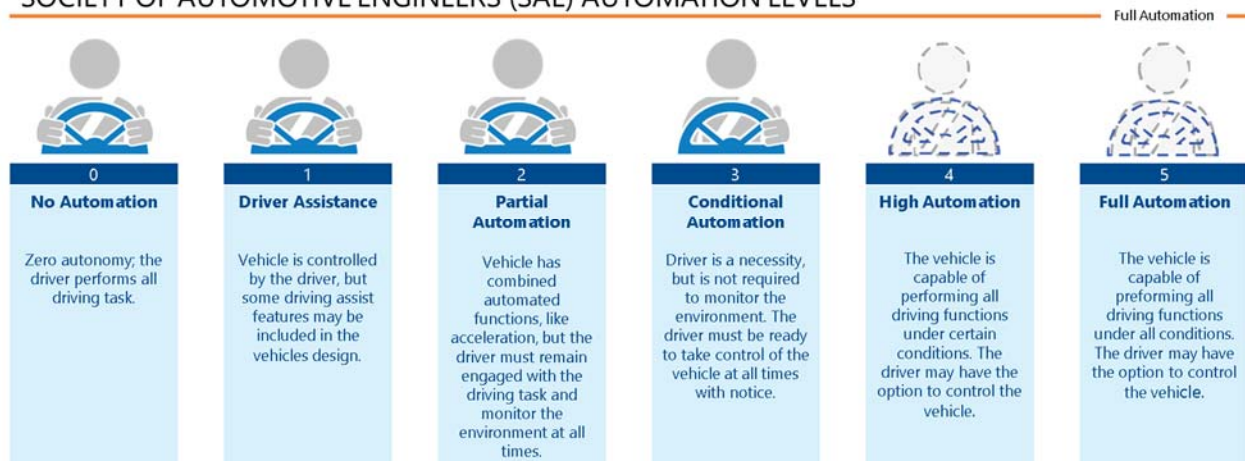


Figure 1: SAE Automation Levels [2]

For this CAV Strategic Plan, the terms **Connected Vehicle (CV)** and **Automated Vehicle (AV)** are combined into **connected and automated vehicles (CAV)**. This term represents a grouping and not necessarily one vehicle having the characteristics of a connected vehicle and an automated vehicle.

## EXECUTIVE SUMMARY

Nearly 40,000 people die in traffic crashes each year in the United States, with 1,188 in Pennsylvania in 2016 [2], and according to National Highway Traffic Safety Administration (NHTSA), more than 90 percent these crashes are attributed to human error. Connected and automated vehicles (CAV) technologies are rapidly advancing, and while the promise for safety benefits is substantial, states have a critical role to play in shepherding this forward. Pennsylvania is in the midst of these mobility disruptions, and the opportunity is now at hand to take assertive steps toward leading the transformation.

The Pennsylvania Joint Statewide Connected and Automated Vehicles Strategic Plan (hereafter the CAV Strategic Plan) serves as a roadmap for organizational change as CAV technology advances.

Investments from private and civic sectors have accelerated the development of new vehicle and infrastructure technology that aims to eliminate injuries and deaths caused by human error leading to vehicle crashes. CAV could significantly improve traffic safety, but these technologies also have consequences on traffic management, infrastructure asset management, data availability, regulation and liability, and models of vehicle ownership. Many vehicle manufacturers have been partnering with technology companies for years and are beginning to release automated vehicles. Pennsylvania must act now to prepare for the anticipated shift in consumer preference for CAV.

**CAV Strategic  
Plan Vision**

*Safe integration of  
connected and  
automated vehicles  
technologies within  
Pennsylvania's  
transportation  
system.*

This document addresses Pennsylvania's chief motivations for CAV planning and operations:

- 1) Inform leadership of CAV developments, including capabilities and limitations, projected timelines, predicted risks, and benefits for traffic management operations and public safety;
- 2) Present the approach and findings from the CAV Strategic Plan's development process;
- 3) Establish the vision, mission, and goals of the Pennsylvania (PA) CAV Program;
- 4) Set proactive objectives and actionable steps for Pennsylvania Department of Transportation (PennDOT); and
- 5) Outline pilot projects that demonstrate the benefit of CAV and advance the PA CAV Program.

In collaboration with internal and external stakeholders, the CAV Strategic Plan focuses on several key business areas and culminates in 45 implementable objectives with identified short- and long-term benefits. Each objective is captured on a single page and is tied to the business areas, needs, and six strategic goals formulated during plan development shown in the figure below.



The CAV Strategic Plan is designed around business motivations and intended to be action oriented. The objectives include identification of stakeholders, investment needed, and next steps. The document concludes with selected pilot projects that Pennsylvania can pursue today.

## INTRODUCTION

The Pennsylvania Joint Statewide Connected and Automated Vehicles Strategic Plan (hereafter the CAV Strategic Plan) was developed in collaboration with multiple internal and external stakeholders over a 12-month period. CAV is disruptive, and this document captures the breadth of processes, considerations, and next steps necessary to advance Pennsylvania in this area. The next several pages present the core of the CAV Strategic Plan, with additional detail provided in the objectives and appendices that follow.

CAV terminologies and acronyms – including levels of automation – were already presented prior to this introduction. The first section below outlines the business case for CAV including the potential to improve safety, reduce emissions, capture lost time, improve quality of life, save money, and improve equitable access to transportation, among others. The timeline for market penetration by the 2040s will have profound implications for most businesses and most governmental departments at varying levels.

The second section describes the process of information gathering to develop the CAV Strategic Plan, including internal and external documents, policies, and initiatives that serve to establish best practices and evaluate the existing nascent CAV Program. Internal information gathering activities included review of applicable Pennsylvania documents, coordination, and facilitation of two workshops with senior staff, as well as several interviews with selected Pennsylvania Department of Transportation (PennDOT) offices and other Pennsylvania agencies. Additional information is included in the appendices. The “Current” sub-sections provide accounts of current CAV initiatives, including winning the designation as one of ten national United States Department of Transportation (USDOT) Automated Vehicle Proving Grounds, the establishment of the Smart Belt Coalition and Policy Task Force, and research collaborations with Carnegie Mellon University (CMU), among others.

Review of various CAV-related documents as part of an external information gathering effort helped ensure the alignment of the CAV Strategic Plan with national guidance and research. Documents reviewed included those published by USDOT, American Association of Motor Vehicle Administrators (AAMVA), American Association of State Highway and Transportation Officials (AASHTO), Transportation Pooled Fund Program, National Cooperative Highway Research Program (NCHRP), and Transportation Research Board (TRB). Summaries are included in the appendices. This research sought to capture knowledge of the most current and successful policies and global best practices enacted by transportation agencies related to CAV technologies.

Using the internal and external information gathered, a Capability Maturity Model (CMM) Evaluation evaluated existing initiatives. Use of a CMM framework to evaluate the CAV Strategic Plan ensures alignment with national guidance and research. The frameworks allow for a rigorous common understanding and improvement of institutional issues that an agency faces on a continual and consistent basis. Six dimensions describe agency capabilities: Business Processes, Systems and Technology, Performance Measurement, Culture, Organization and Staffing, and Collaboration. PennDOT’s Connected Vehicle Program and Automated Vehicle Program each have an average ranking of 1.5 out of 4, across the six dimensions, indicating pilots are underway, but a program is not completely initiated. The Culture and Collaboration dimensions demonstrate the most success. For the Connected Vehicle Program, the current maturity level of the Collaboration dimension is the highest with a score of 2, which reflects existing external partnerships with research institutions, metropolitan planning organizations (MPOs), and the Pennsylvania Turnpike Commission (PTC), as well as the internal collaboration which has come into fruition with the creation of this plan. For the Automated Vehicle Program, the current maturity level of the Culture and Collaboration dimensions is also 2, which reflects the current administration’s emphasis on AV technology implementation, the existing task force with representation from PennDOT, other government agencies, freight carriers, automotive original equipment manufacturers (OEMs), and standards organizations.

The final step of the plan development process was the identification of eight gaps for the CAV Program’s growth and maturity. These gaps were identified in the areas of internal coordination, coordination with public sector,

coordination with private sector, funding, guidance, knowledge, personnel skills and abilities, policy and regulation, and organizational structure.

The third section of the CAV Strategic Plan establishes the CAV Program Vision, Mission, and Goals to guide the program and measure progress. The *vision statement* serves as the optimal and desired state of the program:

*Safe integration of connected and automated vehicles technologies within Pennsylvania's transportation system.*

The *mission statement* identifies the purpose of the program:

*Proactively contribute resources to support a safe and sustainable transportation system through adoption of connected and automated vehicles technologies across Pennsylvania.*

With the vision and mission statement serving as a framework, six goals establish expected outcomes that will demonstrate success of the program. In general, these goals are in line with PennDOT's strategic themes laid out in the PennDOT 20/20 Strategic Direction, and the CAV Strategic Goals section provides further explanations of each:

- 1) Improve Safety
- 2) Enhance Mobility
- 3) Prepare Workforce
- 4) Foster and Sustain Partnerships
- 5) Increase Public Awareness
- 6) Strengthen Economic Collaboration

The fourth section of the CAV Strategic Plan holds 45 objectives across nine business areas that function as a framework for recommended steps to prepare for the arrival of CAV technologies. The nine business areas are Maintenance and Operations, Design and Construction, Planning and Research, Information Technology and Security, Driver Licensing and Motor Vehicles, Modal Considerations, Policy and Legal, Outreach and Collaboration, and Workforce Requirements. The objectives result from the culmination of the findings from internal and external information gathering, CMM evaluation, and the identified gaps, vision, mission, and goals outlined in sections one, two, and three. Each objective is a one-page summary including the recommended steps to achieve the objective, organized as a timeline with the metrics to measure success. Additional information is included on each objective's one-page, such as the lead PennDOT office, key stakeholders, level of investment, CMM impact required to accomplish the objective, as well as the goals addressed, justification for investing, "Day 1 Benefits", and identification of early wins where applicable.

The final section recommends pilot projects in four different practice areas that will most immediately act to accomplish some of the recommended steps within the CAV Strategic Plan. These practice areas are low speed automated shuttle pilots, CV freight application pilots, outreach pilots, workforce, and fleet vehicles pilots.

Public transportation and infrastructure agencies will transition to data-driven business processes relying on wireless communication between vehicles, physical infrastructure, technological devices, and data infrastructure. The Commonwealth of Pennsylvania is a leader in the development and testing of CAV technologies. PennDOT aims to lead by example by setting strategies to collaborate across sectors and update its organizational structure, technology, systems, and business processes for effective and efficient handling of oncoming societal changes.

## A NATIONAL PERSPECTIVE ON CAV

New ideas to improve transportation safety emerge constantly and standards are fine-tuned and evolving. However, traditional transportation projects can take a decade or more to implement, while technology evolves at overwhelming speeds. The pace of technology adoption is now faster than ever before. For example, it took decades for the telephone to reach 50% of households, beginning before 1900, but it only took five years or less for cellphones to accomplish the same penetration in 1990 [3]. Vehicle technology is fast evolving and decision makers should reframe the conventional public policy discussion to responsibly and assertively advance CAV technologies considering social interests, adopting the principles of rapid learning and shared knowledge creation [4].

Future transportation systems will most likely consist of an increasing number of CAVs. Agencies, such as the USDOT, are committed to supporting the innovators who are developing these types of vehicles to ensure their safe testing and deployment before they are available to consumers [2]. Together, these technologies can not only improve vehicle safety, but also improve vehicle efficiency and commute times, alter transportation costs, and fundamentally change mobility around the world.

Automotive manufacturers have announced that they plan to have CAVs publicly available by 2020-2025. Based on this, many transportation professionals anticipate that mixed vehicular environments will shape the next generation transportation systems. CAV technologies will create a shift in the transportation decision-making process.

## A PENNSYLVANIA PERSPECTIVE ON CAV

As one of the leading research states, Pennsylvania is focused on the development and testing of CAV technologies. All Commonwealth agencies are working diligently to ensure that continuing innovation progresses in balance with the safety of the traveling public. Pennsylvania believes that robust public discussion of the issues and opportunities this technology presents will ensure the greatest benefit to all Pennsylvanians. Because of this vision, PennDOT commissioned the creation of a plan to assist preparations for these technological advancements. The result is this CAV Strategic Plan, which achieves four actions:

- Builds upon existing research;
- Identifies steps to prepare for CAV technologies;
- Defines a comprehensive set of focused, reasonable, and deployable applications; and
- Provides critical missing data and information pertaining to the early deployment of CAV.

The CAV Strategic Plan serves as the foundation for all policy and procedural decisions relating to connected and automated vehicles in Pennsylvania.

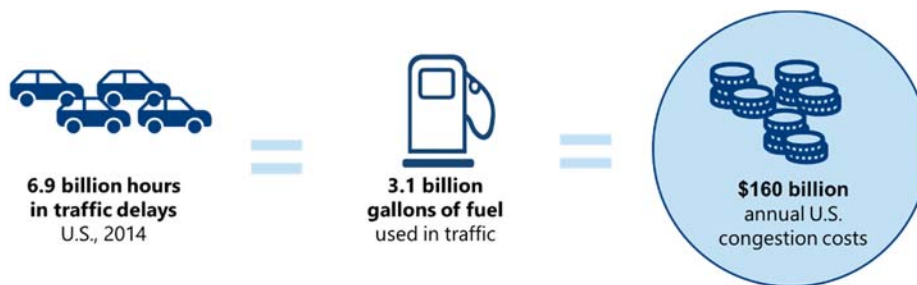


## CAV BUSINESS CASE

The fact that **94 percent** of serious crashes are due to human error according to National Highway Traffic Safety Administration (NHTSA) provides the basis for the belief that CAV will save lives and reduce injuries. CAV have the potential to remove human error from the crash equation, which will help protect drivers and passengers, as well as bicyclists and pedestrians. On average in Pennsylvania each day 355 reportable traffic crashes occurred (about 15 crashes every hour), three persons were fatally injured (one fatality every 7 hours), and 227 persons were injured (about 9 injuries every hour). Essentially the transportation engineering and planning industry has been selling investment in transportation the same way for 50 years by addressing safety and congestion needs. The situation has improved but now we face incremental improvements and sometimes progress is flat. The table above and the diagram below show our current situation on key indicators of the Pennsylvania transportation system. CAV shows the promise of making significant gains in improvement of these key indicators.

**Both National and Pennsylvania 2016 Highway Safety and Mobility Statistics Make the Case of CAV Investment**

	National Statistics	Pennsylvania
Fatalities	37,461	1,188
Economic cost of fatalities per person	\$784	\$1,382
Annual congestion cost	\$63.4 billion	\$2.6 Billion
Tons of freight moved	20.1 Billion	1.0 Billion



A 2015 Intelligent Transportation Society of America study examined existing research to estimate the comprehensive costs of a crash and the number of crashes that four connected vehicle safety applications may prevent. These applications include intersection movement assist, left turn assist, forward collision warning, and lane change warning/blind spot warning. The study concluded that the applications can result in **\$178.8 billion** in societal benefits annually if deployed across the entire United States vehicle fleet. This includes tangible economic benefits such as avoided medical care costs and productivity losses, as well as intangible benefits such as reductions in quality of life because of a motor vehicle crash [5].

### Improved Individual Mobility

CAV may also provide new mobility options to millions more Americans. Today **53 million Americans** have some form of disability. In many places across the country employment or independent living rests on the ability to drive. One study suggests that automated vehicles could create new employment opportunities for approximately 2 million people with disabilities [2].

### Improved Freight Mobility

In 2011, Pennsylvania's multimodal freight transportation system carried approximately **\$1.6 trillion** of goods into, within, out of, and through the state, 2040 projections suggest **\$3.7 trillion** of goods [5]. CAVs will be particularly suitable for long-haul freight travel, due to labor costs and limited routes, mostly on grade-separated highways. The trucking industry has historically embraced many new technologies, truck-based and otherwise, and integrated them into its operations, and CAV technologies will most likely be the same. Apart from trucking, CAV technologies could have an impact on all modes of transportation related to freight movement, starting from the ports where goods

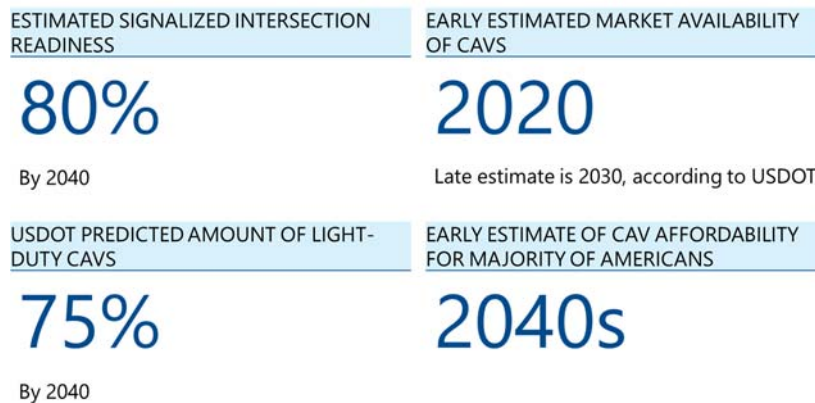
come in, to the consumer’s hands. For example, CV applications and AVs may open new opportunities to enhance port operations, from ship side to road and rail. Possible solutions include platooning in drayage operations, automated sea to shore vehicles used in ports, and driverless container transfer at intermodal terminals.

## Augmented Transit Service

Automated vehicles are particularly suitable as a solution to mitigate the high labor costs and limited routing of public transport travel through complementary services such as “microtransit” – fleets composed of 6-12 passenger vans with frequent, demand-response service ordered via a mobile application [6]. Tests in U.S. cities and suburbs with private businesses and public-private partnerships anticipate proving the usefulness of the technology. Pilot programs with public agencies are often a cost-effective substitute for discontinued bus routes. With the introduction of automated technology, these services would become even more cost-competitive.

## Timeline

Deployment of CAV technologies will be dependent on appeal to the public and will occur over several decades. According to USDOT, slow deployment of CAV technologies in the United States over a 20-year period as existing replacement or upgrades of infrastructure systems occur is likely. The USDOT estimates that environmental and mobility benefits could occur even without widespread market penetration. AASHTO, the USDOT, and Transport Canada supported research in 2015 to determine scenarios for deployment and timelines [7].



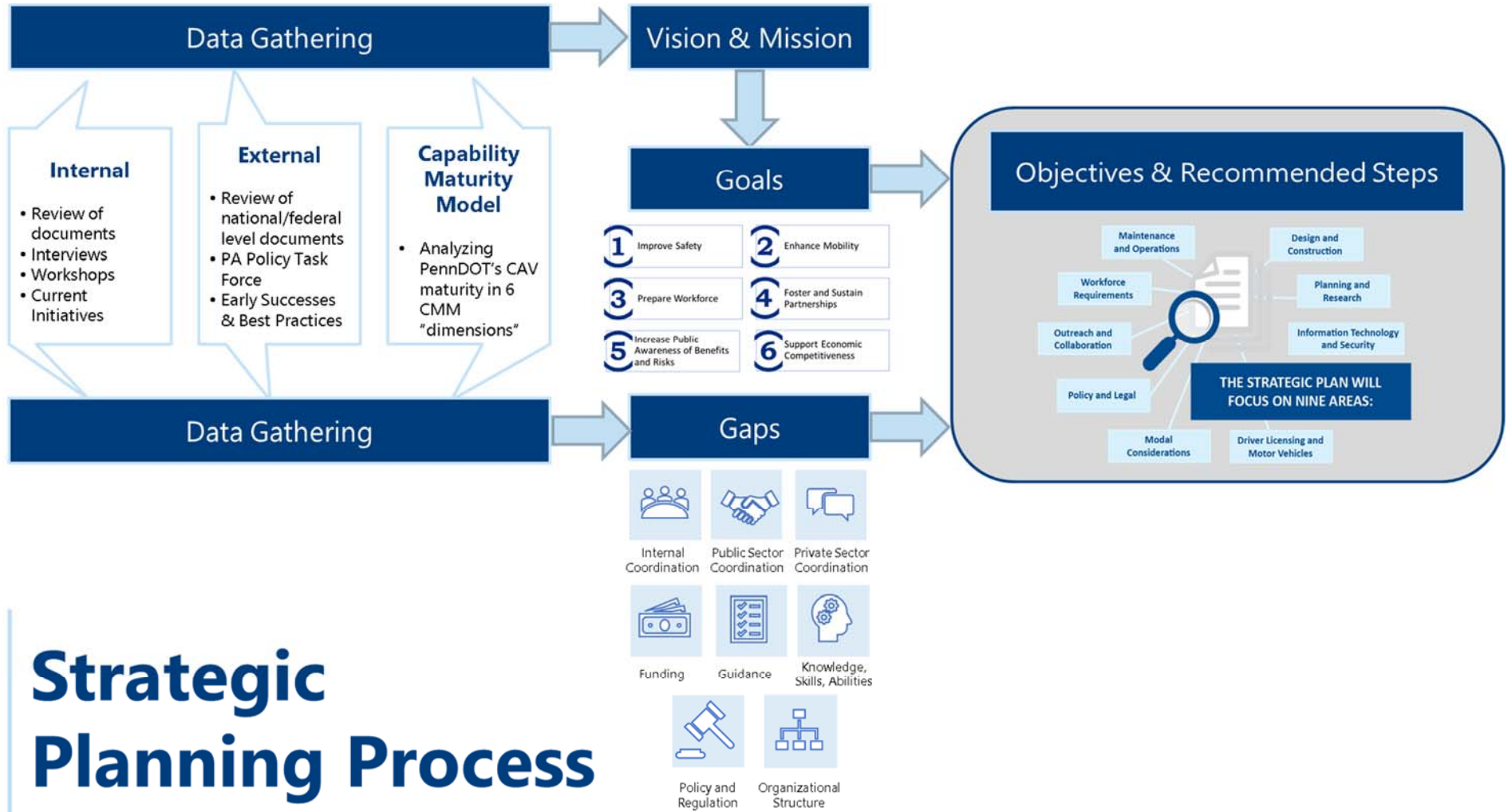
There is a wide range of predictions on the deployment timeframe and consumer adoption of connected and automated vehicles. Level 1 and 2 automation features are becoming more common in new vehicles, with more than a dozen auto manufacturers offering various safety warning systems such as merge warning and high-speed alerts. Adaptive cruise control and lane change assist is already available from more than a dozen vehicle manufacturers [8]. Social barriers to CAV roll out including consumer trust may slow adoption after the initial release, with about 15% of light-duty vehicles on the road automated by 2030 [9]. While private industry has announced an aggressive timeframe, government must consider safety and system security in regulating, deploying, and implementing new connected and automated technologies. Nonetheless, if the automotive industry continues to move quickly, the automated features installed on vehicles may be designed independently of any changes to the existing infrastructure, standards, or design criteria [10].

The recommendations within the CAV Strategic Plan assume that the predictions discussed here are accurate, and widespread access to connected and automated vehicles will occur by the 2040s. However, the process towards CAV market penetration will be a gradual one. The Commonwealth, as well as the rest of the United States, will experience mixed-fleets in the interim period, which will come with its own set of challenges.



## PLAN DEVELOPMENT

The development of the CAV Strategic Plan was a 12-month process that sought to establish a baseline for Pennsylvania. The process included internal and external information gathering, identifying priority issues, defining gaps to fill, and determining appropriate participation.



# Strategic Planning Process

## Internal Information Gathering

Internal information gathering activities included reviews of applicable Pennsylvania documents, facilitation of two workshops with senior staff, and completion of several interviews with selected PennDOT offices and other Pennsylvania agencies. For detailed documentation, refer to Appendix B.

A total of 20 interviews contributed to the development of the CAV Strategic Plan. The interviews provided qualitative feedback on business, institutional, and strategic deployment gaps and served as listening sessions. The primary goals of the interviews were to determine gaps and challenges and document the CAV perspective of different entities within the agencies. Questions included dialog regarding any active or future projects/initiatives that may benefit from CAV from each of their perspectives.

### Interviews were a Significant Source of Internal Information Gathered

Interviewed Agencies	Topics Addressed <i>(Not all topics were addressed with each agency)</i>
PennDOT	Maintenance and Operations
Pennsylvania Turnpike Commission	Design and Construction
Pennsylvania Department of Community and Economic Development	Planning and Research
Pennsylvania State Police	Information Technology and Security
Insurance Federation of Pennsylvania	Driver Licensing and Motor Vehicles
Delaware Valley Regional Planning Commission	Modal Considerations
Southwestern Pennsylvania Planning Commission	Workforce Requirements
Harrisburg Area Transportation Study	Policy and Legal
City of Philadelphia	Outreach and Collaboration

## Current Legislative Initiatives

As the technology for CAV continues to develop, state governments are beginning to debate and address the potential benefits and impacts of these vehicles.

Pennsylvania has one Senate Bill and three House Bills under consideration:

- Senate Bill No. 427, Highly Automated Vehicles and Platooning Testing
  - Status: Pending - Senate Transportation Committee
  - Author: Vulakovich (R), Date of Last Action: 2/24/2017
  - Topics: Definitions, Vehicle Testing, Cybersecurity of Vehicle, Insurance and Liability, Licensing and Registration, Vehicle Inspection Requirements, Operator Requirements, Commercial, Request for Study, Other
  - Summary: Amends Vehicles of the Pennsylvania Consolidated Statutes, in operation of vehicles, provides for highly automated vehicles and platooning testing.
- House Bill No. 1637, Autonomous Vehicle Provisions
  - Status: Pending - House Transportation Committee
  - Author: Marshall (R), Date of Last Action: 6/28/2017
  - Topics: Definitions, Operation on Public Roads, Insurance and Liability, Licensing and Registration, Request for Study, Other
  - Summary: Amends Title 75 of the Pennsylvania Consolidated Statutes, provides for automated vehicles, establishes the Fully Autonomous Vehicle Advisory Committee.
- House Bill No. 1958, Autonomous Vehicles
  - Status: Third consideration and final passage, 3/13/2018
  - Author: Rothman (R), Date of Last Action: Third consideration and final passage, 3/13/2018
  - Topics: Definitions, Operation on Public Roads, Commercial
  - Summary: Amends statutes relating to vehicles, provides additional rules of the road in general, relates to platooning, relates to automated vehicles.
- House Bill No. 2300, Autonomous Vehicles

- Status: Referred to Transportation, 4/24/2015
- Author: Marshall (R), Date of Last Action: Referred to Transportation, 4/24/2015
- Topics: Definitions, Autonomous Shuttle Vehicles, Connected and Highly Autonomous Vehicle Advisory Committee
- Summary: An Act amending Title 75 (Vehicles) of the Pennsylvania Consolidated Statutes, further providing for definitions; and providing for autonomous vehicles, imposing a penalty and establishing the Connected and Highly Autonomous Vehicle Advisory Committee and providing for its powers and duties.

The Autonomous Vehicle Policy Task Force is broadly composed of PennDOT staff, industry leaders, academic experts, sister agencies and constituent representative groups to work as an advisory board for best practices for highly automated vehicles testing policies. Within this context, a highly automated vehicle is a motor vehicle or a mass transit vehicle with full or high automation that is equipped with an automated driving system (ADS). This group has been meeting regularly since the spring of 2016 to develop recommendations for PennDOT's Secretary regarding policies to oversee on-road highly automated vehicles testing. The task force's goal is to create a framework for testing highly automated vehicles in Pennsylvania that balances public safety with innovation and provides flexibility required to keep the state in the forefront of the development of this emerging and potentially transformative technology.

### Current Infrastructure Projects

In 2014, FHWA awarded PennDOT an Accelerated Innovations Deployment (AID) grant. PennDOT plans to use the *grant to deploy innovative technologies, including adaptive traffic control signals and DSRC*, along McKnight Road (SR 4003) from I-279 to Perrymont Rd/Babcock Blvd. in Ross and McCandless Townships.

Through a collaboration between CMU, Cranberry Township, the City of Pittsburgh, PennDOT, and the Southwestern Pennsylvania Commission (SPC), *11 traffic signals in Cranberry Township and 24 traffic signals in Pittsburgh were equipped with Dedicated Short-Range Communications (DSRC) radios*. In January 2015, CMU entered into a Memorandum of Agreement with the USDOT ITS JPO as a member of the Affiliated Test Bed Program.

The same year, *Uber rolled out its first fleet of self-driving cars in Pittsburgh*, making it the first city to let any passenger hail an automated vehicle. The City of Pittsburgh had already entered a mutually beneficial agreement with CMU in 2014 allowing them to use the city as their "urban lab" in exchange for utilizing the university's knowledge as a research and development resource [11]. Existing relationships between CMU and Uber employees, a suitable testing environment, and the Mayor's informal agreement to allow Uber to test its vehicles led to Pittsburgh's selection as a testing ground. The lack of regulation later grew tense as Uber did not meet unofficial promises to provide some public benefits, but the company is still operating vehicles on Pittsburgh's streets [12].

In the summer of 2016, PennDOT developed the *Harrisburg Connected and Automated Vehicle Test Bed* by *equipping eight traffic signals around the State Capitol with DSRC*. This technology allows the traffic signal to broadcast signal phase and timing data to automated vehicles navigating the intersection. Additionally, the signal phase and timing (SPaT) data can be ingested by connected vehicles and used in other connected vehicle applications such as "Red Light Violation Warning."

### Current Collaboration Activities

*The Smart Belt Coalition formed in 2016* and is a strategic partnership composed of five transportation agencies and seven academic institutions throughout Michigan, Ohio, and Pennsylvania. The Coalition's mission is to create a way for transportation agencies, academic institutions, and others to collaborate on initiatives that will advance connected and automated vehicles in the participated partner states.

In 2017, *the Pennsylvania Turnpike Commission finalized a Connected and Automated Vehicles Program Roadmap*. The Turnpike's CAV program roadmap defines the CAV core focus areas, prioritizes CAV applications for

implementation, CAV foundation needs and considerations, CAV “Quick Win” projects, funding sources, and the implementation framework along with a set of action plans. The CAV program identifies the core focus areas for CAV applications based on Turnpike’s established Goals and Objectives defined as part of the Turnpike Strategic Plan. The determination of the core focus areas comes from aligning the overall mission of the PTC with the national best practices, guidance documents, and architectures, defined through the Connected Vehicle Reference Implementation Architecture (CVRIA). “Safety” and “mobility” were identified as overall goals of the PTC’s CAV Program.

*Penn State’s Thomas D. Larson Pennsylvania Transportation Institute, in collaboration with the City of Pittsburgh, has won designation as one of ten national USDOT Automated Vehicle Proving Grounds.* USDOT designated 10 proving ground pilot sites to encourage testing and information sharing around automated vehicle technologies. These proving ground designations will foster innovations that can safely transform personal and commercial mobility, expand capacity, and open new doors to disadvantaged people and communities.

*The first Pennsylvania AV Summit was held September 2017 in State College, Pennsylvania.* PennDOT and Pennsylvania Department of Community and Economic Development (DCED) convened this conference, with the invaluable support of the co-hosts, the Mid-Atlantic Section of the Institute of Transportation Engineers (MASITE) and the Intelligent Transportation Society of Pennsylvania (ITSPA), to foster a wider public understanding and discussion about the benefits and issues of AV technology. The group *conducted a second AV Summit in April 2018.* The 2018 summit focused on local planning and economic development, workforce development and training, and safety.

PennDOT, the Pennsylvania Turnpike Commission and Penn State University are partnering to explore and advance The *Pennsylvania Safety, Transportation and Research Track (PennSTART), a state-of-the-art training and testing facility to address the transportation safety and operational needs of Pennsylvania and the Mid-Atlantic Region.* The facility is anticipated to be operational in 2020 and will benefit emergency responders, transportation organizations, and research institutions.

## External Information Gathering

Review of national guidance, research, existing projects, and organized groups helped ensure this plan enables Pennsylvania to build on examples of success. Documentation from the organizations listed below helped identify the context of nationally applicable activities.

- USDOT
- American Association of Motor Vehicle Administrators
- AASHTO
- Transportation Pooled Fund Program
- National Cooperative Highway Research Program
- Transportation Research Board

Appendix C provides detailed document reviews and relevance to the CAV Strategic Plan.

## Policy Task Force

A CAV Strategic Plan discussion held during the Policy Task Force meeting on November 8<sup>th</sup>, 2017 at the PennDOT Riverfront Office Complex<sup>1</sup> provided an interface with industry partners, legislative representatives, and other

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<sup>1</sup> Participants of the November 8<sup>th</sup> meeting included representatives from PennDOT, Pennsylvania Department of Community and Economic Development, Pennsylvania State Police, Pennsylvania Legislation, Penn State University, Pennsylvania Department of Insurance, Pennsylvania Turnpike Commission, Insurance Federation, General Motors, American Automobile Association (AAA), American Trucking Associations (ATA), Carnegie Mellon University, FHWA, Local Government, Jackie Group, Peloton Technology, Pennsylvania Public Utility Commission, Pennsylvania Trial Lawyers Association, Global Automakers, Pennsylvania Motor Truck Association (PMTA), SAE International, Uber Technologies, and University of Pennsylvania.

interested parties to CAV in Pennsylvania. An open discussion session ensued focused on five areas: opportunities for institutional change; business plan integration; accountability; funding; and partnerships. Further discussion included institutionalization of CAV into the organizational structure within PennDOT; criticality of engagement of all agencies that may be affected by CAV; importance of planning and policy, including urban vs. rural areas; addressing the transportation needs of certain populations; and criticality of an education campaign from the bottom up. Appendix C presents additional detailed information.

## Early Successes and Best Practices

Early successes and best practices in the preparation and deployment of CAV technology helped identify opportunities for Pennsylvania. Appendix D includes summaries of existing pilots, testing facilities examined, and policies reviewed.

North American CAV Locations	International CAV Locations
Tampa, Florida	European Union L3Pilot
New York, New York	United Kingdom MERIDIAN
Wyoming	United Kingdom SCOOP@F
SMART Columbus	Finland, Norway, Sweden and Denmark Nordic Way
Ann Arbor, Michigan	United Kingdom GATEway
MCity, Michigan	European Union eCall
	United Arab Emirates Dubai Autonomous Transportation Strategy

## Capability Maturity Model Evaluation

To ensure that the CAV Strategic Plan aligns with national guidance and research, the Department’s connected and automated vehicle programs were evaluated using a capability maturity model. The assessment of current maturity is based on input from PennDOT staff during a workshop led by staff from the Texas A&M Transportation Institute and the interviews performed as part of the internal data gathering effort.

The Capability Maturity Model framework consists of concepts with roots from the software development industry and the CMM is widely used for various applications in the Information Technology (IT) world. Capability maturity brings together an approach to review common barriers to adoption and success of technology oriented program, such as the Transportation Systems Management and Operations (TSMO) program. The frameworks allow for a rigorous common understanding and improvement of institutional issues that an agency faces on a continual and consistent basis [13]. By understanding and using a capability maturity framework, agencies can:

- Develop consensus around needed agency improvements.
- Identify their immediate priorities for improvements.
- Identify concrete actions to continuously improve capabilities to plan, design, and implement technology programs.

Consistent with the AASHTO Guidance, capabilities of agencies are described in the same six dimensions [13]:



Business Processes	Formal scoping, planning, programming, and budgeting
Systems and Technology	Use of systems engineering, systems architecture standards, interoperability, and standardization
Performance Measurement	Definition of measures, data acquisition, and data utilization
Culture	Technical understanding, leadership, outreach, and program legal authority
Organization and Staffing	Programmatic status, organizational structure, staff development, recruitment and retention
Collaboration	Relationships with public safety agencies, local governments, metropolitan planning organizations (MPOs), and the private sector.

Using the information above and the available literature on the CMM for TSMO, analysts developed a CMM framework under this effort for the CV program and another CMM framework for the AV program.

Appendix E presents the CMM frameworks for connected and automated vehicles programs separately, as well as a detailed explanation of each of the six dimensions provided in tabular form. Figure 2 presents a graphical representation of the CMM level for each of the frameworks developed.

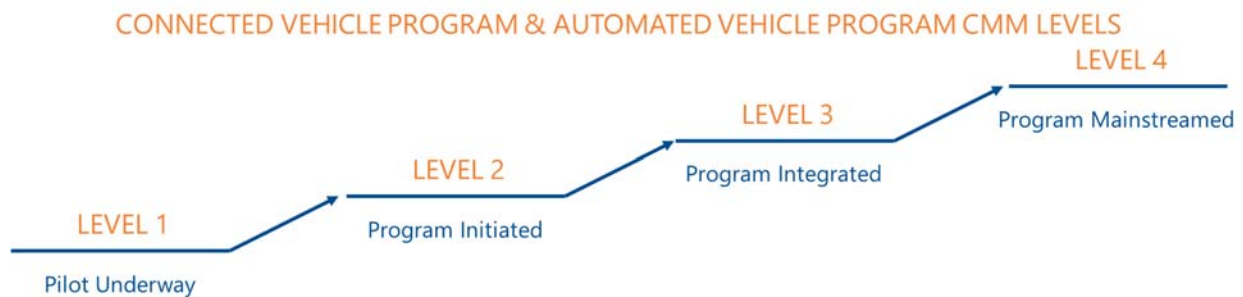


Figure 2: CV Program and AV Program CMM Levels

Using the CMM frameworks created for the connected and automated vehicles programs, PennDOT was ranked.

Figure 3 presents a graphical representation of the ranking of the PennDOT Connected Vehicle Program.



Figure 3: CV Program CMM Ranking

Figure 4 presents a graphical representation of the ranking of the PennDOT Automated Vehicle Program.



Figure 4: AV Program CMM Ranking

The concept of a CMM is to assess the ability of an organization to perform technical work with the desired types of discipline. Increased maturity levels indicate the ability to produce improved quality of products reliably, but does not necessarily correspond to cost efficiency. As part of the CMM workshop, PennDOT staff indicated the desired

level or range of levels for each dimension of maturity for both CVs and AVs. In all cases, PennDOT desires a greater level of maturity than the current assessment.

Program managers expect the progress through CMM levels to move from the lowest maturity level of 1 to the highest desired level, with some time spent in each intervening level. Managers do not anticipate simultaneous maturity characteristics in all cases.

## Actions to Get to the Next Level

The following discussion presents initial steps for each CMM dimension to progress toward the desired maturity level. The *CAV Program Objectives and Recommended Steps* section of this plan will present more detailed strategies to accomplish the actions presented below.

### *Business Processes Dimension*

In the business process dimension, both CV and AV assessed as level 1.5, indicating that some aspects of this dimension had progressed to level 2, but some aspects were still at level 1. Both CV and AV need to take the next step to establish standard practices. For CV, standard practices involve establishing a dedicated budget to implement projects selected through a needs-based analysis. For AV, establishing standard practices include passing legislation and enacting regulations that enable automated operation on public roadways, and harmonizing legislation and regulations with other states to allow consistent interstate operation while addressing data sharing and privacy issues [14]. To advance to the next level, the following should be addressed:

- Continue to participate in peer and national dialogue regarding CAV policy, planning, technical, and legal issues;
- Develop business cases for priority CAV applications regarding both public benefits and agency efficiency;
- Develop a consensus-based regional approach to CAV pilot applications and deployment regarding planning, resource allocation and project development processes;
- Develop consensus regional policy and planning framework for CAV implementation and identify resources for CAV implementation; and
- Establish a framework for ensuring privacy and security management.

### *Systems and Technology Dimension*

In the systems and technology dimension, both CV and AV assessed as level 1, indicating that only limited work has been undertaken. Next steps for CV should be to establish standard practices. This may be accomplished by broadening expertise gained in pilot projects to engineering standards to be applied throughout the state. The engineering standards should apply to CV groups in PennDOT and cooperating groups, such as Information Technology. For AV, next steps involve exploring support for automated operations, both in terms of electronic infrastructure and physical infrastructure. Preparation of the existing infrastructure to support these new technologies will also allow the agency to move to the next level. To advance to the next level, the following should be addressed:

- Continue participation in peer and national dialogues regarding technical specifications of field equipment and standards development;
- Develop a deployment approach;
- Develop detailed CAV use cases, concepts of operations (ConOps), system requirements, and architecture for field applications;
- Develop an approach to Vehicle-to-Infrastructure (V2I) field equipment maintenance;
- License the spectrum for V2I applications according to Federal practice guidelines, and considering regional partnerships;
- Implement a cybersecurity approach for field device deployment; and



- Study and identify synergies with automated vehicle programs including first-mile/last-mile transit, AV bus rapid transit, AV high occupancy toll/managed lanes, and transportation network companies.

### *Performance Measurement Dimension*

In the performance measurement dimension, CV and AV assessed as level 1, indicating that only limited work has been undertaken. Efforts in performance measurement are important for assessing progress in all other dimensions. Without metrics, data, analytics, and program goals for CAV are ad hoc and unsustainable. For CV and AV, next steps involve initiating efforts to collect information on operations involving CV and AV technologies. A project to establish a standard method to easily transmit data from field networks and allow reliable retrieval would improve performance measurement. To advance to the next level, the following should be addressed:

- Identify performance metrics, supporting appropriate data collection and analytics to measure effectiveness of start-up CAV applications;
- Review agency performance measurement program and approach to meeting both Moving Ahead for Progress in the 21st Century Act (MAP-21) and internal agency requirements;
- Review priority CAV applications with respect to their role in providing both operational and asset management data based on probes; and
- Track V2I-related costs and impacts.

### *Organization and Workforce Dimension*

In the organization and workforce dimension, CV and AV assessed as level 1.5, indicating that some aspects of this dimension had progressed to level 2, but some aspects were still at level 1. Next steps should be to broaden the experience base from initial experience and study to full knowledge throughout the organization. While gaining awareness by educating the entire workforce about CV and AV implementation can be beneficial, a more effective next step would be educating and training leaders within each geographic and organizational group. This education and training would address required knowledge, skills, and abilities (KSAs) tailored to the specific needs of each group. To advance to the next level, the following should be addressed:

- Identify and support staff champions;
- Reorganize as appropriate to reduce stove-piping and authority conflicts;
- Review core capacity KSAs needs and job specifics needs for CAV specialty areas, such as systems engineering, data management, communication, and software/hardware versus internal staff availability; and
- Create a stakeholder/decision-maker outreach/communications plan to foster understanding of the CAV business case within the agency, policy-makers, and the public.

### *Culture Dimension*

In the culture dimension, CV assessed as level 1.5 indicating that some aspects of this dimension had progressed to level 2, but some aspects were still at level 1. AV assessed as level 2, indicating that awareness of the topic was widely established. Next steps for CV should be to broaden support of the use of CV tools throughout the organization. Steps to gain broader knowledge should include the publication of benefits studies for use of CV technology along with agency-wide webinars. The AV assessment level benefits from the current public emphasis on AV by technology and automotive companies, as well as support from management. To progress toward level 3, efforts should focus on establishing complete awareness of AV in all business areas with targeted outreach to individual managers. Establishing AV as a consideration in all future work through incorporation of review checklists as a standard practice will also be beneficial. To advance to the next level, the following should be addressed:

- Identify changes needed in agency values and priorities, and culture regarding fostering innovation and embracing technology; and

- Conduct stakeholder outreach to foster understanding of the business case within agency, policy-makers, and the public.

### *Collaboration Dimension*

The collaboration dimension rated most highly in CV and AV. In CV, collaboration is an established practice with an assessment of level 2.5. The next step in CV collaboration is to make geographic collaboration more comprehensive by establishing working relationships with the Philadelphia area as well as state police, first responders, and rural PennDOT districts. In AV, significant collaboration for future deployment is apparent with an assessment of level 2. Next steps include establishing working relationships on AV with agencies responsible for surface roadways and local operations, as well as passing enabling legislation supporting AV operations. To advance to the next level, the following should be addressed:

- Develop consensus among key public sector stakeholders to align objectives with performance measures of achievement;
- Implement collaborative approaches to V2I applications deployment;
- Review opportunities for multijurisdictional peer cooperation (including multistate and multiregional) regarding all key aspects of V2I applications development (systems, business processes, performance); and
- Open conversations with private sector CAV companies and stakeholders to establish mutually beneficial actions that both sectors will accept.

## Gaps

To develop this plan, national and international CAV research was compiled. In addition, multiple workshops and many one-on-one interviews were held. This led to identification of the following gaps.

### Internal Coordination



There is no formal process in place to support coordination within PennDOT at the District or Central Office level regarding the implementation of CAV applications. The limited coordination that does exist is mostly ad hoc and champion-driven. Frequently one region may be doing something that it finds successful, but is not sharing with other regions. Strengthening internal communication and coordination will benefit PennDOT employees and their customers driving on its roadways.

### Public Sector Coordination



There are currently 23 MPOs and regional planning organizations (RPOs) throughout the state, but outreach with their respective counties and municipalities is inconsistent. The introduction of CAV technology will introduce new challenges and require more coordination with transportation and other city agencies. Best practices and federal guidance also ask that states identify a lead agency. PennDOT houses Driver and Vehicle Services (DVS), encompassing Department of Motor Vehicle (DMV) functions, which has a critical role in CAV policy, regulation, and enforcement. Regular engagement between PennDOT – including DVS – and its planning partners can help in identifying pilot projects and bolster the visibility of CAV. PennDOT should take the lead as the transportation agency of the Commonwealth. Other agencies that need to be involved include PTC, Delaware River Port Authority, Delaware River Joint Toll Bridge Commission, DCED, State Police, etc., as well as academia.

### Private Sector Coordination



Producers and consumers of CAV will most likely be primary actors whose market decisions will determine whether and how CAV benefit society. Producers include automobile manufacturers, technology firms, and suppliers. Consumers include private individuals and private-sector fleet owner/operators who could buy and use CAV. Their choices about what technologies to develop, when to deploy them, and how to use them could lead to beneficial or detrimental mechanisms and outcomes, depending on how their roll out is regulated [4]. Therefore, it is imperative to engage these actors early on and begin coordination efforts as soon as possible to be in a position of influence. For example, if CV testing takes place in collaboration with state and local transportation agencies, the agencies will gain valuable institutional information, which would better equip these agencies to implement CV systems in the future [4]. Outlining the desired outcomes and findings from pilot programs and the terms of data sharing before entering conversations with potential collaborators is imperative to success.

### Funding



New infrastructure investments could be necessary to maximize the benefits of these vehicle innovations, and many of these projects would require resources and funding. The Transportation Research Board is funding a project to define potential business models for deployment of the infrastructure needed to support CAV use. These new infrastructure types include highly detailed maps needed for automated driving. Federal, state, and local public agencies could play a role in map creation, depending on what is relevant at their level. For example, they could contribute to the development of open standards for maps, which would allow for a broad interoperability of automated driving systems. They could also collect and publish pertinent data on lane closures, work zones, and weather [1].

## Guidance



Establishing technical standards is essential for V2I and vehicle-to-vehicle (V2V) applications and programs. SAE International, USDOT, and various public and private organizations have established standards for DSRC (SAE J2735 and J2945), which will support a wide variety of V2V and V2I applications. The V2I Deployment Coalition, now known as the Cooperative Automated Transportation Coalition, intends to develop V2I standards, guidelines, and test specifications to support interoperability. Finally, USDOT is funding the development of the Connected Vehicle Reference Implementation Architecture, the goal of which is to support the development of deployments as well as to identify potential interfaces for standardization [1].

MPOs, local public agencies, transit agencies, and state agencies should begin considering CAV strategies in their long-range planning. A general understanding of the technology, which applications work under what conditions, pros and cons of each application, capital costs and funding availability, integration into the existing systems, long term impacts, are some of the items that need to be identified and that need guidance. PennDOT can participate in the creation of this guidance and lead the conversation as it relates to the Pennsylvania transportation system. An example is the integration of CAV into existing ITS Architectures, which provides a common framework to guide planning, defining, and integrating these applications into existing ITS deployments.

## Knowledge, Skills, and Abilities



Many consider CAV the new frontier of mobility. Organizations are still scratching the surface of what is possible and necessary to make CAV and all connected transportation systems a reality. Not only do workers need the skills necessary to design and manufacture CAV, but regulations need to be set in place so that CAV can function on current and future roadways with drivers, pedestrians, and first-responders to be able to manage the rollout of their use. Agencies must work together to create a common set of requirements for workers in the CAV space. Without this, educational and training institutions will not be able to provide the right programming and skills to future workers or to current workers looking to upskill. Current workers in CAV-related occupations who lack CAV-related skills must start to cross-train and develop related skills to remain competitive. Without upskilling and cross-training, the current workforce may render itself obsolete when CAV become the norm. Strengthening connections between employers and the talent system, made up of community colleges, trade schools, workforce boards, universities and 4-year colleges, offsets some of the risks. Without proper engagement by employers, the talent system will not know what employers need to train new workers or upskill current workers [15].

## Policy and Regulation



The existing rules of the road developed over the course of the last 100 years assume that drivers are human beings. However, law enforcement and other government entities may soon need to adapt to a world where this is no longer true [1]. The adoption of connected and automated vehicles systems has a myriad set of implications for legal frameworks at all levels—federal, state, and local. The federal government, primarily through USDOT, is responsible for adopting and enforcing design standards for both vehicles and infrastructure. While the federal government regulates vehicles and their technology, states regulate operation of those vehicles on public roadways. Most state vehicle codes are still silent on the topic of driving automation. In states that do not expressly forbid automated vehicles, their operation may remain de facto legal until shown otherwise. As automated driving systems are increasingly tested and eventually deployed, their operation will be subject to the existing vehicle operation regulatory framework. Questions remain on how to interpret and apply existing requirements [1].

Regulations must be set in place that allow for more private companies to test CAV on roadways in real-life situations. Simulations are helpful but with few states allowing the testing of CAV, companies are limited in their ability to develop vehicles that can appropriately handle current transportation technology (cameras, detectors,

dynamic message signs, among other ITS technologies) as well as future, more connected, transportation technology [15]. Following guideline documents such as NHTSA’s “Automated Driving Systems: A Vision for Safety 2.0” and AAMVA’s “Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles” will enable the Commonwealth to safely adopt policies that will allow for the safe testing of CAV.

CAV and shared mobility will also have a major impact on how we fund transportation infrastructure. For example, if several individuals and families co-own a single CAV, who pays the vehicle registration fee, and how is it collected? And if electric vehicle lithium-ion batteries continue increasing in size and decreasing in cost alongside consumer adoption of automated vehicles, will gas taxes become obsolete? Government agencies at all levels should participate in ongoing conversations at the state level about transportation funding reform, including mileage-based user fees, tolling, local options, and congestion pricing, as well as the evolution of the Comprehensive Transportation Fund, particularly as the relationship between CAV and public transit becomes clearer [1].

## Organizational Structure



The current organizational structure within PennDOT Central Office and the Districts is not conducive to promoting CAV comprehensively. Most of the ongoing CAV efforts led within Central Office are in the Highway Safety and Traffic Operations Division and through an internal task force, which tends to create a silo-effect within the organization. Facilitating coordination and providing support for CAV within Pennsylvania from the Central Office level will require dedicated staffing and resources. The staff intended to manage these responsibilities at the Central Office level are already over committed and may not be able to commit adequate time or resources. Proactively coordinating and managing resources is essential to achieve organizational goals and objectives. Structure is a valuable tool in achieving coordination, as it specifies reporting relationships, delineates formal communication channels, and describes how separate actions of individuals link together.

## CAV PROGRAM VISION AND MISSION

This document formalizes ongoing CAV efforts and creates a strategic framework to reach the vision, mission, and goals set through this process. The approach includes needs and strategies identified during stakeholder outreach and are specific to the development and advancement of the CAV Program in Pennsylvania. The plan also identifies what dimension each strategy will advance, dependencies with other strategies, and a listing of additional resources needed to accomplish the strategy/action.

During the development of the CAV Strategic Plan, the vision and mission guided the program and measurement progress. The vision statement serves as the optimal and desired state of the program. The mission statement identifies the purpose of the program. Below are the vision and mission for CAV in Pennsylvania.

### VISION

Safe integration of connected and automated vehicles technologies within Pennsylvania's transportation system.

### MISSION

Proactively contribute resources to support a safe and sustainable transportation system through adoption of connected and automated vehicles technologies across Pennsylvania.

## CAV PROGRAM STRATEGIC GOALS

The goals are the expected outcomes that demonstrate how to measure program success. This section presents some initial notional goals that establish the direction that will guide the CAV Program focus and decisions. In general, these goals are in line with PennDOT's strategic themes laid out in the PennDOT 20/20 Strategic Direction.

### Goal 1: Improve Safety

One of the primary goals of the CAV Program will be to use these technologies to achieve safety improvements throughout the Commonwealth. This goal will include strategies exploring how CAV technologies can help people avoid crashes through new safety advisories, warnings, messages, and ultimately, automated responses, in addition to exploring ways to enhance traffic incident management and responder safety when a crash does occur.

### Goal 2: Enhance Mobility

CAV technologies have the potential to change transportation on a global scale. These technologies could change traffic patterns and congestion. Therefore, one of the primary goals of the CAV Program will be to use these technologies to achieve these benefits. This goal also includes exploration of methods and management strategies that increase system efficiency and improve individual mobility. A variety of existing programs and applications, including improved traffic management, work zone and incident management, transit management, freight management, and road weather management, and others benefit from this goal.

### Goal 3: Prepare Workforce

One of the greatest challenges to the region's CAV ecosystem is finding necessary talent, and enhancing the workforce involved in CAV will be a critical step in the successful adoption of this technology. There are a variety of steps Pennsylvania can take to help overcome this barrier. The purpose of an enhanced workforce is to facilitate awareness, understanding, acceptance, adoption, and deployment of CAV technologies across all stakeholder groups. Proper training and career development at all levels of the agency will foster continuity of operations and employee pride making it easier to implement innovative technological application such as CAV.

### Goal 4: Foster and Sustain Partnerships

One of the most impactful ways Pennsylvania can improve the CAV ecosystem is via increased collaboration across a variety of areas. An effective communication and education effort raises stakeholder awareness and understanding for strategic direction, initiatives, and priorities. Partnerships are a key element that contribute to deployment acceleration. Research collaboration brings partners onboard to ensure reflection of user needs in technology development— this ultimately achieves higher acceptability and adoption rates. The CAV Program should strategically leverage current partnerships and actively work on establishing new ones to create an extended national and international network that furthers the advancement of CAV by testing and developing new ideas. In addition, healthy partnerships can foster a competitive and innovative environment and thus address current or emerging market failures. PennDOT's existing organizational structure may be strained by new demands to foster and sustain these partnerships with the public and private sector. Thus, structural modifications should address the need for any new employee responsibilities, skillsets, areas of expertise, and the resulting management demands.

### Goal 5: Increase Public Awareness of Benefits and Risks

This goal aims to increase public awareness of CAV technologies in Pennsylvania through education, training, communication, and outreach to address concerns and misconceptions, and develop supportive investment. Outreach and educational campaigns could provide a necessary push to provide additional investment in CAV technologies by both the public and private sectors.

## Goal 6: Support Economic Competitiveness

This emerging industry could drive local job creation, talent retention, and economic development. Pennsylvania should continue to market itself nationally and internationally as the place for CAV testing, research and development, business growth, network connections, and relatively low cost of-living. Doing so may attract more start-ups to locate in the Commonwealth and attract foreign direct investment from international companies that wish to invest here. Partnering with other state agencies will be a critical step to achieve this goal.



## CAV PROGRAM OBJECTIVES AND RECOMMENDED STEPS

Researchers developed several recommendations using the information gathered during the internal and external data gathering, the review and documentation of the early successes and best practices, and the capability maturity model exercise. This report presents the recommendations as short- and long-term objectives, accompanied by actionable steps. The objectives have been broken down into nine business areas, shown in Figure 5.



Figure 5: CAV Strategic Plan Business Areas

Each of the objectives addresses the goals and needs identified earlier in the CAV Strategic Plan. The following subsections present the objectives and actionable steps for each one of the business areas.

### Maintenance and Operations Objectives

Below is an overview of the objectives of the Maintenance and Operations business area (see Page 26 for more details).

- ❖ Objective 1: Identify, Document, and Address Impacts to TMC Operations
- ❖ Objective 2: Identify, Document, and Address Gaps in Roadway Maintenance Procedures
- ❖ Objective 3: Prepare Current ITS and Signal Infrastructure for CAV
- ❖ Objective 4: Establish a Roadway Conditional Data Collection Program for CAV
- ❖ Objective 5: Establish a Traffic Data Management Program for CAV

### Design and Construction Objectives

Below is an overview of the objectives of the Design and Construction business area (see Page 31 for more details).

- ❖ Objective 6: Assess and Update PennDOT Design and Construction Standards to Account for CAV
- ❖ Objective 7: Assess and Update PennDOT Qualified Products List for Construction to Account for CAV
- ❖ Objective 8: Assess Applicability of CAV to Grade Crossings
- ❖ Objective 9: Integrate Advanced Technologies in to Design Process

- ❖ Objective 10: User New Data Analytics Capabilities During Construction

## Planning and Research Objectives

Below is an overview of the objectives of the Planning and Research business area (see Page 36 for more details).

- ❖ Objective 11: Continue Strategic Planning for CAV Technologies
- ❖ Objective 12: Conformance with Systems Engineering Analysis (SEA) for CAV
- ❖ Objective 13: Establish CAV Pilot Programs That Require Inter-Agency and Cross-Sector Collaboration
- ❖ Objective 14: Integrate CAV into Long-Range Transportation Planning Across the Commonwealth
- ❖ Objective 15: Utilize PennDOT's Research Program to Advance Deployment of CAV Applications Expertise

## Information Technology and Security Objectives

Below is an overview of the objectives of the Information Technology and Security business area (see Page 41 for more details).

- ❖ Objective 16: Modernize Communications Infrastructure for CAV
- ❖ Objective 17: Modernize IT Systems to Prepare for CAV
- ❖ Objective 18: Identify CAV Data Storage Needs/Sharing and Reporting Requirements
- ❖ Objective 19: Enhance Security
- ❖ Objective 20: Improve Service Management

## Driver Licensing and Motor Vehicles Objectives

Below is an overview of the objectives of the Driver Licensing and Motor Vehicles business area (see Page 46 for more details).

- ❖ Objective 21: Establish a Framework for Safe and Proper Testing of CAV
- ❖ Objective 22: Identify Changes to Driver Licensing Program
- ❖ Objective 23: Identify Changes to the Inspection Program
- ❖ Objective 24: Modernize Current Inspection Program Business Processes
- ❖ Objective 25: Improve the Driver and Vehicle Services Data Management System

## Modal Considerations Objectives

Below is an overview of the objectives of the Modal Considerations business area (see Page 51 for more details).

- ❖ Objective 26: Engage and Work with Transit Partners for CAV Advancement
- ❖ Objective 27: Assess Impacts of CAV on Truck and Rail Freight
- ❖ Objective 28: Assess Impacts of CAV on Airport and Seaport Operations
- ❖ Objective 29: Assess Safety and Mobility Considerations for Pedestrians and Bicyclists
- ❖ Objective 30: Engage Disadvantaged Modal Partners in CAV Efforts

## Workforce Requirements Objectives

Below is an overview of the objectives of the Workforce Requirements business area (see Page 56 for more details).

- ❖ Objective 31: Adjust Organizational Structure to Support CAV
- ❖ Objective 32: Provide Appropriate Training for Agency Workforce
- ❖ Objective 33: Strengthened Partnerships with Talent Sources
- ❖ Objective 34: Accelerate Technology Acceptance Through Third Party Training
- ❖ Objective 35: Create an In-Reach Plan for PennDOT Districts

## Policy and Legal Objectives

Below is an overview of the objectives of the Policy and Legal business area (see Page 61 for more details).

- ❖ Objective 36: Coordinate with the Pennsylvania Assembly to Establish Political/Legislative Climate to Support CAV Deployments
- ❖ Objective 37: Institutionalize a Procurement Process For CAV
- ❖ Objective 38: Evaluate Effects of CAV on PennDOT Policies
- ❖ Objective 39: Identify Funding Level
- ❖ Objective 40: Create Policies to Incentivize CAV Deployment and Use

## Outreach and Collaboration Objectives

Below is an overview of the objectives of the Outreach and Collaboration business area (see Page 66 for more details).

- ❖ Objective 41: Increase Public Awareness of Benefits and Risks
- ❖ Objective 42: Increase External Awareness of Ongoing CAV Activities within Pennsylvania
- ❖ Objective 43: Initiate Outreach to Planning Partners for CAV
- ❖ Objective 44: Create Strategic Partnerships for CAV Development (Public Sector)
- ❖ Objective 45: Create Strategic Partnerships for CAV Development (Private Sector)

## Guide to Reading the Objectives and Strategies Section

**Goals** that are being addressed by each objective illustrated in blue boxes.

**Lead** identifies the PennDOT Office in charge of carrying out actionable steps to achieve the described objective.

**Key Stakeholders** identifies the key stakeholders that will and should be involved when carrying out the actionable steps under each objective.

**Level of Investment** identifies the appropriate level of investment including monetary, staffing, and training. This is categorized into three levels as follows:

Level	Expertise	Training	Procurement
Level 1	Low	No additional training	Likely through open-end consultant support
Level 2	Medium	Moderate training of existing staff	Likely through open-end consultant support
Level 3	Medium	Moderate training of existing staff	Stand-alone project using traditional methods
Level 4	Highly Specialized	Workforce impact analysis required	Non-traditional procurement methods, such as design-build, P3, etc.

Expertise indicates the expertise needed by the PennDOT staff to accomplish this objective. Training indicates the necessary training that will be needed to accomplish this objective. Procurement indicates the kind of procurement method that should be used to accomplish this objective.

Within the narrative, a **justification** for the recommendation is explained. **Foundational needs, current gaps,** applicable **“Day 1 Benefits”** which provide beneficial returns at the outset of work on the objective and **potential impact** to existing and planned initiatives.

**Maintenance and Operations**

OBJECTIVE 1: IDENTIFY, DOCUMENT AND ADDRESS IMPACTS TO TMC OPERATIONS

**Goals Addressed:** 1 IMPROVE SAFETY, 2 ENHANCE MOBILITY, 3 ENHANCE WORKFORCE, 4 IMPROVE TRAVELER RELIABILITY, 5 INCREASE PUBLIC READINESS, 6 STRENGTHEN ECONOMIC CONTRIBUTIONS

The connected vehicle environment will likely produce an enormous volume of traffic monitoring data and a new interface to communicate with a traveler. Traffic Management Centers (TMCs) must take advantage of these new capabilities. These new applications will require updates to Standard Operating Procedures (SOPs) for TMCs and emergency responders. In the interim years where there is a mix of manual, semi-automated, and fully-automated fleets, give special consideration to queue clearance strategies, emergency responder safety, and traffic operations during lane closures. Potential benefits from integrating CAV technologies into TMC operations include improved incident detection, verification and timely response strategies; improved situational awareness of the impacts to traffic as a result of an incident; broader coverage of real-time conditions, particularly on corridors not instrumented with detection (arterials and rural corridors); improved accuracy, timeliness and relevancy of traveler information and notifications; and support for more proactive and traffic responsive strategies.

Achieving this objective will prepare PennDOT for an integration of CAV technologies into day-to-day TMC operations. This will help the Department better manage traffic operations, support planning, and more efficiently manage maintenance services.

**Day 1 Benefits** – An immediate application from achieving this objective is developing a systematic approach to TMC data management that incorporates more efficient business processes into day-to-day TMC operations.

**Impacts** – Achieving this objective will likely increase the need for additional training and outreach, staffing changes to reflect the need for data analytics expertise; it will also impact union agreements and business processes.

**Recommended Steps:**

- Identify and Document Impacts to TMC Data Management Systems  
Number of Data Types Identified and Impacted by Cost
- Explore Future Staffing Changes at TMCs Based on CAV Technology Impacts  
Annual PennDOT TMC Operations Cost
- Understand Impact on Emergency Responders  
Change in Response Time
- Develop a TMC Connected Vehicle Integration Plan  
Annual PennDOT TMC Operations Cost
- Identify and Document TMC Day-to-Day Operations Impacts  
Annual PennDOT TMC Operations Cost

**Lead:**  
• PennDOT Highway Safety and Traffic Operations

**Key Stakeholders:**  
• PennDOT, Local Municipalities

**Level of Investment:**  
• Level 2

**CMM Dimension Impact:**  
• Business Processes, Collaboration, Organization and Workforce

**Assumptions:**  
• None

A timeline illustration of the **Recommended Steps** together with **Metrics** (📊) for each of these steps is identified, with the result being the accomplishment of the outlined objective. **Immediate actions** are noted with an asterisk (\*).

**CMM Impact** identifies the expected dimension of the capability maturity model (CMM) that will be impacted by accomplishing this objective.

**Assumptions** made when developing the objectives.

# Maintenance and Operations

## OBJECTIVE 1: IDENTIFY, DOCUMENT, AND ADDRESS IMPACTS TO TMC OPERATIONS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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The connected vehicle environment will likely produce an enormous volume of traffic monitoring data and a new interface to communicate with a traveler. Traffic Management Centers (TMCs) must take advantage of these new capabilities. These new applications will require updates to Standard Operating Procedures (SOPS) for TMCs and emergency responders. In the interim years where there is a mix of manual, semi-automated, and highly-automated fleet, give special consideration to quick clearance strategies, emergency responder safety, and traffic operations during lane closures. Potential benefits from integrating CAV technologies into TMC operations include improved incident detection, verification and timely response strategies; improved situational awareness of the impacts to traffic as a result of an incident; broader coverage of real-time conditions, particularly on corridors not instrumented with detection (arterials and rural corridors); improved accuracy, timeliness and relevancy of traveler information and notifications; and support for more proactive and traffic responsive strategies.

Achieving this objective will prepare PennDOT for an integration of CAV technologies into day-to-day TMC operations. This will help the Department better manage traffic operations, support planning, and more efficiently manage maintenance services.

**Lead:**

- PennDOT Highway Safety and Traffic Operations

**Key Stakeholders:**

- PennDOT, PTC, Local Municipalities

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Collaboration, Organization and Workforce

**Assumptions:**

- None

**Day 1 Benefits** – An immediate application from achieving this objective is developing a systematic approach to TMC data management that incorporates more efficient business processes into day-to-day TMC operations.

**Impacts** – Achieving this objective will likely increase the need for additional training and outreach, staffing changes to reflect the need for data analytics expertise. It will also impact union agreements and business processes.

**Recommended Steps:**

5-10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Identify and Document Impacts to TMC Data Management Systems</b>   Number of Data Types Identified and Impacted by CAV</li> <li>• <b>Explore Future Staffing Changes at TMCs Based on CAV Technology Impacts</b>   Annual PennDOT TMC Operations Cost</li> <li>• <b>Understand Impact on Emergency Responders</b>   Change in Response Time</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Develop a TMC Connected Vehicle Integration Plan</b>   Annual PennDOT TMC Operations Cost</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Identify and Document TMC Day-to-Day Operations Impacts</b>   Annual PennDOT TMC Operations Cost</li> </ul>
> 10 Yrs.	

# Maintenance and Operations

## OBJECTIVE 2: IDENTIFY, DOCUMENT, AND ADDRESS GAPS IN ROADWAY MAINTENANCE PROCEDURES

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Current AV technology relies on the use of sensors to navigate autonomously. Monitoring the conditions and maintaining assets such as pavement markings, traffic control devices, and pavement conditions will be integral to the safe and efficient operation of AV. Most level 2 AVs currently use LiDAR and other advanced sensor technology to navigate, but sun glare, snow, or other visibility limitations associated with weather conditions impacts sensor functionality. Develop new roadway standards for traffic control and asset management based on AV needs.

Developments and updates to processes that support CAV deployment, operation, maintenance, and evaluation is a foundational need that once fulfilled by achieving this objective will be critical for successful integration of CAV applications into the transportation system.

Achieving this objective will help PennDOT better understand and prepare for future deployment of CAV.

**Day 1 Benefits** – An immediate benefit to pursuing this objective is the development of a systematic approach to deploy, operate, maintain, and evaluate all new technologies – both CAV and other ITS technologies.

**Lead:**

- PennDOT Highway Safety and Traffic Operations

**Key Stakeholders:**

- PennDOT Districts, PTC, Local Municipalities, FHWA

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes







**Assumptions:**

- None

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective, but after fulfillment it would impact business processes.

### Recommended Steps:

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Understand How CAV will Interface with Maintenance</b>   The Relationship of Annual PennDOT Maintenance Cost vs. CAV Capital Cost</li> <li>• <b>Evaluate the Need for More Frequent Line Striping and Maintenance of Other Traffic Control Devices*</b>   The Relationship of Annual PennDOT Maintenance Cost vs. CAV Capital Cost</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Determine Approximate Increase/Decrease in Annual Maintenance Cost Due to CAV</b>   The Relationship of Annual PennDOT Maintenance Cost vs. CAV Capital Cost</li> <li>• <b>Document Needed Changes to Maintenance Activities Due to CAV</b>   Annual PennDOT Maintenance Cost</li> <li>• <b>Perform Pavement Marking Testing for CAV Applications (District 3 / I-180)</b>   Durability / Visibility</li> </ul>
> 10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Implement Changes to Maintenance Activities</b>   Percent of Roadways compliant to new Standard</li> </ul>



# Maintenance and Operations

## OBJECTIVE 3: PREPARE CURRENT ITS AND SIGNAL INFRASTRUCTURE FOR CAV

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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As CAV applications evolve, it will become more imperative for public agencies to keep abreast of technology used by automakers and suppliers. The SPaT Challenge issued by AASHTO to state and local public-sector transportation signal infrastructure owners and operators to deploy DSRC infrastructure with SPaT broadcasts in at least one coordinated corridor or network (approximately 20 signalized intersections) in each state by January 2020 is an example of how the public sectors can maintain abreast and help advance these applications. Redundant communication systems will be critical to a safe and effective V2I deployment strategy. Leveraging existing fiber optic networks to accommodate future CAV uses is a first step, but there are still many critical corridors without sufficient communications infrastructure. Planning for efficient and redundant statewide communications will require a considerable effort to catalogue and manage the existing fiber assets, as well as plan to build a complete network in the future. Controller replacement, either strategically, or as part of programmed signal modernization projects should also be done to prepare for CAV. These upgrades should include IP-ready ports and NTCIP compliance for a full-scale CAV deployment, while still achieving integration with new or existing systems.

**Lead:**

- PennDOT Highway Safety and Traffic Operations, PennDOT Information Technology and Security

**Key Stakeholders:**

- PennDOT, PTC, Local Municipalities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- Communication network could be fiber or a combination of other technologies.
- Work with local municipalities for signal infrastructure work.

**Day 1 Benefits** – Achieving this objective will assist in preparing for an integration of CAV technologies using the existing ITS and signal infrastructure, with minimum waste of resources, which will set a foundation for a stronger ITS and TSMO program.

**Impacts** – Achieving this will likely have impacts on any planned investment on communication.

### Recommended Steps:

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li><b>Continue Work to Develop Real Time Lane Reservation System</b>   Adoption of Lane Reservation System / % of Projects Using System / System Uptime</li> <li><b>Develop a Systems Engineering Management Plan to Support Ongoing PennDOT CAV Deployment</b>   Travel Time Reliability / Device Uptime</li> <li><b>Inventory and Assess ITS and Signal Infrastructure to Accommodate CAV</b>   % of Infrastructure Inventories</li> <li><b>Integrate CAV Elements into the Traffic Signal Asset Management System (TSAMS)*</b>   % of Elements Mapped</li> </ul>
	<ul style="list-style-type: none"> <li><b>Identify Candidate Corridors for Enhanced Communication Network</b>   Enhanced Communication Network Coverage by Roadway Type</li> <li><b>Create a Communications Network Plan</b>   % of Roadway Miles Covered</li> <li><b>Create a Signal Infrastructure Upgrade Plan</b>   Plan Created / % of Roadway Miles Covered</li> </ul>

# Maintenance and Operations

## OBJECTIVE 4: ESTABLISH A ROADWAY CONDITION DATA COLLECTION PROGRAM FOR CAV

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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CAV are equipped with various sensors and potentially artificial intelligence analyzed data that would be invaluable to asset management. Capturing that data requires creating a plan, then policies and procedures to gather all or key vehicle data to ensure that adequate sample sizes are reached, and that all roadway assets are accounted for. PennDOT should prepare for CAV that will communicate with the infrastructure to capture key data by having compatible roadside units and data sharing agreements in place. Proper data management will be a critical foundational need for the success of CAV management.

Leveraging CAV data for roadway maintenance can replace the need for extensive data collection efforts, but it will require installation of appropriate connected infrastructure assets. CAV may supplement data needs for roadway conditions such as pothole locations, insufficient pavement markings, and inclement. This will require large collaboration efforts with the private sector operators and manufacturers of CAV.

**Lead:**

- PennDOT Bureau of Maintenance and Operations

**Key Stakeholders:**

- PennDOT, Automakers, Fleet Operators

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Systems and Technology, Collaboration

**Assumptions:**

- Assumes automakers will agree to share data with agency.

**Day 1 Benefits** – Some immediate application from achieving this objective includes understanding the type of data generated by CAV.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Develop Procedures to Obtain CAV Data Related to Roadway Conditions when Testing in PA*</b>   Procedure in Place</li> <li>• <b>Request and Use the CAV Data Related to Roadway Conditions when Testing in PA</b>   % of Test Vehicles Sharing Data / Timeliness of Data Received (Realtime vs. Historical)</li> <li>• <b>Assess Data Collected from CAV when Testing in PA Related to Roadway Condition</b>   Number of Uses Identified for Data</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Develop a CAV Data Master Plan for Roadway Condition Monitoring</b>   % of Roadways with Sufficient Sample Size</li> <li>• <b>Develop Procedures to Obtain CAV Data Related to Roadway Conditions</b>   % of Roadways with Sufficient Sample Size</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Collect, Report, and Use CAV Data Related to Roadway Condition for Decision Making</b>   Data Accuracy</li> </ul>



# Maintenance and Operations

## OBJECTIVE 5: ESTABLISH A TRAFFIC DATA MANAGEMENT PROGRAM FOR CAV

Goals Addressed:	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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CAV will produce large amounts of traffic data that would be valuable to traffic management and incident management efforts. Creating a plan, followed by the policies and procedures to gather all or key vehicle data will be needed to be able to experience the full benefits of CAV. Preparing for CAV that will communicate with the infrastructure to capture key traffic data can be accomplished by having compatible RSUs and data sharing agreements in place. The development of performance metrics will also be important to establishing political buy-in and the potential funding needed to manage strong operations and a safe roadway system.

Proper data management will be a critical foundational need addressed for the success of CAV. Leveraging CAV data for maintenance and operations can replace the need for data agreements with private traffic data providers, diminish the need for vehicle detection systems, assist with incident response, and allow for performance metrics and predictive algorithms to better manage traffic, among others.

**Day 1 Benefits** – Some immediate application from achieving this objective includes understanding and preparing for the ubiquity of Big Data in decision making, which can come about independently of CAV.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

**Lead:**

- PennDOT Highway Safety and Traffic Operations

**Key Stakeholders:**

- PennDOT, Office of Administration, Private Industry

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Performance Measurement, Systems and Technology, Collaboration

**Assumptions:**

- Assumes automakers will agree to share data with agency.

**Recommended Steps:**

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Identify Useful, Available CAV Data for Traffic Management Purposes*</b>   Business Cases Outlined</li> <li>• <b>Develop Procedures to Obtain Traffic Data from CAV when Testing in PA*</b>   Procedure in Place</li> <li>• <b>Request and Use the Traffic Data from CAV when Testing in PA</b>   % of Test Vehicles Sharing Data / Timeliness of Data Received</li> <li>• <b>Assess Data Collected from CAV when Testing in PA Related to Traffic Condition</b>   Number of Uses Identified for Data</li> <li>• <b>Develop a Traffic Data Management Plan for CAV Pilots</b>   Procedure in Place / Uptime / Benefit Cost Ratio</li> <li>• <b>Perform Evaluation for Each Pilot Deployed</b>   Benefit Cost Ratio</li> </ul>	
	5-10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Develop a CAV Traffic Data Management Master Plan</b>   % of Roadways with Sufficient Sample Size</li> <li>• <b>Develop Procedures to Obtain Real-Time CAV Traffic Data</b>   % of Roadways with Sufficient Sample Size</li> </ul>
		> 10 Yrs.

# Design and Construction

## OBJECTIVE 6: ASSESS AND UPDATE PENNDOT DESIGN AND CONSTRUCTION STANDARDS TO ACCOUNT FOR CAV

Goals Addressed:	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS

PennDOT has a library of well-defined standards for all types of design and construction transportation projects. Appropriate measures will need to be taken to ensure that all guidance is updated to include CAV through the project delivery process and into construction to provide a safe and contextually sensitive transportation system.

PennDOT will need updated standards to address new installations, such as smart signal infrastructure, curve warning systems, smart lighting, etc. An assessment of PennDOT’s design and construction standards will lay a foundation for standardization of advanced technologies deployment. Once completed, this foundational element will help ensure successful integration of CAV applications into the transportation system will become a reality.

Achieving this objective will assist PennDOT in filling a gap in guidance for standardization and interoperability for new technology applications.

**Lead:**

- PennDOT Deputy Secretary for Highway Administration

**Key Stakeholders:**

- PennDOT, PTC

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes

**Assumptions:**

- Proper training to be developed and implemented.
- Changes in trip generation/distribution are expected.

**Day 1 Benefits** – Some immediate application from achieving this objective includes developing a systematic approach to design and deployment of advanced technologies, which will allow for mainstreaming of these applications into the project development process.

**Impacts** – No immediate impact to existing or planned activities anticipated. However, procurement methods will eventually be impacted for PennDOT construction projects. Also, changing design manuals and construction standards could potentially impact labor codes used on construction projects.

### Recommended Steps:

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Identify Design Changes Needed to Accommodate Advanced Technologies such as CAV*</b>   Successful Update of Standards / % of Signal Compliant to New Standards / Other Elements Installed</li> <li>• <b>Update Standards to Accommodate Design Changes Needed for Advanced Technologies such as CAV</b>   Successful Update of Standards / % of Signal Compliant to New Standards / Other Elements Installed</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Identify Future Roadway Attributes Required / Desired for CAV</b>   Number of Attributes Identified</li> <li>• <b>Assess and Update PennDOT Design Manual(s) and Construction Standards to Account for CAV</b>   Successful Update of Manuals and Publication / % of Projects Compliant</li> </ul>
> 10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Develop Requirements and Guidelines for Installation of CAV Infrastructure</b>   Number of Violations Found</li> <li>• <b>Evaluate and Update Highway Occupancy Permit Procedures</b>   Number of New Permits Issued / Facility Performance</li> </ul>

## Design and Construction

### OBJECTIVE 7: ASSESS AND UPDATE PENNDOT QUALIFIED PRODUCTS LIST FOR CONSTRUCTION TO ACCOUNT FOR CAV

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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PennDOT provides contractors, consultants, Department personnel, manufacturers, suppliers, and others with easy access to a listing of products whose manufacturers have demonstrated the capability to perform in accordance with Department specifications accepted by certification on PennDOT construction projects. Appropriate measures need to be taken to ensure that all guidance is updated to include CAV through the project delivery process and into construction to provide a safe and contextually sensitive transportation system.

An assessment of PennDOT’s Qualified Product List and the Evaluation Tracking System (NPETS) will lay a foundation for effective testing and use of products needed for CAV deployment. Once completion of this foundational need occurs, successful integration of CAV applications into the transportation system will become a reality.

**Lead:**

- PennDOT Deputy Secretary for Highway Administration

**Key Stakeholders:**

- PennDOT

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes

**Assumptions:**

- None

**Day 1 Benefits** – Some immediate application from achieving this objective includes developing a systematic approach to design and deployment of advanced technologies and will allow for mainstreaming of these applications into the project development process.

**Impacts** – No immediate impact to existing or planned activities anticipated.

**Recommended Steps:**

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Conduct and Evaluate Pilot Project for CAV Related Product</b>   Long Term Performance and Durability</li> <li>• <b>Perform Gap Analysis to Determine Modifications to the Qualified Product List Procedure</b>   Number of Modifications Identified</li> <li>• <b>Update Standards to Accommodate Traffic Signal Design Changes Needed for Advanced Technologies such as CAV</b>   Successful Update of Standards/% of Signal Compliant to New Standards</li> </ul>
5-10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Update Qualified Product List to Account for CAV</b>   Number of Modifications Identified / % of Materials Compliant</li> </ul>

# Design and Construction

## OBJECTIVE 8: ASSESS APPLICABILITY OF CAV TO GRADE CROSSINGS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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The PennDOT Grade Crossing Unit performs engineering and administrative liaisons between the Department of Transportation's eleven engineering districts, the Public Utility Commission, and the Railroads that operate within the Commonwealth of Pennsylvania. This Unit provides guidance and direct support to the eleven District Grade Crossing Engineers/Administrators for performing functions that relate to highway-railroad crossings for both Section 130 Safety improvement projects and department highway/bridge projects involving railroad facilities. CAV will facilitate this, and other automated forms of communication between transportation infrastructure and the vehicles, creating an opportunity to innovate the next generation grade-crossing warning systems and assist with the PennDOT Grade Crossing Unit's work.

**Lead:**

- PennDOT Deputy Secretary for Highway Administration

**Key Stakeholders:**

- PennDOT, Pennsylvania Public Utility Company (PUC), Railroad Companies Operating in Pennsylvania

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes

**Assumptions:**

- None

Achieving this objective will greatly improve grade crossing safety. There is a need to bring together stakeholders in both the railroad and automotive industries to lay groundwork for successful adoption of future grade-crossing technologies.

**Day 1 Benefits** – An immediate application from achieving this objective includes improving grade crossing safety.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

- |                  |  |
|------------------|--|
| <b>0-5 Yrs.</b>  | <ul style="list-style-type: none"> <li>• <b>Engage Private Sector to Test CAV technologies at Grade Crossings</b><br/>  Number of Products Tested / Reduction in Grade Crossing Violations</li> <li>• <b>Partner with the Federal Rail Administration to Assess Applicability of CAV for PA Grade Crossings</b><br/>  Number of Applications Developed and Tested</li> </ul> |
| <b>5-10 Yrs.</b> | <ul style="list-style-type: none"> <li>• <b>Develop Standards for CAV Applications for Grade Crossing</b><br/>  Locations Compliant / Reduction in Grade Crossing Violations</li> <li>• <b>Deploy and Evaluate CAV Applications for Grade Crossing</b><br/>  Number of Locations / Reduction in Grade Crossing Violations</li> </ul>   |

# Design and Construction

## OBJECTIVE 9: INTEGRATE ADVANCED TECHNOLOGIES INTO DESIGN PROCESS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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PennDOT has been implementing available, well-tested technologies to make highway pricing, investment, and operations more efficient, which in turn has improved travel speeds, travel-time reliability, and safety and reduce highway expenditures. However, in contrast to the technological advance in the comfort, performance, and safety of the vehicles that use the roads, which may reach new heights with the development of the driverless car, infrastructure technological improvements have been relatively modest. A technology-based approach to improving highway performance is particularly attractive because innovations that increase efficiency have taken on renewed importance.

New highway and vehicle technologies will give PennDOT the opportunity to make more efficient use of the current vehicle-carrying capacity and durability of public highways by adjusting investments to prioritize quantitatively verified management concerns and adjusting operations to respond to real-time variations in highway travel demand.

**Lead:**

- PennDOT Deputy Secretary for Highway Administration

**Key Stakeholders:**

- PennDOT, PTC

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**





- Conduit installation to be based on a Statewide Fiber Plan.

**Day 1 Benefits** – An immediate application from achieving this objective includes improving design and construction processes to address identified highway performance issues.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Make Installation of Conduit for Fiber a Requirement for Applicable Design Projects*</b>   % of Projects with Conduit Installation</li> <li>• <b>Continue Effort to Establish Technology Corridor Along I-99</b>   Project Implemented / Uptime / Crash Reduction / Travel Time Improvements</li> <li>• <b>Mainstream Advanced Technologies into the Design Process</b>   % of Projects with Advanced Technologies Included</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Evaluate Need to Use Modeling Software During Design that has CAV Capabilities</b>   Modeling Software Results vs. Actual Results</li> </ul>
	<b>5-10 Yrs.</b>

# Design and Construction

## OBJECTIVE 10: USE NEW CAV AND DATA ANALYTICS CAPABILITIES DURING CONSTRUCTION

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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PennDOT is a data-rich agency, with various data available through its TSMO Program among other sources. Construction activities are disruptive and introduce unaware drivers to unexpected circumstances. PennDOT has been mitigating these impacts in various way. For example, PennDOT maintains a memorandum of understanding with the Pennsylvania State Police (PSP) that the PSP will provide assistance in construction zones by alerting motorists of queues in freeway traffic projects. As part of this program, PSP monitors queue lengths every 30 minutes while performing their PSP assistance role, records this information on a form, and then provides this information to the project and work zone manager at the beginning of each week. PennDOT districts can use this and CAV data to help predict queue length on future projects. The PennDOT Traffic Engineering and Operations Manual currently provides detailed information, procedures, and guidelines about the PSP assistance program and includes the Queue Length Reporting Form.

**Lead:**

- PennDOT Deputy Secretary for Highway Administration

**Key Stakeholders:**

- PennDOT, PSP

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- None

Another benefit from CAV considerations during construction will come from automation to keep workers out of harm’s way, including innovation such as Driverless Work Zone Impact-Protection Truck.

**Day 1 Benefits** – An immediate application from achieving this objective includes improving work zone safety by using other readily available data or technologies.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Analyze Data that may be Used for Work Zone Management</b>   Work Zone Crash Reduction / Travel Time Improvements</li> <li>• <b>Identify CAV Data that Can be Used During Work Zone Projects*</b>   Number of Data Sources</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Test MOT CAV Technology such as Driverless Work Zone Impact-Protection Truck</b>   Injury Reduction / Benefit Cost Ratio</li> <li>• <b>Integrate CAV Technologies into MOT Procedure</b>   % of Projects Following New Procedures</li> </ul>
<b>5-10 Yrs.</b>	

# Planning and Research

## OBJECTIVE 11: CONTINUE STRATEGIC PLANNING FOR CAV TECHNOLOGIES

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Strategic planning is an organizational management activity that sets priorities, focuses energy and resources, strengthens operations, ensures that employees and other stakeholders are working toward common goals, establishes agreement around intended outcomes/results, and assesses and adjusts the organization's direction in response to a changing environment [16]. Creation of the CAV Strategic Plan is the first step into strategic planning for the changing environment CAV technologies will bring to Pennsylvania's transportation system and continuing in this path will greatly improve the odds for a successful adjustment. Continuing the strategic planning for CAV technologies will lay the foundation for a successful and systematic adoption of CAV technologies into Pennsylvania's transportation system.

Achieving this objective will assist PennDOT in filling a gap in overall guidance for the deployment and adoption of emerging technologies like CAV and will allow for consistency across the Commonwealth.

**Day 1 Benefits** – Day 1 benefits of completing this objective will be to set priorities, focus energy and resources, strengthen operations, ensure that employees and other stakeholders are working toward common goals, and establish agreement around intended outcomes/results all related to the changing environment CAV technologies create.

### Lead:

- PennDOT Leadership / PennDOT Bureau of Planning and Research

### Key Stakeholders:

- PennDOT, PTC, MPOs / RPOs, Local Municipalities, Local Transit Agencies

### Level of Investment:

- Level 2

### CMM Dimension Impact:

- Business Processes, Organization and Workforce, Culture



### Assumptions:

- Special attention from Leadership is required.
- Role definition to start after organizational changes exists and new CAV groups exist.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Present the CAV Strategic Plan to all Stakeholders*</b>   % of Stakeholders Captured</li> <li>• <b>Establish a PennDOT Internal CAV Working Group*</b>   PennDOT Internal CAV Working Group Formed / Number of Meetings Held</li> <li>• <b>Transition from the AV Policy Task Force to a CAV Task Force</b>   CAV Task Force Formed / Number of Meetings Held</li> <li>• <b>Define Roles of Stakeholders within the Public-Sector Who Participate in CAV</b>   Role Definition Completed / Number of Roles Defined</li> <li>• <b>Develop a Statewide CAV Business and Implementation Plan*</b>   Business Plan and Implementation Plan Completed</li> <li>• <b>Routinely Update CAV Strategic Plan</b>   CAV Strategic Plan Updated</li> </ul>
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## Planning and Research

### OBJECTIVE 12: CONFORMANCE WITH SYSTEMS ENGINEERING ANALYSIS (SEA) FOR CAV

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> ENHANCE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> STRENGTHEN ECONOMIC COMPETITIVENESS
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The FHWA released a final rule on ITS projects funded in part by the Highway Trust Fund in January 2001. This rule requires all projects to document conformance with the National ITS Architecture and that regional ITS architectures be developed and maintained. Later, the FHWA interpreted that agency systems related to connected and automated vehicles are included under the provisions of the January 2001 rule. To ensure that this revolutionary technology is effective, the USDOT created the CVRIA, which establishes a framework for the integration and standardization of connected vehicle technologies. As of mid-2017, CVRIA is incorporated into the Architecture Reference for Cooperative and Intelligent Transportation, which forms the basis for a common language definition and early deployment concepts for connected vehicles. The architecture identifies key interfaces across the connected vehicle environment and informs standards for development activities. The CVRIA also supports policy considerations for certification, standards, core system implementation, and other elements of the connected vehicle environment [6]. PennDOT and its local planning partners will need to work together to ensure compliance with federal guidelines.

**Lead:**

- PennDOT Bureau of Planning and Research

**Key Stakeholders:**

- PennDOT, PTC, MPOs/RPOs, Local Municipalities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Collaboration

**Assumptions:**




- A statewide program for Regional ITS Architecture updates exists.
- Updates to be done in partnership with MPOs and RPOs, and with participation from local agencies.

Achieving this objective will assist PennDOT in filling a gap in guidance for standardization and interoperability for CAV applications, as well as set a foundation for regions to become ready for detailed CAV systems engineering analysis. Updating the architectures will also help prepare the state of Pennsylvania to be on the forefront of emerging technologies such as CAV by providing an accurate account of the functions and agreements that are in place between stakeholders.

**Day 1 Benefits** – An immediate application from achieving this objective includes developing a systematic approach to update Pennsylvania’s Regional ITS Architectures.

**Impacts** – Achieving this objective will impact any planned Regional ITS Architecture updates in Pennsylvania.

**Recommended Steps:**

- |                 |  |
|-----------------|--|
| <b>0-5 Yrs.</b> | <ul style="list-style-type: none"> <li>• <b>Conduct a Statewide Effort to Update Pennsylvania’s ITS Architectures with CVRIA Incorporated</b><br/>  Number of Regional ITS Architectures Updated / Buy-in</li> <li>• <b>Develop a Regional Concept of Operations (ConOps) for CAV Deployments</b><br/>  Number of Regions in Pennsylvania with Accepted CAV ConOps</li> <li>• <b>Integrate CAV into Regional Operations Plans</b><br/>  Integration Completed / Benefit to Cost Ratio</li> <li>• <b>Create Systems Engineering Document Templates for CAV</b><br/>  Number of Templates Created</li> </ul> |
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## Planning and Research

### OBJECTIVE 13: ESTABLISH CAV PILOT PROGRAMS THAT REQUIRE INTER-AGENCY AND CROSS-SECTOR COLLABORATION

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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To increase public awareness and stakeholder buy-in, demonstrate the discernable and measurable benefits of CAV technologies in Pennsylvania. To achieve this, the CAV Strategic Plan proposes a set of pilot projects designed to demonstrate the impact of CAV on Pennsylvania. However, these projects still must conform to the regional planning process and be properly programmed by planning partners across the Commonwealth. Since many of the proposed pilot projects require close coordination between state, regional and local officials it is necessary to use the systems engineering process and a strong partnering approach to achieve project implementation. Recent lessons learned from pilot deployments have shown that a lack of integration with other projects at the state level and a lack of local partnering have hampered implementation efforts. Successful procurement of Federal grants to assist with pilot implementation will rely on an implementation plan that incorporates these lessons.

Achieving this objective will help PennDOT obtain a better understanding of this technology. Completing this objective will set a foundation for all future deployment of CAV applications.

**Day 1 Benefits** – Some immediate applications from achieving this objective include setting priority for CAV development and identifying a cross section of stakeholders correctly. This will also help set priority for CAV deployment with stakeholder buy-in.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective. However, as pilot projects are programmed, funding may shift from one project to these pilots.

**Lead:**

- PennDOT Bureau of Planning and Research

**Key Stakeholders:**

- PennDOT Districts, PTC, MPOs / RPOs, Local Municipalities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Collaboration

**Assumptions:**

- Adequate funding levels are available; the technology is mature enough for deployment.
- DSRC is the current technology used. If otherwise, use applicable technology.

#### Recommended Steps:

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Conduct Workshops to Develop Support for Pilot Projects</b>  Number of Projects Programmed – at least one per year</li> <li>• <b>Plan Pilot Projects and Establish Funding Levels</b>  Number of Projects Completed</li> <li>• <b>Apply for Grants for CAV Pilot Projects</b>  Number of Grants Applied for / Success Rate</li> </ul>
5-10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Develop a DSRC Deployment Plan</b>  Plan Developed / Number of Pieces of Equipment Deployed / Uptime</li> <li>• <b>Assess PennDOT Connects for CAV Inclusion</b>  Number of CAV projects in PennDOT Connects</li> </ul>

# Planning and Research

## OBJECTIVE 14: INTEGRATE CAV INTO LONG-RANGE TRANSPORTATION PLANNING ACROSS THE COMMONWEALTH

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Institutionalizing CAV projects as part of transportation planning will take more than just successful pilot projects. Areas across Pennsylvania should monitor the success of all pilots and choose from the menu of options provided to plan projects in their own area. In many cases this will require scenario planning based on assumed operational characteristics of CAV and the level of fleet integration achieved. For these reasons, planning partners should begin to plan projects for regional implementation, which will require education and technical assistance for many institutions. PennDOT has prepared a Resource Guidance for Pennsylvania Planning Partners to assist MPOs/RPOs in developing more effective long-range transportation plans. Without clear requirements and structure, planning partners may advance CAV applications in their individual Long-Range Transportation Plan (LRTP) process, with little or no guidance as to what constitutes a good plan or product. This could potentially result in plans varying in content and operational issues for CAV applications.

Completing this objective will set a foundation for all future deployment of CAV applications. It will also promote a comprehensive analysis of CAV impacts, as well as interoperability of CAV applications across state.

**Day 1 Benefits** – An immediate application from achieving this objective is promoting comprehensive analysis of CAV impacts.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Update the Resource Guidance for Pennsylvania Planning Partners to Incorporate CAV*</b>   Number of CAV Projects Incorporated</li> <li>• <b>Develop Guidelines for Scenario Planning for CAV</b>   Guideline Developed / Scenario Planning Conducted</li> <li>• <b>Assist Agencies in Mapping CAV Applications to Regional Operational Goals</b>   Number of Agencies Assisted</li> <li>• <b>Define Criteria for Prioritizing CAV Projects</b>   Number of CAV Projects Incorporated for Funding</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Perform a Gap Analysis for Existing Planning Model and Analysis Tools</b>   Gap Analysis complete / Number of Tools Updated</li> <li>• <b>Assess Pennsylvania Infrastructure Bank Program for Local CAV Funding Capability</b>   Number of Projects Funded</li> </ul>

**Lead:**

- PennDOT Bureau of Planning and Research

**Key Stakeholders:**

- PennDOT Districts, Local Municipalities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Collaboration

**Assumptions:**

- Federal guidance and rulemaking for CAV is firm.
- CAV projects will have to compete with traditional projects.
- There is selection and availability of tools to assist with incorporating CAV in long-range planning.

## Planning and Research

### OBJECTIVE 15: UTILIZE PENNDOT'S RESEARCH PROGRAM TO ADVANCE DEPLOYMENT OF CAV APPLICATIONS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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The Research Division staff of PennDOT’s Bureau of Planning and Research is responsible for developing, administering, and managing the strategically focused and fiscally constrained PennDOT Research Program. The Research Division also has active involvement in TRB committees, NCHRP panels, and AASHTO research committees. The division administers the Local Technical Assistance Program, stressing transportation technology transfer between the Department and local municipalities. Using these existing resources combined with Pennsylvania’s other key initiatives, such as the newly planned test facility, PennSTART, and existing US DOT approved AV Proving Grounds to test, monitor and advance innovative technology applications, will advance CAV application in PA.

By utilizing PennDOT’s research program to advance CAV maturity and the deployment of CAV applications, the Department will promote a comprehensive analysis of CAV impacts, as well as interoperability of CAV applications across state. It will help PennDOT determine the state-of-practice and industry trends and advancements. This will also set priorities on how CAV testbeds will be utilized, allowing PennDOT to potentially influence the development of CAV technologies (not driven solely by private market and USDOT).

**Lead:**

- PennDOT Bureau of Planning and Research

**Key Stakeholders:**

- PennDOT, PTC, USDOT, MPOs / RPOs, Local Municipalities, Academia

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Collaboration

**Assumptions:**

- None

**Day 1 Benefits** – An immediate application from achieving this objective is gaining firsthand experience with innovative technology applications. Conducting annual CAV open innovation demonstration events at testing facilities across Pennsylvania will demonstrate that Pennsylvania is open for business and willing to investigate the practicality of innovations that show promise.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Conduct State of the Practice Review of Ongoing CAV Development*</b>  Report Completed</li> <li>• <b>Host Stakeholder Workshops to Assess Research Needs and Gaps</b>  Number of Workshops Held / Number of Stakeholders Engaged / Research Projects Funded</li> <li>• <b>Develop Long-Range Research Plan and Timeline for Utilizing CAV Testbed</b>  Testbed Utilization</li> </ul>
<b>5-10 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Integrate CAV Pilot Projects Results into Research Plans</b>  Number of New Research Topics</li> <li>• <b>Use Testbed for CAV Research</b>  Number of Research Projects Funded</li> <li>• <b>Identify Funding Needs to Support Long-Range Research Plan</b>  Funding Allocated vs. Funding Needed</li> </ul>

## OBJECTIVE 16: MODERNIZE COMMUNICATIONS INFRASTRUCTURE FOR CAV

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Various public agencies are working with the automotive industry and research entities to develop, test, and deploy the necessary infrastructure to support CAV. Most of these are currently doing this sporadically through pilot projects. However, as these applications evolve, it will become more imperative for public agencies to keep abreast of the technology used by automakers and suppliers now and in the future to properly prepare. This way, public agencies can ensure current deployment of communications infrastructure includes the latest available technology to support CAV. Enabling the deployment of wireless communication technologies and the associated CAV applications is the basis for successful implementation. PennDOT’s existing fiber optic network can be leveraged to accommodate future CAV uses, but there are still many critical corridors without sufficient communications infrastructure. Planning for efficient and redundant statewide communications will require a considerable effort to catalogue and manage the existing fiber assets, as well as plan to build a complete network in the future. Working with other partners and in harmony with initiatives, such as PTC’s Broadband Public-Private Partnership and the Governor’s Pennsylvania Broadband Initiative, will allow Pennsylvania take advantage of other investment to improve the transportation. Achieving this objective will assist PennDOT with preparing for an integration of CAV technologies using the existing communications infrastructure, with minimum waste of resources and setting a foundation for a stronger ITS and TSMO program.

**Lead:**

- PennDOT Highway Safety and Traffic Operations, PennDOT Infrastructure & Economic Development Delivery Center and Bureau of Infrastructure and Operation

**Key Stakeholders:**

- PennDOT, PTC, Local Municipalities

**Level of Investment:**

- Level 4

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- Communication network could be fiber or a combination of other technologies.
- Some of these steps will depend on CAV rate of penetration.

**Day 1 Benefits** – An immediate application from achieving this objective is achieving a robust knowledge of communications infrastructure currently deployed.

**Impacts** – Achieving this will likely have impacts on planned communication deployments.

### Recommended Steps:

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|------------------|--|
| <b>0-5 YRS.</b>  | <ul style="list-style-type: none"> <li>• <b>Define Communications System Backhaul Requirements, Physical Paths, and Parts of the CAV System</b><br/>  Requirements Identified</li> <li>• <b>Conduct Pilots to Evaluate Communication Technologies for CAV (DSRC, 5G, etc.)</b><br/>  Uptime / Reliability / Benefit Cost Ratio</li> </ul>  |
| <b>5-10 YRS.</b> | <ul style="list-style-type: none"> <li>• <b>Define Wireless Communications Requirements, Communications Network Architecture and Design for CAV Systems and Applications</b><br/>  Uptime / Reliability / Benefit to Cost Ratio</li> <li>• <b>Development of Performance Requirements for Communication Infrastructure</b><br/>  % of Roadway Miles Covered</li> <li>• <b>Support Development of Standardized Interoperable Communications Platform (radio, software, etc.) to be Used by all Responders (First Net)</b><br/>  % of Responders Using Platform</li> </ul> |

# Information Technology and Security

## OBJECTIVE 17: MODERNIZE IT SYSTEMS TO PREPARE FOR CAV

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Some public agencies rely on decades-old, obsolete technologies to support critical mission programs, essential functions, and daily operations. Collectively, agencies report spending about three quarters of their information technology budgets on operating and maintaining those systems [17]. Costs are ever increasing, legacy systems are pervasive, security risks are growing, and new technologies, such as CAV, are continually being introduced. Agencies are challenged to provide a secure environment as access becomes increasingly open and legacy systems potentially lack the flexibility to adapt to these changing needs. PennDOT’s IT systems are no exception. Modernization of legacy systems is one of the strategies of the Pennsylvania Office of Administration’s Enterprise Information Technology Strategic Plan, which directly aligns with the Governor’s IT-related priorities. The Commonwealth will work to modernize applications to improve citizen services, which will directly impact PennDOT. Working together with the Office of Administration should be a priority to PennDOT’s Infrastructure & Economic Development Delivery Center and Bureau of Infrastructure and Operation.

Modernizing with newer technologies is critical to helping PennDOT improve their services for citizens by enhancing government operations, and strengthening cybersecurity, which will become critical aspects for a CAV environment.

**Lead:**

- PennDOT Infrastructure & Economic Development Delivery Center and Bureau of Infrastructure and Operation

**Key Stakeholders:**

- PennDOT, PA Office of Administration, Private Industry, USDOT

**Level of Investment:**

- Level 4

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- None

**Day 1 Benefits** – An immediate benefit is the creation of a robust IT system to support newer technologies and enhance the day-to-day operations of the agency.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective since this is part of Pennsylvania’s Office of Administration Strategic Plan for IT.

### Recommended Steps:

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Identify Upgrades to TMC and other IT Systems</b>   Number of Upgrades Completed / Uptime</li> <li>• <b>Evaluate the Potential Testing Issues that may Arise from CAV Applications Working with an Internet Protocol Version 6 (IPv6) Network</b>   Benefit/Cost Ratio</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Identify Physical Location, Connections and Redundancy Requirements for Localized Storage</b>   Benefit/Cost Ratio</li> <li>• <b>Identify Connection and Redundancy to Cloud Data Storage as Needed</b>   Benefit/Cost Ratio</li> <li>• <b>Upgrade TMC and other IT Legacy Back-Office Systems</b>   Number of Upgrades Completed / Uptime</li> </ul>
<b>5-10 Yrs.</b>	

# Information Technology and Security

## OBJECTIVE 18: IDENTIFY CAV DATA STORAGE NEEDS/ SHARING AND REPORTING REQUIREMENTS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Systematic decision making for connected and automated vehicles technologies will require data of sufficient quantity and quality to ensure appropriate CAV modeling. Data generation, real-time analytics, and actionable informatics enable PennDOT management objectives and regional/State requirements achievement. Aggregation and storage technologies are designed to ensure data is available for modeling, operational decision making, data sharing and data reporting. Determining the appropriate cyber asset and information security criteria is fundamental to ensuring a safe and reliable CAV infrastructure.

Establishing a data management plan will lay the foundation for a successful integration of CAV applications into the transportation system, as well as for PennDOT to take full advantage of the wealth of data generated by CAV.

Achieving this objective will assist PennDOT with filling a gap in data management and standardization not only for data generated by CAV, but for current data sources as well.

**Day 1 Benefits** – Some immediate application from achieving this objective includes developing a data management process that will fulfill current data needs.

**Impacts** – No immediate impact to existing or planned activities anticipated with the fulfillment of this objective.

### Recommended Steps:

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li><b>Identify Data Requirements</b>  Data Needs/Requirements Identified (e.g., latitude/longitude, time, heading, angle, speed, acceleration, yaw rate, throttle position, brake status, steering angle, etc.)</li> <li><b>Identify Data Sources</b>  Number of Data Sources</li> <li><b>Identify Storage Requirements</b>  Benefit Cost Ratio</li> </ul>
<b>5-10 Yrs.</b>	<ul style="list-style-type: none"> <li><b>Identify Data Sharing Requirements (Internal, Governmental, Industry)</b>  % of Requirements Met</li> <li><b>Identify Data Reporting (Internal, Governmental, Industry)</b>  Identify Relationship of Annual PennDOT Maintenance Cost vs. CAV Capital Cost</li> <li><b>Research and Identify Applicable Industry Cyber and Information Standards</b>  Research Completed / % of Standards Met</li> <li><b>Identify PennDOT’s Future Data Needs</b>  Benefit Cost Ratio</li> </ul>

**Lead:**

- PennDOT Infrastructure & Economic Development Delivery Center and Bureau of Infrastructure and Operation

**Key Stakeholders:**

- PennDOT, PTC, PA Office of Administration, Private Industry, USDOT

**Level of Investment:**

- Level 5

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- Requirements will come from the Architecture as well.
- Standards from the FHWA ITS JPO available and used.



# Information Technology and Security

## OBJECTIVE 19: ENHANCE SECURITY

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Digital communication backhaul capabilities create the infrastructure through which operational data moves and on which cyber, and data security applies. Infrastructure-related considerations include device and data security, roadside units, traffic signal controllers, a traffic management center, secure backhaul communications, and functions that ensure security of data transmission and maintenance. To function safely, a CAV system needs security and communications infrastructure to enable and ensure the trustworthiness of communication between vehicles or infrastructure [18], while adhering to privacy and consumer protection policies.

**Day 1 Benefits** – An immediate application from achieving this objective includes identification of security threats in the current communication system. Also, PennDOT will create the required environment of trust.

**Impacts** – Achieving this will likely have impacts on planned communication deployments.

**Lead:**

- PennDOT Highway Safety and Traffic Operations, PennDOT Infrastructure & Economic Development Delivery Center, and Bureau of Infrastructure and Operation

**Key Stakeholders:**

- PennDOT, Office of Administration, PTC, Local Municipalities, USDOT

**Level of Investment:**

- Level 4

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- None

### Recommended Steps:

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li><b>Develop IT Procedures in Accordance with NHTSA / National Institute of Standards and Technology (NIST) Recommendations</b>   Procedures Developed / Compliance with New Procedures</li> <li><b>Evaluate the Recommended Approach Provided by the Center for Internet Security's (CIS) Critical Security Controls for Effective Cyber Defense (CSC)</b>   Benefit Cost Ratio</li> <li><b>Perform a Cybersecurity Gap Assessment*</b>   Benefit to Cost Ratio</li> <li><b>Perform Network and Security Audit*</b>   Audit Performed / Number of Threats Found</li> <li><b>Establish a CAV Risk Assessment Program</b>   Program Established / Reported Annually / Benefit Cost Ratio</li> <li><b>Define Security and Credentials Management Framework and Policy Documentation</b>   % of Responders Using Platform</li> <li><b>Plan Security and Credentials Management Implementation</b>   Risk Reduction</li> </ul>
	<ul style="list-style-type: none"> <li><b>Implement Security and Credentials Management System</b>   System Deployed / Risk Reduction</li> <li><b>Develop and Publish Security Policy, Procedures and Practices</b>   Procedures Published / Annual Update of Procedures</li> <li><b>Identify Privacy Requirements</b>   Requirements Identified</li> </ul>

## OBJECTIVE 20: IMPROVE SERVICE RELIABILITY

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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IT infrastructure is critical to the successful deployment of CAV technologies. Improving the existing system’s reliability and identifying points of failure of the communication system will greatly help Pennsylvania prepare for successful implementation of CAV.

An unreliable system often leads to disruption of service, financial cost and even loss of human life. To be reliable, a system must be robust, and it must avoid failure modes even in the presence of a broad range of conditions including harsh environments, changing operational demands, and system deterioration.

Achieving this objective will assist Pennsylvania to prepare for integrating CAV technologies into day-to-day operations. This will in turn provide for a more reliable IT system.

**Day 1 Benefits** – Some immediate application from achieving this objective includes having a more reliable IT system.

**Impacts** – Achieving this objective will have immediate impacts on current IT projects.

**Recommended Steps:**

\*Denotes immediate action can be taken.

**Lead:**

- PennDOT Highway Safety and Traffic Operations, PennDOT Infrastructure & Economic Development Delivery Center and Bureau of Infrastructure and Operation

**Key Stakeholders:**

- PennDOT, PTC

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology

**Assumptions:**

- None

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Assess IT Customer Service Program for CAV*</b>  Number of Customer Complaints</li> <li>• <b>Enhance IT Customer Service Program for CAV</b>  Reduction of Customer Complaints / System Reliability</li> <li>• <b>Identify and Address Points of Failures in the IT System*</b>  Points of Failure Identified</li> </ul>
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# Driver Licensing and Motor Vehicles

## OBJECTIVE 21: ESTABLISH A FRAMEWORK FOR SAFE AND PROPER TESTING OF AVs

Goals Addressed:	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 ENHANCE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 STRENGTHEN ECONOMIC COMPETITIVENESS

Pennsylvania supports CAV developments and is active in national efforts to develop uniform standards and practices for AVs. With the pace of this innovation accelerating, Pennsylvania should act to sustain its leadership in CAV research, while simultaneously ensuring that public safety remains the paramount priority as AVs are tested on roadways. In conjunction with the American Association of AAMVA, PTC, and other stakeholders, PennDOT should stay abreast of new developments and actively participate in model policies to enable safe testing of AV on Pennsylvania’s roadways. AAMVA, a tax-exempt, nonprofit organization developing model programs in motor vehicle administration, law enforcement and highway safety, is a priority stakeholder in this area of interest. The association serves as an information clearinghouse and represents the state and provincial officials in the United States and Canada who administer and enforce motor vehicle laws, such as PennDOT. Their guidance published May 2018 should be incorporated into next steps with this and related objectives.

**Lead:**

- PennDOT Deputy Secretary for Driver and Vehicle Services

**Key Stakeholders:**

- PennDOT, AAMVA, Law Enforcement, PTC, Local Municipalities

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Workforce

**Assumptions:**

- None






Establishing a framework for AV testing in Pennsylvania will allow PennDOT to ensure public safety, while staying at the forefront of the development of uniform standards and practices for CAV. This will set a foundation for future development and adoption of CAV in PennDOT’s business processes.

**Day 1 Benefits** – An immediate application from achieving this objective includes updating policy, which usually takes some time to update. Impact to IT is also expected.

**Impacts** – Immediate impact is expected to any existing or planned activities in the realm of AV testing.

### Recommended Steps:

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Continue Participating in the AAMVA Autonomous Vehicle Information Sharing Group*</b>   Number of Meetings Attended</li> <li>• <b>Pilot Applications from the Final Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles</b>   Number of Guidelines Piloted</li> <li>• <b>Establish a Permitting Process for AV Testing in Pennsylvania</b>   Number of Pilots Operating Under Permit / Benefit Cost Ratio</li> <li>• <b>Actively Participate in and Monitor Approved AV Testing in Pennsylvania</b>   Safety / Incidents / Data Availability</li> </ul>	
	5-10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Participate in Update of the Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles</b>   Participation in Update / Number of Partners Engaged</li> </ul>

# Driver Licensing and Motor Vehicles

## OBJECTIVE 22: IDENTIFY CHANGES TO DRIVER LICENSING PROGRAM

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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PennDOT’s driver licensing program is centered around driver abilities and record of safety. Depending on the level of CAV operation, a driver may need more, fewer, or different skills to safely operate on the roadway. Licensing standards should be reviewed and updated to reflect varying levels of automation. Since PennDOT houses and operates the Department of Motor Vehicles, they will have unique opportunities to implement progressive standards and licensing requirements early in CAV deployment. PennDOT must use this information to develop short and long-range plans within their driver programs, as well as gain an understanding of the effects on governmental policies and regulations, legal aspects and law enforcement, environmental factors, insurance coverage, driver’s licenses and more.

A thorough review of the driver licensing program will allow PennDOT to identify foundational needs necessary for the successful and safe adoption of CAV technologies.

**Lead:**

- PennDOT Deputy Secretary for Driver and Vehicle Services

**Key Stakeholders:**

- PennDOT, AAMVA, Law Enforcement, PTC, Local Municipalities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Culture

**Assumptions:**

- None

**Day 1 Benefits** – An immediate application from achieving this objective is identifying current deficiencies in the driver licensing program, if any.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective. However, changes in driver training standards and curricula could deter some age groups from driving (elderly or teenage). There will also be a long-term impact on IT systems and staffing.

**Recommended Steps:**

\*Denotes immediate action can be taken.

<b>5-10 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Continue Working with American Association of Motor Vehicle Administrators (AAMVA)*</b>   Number of Meetings Attended</li> <li>• <b>Identification of Driver’s Skills Required for Each Level of Automation</b>   Skills Identified / % of Skill Met</li> <li>• <b>Evaluate the Need for A License or Special Licensing for Automated Vehicle Operators</b>   Needs Identified / Number of Automated Vehicle Operators Affected</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Modify Driver Training Standards and Curricula for Each Level of Automation</b>   % of Drivers Trained</li> <li>• <b>Explore Revisions to PennDOT Driver Licensing Manual</b>   Benefit/Cost Ratio / Revisions Cataloged</li> <li>• <b>Identification of Allowances for Disabled/Medically Impaired Individuals for Levels of Automation</b>   Benefit/Cost Ratio</li> </ul>
	<b>&gt; 10 Yrs.</b>

# Driver Licensing and Motor Vehicles

## OBJECTIVE 23: IDENTIFY CHANGES TO THE INSPECTION PROGRAM

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Pennsylvania requires vehicle safety inspections to ensure that vehicles are maintained for safe operation. According to several studies, safety inspections can prevent vehicle failure on the highways and crashes that may result in injuries or deaths. Vehicle safety inspections are performed at official PennDOT Inspection Stations (usually a repair garage or a service station with a repair shop). Vehicle inspection in Pennsylvania needs to evolve as more CAV are registered. Inspection processes and inspector qualifications will change as on-board unit and sensor technologies become more prevalent. Training and guidance based on industry standards will need to be continually updated to meet the current fleet’s needs and ensure that all vehicles are safe and meet emission or other standards.

When advanced CAV applications become operational, such as vehicles with SAE levels 4 and 5, PennDOT must decide how to handle safety inspections. If the agency chooses to inspect a vehicle’s automated driving capacity, it must determine what to inspect and must allow for the wide variety of automation levels and features across the manufacturers.

**Lead:**

- PennDOT Deputy Secretary for Driver and Vehicle Services

**Key Stakeholders:**

- PennDOT, AAMVA, Law Enforcement, PTC, Local Municipalities

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Culture

**Assumptions:**

- None

**Day 1 Benefits** – An immediate application from achieving this objective is identification of current deficiencies in the safety inspection program, if any.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective. However, if changes are made, extensive training is expected as well as long-term impact on IT systems.

### Recommended Steps:

\*Denotes immediate action can be taken.

5-10 Yrs.	<ul style="list-style-type: none"> <li>• <b>Assess Vehicle Equipment and Inspection Regulations for CAV Applications*</b>   Assessment Completed / % of Regulation Items Addressed</li> <li>• <b>Evaluate How Vehicle Inspections will be Handled (by the State or Rely on Self-Diagnostics)</b>   Assessment Completed / Benefit Cost Ratio</li> <li>• <b>Evaluate If Additional Certificate Is Needed for Inspection</b>   Assessment Completed / Benefit Cost Ratio</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Identify Safety Inspection Applicability to AV Registered Outside of the Commonwealth</b>   Assessment Completed / Cost</li> <li>• <b>Modify Inspection Training Standards and Curricula</b>   % of Individuals Trained</li> </ul>
	> 10 Yrs.

# Driver Licensing and Motor Vehicles

## OBJECTIVE 24: MODERNIZE CURRENT INSPECTION PROGRAM BUSINESS PROCESSES

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Pennsylvania requires vehicle safety inspections to ensure that vehicles are maintained for safe operation. These inspections are performed at official PennDOT Inspection Stations (usually a repair garage or a service station with a repair shop). Modernization of the current PennDOT Inspection Program could provide benefits in terms of improved program effectiveness and/or reduced costs in the operation of the program or borne by vehicle operators. A modernization effort can become even more challenging with the rapid advance in technology, the proliferation of social media platforms, and heightened security concerns that may arise from CAV technologies. Therefore, it is important to start now in preparation for these new technology applications.

An automated inspection program could potentially provide immediate and more accurate information to motorists, reduce fraud and inspection errors, provide a real-time centralized collection of inspection results, streamline the inspection process, and eliminate unnecessary paperwork.

Enhancing communications with inspection stations would allow PennDOT to enable more effective program management and customer service as well as allow for immediate notification to inspection stations about vehicle safety issues.

Fulfilling this objective will allow PennDOT to set a foundation for the adoption of CAV as well as improvement of the current Safety Inspection Program. This will also create a mechanism to better communicate changes to the Safety Inspection Program to those in charge of performing the inspections.

**Day 1 Benefits** – An immediate application from achieving this objective is significantly improving the Safety Inspection Program, while preparing for the future.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective. However, long-term impacts on IT systems is expected.

**Lead:**

- PennDOT Deputy Secretary for Driver and Vehicle Services

**Key Stakeholders:**

- PennDOT, AAMVA, Law Enforcement, PTC, Local Municipalities

**Level of Investment:**

- Level 4





**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Culture

**Assumptions:**

- None

### Recommended Steps:

- |          |   |
|----------|---|
| 0-5 Yrs. | <ul style="list-style-type: none"> <li>• <b>Improve Inspection Sticker Inventory and Inspection Management</b><br/>  Benefits Cost Ratio</li> <li>• <b>Provide Real-Time Centralized Inspection Results</b><br/>  Early Detection of Safety and Emission Component Failures</li> <li>• <b>Enhance Program Management and Customer Service</b><br/>  Assessment Completed / Benefit/Cost Ratio</li> <li>• <b>Enable Immediate Communication with Inspection Stations</b><br/>  Fraud Reduction / Benefit/Cost Ratio</li> </ul> |
|----------|---|

# Driver Licensing and Motor Vehicles

## OBJECTIVE 25: IMPROVE THE DRIVER AND VEHICLE SERVICES DATA MANAGEMENT SYSTEM

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Modernization is not just about replacing old servers and out-of-date code. It is about providing better service to customers and improving services across the board. PennDOT DVS/DMV is both a consumer and provider of data. PennDOT supplies data to law enforcement, tax assessors and other agencies, as needed. As a consumer of data, PennDOT gets data from the Department of Homeland Security, the United States Department of Health and Human Services, and commercial licensing agencies. Managing and protecting data is a top priority for PennDOT.

Fulfilling this objective will allow PennDOT to set a foundation for the integration of CAV data into the existing system. This will also create a mechanism to enhance communication and make data-driven decisions. PennDOT will be able to acquire and analyze critical statistical data regarding vehicle inspections. This will directly benefit public safety and air quality, as the Commonwealth will be better equipped to identify frequent and common safety and emission component failures.

**Lead:**

- PennDOT Deputy Secretary for Driver and Vehicle Services

**Key Stakeholders:**

- PennDOT, AAMVA, Law Enforcement, PTC, Local Municipalities

**Level of Investment:**

- Level 4

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Culture

**Assumptions:**

- Assumes Objective 24 is fulfilled in conjunction with Objective 25.

**Day 1 Benefits** – Some immediate applications from achieving this objective include significantly improving the data management needs of PennDOT’s Driver and Vehicle Services and positively impacting air quality by systematically collecting emission component failure data.

**Impacts** – No immediate impact to existing or planned PennDOT’s Driver and Vehicle Services activities is anticipated with the fulfillment of this objective. However, with the modernization proposed within this objective, IT will be impacted as it will need to prepare for these changes.

### Recommended Steps:

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Mandate e-SAFETY Electronic Inspection Data Collection Program</b>  % of Inspectors using e-SAFETY data collection</li> <li>• <b>Integrate Data into an Educational Tool for Vehicle Inspectors</b>  % of Individuals Trained / Benefit/Cost Ratio</li> <li>• <b>Share Inspection Data with Federal Agencies to help Shape Regulation</b>  Information Shared / Benefit/Cost Ratio</li> </ul>
<b>5-10 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Enable Immediate Communication with Inspection Stations</b>  Fraud Reduction / Benefit/Cost Ratio</li> <li>• <b>Measure Program Effectiveness</b>  Benefit/Cost Ratio</li> </ul>



## Modal Considerations

### OBJECTIVE 26: ENGAGE AND WORK WITH TRANSIT PARTNERS FOR CAV ADVANCEMENT

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Pennsylvania invests over \$1.5 Billion annually in public transportation – ranking fourth in the nation in direct support for public transportation. PennDOT oversees operating and capital investments for 35 fixed route (scheduled local bus, light rail, and commuter rail) systems, 44 community transportation systems, passenger rail service between Pittsburgh and Philadelphia, and 12 intercity bus routes provided by two intercity bus companies. CAV technology will likely impact the public transit industry in a dramatic way during the next two to three decades. The benefits of CAV to microtransit, low speed shuttles and first/last mile solutions is palatable. The prospect of demand responsive transportation using automated vehicles is particularly appealing. Existing CAV testbed can support this level of testing. Not needing to employ a human driver will clearly improve the business case and could also greatly improve the flexibility in terms of fleet operations, as there would be no need for vehicles to stop for the driver to take breaks and vehicles could potentially operate 24 hours per day. Addressing these opportunities early on will allow PennDOT gain a better understanding of the impacts this technology will have on transit. This will give the Department time to prepare for these changes from not only a technical perspective, but also from a policy perspective. How will the funding and policy landscape change to adopt this new technology? These are some of the questions that can be answered by involving transit agencies sooner rather than later.

**Lead:**

- PennDOT Multimodal Transportation

**Key Stakeholders:**

- PennDOT, Local Transit Agencies, MPOs/RPOs, Local Municipalities

**Level of Investment:**

- Level 4

**CMM Dimension Impact:**

- Business Processes, Culture, Organization and Workforce, Collaboration

**Assumptions:**

- None

Achieving this objective will also supports the development of multimodal partnerships to pursue CAV technologies under the premises that CAV technologies need to be able to support multiple modes.

**Day 1 Benefits** – Some immediate benefits from achieving this objective includes a better understanding of how this technology will impact transit and establishing better working relationships with partners. Demonstrating the value of ride-share companies to support CAV technologies with respect to transit services is anticipated to be a benefit as well.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Educate Modal Partners of Benefits and Opportunities for their Domains</b>  Number of Partners Reached</li> <li>• <b>Conduct Collaboration Workshop to Large Scale Public Transit Agencies*</b>  Number of Stakeholders Engage</li> <li>• <b>Establish Partnership Agreements with Modal Partners to Leverage Investments</b>  Amount of Multi-Modal CAV Deployments</li> <li>• <b>Establish Partnership Agreements with Car Sharing Partners to Leverage Investments</b>  Amount of Car Sharing Deployments</li> </ul>
<b>5-10 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Establish a Testbed for Automated Shuttles</b>  Benefit/Cost Ratio</li> </ul>

# Modal Considerations

## OBJECTIVE 27: ASSES IMPACTS OF CAV ON TRUCK AND RAIL FREIGHT

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> ENHANCE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> STRENGTHEN ECONOMIC COMPETITIVENESS
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The benefits of CAV will transcend many areas of transportation, including movement of goods. Recently the USDOT has indicated that next generation CAV guidance will require consideration of multimodal solutions. Pennsylvania ranks first in the country in the number of operating railroads (64) and ranks near the top in total track mileage (more than 5,600 miles). PennDOT provides financial and technical assistance to railroads and businesses while promoting economic development through its grant programs and other resources. For freight considerations, vehicle platooning offers the promise of addressing work force shortages and improving freight reliability. Supporting the movement of freight is a top priority for Pennsylvania. In addition to interstate travel, examining congestion and freight movement in and out of major distribution points also needs consideration.

Assessment of impacts on CAV on truck and rail freight will ultimately lay a foundation for fully realizing the benefits if this technology in a greater scale. Working with truck and rail partners to determine the impacts of this technology will also allow Pennsylvania to learn more about this technology and how it will affect the entire transportation system. To demonstrate if existing infrastructure investment can be sustained with CAV, ramps may have to be evaluated to determine if they are equipped to allow bypass by truck platoons.

**Lead:**

- PennDOT Multimodal Transportation

**Key Stakeholders:**

- PennDOT, PTC, Local Transit Agencies, MPOs/RPOs, Local Municipalities s

**Level of Investment:**

- Level

**CMM Dimension Impact:**

- Business Processes, Systems and Technology, Culture, Organization and Workforce, Collaboration

**Assumptions:**

- Legislature will be in place to support CAV freight applications.
- Truck platooning technology is mature enough to perform demonstration.

**Day 1 Benefits** – Some immediate application from achieving this objective includes understanding the impacts this technology will have on the entire transportation system.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

### Recommended Steps:

<b>0-5 Yrs.</b>	<ul style="list-style-type: none"> <li>• <b>Conduct Collaboration Workshop to Engage Truck and Rail Freight Industry</b>   Workshop Conducted / Number of Stakeholders Engaged</li> <li>• <b>Identification of Freight Short-Term / Long-Term Freight Applications</b>   Benefit/Cost Ratio / Reduction in Travel Time / Integration of CAV Freight Application in PA Comprehensive Freight Movement Plan</li> <li>• <b>Work with Companies with Platooning Technologies to Develop Testbed(s)</b>   Benefit Cost Ratio</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Prepare Ramp Meters (where applicable) to Communicate with Truck Platooning</b>   Travel Time Reduction / Mile of Integration Accomplished</li> </ul>
	<b>5-10 Yrs.</b>

## Modal Considerations

### OBJECTIVE 28: ASSESS CAV IMPACTS ON AIRPORT AND SEAPORT OPERATIONS

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Pennsylvania ranks 9th in the country for volume of goods moved through its ports with over 100 million tons of goods moving through the ports of Erie, Philadelphia, and Pittsburgh. These three ports provide an economic benefit of nearly \$50 billion to the Commonwealth. The department’s ports program was created to oversee and administer the allocation of state funds to the three ports. It also serves as an advocate for both public and privately owned and operated ports. As part of its advocacy efforts, the department has created the Ports Incentive Program to entice shippers to increase their shipping volume through the three ports. Support for automation in ports can further advance this effort. Automation in various forms has been used at many maritime port operations worldwide for over twenty years. Automated container stacking, trailer positioning and container delivery systems are becoming more and more commonplace at major ports to improve safety, security, and efficiency. The use of CAV technology at Pennsylvania seaport and airports can help manage congestion and improve safety.

**Lead:**

- PennDOT Multimodal Transportation

**Key Stakeholders:**

- PennDOT, Local Transit Agencies, MPOs/RPOs, Local Municipalities s

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Collaboration

**Assumptions:**

- None.

Offering incentives to shift traffic to non-peak and lightly used routes will decrease congestion around ports. Reducing congestion around ports would reduce lost capacity and delays at ports. This will in turn allow for CAV truck testing. Also, faster loading and uploading of vessels can increase throughput through ports and a high level of automation can improve productivity of port operations.

**Day 1 Benefits** – An immediate application from achieving this objective includes a better understanding how CAV can impact port operations.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

- |                 |  |
|-----------------|--|
| <b>0-5 Yrs.</b> | <ul style="list-style-type: none"> <li>• <b>Provide Training on Tools to Improve Scheduling with Ground Transportation and Port Freight</b><br/>  Benefit/Cost Ratio</li> <li>• <b>Establish Policies/Incentives for Ports to Transport Goods at Non-Peak Times or via Lightly Used Routes</b><br/>  Benefit/Cost Ratio / Improvements in Lost Capability and Delays at Ports</li> <li>• <b>Develop Policies/Incentives to Encourage Ports to Implement Coordinated Vessel to Rail or Vessel to Truck Automation</b><br/>  Tonnage of Freight Moved Through Ports / Benefit/Cost Ratio</li> </ul> |
|-----------------|--|

## Modal Considerations

### OBJECTIVE 29: ASSESS SAFETY AND MOBILITY CONSIDERATIONS FOR PEDESTRIANS AND BICYCLISTS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Pedestrians and bicyclists are a powerful indicator of the social and economic health and safety of a community. A high level of pedestrian and bicycle activity in a community is often associated with more robust economies and healthier, more socially-cohesive populations, while a lack of pedestrian and bicycle activity on roadways can be an indicator that personal security and safety needs are not being met or that destinations cannot be accessed on foot or by bike. Presently, technology innovations are disrupting the status quo and reshaping the ways in which people travel. Auto manufacturers are offering new vehicle automation technologies to improve safety, ease the driving task, and appeal to car buyers. At the same time, non-traditional entities—such as technology firms like Google/Waymo, Uber, and nuTonomy—are adopting new roles in the transportation arena, advancing shared mobility services and hastening the speed of automation technology development. As vehicle technologies become more automated, navigation around and interactions with pedestrians and bicyclists in complex travel environments will determine their success. Technological advances that are not planned carefully may produce difficult conditions for walking and bicycling, affecting the quality of life in neighborhoods, commercial districts, and other places where human street activity is essential. Thus, it is important for transportation professionals and the broader public to have ongoing conversations about both existing challenges and the problems that may arise in the future [19].

As some of the current detection systems rely on cues from the built environment, there is a need to consider policy and roadway design enhancements that can provide additional contextual warnings, improve detection of pedestrians and bicyclists, and provide a larger safety margin.

#### Lead:

- PennDOT Multimodal Transportation

#### Key Stakeholders:

- PennDOT, Local Transit Agencies, MPOs/RPOs, Local Municipalities

#### Level of Investment:

- Level 3

#### CMM Dimension Impact:

- Business Processes, Organization and Workforce, Collaboration

#### Assumptions:

- As it relates to pedestrian and bicyclist: limitations such as cost, limited accuracy of positioning information, no ability to predict intentions, privacy concerns, trust, expectation, use, reliability, and overreliance should be researched.

**Day 1 Benefits** – As connected, automated, and shared vehicle systems continue to develop, curbside management practices and even traditional parking lot design demand new thinking. These issues are currently being faced by large cities where shared services account for a large portion of its congestion. Understanding curbside management will help with some of these issues.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

#### Recommended Steps:

<b>0-5 Yrs.</b>	• <b>Research Vehicle-to-everything (V2X) Application for Pedestrian and Bicyclists</b>  Research Completed / Benefit Cost Ratio
	• <b>Pilot V2X Application for Pedestrian and Bicyclists</b>  Pilot Completed / Benefit Cost Ratio
<b>5-10 Yrs.</b>	• <b>Better Understand the Limitations and Benefits of V2X Applications</b>  Complete Research / Benefit Cost Ratio
	• <b>Consider Policy Enhancements to Improve Pedestrians and Bicyclists in a CAV Environment</b>  Benefit Cost Ratio / Reduction in Pedestrian and Bicyclist Crashes

## Modal Considerations

### OBJECTIVE 30: ENGAGE DISADVANTAGED MODAL PARTNERS IN CAV EFFORTS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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To assist senior citizens and persons with limited mobility, Pennsylvania invests in affordable and accessible transportation alternatives. There is a wide range of shared-ride and public transportation programs available to help Pennsylvania residents enjoy the benefits of alternative transportation regardless of income or physical disability. All fixed-route public transportation systems statewide offer accessible transportation that meets federal Americans with Disabilities Act (ADA) requirements for persons who travel within 3/4 mile of a fixed route. Beyond the fixed-route service, there are several programs offered in Pennsylvania designed to make transportation accessible to everyone. For example, the free transit program allows senior citizens to ride free on local fixed-route service whenever the local public transit system is operating. In addition, individuals with disabilities have access to a wide range of alternative transportation options, including shared-ride services, paratransit, and discount programs. CAV can greatly benefit all these individuals. Improved mobility for those that cannot drive or do not have access to

**Lead:**

- PennDOT Multimodal Transportation

**Key Stakeholders:**

- PennDOT, Local Transit Agencies, MPOs/RPOs, Local Municipalities, Pennsylvania Department of Aging

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Collaboration

**Assumptions:**

- None.

a private car is one of the major long term selling points of highly automated vehicles. There is great excitement regarding the potential of this technology amongst this community. With an aging population and an increasing tendency amongst young people to delay learning to drive there is a large and growing market for providing improved transport services for those that either cannot or choose not to drive. However, AVs have the potential to go beyond providing mobility for those that cannot drive. A low-cost demand responsive system of automated taxis for example could fundamentally change the way public transport is delivered, which could extract trips from all other modes of travel, including private car, taxi, bus, train, walking, and cycling.

**Day 1 Benefits** – Some immediate application from achieving this objective include better coordination with the disadvantaged community and identification of gaps in current services.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

- |           |   |
|-----------|---|
| 0-5 Yrs.  | <ul style="list-style-type: none"> <li>• <b>Work with Private Ride-Share Companies to Develop a Program for Paratransit Needs</b><br/>  Benefit Cost Ratio / Program Developed</li> <li>• <b>Identify Opportunities for CAV in the Free Transit Program for Senior Citizens and Paratransit</b><br/>  Opportunities Identified / Pilot Identified / Benefit Cost Ratio</li> <li>• <b>Work with the Pennsylvania Department of Aging*</b><br/>  Improved Mobility for Seniors</li> <li>• <b>Ensure Persons with Disabilities are Considered as CAV Deployment Starts</b><br/>  Improved Mobility for Persons with Disability</li> <li>• <b>Identify Opportunities for CAV within the Rural Transportation Program</b><br/>  Benefit Cost Ratio / Improved Mobility in Rural Areas</li> </ul> |
| 5-10 Yrs. | <ul style="list-style-type: none"> <li>• <b>Create Incentives for AV Ride Sharing Discount for Seniors</b><br/>  Benefit Cost Ratio / Improved Mobility for Senior</li> </ul>   |

# Workforce Requirements

## OBJECTIVE 31: ADJUST ORGANIZATIONAL STRUCTURE TO SUPPORT CAV

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Organizational structure refers to how individual and team work within an organization are coordinated. Organizational structure is a valuable tool in achieving coordination, as it specifies reporting relationships, delineates formal communication channels, and describes how separate actions of individuals are linked [15]. Pennsylvania agencies must change their organizational structure to achieve the goals and objectives delineated in this strategic plan.

Development of a new organizational structure to address emerging technologies and their impacts to the transportation network will lay a foundation for the safe adoption of CAV and other technologies that may come along.

Achieving this objective will assist agencies in filling gaps in staffing.

**Day 1 Benefits** – Some of the immediate benefits from adjusting organizational structures include a better adjustment to changing environments brought about by new technologies such as CAV.

**Lead:**

- PennDOT and PTC Leadership

**Key Stakeholders:**

- PennDOT, PTC

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Culture

**Assumptions:**

- None

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective. However, impact to staffing to levels and vacancies in all business areas is expected dependent on organizational change needed.

**Recommended Steps:**

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Identify Gap in Skills, Abilities and Knowledge for CAV *</b>   Cost and Impacts Associated with Needs</li> <li>• <b>Identify Organizational Structure Needs for CAV *</b>   Cost and Impacts Associated with Needs</li> <li>• <b>Create a Career Path Comparable to Other Areas of the Organization</b>   Cost and Impacts Associated with Needs</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Develop an Implementation Plan for Organizational Structure Changes</b>   Plan Developed</li> <li>• <b>Update Job Descriptions to Reflect Advanced Technology Needs</b>   % of Positions Updated</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Work with Other Agencies to Create a Common Set of Requirements for CAV Workers</b>   Number of Positions Updated</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Implement Organizational Structure Changes</b>   % of Changes Implemented</li> </ul>
	5-10 Yrs.

# Workforce Requirements

## OBJECTIVE 32: PROVIDE APPROPRIATE TRAINING FOR AGENCY WORKFORCE

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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Effective workforce management is crucial to successful operations of any system. Workforce management typically includes various tasks and activities required to maintain an efficient and productive operation. Workforce training is one such activity that is fundamental to the effective and sustainable operation of any organization.

With the introduction and deployment of CAV technologies, workforce training will need to evolve significantly within state agencies, such as PennDOT. Collaboration with local and state educational institutions, including provision of funding to support training offered at these institutions, will be important to enhancing workforce training as higher levels of vehicle automation evolve. PennDOT provides in-house training for all new employees who will be working as examiners at driver’s license test centers. In addition, PennDOT will implement a new web-based training program that Driver License Examiners will be required to take to administer the non-commercial skills test. The new web-based training includes information on new vehicle technologies, such as back-up cameras, sensors, and self/auto park features. In a future with CAV, it will be important for PennDOT to continually evaluate its in-house training program and to include coursework and material relevant to CAV. To respond to workforce training needs within the field of CAV, it is recommended that PennDOT encourage its transportation personnel and practitioners to participate in training programs and webinars, which are geared toward educating state and local highway agencies on how to evaluate and effectively implement various technologies. Several programs and certifications related to CAV are or will be supported by the federal government or third party professional groups, such as the SAE, Institute of Transportation Engineers, etc.

**Lead:**

- PennDOT

**Key Stakeholders:**

- PennDOT Staff, PTC, FHWA, Private Industry

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Culture

**Assumptions:**






- None

**Day 1 Benefits** – Enhancing access to training for PennDOT staff will allow more individuals within the organization to become early adopters of this technology and better planners of it.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

- |          |   |
|----------|---|
| 0-5 Yrs. | <ul style="list-style-type: none"> <li>• <b>Identify Training Needs*</b><br/>  Needs Identified / % of Needs Addressed</li> <li>• <b>Develop and Deliver Easily Accessible CAV Training to Agency Staff</b><br/>  % of Staff Trained</li> <li>• <b>Include CAV Training in New Employee Training Requirements as Applicable</b><br/>  Number of New Staff Trained</li> <li>• <b>Encourage Agency Staff to Attend CAV Training Provided by Others</b><br/>  Number of Staff Hours Spent in Training / Number of Training Attended</li> <li>• <b>Work with SAE (and others as Applicable) to Develop a Training Program on the Physical Components of CAV</b><br/>  Program Developed</li> <li>• <b>Work with Coalitions to Establish a CAV Academy</b><br/>  CAV Academy Established / Number of Participants</li> </ul> |
|----------|---|



# Workforce Requirements

## OBJECTIVE 33: STRENGTHENED PARTNERSHIPS WITH TALENT SOURCES

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Connections between employers and talent sources, such as community colleges, workforce boards, universities and 4-year colleges, must be strengthened to enhance the training provided to and received by the current and future workforce. Without proper engagement by employers, talent sources will not know what employers need to train new workers or upskill current workers. The number of individuals able to obtain a bachelor’s degree is limited. Community colleges are the best place for upskilling current workers and preparing new workers for CAV jobs. Transfer programs will help those that can move onto a bachelor’s program or beyond, but community colleges must be engaged for much of the early training. If they are not engaged, there may not be enough space for all future workers to obtain the proper training.

CAV-related work is complex and typically requires workers to have an understanding of engineering, mathematics, and computer science. In addition, because the current work is so focused on IT design and development, employers are most interested in workers with a track record of experience in their field. These workers may be difficult to find because CAV is still so new for many companies and it is difficult for a worker to have several years of experience on a relatively new technology. However, workers with proven experience in their occupation overall are likely good candidates to shift their focus to CAV. This could have implications for employers seeking similar workers as competition for talent is already fierce.

**Lead:**

- PennDOT, PTC

**Key Stakeholders:**

- PennDOT, PTC, Universities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Collaboration

**Assumptions:**

- None

**Day 1 Benefits** – Achieving this objective will allow PennDOT to improve its relationships with various universities and other talent sources within the Commonwealth.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

### Recommended Steps:

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Work with Universities to Identify Needs in Educational Programs</b>   Number of Needs Identified</li> <li>• <b>Establish an Internship Program with a Focus on Emerging Technologies and Partner with Local Universities</b>   Number of Students Participants</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Work with Universities to Develop and Establish Appropriate Educational Programs</b>   Number of New Programs Establishes / % of Identified Needs Fulfilled</li> </ul>

# Workforce Requirements

## OBJECTIVE 34: ACCELERATE TECHNOLOGY ACCEPTANCE THROUGH THIRD PARTY TRAINING

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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The two examples of trade schools or community colleges in the Pittsburgh region offering training related to automobiles or trucks are the Community College of Allegheny County (CCAC) and Rosedale Technical Institute (RTI). Both institutions offer associate degrees and certifications in automotive technology, which are designed to prepare students to be automotive technicians and to be able to repair and service today’s automobiles, and take the tests necessary to earn Pennsylvania Safety and Emission Inspection Licensing and Automotive Service Excellence (ASE) certifications. Vehicle automation will most likely result in additional and/or modified courses added to the certificate and associate degree program curriculums at both institutions. The amount of electronics in vehicles will increase as higher level automated vehicles are able to sense their environment and navigate on their own using LiDAR, radar, and GPS detection devices; and communicate with other vehicles through short-range wireless data exchanges. Along with these features, a complex information system will be standard equipment in highly automated vehicles. As automobiles become more sophisticated, automotive technicians will have to keep up with the advancements in automotive technology to be able to correctly diagnose and quickly repair any vehicle issues presented to them. Therefore, more emphasis in the curriculum for automotive technicians at the CCAC and RTI should be placed on electronics, information technology and electronic communication systems along with computer science.

**Lead:**

- PennDOT, PTC

**Key Stakeholders:**

- PennDOT, PTC, Universities, Pennsylvania Department of Education

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Collaboration

**Assumptions:**

- PennSTART is anticipated to be operational from Year 2020 and will benefit emergency responders, transportation organizations, and research institutions.

Located in Indiana, Pennsylvania, the Highway Safety Center at Indiana University of Pennsylvania provides driver education and improvement programs and first responder and emergency response team training. This presents another partnering opportunity to integrate CAV into an educational program that will be directly impacted by this technology.

**Day 1 Benefits** – Achieving this objective will allow Pennsylvania to improve its relationships with various entities in this field.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

- |                  |   |
|------------------|---|
| <b>0-5 Yrs.</b>  | <ul style="list-style-type: none"> <li>• <b>Advance PennSTART, a Training and Testing Facility, to Address the Transportation Safety and Operational Training Needs*</b><br/>  Number of Trainings Held</li> <li>• <b>Work with Partners to Train First Responders on How to Deal with CAV by Advancing PennSTART</b><br/>  Number of Trainings Held</li> </ul> |
| <b>5-10 Yrs.</b> | <ul style="list-style-type: none"> <li>• <b>Work with Trade Schools or Community Colleges to Integrate CAV into Applicable Trainings</b><br/>  Number of New Courses Established</li> <li>• <b>Work with Indiana University of Pennsylvania to Integrate CAV into Curriculum</b><br/>  Number of New Courses Established</li> </ul>                             |

# Workforce Requirements

## OBJECTIVE 35: CREATE AN IN-REACH PLAN FOR PENNDOT DISTRICTS

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Workforce demographics are changing. As baby boomers retire, millennials now make up the biggest part of the workforce and are moving into management positions. At the same time, members of Generation Z are starting to come out of college and move into their first full-time jobs.

While generational categories might often seem too simplistic, there is no escaping from one underlying truth that they reveal: each successive generation from millennials onward has been more and more demanding, especially concerning the ways their employers talk and listen to them. They expect fewer office politics and increased collaboration, transparency, and feedback. The larger concept that has evolved out of these new requirements is called employee engagement. There is one major part of employee engagement that is highly actionable—internal communications. Companies spend

**Lead:**

- PennDOT

**Key Stakeholders:**

- PennDOT, Universities

**Level of Investment:**

- Level 3

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Collaboration

**Assumptions:**

- None

large amounts of money and resources on their external relations and communication but often neglect internal marketing and communications to their employees. An engaged workforce feels valued, involved and that they genuinely matter. Higher levels of engagement improve morale, boost productivity and lead to a better working environment in general. Effective communications ensure that employees fully understand the company, its values and purposes, what is expected of them to achieve the company goals, and how to fully engage with their own roles.

Internal communication is important because it puts everyone on the same page. Everyone’s marching toward the same goal, which in turn creates a more cohesive strategy and reduces confusion and inefficiencies. As a result, any approach toward internal communications should not come at the tail end of the process, nor is it an optional add-on to a campaign; instead, it should be front and center, clearly articulated for the organization. To have a united front externally, there needs to be education and understanding internally.

**Day 1 Benefits** – Achieving this objective will allow PennDOT to improve its internal communication.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

### Recommended Steps:

\*Denotes immediate action can be taken.

- |          |   |
|----------|---|
| 0-5 Yrs. | <ul style="list-style-type: none"> <li>• <b>Develop a Plan to Engage all Districts in CAV Efforts*</b><br/>  % of District Staff Engaged</li> <li>• <b>Create a Peer-to-Peer Exchange Program within PennDOT</b><br/>  Program Established</li> <li>• <b>Educate PennDOT Leadership About Benefits and Plan For CAV*</b><br/>  Number of Managers Briefed</li> <li>• <b>Encourage and Support CAV Working Groups at the District Level*</b><br/>  Number of Working Groups</li> </ul> |
|----------|---|

## Policy and Legal

### OBJECTIVE 36: COORDINATE WITH THE PENNSYLVANIA ASSEMBLY TO ESTABLISH POLITICAL/LEGISLATIVE CLIMATE TO SUPPORT CAV DEPLOYMENTS

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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There are many misperceptions of CAV technology’s impact on society. Educating legislators of what those impacts will be to their constituency will be an important part of CAV acceptance in Pennsylvania. Further, giving them the tools to explain the benefits to their constituency will be crucial to public acceptance. As the technology for automated vehicles continues to develop, it may be necessary for state and municipal governments to address the potential impacts of these vehicles on the road. Each year, the number of states considering legislation related to CAV has gradually increased. For example, in 2017, 33 states introduced legislation and 22 states—Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Louisiana, Michigan, New York, Nevada, North Carolina, North Dakota, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia and Vermont—and Washington D.C. have enacted legislation related to automated vehicles.

**Lead:**

- PennDOT CAV Internal Working Group and external CAV Task Force

**Key Stakeholders:**

- PennDOT, PTC, MPOs/RPOs, Local Municipalities, Local Transit Agencies, Private Companies

**Level of Investment:**

- Level 1

**CMM Dimension Impact:**

- Business Processes

**Assumptions:**


- PennDOT CAV Internal Working Group and external CAV Task Force are formed.

Achieving this objective will allow Pennsylvania assist in setting a foundation for future development of new technologies related to CAV and allow for safer testing of CAV in Pennsylvania.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

#### Recommended Steps:

\*Denotes immediate action can be taken.

- **Seek Authority from Pennsylvania Assembly to Implement Policies and Regulations for Levels 4-5 Automation\***  
 Number of CAV Test Cases in Pennsylvania under new Policy

0-5 Yrs.

## Policy and Legal

### OBJECTIVE 37: INSTITUTIONALIZE A PROCUREMENT PROCESS FOR CAV

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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PennDOT frequently uses consultants for engineering and related services leading to the construction and/or rehabilitation of transportation infrastructure under the Highway Administration Deputate. Most of the consultants represent engineering firms, but PennDOT also uses non-engineering firms for specialized work and services. Generally, Information Technology supply purchases over \$100,000 are made by the Office of Administration, Information Technology. All Departments, Boards and Commissions send requirements to the Department of General Services for bidding noncontract supply purchases over \$100,000. All supplies used in the roadway (aggregates, bituminous material, concrete, guide fence, steel pipe, traffic paint, signs, culverts, etc.) must be purchased from producers of construction materials approved by the Bureau of Project Delivery.

**Lead:**

- PennDOT Deputy Secretary for Administration

**Key Stakeholders:**

- PennDOT, PA Office of Administration, Department of General Services

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes

**Assumptions:**

- None

Working with all relevant Pennsylvania agencies to evaluate various procurement processes as they pertain to incorporating CAV technologies will be important as these are non-traditional projects. As there is no formal process to procure CAV technologies, it will be important to standardize a process and incorporate various levels of contracting.

**Day 1 Benefits** – Some of the immediate benefits from assessing procurement processes for CAV includes identifying specific gaps for procuring services and products related to advanced technologies currently in use, such as ITS.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

- 0-5 Yrs.

  - **Evaluate Procurement Readiness for CAV Within PennDOT \***  
 Procurement Process Evaluated / Number of Changes Needed
  - **Implement Procurement Changes Identified**  
 Procurement Processed Updated / % of Changes Implemented
  - **Work with the Attorney General’s Office and State Law Enforcement to Identify and Address Regulation and Enforcement Issues**  
 Issues Addressed / Proper Enforcement
  - **Develop Specialized Permitting System for CAV Operations in the Commonwealth**  
 Number of Permits Issued
  - **Implement New Contractual Mechanisms with Private-Sector Providers**  
 Number of Contracts / Funding

## Policy and Legal

### OBJECTIVE 38: EVALUATE EFFECTS OF CAV ON PENNDOT POLICIES

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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The role of state transportation agencies, such as PennDOT, is to develop, maintain, manage, and improve the transportation system in a way that enables individual mobility, supports economic activity, and improves quality of life. These agencies aim to serve a broad public interest and provide services that might not otherwise be provided in the market. To continue to meet these expectations, state and local transportation agencies must strive to understand the impacts of CAV technology. Policy decisions should be made to maximize the positive effects and minimize the negative effects on society [4].

Public agencies are expected to consider the range of societal goals (equity, economic, safety, security, quality of life) in their decisions. Public agencies are expected to consider the interests of individuals and organizations with the understanding that individual interests and the common good do not always align perfectly. The deployment of CAV technologies in the market will have effects on public agencies themselves, the public and private parties. It is the role of a public agency to consider the interests of all these groups, and, in cases where those interests do not align, intervene in the market to maximize potential benefits and minimize negative consequences [4].

CAV could also aggravate funding deficits through increased costs for maintaining and operating roadways. A proliferation of shared AVs, for example, could reduce the amount of revenue from driver licensing, vehicle registration, moving violations, transit fares, and federal funding associated with ridership levels. However, CV technology could potentially increase revenue from road user charges by providing a platform that supports usage-based revenue measurement and reporting. PennDOT and other local transportation agencies need to work together to better prepared for these changes.

**Lead:**

- PennDOT Leadership, PennDOT Deputy Secretary for Administration

**Key Stakeholders:**

- PennDOT, PTC, Pennsylvania Governor’s Office

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Culture

**Assumptions:**

- Assuming legislation passes to allow for various pilots

**Day 1 Benefits** – An immediate benefit from achieving this objective is to better understand the alternative policies needed to be developed in a long term to successfully adapt to CAV.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

<b>0-5 YRS.</b>	<ul style="list-style-type: none"> <li>• <b>Ensure All Segments of the Population are Included in Regulatory/Policy Development</b>  Number of Segments of Population Included</li> <li>• <b>Evaluate Gas Tax Implications of Moving Toward Electric Vehicles</b>  Cost and Impacts Associated with Changes</li> <li>• <b>Identification of Liability and Safety Issues with Pilot Programs</b>  Liability Issues Identified</li> </ul>
<b>5-10 YRS.</b>	<ul style="list-style-type: none"> <li>• <b>Evaluate Impacts of CAV on Vehicle Registration and Licensing Revenue</b>  Revenue Impact</li> <li>• <b>Work with Other Agencies to Create a Common Set of Requirements for CAV Workers</b>  Number of Positions Updated</li> </ul>

OBJECTIVE 39: IDENTIFY FUNDING LEVEL

Goals Addressed:	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS

The State Transportation Improvement Plan (STIP) and the Transportation Improvement Program (TIP) are the first four years of the Twelve-Year Program (TYP), which outline the multimodal transportation improvements spanning a four-year period. The STIP covers the entire state and includes 23 individual TIPs representing the MPOs and RPOs. The TIPs feed into the statewide STIP. PennDOT’s planning partners develop a TIP and solicit public involvement per each MPO/RPO Public Participation Plan. The STIP addresses all modes of transportation, including highways and bridges, public transit, aviation, and rail freight projects that intend to use federal and/or state matching funds excluding specified maintenance funds. This plan provides the public with an active role in the development of transportation plans, programs, and projects beginning in the early stages of plan development and continuing throughout the planning process. As needs and priorities change, the TIP may be modified or amended.

**Lead:**

- PennDOT Leadership, PennDOT Deputy Secretary for Administration

**Key Stakeholders:**

- PennDOT

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Business Processes, Organization and Workforce, Culture

**Assumptions:**

- Legislation passes to allow for various pilots

The State Transportation Commission (STC) reviews and approves the Twelve-Year Program every two years and when finalized, the STC adopts the program. It is then forwarded to the Governor, FHWA, the Federal Transit Administration (FTA), and the Environmental Protection Agency (EPA) for their approval prior to the start of the federal fiscal year, which is October 1 of each year.




All infrastructure funding is limited so it is crucial to determine accurate baseline levels to fund CAV operations, maintenance, and project deployments. Proper funding planning, including determination of resources, stakeholders, and investors will be key to the success of Pennsylvania’s CAV Program.

**Day 1 Benefits** – An immediate benefit from early consideration of funding needs for CAV is to lay a foundation for the proper adoption of these technologies.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

- |          |   |
|----------|---|
| 0-5 Yrs. | <ul style="list-style-type: none"> <li>• <b>Work with Partners to Identify and Program Pilot Deployment Funding*</b><br/>  Funding Allocated / Number of Pilots</li> </ul>     |
|          | <ul style="list-style-type: none"> <li>• <b>Work with Partners to Identify and Program Funding for Operations and Maintenance of Pilots</b><br/>  Funding Allocated</li> </ul> |
|          | <ul style="list-style-type: none"> <li>• <b>Identify and Program Funding Needed to Fulfill CAV Strategic Plan</b><br/>  Implementation Plan / Funding Allocated</li> </ul>     |



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## Policy and Legal

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### OBJECTIVE 40: CREATE POLICIES TO INCENTIVIZE CAV DEPLOYMENT AND USE

Goals Addressed:

1 IMPROVE SAFETY

2 ENHANCE MOBILITY

3 PREPARE WORKFORCE

4 FOSTER AND SUSTAIN PARTNERSHIPS

5 INCREASE PUBLIC AWARENESS

6 SUPPORT ECONOMIC COMPETITIVENESS

The role of state transportation agencies, such as PennDOT, is to develop, maintain, manage, and improve the transportation system in a way that enables individual mobility, supports economic activity, and improves quality of life. Creating policies to incentivize the adoption and use of CAV will enable PennDOT and other local transportation agencies realize the benefits from this technology sooner and safer. Strategies such as granting priority access to AVs and CVs in dedicated lanes on any number of roadway types, including freeways and local streets, and accounting for the different operating characteristics of AVs and CVs will greatly incentivize the use of CAV. Longer trips served by freeways could support the ability of AVs and CVs to travel at close spacing and/or to form fast-moving, densely spaced platoons [4]. Traffic signal priority for CVs involves sophisticated signal timing algorithms that estimate the arrival of platoons of CVs and coordinate the signal timing to increase throughput by providing these platoons green light priority. This would be a more complex version of transit signal priority. The goal would be to decrease the total delay at the traffic signal for all vehicles, but particularly CVs, to stimulate consumer action toward market penetration [4].

#### Lead:

- PennDOT Leadership, PennDOT Deputy Secretary for Administration

#### Key Stakeholders:

- PennDOT, PTC

#### Level of Investment:

- Level 4

#### CMM Dimension Impact:

- Business Processes, Organization and Workforce, Culture

#### Assumptions:

- None



Another opportunity for PennDOT is found in shared AV use as an alternative to mass transit where this is not a viable option. PennDOT could potentially provide subsidies to incentivize shared AV use to ensure alternatives will be available to individually owned AVs, to mitigate congestion and emissions as well.

**Day 1 Benefits** – An immediate benefit from achieving this objective is to better understand the alternative policies needed to be developed in a long term to successfully adapt to CAV.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

#### Recommended Steps:

>10 Yrs.

- **Grant AVs and CVs Priority Access to Dedicated Lanes**  
 CAV Penetration Rate
- **Subsidize Shared AV Use**  
 Funding Available / Ridership

## Outreach and Collaboration

### OBJECTIVE 41: INCREASE PUBLIC AWARENESS OF BENEFITS AND RISKS

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Engaging with individuals and organizations representing the public provides influence on the ultimate stakeholder for PennDOT, which is the citizens and businesses utilizing PennDOT infrastructure. Having these stakeholders fully educated regarding multiple facets of CAV issues, including benefits and risks, allows for a more productive use of public assets.

Also, the introduction of automated vehicles in cities like Pittsburgh, Pennsylvania and Tempe, Arizona has received mixed reactions from the public. Public transportation agencies should engage in an open dialogue between all residents and respond to varying levels of acceptance of this technology. Outreach should not be only prior to introduction of AVs, but ongoing as new concerns emerge.

While many warn of patchwork regulation of AVs, there should also be concern about technophobic sentiment and hostility toward this technology should the public not fully understand the benefits of AV technology and how such vehicles will be operated safely within communities. An open dialogue with the public will assist in filling in these gaps.

Public education about the safety, congestion, mobility, privacy safeguards, and environmental implications of AVs and CVs could affect technology adoption and market penetration and should be addressed on an ongoing basis.

**Day 1 Benefits** – Some immediate application from achieving this objective includes creating a better way to communicate with the public regarding work that PennDOT does on a daily basis.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

#### Recommended Steps:

\*Denotes immediate action can be taken.

0-5 Yrs.	<ul style="list-style-type: none"> <li>• <b>Formalize an Annual CAV Summit*</b>  Number of Attendees/Increase of Number of Attendees</li> <li>• <b>Portable Exhibits at Unconventional Sites*</b>  Number of Stakeholder Reached</li> <li>• <b>Develop an External Communication Plan *</b>  Plan Developed / % of Stakeholders Reached</li> <li>• <b>Develop a Branding Initiative for CAV</b>  Brand Developed / % of Stakeholders Reached</li> <li>• <b>Establish an Update System of What Is Going on to MPO, County, Local Governments</b>  System Established / % of Stakeholders Reached</li> </ul>
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**Lead:**

- PennDOT Leadership, PennDOT Executive Office

**Key Stakeholders:**

- PennDOT Districts, PTC, Local Municipalities

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Collaboration, Cultural

**Assumptions:**

- None

## Outreach and Collaboration

### OBJECTIVE 42: INCREASE EXTERNAL AWARENESS OF ONGOING CAV ACTIVITIES WITHIN PENNSYLVANIA

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Outreach is vital for organizations to building awareness about the work an agency performs for the public, and an important way to express an agency’s interest in today’s environment. Many public agencies struggle with the concept of marketing themselves and their missions. However, Pennsylvania should be more actively sharing the work the agency does with other partners outside of Pennsylvania to attract more interest and become a leader in the advancement of CAV.

The opportunity to collaborate with organizations outside of Pennsylvania is enhanced by direct and indirect interaction with potentially interested parties. Interactions using a variety of mechanisms can initiate such opportunities.

**Day 1 Benefits** – Some immediate application from achieving this objective includes creating a better way to communicate with other agencies and private entities regarding the work that PennDOT and PTC do on a daily basis.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Lead:**

- PennDOT Leadership, PennDOT Executive Office

**Key Stakeholders:**

- PennDOT, PTC, USDOT

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Collaboration, Cultural

**Assumptions:**

- None

**Recommended Steps:**

\*Denotes immediate action can be taken.

- 0-5 Yrs.

  - **Assess the State of the CAV Program in PennDOT and PTC\***  
 Assessment Completed
  - **Set Goals and Strategies for an Outreach Campaign\***  
 Goals and Strategies Set and Agreed Upon
  - **Create an Outreach Plan (Outside of PA)**  
 Plan Completed
  - **Actively Use Social Media to Promote CAV Program**  
 Social Media Use / Followers Growth
  - **Actively Participate in CAV-Related Conference**  
 Number of Attendees/ Number of Presentations Given
  - **Establish an External Peer to Peer Exchange Program**  
 Program Developed / Number of States Participating

## Outreach and Collaboration

### OBJECTIVE 43: INITIATE OUTREACH TO PLANNING PARTNERS FOR CAV

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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Outreach is vital for organizations, vital to building awareness about the work an agency performs for the public, and an important way to express an agency’s interest in today’s environment. Outreach to planning partners will be critical for the successful implementation of CAV. Planners will not need to know all the technical details behind CAV, but it will be important for planners to track developments in these technologies. CAV technology will advance quickly, causing the impacts, opportunities, stakeholders, relationships, and roles of planners to change as well. The Florida Legislature recently passed a law that requires the state’s 26 MPOs to address emerging technologies in their long-range plans. This has proven to be an effective way to guide and maintain consistency throughout the state as it related to how the impacts of CAV will be analyzed. The opportunity to collaborate with planning partners is enhanced by direct and indirect interaction with potentially interested parties.

**Lead:**

- PennDOT Leadership, PennDOT Executive Office

**Key Stakeholders:**

- PennDOT, USDOT

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Collaboration, Cultural

**Assumptions:**

- None

States and MPOs are required to develop a Public Involvement Plan (PIP). PIPs define outreach processes that assure full opportunity for public review and comment during the transportation planning process. There are Federal guidelines on developing a PIP, however agencies have significant flexibility to tailor their PIPs. It is likely that, in many cases, the implementation of PIPs will serve the important role of introducing CAV technology to the general public [20]. Through implementation of the PIP, agencies will have the opportunity to motivate public interest in and regional coordination on CAV planning through presentations, discussion, and small-scale demonstrations of CAV technology and applications.

**Day 1 Benefits** – Some immediate application from achieving this objective includes creating a better way to communicate with planning partners.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

- |          |   |
|----------|---|
| 0-5 Yrs. | <ul style="list-style-type: none"> <li>• <b>Workshop (s) with All MPOs and RPOs to Discuss CAV Impacts*</b><br/>  Workshop (s) Completed / Number of Attendees</li> <li>• <b>Work with MPOs/RPOs to Integrate CAV into PIPs</b><br/>  Integration Completed / % of PIPs with CAV Information</li> <li>• <b>Increase Awareness of Existing CAV Programs for Planners</b><br/>  Number of Stakeholders Reached</li> </ul> |
|----------|---|

## Outreach and Collaboration

### OBJECTIVE 44: CREATE STRATEGIC PARTNERSHIPS FOR CAV DEVELOPMENT (PUBLIC SECTOR)

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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PennDOT discharges some major responsibilities surrounding surface transportation throughout the state. PennDOT also relies on services provided by a multitude of public and private organizations. The evolving nature of CAV necessitates partnering with those organizations to determine advantageous approaches to CAV developments. PennDOT is currently part of the Smart Belt Coalition (SBC), which was formed in 2016 and is a strategic transportation partnership comprised of twelve organizations, including five transportation agencies and seven research and academic institutions, located throughout Michigan, Ohio, and Pennsylvania. The Coalition has organized for the economic benefit, safety, and welfare of the partner states. The SBC is purposed to foster collaboration involving research, testing, policy, standards development, deployments, outreach, and funding pursuits in the area of connected and automated vehicles technology as well as other innovations in the transportation industry. The SBC is a perfect example of how PennDOT should collaborate with other public agencies to better prepare for the safe integration of CAV technologies. Partnerships with local municipalities and local signal maintaining agencies if also critical for the integration of this technology.

**Lead:**

- PennDOT Leadership, PennDOT Executive Office

**Key Stakeholders:**

- PennDOT, PTC, Local Municipalities, Local Transit Agencies, USDOT

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Collaboration, Cultural

**Assumptions:**

- None

**Day 1 Benefits** – Some immediate application from achieving this objective includes creating partnerships for other strategies that need public sector input.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

- |                 |   |
|-----------------|---|
| <b>0-5 Yrs.</b> | <ul style="list-style-type: none"> <li>• <b>Create an Memorandum of Understanding (MOU) Template to Formalize CAV Partnerships*</b><br/>  MOU Template Completed / Number of MOUs Signed</li> <li>• <b>Create Local Transit Agencies Partnership for AV Testing</b><br/>  Benefit Cost Ratio / AV Testing Implemented</li> <li>• <b>Create Partnerships with Local Signal Maintaining Agencies</b><br/>  Pilot Testing with Local Municipality</li> </ul> |
|-----------------|---|

## Outreach and Collaboration

### OBJECTIVE 45: CREATE STRATEGIC PARTNERSHIPS FOR CAV DEVELOPMENT (PRIVATE SECTOR)

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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The private sector is a major player in the CAV environment. Working with the private sector to advance and guide technology development will be critical to make sure the public benefits from this technology. A mechanism to do this can be Public-Private-Partnerships (P3s). Establishing new contractual mechanisms with private-sector providers, including shared data arrangements, to incentivize the development of a viable marketplace for AV and CV technologies.

Another example of collaboration with the private sector in which PennDOT has been participating included the Autonomous Vehicle Policy Task Force, which is broadly comprised of industry leaders, academic experts, sister agencies and constituent representative groups to work as an advisory board to identify best practices for highly automated vehicles testing policies. This group has been meeting regularly since the Spring of 2016 to develop recommendations for PennDOT’s Secretary regarding policies to oversee on-road AV testing. The task force's goal is to create a framework for testing AVs in Pennsylvania that balances public safety with innovation and provides flexibility required to keep the state in the forefront of the development of this emerging and potentially transformative technology.

**Lead:**

- PennDOT Leadership, PennDOT Executive Office

**Key Stakeholders:**

- PennDOT, PTC, USDOT

**Level of Investment:**

- Level 2

**CMM Dimension Impact:**

- Collaboration, Cultural

**Assumptions:**

- None

**Day 1 Benefits** – Some immediate application from achieving this objective includes creating partnerships for other strategies that need public sector input.

**Impacts** – No immediate impact to existing or planned activities is anticipated with the fulfillment of this objective.

**Recommended Steps:**

\*Denotes immediate action can be taken.

- |                 |   |
|-----------------|---|
| <b>0-5 Yrs.</b> | <ul style="list-style-type: none"> <li>• <b>Hold a Vendor Fair for CAV Vendors*</b><br/>  Vendor Attendance</li> <li>• <b>Enable Public Private Partnerships</b><br/>  Number of Public Private Partnerships</li> </ul> |
|-----------------|---|

## PROPOSED PILOT PROJECTS

Using the information gathered during the internal and external data gathering, the review and documentation of the early successes and best practices, and the capability maturity model exercise, several pilots were proposed. As part of each pilot recommendation, the following were identified:

- Existing needs or issues that will be addressed by the pilot.
- Specific applications that will be tested/deployed.
- Stakeholders that will be involved in the pilot (e.g., local municipalities or MPOs).
- Existing infrastructure that will be affected by the pilot (e.g., traffic signal controller), if applicable.
- Potential industry partners.

Below is a list of the proposed pilots. Detailed information can be found in Appendix F.

### Low Speed Automated Shuttle Pilots

- Implement Automate Paratransit Shuttles
- Implement Driverless Shuttles in Pennsylvania State Parks
- Deploy CAV technologies as First/Last Mile Connections in Communities with High Transit Ridership
- Deploy Driverless Shuttles at Airport Facilities between Gates

### Freight Application Pilots

- Install Advanced Curve Speed Warning Systems
- Prioritize Freight Using CAV Technologies

### Outreach Pilots

- Develop a CAV Awareness Campaign
- Develop a Community CAV Challenge
- Designate Smart Corridors

### Work Zone and Fleet Vehicles Pilots

- Deploy Automated Truck Mounted Attenuators in Work Zones
- Implement a Maintenance Plan using CAV Technologies
- Implement Response Management CV Technology at Work Zones



## REFERENCES

- [1] E. P. Dennis, A. Spulber, V. S. Brugeman, R. Kuntzsch and R. Neuner, "Planning for Connected and Automated Vehicles," March 2017. [Online]. Available: <http://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf>. [Accessed 18 October 2017].
- [2] National Highway Traffic Safety Administration, "Automated Vehicles for Safety," 2017. [Online]. Available: <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>. [Accessed 1 March 2018].
- [3] R. G. McGrath, "Harvard Business Review," 25 November 2013. [Online]. Available: <https://hbr.org/2013/11/the-pace-of-technology-adoption-is-speeding-up>. [Accessed 1 March 2018].
- [4] J. Zmud, G. Goodin, M. Moran, N. Kalra and E. Thorn, *Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies*, National Academies Press, 2017.
- [5] Pennsylvania Department of Transportation, "Comprehensive Freight Movement Plan," 2016.
- [6] T. Litman, "Autonomous Vehicle Implementation Predictions: Implications for Transport Planning," 2018.
- [7] Government Accountability Office, "Vehicle-to Infrastructure Technologies Expected to Offer Benefits, but Deployment Challenges Exist," 2015.
- [8] U.S. Department of Transportation (US DOT), "Connected Vehicle Basics," [Online]. Available: [https://www.its.dot.gov/cv\\_basics/index.htm](https://www.its.dot.gov/cv_basics/index.htm). [Accessed 22 February 2018].
- [9] McKinsey & Company and Bloomberg, "An Integrated Perspective on the Future of Mobility," New York, 2016.
- [10] C. Hendrickson, A. Biehler and Y. Mashayekh, "Connected and Autonomous Vehicles 2040 Vision," Pennsylvania Department of Transportation, Harrisburg, 2014.
- [11] P. High, "Why Did Uber Pilot Driverless Cars In Pittsburgh? Here's Why," *Forbes*, 24 January 2017. [Online]. Available: <https://www.forbes.com/sites/peterhigh/2017/01/24/why-did-uber-pilot-driverless-cars-in-pittsburgh-here-is-why/2/#67967bd347ad>. [Accessed 4 May 2018].
- [12] C. Kang, "Pittsburgh Welcomed Uber's Driverless Car Experiment. Not Anymore.," *The New York Times*, 21 May 2017. [Online]. Available: <https://www.nytimes.com/2017/05/21/technology/pittsburgh-ubers-driverless-car-experiment.html>. [Accessed 4 May 2018].
- [13] U.S. Department of Transportation (US DOT), "Business Process Frameworks for Transportation Operations," February 2017. [Online]. Available: [https://ops.fhwa.dot.gov/tsmoframeworktool/cmfm\\_overview.htm](https://ops.fhwa.dot.gov/tsmoframeworktool/cmfm_overview.htm). [Accessed 1 September 2017].
- [14] Kimley Horn and Associates, "Guidelines for Applying the Capability Maturity Model Analysis to Connected and Automated Vehicle Deployment," Federal Highway Administration Office of Operations, Washington, DC, 2017.
- [15] Workforce Intelligent Network, "Connected and Automated Vehicles Skills Gap Analysis," February 2017. [Online]. Available: [https://winintelligence.org/wp-content/uploads/2017/03/WIN\\_ATLAS-UMTRI\\_Report-singlepages-rs.pdf](https://winintelligence.org/wp-content/uploads/2017/03/WIN_ATLAS-UMTRI_Report-singlepages-rs.pdf). [Accessed 21 February 2018].

- [16] Balanced Score Card Institute, "Strategic Planning Basics," 2017. [Online]. Available: <http://www.balancedscorecard.org/BSC-Basics/Strategic-Planning-Basics>. [Accessed 26 February 2018].
- [17] American Council for Technology-Industry Advisory Council (ACT-IAC), "Legacy System Modernization: Addressing Challenges on the Path to Success," American Council for Technology, Fairfax, 2016.
- [18] J. Harding, G. Powell, R. Yoon, J. Fikentscher, C. Doyle, D. Sade, M. Lukuc, J. Simons and J. Wang, "Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application," National Highway Traffic Safety Administration, Washington, DC, 2014.
- [19] L. Sandt and J. M. Owens, "Discussion Guide for Automated and Connected Vehicles, Pedestrians, and Bicyclists," Pedestrian and Bicycle Information Center, Chapel Hill, 2017.
- [20] D. Krechmer, K. Blizzard, M. G. Cheung, R. Campbell, V. Alexiadis, J. Hyde, J. Osborne, M. Jensen, S. Row, A. Tudela, E. Flanigan and J. Bitner, "Connected Vehicle Impacts on Transportation Planning—Primer and Final Report," U.S. Department of Transportation, Washington, DC, 2016.
- [21] SAS, "The Connected Vehicle: Big Data, Big Opportunities," 2015. [Online]. Available: [https://www.sas.com/content/dam/SAS/en\\_us/doc/whitepaper1/connected-vehicle-107832.pdf](https://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/connected-vehicle-107832.pdf). [Accessed 21 February 2018].
- [22] Public Sector Consultants, "Center for Automotive Research," March 2017. [Online]. Available: <http://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf>. [Accessed 1 March 2018].
- [23] M. Zhao, "Advanced Driver Assistant System: Threats, Requirements, Security Solutions," Intel Corporation, 2015.
- [24] D. Fitzpatrick, G. Cordahi, L. O'Rourke, C. Ross, A. Kumar and D. Bevely, "Challenges to CV and AV Applications in Truck Freight Operations," 2016.

PENNSYLVANIA DEPARTMENT OF  
TRANSPORTATION  
JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLE  
STRATEGIC PLAN

APPENDIX A  
CONNECTED AND AUTOMATED VEHICLES TERMINOLOGY

JULY 2018

## Connected and Automated Vehicle Terminology

A vehicle may be connected to some degree, or have some level of automation, or both. The hardware, software, and applications in each area are different, with different terminology, though connected and automated systems may complement each other. In addition, a vehicle may or may not also be electric or shared (e.g., part of a fleet, car sharing program, or a microtransit service).

### Connected Vehicle

A **connected vehicle (CV)** enables safe, interoperable networked wireless communications among vehicles, roadside infrastructure, and others. The following are examples of how CVs can interact with other vehicles, infrastructure, etc.

- **Vehicle-to-Infrastructure (V2I)** is considered the next generation of intelligent transportation systems (ITS). V2I technologies capture vehicle-generated traffic data, wirelessly providing information such as advisories from the infrastructure to the vehicle that inform the driver of safety, mobility, or environment-related conditions. State and local agencies are likely to install V2I infrastructure alongside or integrated with existing ITS equipment.
- **Vehicle-to-Vehicle (V2V)** communications for safety is the wireless exchange of data among vehicles traveling in the same vicinity that offers opportunities for significant safety improvements.
- **Vehicle-to-Everything (V2X)** communication is the passing of information from a vehicle to any entity that may affect the vehicle, and vice versa. It is a vehicular communication system that incorporates other more specific types of communication as V2I, V2V, V2P (Vehicle-to-Pedestrian), V2D (Vehicle-to-Device) and V2G (Vehicle-to-Grid).

The figure on the following page shows the seven categories and the array of connected vehicle applications defined by the United States Department of Transportation (USDOT).

V2I SAFETY	AGENCY DATA	MOBILITY	ENVIRONMENT
<ul style="list-style-type: none"> <li>•Red Light Violation Warning</li> <li>•Curve Speed Warning</li> <li>•Stop Sign Gap Assist</li> <li>•Spot Weather Impact Warning</li> <li>•Reduced Speed/Work Zone Warning</li> <li>•Pedestrian in Signalized Crosswalk Warning (Transit)</li> </ul>	<ul style="list-style-type: none"> <li>•Probe-based Pavement Maintenance</li> <li>•Probe-enabled Traffic Monitoring</li> <li>•Vehicle Classification-based Traffic Studies</li> <li>•CV-enabled Turning Movement &amp; Intersection Analysis</li> <li>•CV-enabled Origin-Destination Studies</li> <li>•Work Zone Traveler Information</li> </ul>	<ul style="list-style-type: none"> <li>•Advanced Traveler Information System</li> <li>•Intelligent Traffic Signal System (I-SIG)</li> <li>•Signal Priority (transit, freight)</li> <li>•Mobile Accessible Pedestrian Signal System (PED-SIG)</li> <li>•Emergency Vehicle Preemption (PREEMPT)</li> <li>•Dynamic Speed Harmonization (SPD-HARM)</li> <li>•Queue Warning (Q-WARN)</li> <li>•Cooperative Adaptive Cruise Control (CACC)</li> <li>•Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)</li> <li>•Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)</li> <li>•Emergency Communications and Evacuation (EVAC)</li> <li>•Connection Protection (T-CONNECT)</li> <li>•Dynamic Transit Operations (T-DISP)</li> <li>•Dynamic Ridesharing (D-RIDE)</li> <li>•Freight-Specific Dynamic Travel Planning and Performance</li> <li>•Drayage Optimization</li> </ul>	<ul style="list-style-type: none"> <li>•Eco-Approach and Departure at Signalized Intersections</li> <li>•Eco-Traffic Signal Timing</li> <li>•Eco-Traffic Signal Priority</li> <li>•Connected Eco-Driving Wireless</li> <li>•Inductive/Resonance Charging</li> <li>•Eco-Lanes Management</li> <li>•Eco-Speed Harmonization</li> <li>•Eco-Cooperative Adaptive Cruise Control</li> <li>•Eco-Traveler Information</li> <li>•Eco-Ramp Metering</li> <li>•Low Emissions Zone Management</li> <li>•AFV Charging / Fueling Information</li> <li>•Eco-Smart Parking</li> <li>•Dynamic Eco-Routing (light vehicle, transit, freight)</li> <li>•Eco-ICM Decision Support System</li> </ul>
V2V SAFETY	ROAD WEATHER		SMART ROADSIDE
<ul style="list-style-type: none"> <li>•Emergency Electronic Brake Lights (EEBL)</li> <li>•Forward Collision Warning (FCW)</li> <li>•Intersection Movement Assist (IMA)</li> <li>•Left Turn Assist (LTA)</li> <li>•Blind Spot/Lane Change Warning (BSW/LCW)</li> <li>•Do Not Pass Warning (DNPW)</li> <li>•Vehicle Turning Right in Front of Bus Warning (Transit)</li> </ul>	<ul style="list-style-type: none"> <li>•Motorist Advisories and Warnings (MAW)</li> <li>•Enhanced MDSS</li> <li>•Vehicle Data Translator (VDT)</li> <li>•Weather Response Traffic Information (WxTINFO)</li> </ul>		<ul style="list-style-type: none"> <li>•Wireless Inspection</li> <li>•Smart Truck Parking</li> </ul>

Figure A-1: Selected Connected Vehicle Applications (Source: USDOT)

Developers anticipate road safety improvements by integrating connected with automated vehicles. Developers also anticipate extended transportation capabilities and improved mobility options to everyone—from the disabled, the elderly, to the inexperienced teenage driver. The USDOT ITS Joint Program Office (ITS JPO) is already moving forward with research that advances the concept of connected vehicles to automated vehicles. The technology currently under development will help automated vehicles by being aware of the vehicles and infrastructure around them not addressed by current sensor technology.



## Automated Vehicles

The capabilities of an **automated vehicle (AV)** vary widely and will continue to evolve for many years, with implications for regulations, human factors, operations, and so forth. The USDOT through National Highway Traffic Safety Administration (NHTSA) has adopted the International Society of Automotive Engineer (SAE) standard definitions shown in the following chart. Legislators, transportation agencies, and practitioners are encouraged to follow these definition levels.

SAE LEVEL	NAME	NARRATIVE DEFINITION
<i>Driver performs part or all of the dynamic driving task</i>		
<b>0</b>	No Automation	The performance by the driver of the entire <i>dynamic driving task</i> , even when enhanced by active safety systems.
<b>1</b>	Driver Assistance	The sustained and <i>operational design domain</i> -specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the <i>dynamic driving task</i> (but not both simultaneously) with the expectation that the driver performs the remainder of the <i>dynamic driving task</i> .
<b>2</b>	Partial Driving Automation	The sustained and <i>operational design domain</i> -specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the dynamic driving task with the expectation that the driver completes the object and event detection and response subtask and supervises the driving automation system.
<i>Automated Driving System ("System") performs the entire dynamic driving task (while engaged)</i>		
<b>3</b>	Conditional Driving Automation	The sustained and <i>operational design domain</i> -specific performance by an <i>Automated Driving System</i> of the entire <i>dynamic driving task</i> with the expectation that the <i>dynamic driving task</i> fallback-ready user is receptive to ADS-issued requests to intervene, as well as to <i>dynamic driving task</i> performance-relevant system failures in other vehicle systems, and will respond appropriately.
<b>4</b>	High Driving Automation	The sustained and <i>operational design domain</i> -specific performance by an <i>Automated Driving System</i> of the entire <i>dynamic driving task</i> and <i>dynamic driving task</i> fallback without any expectation that a user will respond to a request to intervene.
<b>5</b>	Full Driving Automation	The sustained and unconditional (i.e., not <i>operational design domain</i> -specific) performance by an ADS of the entire <i>dynamic driving task</i> and <i>dynamic driving task</i> fallback without any expectation that a user will respond to a request to intervene.

Figure A-1: Levels of Driving Automation (Source: SAE International)

Vehicle automation is enabled by sensors – e.g., radar, lidar, ultrasonic, photonic mixer device (PMD), cameras, night vision devices – and by evolving sensor fusion hardware and software. An equipped vehicle can perceive and monitor near and far fields in every direction, identifying other vehicles, bicycles, pedestrians, traffic control devices, weather, hazardous conditions, etc. The extent to which vehicle systems can process this incoming data, make real time decisions, and actuate control of the vehicle is a key determination of level of automation.

- From Level 1, vehicles are equipped with one or more **Advanced Driver Assistance System (ADAS)**, e.g., brake assist, adaptive cruise control, lane departure warning, and many others.
  - The wide range of ADAS already contribute to safety, and their continued improvement are essential for vehicles at higher levels of automation. The National Safety Council supports a consumer-oriented site, MyCarDoesWhat.org, that explains dozens of ADAS applications.
- At Level 2, a vehicle has some capability to control steering angle and velocity, but a critical aspect of this level is that a licensed driver must actively monitor the driving environment. This level is currently available to consumers in limited vehicle models from at least two automakers.
- At Level 3 and up, the vehicle system is responsible for monitoring the driving environment, but at Level 3 a licensed driver must remain ready to quickly regain situational awareness and vehicle control. The dynamic driving task capability depends on conditions, and the human is responsible for fallback and safety operation.
  - NHTSA refers to a Level 3-5 vehicle as an **Automated Driving System (ADS)**, and American Association of Motor Vehicle Administrators (AAMVA) and others may still use the term **Highly Automated Vehicle (HAV)**.
- A Level 4 vehicle may be referred to as **driverless, self-driving**, and **autonomous** vehicles. These are capable of operating in defined conditions or circumstances, and the system is capable of fallback operation.
- Level 5 adds the capability to perform in any circumstance.



PENNSYLVANIA DEPARTMENT OF  
TRANSPORTATION  
JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLE  
CAV STRATEGIC PLAN

APPENDIX B  
INTERNAL INFORMATION GATHERING AND INVESTIGATIONS

FEBRUARY 2018

## Introduction

Future transportation systems will consist of an increasing number of connected and automated vehicles (CAV). The National Highway Traffic Safety Administration (NHTSA) is considering a ruling that will mandate connected vehicle-to-vehicle (V2V) communications in all new vehicle starting in 2023. Automotive manufacturers such as Nissan, Audi, Toyota, Volvo, and General Motors have announced that they plan to have a fully automated vehicle publicly available by 2020-2025. Mixed vehicular environments will shape the next generation transportation systems.

Vehicles with increasing levels of automation will continue to evolve leading to the introduction of fully automated vehicle operations on public roadways. While private industry is leading the implementation of vehicle automation, state, local, and private organizations responsible for safe operation on their roadways need to develop the technical, institutional, and legal framework to support this automation.

Connected and automated vehicle technologies will create a shift in the transportation decision-making process throughout Pennsylvania.

The Joint Statewide Connected and Automated Vehicle Strategic Plan (hereafter the CAV Strategic Plan) will assist Pennsylvania in preparing for these technological advancements. The CAV Strategic Plan will:

- Look at all of Pennsylvania;
- Build upon existing research;
- Identify the steps the departments should take to prepare for these technologies;
- Define a comprehensive set of focused, reasonable and deployable applications;
- Consider various levels of investment; and
- Provide the Department with critical missing data and information pertaining to the early deployment of connected and automated vehicles.

The CAV Strategic Plan will be used as the foundation for all policy and procedural decisions relating to connected and automated vehicles. Ultimately, the CAV Strategic Plan will be designed to be a “living document” to account for new information and advances.

## Document Purpose

The purpose of this document is to summarize the efforts conducted under Task 1 Internal Information Gathering and Investigations of the Joint Statewide Connected and Automated Vehicle Strategic Plan effort and document findings.

## Internal Data Gathering Activities

The main goal of this task was to gather information within the Commonwealth to create a baseline to build on as the development of the CAV Strategic Plan advances. Internal data gathering activities included review of applicable Pennsylvania documents, coordination, and facilitation of two workshops with senior Pennsylvania Department of Transportation (PennDOT) staff, as well as several interviews with selected PennDOT departments and other agencies.

## Review of Pennsylvania Documents

Part of the task included reviewing existing Pennsylvania documents that will feed into the CAV Strategic Plan. The following Pennsylvania documents were reviewed:

- *Connected and Autonomous Vehicles 2040 Vision (July 2014)*: PennDOT commissioned a one-year project, Connected and Autonomous Vehicles 2040 Vision, with researchers at Carnegie Mellon University (CMU) to assess the implications of connected and automated vehicles on the management and operation of the state’s surface transportation system. This report explored the impacts of connected and automated vehicles on design and investment decisions, communication devices investment, real-time data usage, existing infrastructure, workforce training needs, driver licensing and freight flow as they relate to PennDOT. For each of these areas, a set of recommendations were provided. As connected and automated technologies advance, it was recommended that PennDOT take these actions in a timely manner. A timeline for the recommended actions is part of this report to help PennDOT plan accordingly.
- *Pennsylvania Autonomous Vehicle Testing Policy - Final Report of the Autonomous Vehicle Policy Task Force (November 2016)*: PennDOT supports legislative efforts to set up parameters and policies for Highly Automated Vehicle (HAV) testing programs. HAV are defined in this document as a motor vehicle or a mass transit vehicle with full or high automation that is equipped with an automated driving system. In anticipation to legislative action, and to consider federal HAV guidance, PennDOT convened an Autonomous Vehicle Policy Task Force (“Task Force”) comprised of industry leaders, academic experts, sister agencies and constituent representative groups to work as an advisory board to identify best practices for HAV testing policies. This report, and the policy recommendations it contains, are the product of the Task Force’s six months of work and deliberations
- *Pennsylvania Turnpike Commission Connected and Automated Vehicles (CAV) Program Roadmap (April 2017)*: Turnpike’s CAV program roadmap defines the CAV core focus areas, prioritized CAV applications for implementation, CAV foundation needs and considerations, CAV “Quick Win” projects, funding sources, and the implementation framework along with a set of action plans. The CAV program identifies the core focus areas for CAV applications based on Turnpike’s established Goals and Objectives defined as part of the Turnpike CAV Strategic Plan. The determination of the core focus areas comes from aligning the overall mission of the PTC with the national best practices, guidance documents, and architectures, defined through the Connected Vehicle Reference Implementation Architecture (CVRIA). “Safety” and “mobility” were identified as overall goals of the PTC’s CAV Program.
- *Proposed and Current Connected and Automated Vehicle Legislation*:
  - Senate Bill 1268 – Autonomous and Connected Vehicles: Act amending Title 75 (Vehicles) of the Pennsylvania Consolidated Statutes, providing for automated and connected vehicles.
  - Senate Bill 427 – Highly Automated Vehicles and Platooning Testing: Amends Vehicles of the Pennsylvania Consolidated Statutes, in operation of vehicles, provides for highly automated vehicles and platooning testing. Last date of action was February 24, 2017 and bill is still pending.
  - House Bill 1637 – Autonomous Vehicle Provisions: mends Title 75 of the Pennsylvania Consolidated Statutes, provides for automated vehicles, establishes the Fully Autonomous Vehicle Advisory Committee. Last date of action was June 28, 2017 and bill is still pending.
- *The City of Pittsburgh and the Thomas D. Larson Pennsylvania Transportation Institute Automated Vehicle Proving Grounds (January 2017)*: U.S. Department of Transportation (DOT) has designated

10 proving ground pilot sites to encourage testing and information sharing around automated vehicle technologies. These proving ground designations will foster innovations that can safely transform personal and commercial mobility, expand capacity, and open new doors to disadvantaged people and communities.

- *Smart Belt Coalition (July 2017)*: The Smart Belt Coalition was formed in 2016 and is a strategic partnership comprised of five transportation agencies and seven academic institutions throughout Michigan, Ohio, and Pennsylvania. The Smart Belt Coalition CAV Strategic Plan outlines the initiative that will be taken by the member agencies and universities to advance the CAV technology. According to the plan, these agencies will work together to roll out new technologies and establish a model of interoperability between the agencies.

### Senior Official Workshops

Two workshops with senior PennDOT staff were conducted. The following pages present the agendas and presentation, as well as the meeting notes.

In general, the workshops provided a high-level overview of the PennDOT's and PTC's view on connected and automated vehicles. The workshop stimulated discussion and strived to establish a level of commitment towards connected and automated vehicle technology applications.

**SENIOR OFFICIAL WORKSHOP**

**Pennsylvania Joint Statewide Connected and Automated Vehicles (CAV) Strategic Plan**

**AGENDA**

**September 18, 2017**

**2:30 PM – 4:00 PM**

**PennDOT Central Office on North Street  
Conference Room 8N1**

- |                   |  |
|-------------------|--|
| 2:30 PM – 2:35 PM | Welcome and Introductions: Mark Kopko (Pennsylvania Department of Transportation)  |
| 2:35 PM – 2:40 PM | Workshop Objective: Eric Rensel (Gannett Fleming, Inc.)  |
| 2:40 PM – 2:55 PM | Project Overview: Eric Rensel (Gannett Fleming, Inc.)  |
| 2:55 PM – 3:45 PM | Open Discussion: What is the “Vision” for CAV?<br>Key considerations: <ul style="list-style-type: none"><li>• Opportunities for Institutional Change</li><li>• Business Plan Integration</li><li>• Accountability</li><li>• Funding</li><li>• Partnerships</li></ul> |
| 3:45 PM – 4:00 PM | Next Steps   |

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**SENIOR OFFICIAL WORKSHOP**

**Pennsylvania Joint Statewide Connected and Automated Vehicles (CAV) Strategic Plan**

**AGENDA**

**October 13, 2017**


**9:00 AM – 10:00 AM**

**PennDOT Central Office on North Street  
Conference Room 8N1**

- |                    |  |
|--------------------|--|
| 9:00 AM – 9:05 AM  | Welcome and Introductions: Mark Kopko (Pennsylvania Department of Transportation)  |
| 9:05 AM – 9:10 AM  | Workshop Objective: Eric Rensel (Gannett Fleming, Inc.)  |
| 9:10 AM – 9:15 AM  | Project Overview: Eric Rensel (Gannett Fleming, Inc.)  |
| 9:15 AM – 9:50 AM  | Open Discussion: What is the “Vision” for CAV?<br>Key considerations: <ul style="list-style-type: none"><li>• Opportunities for Institutional Change</li><li>• Business Plan Integration</li><li>• Accountability</li><li>• Funding</li><li>• Partnerships</li></ul> |
| 9:50 AM – 10:00 AM | Possible Interviewee Participants  |

Figure B-1: Presentation Used During Workshops

# Pennsylvania Joint Statewide Connected and Automated Vehicle Strategic Plan





## Project Overview

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### Introduction/Background

- Future transportation systems will consist of an increasing number of connected vehicles and automated vehicles (CAV)
- The Joint Statewide Connected and Automated Vehicle Strategic Plan will assist Pennsylvania in preparing for these technological advancements



 **pennsylvania**  
DEPARTMENT OF TRANSPORTATION



## CAV Strategic Plan Business Areas



## PennDOT CAV Strategic Plan Tasks

- **Task 1: Internal Information Gathering and Investigations**
  - Review existing Pennsylvania documents.
  - Coordinate and facilitate workshop.
  - Conduct interviews.
- **Task 2: External Information Gathering**
  - Review existing national guidance and research documents.
  - Meet with AV Policy Task Force.
- **Task 3: Early Successes and Best Practices**
  - Review and compile CAV pilot deployment early best practices.
  - Review other agencies policies.



## PennDOT CAV Strategic Plan Tasks

- Task 4: Capability Maturity Model (CMM) Evaluation
  - Develop a CMM for CAV
- Task 5: Detailed Pennsylvania CAV Strategic Plan Outline Development
  - Develop CAV Strategic Plan Outline
- Task 6: Proposed Connected and Automated Vehicle Pilots
  - Identify and document CAV pilots
- Task 7: Document Development, Review and Final Documents
  - Develop final CAV Strategic Plan

## Interviews

### Business Areas:

1. Maintenance and Operations
2. Design and Construction
3. Planning and Research
4. Information Technology and Security
5. Driver Licensing and Motor Vehicles
6. Modal Considerations
7. Workforce Requirements
8. Policy and Legal
9. Outreach and Collaboration



## What is the “vision” for CAV?

- Key considerations:
  - Opportunities for Institutional Change
  - Business Plan Integration
  - Accountability
  - Funding
  - Partnerships



**OPEN DISCUSSION**

**SENIOR OFFICIAL WORKSHOP**  
**Pennsylvania Joint Statewide Connected and Automated Vehicles (CAV) Strategic Plan**

**MEETING MINUTES**  
**September 18, 2017**  
**2:30 PM – 4:00 PM**

The Senior Official Workshop for the Pennsylvania Joint Statewide Connected and Automated Vehicles CAV Strategic Plan was held September 18, 2017 from 2:30 PM to 4:00 PM at the Pennsylvania Department of Transportation (PennDOT) Central Office on North Street, Conference Room 8N1 and via teleconference. The following individuals attended:

<i><b>Name</b></i>	<i><b>Title</b></i>	<i><b>Organization</b></i>	<i><b>Initials</b></i>
Leslie S. Richards	Secretary of Transportation	Pennsylvania Department of Transportation	LR
Leo D. Bagley	Executive Deputy Secretary	Pennsylvania Department of Transportation	LB
Kurt J. Myers	Deputy Secretary for Driver & Vehicle Services	Pennsylvania Department of Transportation	KM
George W. McAuley Jr., P.E.	Deputy Secretary for Highway Administration	Pennsylvania Department of Transportation	GM
James D. Ritzman, P.E.	Deputy Secretary for Planning	Pennsylvania Department of Transportation	JR
Roger Cohen (via phone)	Policy Director	Pennsylvania Department of Transportation	RC
Mark Kopko	Manager, Traveler Information and Advanced Vehicle Technology	Pennsylvania Department of Transportation	MK

<i><b>Name</b></i>	<i><b>Title</b></i>	<i><b>Organization</b></i>	<i><b>Initials</b></i>
Mark P. Compton	Chief Executive Officer	Pennsylvania Turnpike Commission	MC
Craig R. Shuey	Chief Operating Officer	Pennsylvania Turnpike Commission	CS
Robert Taylor	Chief Technology Officer	Pennsylvania Turnpike Commission	BT
Stacia A. Ritter	Director of Policy and External Affairs	Pennsylvania Turnpike Commission	SR
Eric Rensel	Vice President	Gannett Fleming, Inc.	ER
Keith Johnson	Senior Project Manager	Gannett Fleming, Inc.	KJ
Alexandra Lopez	ITS Engineer	Gannett Fleming, Inc.	AL

The following was discussed.

Welcome and Introductions:

- MK welcomed everyone and indicated the purpose of this workshop was to gather input from leadership for the development of the Pennsylvania Joint Statewide CAV Strategic Plan (hereafter CAV Strategic Plan).
- MK stated the CAV Strategic Plan will be an all-encompassing document and will consider the various impacts CAV technologies will have on the transportation system. It will be larger than PennDOT by having participation from the Pennsylvania Turnpike Commission (PTC) and other local partners. The plan seeks to identify tipping points, actionable steps, etc. The CAV Strategic Plan will be a living document that can evolve as technology changes.
- MK introduced the consultant team in charge of the developments of the CAV Strategic Plan and transitioned over to ER to begin the open discussion section of the agenda.

Workshop Objective:

- ER began by introducing the consultant team and allowing all attendees to introduce themselves.
- ER further discussed the objective of the workshop and the format to be followed. The idea was to have an open discussion throughout the meeting to gather input from leadership regarding the CAV Strategic Plan.

#### Project Overview:

- ER continued by providing a brief introduction to the topic to be discussed as well as some background information.
- ER also provided a brief description of the scope of work. ER indicated the scope can be categorized into two parts. The first three tasks can be categorized as data gathering tasks, where internal and external data gathering is performed, including nationally and internationally. The last four tasks include the development of the CAV Strategic Plan based on the findings gathered through the first three tasks. Application of the Capability Maturity Model (CMM), list of viable pilots, among others, are some of the major activities part of these tasks.
- ER then discussed the next steps for the development of the CAV Strategic Plan, which included individualized interviews to better capture input from the various business areas to be addressed by the CAV Strategic Plan.

#### Open Discussion: What is the “vision” for CAV?

- Key items the group were to consider were:
  - Business Plan Integration
  - Opportunities for Institutional Change
  - Partnerships
  - Accountability
  - Funding
- ER opened the discussion session by asking the group what was their “vision” for CAV in Pennsylvania.
  - LR began by indicating Pennsylvania was already a national leader, and that her participation in several national CAV forums is proof of that. PennDOT keeps being asked to be on forums with Michigan, Colorado, California, and Utah – which are seen as the current leaders in the area. However, there is still a lot more opportunities available that Pennsylvania needs to take advantage of. LR indicated Pennsylvania needs to also market the initiatives and accomplishments better to get more support from elected officials, as well as the public. Concentrating on the safety benefits CAV technologies can bring to the public is pivotal to the success of the program. Also, economic development impacts are another aspect that should be better promoted. The CAV Strategic Plan should address these two aspects clearly.
  - LR also noted that we need to identify initiatives that makes us different from the other states. We need something very interesting to the public and automated. Real world testing may be an example. We may not know what it is, but we need it. It also should be marketed to the public. We could concentrate on safety and we should emphasize on the economic development of the companies coming here or possible economic development advantages.
  - CS mentioned that we have not been emphasizing the operations side either.

- MC agreed with LR and added that we need to be careful not to fall into a situation like the Betamax – where a new technology did not take off as expected. Therefore, we need to be careful regarding which technologies to test and pilot. It is also important to be able to showcase and demonstrate the benefit CAV technologies will bring. MC indicated this is something that will need to be implemented from within.
- ER continued the discussion by asking the group what their thoughts were regarding the desired perception of Pennsylvania, both by Pennsylvanians and outside the state, as it relates to CAV.
  - CS began by pointing out that the audience would be different. Therefore, the desired message may differ. For internal audience, the message should be safety, impacts on lifestyle and mobility – i.e., providing transportation alternatives to those who are currently unable to drive and depend others for mobility. For the external audience, the message should be one of promotion of the opportunities present in Pennsylvania. “We are open” and “if it works here, it works anywhere” should be the kind of message we should be conveying externally.
  - SR indicated one of the biggest obstacles of this technology is in the perceived fear. We need to be better at marketing not only the driverless aspect of the technology, but also the other applications and the benefits these would bring.
  - JR indicated we need to be clear as to who wins when implementing these types of technologies. The benefits need to be clearly communicated.
  - JR also stated we need to use the technology for the immobile persons in the Commonwealth.
  - LR agreed with all previous comments and added that for the public it may be easier to embrace automated technologies at lower speeds. LR mentioned the 25 mph Local Motors automated vehicles and presented an example at the Elk Country Visitor Center that could potentially be solved by implementing CAV technologies.
  - ER indicated he understood the group would like projects in Pennsylvania to mean something and address meaningful issues. Group agreed.
  - RC indicated some concern also entails who will be in control. Therefore, it is important to get people to recognize the safety benefits. RC also mentioned it was important to move forward and not be paralyzed by the Betamax fear and that PennDOT needs to position itself to run this program for the long term. Thus, as formal structure within the Department may be needed for this to be successful. It is also important to make this all-encompassing and pass legislation as soon as possible to make Pennsylvania more competitive.
- ER continued the discussion by asking the group what were their thoughts about partnerships and what would the next generation need to continue advancing this program.



- GM indicated that ideally, the public would drive this program to success. In other words, if the benefits are clearly stated and communicated, the public will eventually want and demand CAV technologies to be implemented.
  - CS indicated we needed to choose wisely what we invest in to be able to demonstrate the value of this technology.
  - LB emphasized the need to market the benefits to those that currently have limited mobility options.
  - SR indicated we must also keep in mind that this technology will not solve all transportation issues.
  - BT pointed out CAV technologies may present opportunities in rural areas, where public transportation is scarce.
- As a follow up, ER asked the group how they saw the program being run. What kind of resources will be needed as it concerns workforce and funding? Will recruitment requirements have to change since new set of skills may be needed to run this kind of program?
  - MC indicated workforce will probably have to change and provided an example going back to the time computers and email were just being adopted into the work environment. Very few people had the skill to use computers and email, but eventually everyone learned the skill. This may be the same case with CAV technologies. All job description will have to change as this technology becomes more mainstream. There will be need for training programs for existing staff as well as new training that will need to be provided by universities, colleges, technical schools, etc.
  - GM recognized there will be a transition period to get to the ideal workforce needed to run a CAV program.
  - MC indicated it will be important to help transition employees that may not have the skills needed for the future and help them gain new skills that will allow them to be relocated to stay employed in the industry.
- ER then asked what the thoughts of the group were as it pertained to data processing, availability and ownership.
  - BT pointed out that a large amount of data will be produced by these new technologies and it is difficult to know exactly what Pennsylvania would want to do with all this data. There are privacy issues that need to be considered and new business model may come out of these new applications.
  - RC agreed and indicated there will be need for this to evolve as the technology changes and matures. We will need to revisit.
- ER asked about what funding is expected to be dedicated to the CAV program.
  - JR indicated funding would largely depend on the regions the investments are to be made and the goals that were to be achieved.
  - MC also pointed out the funding will need to be made available for both capital and operating expenses.

- KM also indicated investment level may depend on whether other agencies also invest.
- RC commented CAV technologies will not reduce roadway maintenance expenses, on the contrary, it may increase it.
- MC asked the group if it has been expressed that capacity needs will be reduced due to CAV technologies. Group mentioned this has not been expressed confidently, on the contrary, some experts think capacity may need to increase.
- ER asked the group what were their thoughts as to the direction partnerships need go.
  - CS indicated the SmartBelt coalition was a good example of partnerships.
  - LR pointed out that changes in leadership may affect partnerships and this should be considered. Flexibility will be needed for success of program partnerships.
  - LB mentioned the local trucking industry is ready to try Truck Platooning as soon as legislation allows it.
  - MC mentioned states will probably be competing among each other.
- In closing, ER asked the group what they would need the CAV Strategic Plan to be like for a successful implementation.
  - RC indicated plan would need to address how CAV will be elevated through organizational structure. Looking at the organization of the ITS JPO in FHWA may be a good starting point. Partnerships will need to continue to be pursued, especially with the federal government and local agencies. There is also a need to connect the infrastructure and this will need to be done responsibly.
  - SR indicated it was important to emphasize the safety and economic development benefits throughout. Workforce development needs to be addressed as well, which can be accomplished through partnerships with universities.
  - CS mentioned it will be important to identify short-, mid-, and long-term recommendations.
  - BT mentioned it was important to deliver value, such as the AV Summit held earlier this month. Communication with the media and deployment of meaningful pilots will also be important. Identification of quick wins will also be valuable.
  - MC indicated mobility and safety benefits will need to be delivered using this technology.
  - SR mentioned the importance of conveying the safety benefits.
  - LB indicated the need to identify 6- and 12-month recommendations in CAV Strategic Plan.
  - LR agreed with all that the group has stated and added that Pennsylvania will need to start delivering a unique message regarding CAV technologies.
  - GM indicated we needed to start addressing what we can control.
- ER concluded session by asking if there were any questions.
  - LR asked about the next steps.
  - ER indicated the next immediate step will be to conduct the individualized interviews, with that the internal and external data gathering will be completed. After that, the production of the plan itself will begin.

- MK indicated the plan will be structured to be a living document, where assumptions made will be clearly stated to allow for easy update. Present and future opportunities will also be identified as part of the plan. Plan will also be considering any previous work already done on the CAV topic.
- ER indicated that the consultant team will be following up with those unable to attend meeting.
- BT mentioned there is a CAV working group that meets regularly and the consultant team can use this meeting as a forum to get feedback from PTC regarding this topic. ER to reach out to BT to schedule meeting.
- LR also pointed out we needed to consider the multimodal aspect of these applications as well. Need to also meet with legislative affairs and seat in an AV Policy Task Force meeting.

**SENIOR OFFICIAL WORKSHOP**

**Pennsylvania Joint Statewide Connected and Automated Vehicles (CAV) Strategic Plan**

**MEETING MINUTES**

**October 13, 2017**

**9:00 AM – 10:00 AM**

A second Senior Official Workshop for the Pennsylvania Joint Statewide Connected and Automated Vehicle CAV Strategic Plan was held October 13, 2017 from 9:00 AM to 10:00 AM at the Pennsylvania Department of Transportation (PennDOT) Central Office on North Street, Conference Room 8N1 and via teleconference. The following individuals attended:

<i><b>Name</b></i>	<i><b>Title</b></i>	<i><b>Organization</b></i>	<i><b>Initials</b></i>
Glenn Rowe	Chief Traffic Engineering	Pennsylvania Department of Transportation	GR
Jason Sharp	Executive Deputy Chief Council	Pennsylvania Department of Transportation	JS
Kathryn Zerfuss	Legislative Affairs Director	Pennsylvania Department of Transportation	KZ
Mark Kopko	Manager, Traveler Information and Advanced Vehicle Technology	Pennsylvania Department of Transportation	MK
Roger Cohen	Policy Director	Pennsylvania Department of Transportation	RC
Suzanne Itzko	Deputy Secretary for Administration	Pennsylvania Department of Transportation	SI
Eric Rensel	Vice President	Gannett Fleming, Inc.	ER
Keith Johnson	Senior Project Manager	Gannett Fleming, Inc.	KJ
Alexandra Lopez	ITS Engineer	Gannett Fleming, Inc.	AL

The following was discussed.

Welcome and Introductions:

- MK welcomed everyone and indicated the purpose of this workshop was to gather input from leadership for the development of the Pennsylvania Joint Statewide CAV Strategic Plan (hereafter CAV Strategic Plan).
- MK provided a summary of the previous workshop held September 18, 2017 to attendees. MK mentioned that during the previous workshop, the Secretary indicated she sees PennDOT as a national leader in this and foresees the Commonwealth staying there for a while.
- MK stated the CAV Strategic Plan will be an all-encompassing document and will consider the various impacts CAV technologies will have on the transportation system. All senior staff will be interviewed and made participant of the development of the CAV Strategic Plan.
- MK introduced the consultant team in charge of the development of the CAV Strategic Plan and transitioned over to ER to continue with the agenda.

Workshop Objective:

- ER began by introducing the consultant team and allowing all attendees to introduce themselves.
- ER further discussed the objective of the workshop and the format to be followed. The idea was to have an open discussion throughout the meeting to gather input from leadership regarding the CAV Strategic Plan.

Project Overview:

- ER continued by providing a brief introduction to the topic to be discussed as well as some background information.
- ER also provided a brief description of the scope of work. ER indicated the scope can be categorized into two parts. The first three tasks can be categorized as data gathering tasks, where internal and external data gathering is performed, including nationally and internationally. The last four tasks include the development of the CAV Strategic Plan based on the findings gathered through the first three tasks. Application of the Capability Maturity Model (CMM), list of viable pilots, among others, are some of the major activities part of these tasks.
- ER then discussed the next steps for the development of the CAV Strategic Plan, which included individualized interviews to better capture input from the various business areas to be addressed by the CAV Strategic Plan.
- ER also pointed out the final product from this exercise will be a document that is easy to understand and that outreach material will be needed to better communicate with the public.

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Open Discussion: What is the “vision” for CAV?

- Key items the group were to consider were:
  - Business Plan Integration
  - Opportunities for Institutional Change
  - Partnerships
  - Accountability
  - Funding
- ER opened the discussion session by asking the group how do you interpret the Secretary’s vision – previously mentioned by MK – and how would they support it.
  - Group began by addressing the importance of budget and funding. SI indicated having budget for these kind of initiatives is good for the optics and shows commitment. RC agreed. GR also agreed and indicated it is important to classify this correctly because much of what his business area is doing regarding technology innovations is not spelled out correctly. SI indicated it was important not to make funding an afterthought.
  - KZ pointed out it was important for the legislation to pass before putting dollar figures to it.
- As a follow up, ER asked about the legislation and where it currently stands.
  - RC provided a brief history of the bill. RC indicated that if passed, the bill would hopefully say that driver is not needed, PennDOT will be overseer, and this will allow for platooning of trucks. More is to come, hopefully before the winter.
  - JS pointed out that the Federal Highway Administration (FHWA) is now moving ahead, thus, one can assume things will move forward quickly and this should be considered.
- ER continued the discussion by asking the group to assume the legislation has passed. How would we sustain this program and how do you see it taking shape?
  - SI indicated she sees it as an organizational change. There should be a specific area for it.
  - RC indicated there should be a formal structure to address these technologies.
- ER asked if there is a new division created for this, who should be part of it? Where does it belong to?
  - SI mentioned the group should have expertise of different sides, it could be people from all sections grouping together.
  - Group indicated it should be multidisciplinary in nature.
- ER continued discussion by asking group how they thought this technology would change travel experience across Pennsylvania. What could be the benefits?
  - RC indicated it may be difficult to gauge due to the pace of change.
  - GR indicated the key component is to have workforce dedicated to this. Having this will increase focus on it.
- ER asked about the workforce needs. Will workforce have to change to address needs arising from adoption of this technology?

- SI indicated she was not aware of any job classifications for these type pf work.
  - GR indicated this may become a “wait and see” situation. However, manager-type employees may be the one to start working on this first.
- ER asked if the group felt like they already had the people needed to run a program such as this.
  - JS said it would depend on what the Department wants to create. If what is needed is a group on to of this, then a team with expertise in different field would be needed.
  - KJ asked if an “ad-hoc” group would be sustainable. Group indicated that would not work in the long run.
  - The Office of Public Private Partnerships or P3 Office is a good example of what may be needed to run a program like this one. The P3 Office is in planning, but it touches every aspect of the Department.
  - GR indicated there was already a position within the Department doing this type of work, with support from consultants.
  - Group indicated there may be a need for a champion that would be fully dedicated to program.
  - SI suggested having a structure like P3 Office.
  - RC stated the office would need to have a strong intergovernmental and policy nature. Public affairs also would need to be part of it.
- ER asked how could we keep ourselves and our future replacements accountable?
  - SI pointed out that this group was doing it right now.
- ER asked about what partnerships does the group see as needed to continue moving forward.
  - JS indicated it was very important to build partnerships with the state’s legislature, which will be critical to make changes to vehicle code, changes of statutes, etc.
  - GR indicated a good place to start is the attendee list of the 2017 Pennsylvania Automated Vehicle Summit.
  - The private industry is also key. However, JS indicated this could get tricky since we need the private industry to educate us, but we also need to act as regulators.
  - SI indicated her office needs to be part of this because of the new people becoming involved.
- ER concluded session by asking about suggestions for individuals to interview.
  - SI recommended Christopher Norris, Director of Infrastructure and Economic Development Delivery Center Human Resources and Dave Margolis – Bureau of Fiscal Management
  - JS asked that he be the interviewee.
  - KZ recommended her Deputy Director, Nelson Eric.
- MK indicated that in summary it seemed like the conclusion of this discussion was that an office dedicated to this program would be advantageous to ensure a long-term viability with various liaisons within the Department.
  - JS indicated his office could provide employees to work with the group.



- ER asked if there were any outstanding questions or comments the group would like to discuss.
  - GR indicated funding is currently a big need and that his office would need dedicated funding to continue efforts. If a dedicated office were to be set up, a likely Pay Grade 10 level would be needed, with 2 staff minimum and consultant to assist.
  - GR mentioned it might be good to talk with Mike Bonini, Director of the P3 Office, to see how that office functions.

## Interviews

Part of the task also included a series of interviews. The following agencies were interviewed:

- Pennsylvania Department of Transportation (PennDOT)
- Pennsylvania Turnpike Commission (PTC)
- Pennsylvania Department of Community & Economic Development (DCED)
- Pennsylvania State Police (PSP)
- Insurance Federation
- Delaware Valley Regional Planning Commission (DVRPC)
- Southwestern Pennsylvania Commission (SPC)
- Harrisburg Area Transportation Study (HATS)
- City of Philadelphia

The interviews were used to obtain qualitative feedback on business, institutional, and strategic deployment gaps and served as listening sessions. The primary goals of the interviews were to listen to needs, challenges, document the connected and automated vehicle perspective of different entities within the agencies, and understand what success may look like at the end of this planning exercise. Questions regarding any active or future projects/initiatives that may benefit from connected and automated vehicles were asked. The interviews were broken into nine topic sessions:

- I. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)
- II. Design and Construction
- III. Planning and Research (including GIS)
- IV. Information Technology and Security (including security and networking)
- V. Driver Licensing and Motor Vehicles
- VI. Modal Considerations (including bus and rail)
- VII. Workforce Requirements (including training and human relations)
- VIII. Policy and Legal
- IX. Outreach and Collaboration

Each of the interviews were tailored based on the applicable area/department/agency the interview was being conducted with. Not all topic sessions were discussed with all interviewees.

The following pages presents a summary of the interviews conducted and participants, the bank of questions used during the interviews, and detailed interview notes for each conducted interview.

Table B-1 presents a summary of the interviews conducted as part of this effort.

bank of questions used during the interviews

Table B-1: List of Interviews

Organization / Department	Interview Participants	Date Conducted
Southwestern Pennsylvania Commission (SPC) MPO	Doug Smith, Transportation Planning Director	11/13/2017 (Notes)
	Domenic D’Andrea, Manager of Transportation Operations and Safety	
Delaware Valley Regional Planning Commission (DVRPC) MPO	Elizabeth Schoonmaker, Manager, Office of Capital Programming	11/15/2017 (Notes)
	Christopher King, Manager, Office of Transportation Operations Management	
	Laurie Matkowski, Manager, Office of Transportation Operations Management	
	Brett Fusco, Manager, Office of Long-Range Planning	
City of Philadelphia	Richard Montanez, Deputy Commissioner of Transportation	
Insurance Federation	Samuel Marshall, President	11/29/2017 (Notes)
	Jonathan Greer, Vice President	
Harrisburg Area Transportation Study (HATS) MPO	Steve Deck, Director	11/30/2017 (Notes)
	Diane Krug, Associate Director	
	Tim Reardon, Director	
Department of Community & Economic Development	Steve M. D’Ettorre, Policy Director	12/6/2017 (Notes)
	Rick Vilello, Deputy Secretary of Community Affairs and Development	
	Sheri Collins, Deputy Secretary for Technology & Innovation	
Pennsylvania State Police	Ed Hoke, Major	12/6/2017 (Notes)
	Jim Warner, Lieutenant	
Planning & Contract Management Division	Brian Hare, Planning Division Manager	12/11/2017 (Notes)
Director of Bureau of Fiscal Management	Dave Margolis, Director of Bureau of Fiscal Management	12/15/2017 (Notes)
PennDOT Driver and Vehicle Services	Kurt J Myers, Deputy Secretary	12/20/2017 (Notes)
	Kara Templeton, Director, Bureau of Driver Licensing	
	Alexis Campbell, Community Relations Coordinator	
	Anita M Wasko, Director, Bureau of Motor Vehicles	
Highway Safety and Traffic Operations Division	Douglas Tomlinson, Traffic Operations Section	1/2/2018 (Notes)
	Glenn Rowe, Chief of Highway Safety and Traffic Operations Division	

Organization / Department	Interview Participants	Date Conducted
	Daniel Farley, Traffic Signals and Operational Analysis	
	Mark Kopko, Manager, Advanced Vehicle Technology	
Information Systems and Technology Office	Philip Tomassini, Chief Information Officer	1/3/2018 (Notes)
	Michael DeMatt, Director of Bureau of Infrastructure and Operations	
	Scott Hoffman, Chief of Network Administration Division	
	Mike Patterson, Delivery Center Chief Information Security Officer	
Multimodal Transportation	Anthony McCloskey, Director Bureau of Aviation	1/12/2018 (Notes)
	Anthony Stever, Operating Assistance Manager	
	Danielle Spila, Director Bureau of Public Transportation	
	Stephen Panko, Transportation Planning Manager	
	Elizabeth Bonini, Rail State Safety Oversight Manager	
PennDOT District 11	Daniel Fedio, Civil Engineer Traffic	1/18/2018 (Notes)
	Benjamin DeVore, Tunnel Maintenance Manager	
PennDOT District 2	Dennis Prestash	1/25/2018 (Notes)
	Erik Brown, District Traffic Engineer - Maintenance	
PennDOT District 6	Louis Belmonte, Assistant District Executive - Operations	1/25/2018 (Notes)
	Emmanuel Anastasiadis, Traffic Operations and ITS	
	Ashwin Patel, Senior Manager-Traffic Engineering & Safety Division	
PennDOT District 8	Jason Bewley, District Traffic Engineer	2/9/2018 (Notes)
	Eric Kinard, Signal Unit Supervisor	
	Chris Flad, Traffic Unit – Signals	
	Nate Walker, Planning/Programming	
	Chris McKee, Project Manager	
PennDOT District 5	Michael W Rebert, District Executive	1/23/2018 2/13/2018 2/15/2018 (Notes)
	Dennis Toomey, District Traffic Engineer	
	Dennis McArdle, District Safety Manager	
	John Harmonosky, Assistant Construction Engineer	
	Kevin Milnes, Construction Support Services Engineer	
	Dave Rostron, Design Services Engineer	
	Scott Vottero, Project Development Engineer	
	Jill Krause, ADE-Maintenance	
	Robert Taylor	1/31/2018

Organization / Department	Interview Participants	Date Conducted
Pennsylvania Turnpike Commission CV Working Group Meeting	Kenneth Juengling	(Notes)
	Joseph Suess	
	Michael Metz	
	Kevin Geiger	
	Cory Greene	
	Gregory Yetter	
	Timothy Scanlon	
	Todd Smith	
	Amber Reimnitz	
	Stacia Ritter	
Michael Davidson		

**PENNSYLVANIA DEPARTMENT OF TRANSPORTATION  
JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN**

Table B-2: Bank of Questions for Interviews

BUSINESS AREA	IMPACTS	QUESTIONS
All	General	Are familiar with CAV? / What is your perspective of CAV? / What are some foundational needs? / How do you see this technology fitting within your agency's organizational structure? / What are some of the concerns (and excitement) you have regarding this technology? / If PennDOT could choose one area to invest in time or resources for preparing <b>technically</b> and/or <b>culturally</b> for the arrival of connected vehicles what should that be? / What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges? / What would success be like at the end of this planning exercise? / Do you think PennDOT should be willing to invest financially in preparation for CAV?
Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)	Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices	Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies? / What are some day 1 uses? / Are there any active or future projects/initiatives related to CAV?
Design and Construction	Road infrastructure / Parking	Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies? / What are some day 1 uses?
Planning and Research	Data / Car Ownership / Zoning / Travel Demand	Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies? What are some day 1 uses? / Impacts on planning activities?
Information Technology and Security	Cyber-security / Data / Communication Infrastructure	Has your organization considered how you plan to handle network and data security in DSRC systems?
Driver Licensing and Motor Vehicles	Human-Machine Interactions / Car Ownership	How will CAV impact driver licensing?
Modal Considerations	Bus / Rail / Protection of Non-Motorized Users / Last and First Mile	Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?
Workforce Requirements	Training / Human relations	What sort of training would you need / How can training be most beneficial? / is PennDOT culturally prepare for CAV? /
Policy and Legal	Liability / Protection of Public Benefits / Funding	Are there concerns within your organization regarding liability issues that might be associated with CV? / How would a new technology (i.e., Connected Vehicle) become part of your organization's overall qualified products program?
Outreach and Collaboration	Public-Private-Partnerships / Public / Parking / Communication	Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with Southwestern Pennsylvania Commission (SPC)

**Organization:** Southwestern Pennsylvania Commission (SPC)  
**Date:** November 13, 2017  
**Participant (s):** Doug Smith (DS) – SPC  
 Dom D’Andrea (DD) – SPC  
**Interviewer (s):** Keith Johnson (KJ) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- KJ provided an introduction of the scope of services for the task at hand.
- KJ asked if webinar could be recorded for record keeping purposes and group agreed.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>		
<ul style="list-style-type: none"> <li>• Are familiar with CAV? What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Very familiar with it. In next long-range plan, will be using scenario planning and “forces of change” including technology.</li> <li>• Still determining how to incorporate it into long range plan.</li> <li>• Biggest difficulty is range of uncertainty with it.</li> <li>• Could mean different things rural vs urban.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Traffic Operations/ITS Group may be most affected but cuts across all areas.</li> <li>• AASHTO and AAMVA (Motor Vehicle Assoc.) created a group for CAV and SPC has been participating in conference calls.</li> <li>• There is a lot of discussion but not a lot of actionable items so far.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• DSRC- on a larger scale (currently on Baum / Centre Ave. Corridor, and going to McKnight Road soon) – will be able to get research data on this to see if using wisely (people who want the test bed and what are we getting out of this). What do we get out of it? What are we getting for the public dollar with this? CMU would like to see – availability for work zones to car testing. Automated Enforcement.</li> </ul>



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Southwestern Pennsylvania Commission (SPC)**

Business Area / Impacts	Impacts	Notes
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Safety</li> </ul>	<ul style="list-style-type: none"> <li>Safety benefits from the program.</li> <li>Commuter info.</li> <li>ATWIC.</li> <li>Signal program.</li> <li>Work Zone – Auto work zone vehicles.</li> <li>Asset Management becomes more important (cars must see pavement markings, for example).</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Funding</li> <li>Planning</li> </ul>	<ul style="list-style-type: none"> <li>Funding – CAV paired with mobility as a service lends itself to electric vehicles – leads to gas tax issue for Commonwealth and feds.</li> <li>CAV and mobility as a service – what does that mean for gas tax and funding for how roadways will be maintained.</li> <li>Scenario planning – trying to identify potential impacts to travel demand from a qualitative perspective.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Southwestern Pennsylvania Commission (SPC)**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>Impacts on planning activities?</li> </ul>	<ul style="list-style-type: none"> <li>Planning</li> </ul>	<ul style="list-style-type: none"> <li>SPC is not looking at modeling this kind of technology yet. In next long-range plan, - seeing how we do scenario planning and “forces of change” including technology. Biggest difficulty is range of uncertainty with it. Could mean different things rural vs urban.</li> <li>Long range planning will include consideration of CAV as a force of change.</li> <li>TIP Programing - We would like to know possible pilots as soon as possible – need to plan for placeholders on the TIP Program and be informed of what is going on from a programming standpoint.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Has your organization considered how you plan to handle network and data security in DSRC systems?</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>Major challenge to make secure, but not a task that MPOs are likely to play a role in.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>How will CAV impact driver licensing and/or ownership?</li> </ul>	<ul style="list-style-type: none"> <li>Car Ownership</li> <li>Culture</li> </ul>	<ul style="list-style-type: none"> <li>Ownership – could be very different between rural and urban areas.</li> <li>Price will affect this (cost high – more of fleet possibility).</li> <li>Cultural change – similar to air bag usage – was optional for long time – then became mandatory – is government going to handle when level 5 is here (mandate vs voluntary)?</li> <li>Maintenance of vehicle – how does this work if they quit working.</li> <li>Labor force – how will we fix them when they break down – lends to fleet model.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>		<ul style="list-style-type: none"> <li>Will the government decide when a CAV car is safer than a regular vehicle? Like airbags mandate.</li> <li>Maintenance of vehicles?</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Southwestern Pennsylvania Commission (SPC)**

Business Area / Impacts	Impacts	Notes
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Transit</li> </ul>	<ul style="list-style-type: none"> <li>Connection from downtown to airport has always been a topic of discussion. Cost and impacts to the community likely to preclude light rail. A “CAV mode” may be more feasible. A pilot project may be less expensive and more adaptable.</li> </ul>
	<ul style="list-style-type: none"> <li>Freight</li> </ul>	<ul style="list-style-type: none"> <li>Technologies available right now.</li> <li>Truck Platooning (labor problem in trucking).</li> </ul>
	<ul style="list-style-type: none"> <li>Pedestrian</li> </ul>	<ul style="list-style-type: none"> <li>Interaction with Pedestrians and CAV – are Pedestrians going to take over the street?</li> <li>People will behave differently if CAV is out there.</li> </ul>
	<ul style="list-style-type: none"> <li>Last and First Mile</li> </ul>	<ul style="list-style-type: none"> <li>SPC always looking at that. Interest in what new CEO of Port Authority of Allegheny County (PAAC) will come from with this (she is from area where integrated UBER with system).</li> </ul>
	<ul style="list-style-type: none"> <li>Other</li> </ul>	<ul style="list-style-type: none"> <li>Huge potential for disadvantaged people that have limited mobility.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>Educating staff on the information available.</li> <li>If get to the point of gathering data – being able to handle Big Data modeling and analysis.</li> <li>No need in particular, just staying up to date.</li> <li>Data processing skills, may be needed - a lot of data may become available so new skills will be needed to process this data.</li> <li>DOT does statewide modeling in Ohio (and some regional MPO models) – perhaps PennDOT could recommend modeling methodology of CAV for MPO’s.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Southwestern Pennsylvania Commission (SPC)**

Business Area / Impacts	Impacts	Notes
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Are there concerns within your organization regarding liability issues that might be associated with CV?</li> </ul>	<ul style="list-style-type: none"> <li>Funding</li> </ul>	<ul style="list-style-type: none"> <li>Funding – CAV paired with mobility as a service lends itself to electric vehicle – leads to gas tax issue for Commonwealth and the feds.</li> </ul>
<ul style="list-style-type: none"> <li>How would a new technology (i.e., Connected Vehicle) become part of your organization’s overall qualified products program?</li> </ul>	<ul style="list-style-type: none"> <li>Planning</li> </ul>	<ul style="list-style-type: none"> <li>TIP Programing - We would like to know possible pilots as soon as possible – need to plan for placeholders on the TIP Program and be informed of what is going on from a programming standpoint.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Other</li> </ul>	<ul style="list-style-type: none"> <li>Business model for auto industry.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Collaboration</li> <li>Outreach</li> </ul>	<ul style="list-style-type: none"> <li>Collaboration – a lot of this stuff is going on – (smart city, smart state coalition) we need to have more updates on what is going on.</li> <li>From a strategic perspective: Encourage urban test best, pilot projects, some dedicated guideways.</li> <li>Outreach to be done by OEM.</li> <li>Media coverage.</li> <li>Collaboration if very important.</li> <li>It will be helpful to provide more regular updates to the planning partners regarding CAV initiatives, such as SmartBelt coalition, etc.</li> </ul> <p>Who else to interview?</p> <ul style="list-style-type: none"> <li>- Freight</li> <li>- Local government</li> <li>- Transit</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Southwestern Pennsylvania Commission (SPC)**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"><li>Are there any specific population sectors you feel could benefit or be at a disadvantage with CAV?</li></ul>	<ul style="list-style-type: none"><li>Public</li></ul>	<ul style="list-style-type: none"><li>Disadvantaged.<ul style="list-style-type: none"><li>Elderly population – with the new technology.</li></ul></li></ul>
<ul style="list-style-type: none"><li>Other?</li></ul>	<ul style="list-style-type: none"><li>Outreach</li></ul>	<ul style="list-style-type: none"><li>Get ITS world congress to PA.</li></ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Delaware Valley Regional Planning Commission (DVRPC) and City of Philadelphia**

**Organization:** Delaware Valley Regional Planning Commission (DVRPC) / City of Philadelphia

**Date:** November 15, 2017

**Participant (s):** John Ward (KW) – DVRPC  
 Elizabeth Shoonmaker (ES) – DVRPC  
 Chris King (CK) – DVRPC  
 Brett Fusco (BF) – DVRPC  
 Laurie Matkowski (LM) – DVRPC  
 Richard Montanez (RM) – City of Philadelphia

**Interviewer (s):** Keith Johnson (KJ) – Gannett Fleming, Inc.

**General Notes:**

- KJ provided an introduction of the scope of services for the task at hand.
- KJ asked if webinar could be recorded for record keeping purposes and group agreed.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• RM – smart cities partnership – CV are part of the discussion, but concentrating on existing infrastructure. (ex: lighting, adaptive signals – need a 5G connection but not easy – need to be 100ft apart – difficult).</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Pilot project – many projects in the pipeline.</li> <li>• Recognizing the TSMO strategies from a coordination standpoint.</li> <li>• There is an uncertainty out there, so not sure what we should concentrate on.</li> </ul>
<ul style="list-style-type: none"> <li>• What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• CAV Strategic Plan – no one plan for the entire state – open ended. How can CAV be woven into community planning?</li> <li>• Do not overhype CAV (15 -20 years down the road). On benefit side – maybe don't assume benefit until we know. Ex: At what point would we have dedicated lanes?</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Delaware Valley Regional Planning Commission (DVRPC) and City of Philadelphia**

Business Area / Impacts	Impacts	Notes
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Local Municipalities</li> </ul>	<ul style="list-style-type: none"> <li>Municipalities – maintaining what they need to do, pavement markings, signal, - need to get municipal infrastructure to a “good repair” standpoint before CAV.</li> <li>What about local municipalities – will they support it?</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>RM: Example: City of Philadelphia has tried to put out wireless infrastructure, very difficult.</li> <li>The current policy system is not set up to rollout these types of things out. It’s a whole new cost that current cap costs may restrict.</li> <li>Ex: wireless costs.</li> <li>RM – right of way for V2I, fitting into “a 400-year-old city designed for horses” is difficult.</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Impacts on planning activities?</li> </ul>	<ul style="list-style-type: none"> <li>Car Ownership</li> </ul>	<ul style="list-style-type: none"> <li>Long Range Plan – Brett leading effort. Highly Autonomous Vehicles (HAVs) incorporated throughout the document. However, there is uncertainty in the planning process on what the implications are. Have done some scenario planning. No one has a good handle on implications in the future.</li> <li>Externalities in the system not be being factored in as benefits (Ex: lower air pollution).</li> <li>Scenario planning – need to have different ways to lay this out. No one knows how to model this.</li> </ul>



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Delaware Valley Regional Planning Commission (DVRPC) and City of Philadelphia**

Business Area / Impacts	Impacts	Notes
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Communication</li> <li>Data</li> </ul>	<ul style="list-style-type: none"> <li>Communications between the TMC and other modes while CAV gets to be a larger component.</li> <li>TSMO planning supporting CAV, but infrastructure needs to be made now.</li> <li>Data – data ownership and usage – need training on this from security to using “big Data”</li> <li>Law enforcement – are they data enforcers now?</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Transit</li> <li>Freight</li> <li>Last and First Mile</li> </ul>	<ul style="list-style-type: none"> <li>Automated buses / higher service frequency – we are in a dense region.</li> <li>RM – trying to do a pilot in university city section / Schuylkill Yards area.</li> <li>RM Thinking about with the expansion of Philaport /Southport – setting up platooning possibly (rail vs roads). When large ships start coming in, could cause large amount of truck congestions – perhaps looking at coordination of trucking in this area.</li> <li>Possibility with transit.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>First responder training.</li> <li>Not necessarily DVRPC staff.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Delaware Valley Regional Planning Commission (DVRPC) and City of Philadelphia**

Business Area / Impacts	Impacts	Notes
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Are there concerns within your organization regarding liability issues that might be associated with CV?</li> </ul>	<ul style="list-style-type: none"> <li>Revenue</li> <li>Funding</li> </ul>	<ul style="list-style-type: none"> <li>RM – parking revenues going down when CAV is here??? City collects approx. \$24M/year in parking and funds school district. Need a roundtable discussion.</li> <li>Any revenue we are depending on now (if electric vehicles dominate, effects gas tax revenue. Gas tax is “broken” – this could lead to a further breaking of the gas tax.</li> <li>Think how these things work out before implementation.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Workforce</li> </ul>	<ul style="list-style-type: none"> <li>Displacement of workforce with some of these applications. (trucking, in Philadelphia., refinery workforce if fuel consumption drops, etc.).</li> <li>Displaced workforce – training for them.</li> <li>Funding constraint in general, where do the funds come from. In long range plan, any new ITS, etc., put out a guesstimate on it.</li> <li>PennDOT process of incorporating into business plans.</li> <li>Risk could take our eyes off the ball of how the cities should be (from a pedestrian, walking, more livable standpoint.</li> <li>Lot of things in the existing system need to be addressed Examples: liability in the system, traffic laws, municipal responsibilities.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>Are there any specific population sectors you feel could benefit or be at a disadvantage with CAV?</li> </ul>	<ul style="list-style-type: none"> <li>Public</li> </ul>	<ul style="list-style-type: none"> <li>Disadvantaged (wheelchair, visually impaired), elderly.</li> <li>RM: Acceptance of technology (guy fixing his own car will not accept), flip side – Uber model of using an app.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Delaware Valley Regional Planning Commission (DVRPC) and City of Philadelphia**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"><li>• Other?</li></ul>	<ul style="list-style-type: none"><li>• Communication</li></ul>	<ul style="list-style-type: none"><li>• Need to keep coordinating with PennDOT on what is going in the area.</li><li>• Communicating to agencies that are not at the table (they are going to be responding these things on the street. (responders, zoning code, etc.) from a county and municipal standpoint.</li><li>• CAV touches so many different areas – everyone needs to be part of this conversation. Ex PennTIME.</li></ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **The Insurance Federation of Pennsylvania**

**Organization:** The Insurance Federation of Pennsylvania  
**Date:** November 15, 2017  
**Participant (s):** Samuel Marshall (SM) – The Insurance Federation of Pennsylvania  
 Jonathan Greer (JG) – The Insurance Federation of Pennsylvania  
 Mark Kopko (MK) – Pennsylvania Department of Transportation  
**Interviewer (s):** Eric Rensel (ER) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- ER provided an introduction of the scope of services for the task at hand.
- SM and JG provided an overview of the Insurance Federation of Pennsylvania and its purpose, which included to represent insurance companies, worker compensation, etc.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Yes. Very positive reaction towards technology. Federation is looking forward to what this technology may bring in terms of safety.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Concern as an industry is that the testing in PA needs to be as safe as possible. Not based on an honor system. Does not want test cars on the streets. PennDOT says this is an economic development opportunity for PA, but in his opinion PennDOT's role should be safety.</li> <li>• PA may want to open up to big tech companies to open headquarters, but security is most critical.</li> <li>• Technology has slowly been adopted into cars, and members are already dealing with such things.</li> </ul>
<ul style="list-style-type: none"> <li>• What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Success would be a regulatory structure that would provide oversight of the CAV industry as it develops and test technology.</li> <li>• Safety standards.</li> <li>• Monitoring progress.</li> <li>• Make sure that those testing have adequate insurance.</li> </ul>
<ul style="list-style-type: none"> <li>• What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Data sharing is one of the issues we have currently.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **The Insurance Federation of Pennsylvania**

Business Area / Impacts	Impacts	Notes
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>• Has your organization considered how you plan to handle network and data security in DSRC systems?</li> </ul>	<ul style="list-style-type: none"> <li>• Data</li> </ul>	<ul style="list-style-type: none"> <li>• Insurance utilizes data a lot. But it is still unknown what CAV will look like in the future.</li> <li>• Example, the most difficult thing to train a computer to do is a left turn. Moral judgements too are far away from now.</li> <li>• How people drive, when they drive, where they drive.</li> <li>• Currently we use data to determine safety parameter. The data produced by CAV will be possibly used the same.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Liability</li> </ul>	<ul style="list-style-type: none"> <li>• Insurance, liability will be one of the biggest issues.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **The Insurance Federation of Pennsylvania**

Business Area / Impacts	Impacts	Notes
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• PennDOT's role should be as an overseer.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• Are there concerns within your organization regarding liability issues that might be associated with CV?</li> </ul>	<ul style="list-style-type: none"> <li>• Liability</li> </ul>	<ul style="list-style-type: none"> <li>• Liability is of big concern. Also, security breaches should they be reported? And to whom?</li> <li>• Need stronger regulation.</li> <li>• Oversee not partner should be the agencies' role. Primary role should be to protect consumers.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking / Communication</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Public-Private-Partnerships</li> </ul>	<ul style="list-style-type: none"> <li>• PennDOT sees Uber/Google as partners. Insurance people see the Federation as regulators not partners.</li> <li>• Main partnership should be with consumers. #1 partner should Insurance Federation.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Tri-County Regional Planning Commission (TCRPC) / Harrisburg Area Transportation Study (HATS)**

**Organization:** Tri-County Regional Planning Commission (TCRPC) / Harrisburg Area Transportation Study (HATS)

**Date:** November 30, 2017

**Participant (s):** Tim Reardon (TR) – TCRPC  
Diane Krug (DK) – TCRPC  
Steve Deck (SD) – TCRPC  
Casey Baxendale (CB) – TCRPC

**Interviewer (s):** Keith Johnson (KJ) – Gannett Fleming, Inc.  
Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- KJ provided an introduction of the scope of services for the task at hand.
- KJ asked if webinar could be recorded for record keeping purposes and group agreed.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Limited understanding of CAV. CB is trying to keep up with information.</li> <li>• Working on LRTP and technology will be part of the plan.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Not particularly, unless we increase our staff size.</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Parking</li> </ul>	<ul style="list-style-type: none"> <li>• Looking at oversized / too much parking (urban and suburban) – could parking be reduced much more?</li> <li>• Shared ride would also have an effect.</li> <li>• Repurpose land.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Tri-County Regional Planning Commission (TCRPC) / Harrisburg Area Transportation Study (HATS)**

Business Area / Impacts	Impacts	Notes
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Long Range Planning</li> </ul>	<ul style="list-style-type: none"> <li>Just starting a Long-Range Plan. Idea is to identify technologies that will affect transportation. Will not try to “guess” where we will be in 2040 for example. Will look at next few years only, then update the plan as time passes.</li> <li>Someone will have to make a policy decision about moving from a capital investment to a more operations situation.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Data</li> </ul>	<ul style="list-style-type: none"> <li>Data Collected from CAV – we would incorporate into our Congestion Management and Air Quality - using real time data.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Has your organization considered how you plan to handle network and data security in DSRC systems?</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>Security issue will be one of the most important one.</li> <li>No one will know for sure about liability until you have actual penetration of these vehicles and see some cases develop.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Liability</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance or liability of vehicles.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>How will CAV impact driver licensing and/or ownership?</li> </ul>	<ul style="list-style-type: none"> <li>Licensing</li> </ul>	<ul style="list-style-type: none"> <li>Licensing concept – will have to evolve as technology grows.</li> <li>Testing will need to be able to assess if the driver will be capable of engaging if system fails.</li> </ul>



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Tri-County Regional Planning Commission (TCRPC) / Harrisburg Area Transportation Study (HATS)**

Business Area / Impacts	Impacts	Notes
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Transit</li> </ul>	<ul style="list-style-type: none"> <li>Probably best opportunity – demand responsive- not 40 ft. vehicles.</li> <li>Might (probably) affect overall transit.</li> <li>Capital Area Transit Bridge (on TIP) will be a transit only (and possibly emergency vehicle use) route. Could benefit from technology. Could also use bike/ped. (southern end of island – cross river connection).</li> </ul>
	<ul style="list-style-type: none"> <li>Freight</li> </ul>	<ul style="list-style-type: none"> <li>Recently completed Regional Freight Plan. CAV was discussed, but not in depth.</li> </ul>
	<ul style="list-style-type: none"> <li>Bike</li> </ul>	<ul style="list-style-type: none"> <li>New bikeshare program is going very well so far. Could be enhanced by CAV.</li> </ul>
	<ul style="list-style-type: none"> <li>Last and First Mile</li> </ul>	<ul style="list-style-type: none"> <li>Probably best opportunity – demand responsive- not 40 ft. vehicles.</li> <li>Probably not going to just drive it a few blocks to go somewhere.</li> <li>Tying into the rail stations.</li> </ul>
	<ul style="list-style-type: none"> <li>Auto Ownership</li> </ul>	<ul style="list-style-type: none"> <li>Younger demographics not driving as much – might be reduced somewhat.</li> <li>Function of living in urbanized vs nonurbanized (i.e., suburban, rural).</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>Technical and vocational training in general for this area.</li> </ul>
<ul style="list-style-type: none"> <li>Other</li> </ul>	<ul style="list-style-type: none"> <li>Culture</li> </ul>	<ul style="list-style-type: none"> <li>Culture – there is a resistance to change, particularly in Central PA. (i.e., resistance to self-driving vehicles).</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Tri-County Regional Planning Commission (TCRPC) / Harrisburg Area Transportation Study (HATS)**

Business Area / Impacts	Impacts	Notes
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Are there concerns within your organization regarding liability issues that might be associated with CV?</li> </ul>	<ul style="list-style-type: none"> <li>Parking</li> </ul>	<ul style="list-style-type: none"> <li>If number of vehicles are reduced, parking revenue, etc. may decrease. Thus, municipalities may see reduction of revenue, which may possibly need to be offset by other fees.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>Security issue will a concern (hacking into system).</li> <li>Liability will be a question until we have a wait and see in place.</li> <li>How will insurance rates be affected?</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>Are there any specific population sectors you feel could benefit or be at a disadvantage with CAV?</li> </ul>	<ul style="list-style-type: none"> <li>Public</li> </ul>	<ul style="list-style-type: none"> <li>Elderly and handicap will be benefitted most for such technology.</li> <li>Will vehicles be affordable? If not, could hinder low-income individuals.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Culture</li> <li>Outreach</li> </ul>	<ul style="list-style-type: none"> <li>Open to pilot projects as they come up.</li> <li>Culture – there is a resistance to change – concern with new technology.</li> <li>Outreach – need assistance with regular outreach program (i.e., Environmental Justice communities).</li> <li>We will be educating the public so will be essential.</li> <li>Staff keeping up with the development is good, but trying to figure out where it is going is difficult.</li> <li>Roger Cohen coming into to give us an update.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Department of Community & Economic Development (DCED)**

**Organization:** Department of Community & Economic Development (DCED)

**Date:** December 6, 2017

**Participant (s):** Steve M. D’Ettorre (SD) – DCED  
Rick Vilello (RV) –DCED  
Evelyn Shenelli (ES) – DCED  
Sheri Collins (SC) – DCED

**Interviewer (s):** Eric Rensel (ER) – Gannett Fleming, Inc.  
Laurie Matkowski (LM) – Gannett Fleming, Inc.  
Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- ER provided an introduction of the scope of services for the task at hand.
- ER asked if webinar could be recorded for record keeping purposes and group agreed.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Yes, DCED currently participates in the AV Policy Task Force and has been heavily involved and being part of it since the beginning. DCED is a very active copartner with PennDOT.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• Workforce</li> </ul>	<ul style="list-style-type: none"> <li>• In general, we think we are ready. DCED has programs and staff in place that deal with workforce and technology.</li> <li>• There are a few tweaks that need to be made, but for the most part DCED should be ready to go.</li> </ul>
<ul style="list-style-type: none"> <li>• What are some of the needs and/or gaps you perceive in your area? What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>• Technology</li> <li>• Funding</li> </ul>	<ul style="list-style-type: none"> <li>• There is fear of the unknown. Technology has changed a lot in the last 30 years. Just by looking at radio in cars we can see the difference.</li> <li>• Cost may be one of the biggest hurdles. Pricing of this new technology will determine the adoption of this technology.</li> <li>• Local governments may pose some hurdles. Counties, cities, etc. have different policies. Rural areas are sometime behind when adopting new technologies.</li> <li>• The automated vehicle must be truly automated because funding is limited to provided infrastructure.</li> <li>• Need to figure how can we get supporting technology funded.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Department of Community & Economic Development (DCED)**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>Smart Community</li> <li>Economic</li> </ul>	<ul style="list-style-type: none"> <li>A “smart community” approach may be the way to accomplish this. It must be based on the community type – some communities may include all aspects of this technology, while others some may not want CAV – i.e., walkable communities may not want CAV as part of their community.</li> <li>Making it clear Pennsylvania is a player in the CAV world. Drive this point home. We are business friendly to the AV world. We have the climate to better test vehicles. We are very supporting of this effort.</li> <li>Pennsylvania needs to position itself in the forefront. Continue moving forward with the work already being done and start implementing in small doses. Don’t let other states win.</li> </ul>
<b>2. Maintenance and Operations</b>	<b>Safety / Mobility / Reliability / Data</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Impacts on planning activities?</li> </ul>	<ul style="list-style-type: none"> <li>Economic</li> </ul>	<ul style="list-style-type: none"> <li>There is not a specific economic impact for CAV, more in general terms. Disruptive technologies, may bring jobs – high paying – car manufacturing, more revenue, etc. technical careers may also be needed in the future is all this happens.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Department of Community & Economic Development (DCED)**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• DCED already participates in workforce programs that allow for improved training within companies.</li> <li>• There is a new initiative by the Governor that relates to manufacturing that can be linked up with CAV.</li> <li>• Pennsylvania has a multitude of colleges and university, with strong engineering programs. Technology and Innovation Department was established back in 2003 and has evolved since.</li> <li>• They believe they are ready to go, but technology changes quickly and we need to do that.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking / Communication</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania State Police**

**Organization:** Pennsylvania State Police  
**Date:** December 6, 2017  
**Participant (s):** Major Ed Hoke (ED) – Pennsylvania State Police  
 Lieutenant Jim Warner (JW) – Pennsylvania State Police  
 Captain Troy Park (TP) – Pennsylvania State Police  
**Interviewer (s):** Eric Rensel (ER) – Gannett Fleming, Inc.  
 Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Yes, Pennsylvania State Police participates in AV Policy Task Force.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• We would have to make assumptions regarding when this will be happening.</li> <li>• State Police has a full IT staff, but none are involved in the CAV project.</li> <li>• The Office of Administration has taken over the IT Department.</li> <li>• Some of the IT staff may be assigned to other agencies.</li> <li>• There is constant coordination between State Police and its IT staff. There is a steering committee that helps address IT needs.</li> </ul>
<ul style="list-style-type: none"> <li>• What are some of the needs and/or gaps you perceive in your area?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Everything is relevant depending on how the technology develops.</li> <li>• Crash reduction may be seen significantly.</li> <li>• This is not going to happen overnight.</li> <li>• There will be an evolution process.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania State Police**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Recommended Pennsylvania Chief of Police become part of Task Force.</li> <li>Plenty of benefits from this technology. i.e., move over laws may be easier to enforce. Makes it safer for everyone. Safety benefits for all.</li> <li>Access to information, data sharing is lagging. Courts for example cannot keep up with technology and information sharing.</li> <li>Educating legislators, court system, public, etc. is important.</li> <li>Mission is to reduce crashes and injuries – anything that helps with this is welcome. However, there are a lot of questions and lack of guidelines as to how to proceed.</li> <li>Right now, is a big mystery.</li> <li>Recognize we cross state lines.</li> </ul>
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>The State Police is in constant state of evolution.</li> <li>Things have change a lot and State Police has adopted changes. They are constantly looking at what new technologies are available. i.e., technology on patrolling vehicles.</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania State Police**

Business Area / Impacts	Impacts	Notes
5. Information Technology and Security	Cyber-security / Data / Communication Infrastructure	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>There is also concern of hacking and maliciously operating vehicles. Vehicles may become weaponized as well - tool for terrorist. Load up a car with explosives and send on an attack.</li> </ul>
6. Driver Licensing and Motor Vehicles	Human-Machine Interactions / Car Ownership	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
7. Multi-Modal Considerations	Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
8. Workforce Requirements	Training / Human relations	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
9. Policy and Legal	Liability / Protection of Public Benefits / Funding	
<ul style="list-style-type: none"> <li>Are there concerns within your organization regarding liability issues that might be associated with CV?</li> </ul>	<ul style="list-style-type: none"> <li>Policy</li> </ul>	<ul style="list-style-type: none"> <li>Laws do not deal with automated vehicles. No prohibition neither. This presents a challenge to law enforcement, it is not clear who is responsible for traffic moving violation, crashes, etc. most crashes are attributed to driver error.</li> <li>There is also concern of hacking and maliciously operating vehicles. Vehicles may become weaponized as well - tool for terrorist. Load up a car with explosives and send on an attack.</li> </ul>



PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Pennsylvania State Police**

Business Area / Impacts	Impacts	Notes
<p><b>10. Outreach and Collaboration</b></p>	<p><b>Public-Private-Partnerships / Public / Parking /Communication</b></p>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>

**End Notes**

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Planning Division**

**Organization:** Pennsylvania Department of Transportation Planning Division  
**Date:** December 11, 2017  
**Participant (s):** Brian Hare (BH) – Pennsylvania Department of Transportation Planning Division  
 Shelley Scott (SS) – Pennsylvania Department of Transportation Planning Division  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.
- LM asked if webinar could be recorded for record keeping purposes and group agreed.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• We do not have specific meetings to discuss CAV.</li> <li>• CAV will have impact on planning, but we do not know how it looks like.</li> <li>• Cars now have plenty of technology features, many time rear ends can be prevented from happening with all the new features in the cars now.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Three perspectives – what does the CAV for asset management, for investment, how capacity looks like in the future, safety impacts will be huge.</li> </ul>
<ul style="list-style-type: none"> <li>• What are some of the needs and/or gaps you perceive in your area?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Land use development, how will this be affected? Does parking go away or does it become a bigger issue?</li> <li>• What does it mean for moving goods?</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Planning Division**

Business Area / Impacts	Impacts	Notes
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Impacts on planning activities?</li> </ul>	<ul style="list-style-type: none"> <li>Funding</li> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>We will be answering different questions when CAV is fully adopted.</li> <li>Undeserved communities and the disabled may not be able to buy an AV. So where does transit come in? will it be easier to get access CAV or more difficult.</li> <li>What about pedestrians and bicyclist? What is the future of transit in a CAV world?</li> <li>How to prioritize funding? Will it affect the priorities of funding?</li> <li>What about acceptance of CAV? By different generations? Will this look at the people side of CAV?</li> <li>Who is teaching people what the cars can do? Education of consumers?</li> <li>More you talk about it, the more questions you get.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Planning Division**

Business Area / Impacts	Impacts	Notes
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• How would a new technology (i.e., Connected Vehicle) become part of your organization's overall qualified products program?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• What does it mean for trucking in the future? How would laws change? Best thing we can do now is to identify the questions since we do not have the answers yet.</li> <li>• What about drones? And how would they effect movement of goods.</li> <li>• What does it mean for land development?</li> <li>• Air quality is one of the biggest concerns.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>• Do you have the partnerships today to prepare in the future?</li> </ul>	<ul style="list-style-type: none"> <li>• Communication</li> </ul>	<ul style="list-style-type: none"> <li>• PennDOT is partially prepared for the adoption of this technology. There are relationships and partnerships in place right now to help us prepare for this. Example is the Freight Plan and the collaboration for that effort.</li> <li>• We not have all the right connections, but we are moving in the right direction.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Fiscal Management**

**Organization:** Pennsylvania Department of Transportation Bureau of Fiscal Management  
**Date:** December 15, 2017  
**Participant (s):** David L Margolis (DM) Pennsylvania Department of Transportation Bureau of Fiscal Management  
**Interviewer (s):** Keith Johnson (KJ) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- KJ provided an introduction of the scope of services for the task at hand.
- KJ asked if webinar could be recorded for record keeping purposes and group agreed.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Looking ahead to items that will require funding.</li> <li>• Siloed thinking is not ideal for this.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• BOMO – Traffic Management</li> </ul>	<ul style="list-style-type: none"> <li>• Creating Highway Systems Technology Appropriation to highlight highway operations.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• Traffic Monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• Traffic flow and incident management highly visible to public.</li> </ul>
<ul style="list-style-type: none"> <li>• What are some of the needs and/or gaps you perceive in your area?</li> </ul>	<ul style="list-style-type: none"> <li>• Comprehensive long-range traffic management plan</li> </ul>	<ul style="list-style-type: none"> <li>• Integrating or transitioning current with or to emerging technology.</li> </ul>
<ul style="list-style-type: none"> <li>• What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Ability to use CAV capabilities when available.</li> <li>• Will need some periodic checking once established.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Fiscal Management**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>Budget process can require a couple years lead time for major investments</li> </ul>	<ul style="list-style-type: none"> <li>State budget and TIP process.</li> <li>Are we making investments now that may not work for the future?</li> <li>Leading edge vs. wait to be prove – where should we be.</li> <li>We need to invest wisely. Which technologies we should pursue?</li> <li>Direct benefit to the public is most valuable.</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Funding</li> </ul>	<ul style="list-style-type: none"> <li>In next TIP – tell MPO to set aside funds for TSMO/ITS.</li> <li>Funding cycles will need to be taken into consideration. Need to keep in mind that funding will not be available next year right away. But we could put a placeholder and let the different appropriation committees know.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Fiscal Management**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>• Cross-functional work groups</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination of diverse program areas with direct involvement.</li> </ul>
<ul style="list-style-type: none"> <li>• Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination always a challenge in a large diverse organization with many highly specialized technical areas.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking / Communication</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services**

**Organization:** Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services  
**Date:** December 15, 2017  
**Participant (s):** Kurt Myers (KM) – Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services  
 Anita Wasko (AW) – Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services  
 Alexis Campbell (AC) – Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services  
**Interviewer (s):** Eric Rensel (ER) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- ER provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Yes, group is familiar with CAV.</li> </ul>
<ul style="list-style-type: none"> <li>• What are some of the needs and/or gaps you perceive in your area?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Sandbox analysis – during the transition period, these vehicles will need to play well in the sandbox with other vehicles that are not automated.</li> <li>• 5% of vehicles registered in PA are 1989 or older. What do we do about those?</li> <li>• Need additional guidance from NHTSA.</li> </ul>
<ul style="list-style-type: none"> <li>• What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Need to ensure we stay engaged. Continue role as a leader nationally. Need to broaden the people that are having the conversation of CAV. Only a small group in PennDOT are having these conversations. Need to broaden impact and allow for conversation within the Department. Then bring in outside stakeholders. Get more people involved, more agencies.</li> </ul>



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Safety inspection program is very labor intensive. Would like to be more electronically connected. Need to focus more on technology.</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Data</li> </ul>	<ul style="list-style-type: none"> <li>Daily inspection should become a reality. Future systems will be a lot more proactive. Work with technology company to talk about how this could happen.</li> <li>Big Data capability would be needed.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services**

Business Area / Impacts	Impacts	Notes
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Inspection Program</li> </ul>	<ul style="list-style-type: none"> <li>What does the vision of the secretary mean for Driver Licensing and Motor Vehicles?</li> <li>Inspection – how do we insure all aspects of vehicles work correctly. Will inspection work the same or more self-diagnostics?</li> <li>Training stand-point – working knowledge of how to repair high-tech. especially for level 3 or higher.</li> <li>How do we sanction vehicle that is not operating accurately? Do you assign points to vehicles instead of driver when citing? Will that allow us to remove vehicle until issues are addressed.</li> <li>Need to review safety inspection regulations - which one need to be updated/revised.</li> <li>Now vehicles are inspected for safety features. Will there be repairs be done by PA itself to assure vehicle is safety to operate to give it a “safety sticker.” Validation Sticker. Vs. point program. Where would AV fall under?</li> <li>PA Safety Inspection Regulations – example LED lighting how many diodes would need to be out to consider a light to be unsafe. PA is currently dealing with this issue because regulation does not address this. Things will be more complex as these vehicles enter the market.</li> <li>Pennsylvania has always been a leader in the country in the inspection program arena. Pennsylvania should take a lead in developing a new inspection program for CAV. Only a few states that have inspection program. Mandate came out before the 70s – NHTSA then dropped requirement. States inspection program has reduced. AV will need some type of validation. How will the program work? It cannot be left to the car manufacturers and the owner of the vehicles. 120-170 lives are safe by inspection program – per study. Would like to work with car manufacturer to pioneer this “inspection.”</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Bureau of Driver & Vehicle Services**

Business Area / Impacts	Impacts	Notes
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Need more education for technician.</li> <li>• Multilevel.</li> <li>• Partnerships with technical colleges would be critical</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking / Communication</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Communication</li> <li>• Partnership</li> </ul>	<ul style="list-style-type: none"> <li>• Several automotive-related associations and PennDOT are in constant involvement. Re-certification program for safety inspectors are already in place. Private garages doing inspection must be certified to be able to do inspections.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division**

**Organization:** Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division  
**Date:** January 2, 2018  
**Participant (s):** Glenn Rowe (GR) – Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division  
 Douglas Tomlinson (DT) – Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division  
 Daniel Farley (DF) – Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division  
 Mark Kopko (MK) – Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division  
**Interviewer (s):** Eric Rensel (ER) – Gannett Fleming, Inc.  
 Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.
- Group agreed CAV will need a separate vision and mission statements.
- Group indicated it was important to understand and keep in mind each business area may have unique characteristics that will need to be considered when creating the CAV Strategic Plan.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Yes, group is very familiar with CAV.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Need to identify what PennDOT's role is.</li> <li>• Need to see a vision and mission for this program.</li> <li>• Organizational structure change may not be necessary at this point.</li> <li>• Identifying champions in each business area may be more appropriate for now.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• PA should be open to testing of this new technology. This will allow for products to be developed based on PA conditions, i.e., weather, roadways, etc.</li> <li>• Some of the testing is already being done here. We need to expand.</li> <li>• Other state agencies should also be taking the lead in these efforts.</li> <li>• Dedicated funding will be needed.</li> <li>• Some of the installations for testing in PA have been done ad-hoc. Candidate locations for CAV deployment should be well thought out.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>PennDOT needs to clarify the purpose of this program. What are we doing with CAV and what are the roles and responsibilities. Also, objectives need to be better defined. Why are we doing this? For safety, economic competitiveness, etc.</li> <li>We already know some of the benefits this technology may bring. The question is how do we get those benefits faster.</li> <li>Public acceptance is needed. Once buy-in and acceptance come, we will start to see most of those benefits.</li> <li>One-stop resource is not available for applications.</li> <li>Need to improve consistency throughout.</li> <li>Need to have people understand what CAV is before moving forward with full implementation.</li> <li>Must be able to do everything with a purpose.</li> <li>Need to be able to answer who, what, where, why, and when before a full deployment is considered.</li> <li>IT need to be involved from the beginning.</li> </ul>
<ul style="list-style-type: none"> <li>What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Must be applicable to multiple jurisdictions, not only state agency.</li> <li>An approach can be to take “baby-steps” first – i.e., start with small deployments and obtain lessons learned and apply this to future policies, deployments, etc.</li> <li>Need to do it in controlled areas – for example deploy CAV for snowplows.</li> <li>It would be ideal to get direction from the Governor and higher-ups.</li> <li>A step-approach may be ideal.</li> <li>Need to tie recommendations to a timeframe.</li> <li>A working group with membership from each one of the business areas may be the best approach for now. Should come from a mandate from PennDOT Secretary.</li> <li>Clearly set a course of action.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division**

Business Area / Impacts	Impacts	Notes
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>What are some day 1 uses?</li> </ul>	<ul style="list-style-type: none"> <li>Interoperability</li> </ul>	<ul style="list-style-type: none"> <li>Need to improve what we are already doing, i.e., improve accuracy and timeliness of traveler information disseminated by adding lane closures not only by location and roadway but also by lane.</li> <li>Interoperability is critical to success.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Performance Measures</li> </ul>	<ul style="list-style-type: none"> <li>There needs to be consequences for not meeting expectations. For example, uptime of devices is critical and need to be accounted for.</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Impacts on planning activities?</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Need to get CAV into planning as soon as possible.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Data</li> </ul>	<ul style="list-style-type: none"> <li>It is difficult to determine which applications/technologies meet the needs since there are no standards developed yet.</li> <li>Data will become a source of funding – PennDOT should be looking at monetizing data as a source of potential funding.</li> <li>Data will need to be at a higher-quality as well.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division**

Business Area / Impacts	Impacts	Notes
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Multimodal considerations are critical as well. An example is a potential pilot in the Philadelphia Airport shuttle to Terminal F – this could be an ideal candidate for a pilot, but need collaboration from other modes.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Training needs will increase as market penetration increases.</li> </ul>
<ul style="list-style-type: none"> <li>• Other</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Additional skills will be needed to better assimilate this technology.</li> <li>• Public sector needs to be trained as well. Trained those already employed by the Department.</li> <li>• Operations Academy is a good forum to train public sector on CAV.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Policy</li> </ul>	<ul style="list-style-type: none"> <li>• There are two bills currently being considered. Both bill create a AV committee/group.</li> <li>• Procurement methods may need to be modified to accommodate this new technology.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division**

Business Area / Impacts	Impacts	Notes
<p><b>10. Outreach and Collaboration</b></p>	<p><b>Public-Private-Partnerships / Public / Parking /Communication</b></p>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Communication</li> <li>• Partnerships</li> </ul>	<ul style="list-style-type: none"> <li>• Partnering with other agencies is critical – i.e., SmartBelt Coalition.</li> <li>• Need to learn from others and capture best practices.</li> <li>• Need to stay involved in national groups.</li> <li>• Need to create a working relationship with USDOT to have more cutting-edge research and application development be done in PA. How can we build this relationship with USDOT?</li> <li>• Need a better relationship with universities.</li> <li>• Information needs to be better disseminated. Training and data sharing are critical.</li> </ul>

### End Notes



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Information Systems and Technology Office**

**Organization:** Pennsylvania Department of Transportation Information Systems and Technology Office  
**Date:** January 3, 2018  
**Participant (s):** Philip Tomassini (PT) – Pennsylvania Department of Transportation Information Systems and Technology Office  
 Michael DeMatt (MD) – Pennsylvania Department of Transportation Information Systems and Technology Office  
 Scott Hoffman (SH) – Pennsylvania Department of Transportation Information Systems and Technology Office  
 Mike Patterson (MP) – Pennsylvania Department of Transportation Information Systems and Technology Office  
 Mark Kopko (MK) – Pennsylvania Department of Transportation Highway Safety and Traffic Operations Division  
**Interviewer (s):** Eric Rensel (ER) – Gannett Fleming, Inc.  
 Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- ER provided an introduction of the scope of services for the task at hand.
- MK indicated the plan will include the nine business areas within PennDOT including Information Systems and Technology.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Group was somewhat familiar with CAV.</li> <li>• Who is setting the priorities and what input does PennDOT have.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Security, infrastructure, identify skill sets, and resiliency.</li> <li>• Be involved.</li> </ul>
<ul style="list-style-type: none"> <li>• What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Group would like to know how are other states frame and how they are addressing this new technology.</li> <li>• Consistency is important, having standards will be important.</li> <li>• Objectives are important. Roles and responsibilities. Relationships need to be identified. What type of skill sets. Need to be able to build out detailed business plans out of this CAV Strategic Plan.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Information Systems and Technology Office**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Biggest inconsistency is fiber network.</li> <li>Who is standardizing the messages? Is there a standard out there already? These are some of the questions the group would like answered.</li> <li>TMCs were doing their own things before. Group will need to know what will be needed in the next six months, 1 year, 5 years, etc.</li> <li>Will need additional skills as things move forward.</li> <li>Office of Administration – overarching umbrella to IT PennDOT. Other people need to get involved.</li> <li>Sustainability and availability is crucial.</li> </ul>
<p><b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b></p>	<p><b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b></p>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Coordination</li> </ul>	<ul style="list-style-type: none"> <li>IT needs to be involved at early stages.</li> <li>Coordination is crucial.</li> </ul>
<p><b>3. Design and Construction</b></p>	<p><b>Road infrastructure / Parking</b></p>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Coordination</li> </ul>	<ul style="list-style-type: none"> <li>IT needs to be involved at early stages.</li> <li>Coordination is crucial.</li> </ul>
<p><b>4. Planning and Research</b></p>	<p><b>Data / Car Ownership / Zoning / Travel Demand</b></p>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Information Systems and Technology Office**

Business Area / Impacts	Impacts	Notes
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Connected vehicles can generate a lot of data. Based off the numbers coming out of the Ann Arbor safety pilot, if Pennsylvania has full market penetration and only retains 0.5% of the data, that would work out to be 3,286 TB of data a year. What does PennDOT need to do to prepare for the future?</li> </ul>	<ul style="list-style-type: none"> <li>Data</li> </ul>	<ul style="list-style-type: none"> <li>Data needs are not ready to be met, but the office is prepared to evolve and get ready for this.</li> <li>Hybrid with cloud and servers.</li> </ul>
<ul style="list-style-type: none"> <li>Most US DOT connected vehicle applications are designed to work on an IPV6 network. This has posed an issue to numerous states testing applications. Do you foresee this being an issue for PennDOT?</li> </ul>	<ul style="list-style-type: none"> <li>Standards</li> </ul>	<ul style="list-style-type: none"> <li>IPV6 – will pose challenge, but they are getting ready for it. Internal may pose a challenge.</li> </ul>
<ul style="list-style-type: none"> <li>Other</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>Physical locks on the devices - best practices into contractors – simple things as this can make a big difference.</li> <li>Privacy will be a big thing. Privacy policy will be needed.</li> <li>Moving towards the cloud – PennDOT already handle a lot of data already. Using the cloud for Waze data right now.</li> <li>Server farm will probably be there for a while still. But they are constantly looking for what is the best for the customer.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Pennsylvania Department of Transportation Information Systems and Technology Office**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• We do not know at this point.</li> <li>• Participation in state conferences and national conferences.</li> <li>• Close relationships with other peers as to what is going on will also be important.</li> </ul>
<ul style="list-style-type: none"> <li>• Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Need to better train the staff as to what will happen. They do not know what will happen with this technology – i.e., 3K TB of data per year.</li> </ul>
<ul style="list-style-type: none"> <li>• Other</li> </ul>	<ul style="list-style-type: none"> <li>• Support</li> </ul>	<ul style="list-style-type: none"> <li>• IT support at each District dedicated to ITS may be needed.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination</li> </ul>	<ul style="list-style-type: none"> <li>• Need to coordinate with other agencies.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

Interview with **Pennsylvania Department of Transportation Information Systems and Technology Office**

Business Area / Impacts	Impacts	Notes
<p><b>10. Outreach and Collaboration</b></p>	<p><b>Public-Private-Partnerships / Public / Parking /Communication</b></p>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Coordination</li> </ul>	<ul style="list-style-type: none"> <li>PA IT Council is on-going. Once every two months. State CIO – OA – leads that group.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Multimodal Transportation**

**Organization:** Pennsylvania Department of Transportation Multimodal Transportation  
**Date:** January 12, 2018  
**Participant (s):** Anthony McCloskey (AM) – Pennsylvania Department of Transportation Multimodal Transportation  
 Anthony Stever (AS) – Pennsylvania Department of Transportation Multimodal Transportation  
 Danielle Spila (DS) – Pennsylvania Department of Transportation Multimodal Transportation  
 Stephen Panko (SP) – Pennsylvania Department of Transportation Multimodal Transportation  
 Elizabeth Bonini (EB) – Pennsylvania Department of Transportation Multimodal Transportation  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Group is familiar with CAV technologies.</li> </ul>
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? / What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Labor loss.</li> <li>Should connect with P3 Office.</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Multimodal Transportation**

Business Area / Impacts	Impacts	Notes
4. Planning and Research	Data / Car Ownership / Zoning / Travel Demand	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
5. Information Technology and Security	Cyber-security / Data / Communication Infrastructure	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
6. Driver Licensing and Motor Vehicles	Human-Machine Interactions / Car Ownership	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
7. Multi-Modal Considerations	Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership	
<ul style="list-style-type: none"> <li>• Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>• Transit</li> </ul>	<ul style="list-style-type: none"> <li>• Pilot in Philadelphia airport makes sense. However, union contracts are complicated issues.</li> <li>• Statewide project – GPS technology in buses (CAD/AVL) may be a good way to start.</li> </ul>
	<ul style="list-style-type: none"> <li>• Rail/Freight</li> </ul>	<ul style="list-style-type: none"> <li>• It may be helpful to use technology to switch locomotives.</li> </ul>
	<ul style="list-style-type: none"> <li>• Pedestrian</li> </ul>	<ul style="list-style-type: none"> <li>• People with disability and blind are very interested in this transportation mode. Seniors as well.</li> <li>• Regional Transportation Alliance of Southwestern PA – this is a point of conversation for that forum.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation Multimodal Transportation**

Business Area / Impacts	Impacts	Notes
	<ul style="list-style-type: none"> <li>Bike</li> </ul>	<ul style="list-style-type: none"> <li>Bicyclist and pedestrian need to be educated.</li> <li>Port was not talked about, moving containers, making connection to other are areas where this technology may be helpful.</li> </ul>
	<ul style="list-style-type: none"> <li>Coordination</li> </ul>	<ul style="list-style-type: none"> <li>Need to provide win-win for all – revenue generation in big airports.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>Both PennDOT employees and consultants need to be trained.</li> <li>PennTRAIN provides training for transit agencies and could be a good way to start training individuals about CAV.</li> </ul>
<ul style="list-style-type: none"> <li>Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>Aviation – people understand concepts and that’s all. They get, but not very familiar.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Funding</li> </ul>	<ul style="list-style-type: none"> <li>Funding has a lot of flexibility. State funding are mostly used. Federal fund would probably be able to be used.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Collaboration</li> </ul>	<ul style="list-style-type: none"> <li>AV Summit helped a lot. Having transit involved was very beneficial.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Outreach</li> </ul>	<ul style="list-style-type: none"> <li>Product – first education and outreach to all. Regions have different need, mobility options.</li> </ul>

### End Notes



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 11**

**Organization:** Pennsylvania Department of Transportation District 11  
**Date:** January 18, 2018  
**Participant (s):** Daniel Fedio (DF) – Pennsylvania Department of Transportation District 11  
 Benjamin DeVore (BD) – Pennsylvania Department of Transportation District 11  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- Please review the following questions / topic areas before the interview meeting if you have time. We understand that you may not have answers to some of the topics. Feel free to fill out this checklist beforehand.
- LM provided an overview of the project and the purpose of the meeting.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Yes, somewhat familiar.</li> <li>• Some experience with installation of DSRC.</li> <li>• Not a lot of communication with Central Office regarding this effort.</li> <li>• Ben was previously RTMC manager.</li> <li>• Received direction from Central Office and did not provide much guidance.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• District designs their own ITS projects.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Who are we servicing by doing this? Need a vision.</li> <li>• Need a reason for implementing projects and technologies.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 11**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>No knowledge base locally, except for the usual ITS related knowledge.</li> <li>Willingness of municipalities to accept deployment is imperative. May need to bundle this up with other “perks” to entice local municipalities to join in.</li> <li>Local municipalities maintain and operate traffic signals.</li> <li>PennDOT should be in charge of operating and maintaining major corridors if more involvement in signal operations is desired.</li> </ul>
<ul style="list-style-type: none"> <li>What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>It will be helpful to get better direction from Central Office.</li> </ul>
<p><b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b></p>	<p><b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b></p>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Any one of the projects that are ongoing can have this kind of applications, as long as funding is available.</li> <li>Cranberry is the most progressive town in District 10.</li> <li>Applications in the tunnels as well.</li> </ul>
<ul style="list-style-type: none"> <li>What are some day 1 uses?</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance</li> <li>Work Zones</li> </ul>	<ul style="list-style-type: none"> <li>There are opportunities in work zone operations. Very interested in this.</li> <li>In tunnels, this technology may also have applicability.</li> <li>It can help with detours in construction projects.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Standards</li> </ul>	<ul style="list-style-type: none"> <li>DSRC deployment already happen in the district. However, equipment has been deployed but not in use. Need a plan on how to use the equipment.</li> <li>Very difficult to know where we are going.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 11**

Business Area / Impacts	Impacts	Notes
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Work zones is an area of opportunity.</li> <li>Money and resources are needed to be able to deploy this technology.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>How do we know if the equipment is working? Evaluation of the deployment need to be part of the deployments.</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance</li> </ul>	<ul style="list-style-type: none"> <li>ITS infrastructure is maintained by a contractor.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 11**

Business Area / Impacts	Impacts	Notes
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>No one has relevant experience. Only a few were involved with the DSRC deployment.</li> <li>Guidelines from Central Office will be highly appreciated.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Guidelines from Central Office will be highly appreciated.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Coordination</li> </ul>	<ul style="list-style-type: none"> <li>CMU interaction is limited. This is geared more toward Pittsburgh.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 2**

**Organization:** Pennsylvania Department of Transportation District 2  
**Date:** January 25, 2018  
**Participant (s):** Dennis Prestash (DP) – Pennsylvania Department of Transportation District 2  
 Erik Brown (EB) – Pennsylvania Department of Transportation District 2  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Group is familiar with CAV technologies.</li> <li>• With Penn State University within the District, involvement will be high.</li> <li>• Trying to partner with universities, such as Carnegie Mellon University.</li> <li>• Working with Penn State to form a technology corridor, which will eventually include connected and automated vehicles (I-99). Only at the scope of work stage, no funding is yet set.</li> <li>• Adaptive corridors are coming online as well.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• District is embracing emerging technologies.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 2**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area? What are some of the challenges?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Many of rural municipalities have very limited budget.</li> <li>Taking over the signals will be challenging for the district. Staffing is limited and equipment is not readily available for work such as this (for example, PennDOT does not have bucket trucks).</li> <li>Staff needs to be able to keep up with emerging technologies. Training will be necessary.</li> <li>Cyber security is also very important.</li> <li>Fiber is needed. Enhanced communication.</li> <li>Mixed vehicle environment will be a challenge as well. This will be especially true in rural areas.</li> </ul>
<ul style="list-style-type: none"> <li>What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>To have the same goals for all, guidance.</li> <li>Will need to be implemented into the TIP.</li> <li>Cyber security and communication infrastructure.</li> <li>Need to stay consistent throughout all Districts.</li> </ul>
<p><b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b></p>	<p><b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b></p>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Identified fiber location through I-80 and I-99 (D9 and D3). They started to plan future for fiber to connect districts. Fiber go into test track, to I-99 to District Office and connect a couple maintenance offices. Fiber backbone is the priority.</li> <li>Central Office Traffic Operations Division has been tasked to lower cost, lease lines are expensive and fiber may be a solution.</li> <li>Truck platooning will be an important aspect as well to keep in mind.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 2**

Business Area / Impacts	Impacts	Notes
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Standards</li> </ul>	<ul style="list-style-type: none"> <li>ITS Architecture exercise brought everyone together in the district, including design, construction, maintenance, etc.</li> <li>Architecture, CAV Strategic Plan, Operations Plan were the results of this exercise.</li> <li>Design and construction are very open to adding ITS and other technology applications to projects.</li> <li>Effort was led by the District. Central Office will start to lead this effort for the Commonwealth.</li> <li>Need to get construction involved in CAV, especially for work zones where speed reduction occurs, etc.</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 2**

Business Area / Impacts	Impacts	Notes
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Transit</li> <li>Bike and Pedestrians</li> </ul>	<ul style="list-style-type: none"> <li>District works with transit agencies, specifically for transit signal priority. District has very good working relationships with those agencies.</li> <li>Bike and pedestrian features are a constant part of the projects in the District.</li> <li>Pedestrian and bicyclist interaction with AV will present a challenge and needs to be considered.</li> <li>Research and pilots for pedestrian and bicyclist will need to be conducted. Applications in universities is a good possibility.</li> <li>Parking.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>Other</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>Consultants assist and complement in-house staff in terms of manpower and knowledge.</li> <li>One open-end for traffic operations services. Most districts have for design. This allow for quick turnaround.</li> <li>Municipal entities – since most of district is rural, knowledge may be limited. The urban area may have more knowledge that the rural as it relates to CAV. Some rural areas do not have signals, or very good internet access.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 2**

Business Area / Impacts	Impacts	Notes
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination</li> </ul>	<ul style="list-style-type: none"> <li>• District has a very good working relationship with planning partners. This should easily translate to CAV projects and applications.</li> <li>• Three planning partners – one urban and two rural.</li> <li>• We need to do a very good job with communicating with the public. Interaction and education will be vital.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 6**

**Organization:** Pennsylvania Department of Transportation District 6  
**Date:** January 25, 2018  
**Participant (s):** Louis Belmonte (LB) – Pennsylvania Department of Transportation District 6  
 Emmanuel Anastasiadis (EA) – Pennsylvania Department of Transportation District 6  
 Ashwin Patel (AP) – Pennsylvania Department of Transportation District 6  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>District has been involved in technology since 1993. One of the most robust systems can be found in the district.</li> <li>District is very familiar with CAV.</li> <li>Active traffic management, integrated corridor management, are some of the active programs within the district.</li> <li>I-66 will be a corridor that will have technology to allow communication between the infrastructure and vehicles.</li> <li>District has a vision for what they need to.</li> </ul>
<ul style="list-style-type: none"> <li>How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>We need to prepare ourselves for this technology.</li> </ul>
<ul style="list-style-type: none"> <li>If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Multimodal aspect will be the focus.</li> </ul>
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Balance between the CAV and current needs.</li> <li>Funding is the biggest hurdle.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 6**

Business Area / Impacts	Impacts	Notes
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Pilots</li> </ul>	<ul style="list-style-type: none"> <li>I-66.</li> <li>I-95 has been studied a few times and this may present a good opportunity for deployment.</li> <li>Green Light Program will also present an opportunity for CAV.</li> <li>District will be taking over maintenance of traffic signals in some areas. This will be beneficial for CAV.</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Communication</li> </ul>	<ul style="list-style-type: none"> <li>Connection between all emergency centers will allow for CAV to work better.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Standards</li> </ul>	<ul style="list-style-type: none"> <li>Design and construction are already doing ITS, so adoption of CAV should be relatively easy.</li> <li>Some minor changes will be needed.</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>Cyber security will also be critical. Security for traffic signals is very important.</li> <li>Fiber encompasses the majority of communication.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 6**

Business Area / Impacts	Impacts	Notes
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>	<ul style="list-style-type: none"> <li>• NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>• Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>• Transit</li> </ul>	<ul style="list-style-type: none"> <li>• Modernize the bus stop.</li> <li>• SEPTA partnership is important as well.</li> <li>• With data sharing, travel times will be able to be shared with transit riders.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>• What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• CAV training in general will be needed for both PennDOT employees as well as consultants.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Guidance</li> </ul>	<ul style="list-style-type: none"> <li>• Looking for guidance from Central Office.</li> </ul>
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking / Communication</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Partnerships</li> </ul>	<ul style="list-style-type: none"> <li>• Working with planning partners will be very important.</li> </ul>

### End Notes

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 8**

**Organization:** Pennsylvania Department of Transportation District 8  
**Date:** February 8, 2018  
**Participant (s):** Jason Bewley (JB) – Pennsylvania Department of Transportation District 8  
 Eric Kinard (EK) – Pennsylvania Department of Transportation District 8  
 Chris Flad (CF) – Pennsylvania Department of Transportation District 8  
 Nate Walker (NW) – Pennsylvania Department of Transportation District 8  
 Chris McKee (CM)– Pennsylvania Department of Transportation District 8  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Group is aware of CAV and HAV. We have discussed how to incorporate this technology into large projects.</li> <li>• Last week there was a forum online headed by Secretary Richards and the District participated.</li> <li>• In District 8 – elected official level demonstration was done around the capital complex.</li> <li>• At least one MPO (HATS) is interested in having a pilot.</li> <li>• Proximity with Central Office helps coordination.</li> </ul>
<ul style="list-style-type: none"> <li>• What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• District would like to see how this fits into policies, what are the expectations.</li> <li>• What are the goals, what are we aiming for are questions that need to be answered?</li> </ul>
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 8**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Pilots</li> </ul>	<ul style="list-style-type: none"> <li>There are currently no initiatives that involve CAV.</li> <li>Looking forward, there may be opportunities to integrate this technology into operations and maintenance.</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Pilots</li> </ul>	<ul style="list-style-type: none"> <li>Ongoing widening of major highway is ongoing. However, it may be difficult incorporate this technology onto these types of projects.</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Partnerships</li> </ul>	<ul style="list-style-type: none"> <li>Planning partners are aware and HATS is working on submitting a supplementing funding plan to incorporate this technology into planning.</li> <li>A policy or having this requirements on a design manual may help incorporate this technology into more projects.</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>IT</li> </ul>	<ul style="list-style-type: none"> <li>IT Program is very progressive and accepting of new technologies. As well as well prepared.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 8**

Business Area / Impacts	Impacts	Notes
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Transit</li> <li>Freight</li> </ul>	<ul style="list-style-type: none"> <li>Transit routes could be a priority.</li> <li>Freight also should be a priority.</li> <li>81 corridor is a key corridor for freight.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>District has staff that can keep up with technologies.</li> <li>Would like to have a statewide group for this, which should include district representation.</li> <li>Need some outreach from Central Office and have a workgroup that the Districts can participate on.</li> </ul>
<ul style="list-style-type: none"> <li>Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li>Workforce</li> </ul>	<ul style="list-style-type: none"> <li>Union workforce will need to be consider.</li> <li>Workforce of the District is very receptive to technology, including management.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Policy</li> </ul>	<ul style="list-style-type: none"> <li>District would like to have a policy and vision/mission for the technologies as guidance.</li> <li>District would like to know what the vision is, and the funding that will be allocated to it.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 8**

Business Area / Impacts	Impacts	Notes
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships/ Public / Parking</b>	
<ul style="list-style-type: none"> <li>• Other?</li> </ul>	<ul style="list-style-type: none"> <li>• Outreach</li> <li>• Collaboration</li> </ul>	<ul style="list-style-type: none"> <li>• Need to do outreach with local municipalities since they operate and maintain the traffic signals. These agencies will be key partners.</li> <li>• District believes local municipalities should keep the signal maintenance and operations and PennDOT should focus on creating partnerships to make this successful. District believes they need buy-in from local municipalities. District does not have the workforce to take on this task.</li> <li>• District 8 has several planning partners, transit agencies, etc.</li> </ul>

### End Notes



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 5**

**Organization:** Pennsylvania Department of Transportation District 5  
**Date:** January 23, 2018 / February 13, 2018 / February 15, 2018  
**Participant (s):** Michael W Rebert (MR) – Pennsylvania Department of Transportation District 5  
 Dennis Toomey (DT) – Pennsylvania Department of Transportation District 5  
 Dennis McArdle (DM) – Pennsylvania Department of Transportation District 5  
 John Harmonosky (JH) – Pennsylvania Department of Transportation District 5  
 Kevin Milnes (KM) – Pennsylvania Department of Transportation District 5  
 Dave Rostron (DR) – Pennsylvania Department of Transportation District 5  
 Scott Vottero (SV) – Pennsylvania Department of Transportation District 5  
 Jill Krause (JK) – Pennsylvania Department of Transportation District 5  
**Interviewer (s):** Laurie Matkowski (LM) – Gannett Fleming, Inc.  
 Alexandra Lopez (AL) – Gannett Fleming, Inc.

**General Notes:**

- LM an AL provided an introduction of the scope of services for the task at hand.

Business Area / Impacts	Impacts	Notes
<b>1. All</b>	<b>General</b>	
<ul style="list-style-type: none"> <li>• Are familiar with CAV? / What is your perspective of CAV?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Understand the different levels of automation.</li> <li>• Know some of the services are already on some of the vehicles.</li> <li>• It will help in safety and work zone areas.</li> <li>• As technology progresses, it will be beneficial to transportation.</li> <li>• Always on board for innovation and technologies that enhances safety.</li> <li>• Have concern with liability.</li> </ul>
<ul style="list-style-type: none"> <li>• How do you see this technology fitting within your agency's organizational structure?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• We need to prepare ourselves for this technology.</li> </ul>
<ul style="list-style-type: none"> <li>• If PennDOT could choose one area to invest in time or resources for preparing technically and/or culturally for the arrival of connected vehicles what should that be?</li> </ul>	<ul style="list-style-type: none"> <li>• General</li> </ul>	<ul style="list-style-type: none"> <li>• Work zone set ups could be a good area to start on.</li> <li>• Training will be a very important aspect.</li> <li>• Very little is understood as to is expected to happen with this technology.</li> <li>• Currently lean on consultants to perform design and other highly technical tasks.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 5**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>What are some of the needs and/or gaps you perceive in your area?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>There are still some issues that need to be worked out. For example, sometimes turn by turn navigation has it wrong.</li> <li>What would be the interaction with flaggers, for example? Or emergency vehicles.</li> <li>Interaction with signage will be critical as well.</li> <li>Rail road crossing will also be critical.</li> <li>Adverse weather conditions.</li> <li>State boundaries and off-roads.</li> <li>Issues during construction, pavement markings may be left during construction.</li> <li>There are three types of pavement marking paints. At this point, there are no plans for CAV-related paint-types.</li> <li>Need an introductory course.</li> <li>No interaction with central office regarding this technology.</li> <li>Disconnect between the Districts and Central Office.</li> <li>Need to systematically brief the Districts to better share the information.</li> <li>Central Office needs to do a better job at sharing information and lessons learned from other pilots, for example.</li> <li>Major concern is weather.</li> <li>Concern for funding as well.</li> <li>Emergency vehicle interaction with AV.</li> <li>Rail road crossings as well – most do not have drop-down gates.</li> </ul>
<ul style="list-style-type: none"> <li>What would success be like at the end of this planning exercise?</li> </ul>	<ul style="list-style-type: none"> <li>General</li> </ul>	<ul style="list-style-type: none"> <li>Better explanation of applications and impact the technology may have on the transportation system.</li> <li>Criteria to assess candidate location. What roadway characteristics need to be met to deploy this technology?</li> <li>Criteria to be followed in selecting pilot corridors.</li> <li>Districts need to be brought up to speed.</li> <li>Need to provide awareness training.</li> <li>What does CAV mean and how are they being rolled out in other parts of the country. Once this occurs, the District will be able to provide feedback how this will affect all areas within the District.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 5**

Business Area / Impacts	Impacts	Notes
<b>2. Maintenance and Operations (including traffic operations, traffic signals, safety, work zones, and freight)</b>	<b>Safety / Mobility / Reliability / Data / Lane Markings / Traffic Signs / Roadside Devices</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Pilots</li> </ul>	<ul style="list-style-type: none"> <li>I-78, I-80, I-81 are heavily traveled by trucks – about 40%.</li> <li>District is open to a pilot there.</li> </ul>
<ul style="list-style-type: none"> <li>What are some day 1 uses?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>Training will be needed.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Standards</li> </ul>	<ul style="list-style-type: none"> <li>Providing specifications will allow the Department to adjust quickly.</li> </ul>
<b>3. Design and Construction</b>	<b>Road infrastructure / Parking</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Communication</li> </ul>	<ul style="list-style-type: none"> <li>Connection between all emergency centers will allow for CAV to work better.</li> </ul>
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Standards</li> </ul>	<ul style="list-style-type: none"> <li>Design and construction are already doing ITS, so adoption of CAV should be relatively easy.</li> <li>Some minor changes will be needed.</li> </ul>
<b>4. Planning and Research</b>	<b>Data / Car Ownership / Zoning / Travel Demand</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>5. Information Technology and Security</b>	<b>Cyber-security / Data / Communication Infrastructure</b>	

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 5**

Business Area / Impacts	Impacts	Notes
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Security</li> </ul>	<ul style="list-style-type: none"> <li>Cyber security will also be critical. Security for traffic signals is very important.</li> <li>The IT staff should be prepared for this new technology.</li> </ul>
<b>6. Driver Licensing and Motor Vehicles</b>	<b>Human-Machine Interactions / Car Ownership</b>	
<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>	<ul style="list-style-type: none"> <li>NA</li> </ul>
<b>7. Multi-Modal Considerations</b>	<b>Transit / Rail / Freight / Non-Motorized Users / Last and First Mile / Car Ownership</b>	
<ul style="list-style-type: none"> <li>Are there any active or future projects/initiatives that may benefit from connected and automated vehicles technologies?</li> </ul>	<ul style="list-style-type: none"> <li>Transit</li> </ul>	<ul style="list-style-type: none"> <li>Modernize the bus stop.</li> <li>SEPTA partnership is important as well.</li> <li>With data sharing, travel times will be able to be shared with transit riders.</li> </ul>
<b>8. Workforce Requirements</b>	<b>Training / Human relations</b>	
<ul style="list-style-type: none"> <li>What sort of training would you need?</li> </ul>	<ul style="list-style-type: none"> <li>Training</li> </ul>	<ul style="list-style-type: none"> <li>CAV training in general will be needed for both PennDOT employees as well as consultants.</li> </ul>
<ul style="list-style-type: none"> <li>Is PennDOT (or your organization) culturally prepare for CAV?</li> </ul>	<ul style="list-style-type: none"> <li>Workforce</li> </ul>	<ul style="list-style-type: none"> <li>There are no experts at this point within the District workforce.</li> <li>It can be said that District may can adapt fairly quick once adoption begins.</li> </ul>
<b>9. Policy and Legal</b>	<b>Liability / Protection of Public Benefits / Funding</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Guidance</li> </ul>	<ul style="list-style-type: none"> <li>Looking for guidance from Central Office.</li> </ul>

# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLES CAV STRATEGIC PLAN

### Interview with **Pennsylvania Department of Transportation District 5**

Business Area / Impacts	Impacts	Notes
<b>10. Outreach and Collaboration</b>	<b>Public-Private-Partnerships / Public / Parking /Communication</b>	
<ul style="list-style-type: none"> <li>Other?</li> </ul>	<ul style="list-style-type: none"> <li>Collaboration</li> </ul>	<ul style="list-style-type: none"> <li>Working with planning partners will be very important.</li> <li>It will be important to learn what other districts are doing and learn how they funded the pilot projects and the results from that deployment – would like to hear from District 11.</li> <li>There is constant communication among stakeholders already.</li> <li>District currently has a good working relationship with municipalities.</li> </ul>

### End Notes

**PENNSYLVANIA TURNPIKE COMMISSION CV WORKING GROUP**  
**Pennsylvania Joint Statewide Connected and Automated Vehicles (CAV) Strategic Plan**

**MEETING MINUTES**  
**January 31, 2018**  
**9:00 AM – 11:00 AM**

A Pennsylvania Turnpike Commission (PTC) CV Working Group Meeting was attended and session on the Pennsylvania Joint Statewide CAV Strategic Plan was conducted January 31, 2018 from 9:00 AM to 11:00 AM at the PTC Headquarters. The following individuals attended:

<b>Name</b>	<b>Organization</b>	<b>Initials</b>
Robert Taylor	Pennsylvania Turnpike Commission (PTC)	RT
Mike Pack	Pennsylvania Turnpike Commission (PTC)	MP
Kenneth Juengling	Pennsylvania Turnpike Commission (PTC)	KJ
Joseph Suess	Pennsylvania Turnpike Commission (PTC)	JS
Michael Metz	Pennsylvania Turnpike Commission (PTC)	MM
Kevin Geiger	Pennsylvania Turnpike Commission (PTC)	KG
Cory Greene	Pennsylvania Turnpike Commission (PTC)	CG
Gregory Yetter	Pennsylvania Turnpike Commission (PTC)	GY
Timothy Scanlon	Pennsylvania Turnpike Commission (PTC)	TS
Todd Smith	Pennsylvania Turnpike Commission (PTC)	TS
Amber Reimnitz	Pennsylvania Turnpike Commission (PTC)	AR
Stacia Ritter	Pennsylvania Turnpike Commission (PTC)	SR
Michael Davidson	Pennsylvania Turnpike Commission (PTC)	MD

The following items were discussed:

- Roadmap
  - MP:
    - Focused on CV side
    - Started an early project from that roadmap
    - Hoping to go live in July with mobile work zone
      - Evaluate July – November of 2018
    - Will tell a lot about how we can deploy to other business areas like TIM
  - AR is doing DSRC work and a DSRC architecture:
    - How will the TMC communicate with the DSRC/TIM units.
    - What density of RSUs?
    - With it being so new and so many unknowns, lessons learned are crucial.
    - Got FCC license to be allowed to deploy RSUs.
    - That was a big step.
- RT:
  - Compton is supportive but wants to see quick wins.
  - Broadband fiber network will provide communication needed.
  - Using Cisco to deploy statewide program.

- Making sure they are ready to support the maintenance
- What about AV?
  - Automated TMA is a priority. 15-20 TMA hits per year.
  - Waiting for legislation.
  - Biggest ask is to make sure there are good pavement markings.
  - Lane reservation system for work zones is crucial for accurate work zone information.
- What about IT readiness? Tight integration with other areas?
  - Just kicked off ATMS with IBI.
  - Second phase deployed by 2020. There are future modules to be added if needed.
  - Getting traveler information out to RSUs and OBUs.
  - What groups?
    - Other groups are included throughout
    - Will update enterprise CAV Strategic Plan this year
    - Maintenance is a big partner.
    - How do we prepare for a connected fleet?
    - Updating the operations and maintenance manual
      - Every project will now be an IT project
- Do you have the workforce to support?
  - We do have the KSAs we need
    - We have never been at a table like this together so much, so I think we are set for success.
  - Educating the partners is an important part of that.
  - We have good KSAs but probably not enough people.
  - MM:
    - Shear number of devices is daunting.
    - What percentage of coverage?
    - Talking to Cisco about the kind of network needed.
    - Broadband project is key.
    - With industry day for upcoming maintenance contracts, must be aware of capabilities.
- What are your thoughts on O&M?
  - Will take more than an electrical contractor.
  - There is a radio involved and that is a unique set of problems.
  - Engineers will have to be part of the solution.
- What about delivery of quick wins?
  - The radios.
  - What is needed for data exchange.
  - Putting "Compute" along the road changes the dynamic.
- What about the financial aspects?
  - How do you pay for it long term?
    - That is why we are demonstrating quick wins. We must make the case for funding.
- What about the data?
  - Currently developing a big data strategy.
  - Not just CAV, but more in general.
  - System integration is a discussion but separate from big data.

- Cybersecurity
  - Don't really have a plan yet, but that is being developed now.
- Law Enforcement Community
  - Quarterly incident management task force with Troop T.
  - Haven't done as good a job with other paid services.
  - Crash by tesla created a lot of interesting discussions.
- What about the relationship between PTC and PennDOT?
  - Must work together to establish the standard message sets.
  - Must be good coordination for the radios to make sure local traffic signals are not impacted.
  - From the data stand point, there must be coordination.
  - Infrastructure deployments and the licensing process.
  - Lane reservation system is about to kickoff.
- USDOT
  - Participating in a work zone data sharing idea
- Buy-in will be the hardest part.
- Hardest part of automated TMA will be selling the benefit.
- Employee engagement plan.
- Workforce changes will need to occur for younger tech savvy persuasion.
- What makes this exercise successful?
  - Documenting the ideas and agreements.
  - More technical people involved.
  - Knowing what the real benefits are, what it will accomplish.
  - How and what to plan for? What to include in the capital plan?
  - How to invest.
  - Fill the gap of industry expansion and understanding. Think about all the training and standards developed by FHWA during ITS deployment.
  - What if the quick wins do not work?
  - What policies and procedures to deploy.
  - How do we get the in between IT person involved?
  - How the document will relate to PTC.
  - Strong Day 1 coordination and agreement.
  - What is the ultimate goal?
  - Identifies the big picture and how we fit in.
  - Must be sellable.
  - Training needs are clearly articulated.
  - Allows us to remain a customer based organization
  - Allows us to manage expectations with capital investment.
  - Understanding our role.
  - Proof of concept.
  - Not so specific that it ties their hands on implementing technology that is not known – flexibility.
  - Contingency planning incase a pilot project fails.
  - Also thinking ahead to a fully CV/AV world and what process change does that create.



## Outline of Needs, Feedback, and Identified Gaps for Each Topic

Table B-3 presents a summary of the needs, feedback and identified gaps for each of the nine business areas identified earlier. This information was gathered after completing all items under Task 1 Internal Information Gathering and Investigations of the Joint Statewide Connected and Automated Vehicle CAV Strategic Plan.

Table B-3: Outline of Needs, Feedback and Identified Gaps

Area	Needs/Gaps/Feedback
Maintenance and Operations	<ul style="list-style-type: none"> <li>• Elevated importance of Asset Management (pavement markings, traffic signals)</li> <li>• Develop delivery system for vehicles to receive work zone restrictions - Smart Work Zones</li> <li>• Ensure that municipalities are prepared for CAV - pavement markings, signal, etc.</li> <li>• Develop municipalities support and buy in</li> <li>• Focus on day 1 improvements that can be made - improve accuracy and timeliness of traveler information dissemination. Add more detail to this reporting - adding lane closures by location, roadway, and lane</li> </ul>
Design and Construction	<ul style="list-style-type: none"> <li>• There is limited wireless infrastructure in the state and some examples, including the City of Philadelphia have tried to deploy unsuccessfully.</li> <li>• There are Right-Of-Way concerns with these new technologies. Established infrastructure in PA cities in PA create space limitations.</li> <li>• Need to focus on communications infrastructure now - Fiber Optic Communication System</li> <li>• Should consider updating ITS Architectures - The exercise brought together everyone in the regions/districts, including design, construction, maintenance, and operations</li> <li>• Work to get construction involved in CAV - One of the best applications could be in Work Zones</li> <li>• A connection between all emergency operations centers will be essential and should allow CAV technology to thrive</li> <li>• PTC prioritizing Automated Truck Mounted Attenuators (TMAs) but currently waiting on legislation changes to allow for it</li> </ul>
Planning and Research	<ul style="list-style-type: none"> <li>• CAV paired with mobility as a service lends itself to the onset of electric vehicles. This will affect the current state/federal revenue stream that comes from the gas tax and could be detrimental to the preservation of the Commonwealth's infrastructure.</li> <li>• Determine potential impacts to travel demand in the Commonwealth that stems from the technology.</li> </ul>

Area	Needs/Gaps/Feedback
	<ul style="list-style-type: none"> <li>• Need to plan for placeholders on the TIP and plan for the long run</li> <li>• Use the ITS Architectures – statewide and regional to plan for CAV and operations</li> <li>• DVRPC currently accounting for Highly Autonomous Vehicles (HAVs) in their Long-Range Plan but there are uncertainties as to what the implications will be.</li> <li>• Need to capture and quantify some of the externalities of CAV - ex. Lower air pollution</li> <li>• Need to focus on scenario planning. No one knows how this will be modeled</li> <li>• Long Range Planning - Start with identifying what technologies will affect transportation in the Commonwealth. Only look a few years at a time and treat it as a living document.</li> <li>• Use real time data collected from CAVs and incorporate it into planning models - Congestion Management and Air Quality.</li> <li>• Understand users, as different generations will perceive CAV technology differently.</li> <li>• This technology will affect rural and urban municipalities differently - Rural municipalities may not have appropriate funding to advance the technology and keep up with urban settings</li> <li>• PTC currently working on a DSRC Architecture <ul style="list-style-type: none"> <li>○ Need to determine how the DSRC will communicate with the TMC and what the density of Roadside Units will be</li> <li>○ Received FCC license to deploy and operate DSRC RSU</li> </ul> </li> <li>• PTC Management is mostly on board with CAV technology</li> <li>• Broadband fiber network along PTC System</li> <li>• PTC - Focus on quick wins to prioritize the funding for heavier lifts</li> </ul>
Information Technology and Security	<ul style="list-style-type: none"> <li>• Major issues but who will take responsibility for security?</li> <li>• Focus on the usage and ownership of Big Data. Need to provide training to stakeholders regarding the security and utilization of Big Data.</li> <li>• Who will become the ‘data enforcers’?</li> <li>• PennDOT should explore the possibility of monetizing their Data sources and turning it into a revenue stream</li> </ul>
Driver Licensing and Motor Vehicles	<ul style="list-style-type: none"> <li>• Potential difference in cost of CAV ownership in urban vs. rural setting</li> </ul>

Area	Needs/Gaps/Feedback
	<ul style="list-style-type: none"> <li>• Onset of CAV will pose a significant cultural change (especially if/when they become mandatory)</li> <li>• Maintenance of these vehicles may lead to significant workforce and labor implications (specialized skillset required)</li> <li>• Identify next steps for Drivers Licensing and Motor Vehicle after it is determined that that CAV technology is safer than traditional vehicle?</li> <li>• Testing will need to be able to asses if a driver is capable of taking over if a CAV system fails.</li> <li>• Younger demographic may not drive as much because they will grow up with the technology. This will depend on urban vs. rural settings.</li> <li>• How would inspections be handled? Qualified technicians vs. rely on vehicle self-diagnostics</li> <li>• Sanction vehicles with operating issues - Deploy point system like existing driver licensing except assign points to vehicle manufacturers</li> <li>• Review and update safety inspection regulations and guidelines</li> <li>• Should PA be responsible for ensuring that the CAV safety features are fully functioning as part of an inspection program? The CAVs that pass the “inspection” would be given a sticker similar to current policy. This practice would require significant changes to the workforce and skill requirements.</li> </ul>
Modal Considerations	<ul style="list-style-type: none"> <li>• Potentially setup a pilot CAV project to get people from downtown Pittsburgh to the Airport</li> <li>• Potential automated bus pilot in Philadelphia’s University City and Schuylkill Yards section</li> <li>• Platooning operations (rail vs. roads) after the Philaport/Southport expansion. Look to coordination of trucking operations in this area.</li> <li>• Consider how automated technology in freight can benefit modal transfer of freight (trucks used to transfer goods from seaport to railroads).</li> <li>• Automated/connected vehicles and truck platooning may have an effect on the PennDOT oversize/overweight permitting process.</li> <li>• Consider high quality public transit and ride-sharing services in urbanized settings to emphasize the appeal and affordability of a shared mobility model</li> <li>• Rural and suburban AV shared mobility models may replace traditional paratransit services</li> <li>• Automated vehicle technology will need to consider all roadway users (bikes, pedestrians, etc.)</li> </ul>

Area	Needs/Gaps/Feedback
	<ul style="list-style-type: none"> <li>• How will pedestrians react when they know CAV technology is out there?</li> <li>• Automated vehicles may decrease bike/pedestrian crashes or give off the perception of increased safety for these users. This perceived sense of security could lead to an increase in other modal uses such as bicycles.</li> <li>• Deployment of connected and automated vehicles may influence PennDOT Design Manuals and Design Checklists in the future.</li> <li>• Department funding is used for multimodal applications but project delivery is focused on roadway only.</li> <li>• District Execs are measured on roadway performance only, not overall mobility</li> <li>• Freight is not a performance measurement for districts</li> <li>• ‘Moving people and goods’ can be via any mode, but freight tonnage or total trips are not considered in large or small-scale programming</li> <li>• There has been a lack of research conducted on automated transit vehicles such as busses or trolleys in Pennsylvania.</li> <li>• PennDOT has influence on automated freight movement along interstates and other state-owned roadways but will need to work extensively with municipalities to implement technology on local roads.</li> <li>• First and last mile trips - Need to bridge the gap between where transit ends and people’s homes/businesses.</li> <li>• Reduction in car ownership and VMT may prompt a shift to accommodate more multi-modal projects in transportation planning. PA Drivers may not be ready for the shift from private car ownership to shared mobility. Outreach and public education will be needed if funding shifts away from traditional programming.</li> <li>• May need to evaluate current automated vehicle testing legislation to allow for testing of automated shuttles/transit vehicles on PA Roads. For example, California will need to revise current legislation to allow for AV Shuttle testing on their roads as part of the Contra Costa Transportation Authority. The law currently permits testing on public roads if the vehicle has a steering wheel, brake pedal, and accelerator. The bill will need to be amended to allow for testing on public roads in California. Should look to Florida as a model for this legislation as their law states that the vehicles must have a means to engage and disengage the</li> </ul>

Area	Needs/Gaps/Feedback
	<p>automated technology that is easily accessible to the operator.</p>
<p>Workforce Requirements</p>	<ul style="list-style-type: none"> <li>• Improve educational outreach, training, and awareness starting at the K-12 level and work with industry leaders to develop materials to assist with this. This will be needed</li> <li>• Workers in some driving occupations might have difficulty finding alternative employment with the onset of automated technology (non-transferrable skills).</li> <li>• Pennsylvania must understand how a reduction of driving occupations will affect companies especially with a large union presence. An estimated 15.6% of workers in transportation and material moving occupations are union members. (Table 3 from News Release Bureau of Labor Statistics USDL-17-0107)</li> <li>• The cost of higher education is a large deterrent for people wanting to go back to school to learn another skill.</li> <li>• Curriculum and training needs will change at multiple levels including community colleges, trade schools, and universities.</li> <li>• Explore the possibility of automated technology replacing State DOT Maintenance and Construction jobs (e.g. automated line painting, automated attenuator truck, etc.)</li> <li>• Would need more staff to handle the processing and modeling of the large influx of data coming from CAV technology</li> <li>• Explore the possibility of modeling methodologies of CAV for MPOs</li> <li>• Displacement of workforce if gas consumption is reduced - Philadelphia refinery workforce</li> <li>• Establish partnerships with technical colleges to prepare the workforce for this new technology</li> <li>• Utilize the Operations Academy to train the public sector on CAV</li> <li>• Need to consider the implications of unions</li> <li>• PTC - Operations and Maintenance of DSRC Device will require skillsets beyond electrical contractors - RF Engineers</li> </ul>
<p>Policy and Legal</p>	<ul style="list-style-type: none"> <li>• CAV paired with mobility as a service will lead to a switch to electric vehicles. This will decrease the revenue from the gas tax and leave infrastructure projects with little funding.</li> <li>• Parking revenues to decrease as CAV technology becomes more prevalent. City of Philadelphia collects approx. \$24 Million from parking - How will this be replaced?</li> </ul>

Area	Needs/Gaps/Feedback
	<ul style="list-style-type: none"> <li>• Many aspects of the existing system need to be revisited before CAVs - Traffic laws, liability models, and municipal responsibilities</li> <li>• Need to explore liability further</li> <li>• Should security breaches be reported and who will people report them to?</li> <li>• Primary role of the CAV technology should be to protect customers and users.</li> <li>• Determine how insurance rates will be affected?</li> <li>• Explore alternate procurement methods to accommodate the new technology</li> <li>• How will law enforcement prevent weaponized AVs?</li> </ul>
Outreach and Collaboration	<ul style="list-style-type: none"> <li>• Conduct outreach with OEMs</li> <li>• Consider media coverage to prepare the public</li> <li>• Provide regular updates to planning partners and other stakeholders on the current CAV landscape (Smart cities, smart belt coalition)</li> <li>• Market the new technology to help disadvantaged population - Elderly and disabled</li> <li>• Work to get ITS World Congress in PA</li> <li>• Potential problems with public acceptance of CAV technology - How do you market the technology to get the most acceptance?</li> <li>• Keep the conversation going with agencies that do not always have a seat at the CAV table - Counties, first responders, other local officials and agencies</li> <li>• While PennDOT sees companies like Uber and Google as partners, the insurance industry sees the Insurance Federation as regulators not partners.</li> <li>• Need to establish introductory courses for PennDOT Employees so everyone could get out in front of the technology</li> <li>• There is very little interaction between CO and the Districts when it comes to this technology - Setup a regular briefing between CO and the Districts to keep them informed and on the same page.</li> <li>• Establish criteria to assess candidate or pilot locations - Base it on surrounding roadway characteristics</li> <li>• PTC and PennDOT need to improve collaboration and communication with respect to data, infrastructure deployments, licensing processing, and continue collaboration on the lane reservation system</li> </ul>

PENNSYLVANIA DEPARTMENT OF  
TRANSPORTATION  
JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLE  
STRATEGIC PLAN

APPENDIX C  
SUMMARY OF EXTERNAL INFORMATION GATHERING EFFORTS

DECEMBER 2017

## Introduction

Future transportation systems will consist of an increasing number of connected and automated vehicles (CAV). The Center for Automotive Research defines connected vehicles as vehicles that use a variety of communication technologies to communicate with the driver, other cars on the road, roadside infrastructure, and the “Cloud.” The National Highway Traffic Safety Administration (NHTSA) defines automated vehicles as those in which operation of the vehicle occurs without direct driver input to control the steering, acceleration, and braking and are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode. Together, these technologies can be used to not only improve vehicle safety, but also to improve vehicle efficiency and commute times.

NHTSA is expected to make a ruling that will mandate connected vehicle-to-vehicle (V2V) communications in all new vehicles. Automotive manufacturers such as Nissan, Audi, Toyota, Volvo, Ford and General Motors have announced that they plan to have a fully automated vehicle publicly available by 2020-2025. Mixed vehicular environments will shape the next generation transportation systems and connected and automated vehicle technologies will create a shift in the transportation decision-making process throughout Pennsylvania.

This document is a result of an effort of the Pennsylvania Department of Transportation (PennDOT) to generate a Joint Statewide Connected and Automated Vehicles (CAV) Strategic Plan to assist Pennsylvania in preparing for these technological advancements. The Joint Statewide CAV Strategic Plan will:

- Look at all of Pennsylvania;
- Build upon existing research;
- Identify steps departments should take to prepare for these technologies;
- Define a comprehensive set of focused, reasonable and deployable applications;
- Consider various levels of investment; and
- Provide the Department with critical missing data and information pertaining to the early deployment of connected and automated vehicles.

The Joint Statewide CAV Strategic Plan will be used as the foundation for all policy and procedural decisions relating to connected and automated vehicles.

## Document Purpose

The purpose of this document is to summarize the efforts conducted under Task 2 External Information Gathering of the Joint Statewide CAV Strategic Plan effort and document findings.

## Matrix of Sources Consulted

To ensure that the Joint Statewide CAV Strategic Plan aligns with national guidance and research, various connected and automated vehicles documents were reviewed as part of Task 2 External Information Gathering. Documents reviewed included those published by the following entities:

- *United States Department of Transportation (USDOT)*: A federal executive department of the United States government concerned with transportation governed by the United States Secretary of Transportation. Its mission is to serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future. The USDOT



contains administrations and bureaus such as the National Highway Traffic Safety Administration (NHTSA), Federal Highway Administration (FHWA), Federal Transit Administration (FTA), Federal Motor Carrier Safety Administration (FMCSA), etc.

- *American Association of Motor Vehicle Administrators (AAMVA)*: A tax-exempt, nonprofit organization developing model programs in motor vehicle administration, law enforcement, and highway safety. The association also serves as an information clearinghouse in these areas and acts as the international spokesperson for these interests. Founded in 1933, AAMVA represents the state and provincial officials in the United States and Canada who administer and enforce motor vehicle laws. AAMVA's programs encourage uniformity and reciprocity among the states and provinces. The association also serves as a liaison with other levels of government and the private sector. Its development and research activities provide guidelines for more effective public service.
- *American Association of State Highway and Transportation Officials (AASHTO)*: A nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system. AASHTO works to educate the public and key decision makers about the critical role that transportation plays in securing a good quality of life and sound economy for our nation. AASHTO serves as a liaison between state departments of transportation and the Federal government. AASHTO is an international leader in setting technical standards for all phases of highway system development. Standards are issued for design, construction of highways and bridges, materials, and many other technical areas.
- *Transportation Pooled Fund Program*: The Federal Highway Administration (FHWA) administers the Transportation Pooled Fund (TPF) Program as a means for interested States, FHWA, and other organizations to partner when significant or widespread interest is shown in solving transportation-related problems. Partners may pool funds and other resources to solve these problems through research, planning, and technology transfer activities. It provides greater benefits to participating interests as compared to individual entities conducting or contracting for research on their own.
- *National Cooperative Highway Research Program (NCHRP)*: A forum for coordinated and collaborative research, the National Cooperative Highway Research Program (NCHRP) addresses issues integral to the state Departments of Transportation (DOTs) and transportation professionals at all levels of government and the private sector. The NCHRP provides practical, ready-to-implement solutions to pressing problems facing the industry. The NCHRP is administered by the Transportation Research Board (TRB) and sponsored by the member departments.
- *Transportation Research Board (TRB)*: A non-profit organization that provides independent, objective, and interdisciplinary solutions. TRB manages transportation research by producing publications and online resources. It convenes experts that help to develop solutions to problems and issues facing transportation professionals. TRB also provides advice through its policy studies that tackle complex and often controversial issues of national significance. TRB is powered by volunteers, learn how to connect with TRB to find out about new research and volunteer opportunities.

Table C-1 presents a summary of sources consulted and how each one of the sources will provide input on the final Joint Statewide Connected and Automated Vehicles Strategic Plan. Following Table C-1, a one-page summary of each of the documents reviewed is presented. A database was created and submitted as part of the deliverable for Task 2 containing the one-page summaries of each document as well as the original document for future reference.

Table C-1: Matrix of Sources Consulted

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles	AAMVA	NA	May-18	<a href="https://www.aamva.org/GuidelinesTestingDeploymentHAVs-May2018/">https://www.aamva.org/GuidelinesTestingDeploymentHAVs-May2018/</a> The purpose	The purpose of this report is to address how automated vehicle technology will directly impact vehicle registration and titling programs; driver training, testing, and licensing programs; enforcement of traffic laws; and first response to traffic related incidents.	This document is useful for the development of the Joint Statewide CAV Strategic Plan because it outlines several guidelines the Commonwealth could follow to better prepare for CAV in term of Driver and Vehicle Services. This report also contains recommendations for jurisdictions that choose to regulate testing and deployment of CAV.
Automated Driving Systems 2.0: A Vision for Safety	USDOT NHTSA	NA	Sep-17	<a href="https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf">https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf</a>	This document replaces the Federal Automated Vehicle Policy released in 2016. This updated policy framework offers a path forward for the safe deployment of automated vehicles by encouraging new entrants and ideas that deliver safer vehicles; making Department regulatory processes more nimble to help match the pace of private sector innovation; and supporting industry innovation and encouraging open communication with the public and with stakeholders.	This guideline document helps lay a path within the Joint Statewide CAV Strategic Plan for the safe testing and deployment of new auto technologies.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Adopting and Adapting: States and Automated Vehicle Policy	Eno Center for Transportation	Paul Lewis, Gregory Rogers, Stanford Turner	Jun-17	<a href="http://www.enotrans.org/wp-content/uploads/2017/06/StateAV_FINAL-1.pdf">http://www.enotrans.org/wp-content/uploads/2017/06/StateAV_FINAL-1.pdf</a>	This document provides a collection of policies regarding automated vehicles (AV) and outlines how they vary from state to state. There are four approaches that states take with respect to AV policy: having no regulations or laws; expressing interest in AV, but having no official legislation; explicitly allowing AV testing; and legally allowing fully automated vehicles to be deployed beyond the testing phase. These approaches have not been shown to necessarily attract or deter AV developers and universities play a large role in research and pilot programs.	This document is useful for the development of the Joint Statewide CAV Strategic Plan because it outlines several initiatives that could be done within the state government level to adapt to AV technology. State governments need to adapt their planning procedures, regulations, and the way they manage their roadway network to allow AV technology to reach its full potential. This document specifically lays out guidance on how states should prepare for future technology.
Notice of Proposed Rulemaking	USDOT NHTSA	NA	Jan-17	<a href="https://www.gpo.gov/fdsys/pkg/FR-2017-01-12/pdf/2016-31059.pdf">https://www.gpo.gov/fdsys/pkg/FR-2017-01-12/pdf/2016-31059.pdf</a>	This document proposes to establish a new Federal Motor Vehicle Safety Standard (FMVSS), No. 150, to require all new light vehicles to be capable of vehicle-to-vehicle (V2V) communications and to standardize the message and format of V2V transmissions. The proposed rule outlines the requirements of these V2V systems, including how they communicate and what levels of security are required for receiving and transmitting messages with other vehicles.	This document is relevant to the Joint Statewide CAV Strategic Plan since it discusses the development of a new Federal Motor Vehicle Safety Standard. The new standard will allow communication of basic safety messages between vehicles on the roadway. If this standard is developed and approved, the Pennsylvania Department of Transportation (PennDOT) and/or other state agencies should be aware of the technology/standardization and understand how they can use the technology and data to their advantage.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Multi-Modal Intelligent Traffic Signal System – Phase II	Connected Vehicle Pooled Fund Study University of Virginia	University of Arizona (Lead), University of California PATH Program, Savari Networks, Inc., and Econolite	Sep-16	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/53-MMITSS-Phase-2-Final-Report-FINAL-092520161.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/53-MMITSS-Phase-2-Final-Report-FINAL-092520161.pdf</a>	The objectives of this project were to develop a detailed design, construct the software and hardware system, and conduct a field test of a comprehensive traffic signal system that services multiple modes of transportation, including general vehicles, transit, emergency vehicles, freight fleets and pedestrians.	This research document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of this effort.
Federal Automated Vehicle Policy	USDOT NHTSA	NA	Sep-16	<a href="https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016">https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016</a>	The United States Department of Transportation (USDOT) and its National Highway Traffic Safety Administration (NHTSA) issued a Federal policy for automated vehicles, laying a path for the safe testing and deployment of new auto technologies that have enormous potential for improving safety and mobility for Americans on the road. The policy sets a proactive approach to providing safety assurance and facilitating innovation through four key parts. Vehicle performance guidance uses a 15-point Safety Assessment to set clear expectations for manufacturers developing and deploying automated vehicle technologies. Model state policy delineates the Federal and State roles for the regulation of highly automated vehicle technologies as part of an effort to build a consistent national framework of laws to govern self-driving vehicles. Finally, the policy outlines options for the further use of current federal authorities to expedite the safe introduction of highly automated vehicles into the marketplace, as well as discusses new tools and authorities the federal government may need as the technology evolves and is deployed more widely.	The Federal Automated Vehicles Policy helps lay a path within the Joint Statewide CAV Strategic Plan for the safe testing and deployment of new auto technologies.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
USDOT Guidance Summary for Connected Vehicle Deployments	USDOT ITS JPO	Cory Krause (Noblis) Walt Fehr (Volpe)	Jul-16	<a href="https://ntl.bts.gov/lib/60000/60400/60443/FHWA-JPO-16-337.pdf">https://ntl.bts.gov/lib/60000/60400/60443/FHWA-JPO-16-337.pdf</a>	To assist Connected Vehicle (CV) Pilot Deployers complete Concept Development Phase deliverables, the USDOT Intelligent Transportation Systems (ITS) Joint Program Office (JPO) provided additional guidance on application requirements, deliverables, and key challenges they will face. The application requirements address new code, existing applications, the connected vehicle Security Credential Management System (SCMS), and the System Requirements Specification (SyRS) document. The main challenges faced by developers include archiving the code, supporting integration and future use, utilizing the SCMS, and controlling the cost and schedule. This guidance document provides information to move past the challenges and fulfill all requirements.	This document is useful for CAV applications in Pennsylvania since it contains explicit deployment guidelines for such applications. The document also explains the deliverables that must occur during the Application Deployment Plan process and outlines key challenges. Agencies and researchers working toward the deployment of CV pilots must be aware of the requirements and deliverables that have been outlined in this document.
Connected Vehicle Reference Implementation Architecture (CVRIA)	USDOT ITS JPO	Iteris	Jun-16	<a href="http://local.iteris.com/cvria/">http://local.iteris.com/cvria/</a>	This guidance document was developed as the basis for identifying the key interfaces across the connected vehicle environments, which will support future analysis to identify and prioritize standards development activities. CVRIA was developed in four views: enterprise, functional, physical, and communications. The document also provides guidance on developing the CVRIA, including a list of source documents and primary resources.	The development of the architecture will assist implementers of CAV technology by serving as a framework of useful policy and state specific guidelines down the road. The CVRIA should be used to assist with the development of CAV standards based on stakeholder input.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Best Practices for Surveying/Mapping Roadways and Intersections for Connected Vehicle Applications	Connected Vehicle Pooled Fund Study University of Virginia	Farrell, M. Todd, and M. Barth University of California, Riverside (UCR)	May-16	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/Mapping-Final-Report-FINAL-20160915.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/Mapping-Final-Report-FINAL-20160915.pdf</a>	The goal of this project was to analyze and document the surveying and mapping requirements for expected connected vehicle applications, and to determine the best practices that should be used to satisfy them. An emphasis was placed on efficiency, particularly with respect to lowering the costs and time required. Additional considerations included safety of personnel performing the work, accuracy of the measurements, minimal/no lane closures needed, minimal time required to complete the work, and creation of maps that are easy to update as aspects of the location change.	This research document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of the Joint Statewide CAV Strategic Plan.
NCHRP Policy and Planning Actions to Internalize Societal Impacts of CV and AV Systems in Market Decisions	NCHRP	B. Ray Derr Texas A&M Transportation Institute	May-16	<a href="http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3934">http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3934</a>	NCHRP provides policy and planning strategies to help internalize the societal impacts of AV and CV technologies in market decisions made by consumers and producers. The positive and negative impacts of CAV technology are discussed, including reduced collisions and inefficient urban growth patterns, and potential solutions are provided. Solutions include taxes and fees, subsidies and grants, planning, and policy making. The document also provides information on the research being conducted, what agencies are conducting the research, and how the research is broken up into six tasks to produce a final deliverable in 15 months.	This document provides policy and planning strategies to help internalize societal impacts for automated vehicles and connected vehicles. Automated technologies in the automobile industry have the ability to revolutionize personal transport, freight, and transit. Since these technologies will be deployed independently from state to state, it is important that each state understand the positive and negative impacts from AV and CV. Pennsylvania and its regional/local governments could benefit greatly if they are sufficiently prepared for the onset of this technology. This would include implementing regulation and taxes as well as hosting public education seminars.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Automated Commercial Motor Vehicles: State of the Industry and Potential Safety Impacts	USDOT FMCSA	Brian Routhier USDOT FMCSA	Jan-16	<a href="https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/Automated%20CMVs-State%20of%20the%20Industry%20and%20Potential%20Safety%20Impacts-508C.pdf">https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/Automated%20CMVs-State%20of%20the%20Industry%20and%20Potential%20Safety%20Impacts-508C.pdf</a>	This report provides information on current automated technology, anticipated advancements, and active and proposed projects relating to automated commercial motor vehicles. An overview of the different levels (1-4) of automation is provided, as well as information on technical and policy changes. A number of proposed Federal Motor Carrier Safety Administration (FMCSA) projects, Federal Highway Administration (FHWA) projects, and FMCSA joint projects are also discussed.	This document outlines the levels of automation for commercial vehicles and discusses the potential obstacles for the development of automated commercial vehicles. The document should help when developing the policy and framework for CAV from the freight and motor carrier standpoint.
Automated and Connected Vehicles: Summary of the 9th University Transportation Centers Spotlight Conference	Transportation Research Board	Katherine F. Turnbull Texas A&M Transportation Institute	Nov-15	<a href="http://www.trb.org/Main/Blurbs/174288.aspx">http://www.trb.org/Main/Blurbs/174288.aspx</a>	Three plenary sessions summaries from the conference discuss automated vehicle institutional policies, infrastructure design and operations, and planning. Plenary session 1 discussed an AV best practices working group along with ethical considerations for AV systems, and insurance related to these systems. Plenary session 2 discussed infrastructure design and operations and focuses on the Ohio Smart Mobility Initiative. Plenary session 3 focused on planning and specifically CAV deployment implications on transportation agencies and travel behavior.	This document provides notes from the Automated and Connected Vehicles session during the Transportation Research Board conference proceedings on November 4-5, 2015. The conference provided insight on several aspects of the connected and autonomous vehicle technologies including institutional policy, planning and infrastructure design and operations. Consideration of these topics will be important when the Joint Statewide CAV Strategic Plan effort begins.



DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
5.9 GHz Dedicated Short Range Communication Vehicle-Based Road and Weather Condition Application	Connected Vehicle Pooled Fund Study University of Virginia	Synesis Partners LLC	Aug-15	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/90-CVPFS_DSRC_RdWx_Documents_v1.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/90-CVPFS_DSRC_RdWx_Documents_v1.pdf</a>	The objectives of this research project were to develop and test the acquisition of road and weather condition information from 5.9 gigahertz (GHz) dedicated short range communications (DSRC)-equipped public agency vehicles; to transmit this data via roadside equipment (RSE) to a central server; and ultimately to store it in the Clarus system for use by agency maintenance personnel.	The 5.9 GHz Dedicated Short Range Communication Vehicle-Based Road and Weather Condition Application research document will provide information for short and long-term recommendations, as well as for potential pilot projects to be documented as part of the Joint Statewide CAV Strategic Plan.
ITS Strategic Plan 2015-2019	USDOT ITS JPO	NA	Dec-14	<a href="https://www.its.dot.gov/strategicplan.pdf">https://www.its.dot.gov/strategicplan.pdf</a>	This document constitutes the Intelligent Transportation Systems Strategic Plan covering the years 2015 to 2019; it builds on the progress of the 2010-2014 plan and presents a wide array of technical, policy, institutional, and organizational concepts. It provides a comprehensive perspective that is based on an inclusive, collaborative, interactive, and iterative process, with a wide mix of stakeholder engagement opportunities that ensured that the Strategic Plan reflects the aspirations of the multi-faceted ITS community across the nation. This new plan has the following: identifies a vision; outlines technology lifecycle stages and strategic themes articulating outcomes and performance goals that define six program categories; describes “Realizing Connected Vehicle Implementation” and “Advancing Automation” as the primary technological drivers of current and future ITS work across many sectors; and, presents enterprise data, interoperability, ITS deployment support, and emerging ITS capabilities as additional program categories that are supplemental and interdependent activities critical to achieving the program’s vision. The plan further identifies research questions aligned to every program category in each stage of the technology lifecycle, in addition to cross-cutting organizational and operational disciplines that relate to the program categories.	The USDOT ITS Strategic Plan 2015-2019 will lay a foundation for the Joint Statewide CAV Strategic Plan and provide a comprehensive nationwide perspective of connected and automated vehicles technologies.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Deployment Strategy for Rural Connected Vehicle Systems	ENTERPRISE Transportation Pooled Fund	Cogenia Partners	Sep-14	<a href="http://www.enterprise.prog.org/Projects/2010_Present/intellidriveconops.html">http://www.enterprise.prog.org/Projects/2010_Present/intellidriveconops.html</a>	This document describes the deployment options and the recommended strategy of the deployment of a Rural Connected Vehicle system. The intent of this effort was to identify the needs of rural users and the constraints imposed by the rural environment, and to conceptualize a variant of the connected vehicle system that is uniquely adapted to meet those needs given those constraints.	The Deployment Strategy for Rural Connected Vehicle Systems research document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of this effort that will directly impact the rural areas of PA.
Impacts of Vehicle Automation on Workforce Training and Driver's Licensing	Transportation Research Board	Yeganeh Mashayekh Hayeri (Upenn); Corey Harper, Chris T. Hendrickson, Allen Biehler (Carnegie Mellon University)	Aug-14	<a href="https://trid.trb.org/view.aspx?id=1337661">https://trid.trb.org/view.aspx?id=1337661</a>	This article evaluates the impacts that vehicle automation will have on workforce training and driver's licensing and provides recommendations on how to accommodate these changes. Vehicle technician training will move towards electronics and computer science, and engineering certification exams will shift to include updated and new curricula relating to CAVs. Driver training will begin to focus more on emergency situations and handling system malfunctions. Licensing should expand to include different levels of light-duty vehicle licenses for fully-automated and manual/semi-automated vehicles. Skills tests will decrease and eventually become obsolete for fully-automated vehicles, but knowledge tests will increase with increasing technological components of vehicles. People with medical impairments will likely be able to receive licenses for vehicles that do not require any human interaction. The article recommends that the industry continue to update and change its educational and licensing systems with the increase in automated vehicle technology.	This document was produced as part of research project conducted for the Pennsylvania Department of Transportation by Carnegie Mellon University. The document provides insight toward the future of the transportation industry and makes recommendations to ensure the workforce is prepared for the changes. The document also evaluates the changes that will be necessary to ensure the driver licensing program remains relevant with emerging CAV technology. The evolution of the Transportation workforce in Pennsylvania will play a very important role when CAV deployment begins. The recommendations outlined in this document should be considered when laying out the framework for the CAV Strategic Plan.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
National Connected Vehicle Field Infrastructure Footprint Analysis	USDOT ITS JPO	James Wright (AASHTO); J. Kyle Garrett (Synesis Partners); Christopher J. Hill, Ph.D., PMP (Booz Allen Hamilton); Gregory D. Krueger, P.E. (Leidos); Julie H. Evans (Leidos); Scott Andrews (Cogenia Partners); Christopher K. Wilson (Cogenia Partners); Rajat Rajbhandari (Texas Transportation Institute); Brian Burkhard (Transpo Group)	Jun-14	<a href="https://ntl.bts.gov/lib/52000/52600/52602/FHWA-JPO-14-125_v2.pdf">https://ntl.bts.gov/lib/52000/52600/52602/FHWA-JPO-14-125_v2.pdf</a>	The American Association of State Highway and Transportation Officials (AASHTO), with the support of USDOT and Transport Canada, undertook a Connected Vehicle Field Infrastructure Footprint Analysis to provide supporting information to agency decision-makers. This report consists of a vision for a national footprint; a description of the background for and current research on connected vehicle deployments; a set of assumptions underlying the infrastructure footprint analysis; the applications analysis; the deployment concepts, the preliminary national footprint, including the value proposition, deployment objectives, context, scenarios, and experience to date; and a preliminary deployment and operations cost estimation.	The National Connected Vehicle Field Infrastructure Footprint Analysis will help in the analysis of possible pilot projects that can be deployed soon as part of the Joint Statewide CAV Strategic Plan.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Traffic Management Centers in a Connected Vehicle Environment	Connected Vehicle Pooled Fund Study University of Virginia	Kimley-Horn and Associates, Inc. (KHA), Noblis, DGD Enterprises, and Bernie Wagenblast	Jun-13	<a href="http://www.cts.virginia.edu/cvpfs_research/">http://www.cts.virginia.edu/cvpfs_research/</a>	This project examined operational, technical and policy impacts of a new traffic management center (TMC) environment. The objectives of this project were to identify current connected vehicle activities that have the potential to have the highest impact on TMCs; identify what TMC functions or activities could most benefit from integrating connected vehicle data and capabilities; assess overall “readiness” of TMCs to adapt to a connected vehicle environment and identify challenges, constraints and potential timeframe considerations; and develop a concept for a future TMC within a connected vehicle environment to be able to proactively plan for future TMC operations, partnerships, and capabilities.	This research document will provide information regarding impacts PA TMCs may face due to deployment of CAV applications. This will feed into the short- and long- term recommendation that will be part of the PA Joint Statewide CAV Strategic Plan.
Enabling Accelerated Installation of Aftermarket On-Board Equipment for Connected Vehicles	Connected Vehicle Pooled Fund Study University of Virginia	Industrial Technology Research Institute, California PATH of the University of California at Berkley, and Visteon Corporation	May-12	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_AFTER99_Final1.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_AFTER99_Final1.pdf</a>	The goal of this project was to evaluate the potential approaches for accelerating the introduction of aftermarket on-board equipment (OBE) devices to the vehicle fleet. The objectives of this project were to analyze industry’s ability to manufacture multi-band aftermarket OBE units; to identify actions necessary to reduce consumer cost of aftermarket OBE purchase; and to identify actions needed to accelerate installation of aftermarket OBE units in the vehicle fleet. The four deliverables for the project included a State of the Industry Report, Vendor/Market Readiness Report, Procurement Guidance Document, and Strategic Report summarizing recommended actions.	This research document will provide information for short and long-term recommendations, as well as for potential pilot projects to be documented as part of the Joint Statewide CAV Strategic Plan.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Certification Program for Cooperative System/Connected Vehicle Technologies	Connected Vehicle Pooled Fund Study University of Virginia	Timothy J. McGuckin, Executive Director, OmniAir Consortium, Inc.	May-12	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_CERT99_Final.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_CERT99_Final.pdf</a>	A critical component to the overall success of national, interoperable Cooperative System and Connected Vehicle deployments is a robust certification process that ensures performance and interoperability of said technologies and systems. This project investigated the current landscape of certification activity in this space, assessed the needs of state and local infrastructure owners, and identified the gaps that may exist between current activity and state and local needs. The deliverable consisted of actionable certification-related recommendations that further promote state & local efforts to deploy cooperative and connected transportation systems.	The Certification Program for Cooperative System/Connected Vehicle Technologies research document will provide information for short- and long- term recommendations as it relates to the workforce requirements area of the Joint Statewide CAV Strategic Plan.
Multi-Modal Intelligent Traffic Signal System – Phase I: Development of Concept of Operations, System Requirements, System Design and a Test Plan	Connected Vehicle Pooled Fund Study University of Virginia	University of Arizona (Lead), University of California PATH Program, Savari Networks, Inc., SCSC, Econolite, Kapsch, and Volvo Technology	Apr-12	<a href="http://www.cts.virginia.edu/cvpfs_research/">http://www.cts.virginia.edu/cvpfs_research/</a>	The objectives of this project are to develop a concept of operations, systems requirements and system design for a comprehensive traffic signal system that services multiple modes of transportation, including general vehicles, transit, emergency vehicles, freight fleets and pedestrians; and to prepare for field testing/demonstration of the developed Multi-Modal Intelligent Traffic Signal System.	Multi-Modal Intelligent Traffic Signal System – Phase I document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of the Joint Statewide CAV Strategic Plan.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Investigating the Potential Benefits of Broadcasted Signal Phase and Timing (SPaT) Data under IntelliDriveSM	Connected Vehicle Pooled Fund Study University of Virginia	California PATH Program Institute of Transportation Studies University of California, Berkeley	May-11	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_SPAT99_Final.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_SPAT99_Final.pdf</a>	This report identifies the transportation applications that could be implemented if real-time data about traffic Signal Phase and Timing (referred to as SPaT data) could be broadcasted for signalized intersections and received by vehicles. These applications can support improvements in both safety and mobility of arterial driving. Preliminary estimates are provided of the potential benefits that could be gained from these applications if all vehicles and signalized intersections were equipped. Actual benefits will be scaled down based on actual market penetrations. Finally, some of the practical considerations involved in implementing SPaT messaging from signalized intersections are addressed, based on recent experimental experience. The goal of this project was set to investigate the potential benefits of using broadcasted SPaT data under an IntelliDrive <sup>SM</sup> environment.	This research document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of the Joint Statewide CAV Strategic Plan.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
Investigation of Pavement Maintenance Applications of IntellidriveSM (Final Report): Implementation and Deployment Factors for Vehicle Probe-Based Pavement Maintenance (PBPM)	Connected Vehicle Pooled Fund Study University of Virginia	Jeremy Dawkins, Richard Bishop (Bishop Consulting), Buzz Powell, David Bevly Auburn University	May-11	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_PMSA99_Final.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_PMSA99_Final.pdf</a>	The international roughness index (IRI) is a standardized pavement roughness measurement that was developed in the 1980s. IRI is usually calculated from longitudinal profile measurements obtained during pavement profiling surveys using specialized equipment. Another important measurement needed for pavement maintenance is detecting and locating (mapping) potholes. It is expected that, using IntelliDrive <sup>SM</sup> probe vehicles, pavement condition may be assessed with greater coverage in a timelier manner. As such, the goal of this project was to investigate if vehicular data available from IntelliDrive <sup>SM</sup> can be used to measure the pavement condition. Specific objectives include to develop estimates of the International Roughness Index (IRI); to detect and map potholes; and to understand and document specific risks, constraints and opportunities in a large-scale deployment of the proposed system.	The Investigation of Pavement Maintenance Applications of Intellidrive <sup>SM</sup> research document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of this effort.

DOCUMENT TITLE	AGENCY/ ORGANIZATION	AUTHOR(S)	PUBLICATION DATE	SOURCE	SUMMARY	RELATIONSHIP TO PENNSYLVANIA JOINT STATEWIDE CAV STRATEGIC PLAN
IntelliDrive <sup>SM</sup> Traffic Signal Control Algorithms	Connected Vehicle Pooled Fund Study University of Virginia	Brian L. Smith, Ramkumar Venkatanarayana, Hyungjun Park, Noah Goodall, Jay Datesh, and Corbin Skerrit University of Virginia	Apr-11	<a href="http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_SIG99_Final.pdf">http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_SIG99_Final.pdf</a>	Current traffic signal control algorithms cannot take full advantage of the rich vehicular information that will be available from IntelliDrive <sup>SM</sup> (Connected Vehicles). As such, the goal of this research project was to develop and investigate expected benefits of traffic signal control algorithms designed specifically to take advantage of IntelliDrive <sup>SM</sup> . The objectives were to develop and evaluate new traffic signal control algorithms by fully utilizing new IntelliDrive <sup>SM</sup> data sources; to develop tools for generating meaningful arterial Measures of Effectiveness (MOEs) from IntelliDrive <sup>SM</sup> data sources; and to understand and document specific risks, constraints and opportunities of the developed algorithms in a large-scale deployment.	The IntelliDrive <sup>SM</sup> Traffic Signal Control Algorithms research document will provide information for short- and long- term recommendations, as well as for potential pilot projects to be documented as part of the Joint Statewide CAV Strategic Plan.



## Jurisdictional Guidelines for the Safe Testing and Deployment of HAVs

May 2018

American Association of Motor Vehicle Administrators (AAMVA)

<https://www.aamva.org/GuidelinesTestingDeploymentHAVs-May2018/>

**The purpose of this report is to address how automated vehicle technology will directly impact vehicle registration and titling programs; driver training, testing, and licensing programs; enforcement of traffic laws; and first response to traffic related incidents.**

AAMVA recognized an opportunity to provide leadership and assistance to the motor vehicle administrative and law enforcement communities by establishing the Autonomous Vehicle Working Group (AVWG) to examine the potential impacts of highly automated vehicle (HAV) testing and deployment on these communities and to develop guidance.

This report contains recommendations for jurisdictions that choose to regulate testing and deployment of highly automated vehicle (HAVs). The recommendations are voluntary; jurisdictions are not required to adopt them. The following provides a summary of the four major sections outlined in this report to address the safe testing and deployment of HAVs.

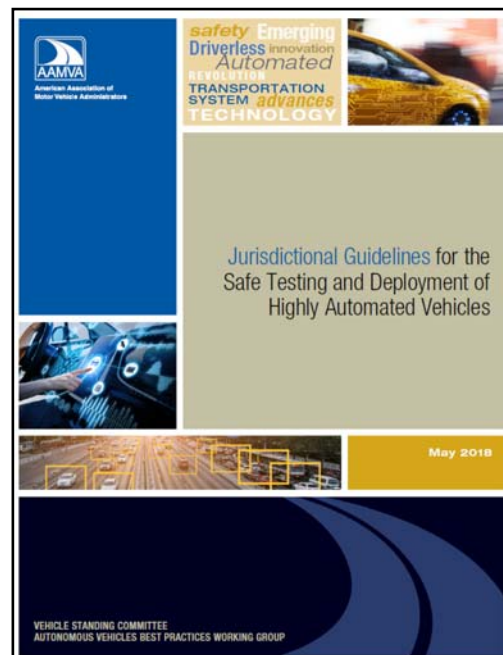
**Administrative Considerations**—This chapter addresses the administrative considerations for the safe testing and deployment of HAVs.

**Vehicle Credentialing Considerations**—This chapter addresses how automated vehicle technology will directly impact vehicle registration, titling programs, license plates, financial responsibility, and safety standards.

**Driver Licensing Considerations**—This chapter addresses how automated vehicle technology will directly impact driver training, driver testing and licensing programs.

**Law Enforcement Considerations**—This chapter addresses how automated vehicle technology will directly impact enforcement of traffic laws and first response to traffic related incidents.

AAMVA will continue to work closely with and coordinate HAV initiatives through partnerships with the United States Department of Transportation (U.S. DOT) and the Canadian Council of Motor Transport Administrators (CCMTA).



### Key Terms and Acronyms

HAVs | Highly Automated Vehicles

DDT | Dynamic driving task

AVWG | Autonomous Vehicle Working Group

## Automated Driving Systems 2.0: A Vision for Safety

September 2017

U.S. Department of Transportation (DOT) / National Highway Traffic Safety Administration (NHTSA)

[https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0\\_090617\\_v9a\\_tag.pdf](https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf)

**This document replaces the Federal Automated Vehicle Policy released in 2016. This updated policy framework offers a path forward for the safe deployment of automated vehicles by encouraging new entrants and ideas that deliver safer vehicles; making Department regulatory processes more nimble to help match the pace of private sector innovation; and supporting industry innovation and encouraging open communication with the public and with stakeholders.**

In this document, NHTSA offers a nonregulatory approach to automated vehicle technology safety. Section 1: Voluntary Guidance for Automated Driving Systems supports the automotive industry and other key stakeholders as they consider and design best practices for the testing and safe deployment of Automated Driving Systems (ADSs - SAE Automation Levels 3 through 5 – Conditional, High, and Full Automation Systems). It contains 12 priority safety design elements for consideration, including vehicle cybersecurity, human machine interface, crashworthiness, consumer education and training, and post-crash ADS behavior.

Vehicles operating on public roads are subject to both Federal and State jurisdiction, and States are beginning to draft legislation to safely deploy emerging ADSs. To support this, NHTSA offers Section 2: Technical Assistance to States, Best Practices for Legislatures Regarding Automated Driving Systems. The section clarifies and delineates Federal and State roles in the regulation of ADSs. NHTSA remains responsible for regulating the safety design and performance aspects of motor vehicles and motor vehicle equipment; States continue to be responsible for regulating the human driver and vehicle operations. The section also provides Best Practices for Legislatures, which incorporates common safety-related components and significant elements regarding ADSs that States should consider incorporating in legislation. In addition, the section provides Best Practices for State Highway Safety Officials, which offers a framework for States to develop procedures and conditions for ADSs' safe operation on public roadways. It includes considerations in such areas as applications and permissions to test, registration and titling, working with public safety officials, and liability and insurance. This document serves to support industry, Government officials, safety advocates, and the public.



### Key Terms and Acronyms

ADSs | Automated Driving Systems

ODD | Operational Design Domain

OEDR | Object and Event Detection and Response

### Adopting and Adapting: States and Automated Vehicle Policy

June 2017

Eno Center for Transportation

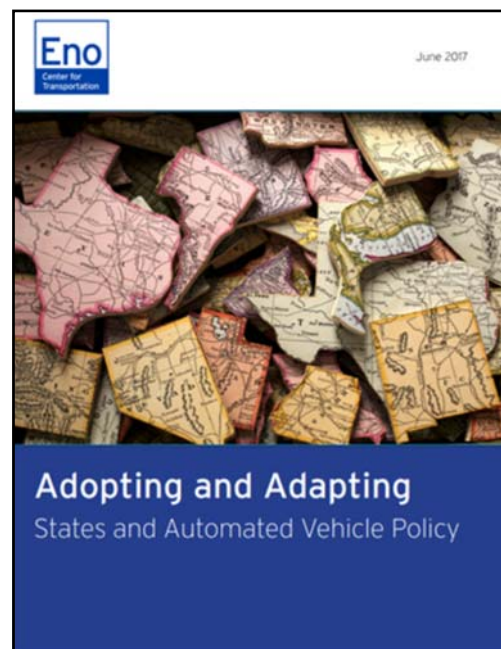
[http://www.enotrans.org/wp-content/uploads/2017/06/StateAV\\_FINAL-1.pdf](http://www.enotrans.org/wp-content/uploads/2017/06/StateAV_FINAL-1.pdf)

**Provides a collection of policies concerning automated vehicles and outlines how they vary from state to state.**

The major topics included about state automated vehicle policies are existing approaches to automated vehicles, state-level regulations, infrastructure investment and funding, and research and workforce training.

States have one of four approaches to automated vehicle policy:

1. They have no regulations or laws specifically for automated vehicles, but may be working to create laws.
2. They have explicitly expressed interest in automated vehicles but have passed no laws. Interest is expressed through executive orders, proclamations, studies, etc.
3. They explicitly allow automated vehicle testing. This is the case in MI, CA, UT, NV, and TN, which all have varying laws to create a framework for automated vehicle testing.
4. They have laws that allow fully automated vehicles to be deployed beyond the testing phase. Only FL and GA allow for the operation of driverless vehicles, while DC allows deployed fully automated vehicles only if a driver is still present.



Although legislation varies by state, it will not necessarily attract or deter automated vehicle testing. While some states have steadily housed automated vehicle testing even before legislation was created, others have legislation in place but have attracted no major companies for testing. Some states have stricter regulations than others, potentially requiring certifications and specific reporting requirements.

It is important for states to invest in improving roadways and keeping them in a good state of repair to help facilitate automated vehicles. As this is not always the case, developers are beginning to work towards advancing systems to work with the current state of existing roadways.

Universities play a large role in research and pilot programs for automated vehicles since they are not subject to state laws when operating on university grounds.

### Key Terms and Acronyms

The Eno Center | The Eno Center strives to cultivate creative leadership and to impact emerging issues for the nation's multi-modal transportation system

Pennsylvania's AV Policy Approach | Pennsylvania falls under Approach 2 as they have established an AV task force but currently have no formal legislation

**National Highway Traffic Safety Administration Notice of Proposed Rulemaking**

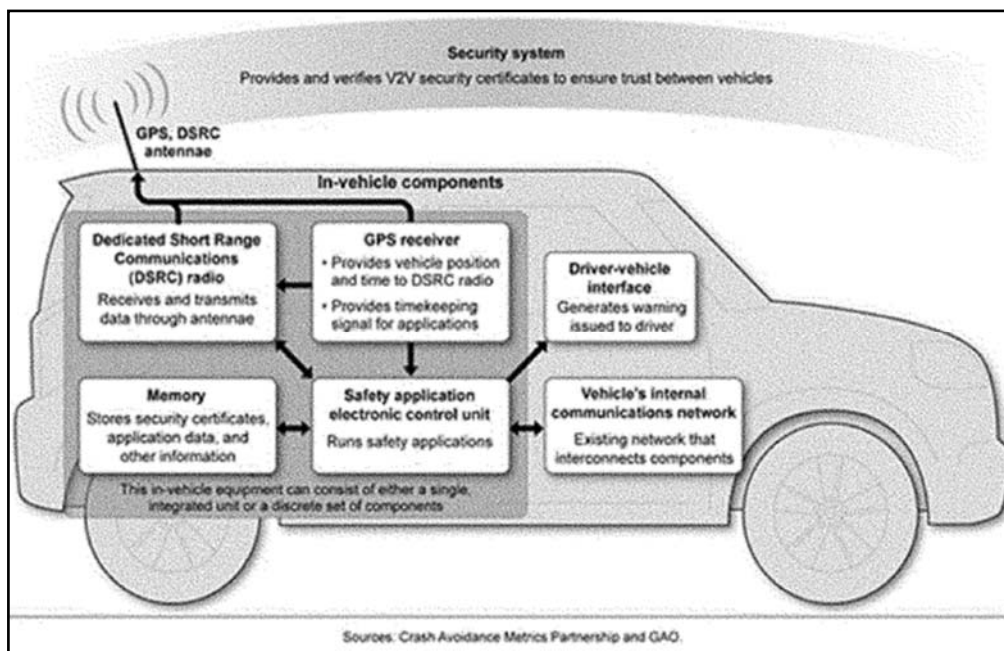
January 12, 2017

National Highway Traffic Safety Administration

<https://www.gpo.gov/fdsys/pkg/FR-2017-01-12/pdf/2016-31059.pdf>

**NHTSA is proposing to issue a new FMVSS, No. 150, to require all new light vehicles to be capable of V2V communications and to standardize the message and format of V2V transmissions.**

NHTSA believes that V2V communications will be able to address crashes that cannot be prevented by current in-vehicle camera and sensor-based technologies due to the fact that V2V communications contain additional information and are not affected by weather, lighting, and cleanliness like vehicle-resident sensors. In the longer-term this will be the first step towards self-driving cars.



V2V communications will also face challenges that are not present for vehicle-resident sensors, which is what these new NHTSA FMVSS are needed. Vehicles must be able to communicate a standard set of information using interoperable communications that all vehicles can understand. Additionally, the benefits of a V2V system depend directly on wide-spread adoption of the system. NHTSA sees this as unlikely to happen voluntarily, which is why it will be required.

The proposed rule outlines the V2V system as a combination of many elements including: a radio technology for the transmission and reception of messages, the structure and contents of BSMs, and the authentication of incoming messages; the capability to receive over-the-air security and software updates; and firewalls between V2V modules to isolate them from being used as a conduit into other vehicle systems.

**Key Terms and Acronyms**

FMVSS | Federal Motor Vehicle Safety Standards

BSM | Basic Safety Message



## Multi-Modal Intelligent Traffic Signal System – Phase II

September 2016

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

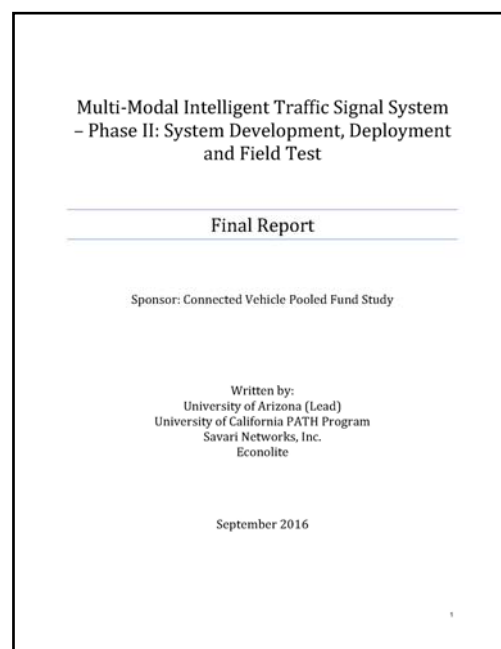
[http://www.cts.virginia.edu/cvpfs\\_research/](http://www.cts.virginia.edu/cvpfs_research/)

**The objectives of this project were to develop a detailed design, construct the software and hardware system, and conduct a field test of a comprehensive traffic signal system that services multiple modes of transportation, including general vehicles, transit, emergency vehicles, freight fleets and pedestrians.**

This document constitutes the final report for the Multi-Modal Intelligent Traffic Signal Systems (MMITSS) Phase II Development and Field Testing Project. The purpose of this document was to capture project details and experience in addition to the documentation in the MMITSS Concept of Operations, MMITSS System Requirements, and MMITSS Detailed Design Documents including laboratory and field-testing procedures and experience, simulation modeling approach and tools developed, general impressions and findings, and recommendations for future MMITSS development and deployment opportunities.

The MMITSS project was divided into four technical segments. The development of the Concept of Operations (ConOps), including the solicitation of Stakeholder inputs and feedback, was the first technical stage. The reviewed Stakeholder inputs and ConOps were used to develop, define, and populate the MMITSS system requirements in the second technical stage. In the third stage, the system requirements and prior research were used to define the MMITSS system design. The design effort utilized the California test bed and the Arizona test bed as the target implementation networks. The final stage included Detailed Design, System Implementation and Integration, Field Integration and Testing, and a System Demonstration.

The Phase II MMITSS development, field testing, and demonstrations resulted in two MMITSS prototypes (Arizona –AZ and California-CA) that realized advanced traffic control in a connected vehicle environment. Both prototypes implemented traffic control algorithms that utilized the rich data available from connected vehicles. The AZ MMITSS utilized concepts from adaptive and priority based traffic signal control together with the NTCIP standard for communications to the traffic signal controller. The CA MMITSS utilized enhancements to more traditional traffic signal control where the control logic resided within the Caltrans 2070 controller firmware, but adjustments were made based on connected vehicle data.



### Key Terms and Acronyms

MMITSS | Multi-Modal Intelligent Traffic Signal Systems

CVRIA | Connected Vehicle Reference Implementation Architecture

ConOps | Concept of Operations

## Federal Automated Vehicles Policy

September 2016

National Highway Traffic Safety Administration (NHTSA)

<https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016>

**United States Department of Transportation (USDOT) issued a policy for automated vehicles, laying a path for the safe testing and deployment of new auto technologies that have enormous potential for improving safety and mobility for Americans on the road.**

The policy sets a proactive approach to providing safety assurance and facilitating innovation through four key parts.

Vehicle performance guidance uses a 15-point Safety Assessment to set clear expectations for manufacturers developing and deploying automated vehicle technologies. The Vehicle Performance Guidance for Automated Vehicles for manufacturers, developers and other organizations includes this 15 point Safety Assessment for the safe design, development, testing and deployment of automated vehicles.

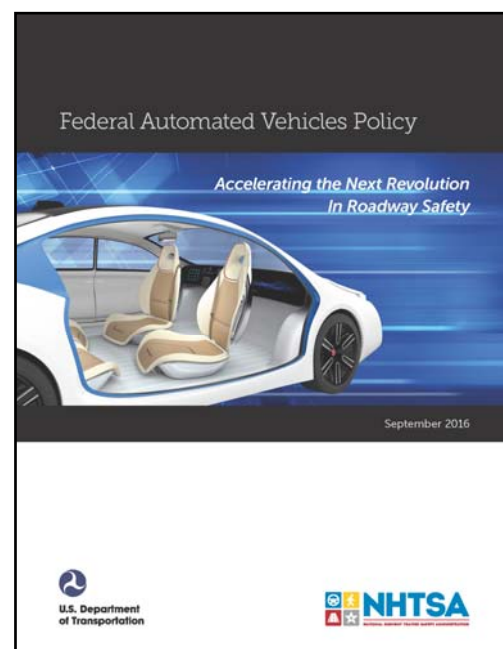
Model state policy delineates the Federal and State roles for the regulation of highly automated vehicle technologies as part of an effort to build a consistent national framework of laws to govern self-driving vehicles.

The policy also outlines options for the further use of current federal authorities to expedite the safe introduction of highly automated vehicles into the marketplace.

Finally, it discusses new tools and authorities the federal government may need as the technology evolves and is deployed more widely.

This Policy sets out an ambitious approach to accelerate the highly automated vehicles (HAV) revolution. Policy was issued as agency guidance rather than in a rulemaking in order to speed the delivery of an initial regulatory framework and best practices to guide manufacturers and other entities in the safe design, development, testing, and deployment of HAVs.

The primary focus of the policy is on highly automated vehicles, or those in which the vehicle can take full control of the driving task in at least some circumstances. Portions of the policy also apply to lower levels of automation, including some of the driver-assistance systems already being deployed by automakers today.



## Key Terms and Acronyms

USDOT | United States Department of Transportation

HAV | Highly Automated Vehicles

15-point Safety Assessment | Vehicle Performance Guidance for Automated Vehicles

### USDOT Guidance Summary for Connected Vehicle Deployments

July 2016

USDOT Intelligent Transportation Systems Joint Program Office

<https://ntl.bts.gov/lib/60000/60400/60443/FHWA-JPO-16-337.pdf>

**To assist Pilot Deployers complete Concept Development Phase deliverables, USDOT provides additional guidance on application requirements, deliverables, and key challenges they will face.**

The SET-IT software, developed by USDOT and Iteris, provides a single software tool that integrates drawing and database tools with the CVRIA so that users can develop project architectures for pilots, test beds and early deployments. The application requirements address new code, existing applications, the Connected Vehicle Security Credential Management System (SCMS), and the System Requirements Specification (SyRS) document. All new codes (including pseudo-code and coding algorithms) and applications must be released on the USDOT Open Source Application Development Portal

(OSADP), and new applications must also be licensed under an Open Source License (preferably Apache 2.0). Existing applications used for the Pilot Deployment do not need to be open source or available to the public, however, any new interfaces or modifications made to the applications must be added on the OSADP. A minimum of one part of the developed application must use at least part of the SCMS, and additional security systems may be used independently or along with SCMS. All requirements of the application must be included in the SyRS document, and contractors are also encouraged to make a traceability matrix to follow a clear path to the origin of the requirement for the application feature.

The key challenges to Pilot Deployers include archiving the code, supporting integration and future use, utilizing the SCMS, and controlling the cost and schedule. To archive new code, all requirements outlined in the the OSADP and ITSForge website must be met and will be reviewed by USDOT before final submission. Pilot Deployers are encouraged to consider the total life cycle of the application early on, concentrate on how application modifications will be used in the future, and develop all codes with the mindset of reusability. Pilot Teams are encouraged to take time to understand the system and attend bi-weekly roundtables to address more detailed questions. Pilot Deployers should ensure that timetables and budgets are detailed with set goals and milestones. They should also keep the entire software development team in mind when setting these goals and avoid requirement inflation and scope creep through utilizing the SyRS. The newest version of the software (SET-IT 2.0) is now available on the USDOT-JPO website. The update includes bug fixes from the previous version and the ability to generate a “communications view of the drawings and tables.



### Key Terms and Acronyms

SCMS | Connected Vehicle Security Credential Management System

SyRS | System Requirements Specifications

USDOT OSADP | Open Source Application Development Portal

## Connected Vehicles Reference Implementation Architecture

June 23, 2017

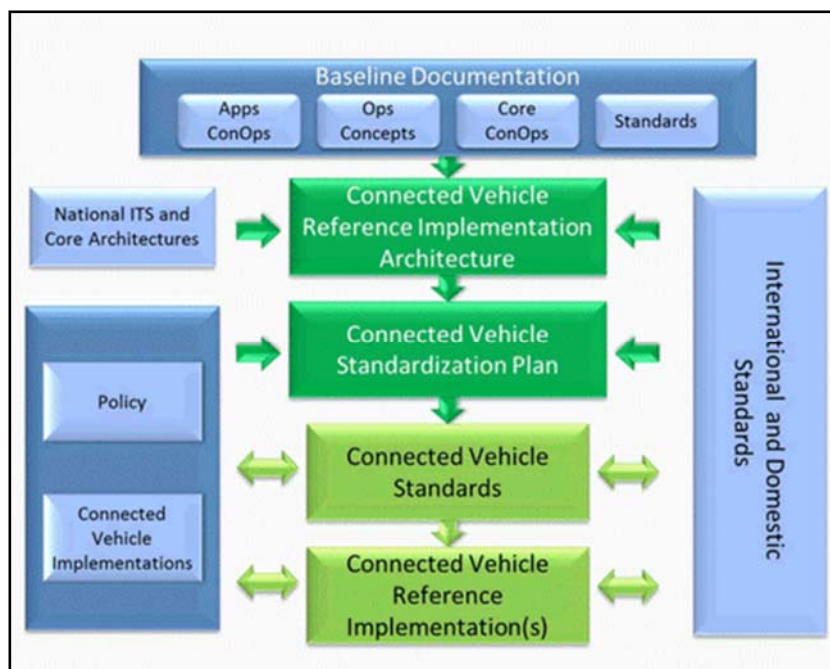
USDOT Intelligent Transportation Systems Joint Program Office

<http://local.iteris.com/cvria/>

**This guidance was developed as the basis for identifying the key interfaces across the connected vehicle environment, which will support future analysis to identify and prioritize standards development activities.**

CVRIA is developed in 4 views:

- Enterprise - describes the relationships between organizations and their roles in the CAV environment
- Functional - describes abstract functional processes and their interactions that satisfy system requirements
- Physical - describes physical objects, their application objects, and high-level interfaces between those objects
- Communications - describes sets of protocols required to support communications among physical objects



The document also provides guidance on the approach to develop the CVRIA. This includes a list of source documents: baseline ConOps for connected vehicle applications, operational concepts, core system ConOps, existing standards, existing national ITS architecture, core system architecture, and international/domestic standards.

This also includes primary sources for application concepts and needs such as reports from USDOT, the DMA program, and the VSC-A final report.

The CVRIA provides a unifying framework that covers ITS comprehensively but focuses on including connected vehicle within traditional infrastructure ITS capabilities.

### Key Terms and Acronyms

ConOps | Concept of Operations

CVRIA | Connected Vehicles Reference Implementation Architecture

DMA | Dynamic Mobility Applications

VSC-A | Vehicle Safety Communications - Applications



### Best Practices for Surveying/Mapping Roadways and Intersections for CV

May 2016

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

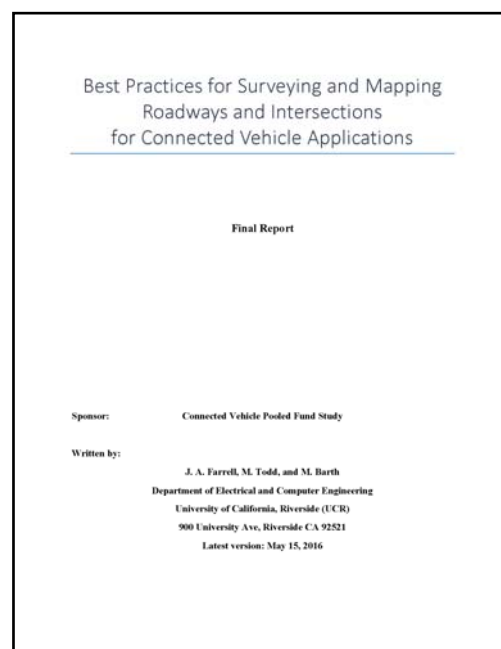
[http://www.cts.virginia.edu/wp-content/uploads/2014/04/90-CVPFS\\_DSRC\\_RdWx\\_Documents\\_v1.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/90-CVPFS_DSRC_RdWx_Documents_v1.pdf)

**The goal of this project was to analyze and document the surveying and mapping requirements for expected connected vehicle (CV) applications, and to determine the best practices that should be used to satisfy them.**

This report presents a technology and methodology review of current mapping methods and technologies. An emphasis was placed on efficiency, particularly with respect to lowering the costs and time required. Additional considerations included safety of personnel performing the work, accuracy of the measurements, minimal/no lane closures needed, minimal time required to complete the work, and creation of maps that are easy to update as aspects of the location change.

In the report, several ways that maps can be acquired were described. Based on the analysis, it was found that mobile terrestrial laser scanning (MTLS) methods work best for connected vehicles purposes. The research team reviewed the MTLS approach and examined the mapping and positioning accuracy requirements of a large number of CV applications, particularly those applications listed in the Connected Vehicle Reference Implementation Architecture (CVRIA).

Mobile Positioning and Mapping System (MPMS) were mounted on a vehicle platform, which collects positioning and mapping data from a variety of sensors and combines them to provide accurate, and continuously available information about both the trajectory of the MPMS and the surrounding areas, yielding more accurate and precise location detail and associated feature maps. This is achieved through a combination of global positioning satellite (GPS) technology, feature-based aiding sensors (vision, RADAR, LI-DAR) and high-rate kinematic sensors to capture and process multiple location and feature-based signals and to bridge data gaps whenever sensor reception is interrupted. For successful collaboration with automakers, it is expected that some entities will develop and maintain continent-scale roadway map databases, and eventually global scale. Maintenance of this master map will result in differences between the master map and the maps stored on user vehicles. The processes, general standards, and the SAE J2735 standard, which along with its modifications for demonstration purposes is the dominant standard for connected vehicle applications, were also discussed.



### Key Terms and Acronyms

MTLS | Mobile Terrestrial Laser Scanning

CVRIA | Connected Vehicle Reference Implementation Architecture

MPMS | Mobile Positioning and Mapping System

**NCHRP - 20-102(01) - Policy and Planning Actions to Internalize Societal Impacts of CV and AV Systems in Market Decisions (Interim Report)**

May 2016

National Cooperative Highway Research Program

[http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-102\(01\)\\_InterimReport.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-102(01)_InterimReport.pdf)

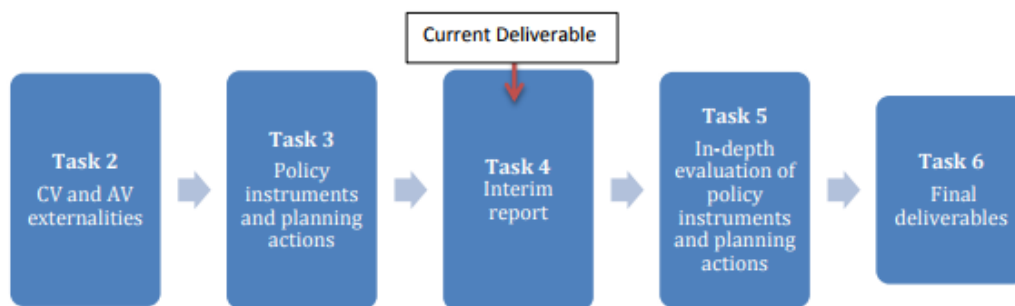
**Provides policy and planning strategies to help internalize the societal impacts of AV and CV technologies in market decisions made by consumers and producers.**

The NCHRP defines the positive and negative impacts that CAV technology may have on social welfare and market economics. The major positive impact is a reduction in collisions, not only for the owner of the CAV, but also for any car it avoids hitting. The major negative impact is an anticipated increase in commute times due to CAV technology potentially leading to inefficient and problematic urban growth patterns.

The report provides potential solutions to these issues through policy intervention. These solutions include taxes and fees, economic regulations, and subsidies or grants. Taxes and fees would work by discouraging the purchase of non-automated vehicles and thus encouraging the purchase of CAVs. Economic regulations, such as allowing drivers to purchase vehicles directly from consumers, will also encourage the use of CAVs. Subsidies and grants also encourage CAV use by offsetting the costs.

The report also suggests taking action through planning by including CAVs in LRTP, SRTP, and ITS plans.

Research into these issues is being conducted by a team comprised of four organizations and two research professionals. These include Texas A&M Transportation Institute, RAND Institute, Southwest Research Institute, University of Utah, André Weimerskirch of the University of Michigan Transportation Research Institute, and Shelly Row of Shelly Row Associates, LLC. The research is being broken up into six tasks which will result in a final deliverable within 15 months. Task 1 is the study management, Task 2 covers societal benefits and private sector interests, Task 3 covers policy and planning actions, Task 4 is the interim report, Task 5 is an in-depth evaluation of policy and planning actions, and Task 6 is the final deliverables.



Note: Task 1 is the study management.

**Key Terms and Acronyms**

NCHRP

LRTP | Long-Range Transportation Plan

SRTP | Short-Range Transportation Plan

## Automated Commercial Motor Vehicles: State of the Industry and Potential Safety Impacts

January 2016

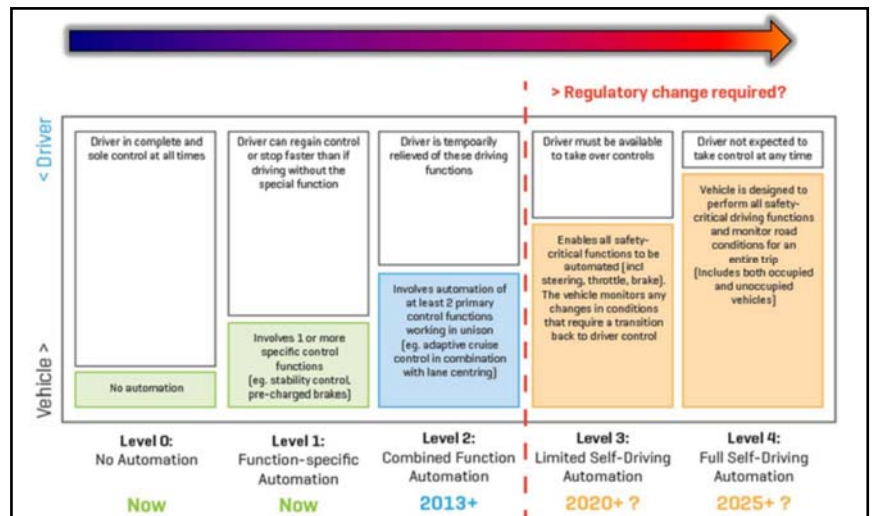
USDOT Federal Motor Carrier Safety Administration

<https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/Automated%20CMVs-State%20of%20the%20Industry%20and%20Potential%20Safety%20Impacts-508C.pdf>

The United States Department of Transportation Federal Motor Carrier Administration provides information on current automated technology, anticipated advancements, and active and proposed projects relating to Automated Commercial Motor Vehicles.

This documents outlines the levels of automation (from 0 to 4) for commercial vehicles and discusses the potential obstacles for the development of automated vehicles.

- Levels 1 to 2 are reflected in current commercial vehicle automation such as emergency braking, forward collision warning, lane departure warning, and smart cruise.
- Level 3 falls under near-term implementation and will function in constrained environments such as port queues, distribution warehouses, and mine hauling. The major function of commercial vehicles at Level 3 will be platooning, where a driver operates a first vehicles and additional vehicles follow under lateral and longitudinal control, as close as 36 feet from each other.



- Level 4 is not expected until after 2025, where the vehicle will be designed to perform all safety-critical driving functions, monitor road conditions for the entire trip, and not require the driver to take control at any time.

The document also includes information on technical and policy changes including public expectations, human factors, cybersecurity, testing and certifications, harmonizing state and local regulations, NHTSA mandates, FMCSRs, and inspections.

Additionally, a number of proposed FMCSA projects, active FHWA projects, and FMCSA joint projects are discussed. These projects include general CAV research, partial automation for truck platooning, CDL licensing, heavy truck CACC, automated truck queues, deployment engagement, and CAV analysis.

### Key Terms and Acronyms

FMCSR | Federal Motor Carrier Safety Regulations

CACC | Cooperative Adaptive Cruise Control

### Automated and Connected Vehicles: Summary of the 9th University Transportation Centers Spotlight Conference

November 2015

Transportation Research Board

<http://onlinepubs.trb.org/onlinepubs/conf/CPW19.pdf>

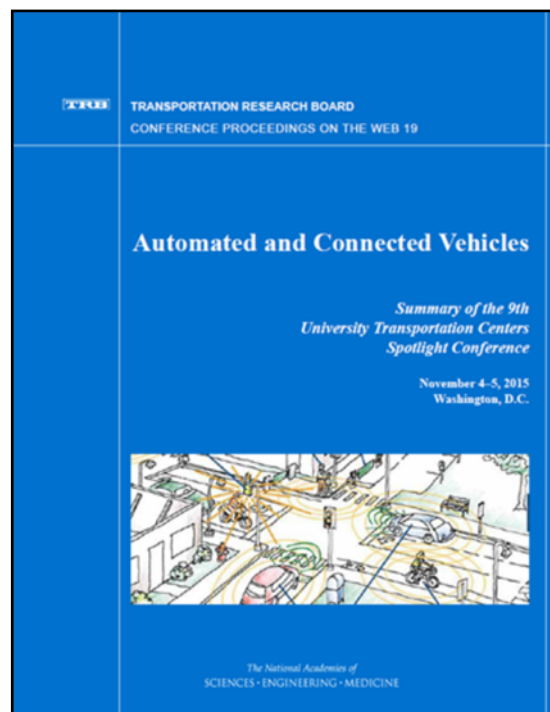
**Three plenary sessions summaries from the conference discuss automated vehicle institutional and policies, infrastructure design and operations, and planning.**

Plenary Session 1 discusses the AAMVA's automated vehicle best practices working group, ethical considerations for vehicle automation systems, and insurance related to automated driving systems. The working group is a NHTSA-funded 2 year project working with multiple stakeholders to gather, organize, and share information on testing and public use of automated vehicles. Ethical considerations were compiled through a collaboration between philosophy and engineering organized by a CA Polytechnic institute professor. One major consideration is the effect crash severity will have on insurance. Once minor crashes are eliminated, crashes that do occur, though rare, will be much more severe.

Plenary Session 2 discusses infrastructure design and operations, specifically focusing on the Ohio Smart Mobility Initiative. This initiative focuses on the development of smart mobility and smart city technology, which have major impacts on the state's transportation industry and will drive significant job growth. It also outlines the seven pillars of the initiative:

Technologies to improve safety; smart infrastructure; data analytics and cybersecurity; energy savings from autonomous applications; elderly and disabled mobility enhancements; food safety, security, and delivery; and artificial intelligence and ethics.

Plenary Session 3 focuses on planning, specifically CAV deployment implications on transportation agencies and travel behavior. It stresses that defining AVs vs CVs is important to develop a common understanding between agencies. This will eliminate confusion and uncertainty surrounding CAVs. It is also important to take into consideration the growth of CAVs over the next 25 years when planning for future mobility.



### Key Terms and Acronyms

Smart City | A city where investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic development and a high quality of life

UTC | University Transportation Centers, through the USDOT UTC Program, advance transportation research and technology and develop the next generation of transportation engineers

AAMVA| American Association of Motor Vehicle Administrators

### 5.9 GHz DSRC Vehicle-Based Road and Weather Condition Application

August 2015

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

[http://www.cts.virginia.edu/wp-content/uploads/2014/04/90-CVPFS\\_DSRC\\_RdWx\\_Documents\\_v1.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/90-CVPFS_DSRC_RdWx_Documents_v1.pdf)

**The objective of this research project was to develop and test the acquisition of road and weather condition information on public agency vehicles and transmit it to roadside equipment over 5.9 GHz Dedicated Short-Range Communications (DSRC).**

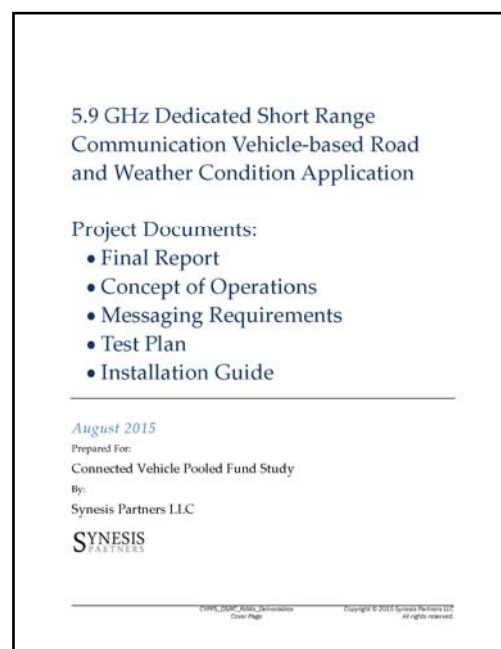
The project consisted of four tasks that included activities needed for this and any other similar Connected Vehicle (CV) application development initiatives. Development of the 5.9 GHz DSRC vehicle-based data acquisition system in this project began with a Concept of Operations and an analysis of Messaging Requirements. The Concept of Operations developed for this project describes concepts for a system to support road weather operations using 5.9 GHz DSRC for mobile data gathering. The Messaging Requirements developed for this project addressed application of the DSRC standards, device interfaces and data element definitions for data acquisition and communications.

This research project also developed the on-board equipment (OBE), roadside equipment (RSE) and data transmission components, and determined any adaptations needed to support integration with existing an existing DSRC deployments on the Long Island Expressway.

As part of the application installation and testing phase, the research project determine needed equipment, selected deployment sites, assembled and tested the system hardware and software in preparation. Testing parameters were documented in a Test Plan, and the deployment process is described in an Installation Guide.

This project successfully developed and demonstrated a capability for aggregating weather-related data from a variety of original and aftermarket vehicle on-board sensors, sending the data over a DSRC connection from the vehicle to the roadside, and making the data available to other agency systems.

This report also described some of the challenges and opportunities encountered in the project, and offers recommendations for future consideration.



### Key Terms and Acronyms

DSRC | Dedicated Short-Range Communications

OBE | On-board Equipment

RSE | Roadside Equipment



### ITS Strategic Plan 2015-2019

December 2014

United States Department of Transportation (USDOT)

<https://www.its.dot.gov/strategicplan.pdf>

**This document constitutes the Intelligent Transportation Systems (ITS) Strategic Plan covering the years 2015 to 2019; it builds on the progress of the 2010-2014 plan and presents a wide array of technical, policy, institutional, and organizational concepts.**

This document provides a comprehensive perspective that is based on an inclusive, collaborative, interactive, and iterative process, with a wide mix of stakeholder engagement opportunities that ensured that the Strategic Plan reflects the aspirations of the multi-faceted ITS community across the nation. This new Plan: identifies a vision – “Transform the Way Society Moves,” and the ITS Joint Program Office (JPO) associated mission of advancing research that cuts across all surface modes; outlines technology lifecycle stages and strategic themes articulating outcomes and performance goals that define six program categories; describes “Realizing Connected Vehicle Implementation” and “Advancing Automation” as the primary technological drivers of current and future ITS work across many sectors; and, presents enterprise data, interoperability, ITS deployment support, and emerging ITS capabilities as additional program categories that are supplemental and interdependent activities critical to achieving the program’s vision. The plan further identifies research questions aligned to every program category in each stage of the technology lifecycle, in addition to cross-cutting organizational and operational disciplines that relate to the program categories.



Building on the momentum and success of prior and current research, and working on the areas that are at the forefront of ITS research going forward, two primary strategic priorities have been defined. These are: Realizing Connected Vehicle (CV) Implementation and Advancing Automation.

Enable Safer Vehicles and Roadways, Enhance Mobility, Limit Environmental Impacts, Promote Innovation, and Support Transportation System Information Sharing are the themes embedded in the program categories.

The plan includes program categories to provide the necessary structure for research, development, and adoption of ITS technologies. The program categories are: Connected Vehicles, Automation, Emerging

### Key Terms and Acronyms

ITS | Intelligent Transportation Systems

CV | Connected Vehicle

JPO | Joint Program Office

## Deployment Strategy for Rural Connected Vehicle Systems

September 2014

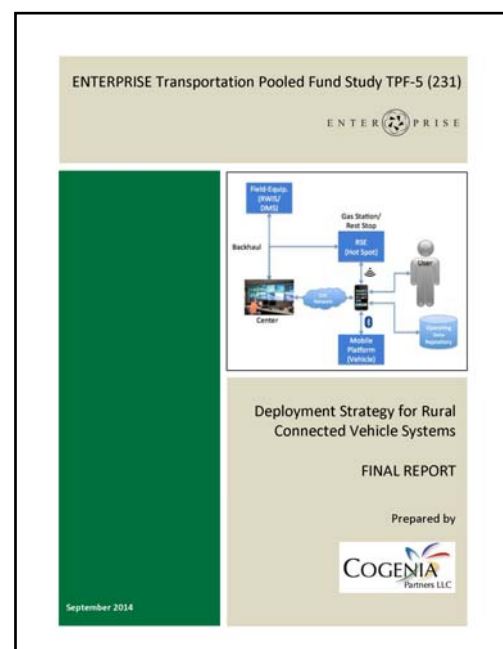
National Cooperative Highway Research Program (NCHRP) / ENTERPRISE Transportation Pooled Fund

[http://www.enterprise.prog.org/Projects/2010\\_Present/intellidriveconops.html](http://www.enterprise.prog.org/Projects/2010_Present/intellidriveconops.html)

**The intent of this effort was to identify the needs of rural users and the constraints imposed by the rural environment, and to conceptualize a variant of the connected vehicles (CV) system that is uniquely adapted to meet those needs given those constraints.**

This document outlines ways that the system could be deployed, specifically the technical approach to deployment, and the strategy for executing that technical approach. It also outlines what could be achieved at which rough timeframes, and outlines the key challenges and open questions.

The rural connected vehicle system is composed of several overlapping elements intended to provide roadway information and connected vehicle services for rural travelers on an opportunity basis. i.e., when connectivity is available. By way of an example, at a rest stop the user's device (smartphone, car system or dedicated device) would connect using WiFi, and request traveler information for the region around that rest stop. The system would provide roadway information for all of the road segments ahead up to the next known connectivity point. The system includes a mobile segment, a roadside or field segment, and a center segment. It is recommended that the initial deployment of the system take place using existing consumer devices such as smartphones and other devices capable of supporting application downloads and at least WiFi communications.



Information delivery related applications must deliver information for all of the road segments ahead of the user vehicle that lie in non-coverage communications zones. This means that the messages may contain more data than their urban counterparts, and the user side applications must be able to select and present from this larger body of content as the user moves along the road network within the non-coverage zone. Similarly, data collection applications (e.g., probe data) must collect data over longer distances than might be used in an urban environment because the road network between coverage zones may include significantly longer road segments. Any deployment of these applications must address the issue of what data is considered personally identifiable information, the degree to which such information may be collected from willing participants, and what restrictions must be imposed to assure that such information is protected.

### Key Terms and Acronyms

CV | Connected Vehicles

WiFi | Wireless Communications

ITS | Intelligent Transportation Systems

## Impacts of Vehicle Automation on Workforce Training and Driver's Licensing

August 1, 2014

Transportation Research Board

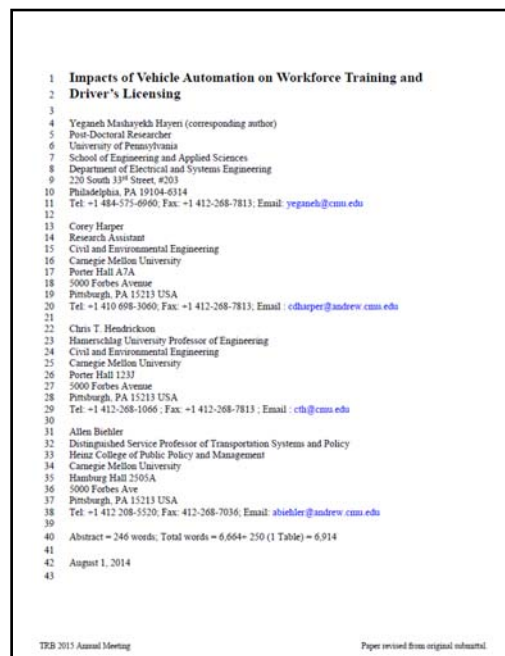
Document accessed through TRB

### To evaluate the impacts that vehicle automation will have on workforce training and driver's licensing and provide recommendations on how to accommodate these changes.

As vehicles become more automated, training for workers in the transportation industry will need to change. For transportation engineers, this means the PTOE and PTP exam concepts will change, and new curricula such as human factors and ergonomics will be added for certification. For vehicle technicians and repair workers, courses at community colleges, trade schools, and university will need to shift toward a focus on electronics and computer science. Training offered to responders and drivers will also change to add focus to handling emergency situations in the case of a system malfunction or failure. Transportation and vehicle industry training offered through government agencies such as USDOT, will also begin to shift more towards emerging CAV technologies.

Driver licensing will also require changes as vehicles become more automated. The amount of change will most likely correlate to the level of automation. Skills testing criteria will likely begin to include handling emergency situation and system malfunctions, and, once vehicles are fully automated, will become obsolete. As skills testing decreases with higher levels of automation, knowledge testing will likely increase. It may also become necessary to eliminate different levels of licensing for light-duty vehicles. For individuals who prefer manual vehicles or are not operating fully autonomous vehicles, they will still require a full driver's license. A second level of licensing, only for fully autonomous vehicles, would be suitable for drivers that cannot operate a vehicle on their own, such as those with medical impairment, or those who choose to only use fully autonomous vehicles.

The report makes a number of recommendations to accommodate these changes, generally focusing on changing and increase training and education to focus on electronics, computer science, and automated vehicle technology; updating the curricula and testing for engineering and professional certifications; and introducing different levels of light-duty vehicle driver's licensing.



### Key Terms and Acronyms

PTOE | Professional Traffic Operations Engineers

PTP | Professional Transportation Planner

SAE | Society of Automotive Engineers



### National Connected Vehicle Field Infrastructure Footprint Analysis

June 2014

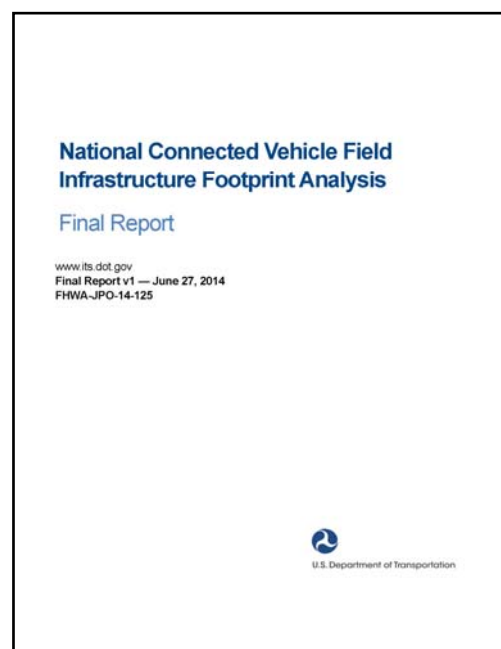
USDOT Intelligent Transportation Systems Joint Program Office

[https://ntl.bts.gov/lib/52000/52600/52602/FHWA-JPO-14-125\\_v2.pdf](https://ntl.bts.gov/lib/52000/52600/52602/FHWA-JPO-14-125_v2.pdf)

**The American Association of State Highway and Transportation Officials (AASHTO), under the sponsorship of United States Department of Transportation (USDOT) and Transport Canada, undertook a Connected Vehicle Field Infrastructure Footprint Analysis to provide supporting information to agency decision-makers.**

This document consists of a vision for a national footprint; a description of the background for and current research on connected vehicle deployments; a set of assumptions underlying the infrastructure footprint analysis; the applications analysis; the deployment concepts, the preliminary national footprint, including the value proposition, deployment objectives, context, scenarios, and experience to date; and a preliminary deployment and operations cost estimation. This document also includes:

- A description of the justification for and value of deployment of connected vehicle infrastructure.
- A compilation of the possible data, communications, and infrastructure needs of the priority applications.
- A set of generic deployment concepts and their needs under different operational conditions.
- A set of scenarios identifying how and where agencies might implement secure, connected vehicle infrastructure, including dedicated short range communications (DSRC); and what funding strategies they might use to support such deployment, and a synthesis of these scenarios into a preliminary national footprint of connected vehicle field infrastructure.
- A set of activities and timelines for deploying connected vehicle field infrastructure across and among State and local agencies.
- Estimates of potential costs for deployment, operations, and maintenance.
- Estimates of workforce and training requirements; and identification of policy and guidance needs.
- Identification of implementation challenges and institutional issues and identification of the timing by which those issues need to be resolved to achieve impactful deployment.



### Key Terms and Acronyms

AASHTO | American Association of State Highway and Transportation Officials

USDOT | United States Department of Transportation

DSRC | Dedicated Short Range Communications

### Traffic Management Centers in a Connected Vehicle Environment

June 2013

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

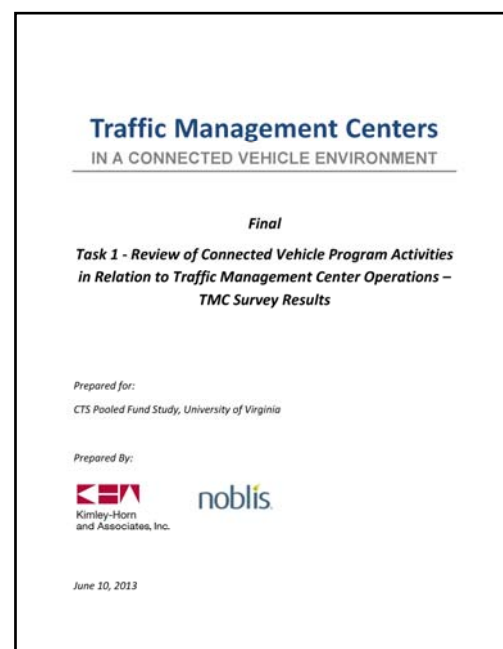
[http://www.cts.virginia.edu/cvpfs\\_research/](http://www.cts.virginia.edu/cvpfs_research/)

**The role of the Traffic Management Centers (TMCs) and TMC operations will be impacted or influenced by a future connected vehicle (CV) environment. To better prepare for the potential impacts, and to identify operational activities, resource and system needs, the Connected Vehicle Pooled Fund Study (PFS) initiated this project to identify how a connected vehicle environment will shape the role and function of TMCs.**

This research project examined operational, technical, and policy impacts of a new TMC environment, and informed the Connected Vehicle PFS members about priority needs and gaps that would need to be addressed relative to TMCs in a future connected vehicle environment.

Key operational functions performed by TMCs were summarized as part of this project. The readiness of TMCs to integrate new processes, functions, and data in a connected vehicle environment was also assessed. Also, investigation of the expected changes a TMC may undertake in a connected vehicle environment was conducted. In investigating these potential changes, special consideration was given to the type of connected vehicle data that may be available to TMCs, how these data may be used to enhance TMC operations, the role of third party data providers in providing these data, the types of connected vehicle applications that may be implemented by TMCs, and how roadside equipment (RSE) units and on-board equipment (OBE) units can be incorporated into TMC operations.

A vision for a future TMC in a connected vehicle environment was also developed as part of this research project. This served as a high-level Operational Concept, and presented potential operational scenarios of a TMC operating environment integrating information sources and capabilities from connected vehicle platforms and systems. This vision is envisioned to present: (i) types of information that are anticipated to be available to TMCs through connected vehicle platforms, (ii) how that data could be integrated into TMC operations and systems, (iii) potential benefits, and (iv) potential changes to TMC operating environments, such as enhanced decision support, more responsive strategy implementation, and broader coverage of real-time conditions.



### Key Terms and Acronyms

TMCs | Traffic Management Centers

CV | Connected Vehicles

RSE | Roadside Equipment

## Enabling Accelerated Installation of Aftermarket for Connected Vehicles (CV)

May 2012

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

[http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS\\_AFTER99\\_Final1.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_AFTER99_Final1.pdf)

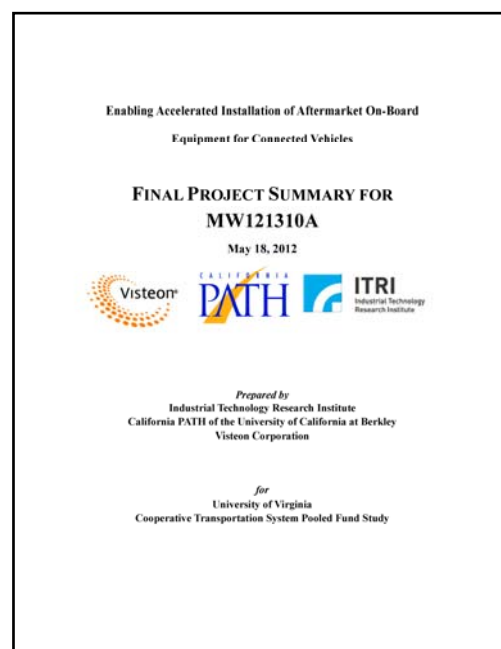
**This research project evaluated the potential approaches for accelerating the introduction of aftermarket on-board equipment (OBE) devices to the vehicle fleet.**

Without a rapid deployment, the safety, mobility, and efficiency benefits of the USDOT Connected Vehicle Research Program will not be realized. It is widely recognized that deployment on new vehicles alone will not provide the penetration expedient enough for maximum benefit. Therefore, aftermarket deployment is critical. The combination of aftermarket OBE devices and new vehicles equipped with 5.9 GHz dedicated short range communications (DSRC) or other communication technologies will more effectively produce benefits to the consumers.

This report analyzed and compared the current available communications technologies using literature reviews, related reports, and expert opinions as inputs for the analysis. In addition, the wireless technologies and applications commonly used by different modes of transportation including light passenger vehicles, transit vehicles, and heavy trucks were examined. Finally, the report also compared various communication technologies in different application service scenarios to determine the key functions and requirements.

A Vendor/Market Readiness Report was also produced as part of this research project. This report summarized industry's views of the current market readiness through interviews conducted with OEM experts. In addition, the availability of OBE hardware manufacturers to provide aftermarket multi-band OBE product has been documented. Finally, the report captures consumer insight through focus groups on product attributes, unmet consumer needs, aftermarket OBE pricing, time to market for OBE applications, and where to distribute aftermarket OBE products.

A Procurement Guidance Document was also prepared as part of this research project. The guidance document is based on findings reported in the first two deliverables of the Pooled Fund Study, the State of the Industry and Vendor/Market Readiness Reports, and is enhanced with additional content to specifically address the considerations for OBE procurement.



### Key Terms and Acronyms

COBE | On-board Equipment

CV | Connected Vehicle

DSRC | Dedicated Short Range Communications

### Certification Program for Cooperative System/Connected Vehicle Technologies

May 2012

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

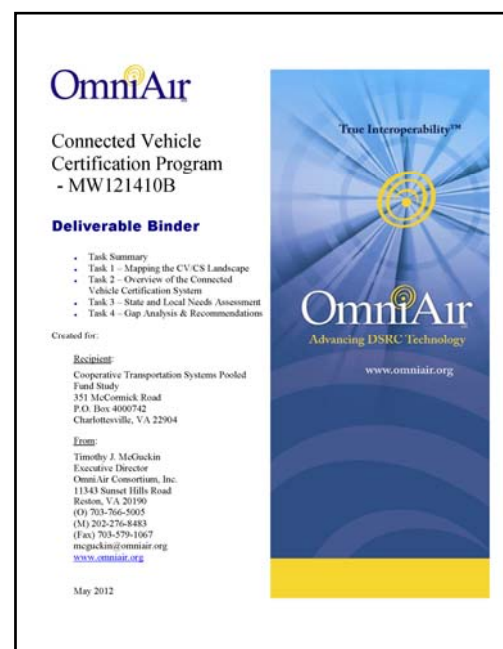
[http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS\\_CERT99\\_Final.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_CERT99_Final.pdf)

**A critical component to the overall success of national, interoperable Cooperative System and Connected Vehicle deployments is a robust certification process that ensures performance and interoperability of said technologies and systems. This project investigated the landscape of certification activity in this space, assessed the needs of state and local infrastructure owners, and identified the gaps that may exist between current activity and state and local needs.**

The goal of this project was to develop the foundational knowledge needed to inform Pooled Fund Study (PFS) members on certification issues, providing information to facilitate a uniform and consistent certification framework necessary to future deployment of Cooperative System/Connected Vehicle (CS/CV) technologies. The study had two components: 1) understanding the current landscape of certification activities in this space; and, 2) assessing and analyzing state and local needs to ensure conformance and promote interoperability for CS/CV deployments.

This research project provided a summary of the interconnected certification initiatives within, adjacent to, or impacting the CS/CV community, emphasizing current points of state & local relevance. As a result, a series of interactive maps of the Connected Vehicle space to visually convey the goals, relationships and content of the organizations in this sector was constructed. The technology used to produce this deliverable is a product cloud computing-based platform called Mindomo, which produces interactive, multimedia-rich mind maps. The research team also collected and synthesized industry deliverables specific to CS/CV certification programs and analyzed several current certification programs of relevant technologies, which served as a benchmark for an infrastructure operator-focused CS/CV program.

Research was also conducted through detailed interviews and surveys to determine the needs of state & local authorities and how much variability there was in this target population. Finally, connections and disconnection between the needs of the state & local infrastructure operators and the current CS/CV certification initiatives were also identified. The report identified key actions to promote state/local positions in the development of national CS/CV certification apparatus and to move certification programs toward deployment.



### Key Terms and Acronyms

PFS | Pooled Fund Study

CS/CV | Cooperative System/Connected Vehicle

Mindomo | Interactive, Multimedia-Rich Mind Maps Creator

## Multi-Modal Intelligent Traffic Signal System – Phase I

April 2012

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

[http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS\\_AFTER99\\_Final1.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_AFTER99_Final1.pdf)

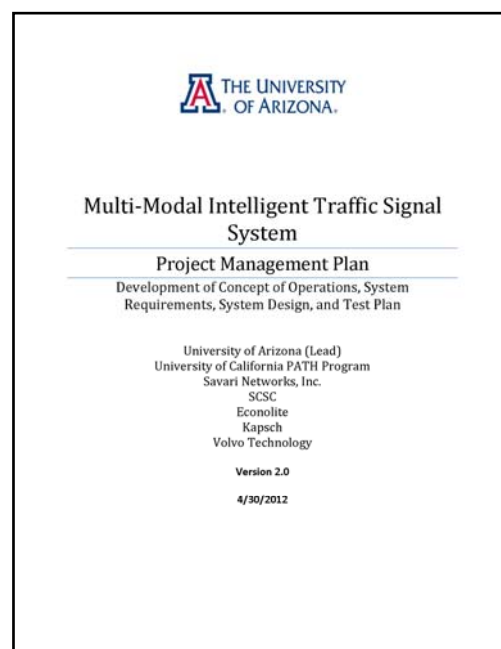
**This research project developed a concept of operations, systems requirements and system design for a comprehensive traffic signal system that services multiple modes of transportation, including general vehicles, transit, emergency vehicles, freight fleets and pedestrians. Project also prepared for field testing/demonstration of the developed Multi-Modal Intelligent Traffic Signal System.**

Review and assessment of research related to multi-modal intelligent traffic signal systems (MMITSS) was conducted and documented as part of this research project. An important observation from this review is that while all traffic control systems serve multiple modes of travel, the review found no comprehensive study or demonstration project that addressed simultaneous optimization of all models of travel.

The Concept of Operations document, or ConOps, produced as part of this project, captured a vision and a roadmap for the development, deployment, operation and maintenance of future MMITSS based upon stakeholder views. The ConOps identified and defined goals to support a transformation of traffic signal control from today's technology into a safer, more efficient, and demonstrable system for the future.

Final System Requirements (SyRS) Document was also produced as part of this research project. The system requirements forms the basis for the design, implementation, testing, and acceptance of any system. The requirements were related to the system functionality, the technology available to build the system, functional performance, acquisition, and operating cost. Requirements were testable and based on sound understanding and analysis of the problem. A high level system and software design for the MMITSS was also developed as part of this research project.

Finally, a Deployment and Field Test Plan was produced as part of this research project. The purpose of this document was to establish a structured plan for development, deployment and field testing of a select subset of MMITSS functionality. The plan is a continuation of the Phase I findings including the ConOps, Requirements, and Design. This plan will be carried out a Phase II.



### Key Terms and Acronyms

MMITSS | Multi-Modal Intelligent Traffic Signal System

ConOps | Concept of Operations

SyRS | System Requirements



### Investigating the Potential Benefits of Broadcasted SPaT Data under IntelliDrive<sup>SM</sup>

May 2011

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

[http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS\\_SPAT99\\_Final.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_SPAT99_Final.pdf)

**This report identifies the transportation applications that could be implemented if real-time data about traffic Signal Phase and Timing (referred to as SPaT data) could be broadcasted for signalized intersections and received by vehicles.**

One of the most promising vehicle-infrastructure cooperation opportunities expected from the emerging Connected Vehicle technologies (referred to as IntelliDrive<sup>SM</sup> at the time this project was initiated) is the real-time provision of traffic SPaT information to vehicles approaching signalized intersections.

The types of data that could be incorporated within SPaT applications are presented in this report, followed by a definition of use cases for these data. The use cases were then expanded into skeletal Concepts of Operations for each application, where they have been segregated into safety and mobility categories.

The safety applications included CICAS-V (signal violation warning), CICAS-TSA (traffic signal adaptation, extending all-red), signal status display in vehicle, vulnerable road user warnings near intersections (pedestrians, bikes), truck signal change warning, alerting drivers about imminent emergency vehicle pre-emption, among others.

The mobility applications included transit signal priority, arterial truck driving support, eco-driving support, traffic signal control optimization, "All-User" optimization of traffic control, among others.

These applications can support improvements in both safety and mobility of arterial driving. Preliminary estimates are provided of the potential benefits that could be gained from these applications if all vehicles and signalized intersections were equipped. Actual benefits will be scaled down based on actual market penetrations.

Finally, some of the practical considerations involved in implementing SPaT messaging from signalized intersections are addressed, based on recent experimental experience. The goal of this project was set to investigate the potential benefits of using broadcasted SPaT data under an IntelliDrive<sup>SM</sup> environment.



### Key Terms and Acronyms

IntelliDrive<sup>SM</sup> | Connected Vehicles

IRI | International Roughness Index

PDPM | Probe Data Performance Management

### Investigation of Pavement Maintenance Applications of IntelliDrive<sup>SM</sup>

May 2011

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

[http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS\\_PMSA99\\_Final.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_PMSA99_Final.pdf)

**This research project investigated whether vehicular data available from connected vehicles can be used to measure pavement conditions, particularly as compared to current techniques used by DOTs to measure the International Roughness Index (IRI).**

Pavement maintenance is a vital function for transportation agencies. Current methods are quite costly, entailing visual inspections from agency staff and traversing the roads using specially-equipped measurement vehicles. Connected vehicles offer an alternative. Given the sensing and computing power on today's vehicles, each vehicle on the road is a storehouse of valuable information.

Assessing pavement quality through probe data is called Probe Data Performance Management (PDPM). Using the probe vehicle's onboard sensors, the roughness of sections of road can be assessed. Simple algorithms using the measurements from the onboard sensors can be related to the International Roughness Index (IRI) of the road. Additionally the sensor measurements can be used to identify potholes or bumps on the road.

The key for PDPM is to have enough vehicles reporting pavement-relevant data to be able to contribute to DOT pavement management programs. Some forms of probe data require a particular critical mass of reporting vehicles to keep up with changing conditions on the road; this is the case with traffic monitoring. By contrast, pavement quality changes much more slowly. Therefore, even very low levels of PDPM vehicles can have some benefit. The benefit scales up with the number of reporting vehicles until saturation occurs. Therefore, the earliest timeframe for a "full" deployment of PDPM would be early in the next decade. Nevertheless, beneficial data would begin flowing much sooner. PDPM offers the potential for cost-effective pavement assessment using sensors already on today's automobiles. The roll-out of probe data services in the U.S. by car-makers is expected to begin near-term, based on existing approaches overseas. However, PDPM does not offer the type of business case to car-makers that traffic and weather information do. Therefore, the infrastructure community needs to stimulate a PDPM pavement data market at the national level, to motivate data providers to seek this information, which will motivate car companies to provide it.



### Key Terms and Acronyms

IntelliDrive<sup>SM</sup> | Connected Vehicles

IRI | International Roughness Index

PDPM | Probe Data Performance Management

## IntelliDrive<sup>SM</sup> Traffic Signal Control Algorithms

April 2011

Virginia Department of Transportation (Lead State) / Connected Vehicle Pooled Fund Study

[http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS\\_SIG99\\_Final.pdf](http://www.cts.virginia.edu/wp-content/uploads/2014/04/PFS_SIG99_Final.pdf)

**This research project sought to develop and investigate expected benefits of traffic signal control algorithms designed specifically to take advantage of IntelliDrive<sup>SM</sup> (Connected Vehicles).**

The objectives of this research project were to develop and evaluate new traffic signal control algorithms by fully utilizing new IntelliDrive<sup>SM</sup> (Connected Vehicles) data sources; to develop tools for generating meaningful arterial Measures of Effectiveness (MOEs) from IntelliDrive<sup>SM</sup> data sources; and to understand and document specific risks, constraints and opportunities of the developed algorithms in a large-scale deployment.

The research project was organized into five tasks:

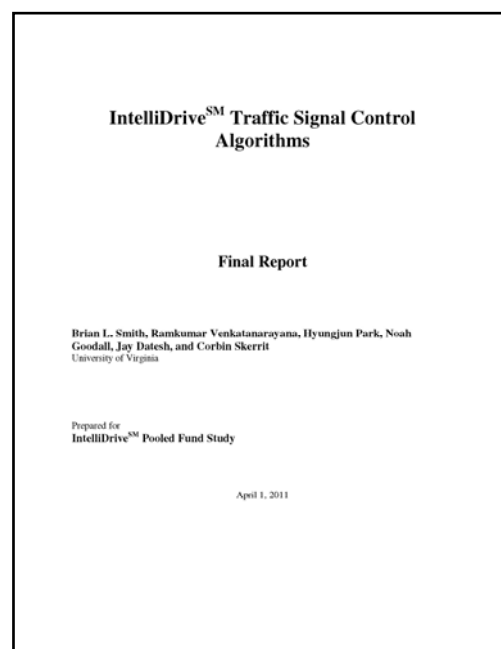
The Investigation of the IntelliDrive<sup>SM</sup> Data Sources Task — investigated the potential data sources available in an IntelliDrive<sup>SM</sup> environment, and the potential and limitation of those sources.

The Development of New Traffic Signal Control Algorithms Under IntelliDrive<sup>SM</sup> Task— proposed three traffic control strategies using IntelliDrive<sup>SM</sup> data as the primary data source.

The Development of Tools for Generating Arterial MOEs from IntelliDrive<sup>SM</sup> Task— investigated the effect that IntelliDrive<sup>SM</sup> data would have on the collection of signalized intersection MOEs, and proposed new performance metrics. The new metrics included person delay, sudden decelerations, changes in lateral acceleration, network connectivity, aggregate regulation compliance, driver behavior modeling, and weather/light conditions.

The Evaluation of the Developed Traffic Signal Control Algorithms Task— evaluated the traffic signal control algorithms developed in Task 2 on a virtual IntelliDrive<sup>SM</sup> test bed. The algorithms showed a significant improvement over coordinated-actuated signal control. All three algorithms began to experience benefits at 25% market penetration.

The Deployment Analysis Task—investigated the potential implications of a large-scale real-world implementation of IntelliDrive<sup>SM</sup> at signal systems. The task included a cost-benefit analysis of IntelliDrive<sup>SM</sup> signal control versus a system using loop or video detection.



### Key Terms and Acronyms

IntelliDrive<sup>SM</sup> | Connected Vehicles

MOEs | Measures of Effectiveness

Performance Metrics | Measures of Effectiveness



## Autonomous Vehicle Policy Task Force

As part of the external information gathering effort, the consultant team also participated in the Autonomous Vehicle Policy Task Force meeting held November 8<sup>th</sup>, 2017 at the PennDOT Riverfront Office Complex.

The Autonomous Vehicle (AV) Policy Task Force is broadly comprised of industry leaders, academic experts, sister agencies and constituent representative groups to work as an advisory board to identify best practices for highly automated vehicles (HAVs) testing policies. This group has been meeting regularly since the spring of 2016 to develop recommendations for PennDOT's Secretary regarding policies to oversee on-road HAV testing. The task force's goal is to create a framework for testing HAVs in Pennsylvania that balances public safety with innovation and provides flexibility required to keep the state in the forefront of the development of this emerging and potentially transformative technology.

Participants of the November 8<sup>th</sup> meeting included representatives from PennDOT, Pennsylvania Department of Community and Economic Development, Pennsylvania State Police, Pennsylvania Legislation, Penn State University, Pennsylvania Department of Insurance, Pennsylvania Turnpike Commission, Insurance Federation, General Motors, American Automobile Association (AAA), American Trucking Associations (ATA), Carnegie Mellon University, FHWA, Local Government, Jackie Group, Peloton Technology, Pennsylvania Public Utility Commission, Pennsylvania Trial Lawyers Association, Global Automakers, Pennsylvania Motor Truck Association (PMTA), SAE International, Uber Technologies, and University of Pennsylvania. A total of 45 minutes was allotted to the discussion of the Joint Statewide Connected and Automated Vehicle Strategic Plan.

Various topics were discussed during the meeting, including PennDOT and legislative updates, a review of the 2017 Pennsylvania Automated Vehicle Summit, an update on future focus areas for the various Task Force Subcommittees, the Joint Statewide CAV Strategic Plan discussion, and a summary of upcoming public engagements. Major takeaway from the general discussion during the meeting include:

- An update from PennDOT and discussion on the proving grounds and Middletown Shuttle.
- A discussion on the House legislation passed on September 6, 2017 known as the Self-Drive Act, the Senate bill known as the AV Start Pact, which is still being considered, and the NHTSA Automated Driving Systems Guidance 2.0.
- Further exploration by the Task Force Subcommittees on public outreach and engagement, as well as work force training and education.
- A discussion of the Joint Statewide CAV Strategic Plan provided a brief overview scope of work and purpose of the plan. Then an open discussion session ensued focused on five areas: opportunities for institutional change; business plan integration; accountability; funding; and partnerships. Further discussion included institutionalization of CAV into the organizational structure within PennDOT; criticality of engagement of all agencies that may be affected by CAV; importance of planning and policy, including urban vs. rural areas; addressing the transportation needs of certain populations; criticality of an education campaign from the bottom up. Task Force members were encouraged to contact the consultant team for additional input after the meeting.

For detailed information refer to the draft meeting minutes in the next few pages prepared by the meeting organizer.

<i>Client / Agreement / #</i>	PennDOT Program Center / Planning Open End / E03449	
<i>Project / MBI #</i>	WO#2 - Autonomous Vehicle Task Force / 152937	
<i>Date / Time / Location</i>	08-Nov-2017 / 10:30 AM – 12:10 PM / PennDOT Riverfront Office Complex, Room TU409	
<i>Attendees/ Representing</i>	PennDOT: Leo Bagley (LB); Andrew Blum (AB); Lev Boonin (LB); Roger Cohen (RC); Rich Kirkpatrick (RK); Mark Kopko (MK); Emma Lowe (EM); Kurt Myers (KM); Eric Nelson (EN); Glenn Rowe (GR); Jason Sharp (JS); Kara Templeton (KT)	
	PA DCED: Steve D’Ettorre (SD)	
	PA State Police: Major Ed Hoke (EH); Captain Troy Park (TP); Captain Beth Readler (BR); Lt. Brian Ianuzzi (BI)	
	PA Leg. Sprt: Jason Gerard (JG); Merideth Biggica (MB), Greg Moreland (GM); Charlie O’Neill (CO); Nolan Ritchie (NR)	
	Penn State University: Eric Donnell (ED)	Jackie Group: Jackie Erickson (JE)
	PA Dept. of Insurance: Mark Lersch (ML)	Peloton: Nandi Chhabra (NC); Adam Healy (AH)
	PA Turnpike Commission: Mike Pack (MP)	PUC: Joseph Cardinale (JC)
	Insurance Federation: Samuel Marshall (SM)	PA Trial Lawyers Assn: Larry Coben (LC)
	GM: n/a	Global Automakers: Mark Singel (MS)
	AAA: Ted Leonard (TL)	PMTA: n/a
	ATA: n/a	SAE: Bill Gouse (BG)
	CMU: Stan Caldwell (SC)	Uber Technologies: Shari Shapiro (SS)
	FHWA: Phil Bobitz (PB); Roger Ryder (RR)	Univ. of Penn.: Erick Guerra (EG)
	Local Gov’t: Alex Pazuchanics (AP)	
	Gannett Fleming: Eric Rensel (ER)	
Michael Baker: Jeffrey Bergsten (JB); Brian Funkhouser (BF); Fatema Siddiquee (FS); Matt Smith (MS)		

**Meeting Purpose:** Provide and receive status updates regarding automated vehicles in Pennsylvania.

Notes:	Follow-ups:
1. Welcome (RC and KM) <ul style="list-style-type: none"> <li>a. Introduced new Task Force member Jackie Erickson of the Jackie Group. Ms. Erickson works with start-ups in the autonomous space but also aerial space. She is a co-founder of Pittsburgh Robotics Network, dedicated to the growth and promotion of Pittsburgh’s robotics companies and research institutions.</li> </ul>	➤ n/a
2. Roll Call (JB) <ul style="list-style-type: none"> <li>a. Members present introduced themselves.</li> </ul>	➤ n/a

Notes:	Follow-ups:
<p>3. PennDOT Updates</p> <ul style="list-style-type: none"> <li>a. HAV Strategic Plan (MK) – The Department has been working on the development of an AV Strategic Plan for Pennsylvania. This will be a subject of a later agenda item in today’s meeting.</li> <li>b. Proving Grounds (MK) – Pennsylvania had two proving grounds designated by FHWA earlier this year in the City of Pittsburgh and Penn State. They are among 10 proving grounds so designated across the country. With the change in administration, there has not been a lot of movement on the Federal side, although at the local level, the proving grounds are blazing their own trail and holding routine meetings to discuss proposals and plans.</li> <li>c. Middletown Shuttle (AB) – PennDOT has held several meetings with PSU-Harrisburg, which has been interested in working with the Department. PennDOT is taking initial steps to educate PSU staff in preparation for the shuttle’s operation. PennDOT is looking for a timetable to get a prototype ready – possibly for the next school year. The shuttle will operate on private roadways. It is hoped that such pilots will be identified in the forthcoming legislation.</li> <li>d. The vision is to deploy a slow-moving driverless shuttle emanating from the new Middletown Amtrak station (which PennDOT is in the process of rebuilding) and use that as a hub for connections to PSU-Harrisburg (which is the fastest-growing campus in the PSU system). With international students coming in to PSU-Harrisburg by both air and rail, such a connection will be very useful. PennDOT views this as the first pilot of what could be a series of similar projects deployed around the state.</li> <li>e. Planning for this pilot will move forward and we will be entertaining ideas and proposals for similar ones across the state. Potential options could include Presque Isle or Gettysburg. The technology is ready today for on-road testing. PennDOT is hopeful that this will be a useful demonstration. NR: Was an article recently from the World Congress of their shuttle pilot. RC: Our team will be scanning the environment of areas that have deployed this technology and gain lessons learned from other, similar deployments in California, Texas, and Europe.</li> </ul>	<p>➤ n/a</p>
<p>4. Six-State Trooper AV Demonstration in Gettysburg (TP)</p> <ul style="list-style-type: none"> <li>a. TP: The demonstration occurred in September. The International Association of the Chiefs of Police met recently in Philadelphia and Deputy Secretary Kurt Myers spoke.</li> </ul>	<p>➤ n/a</p>
<p>5. Legislative Updates</p> <ul style="list-style-type: none"> <li>a. Federal Legislation. KT: Over the past few months, there has been much activity as it relates to proposed legislation. The House passed legislation on September 6, 2017 known as the Self-Drive Act. Several highlights of the Act clarify the responsibilities and roles that NHTSA will play, including</li> </ul>	<ul style="list-style-type: none"> <li>➤ <b>BF:</b> Upload LB’s spreadsheet to the SharePoint site.</li> <li>➤ <b>EL:</b> Check with Secretary Richards on her providing</li> </ul>

Notes:	Follow-ups:
<p>a pre-emption that that state laws do not interfere with the design and performance of automated vehicles. It also requires manufacturers to develop detailed cyber-security plans. It also establishes a council of various parties that are stakeholders within the industry. The Act also mentions the increased number of vehicles for exemptions...from roughly 2,500 a year and increasing substantially over time due to AVs (to maybe 50,000 by year 2 and 100,000 in years 3 and 4). The legislation did not address trucks.</p> <p>b. On the Senate side, a corresponding bill was known as the AV Start Pact, which was introduced in September. It is still being considered. There are many similarities to the House bill, as trucks were also not included. Next steps will include a full vote on it before the Senate.</p> <p>c. In the meeting packet there was a matrix that describes the two pieces of legislation. LB: Anything in the NHTSA guidelines is entirely voluntary. AP: Is AASHTO taking any positions? KT: At times when comments are being sought, AAMVA accepts feedback from the States...they have been submitting a joint letter on some of the proposed bills. AAMVA is taking PennDOT's feedback to them into consideration. SC: ITS America has also been very active with this with an active working group and may be another opportunity for Pennsylvania to weigh in. EL: To check status of Secretary input to AAMVA.</p> <p>d. State Legislation. NR: SB 427 was led by Senator Vulakovich. We have a plan as of now to bring forth a "gut and replace" amendment to SB 427 if we are in session the week of December 11. (If not then, then early next year.) There is loose agreement among legislators on some areas, including registration, titling, penalties, and state pre-emption, and the advisory committee. Areas where negotiations continue include the types and purposes of different vehicles. We are considering: platooning, work zone vehicle, shuttles, and two different types of passenger vehicles...level 5 (no human operator), and Levels 4 and below. GM: The House is working on different concepts and ideas and having discussions with stakeholders and others. These include Eric Nelson in the PennDOT office, PSP, and Peloton to draft the best bill possible. RC extended his thanks for the work they are doing, as future direction will be shaped by the decisions that are made at the capitol.</p> <p>e. <a href="#">NHTSA 2.0 Revised Guidance</a> – There is a live link available in the agenda. RC: Encouraged members to read it as a useful resource. KT: This is a skinnier version as opposed to the initial guidelines...slimmed down to two sections. This focuses specifically on levels 3-5. NHTSA is already working on a version 3.0.</p>	<p>status/comments to AAMVA.</p>
<p>6. AV Summit Review</p>	<p>➤ <b>All:</b> Indicate interest in planning for the next Summit, in April 2018.</p>

Notes:	Follow-ups:
<ul style="list-style-type: none"> <li>a. Summary. RC thanked all for their participation. He referenced ED's work at the test track and the demonstrations. The conference itself attracted close to 300 people across the Commonwealth, with strong representation from the MPOs. One of the Summit's focus areas was on work force development, which was shaped by DCED. There was some disappointment registered in the level of involvement of representatives from the state's transit agencies. It speaks of a gap in recognition and understanding within the transit community as to what this technology entails for the industry; PennDOT will keep trying to engage them. The Summit planning team is in the final stages of preparing a document summarizing the Summit proceedings. It will be a standing documentation of what transpired in State College.</li> <li>b. Mark Your Calendars: Next Summit, 09/10-April-2018 in Pittsburgh. RC: We'll be getting the word out officially on this very soon. If anyone would like to participate in planning the conference, they may join the work team, which meets every Thursday afternoon.</li> <li>c. Exit survey results. AB reported that a majority agreed that AV should be a subject of future research for PennDOT. Lowest ratings were reserved for the venue and facilities. There were some kudos on the balance of the sessions, while others wanted to see even more interaction.</li> </ul>	
<p>7. Task Force Subcommittees. RC thought it would be useful now that the policy has been drafted, to maintain subcommittees led by members of our work group from PennDOT and DCED to dig deeper on:</p> <ul style="list-style-type: none"> <li>a. Public Outreach/Engagement – not just citizens, but also the marketing to the technology industry and community to come to Pennsylvania as a site for testing, given the resources we have available.</li> <li>b. Work Force/Training/Education – this is an outgrowth of the Summit. This is something that DCED is trying to get their hands around and so we want to focus on how to mitigate the potential disruptions and what the training needs are, as these will need a trained workforce to draw from.</li> <li>c. NR: The Task Force subcommittees could also focus on <b>local governments</b>, as many of them do not fully know what's coming and have no idea how to prepare for this technology. Having technical guidance would be beneficial. RC: We can add that.</li> <li>d. RC asked the Task Force to consider joining one of the three prospective subcommittees, and to contact Brian Funkhouser of intentions (<a href="mailto:brian.funkhouser@mbakerintl.com">brian.funkhouser@mbakerintl.com</a>). Hopefully this will be a fruitful process that will advance our work.</li> </ul>	<ul style="list-style-type: none"> <li>➤ <b>All:</b> Make BF aware of any interest in participating on subcommittees.</li> </ul>
<p>8. Strategic Plan Facilitated Discussion and Feedback (MK, ER)</p> <ul style="list-style-type: none"> <li>a. RC introduced ER, who is working on the AV Strategic Plan. MK: It should be emphasized that this plan is not just for PennDOT, because technology</li> </ul>	<ul style="list-style-type: none"> <li>➤ <b>All:</b> Contact ER for more input on the AV Strategic Plan.</li> </ul>



Notes:	Follow-ups:
<p>is bigger than any one agency or industry. ER reviewed the components of the plan via a brief slide presentation.</p> <ul style="list-style-type: none"> <li>b. CAV is part of the future of Pennsylvania transportation. The draft plan describes the investments that need to be made. The plan is looking across nine different business areas...not all of them are engineering-related. We want to know which ones are the most important as PennDOT ramps up its investments in these areas. The planning process is approximately halfway completed, as the team has been meeting with organizations both within and outside of PennDOT.</li> <li>c. The plan is looking at five fundamental areas: opportunities for institutional change; business plan integration; accountability; funding; and partnerships.</li> <li>d. RC: We need to institutionalize the connected and automated vehicle initiatives within some organizational structure within PennDOT. KM: Critical to this is the engagement of all the state agencies that touch AV and the technology being used. Our focus is on the safe operation of these vehicles. There has been trial and error in other areas where there is no long-range vision.</li> <li>e. LB: Within the World Congress, one of the sessions was the planning policy aspects of CAV. It is important for us to look at the planning and policy aspects for CAV, and the cities' role (and boroughs) since there will be significant impacts to urbanized areas, and how will rural areas take advantage? GR: This can be reinforced by what we heard at the Summit. Europe is trying to integrate this as to how it will develop land use (in addition to safety). Their rural areas need connections, and land use discussions will help drive that.</li> <li>f. AP: The nature of future investment needs to be subservient to the plans of the communities and their land use decisions. There is uncertainty in what the business model associated with CAV is, in terms of private ownership and fleets, which makes planning much more challenging as to what that 10-year horizon looks like.</li> <li>g. SC: PennDOT has done this successfully in signals and pavement markings with multiple jurisdictions in the same area. Having a plan in what we're doing to take care of the roadway...the locals need that guidance just as PennDOT did for the Green-Light Go Program, etc. in order to meet a standard. If it is seen as being overwhelming, the locals will do nothing.</li> <li>h. EL: A key way to address uncertainty is to address the transportation needs of certain populations, and how municipalities can use AV to serve mobility needs. How will child safety be impacted by AV? Can we capitalize on that research? Municipal officials at times aren't creative enough to think of how the technology can already be applied (e.g., Meals on Wheels, or other</li> </ul>	

Notes:	Follow-ups:
<p>senior social services, etc.). The more we can clarify those situations and opportunities, the more it will aid in future dialog with municipal officials.</p> <ul style="list-style-type: none"> <li>i. AB: An education campaign is vital from a bottoms-up approach.</li> <li>j. SC: Another incentive...we did a smart community challenge to smaller municipalities. We had responses from eight of 10 counties in southwest Pennsylvania. The idea is that a neighboring municipality could say "if they can do it, we can too." ER: Does the delivery mechanism to local government support need to change to something SC alluded to, or is there another model? Or should funding strategies be more flexible?</li> <li>k. SD: Figure out who to reach out to, then use local government associations, as they have more knowledge of what's "on the ground" to remove the uncertainty and fear surrounding this technology. Many local governments are in older communities who may not see the need for new technology. We need to bring them to the table sooner rather than later.</li> <li>l. EL: It is worth stating that we need to be mindful of how education is packaged...is it free or online? Identify what the local needs are through local government associations will be crucial. RC: Uber has been doing a lot of this and has lessons learned in targeting certain populations. SS: There is a digital divide, which affects the elderly and low-income families. The other piece is: what kind of design ideas and systems can you put in place as a state to address those types of questions? Costs and dispatch resources like rabbittransit use to dispatch uber on behalf of seniors as an intermediary function to overcome the barriers to using the technology. The Commonwealth can play an important role in this.</li> <li>m. ER: What partnerships are still needed? What are the changes you need from government to achieve the success we're talking about? What do you need from private industry?</li> <li>n. AP: Best practice research. Many of the concepts are producing solutions. We in government are not set up to deliver in that manner, so developing a community of practice is important to delivering.</li> <li>o. JE: We need to address what reality is right now, including the things that companies like Delphi and Argo are doing. Bring those software engineers to talk about deployments and demonstrate that we have the safest vehicles on the road, etc.</li> <li>p. EL: One of the biggest groups missing is education. Without a workforce development component, this will be for naught. Engage more of the education community, including younger students and young childhood development.</li> <li>q. SC: Just met with a technical school which acknowledged we need to train our students in AV repair. We have all of the connected vehicle components and we need to ensure that these job opportunities and make</li> </ul>	

Notes:	Follow-ups:
<p>the community aware...including the technical schools and community colleges so they can prepare for the future economic development impact and ensure robotics do not eliminate all their jobs.</p> <p>r. AP: We must include electrification as that trend happens simultaneously and a statewide deployment strategy looks like. RC: We are increasingly seeing the intertwining of these two issues. What will the financing model be? GM: There will be a hearing on Monday at 11:00 to HB 1446 on electric charging stations.</p> <p>s. Contact Eric Rensel at <a href="mailto:erensel@gfnet.com">erensel@gfnet.com</a> to provide more input on the AV Strategic Plan.</p>	
<p>9. Public Engagement Summary (RC)</p> <p>a. ED: The annual Safety Conference will be held on December 6-8 at the Penn Stater in State College. Sessions will include technology and other topics that were discussed as part of today's meeting.</p>	<p>➤ n/a</p>
<p>10. Adjournment, and Lunch (RC, KM)</p> <p>a. There being no further business, RC thanked everyone for attending declared the meeting adjourned at 12:05 PM.</p>	<p>➤ n/a</p>

DRAFT



# PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

## JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLE STRATEGIC PLAN

### APPENDIX D

#### SUMMARY OF SELECTED CONNECTED AND AUTOMATED VEHICLES SYSTEMS EARLY SUCCESSES AND BEST PRACTICES

OCTOBER 2017

## Introduction

The future transportation systems will consist of an increasing number of connected and automated vehicles (CAV). The Center for Automotive Research defines connected vehicles as vehicles that use a variety of communication technologies to communicate with the driver, other cars on the road, roadside infrastructure, and the “Cloud.” National Highway Traffic Safety Administration (NHTSA) defines automated vehicles as those in which operation of the vehicle occurs without direct driver input to control the steering, acceleration, and braking and are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode. Together, these technologies can be used to not only improve vehicle safety, but also to improve vehicle efficiency and commute times.

This document is a result of an effort of the Pennsylvania Department of Transportation (PennDOT) to generate a Joint Statewide Connected and Automated Vehicles Strategic Plan to assist Pennsylvania in preparing for these technological advancements. Joint Statewide Connected and Automated Vehicles Strategic Plan will:

- Look at all of Pennsylvania;
- Build upon existing research;
- Identify the steps the departments should take to prepare for these technologies;
- Define a comprehensive set of focused, reasonable and deployable applications;
- Consider various levels of investment; and
- Provide the Department with critical missing data and information pertaining to the early deployment of connected and automated vehicles.

The Strategic Plan will be used as the foundation for all policy and procedural decisions relating to connected and automated vehicles.

## Document Purpose

The purpose of this document is to summarize the efforts carried out under Task 3 Early Successes and Best Practices of the Joint Statewide Connected and Automated Vehicle Strategic Plan effort. To accomplish this task, the consultant team conducted electronic searches for information and published material describing CAV activities throughout the world. Then the information collected was analyzed to identify best practices and document lessons learned for PennDOT.

## Document Overview

Early successes and best practices in the preparation and deployment of connected and automated vehicle technology were researched and identified as part of this task. Existing pilots and testing facilities were examined and are summarized as part of this document, including the following:

- USDOT Pilot Deployments
  - Tampa
  - New York
  - Wyoming
- SMART Columbus
- Ann Arbor Safety Pilot
- MCity

The *Connected and Automated Vehicles Pilots* section of this document summarizes the pilots researched as part of this effort. Both national and international pilots were researched and summarized.

The *Other Agencies' Policies* section presents a summary of the policies by other Departments of Transportation researched as part of this effort. State and Federal policies were researched for the United States and a couple of international policies were identified and summarized.

The *Matrix of Early Successes and Best Practices* section summarizes early successes and best practices identified as part of this effort for the pilots and policies researched.

A common theme throughout the document is the relationship between the best practices identified and the Capability Maturity Model (CMM). The Capability Maturity Model framework consists of concepts with roots from the software development industry and the CMM is widely used for various applications in the Information Technology (IT) world. Capability maturity brings together an approach to review common barriers to adoption and success of technology oriented program, such as the Transportation Systems Management and Operations (TSMO) program. The frameworks allow for a rigorous common understanding and improvement of institutional issues that an agency faces on a continual and consistent basis (11). By understanding and using a capability maturity framework, agencies can:

- Develop consensus around needed agency improvements.
- Identify their immediate priorities for improvements.
- Identify concrete actions to continuously improve capabilities to plan, design, and implement technology programs.

Because of the benefits CMM brings to a technology program and its wide use in the advancement of the TSMO programs throughout the county, this framework was used to catalog the best practices derived from this effort. CMM is usually described in the following six dimensions:

1. Business Process
2. Systems and Technology
3. Performance Measurement
4. Workforce
5. Culture
6. Collaboration

The best practices were cataloged using the CMM framework, which will be created for CAV as part of Task 4 of the PennDOT Joint Statewide Connected and Automated Vehicles Strategic Plan effort.

## Connected and Automated Vehicles Pilots

In the last few years, connected and automated vehicle research and pilot projects have boomed rapidly. This report documents the most relevant pilot projects deployed. Through this process, the Pennsylvania Department of Transportation (PennDOT) Joint Statewide Connected and Automated Vehicles Strategic Plan will capture knowledge of the most current and successful projects and global best practices. This material will help ensure that Pennsylvania remains among the leaders in development and deployment of the one of the most beneficial transportation technologies.

### North America

In North America, there are several major connected and automated vehicle (CAV) developments. At the national level, the US Department of Transportation (USDOT) is expanding its Connected Vehicle Pilot program and has selected sites for its first wave of deployments. Several new automated vehicle trials are in the works on several college campuses, theme parks, airports, downtown areas, etc. States with existing CAV testing centers, such as Michigan, Florida, and Virginia, are expanding and adding to their testing assets.

In September 2015, the USDOT Joint Program Office (JPO) initiated pilot deployments of connected vehicle applications in three locations – Wyoming, New York City, and Tampa. USDOT JPO intends for these pilot deployments to showcase the capabilities of connected vehicle (CV) technologies to improve multi-modal surface transportation system performance and enable enhanced performance-based system management. Each of the three selected deployment sites has completed the Concept Development Phase (Phase 1) of the program and are now in the Design/Build/Test Phase (Phase 2). USDOT expects the deployment sites to be complete and fully operational by May 2018. Once the deployment sites become fully operational, USDOT expects the pilot deployments to become a permanent part of the surface transportation system in these locations, providing a foundation upon which the agencies can expand and enhance their transportation systems management and operations capabilities.

### Tampa Connected Vehicle Pilot Deployment

The goal of the Tampa Connected Vehicle Pilot Deployment (CVPD) is to transform the experience of automobile travelers, transit riders, and pedestrian by preventing crashes, enhancing traffic flow, improving transit trip times, and reducing emissions of greenhouse gases in the downtown Tampa area (1). The Tampa Hillsborough Expressway Authority (THEA) and its partner entities will be equipping buses, streetcars, and privately owned vehicles with CV technologies that will allow them to exchange safety and travel condition information with each other and with the infrastructure. The objectives of the Tampa CVPD are to:

- Reduce morning peak-hour delays and rear-end crashes on the Lee Roy Selmon Expressway's Reversible Express Lane (REL) exit to downtown Tampa.
- Reduce vehicle/pedestrian conflicts at a busy mid-block crosswalk near the Hillsborough County Courthouse.
- Support traffic signal optimization on commuting corridors in downtown Tampa.
- Enhance transit signal priority in the Marion Street Transitway.
- Reduce vehicle and pedestrian conflicts with the TECO Streetcar line in downtown Tampa.

Figure D-1 shows the corridors where THEA plans to deploy CV technologies in the downtown areas.

To support these objectives, THEA will be deploying the following applications as part of their CVPD (1):

- **End of Ramp Deceleration Warning** – This application warns drivers to slow down to a recommended speed as the vehicle approaches the end of a queue.
- **Wrong Way Entry** – This application warns drivers that enter the REL from the wrong direction. The application will also broadcast a warning to other equipped vehicles on the REL to be alert for wrong-way vehicles.
- **Mobile Accessible Pedestrian Signal System** - This application allows pedestrians equipped with a smartphone application approaching a crosswalk at a signalized intersection to request service from the traffic signal.
- **Pedestrian in a Signalized Crosswalk Vehicle Warning** -- This application warns drivers of pedestrians using a crosswalk in the projected path of the vehicle.
- **Vehicle Turning Right in Front of Transit Vehicle** – This application alerts a streetcar operator when a vehicle is turning right at an intersection as the streetcar is approaching.
- **Intelligent Signal System** – This application optimizes traffic signal timing based on real-time connected vehicle data.
- **Transit Signal Priority** – This application gives buses priority at traffic signals to keep them running on schedule.
- **Forward Collision Warning** – This application warns drivers when a forward collision is imminent.
- **Emergency Electronic Brake Light Warning** - This application alerts drivers when vehicles ahead are braking hard.
- **Intersection Movement Assist** – This application warns drivers when it is not safe to enter an intersection.
- **Probe data Enabled Traffic Monitoring** – This application gathers traffic data from collected vehicles in real-time and provides to traffic managers to assist in optimizing traffic flow.

In the Tampa CVPD, THEA plans to deploy CV technologies in 1,600 privately owned vehicles, ten buses, and ten street cars. THEA also plans to install 40 roadside units at strategic locations in the downtown area to support the CV applications (1).

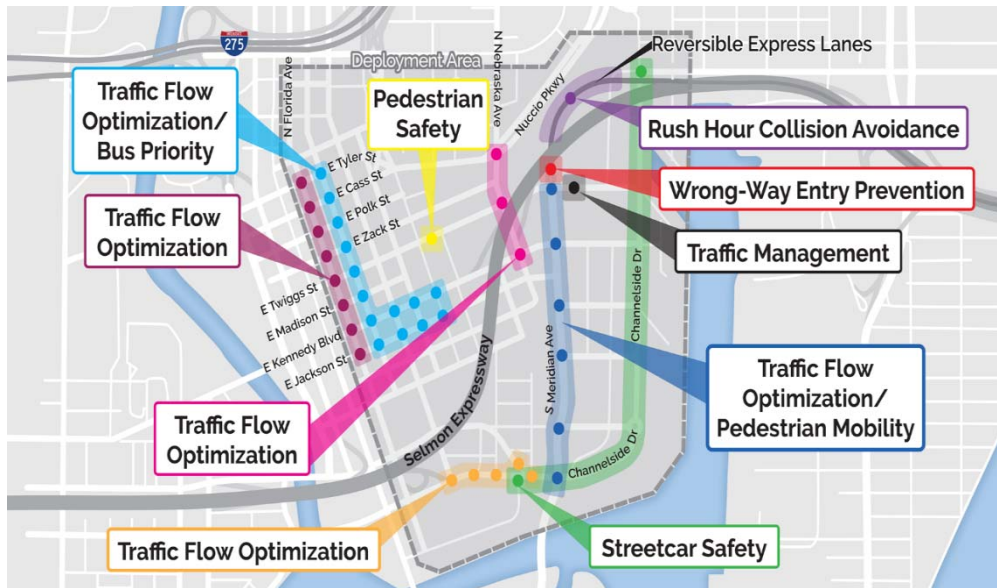


Figure D-1: The Tampa CVPD Deployment Corridors

Source: (2)

### New York City Connected Vehicle Pilot Deployment

The focus of the New York City CVPD is to improve the safety of travelers and pedestrian in support of the city's Vision Zero Initiative (3). Led by the New York City Department of Transportation (NYCDOT), the goal of the pilot is to reduce crash frequency and severity, manage vehicle speeds, and assess the potential for deploying CV technologies in a dense urban environment. As shown in Figure D-2, the deployment area encompasses three distinct areas in the boroughs of Manhattan and Brooklyn:

- A 4-mile segment of Franklin D. Roosevelt (FDR) Drive on the Upper East Side and East Harlem neighborhoods of Manhattan.
- Four one-way corridors (1<sup>st</sup>, 2<sup>nd</sup>, 5<sup>th</sup>, and 6<sup>th</sup> Avenues from 14<sup>th</sup> to 57<sup>th</sup> Streets).
- A 1.6-mile segment of Flatbush Ave in Brooklyn.

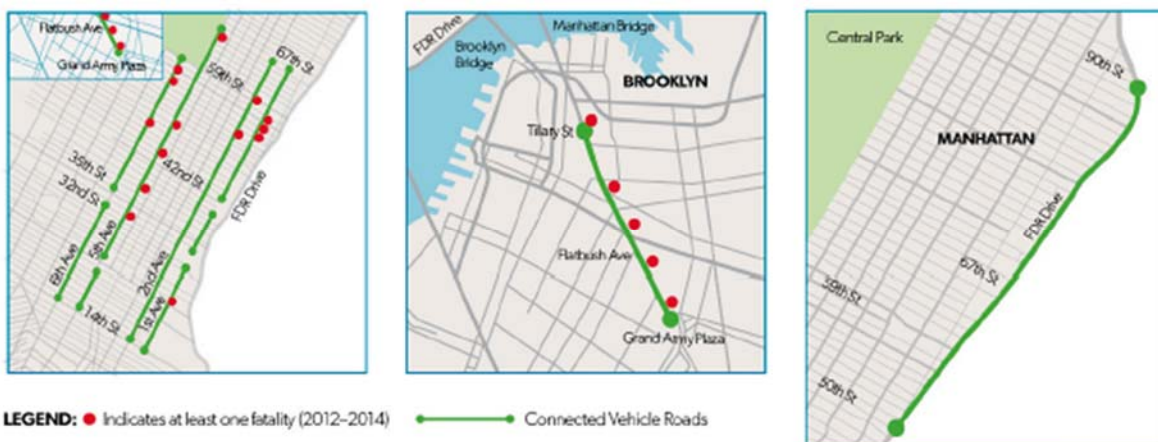


Figure D-2: NYC CVPD Deployment Corridors

Source: (4)

The NYC CVPD will support the following specific vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications (3):

- **Forward Collision Warning** – This application alerts drivers in the event of an imminent rear-end crash with a remote vehicle ahead.
- **Emergency Electronic Brake Lights** – This application alerts drivers of stopped or hard-breaking vehicles ahead in time to safely avoid a crash.
- **Blind Spot Warning** – This application alerts drivers when a remote vehicle is traveling in the adjacent lane near the connected vehicle and issues an alert to avoid side-swipe crashes.
- **Lane Changing Warning** – Similar to the Blind Spot Warning application, this application alerts drivers conduct a lane change when another vehicle is in the adjacent lane in the same direction of travel.
- **Intersection Movement Assist** – This application alerts the driver attempting to cross or turn when it is not safe to enter the intersection.
- **Vehicle Turning Right in Front of Bus Warning** – This application alerts a bus operator if a remote vehicle attempts to pull in front of the bus to make a right turn.
- **Speed Compliance** – This application alerts drivers when they exceed the posted regulatory speed limit.
- **Curve Speed Compliance** – This application alerts drivers that are approaching a curve that they are exceeding the recommended advisory speed.
- **Speed Compliance in Work Zones** – This application alerts drivers that they are exceeding the regulatory speed limit of a designated work zone.
- **Red Light Violation Warning** – This application provides an alert to the driver of impending red light violations.
- **Oversize Vehicle Compliance** – This application alerts commercial vehicle operators when their vehicle exceeds the height-restriction of roadway infrastructures, such as bridge or tunnel clearances.
- **Emergency Communications and Evacuation Information** – This application provides alerts to drivers of travel and evacuation information during emergency events.
- **Pedestrian in Signalized Crosswalk** – This application alerts drivers to the presence of pedestrian crossing at a signalized intersection.
- **Mobile Accessible Pedestrian Signal System** – This application informs a visually-impaired or audibly-impaired pedestrian of the signal status and provide orientation to the crosswalk to assist in crossing the street.

In addition to testing these applications, equipped vehicles will integrate with existing infrastructure detection to provide information to New York City's Midtown in Motion adaptive traffic signal system.

The New York City CVPD will be deploying CV technologies in up to 8,000 vehicles, including 5,850 taxis; 1,250 MTA buses; 400 UPS fleet vehicles; 250 NYCDOT fleet vehicles; and 250 Department of Sanitation fleet vehicles. NYCDOT also plans to install roadside units at approximately 310 signalized intersections, eight on FDR Drive, and 36 support locations (such as river crossing, airports, vehicle garages, etc.) throughout the city (3).

### Wyoming Connected Vehicle Pilot Deployment

The goal of the Wyoming CVPD is to improve driver safety, particularly for commercial vehicle operators, on I-80 (5). I-80, which runs the entire length of the southern edge of the state, is susceptible to multi-vehicle collisions and roadway closures during winter weather due to icy roads and low visibility from



blizzard conditions. These events can result in fatalities, extended closures, and significant economic loss. The Wyoming CVPD includes a variety of applications to support a range of existing and new services, including traveler information, roadside alerts, and dynamic travel guidance for freight and passenger travel. These applications include the following (5):

- **Forward Collision Warning** – Using V2V communications, this application issues warning to drivers if another connected vehicle ahead is going in the same travel lane and direction. This application will help drivers avoid front-to-rear vehicle collisions by detecting when other vehicles are stopped or moving slowly ahead of the vehicle.
- **Infrastructure to Vehicle (I2V) Situational Awareness** – This application allows connected vehicles to receive information about downstream conditions that may impact their travel. This application would provide drivers with information about downstream road conditions, weather alerts, speed restrictions, vehicle restrictions, incidents, parking, and road closures.
- **Work Zone Warning** – This application extends the I2V Situational Awareness application to provide information to vehicles approaching work zones. The approaching connected vehicle will receive information about work zone conditions, including obstructions in the travel lane, lane closures, lane shifts, speed reductions, and vehicle entering and exiting work zones.
- **Spot Weather Impact Warning** – This application broadcasts localized road condition information to drivers. The purpose of this application is to alert drivers of fog and icy roads that may exist only at isolated locations on I-80.
- **Distress Notification** – This application enables connected vehicles to communicate a distress message if the vehicle's sensors detect an event that might require assistance from other or if the driver initiates a distress request.

To support this pilot, Wyoming Department of Transportation (WyDOT) is deploying 75 roadside units in various sections of I-80 that can receive and broadcast messages using dedicated short-range communication (DSRC). WyDOT will install these RSUs at locations upstream of identified hotspot areas. Through their collaboration partners, WyDOT will also equip 400 vehicles that regularly use I-80 with onboard equipment designed to provide connected vehicle information and to receive alerts and advisories issued by WyDOT. A portion of the equipped vehicle will have additional capabilities to collect and transmit environmental and road weather conditions information through mobile weather sensors (5). Figure D-3 shows the deployment corridor.



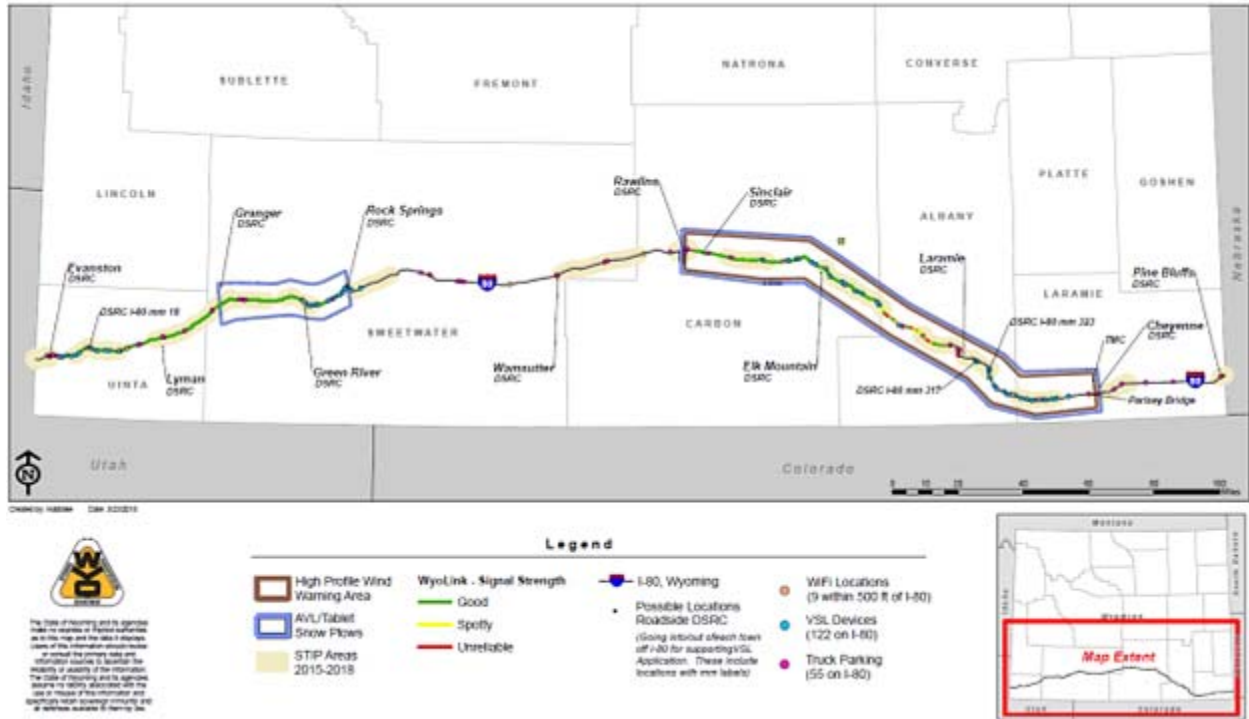


Figure D-3: Wyoming CVPD Deployment Area

Source: (6)

### SMART Columbus

In December 2016, USDOT awarded the City of Columbus \$50 million to serve as the demonstration locations for the Smart City Challenge (6). From a transportation perspective, a Smart City is one in which integrates data, applications, and technology to develop, first-of-its-kind smart transportation system to help people and goods move faster, cheaper, and more efficiently. The objectives of the Smart City Challenge are as follows:

- Provide first-mile and last-mile service for transit users to connected underserved communities to jobs.
- Facilitate the movement of goods into and within a city.
- Coordinate data collection and analysis across systems and sectors.
- Reduce inefficiency in parking systems and payment.
- Limit the impacts of climate change and reduce carbon emissions.
- Optimize traffic flow on congested freeways and arterial streets.

The City of Columbus, along with their partners, have identified the following projects to be implemented as part of the Smart Columbus Deployment:

- **Integrated Data Exchange** — This project integrates data from multiple sources allowing stakeholders to make better decisions and solve problems to move people more efficiently.
- **Connected Vehicles** — This project installs DSRC devices in vehicles and in the infrastructure, that allows the deployment of safety and mobility applications.
- **Common Payment System** — This project integrates several diverse payment systems that would allow travelers to make only one payment across multiple modes.

- **Multimodal Trip Planning** — This system allows users to plan trips using multiple modes to reach their destination.
- **Smart Mobility Hubs** — This project allows multiple transportation users – cyclists, drivers, transit users – a place to meet to access the transportation network.
- **Smart Street Lighting** — This project adds light-emitting diode (LED) lights and Wi-Fi connectivity in residential areas.
- **Mobility Assistance** — This project focuses on developing technologies and system to help individuals with cognitive disabilities access the transportation system.
- **Enhanced Permit Parking** — This project is deploying technologies that would help reduce the infiltration of unwanted parking in residential areas.
- **Event Parking Management** — This project uses technologies to help users find parking during major events in downtown Columbus.
- **Delivery Zone Availability** — This project is intended to help commercial delivery vehicles to schedule and coordinate deliveries in downtown Columbus.
- **Connected Electric Autonomous Vehicles** — This project involves deploying six electric autonomous vehicles (EAVs) on set routes connecting popular retail and commercial hubs in northeast Columbus.
- **Truck Platooning** — This project permits the electronic coupling of long-haul trucks to allow them to move as a coordinated string on the freeway.
- **Interstate Truck Parking** — This project provides locations, facilities, and amenities for trucks to park in and around the Columbus area.

The City of Columbus is in the early stage of system design and expects to begin rolling out these projects mid- to late 2018.

### Ann Arbor Safety Pilot Model Deployment

The Safety Pilot Model Deployment (SPMD) was the first large-scale connected vehicle test in the United States. USDOT’s purpose for the SPMD was to demonstrate the applicability of V2I and V2V communications to improve safety and to assist in potential rule making associated with the widespread deployment of these devices in the vehicle fleet. As a result, the USDOT, under the leadership of the University of Michigan Transportation Research Institute (UMTRI) acting as the test conductor, equipped nearly 3,000 vehicles and instrumented more than 70 miles of roadway in Ann Arbor, Michigan. The SPMD site encompassed the northeast, and a portion of the southeast corner of Ann Arbor, Michigan. Figure D-4 shows the locations of the SPMD corridors in Ann Arbor (8).

USDOT’s objective of the SPMD was to support the evaluation of DSRC technology for V2V safety applications in a real-world, concentrated environment. The primary focus of the SPMD was to collect data to support: (1) the functional evaluation of V2V safety applications, (2) the assessment of the operational aspects of messages that support vehicle-to-infrastructure (V2I) safety applications, and (3) comprehension of the operational and implementation characteristics of a prototype security operating concept (8).

The deployers equipped the majority of the vehicles with a *vehicle awareness device* (VAD). VADs transmit the basic safety message only and do not perform any safety functions. They act as the “remote vehicles” or the “target vehicles.” The SPMD installed VADs on passenger, medium-duty, heavy-duty, and transit vehicles. The VAD installations were a mix of personal and fleet vehicles.

The deployers equipped other vehicles with *aftermarket safety devices* (ASD). The SPMD installed ASDs in passenger vehicles only. ASDs generate warnings with an audible cue to the driver. The SPMD deployed two additional ASD-like devices: the first on motorcycles (ASDM), and the other on one bicycle (ASDB). ASDMs transmit and receive messages, but do not provide warnings to the motorcycle driver. The ASDB received messages only (the opposite of the VAD) and did not provide any safety warnings to support data collection for bicycle crash avoidance research and analysis.

The SPMD also equipped commercial trucks with *retrofit safety device* (RSD) kits. The RSD is a type of aftermarket device but for the commercial fleet. Unlike the ASD used in passenger vehicles, the RSD connects to the truck's data bus, giving additional input for the safety warning threat assessment. The RSD installation also included a tablet to provide a visual cue in addition to the audio to the driver. The deployers installed RSD kits on two local Ann Arbor fleets. An offshoot of the RSD was the Transit Retrofit Platform (TRP). It was specifically designed for transit and installed on UM bus fleet for testing.

Last, there were two integrated device platforms: *integrated light vehicles* (ILV) and *commercial connected vehicle – integrated truck* (CCV-IT). Devices were connected to the vehicle data bus and had a suite of warnings that include visual, haptic, and audio cues. CAMP, as a subcontractor to USDOT, supplied the ILVs while Battelle provided the CCV-ITs.

On the infrastructure side, the SPMD installed DSRC devices known as roadside equipment (RSE) in Northeast Ann Arbor in the SPMD area. Also, the deployment agencies installed signal-phase-and-timing-enabled traffic signal controllers. The deployers developed an interface device to exchange signal time and phasing information between the traffic signal controllers and the RSEs. For TRP, the SPMD deployers also installed pedestrian detection hardware at the intersection in front of the University of Michigan Hospital.



Figure D-4: Safety Pilot Model Deployment Area

Source: (8)

## Mcity

Mcity is a test facility built by the University of Michigan, in collaboration with the Michigan Department of Transportation, to provide a realistic, controlled environment for testing automated and connected vehicle technologies. The facility is located on a 32-acre site on the University of Michigan’s North Campus. It consists of about 16 acres of roads and traffic infrastructure designed to replicate real-world urban and suburban conditions with approximately five lane-miles of roads with intersections, traffic signs and signals, sidewalks, simulated buildings, street lights, and obstacles, etc. The test facility includes the following attributes:

- 1000’ North/South straight.
- Various road surfaces (concrete, asphalt, brick, dirt).
- Variety of curve radii, ramps.
- Two, three, and four-lane roads.
- Round-about and “tunnels.”
- Sculpted dirt and grassy areas.
- Variety of signage and traffic control devices.
- Fixed, variable street lighting.
- Crosswalks, lane delineators, curb cuts, bike lanes, grade crossings.
- Hydrants, sidewalks, etc.

- “Buildings” (both fixed and movable).

Figure D-5 provides a summary of the Mcity Test Facilities.

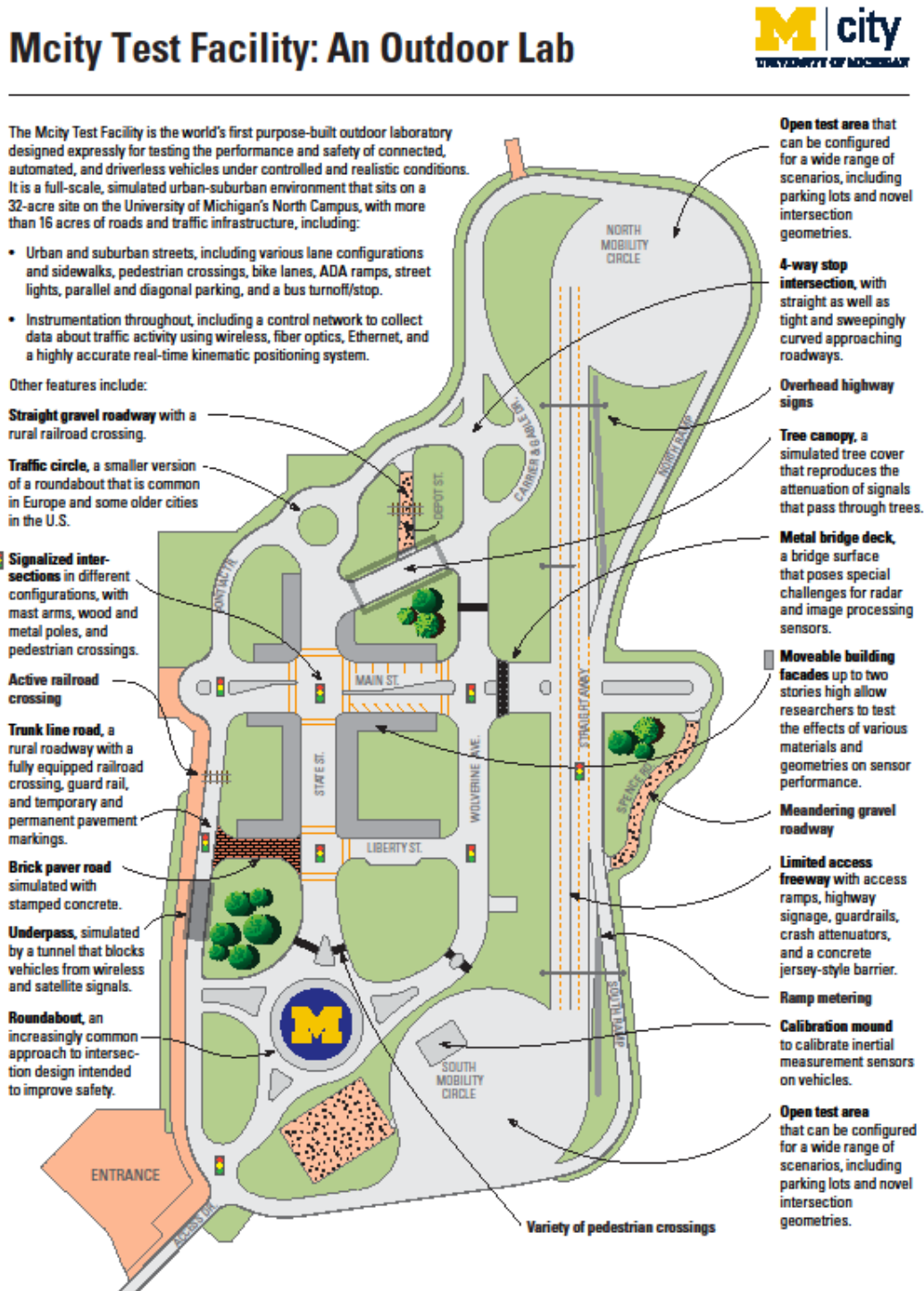


Figure D-5: Mcity Test Facilities

Source: (10)



## International

A number of pilot projects have been underway internationally. Most of these efforts have been in Europe, although Australia and Asia also have development projects underway.

### *European Union L3Pilot*

Officially started September 14, 2017, L3Pilot tests the viability of automated driving as a safe and efficient means of transportation. The project focuses on large-scale piloting of SAE Level 3 functions, with additional assessment of some Level 4 functions. The functionality of the systems used is exposed to variable conditions with 1,000 test drivers and 100 vehicles in 11 European countries (11).

The tested functions cover a wide range from parking to overtaking, and urban intersection driving. These tests will provide valuable data for evaluation of technical aspects, user acceptance, driving and travel behavior, and impact on traffic and society.

With its large coverage of driving situations, L3Pilot is the first project worldwide demonstrating and testing a comprehensive setup of automated driving functions.

### *United Kingdom MERIDIAN*

Initiated in September 2017, MERIDIAN, funded jointly by the government's flagship CAV investment program and by industry, will create a cluster of excellence in driverless car testing, along the M40 corridor between Coventry and London, to accelerate the development of this technology, grow intellectual capital and attract overseas investment in the UK (12).

A key part of the Industrial Strategy commitment to develop world-class CAV testing facilities and infrastructure, the launch of the MERIDIAN brand follows a call for evidence by the Centre of Connected and Autonomous Vehicles (CCAV) in May 2016 into how the UK can integrate and strengthen its CAV testing facilities and to consider the case for a test bed to provide a focus for the industry.

Responses to the consultation were published in March 2017, reflected broad industry support from the Automotive Council, among other sectors and companies, for coordinating the UK's existing testing facilities and for Government funding to support this work.

### *United Kingdom SCOOP@F*

SCOOP@F is a pilot deployment project of cooperative intelligent transport systems that is, based on the exchange of information between vehicles and between the vehicle and the road. Vehicles are equipped with on-board units that transmit the events detected automatically by the vehicle's sensors (slippery road, shock, sudden braking, etc.) to upstream vehicles and to the road manager. The manager can also transmit information to the units embedded in the vehicles. Its main objective is to improve the safety of road transport and of road operating staff during road works or maintenance (12).

The project aims to deploy 3,000 vehicles on 2,000 km of roads in five locations: Île-de-France, A4 motorway, Isère, Bordeaux and Brittany ring road. It was launched in 2014 and is due to be completed in 2018. It is the subject of a 50% grant from the European Union. SCOOP brings together many public and private partners around the French Ministry of Ecological and Solidarity Transition.

The pilot is organized in two waves. The first wave (2014-2017) focuses on site alert services, unannounced and unsafe events, and data collection for the manager.

The second wave (2016-2018) includes new services and explores the possibilities of a mixed Wi-Fi / cellular technology where cellular (3G / 4G) takes over Wi-Fi in areas not covered by on-board units of the road. Specifications are in the process of being written. Scoop is also a European project: cross-tests are organized with Austria, Spain and Portugal to control the interoperability of the systems.

#### *Finland, Norway, Sweden and Denmark Nordic Way*

Nordic Way is a pilot project that seeks to enable vehicles to communicate safety hazards through cellular networks on a road corridor through Finland, Norway, Sweden and Denmark (12).

The project is a collaboration between public and private partners in the four countries, and is co-financed by the European Union within the Connecting Europe Facility program 2015-2017.

During the project, cars will utilize cellular networks to share specific and low latency traffic safety information regarding e.g. obstacles on the road, weather conditions, slippery surfaces and accidents. Voluntary drivers of up to 2000 vehicles will connect and share information with other vehicles on the road and the surrounding infrastructure in a C-ITS network.

#### *United Kingdom GATEway*

GATEway stands for Greenwich Automated Transport Environment whose purpose is to understand how automated vehicles will fit into our future urban mobility needs and the barriers that need to be overcome before these vehicles become a reality on our roads. It's not about developing new technologies, but improving our understanding of the public and industry perception and acceptance of automated vehicles (12).

The GATEway group also wanted to create a safe and validated test bed environment in the UK, where other organizations and developers can bring their technology and test it against the results of our trials.

Specific trials include:

- Automated passenger shuttle trials: exploring the use of automated shuttle vehicles as a small-scale transport service.
- Automated urban deliveries trials: using automated vehicles for last mile transportation; potentially from a local delivery depot to a residential neighborhood.
- Remote teleoperation demonstrations: where a human operator can maneuver, or recover a fully automated vehicle to a safe mode of operation.
- High-fidelity simulator trials: to investigate how drivers of regular vehicles respond and adapt their behavior to the presence of automated vehicles on the road.

#### *European Union eCall*

eCall is an initiative with the purpose to bring rapid assistance to motorists involved in a collision anywhere in the European Union. In case of a crash, an eCall-equipped car automatically calls the nearest emergency center. Even if no passenger is able to speak, e.g. due to injuries, a 'Minimum Set of Data' is sent, which includes the exact location of the crash site. Shortly after the accident, emergency services therefore know that there has been an accident, and where exactly.

eCall cuts emergency services response time. It goes down to 50% in the countryside and 60% in built-up areas. The quicker response will save hundreds of lives in the EU every year. The severity of injuries will be considerably reduced in tens of thousands of cases. The European Commission projected this could

reduce traffic fatalities by at least 4%. As eCall normally 'sleeps', it does not allow vehicle tracking outside emergencies.

On April 28, 2015 the European Parliament voted in favor of eCall regulation which requires all new cars be equipped with eCall technology from April 2018. eCall will be seamlessly functioning throughout Europe by that time. In the event of a serious accident, eCall automatically dials 112 - Europe's single emergency number (12).

#### *United Arab Emirates Dubai Autonomous Transportation Strategy*

The Dubai Autonomous Transportation Strategy aims to transform 25% of the total transportation in Dubai to autonomous mode by 2030.

The strategy will help cut transportation costs by 44%, resulting in savings of up to AED (United Arab Emirates currency) 900 million a year. It will also help save AED 1.5 billion a year by reducing environmental pollution by 12%, as well as generate AED 18 billion in annual economic returns by increasing the efficiency of the transportation sector in Dubai by 2030. The Strategy features four main pillars: Individuals, Technology, Legislative Structure, and Infrastructure.

The main sectors identified for the application of the strategy are: autonomous metro, autonomous buses, autonomous taxis, in addition to other autonomous transportation means used in the first and final stages of trips. The concept of autonomous transportation will also be applied in commercial areas, residential complexes and parks across the emirate. A recent component to this was Dubai's purchase agreement with Tesla to buy 200 Tesla vehicles for their self-driving taxi plan (12).

## Other Agencies' Policies

In the last few years, connected and automated vehicle research and pilot projects have boomed rapidly and most agencies are trying to keep up with this rapidly changing technology. This report also documents the most relevant policies enacted by transportation agencies related to connected and automated vehicle technologies. Through this process, the PennDOT Joint Statewide Connected and Automated Vehicles Strategic Plan will capture knowledge of the most current and successful policies and global best practices. This material will help ensure that Pennsylvania remains among the leaders in development and deployment of the one of the most beneficial transportation technologies. The following sections present an overview of the policies researched.

### North America

Electronic searches for information and published material describing CAV technology activities throughout the country were conducted to identify policies enacted by various transportation agencies to address CAV. The information collected was analyzed to identify best practices and document lessons learned for PennDOT.

#### State Level

Many states are entering the CAV environment with their own research and policy development. For the most part agencies are evolving their intelligent transportation systems (ITS) policies to take advantage of the potential of the technology. For instance, the Virginia Department of Transportation (VDOT) wants to attract the CAV industry by making available transportation operations data for use in the advancement of the technology. VDOT has made an investment in the Virginia Connected Corridor (VCC) in Northern Virginia with DSRC deployment along I-66 and the major arterials corridors of Route 7 and Route 50



opening the door for research and development activities. The VCC and data portal availability is intended to encourage device and application development to further CAV evolution and leverage existing programs such as traveler information in the process. The VDOT Innovation and Technology Innovation Plan encompasses these approaches to improve safety and operations of the transportation system.

The more prevalent debate centers around automated vehicles on public roadways. States are addressing concerns of automated vehicles operating on roadways including liability and safety of the public. Legislative actions have been taken in some states and many others are weighing their options. The challenge of automated vehicles is immaturity of the technology and the uncertainty of its introduction in volume into the transportation market. Figure D-6 illustrates the state legislative actions taken on the topic of automated vehicles as of June 2017. Since then, North Carolina and Connecticut have moved forward with legislation.

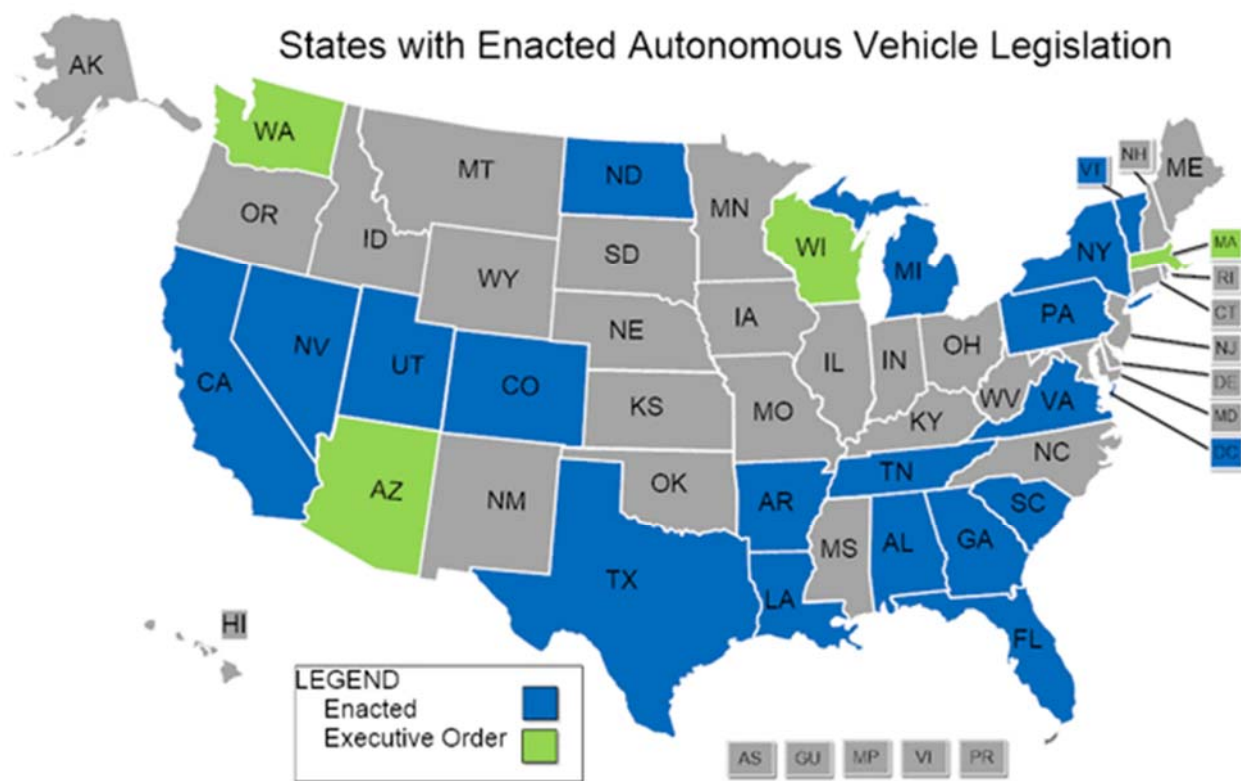


Figure D-6: States with Enacted Autonomous Vehicle Legislation

Source: (14)

Since 2012, 41 states have introduced or are considering automated vehicle legislation. 20 states have now passed legislation while 4 have issued executive orders related to automated vehicles. The key automated vehicle legislation topics have been focused on automated vehicle definition, testing, study and oversight as noted in Table D-1.

Table D-1 Key Autonomous Vehicle Legislative Topics

Commercial (including platooning)	Cybersecurity of Vehicle
Definitions	Infrastructure and Connected Vehicles
Insurance and Liability	Licensing and Registration
Operation on Public Roads	Operator Requirements
Privacy of Collected Vehicle Data	Request for Study
Vehicle Inspection Requirements	Vehicle Testing
Other	

Figure D-7 provides insight into the range of regulatory activity in a sampling of states such as Nevada, Michigan, Arizona, Tennessee, Connecticut, California, and New York. The positions vary from state to state indicating different views and tolerances for autonomous vehicles on their roadways.

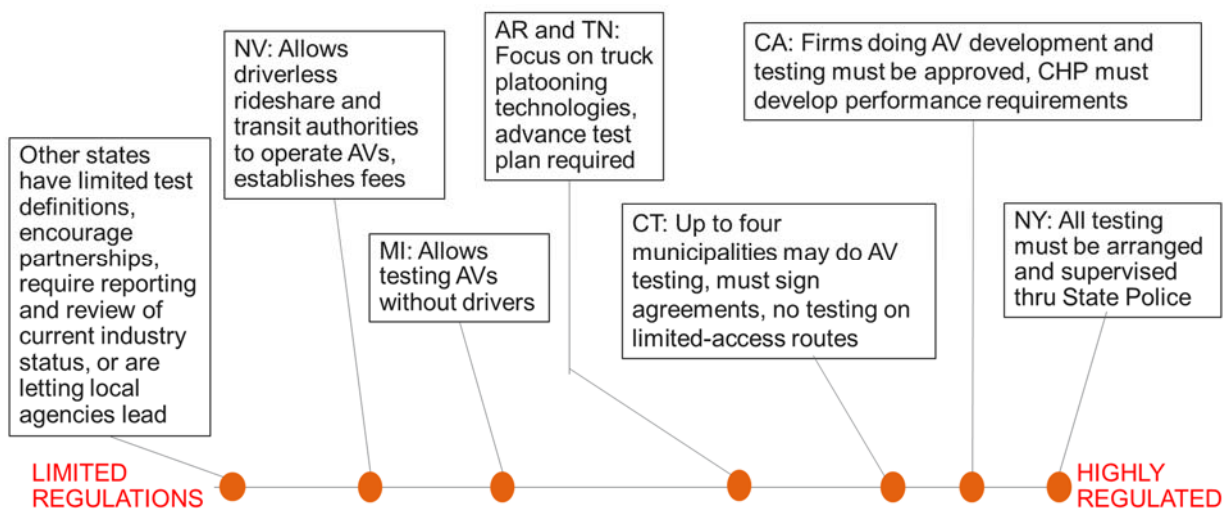


Figure D-7 Testing Requirements

Driver requirements have been established by states as well. Figure D-8 illustrates several state positions on their standards for drivers and automated vehicles. Approaches range from driverless allowances to having a driver behind the wheel to specific roads being the only place for vehicle testing.

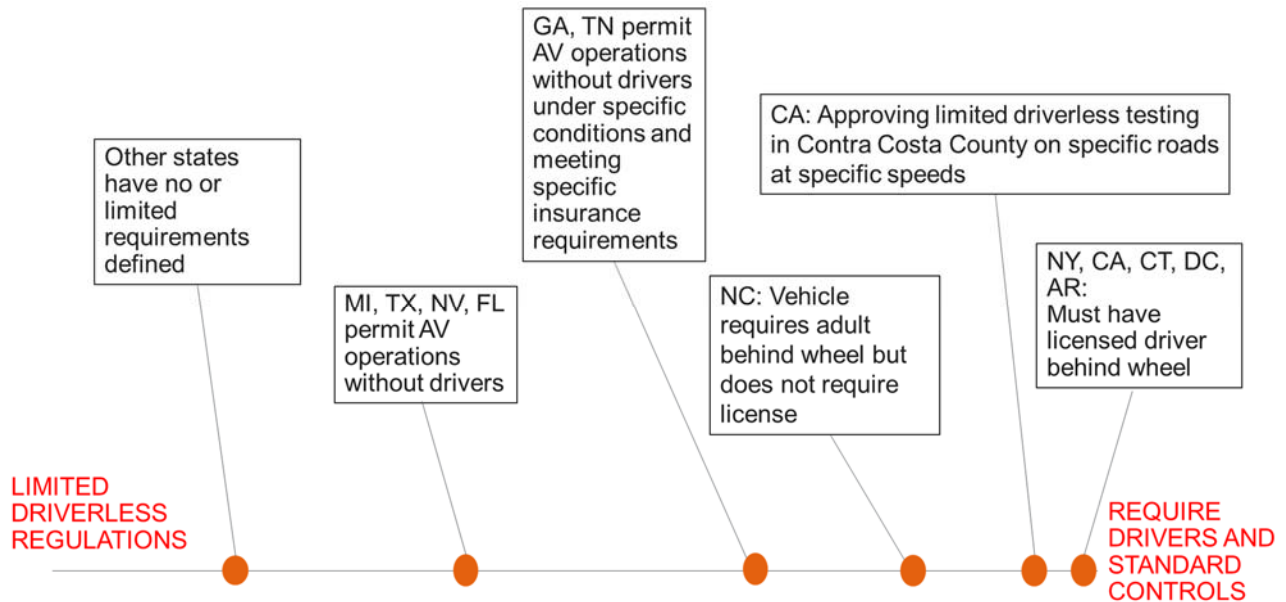


Figure D-8 Driver Requirements

Table D-2 provides a summary of all the agencies’ policies and efforts researched for this task in the United States. The column labeled “Applicable CMM Dimension(s)” makes reference to the capability maturity model (CMM) dimension the policy or effort relates to and/or attempts to address. The CCM dimensions are further explained below (13):

- **Business Process:** relates to the internal business practices, processes and procedures that an agency has adopted to guide the development to their CAV deployments. This would include formalized planning, process and procedures for scoping deploying, how CAV deployments are programmed and budgeted, and the process that agencies use to define, develop, and procure deployments (internal lead vs contract).
- **Systems and Technologies:** relates to the internal practices, processes and procedures that an agency has adopted to guide the selection, design, and operations of their CAV technologies and support systems. This would include use and development of regional architectures, the use of system engineering in the planning and design of the projects, use of formalized testing and validation procedures, and the use of standards and other requirements to promote interoperability.
- **Performance Measurement:** relates to the practices, processes and procedures that an agency has to assess the effectiveness of their CAV deployments. This would include descriptions and definitions for how performance will be assess, the types of tools and techniques that are used to acquire the performance measures, data storage and data retention policies and practices, how agencies use the performance measures to support long-term sustainability of the deployments, and the process and procedures used to secure personal identification Information (PII), the use of system engineering in the planning and design of the projects, use of formalized testing and validation procedures, and the use of standards and other requirements to promote interoperability.
- **Workforce:** relates to the practices, processes and procedures that an agency has implemented to prepare its organization and workforce to support to CAV deployments. This would include

what changes in the organizational structure agencies have adopted to support CAV deployments, steps agencies have performed to train and retain staff to support CAV technologies, and what steps agencies have performed to develop knowledge, skills and abilities (KSAs) of internal staff to support CAV deployments.

- **Culture:** relates to the practices, processes and procedures that an agency has implemented to change the culture of their agency related to CAV deployments. This would include what agencies have done to improve the technical understanding of their staffs, to develop leaders and champions to support CAV technologies, to promote and garner support for the CAV deployments, and what steps they have taken to establish formal CAV programs.
- **Collaboration:** relates to processes and procedures that an agency is using to collaborate with other key regional stakeholders. These other stakeholders include local and state public safety organization (state police, local police, fire, motor vehicle regulators, etc.), the role of local governments, metropolitan planning organizations (MPO), etc. have played in the deployment, and any outsourcing and public-private partnerships used to support the deployments.

Table D-2: List of CAV Policies and Efforts endorsed by other Agencies in the United States

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Alabama	Department of Transportation	Bill SJR 81	Bill established the Joint Legislative Committee to study self-driving vehicles.	May 2016	Systems and Technologies / Collaborations
Alabama	Department of Transportation	Intelligent Transportation Systems (ITS) Strategic Business Plan	This ITS Strategic Business Plan serves as the roadmap for the necessary actions and priorities to appropriately guide the ITS program over the next five years in Alabama. One of the goals stated in the plan is to provide maintenance activities needed to support mobility and future connected vehicles. Plan recognizes the impact such technology will have in the transportation industry, but no policy and/or actions are identified.	September 2015	Business Process
Arizona	Department of Transportation	Executive Order 2015-09	The Arizona Self-Driving Vehicles Oversight Committee was created by Governor Doug Ducey to support research and development of self-driving vehicle technology in Arizona. Gov. Ducey created the panel, made up of transportation, public safety and policy experts, to advise ADOT, the Department of Public Safety, universities and other public agencies on how best to advance the testing and operation of self-driving vehicles on public roads. Its goals align with the governor's mission of boosting economic growth, creating jobs and promoting innovation that improves the way Arizonans live.	August 2015	Systems and Technologies / Collaborations
Arizona	Department of Transportation	Organizational Structure	Transportation Systems Management and Operations (TMSO) Director leads the efforts for optimizing the performance of existing infrastructure by implementing multimodal, intermodal and often cross-jurisdictional systems, services and projects, including connected vehicles and automated vehicles efforts.	NA	Workforce
Arizona	Department of Transportation	Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)	The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) is the merging of the National ITS Architecture and the Connected Vehicle Reference Implementation Architecture (CVRIA). ARC-IT describes the general framework used in the planning and deployment of ITS. ARC-IT replaces the old National ITS Architecture that established the guidelines for specific ITS features known as service packages. ARC-IT defines 133 service packages from vehicle emergency response to traffic signal control to autonomous vehicle safety systems. The objective of this project is to ensure that all ITS investments in the State will have established common communication protocols, avoid duplication of investment in infrastructure, provide the ability to share data sources between agencies, and update existing legacy ITS Architecture, bringing the State into compliance with the nationally established ITS standards and architecture.	On Going Effort	Systems and Technologies
California	Various Agencies	Bill SB 1298	Bill requires the Department of the California Highway Patrol to adopt safety standards and performance requirements to ensure the safe operation and testing of autonomous vehicles, as defined, on the public roads in this state. Permits autonomous vehicles to be operated or tested on the public roads in this state pending the adoption of safety standards and performance requirements that would be adopted under this bill.	September 2012	Business Process / Performance Measurement
California	Contra Costa Transportation Authority	Bill AB 1592	Bill authorizes the Contra Costa Transportation Authority to conduct a pilot project for the testing of autonomous vehicles that are not equipped with a steering wheel, a brake pedal, an accelerator, or an operator inside the vehicle, if the testing is conducted only at specified locations and the autonomous vehicle operates at specified speeds.	September 2016	Systems and Technologies

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
California	San Diego Association of Governments (SANDAG)	San Diego Forward: The Regional Plan	SANDAG is the San Diego region's primary public planning, transportation, transit construction, and research agency, providing the public forum for regional policy decisions about growth, transportation planning and transit construction, environmental management, housing, open space, energy, public safety, and binational topics. SANDAG's Regional Plan provides a roadmap to grow and evolve, and it prioritizes 35 years of regional transportation projects to create a framework for much of the region's transportation infrastructure. The plan envisions a network of high-tech tools to help transportation managers keep the system running smoothly, and to help travelers make their trips faster, more efficient, and trouble-free, which includes connected and automated vehicles.	September 2015	Business Process
California	Metropolitan Transportation Commission (MTC)	Catapult Bay Area	MTC's Connected Vehicle Program, branded as "Catapult Bay Area," supports connected vehicle, automated vehicle and autonomous vehicle deployments in the San Francisco Bay Area using Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Vehicle-to-Everything (V2X) communications. Catapult Bay Area aims to improve safety, mobility and the environment in the region through innovation and technology. The goals of MTC's Catapult Bay Area Program are to: implement projects that can help the region meet the project performance targets identified in Plan Bay Area 2040; provide support to local agencies interested in deploying connected vehicle projects within their jurisdictions; provide technical seminars on relevant topics to help municipalities understand the technology and better prepare for this future technology; keep local municipalities and other stakeholders engaged by providing updates at the bi-monthly Arterial Operations Committee meetings; and keep a pulse on technology and policy advancements being made at the federal, state and local levels.	NA	Business Process / Workforce / Culture / Collaborations
Colorado	Senate	Bill SB 213	Bill defines automated driving system, dynamic driving task and human operator. Allows a person to use an automated driving system to drive or control a function of a motor vehicle if the system is capable of complying with every state and federal law that applies to the function that the system is operating. Requires approval for vehicle testing if the vehicle cannot comply with every relevant state and federal law. Requires the department of transportation to submit a report on the testing of automated driving systems.	August 2017	Systems and Technologies
Colorado	Department of Transportation	RoadX	RoadX is Colorado's bold vision and commitment to being a national leader in the partnerships and use of innovative technology for crash-free, injury-free, delay-free travel in Colorado. RoadX will use 21 <sup>st</sup> century technology and ingenuity to solve our current infrastructure challenges. Bold thinking and bold actions drive progress. That means smarter roadways with more informed drivers and, eventually, self-driving cars that can communicate with the roads on which they travel. It will be a rapid, fast-paced enterprise to frame how the Colorado Department of Transportation (CDOT) will build tomorrow—today. It will foster an environment where private industry has a direct pipeline to deploy technological solutions to transform an aging transportation system. The project aims to team the public sector and private companies to deploy comprehensive technology solutions over the next 10 years can help make Colorado's roads crash-free, injury free, delay-free. The Department has committed \$20 million in budget.	November 2015	Business Process / Systems and Technologies / Collaborations



LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Connecticut	Various Agencies	Bill SB 260	Bill defines terms including “fully autonomous vehicle,” “automated driving system,” and “operator.” Requires the development of a pilot program for up to four municipalities for the testing of fully autonomous vehicles on public roads in those municipalities. Specifies the requirements for testing, including having an operator seated in the driver’s seat and providing proof of insurance of at least \$5 million. Establishes a task force to study fully autonomous vehicles. The study must include an evaluation of National Highway Traffic Safety Administration (NHTSA) standards regarding state responsibility for regulating automated vehicles (AVs), an evaluation of laws, legislation and regulations in other states, recommendations on how Connecticut should legislate and regulate AVs, and an evaluation of the pilot program.	June 2017	Business Process / Systems and Technologies
Florida	Department of Transportation	Bill HB 1207	Bill defines “autonomous vehicle” and “autonomous technology.” Declares legislative intent to encourage the safe development, testing and operation of motor vehicles with autonomous technology on public roads of the state and finds that the state does not prohibit or specifically regulate the testing or operation of autonomous technology in motor vehicles on public roads. Authorizes a person who possesses a valid driver’s license to operate an autonomous vehicle, specifying that the person who causes the vehicle’s autonomous technology to engage is the operator. Authorizes the operation of autonomous vehicles by certain persons for testing purposes under certain conditions and requires an instrument of insurance, surety bond or self-insurance prior to the testing of a vehicle. Directs the Department of Highway Safety and Motor Vehicles to prepare a report recommending additional legislative or regulatory action that may be required for the safe testing and operation of vehicles equipped with autonomous technology, to be submitted no later than Feb. 12, 2014.	April 2012	Business Process
Florida	Department of Transportation	Bill HB 599	The relevant portions of this bill are identical to the substitute version of HB 1207.	April 2012	Business Process
Florida	Department of Highway Safety and Motor Vehicles	Bill HB 1399	Required Florida Department of Highway Safety and Motor Vehicles (DHSMV) to submit a report recommending additional legislative or regulatory action that may be required for safe operation and testing.	July 2012	Business Process
Florida	Department of Transportation	Bill HB 7027	Bill permits operation of autonomous vehicles on public roads by individuals with a valid driver license. This bill eliminates the requirement that the vehicle operation is being done for testing purposes and removes a number of provisions related to vehicle operation for testing purposes. Eliminates the requirement that a driver be present in the vehicle. Requires autonomous vehicles meet applicable federal safety standards and regulations.	April 2016.	Business Process
Florida	Department of Transportation	Bill HB 7061(2016)	Bill defines autonomous technology and driver-assistive truck platooning technology. Requires a study on the use and safe operation of driver-assistive truck platooning technology and allows for a pilot project upon conclusion of the study.	April 2016	Business Process / Systems and Technologies / Collaborations

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Florida	Department of Transportation	Florida Automated Vehicles Working Groups	The FDOT has organized Working Groups comprised of stakeholders that may be impacted by and/or have an impact on the adoption of automated vehicles in Florida. More than sixty individuals representing state agencies, trade organizations, transportation consultants, insurance providers, automobile manufacturers, and others make up the 3 working groups (Policy, Transportation/Infrastructure, and Modal Applications). Each working group is tasked to identify challenges and opportunities associated with these technologies on public roadways and to discuss how the challenges could be mitigated and how to leverage the opportunities. The overarching goal of these working groups is to provide FDOT, and other state agencies, recommendations on how to address potential policy adoption or amendments, engineering and design standard changes, and infrastructure investment priorities.	2014	Business Process / Culture / Workforce / Collaboration
Georgia	Various Agencies	Bill HB 472	Bill specifies that the law prohibiting following too closely does not apply to the non-leading vehicle in a coordinated platoon. Defines coordinated platoon as a group of motor vehicles traveling in the same lane utilizing vehicle-to-vehicle communication technology to automatically coordinate the movement of the vehicles.	July 2017	Business Process / Systems and Technologies
Georgia	Various Agencies	Bill SB 219	Bill defines automated driving system, dynamic driving task, fully autonomous vehicle, minimal risk condition and operational design domain. Exempts a person operating an automated motor vehicle with the automated driving system engaged from the requirement to hold a driver's license. Specifies conditions that must be met for a vehicle to operate without a human driver present in the vehicle, including insurance and registration requirements.	July 2017	Business Processes
Illinois	Department of Innovation & Technology	Executive Order 01-16	Governor Rauner issued Executive Order 01-16 establishing the Department of Innovation & Technology (DoIT), a new state agency with responsibility for the information technology functions of agencies under the jurisdiction of the Governor. The DoIT delivers statewide information technology and telecommunication services and innovation to state government agencies, boards and commissions as well as policy and standards development, lifecycle investment planning, enterprise solutions, privacy and security management, and leads the nation in Smart State initiatives. A Smart State is a state with a vision, a plan, and an execution road map to enact the digital transformation of government by investing in a 3rd Platform — information and communications technology (ICT). This 3rd Platform includes mobile technologies, big data analytics, social networks, and cloud services as its foundation for a set of innovation accelerators, such as the Internet of Things (IoT), cognitive computing, and robotics, that enable potentially radical new work processes, services, and products.	January 2016	Business Process / Systems and Technologies / Performance Measurement / Workforce / Collaborations
Iowa	Department of Transportation	Automated Vehicle Technology Project Vision Document	The State of Iowa is taking a proactive approach to preparing for increasing levels of vehicle automation. This document sets out a comprehensive vision for the Iowa Department of Transportation's (DOT) role in the future transportation environment, and a plan for accelerating progress towards that future.	March 2017	Business Process
Iowa	Department of Transportation	Transportation Systems Management and Operations (TSMO) Strategic Plan	The TSMO Strategic Plan is composed of three components: TSMO Strategic Plan, TSMO Program Plan and TSMO Service Layers. The Connected and automated vehicles efforts are part of the Service Layer Plans. Iowa sees its DOT's primary role as an information service provider.	February 2016	Business Process / Systems and Technologies
Louisiana	Various Agencies	Bill HB 1143	Bill defines "autonomous technology" for purposes of the Highway Regulatory Act/traffic laws.	June 2016	Business Process
Louisiana	Department of Transportation	Louisiana Statewide ITS Architecture	The Louisiana Statewide ITS Architecture was updated to address advanced vehicle systems, such as connected and automated vehicles technologies.	September 2016	Systems and Technologies



LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Maryland	Department of Transportation	Connected and Automated Vehicles (CAV) Working Group	In 2015, Maryland Transportation Secretary Pete Rahn established the Connected and Automated Vehicles (CAV) Working Group as the central point of coordination for the development and deployment of emerging CAV technologies in Maryland. The Working Group handles strategic planning for Maryland Department of Transportation (MDOT) concerning connected and automated vehicles. The group includes a diverse membership of transportation stakeholders, including elected officials, state and local agency representatives, highway safety organizations, representatives from the private sector and automotive industry. The group evaluates the latest research, tracks federal and state laws, policies and programs, and coordinates with other agencies, organizations and businesses to set the course for the future of automated and connected vehicles in Maryland.	2015	Business Process
Massachusetts	Department of Transportation	Executive Order No. 572	Governor Charles D. Baker signed Executive Order No. 572 to promote the testing and deployment of Highly Automated Driving Technologies. The Automated Vehicles Working Group was also established by this executive order. The AV Working Group will encourage the development of autonomous vehicles and their component parts in Massachusetts, and to that end will work with companies in the sector to support innovation and development and consider proposing changes to statutes or regulations that would facilitate the widespread deployment of highly automated vehicles in Massachusetts while ensuring the safety of the public. Massachusetts Department of Transportation (MassDOT), with input from the AV Working Group and other technical experts as deemed appropriate, will issue guidance to allow for the safe testing of such technologies on designated state highways and on other public roadways in municipalities that desire to permit such testing. The guidance shall complement the process for Testing Highly Automated Vehicles.	October 2016	Business Process / Systems and Technologies
Michigan	Various Agencies	Bill SB 995	Bill allows for autonomous vehicles under certain conditions. Allows operation without a person in the autonomous vehicle. Specifies that the requirement that commercial vehicles maintain a minimum following distance of 500 feet does not apply to vehicles in a platoon.	December 2016	Business Process / Systems and Technologies
Michigan	Various Agencies	Bill SB 996	Bill allows for autonomous vehicles under certain conditions. Allows operation without a person in the autonomous vehicle.	December 2016	Business Process / Systems and Technologies
Michigan	Various Agencies	Bill SB 997	Bill defines automated driving system. Allows for the creation of mobility research centers where automated technology can be tested. Provides immunity for automated technology manufacturers when modifications are made without the manufacturer's consent.	December 2016	Business Process / Systems and Technologies
Michigan	Various Agencies	Bill SB 998	Bill exempts mechanics and repair shops from liability on fixing automated vehicles.	December 2016	Business Process
Michigan	Various Agencies	Bill SB 169	Bill defines "automated technology," "automated vehicle," "automated mode," expressly permits testing of automated vehicles by certain parties under certain conditions, defines operator, addresses liability of the original manufacturer of a vehicle on which a third party has installed an automated system, directs state Department of Transportation to submit a report by Feb. 1, 2016.	December 2013	Business Process / Systems and Technologies

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Michigan	Various Agencies	Bill SB 663	Bill limits liability of vehicle manufacturer or upfitter for damages in a product liability suit resulting from modifications made by a third party to an automated vehicle or automated vehicle technology under certain circumstances; relates to automated mode conversions.	December 2013	Business Process / Systems and Technologies
Michigan	Department of Transportation	Connected and Automated Vehicle Technology Strategic Plan	The purpose of this document is to align the Michigan Department of Transportation's (MDOT) long-term plans with recent advances in technology and policy regarding connected and automated vehicles. Document is divided into six strategic focus areas: leadership, safety, customer services, partnerships, system linkages, and efficiency. These categories relate to the six of the seven strategic areas of focus in MDOT departmental strategic plan. The remaining area, departmental workforce is assumed to be outside of the scope of connected and automated vehicle technology strategic planning.	July 2013	Business Process / Systems and Technologies
Minnesota	Department of Transportation	Statewide Multimodal Transportation Plan	The Statewide Multimodal Transportation Plan is Minnesota's highest level policy plan for transportation. It is a 20-year plan based on the Minnesota GO Vision for a transportation system that maximizes the health of people, the environment and our economy. The plan is for all types of transportation and all transportation partners. It is about more than just roadways and more than just the Minnesota Department of Transportation. It evaluates the status of the entire transportation system, takes into account what is changing, and provides direction for moving forward over the next 20 years. One of the work plan activities within plan is study and work with transportation partners to prepare for connected and autonomous vehicles.	January 2017	Business Process / Systems and Technologies
Nevada	Department of Motor Vehicles	Bill AB 511	Bill authorizes operation of autonomous vehicles and a driver's license endorsement for operators of autonomous vehicles. Defines "autonomous vehicle" and directs state Department of Motor Vehicles (DMV) to adopt rules for license endorsement and for operation, including insurance, safety standards and testing.	June 2011	Business Process
Nevada	Various Agencies	Bill SB 140	Bill prohibits the use of cell phones or other handheld wireless communications devices while driving in certain circumstances, and makes it a crime to text or read data on a cellular phone while driving. Permits use of such devices for persons in a legally operating autonomous vehicle. These persons are deemed not to be operating a motor vehicle for the purposes of this law.	June 2011	Business Process
Nevada	Various Agencies	Bill SB 313	Bill relates to autonomous vehicles. Requires an autonomous vehicle that is being tested on a highway to meet certain conditions relating to a human operator. Requires proof of insurance. Prohibits an autonomous vehicle from being registered in the state, or tested or operated on a highway within the state, unless it meets certain conditions. Provides that the manufacturer of a vehicle that has been converted to be an autonomous vehicle by a third party is immune from liability for certain injuries.	June 2013	Business Process

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Nevada	Various Agencies	Bill AB 69	Bill defines terms including “driver-assistive platooning technology,” “fully autonomous vehicle” and “automated driving system.” Allows the use of driver-assistive platooning technology on highways in the state. Preempts local regulation. Requires the reporting of any crashes to the department of motor vehicles within 10 days if the crash results in personal injury or property damage greater than \$750. Allows a fine of up to \$2,500 to be imposed for violations of laws and regulations relating to autonomous vehicles. Permits the operation of fully autonomous vehicles in the state without a human operator in the vehicle. Specifies that the original manufacturer is not liable for damages if a vehicle has been modified by an unauthorized third party. Allows the DMV to adopt certain regulations relating to autonomous vehicles. Defines “driver,” for purposes of an autonomous vehicle, to be the person who causes the automated driving system to engage. Specifies that the following distance requirement does not apply to a vehicle using platooning technology. Imposes an excise tax on the connection of a passenger to a fully autonomous vehicle for the purpose of providing transportation services. Specifies requirements for autonomous vehicle network companies, including a permitting requirement, prohibitions on discrimination, and addressing accessibility. Permits the use of autonomous vehicles by motor carriers and taxi companies if certain requirements are met.	June 2017	Business Process
Nevada	Department of Motor Vehicles	Autonomous Vehicle Testing Permit	Manufacturers, software developers and others interested in testing their vehicles in Nevada must submit an application to the Department of Motor Vehicles along with proof that one or more of autonomous vehicles have been driven for a combined minimum of at least 10,000 miles, a complete description of the autonomous technology, a detailed safety plan, and a plan for hiring and training test drivers. Application is available online at <a href="http://www.dmvnv.com/autonomous.htm">http://www.dmvnv.com/autonomous.htm</a>	Last update was August 2016	Business Process
Nevada	Various Agencies	Nevada Center for Advanced Mobility	The Nevada Center for Advanced Mobility (NCAM) provides a one-stop shop for technology companies looking to demonstrate their technology in Nevada. It brings together industry, government and academia to develop and deploy policies and programs to support advanced mobility technology.	February 2016	Business Process
New York	Department of Motor Vehicles	Bill SB 2005(2017)	Bill allows the commissioner of motor vehicles to approve autonomous vehicle tests and demonstrations. Requires supervision from the state police for testing. Specifies requirements for operation, including insurance of five million dollars. Defines autonomous vehicle technology and dynamic driving task. Requires a report on testing and demonstration.	April 2017.	Business Process
New York	Department of Transportation	Strategic Highway Safety Plan 2017-2022	The Strategic Highway Safety Plan (SHSP) is a comprehensive five-year transportation safety plan developed by the state department of transportation in partnership with local, state, federal, and tribal organizations and other key safety stakeholders. Plan presents strategies that will help New York State prepare for the ever-evolving environment of CAV technologies.	2017	Business Process
North Carolina	Various Agencies	Bill HB 469	Bill establishes regulations for the operation of fully autonomous motor vehicles on public highways of this state. Defines terms. Specifies that a driver’s license is not required for an AV operator. Requires an adult be in the vehicle if a person under 12 is in the vehicle. Preempts local regulation. Establishes the Fully Autonomous Vehicle Committee.	December 2017	Business Process
North Carolina	Various Agencies	Bill HB 716	Bill modifies the follow-too-closely law to allow platooning.	August 2017	Business Process
North Dakota	Department of Transportation	Bill HB 1065	Bill provides for a study of autonomous vehicles. Includes research into the degree that automated motor vehicles could reduce traffic fatalities and crashes by reducing or eliminating driver error and the degree that automated motor vehicles could reduce congestion and improve fuel economy.	March 2015.	Business Process

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
North Dakota	Department of Transportation	Bill HB 1202	Bill requires the department of transportation to study the use of vehicles equipped with automated driving systems on the highways in this state and the data or information stored or gathered by the use of those vehicles. Also requires that the study include a review of current laws dealing with licensing, registration, insurance, data ownership and use, and inspection and how they should apply to vehicles equipped with automated driving systems.	August 2017	Business Process
Oregon	Department of Transportation	Organizational Structure	ODOT has a Connected, Automated Vehicles and Electric Vehicles Advisor, who works out of the ODOT's Director's Office and coordinate ODOT's efforts related to these new technologies, including coordinating with other Oregon state agencies and external stakeholders at the state and national level, engaging on state and federal policy and legislation, and identifying and responding to funding opportunities. Part of the Innovative Program.	2016	Workforce
South Carolina	Various Agencies	Bill HB 3289	Bill specifies that minimum following distance laws for vehicles traveling along a highway do not apply to the operator of any non-leading vehicle traveling in a platoon.	May 2017	Business Process
Tennessee	Various Agencies	Bill SB 598	Bill relates to motor vehicles. Prohibits local governments from banning the use of motor vehicles equipped with autonomous technology.	April 2015	Business Process
Tennessee	Various Agencies	Bill SB 2333	Bill allows a motor vehicle to be operated, or to be equipped with, an integrated electronic display visible to the operator while the motor vehicle's autonomous technology is engaged.	March 2016	Business Process
Tennessee	Various Agencies	Bill SB 1561	Bill redefines "autonomous technology" for purposes of preemption. Defines "driving mode" and "dynamic driving task."	April 2016	Business Process
Tennessee	Various Agencies	Bill SB 676	Bill permits the operation of a platoon on streets and highways in the state after the person provides notification to the department of transportation and the department of safety.	April 2017	Business Process
Tennessee	Various Agencies	Bill SB 151	Bill creates the "Automated Vehicles Act." Defines a number of terms. Modifies laws related to unattended motor vehicles, child passenger restraint systems, seat belts, and crash reporting in order to address Automated Driving System (ADS) operated vehicles. Specifies that ADS-operated vehicles are exempt from licensing requirements. Permits ADS-operated vehicles on streets and highways in the state without a driver in the vehicle if it meets certain conditions. Preempts local regulation of ADS-operated vehicles. Specifies that the ADS shall be considered a driver for liability purposes when it is fully engaged and operated properly. Makes it a class A misdemeanor to operate a motor vehicle on public roads in the states without a human driver in the driver's seat without meeting the requirements of this Act. Specifies that this Act only applies to vehicles in high or full automation mode.	June 2017	Business Process
Texas	Various Agencies	Bill HB 1791	Bill allows the use of a connected braking system in order to maintain the appropriate distance between vehicles. Specifies that "connected braking system" means a system by which the braking of one vehicle is electronically coordinated with the braking system of a following vehicle.	May 2017	Business Process
Texas	Various Agencies	Bill SB 2205	Bill defines a number of terms, including "automated driving system," "automated motor vehicle," "entire dynamic driving task" and "human operator." Preempts local regulation of automated motor vehicles and automated driving systems. Specifies that the owner of an automated driving system is the operator of the vehicle when the system is engaged and the system is considered licensed to operate the vehicle. Allows an automated motor vehicle to operate in the state regardless of whether a human operator is present in the vehicle, as long as certain requirements are met.	September 2017	Business Process

LOCATION	AGENCY	POLICY / EFFORT	RELEVANT PROVISIONS/INFORMATION	EFFECTIVE DATE	APPLICABLE CMM DIMENSION(S)
Texas	Department of Transportation	Transportation Systems Management and Operations (TSMO) Statewide Strategic Plan	Texas Department of Transportation (TxDOT) Statewide TSMO Strategic Plan provides background information and a business case regarding the value of TSMO; provides a framework and guidance for districts and/or regions to develop a district- or region-specific TSMO Program Plan; and identifies central support available from the TxDOT divisions. The TxDOT Statewide TSMO Strategic Plan includes a business case for TSMO; statewide mission, vision, and goals statements; an introduction to how mobility strategies benefit the TSMO program; and the statewide TSMO strategy. Connected vehicles is addressed in the plan as a district service layer activity.	August 2017	Business Process
Utah	Department of Transportation	Bill HB 373	Bill authorizes the Department of Transportation to conduct a connected vehicle technology testing program.	April 2015	Business Process / Systems and Technologies
Utah	Various Agencies	Bill HB 280	Bill requires a study related to autonomous vehicles, including evaluating NHTSA and American Association of Motor Vehicle Administrators (AAMVA) standards and best practices, evaluating appropriate safety features and regulatory strategies and developing recommendations.	March 2016	Business Process / Systems and Technologies
Virginia	Various Agencies	Bill HB 454	Bill allows the viewing of a visual display while a vehicle is being operated autonomously.	April 2016	Business Process
Virginia	Department of Transportation	2017 Business Plan Update	The plan outlines the Department's objectives for fiscal year 2017 as they pursue their mission. Connected and automated vehicles technology applications are part of the business plan.	2017	Business Process
Vermont	Department of Transportation	Bill HB 494	Bill requires the department of transportation convene a meeting of stakeholders with expertise on a range of topics related to automated vehicles. The secretary of transportation must report to the House and Senate committees on transportation regarding the meetings and any recommendations related automated vehicles, including proposed legislation.	May 2017	Business Process
Washington	Various Agencies	Executive Order 17-02	Executive Order establishing an autonomous vehicle work group and enable pilot programs throughout the State in partnership with entities that are developing autonomous vehicle technology equipment.	June 2017	Business Process / Systems and Technologies
Washington, D.C.	Various Agencies	Bill 2012 DC B 19-0931	Bill defines "autonomous vehicle" as "a vehicle capable of navigating District roadways and interpreting traffic-control devices without a driver actively operating any of the vehicle's control systems." Requires a human driver "prepared to take control of the autonomous vehicle at any moment." Restricts conversion to recent vehicles, and addresses liability of the original manufacturer of a converted vehicle.	April 2013	Business Process
Wisconsin	Various Agencies	Executive Order#245	Governor Scott Walker issued Executive Order #245 creating the Governor's Steering Committee on Autonomous and Connected Vehicle Testing and Deployment, which will advise the Governor on how to best advance the testing and operation of automated vehicles in Wisconsin.	May 2017	Business Process / Systems and Technologies



## Federal Level

At the Federal Government level, CAV continues to evolve. Research into connected vehicle technologies has a long history dating back to the early 1990s with the Automated Highway System (AHS) followed later by the Vehicle-Infrastructure Integration (VII) Initiative which morphed into the Connected Vehicle Program today. Early research focused on the development of low latency, high bandwidth communication for vehicle to vehicle and vehicle to infrastructure safety applications. The research developed Dedicated Short Range Communications (DSRC) and has given way to test beds and pilot deployments for safety and mobility demonstrations.

Underlying the research and pilot deployment projects, the Federal Government has also pursued policy and rule-making efforts to guide connected vehicle and, more recently, Automated Driving Systems (ADS). The Secretary of Transportation and the National Highway Traffic Safety Administration (NHTSA) released guidance on automated vehicles entitled “Automated Driving Systems (ADS): A Vision for Safety 2.0”. The new guidance is not prescriptive but labeled as Voluntary Guidance. It focuses on the SAE International Levels of Automation 3 through 5 addressing conditional, high and full automation levels for ADS. It clarifies the guidance process for ADS, encourages transportation organizations to proceed with the testing and deployment of ADS, and clarifies the Federal and State roles regarding ADS.

The Federal Government is taking a supporting and guiding role with regard to the ADS industry. On the Connected Vehicle Program, they initiated development of rule-making for Vehicle to Vehicle communications within NHTSA based on the results of the Ann Arbor Connected Vehicle Safety Pilot. While the NHTSA Advanced Notice for Proposed Rule-Making is expected to be centered on the basic safety message transmission between connected vehicles, it has not been released.

Other Federal programs clearly support the advancement of connected vehicles and now connected automated vehicles (CAV). CAVs employ automated vehicle features augmented with connected vehicle message exchanges and system interfaces. CAVs present a logical evolution of these advanced technology applications.

- Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) – The US DOT has evolved the National ITS Architecture to be integrated with the Connected Vehicle Reference Implementation Architecture (CVRIA) which functionally defined the connected vehicle environment. ARC-IT provides a unifying framework that covers ITS comprehensively, including connected vehicle and “traditional” infrastructure ITS capabilities. ARC-IT and the accompanying toolset help implementers develop regional architectures to effectively meet their needs and assure regulatory compliance while facilitating efficient, secure interoperable ITS deployments. By integrating connected vehicle into the National ITS Architecture or ARC-IT, the US DOT has supported the development of connected vehicle planning within the ITS environment that has been developed by state and local agencies across the country. ARC-IT and its tools support the planning of connected vehicle projects alongside ITS projects and allow for the deliberate phasing of connected vehicle technology as it continues to evolve.
- Standards Harmonization – The US DOT has been involved at the international level regarding standards harmonization activities across ITS and connected vehicles. Harmonization task groups have been engaged in security and communications protocols, harmonization of the US basic safety message (BSM) and European cooperative awareness message (CAM), infrastructure messages, and cooperative ITS security policy, standards selection, gap analysis, and identifiers

for connected vehicle architectures. These international cooperation efforts have addressed connected vehicles on a global scale and combined the ideas of an international community.

- Security and Credentials Management – Trusted communications is the underpinning of the connected vehicle environment. The US DOT is addressing the safe, secure, and privacy-protective operational environment through the development and evolution of the Security and Credentials Management (SCMS) system. The SCMS makes possible the secure exchange of information among vehicles, roadway infrastructure, traffic management centers, and wireless mobile devices. The US DOT has partnered with the automotive industry and industry security experts through the Crash Avoidance Metrics Partnership (CAMP) to design and develop the SCMS. US DOT encourages all organizations deploying connected vehicle technologies to use the SCMS so that a single support system is leveraged across deployments and, further, to maximize the investment of funding toward connected vehicle system and application development.

The Federal Government has supported connected vehicle technology development through research and pilot deployments. The policy environment is still evolving at the Federal level and has been advisory in nature to this point. The US DOT's participation in the Vehicle to Infrastructure (V2I) Deployment Coalition with AASHTO and ITE has moved the discussion of connected vehicle from an automobile focus to infrastructure owner's perspective in the agencies that will be deploying connected vehicle infrastructure. The Deployment Coalition has initiated the SPAT Challenge to promote the deployment of roadside equipment including DSRC radios to transmit signal phase and timing (SPAT) data from signal systems at the intersection roadside to increase safety and mobility using connected vehicle technology. The objective of the SPAT Challenge is to deploy DSRC technology in each state within the next 5 years to accelerate connected vehicle deployment within the agencies as well as to gain experience with the new technology.

## International

Electronic searches for information and published material describing CAV technology activities throughout the world were conducted to identify policies enacted by transportation agencies to address CAV. The information collected was analyzed to identify best practices and document lessons learned for PennDOT. The sections below present the two policies found for international agencies addressing CAV technologies.

### Germany Federal Ministry of Transport and Digital Infrastructure

Germany published a report titled the *Ethics Commission: Automated and Connected Driving*. The Report was developed by a multidisciplinary Ethics Commission established in September 2016 for the purpose of developing essential ethical guidelines for the use of automated and connected car. This report attempted to address the Business Process and Culture dimensions of the CMM (12).

### Germany AV Bill

In June 2017, Germany enacted a bill legalizing automated vehicles ("AV Bill"). The AV Bill modifies the current Road Traffic Act and defines the requirements for highly and fully automated vehicles to use public roads. It further addresses the rights and duties of the driver when activating the automated driving mode. The AV Bill does not change the general liability concept under German law. Therefore, both the driver and the owner remain liable even if the vehicle is in automated driving mode, with drivers able to avoid liability if they lawfully used the automated driving mode. Automated vehicles must be equipped with a black box to identify whether the driver or the system had control at the time of an accident. Since this

will help the driver/owner (or, in practice, the "owner's" insurance company) to prove that the vehicle caused the accident, the relevance of German product liability rules and product liability insurance is likely to increase (12). AV Bill attempts to address the Business Process, Systems and Technologies, and Culture dimensions of the CMM.

## Matrix of Early Successes and Best Practices

Table D-3 presents the matrix of early successes and best practices identified as part of this effort for the pilots and policies researched. The best practices were categorized based on the six dimensions of the capability maturity model. The six dimensions are further explained below:

- **Business Process:** relates to the internal business practices, processes and procedures that an agency has adopted to guide the development to their CAV deployments. This would include formalized planning, process and procedures for scoping deploying, how CAV deployments are programmed and budgeted, and the process that agencies use to define, develop, and procure deployments (internal lead vs contract).
- **Systems and Technologies:** relates to the internal practices, processes and procedures that an agency has adopted to guide the selection, design, and operations of their CAV technologies and support systems. This would include use and development of regional architectures, the use of system engineering in the planning and design of the projects, use of formalized testing and validation procedures, and the use of standards and other requirements to promote interoperability.
- **Performance Measurement:** relates to the practices, processes and procedures that an agency has to assess the effectiveness of their CAV deployments. This would include descriptions and definitions for how performance will be assess, the types of tools and techniques that are used to acquire the performance measures, data storage and data retention policies and practices, how agencies use the performance measures to support long-term sustainability of the deployments, and the process and procedures used to secure personal identification Information (PII), the use of system engineering in the planning and design of the projects, use of formalized testing and validation procedures, and the use of standards and other requirements to promote interoperability.
- **Workforce:** relates to the practices, processes and procedures that an agency has implemented to prepare its organization and workforce to support to CAV deployments. This would include what changes in the organizational structure agencies have adopted to support CAV deployments, steps agencies have performed to train and retain staff to support CAV technologies, and what steps agencies have performed to develop knowledge, skills and abilities (KSAs) of internal staff to support CAV deployments.
- **Culture:** relates to the practices, processes and procedures that an agency has implemented to change the culture of their agency related to CAV deployments. This would include what agencies have done to improve the technical understanding of their staffs, to develop leaders and champions to support CAV technologies, to promote and garner support for the CAV deployments, and what steps they have taken to establish formal CAV programs.
- **Collaboration:** relates to processes and procedures that an agency is using to collaborate with other key regional stakeholders. These other stakeholders include local and state public safety organization (state police, local police, fire, motor vehicle regulators, etc.), the role of local



governments, metropolitan planning organizations (MPO), etc. have played in the deployment, and any outsourcing and public-private partnerships used to support the deployments.

Table D-3: Matrix of Early Successes and Best Practices

ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
<p>New York City Department of Transportation: Connected Vehicle Pilot</p>	<p><u>USDOT Pilot:</u> NYC DOT will provide and install the original equipment at no cost to the stakeholders. While no agreement has been made regarding maintenance of the devices installed in the vehicles, language in the draft Memorandum of Understanding indicated that NYC DOT will be responsible for the maintenance of the devices installed in the vehicle. “Participants” (i.e., drivers and stakeholder agencies) will be responsible for replacing lost, stolen, or vandalized devices. Participants are also responsible for reporting equipment malfunctions to the NYC DOT. The devices will remain the property of the DOT and may not be removed from the vehicles without prior written consent from the NYC DOT. Any removed devices shall be returned to the NYC DOT.</p>	<p><u>USDOT Pilot:</u> To achieve the goals and objectives, the NYC CVPD are deploying the following CV applications:</p> <ul style="list-style-type: none"> <li>● Speed Compliance;</li> <li>● Curve Speed Compliance;</li> <li>● Work Zone Speed Compliance;</li> <li>● Forward Crash Warning; Emergency Electronic Brake Lights;</li> <li>● Blind Spot Warning/Lane Change Assist;</li> <li>● Intersection Movement Assist;</li> <li>● Vehicle Turning Right in Front of Bus Warning;</li> <li>● Red Light Violation Warning;</li> <li>● Oversize Vehicle Warning; Pedestrian in Signalized Crosswalk Warning;</li> <li>● Mobile Accessible Pedestrian Signal System;</li> <li>● Evacuation Notification; and</li> <li>● Intelligent Signal System CV Data.</li> </ul> <p>Up to 8,000 fleet vehicles and at least 5 different vehicle types (5,850 taxis, 1,250 MTA buses; 400 UPS vehicles; 250 NYCDOT fleet vehicles; 250 DSNY vehicles)</p>	<p><u>USDOT Pilot:</u> Safety is the primary focus of the NYC CVPD; therefore, NYCDOT is using performance measured centered on speed management and crash reduction to assess the safety impacts of the NYC CVPD program. NYC DOT also plans to capture secondary benefits related to improvement mobility due safety improvements as well. Other improvements such as environmental impacts will not be measured directly, but estimate from mobility improvements that are directly measured such as travel time savings, queue reduction, and reductions in braking.</p>	<p><u>USDOT Pilot:</u> NYC DOT does not anticipate the need for any operational changes as a result of deploying the CVPD. When fully deployed, vehicle drivers will hear audible messages in support of the night applications implemented through the deployment. A training program will be implemented so that drivers are aware of how alerts will be issued to the drivers. Passive data collection points will be established to gather data from the vehicles throughout the day. Minimal daily operational changes will be needed by the drivers.</p>	<p><u>USDOT Pilot:</u> The NYC DOT is responsible for all administrative, maintenance and policy support for the deployment. NYC DOT Legal Council is leading the development and execution of Memoranda of Understanding with the stakeholders. NYC DOT has taken the lead in all governance processes including risk management, quality control, procurement, and project implementation. NYC DOT will also be responsible for the infrastructure aspects of the system, and the various stakeholder will assume responsibility for the installation of vehicle equipment, with oversight (specifications, equipment, and training) from the NYC DOT. Agreements will be used to identify paths for problem resolution. The NYC DOT has subcontracted much of the concept development, systems design, system documentation, and testing and verification to a team of contractors.</p>	<p><u>USDOT Pilot:</u> Key stakeholders participating in the NYC CVPD include the following:</p> <ul style="list-style-type: none"> <li>● The City of New York Department of Sanitation;</li> <li>● The Metropolitan Transportation Authority;</li> <li>● The New Your State Motor Truck Association;</li> <li>● The New York City Taxi and Limousine Commission;</li> <li>● Pedestrians for Accessible and Safe Streets Coalition.</li> </ul> <p>NYC DOT engaged each of these stakeholders early in the project development stage. Each of these stakeholders provided letter of support as part of the project proposal submittal. NYDOT continued this engagement into the Concept of Operations (ConOps) stage of the project by sending each stakeholder draft versions of the concept of operations. NYC DOT conducted a meeting with all the stakeholders to step through the ConOps and respond to questions and solicit buy-in.</p>

ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
<p>Tampa Hillsborough Expressway Authority (THEA): Connected Vehicle Pilot Deployment</p>	<p><u>USDOT Pilot:</u> The THEA CV Pilot is being designed, deployed and operated in three phases. Phase 1 is a contract between the USDOT and THEA and covers 100% of the costs, based on the original proposal submitted by THEA, for the design activities associated with the Pilot deployment. Phases 2 and 3 cover the final design, implementation, testing, operations and data collection for the duration of the pilot. Phases 2 and 3 are being contracted as a cooperative agreement between THEA and the USDOT. Ongoing operations after the completion of Phase 3 are not funded by the USDOT.</p>	<p><u>USDOT Pilot:</u> The Tampa Connected Vehicle Pilot will equip buses, streetcars, and privately-owned vehicles with connected vehicle technology, which will enable them to communicate vital information with each other and transportation infrastructure elements. Pedestrians will also participate by downloading and using a smartphone app. Drivers, transit riders, and pedestrians in the connected vehicle environment will enjoy a range of safety and mobility benefits, including crash prevention, enhanced traffic flow, and greenhouse gas reductions.</p> <ul style="list-style-type: none"> <li>• 1,600 privately owned vehicles equipped with onboard units</li> <li>• 10 buses equipped with onboard units</li> <li>• 10 streetcars equipped with onboard units</li> <li>• 500 or more pedestrian participants</li> <li>• 40 roadside units at the busiest intersections</li> </ul>	<p><u>USDOT Pilot:</u> THEA has developed a performance measurement plan to ascertain the effectiveness of the CV applications regarding the four “pillars” of mobility, safety, environment, and agency efficiency. THEA identified performance measures for each use case scenario that were tied to the goals of the deployment. The measures are intended to be credible and based on data availability. Further, the identified performance measures are intended to be clear, reliable, and responsive to change and are tied to the target values discussed in the approved ConOps document.</p>	<p><u>USDOT Pilot:</u> The deployment, operations and maintenance of the Pilot will be the responsibility of THEA and THEA’s contractors/vendors. The deployment and operations, however, will require coordination with the City of Tampa, HART and the Florida Department of Transportation. There are already contractual relationships between all of these agencies that, based on an initial review, cover all aspects of the Pilot program and no new agreements or addendums are anticipated.</p>	<p><u>USDOT Pilot:</u> THEA is the responsible entity for the execution of the CV Pilot. As such, THEA will be the lead agency for the entire project, including technical, policy and funding. THEA has developed partnerships of multiple stakeholders to deploy infrastructure, both in the vehicle and along the roadside, and applications using data captured from multiple sources (e.g., vehicles, mobile devices, and infrastructure) across multiple elements of the surface transportation system (i.e., transit, arterial, and electronically tolled roadways) to support improved system performance. The deployment of the Pilot will require partnerships as the Pilot site comprises multiple jurisdictions. These partnerships and the decision-making authority and guidance follow the ad hoc organization that already exists as is authorized by the interlocal agreement.</p>	<p><u>USDOT Pilot:</u> Key Stakeholders in the Tampa CVPD Deployment include the following:</p> <ul style="list-style-type: none"> <li>• USDOT</li> <li>• Florida Department of Transportation</li> <li>• City of Tampa</li> <li>• Hillsborough Area Regional Transit (HART)</li> <li>• University of South Florida Center for Urban Transportation Research</li> <li>• HNTB</li> <li>• Siemens</li> <li>• BrandMotion</li> <li>• Global-5 Communications.</li> </ul>

ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
Wyoming Department of Transportation: Connected Vehicle Pilot Deployment	<p><u>USDOT Pilot:</u> WYDOT expects the use of roadside DSRC devices and DSRC radios in state-owned vehicles to become a standard part of the department's operation after the completion of the pilot project. As such, much of the work involved in the pilot project will be completed by department staff as part of their regular duties.</p> <p>WYDOT will use their approved contracting and procurement methods and other processes will be defined in the agreements.</p> <p>WYDOT will be supported by fleet partners who will sign a memorandum of understanding (MoU) identifying roles and responsibilities for the pilot.</p>	<p><u>USDOT Pilot:</u> WyDOT deploying connected vehicle technology and applications along the 402 miles of I-80 in Wyoming. V2V and V2I applications will enable communication with drivers for alerts and advisories regarding various road conditions. Information from these applications is made available directly to vehicles equipped to receive the messages or through WYDOT's existing traveler information sources. Data collected from the equipped vehicles not only support in-vehicle applications but also enable better traffic and incident management along the I-80 corridor. Conditions reported from connected vehicles will enable better setting of variable speed limits along the corridor. Integration with existing transportation management center (TMC) resources, such as construction, parking, and road condition reporting, enable transmission of timely situational awareness alerts to the equipped vehicle</p>	<p><u>USDOT Pilot:</u> WyDOT has developed a performance evaluation plans includes to assess the extent to which the deployment:</p> <ul style="list-style-type: none"> <li>• Improved Road Weather Condition Reports Received into the TMC</li> <li>• Improved ability of the TMC to Generate Alerts and Advisories</li> <li>• Efficiently Disseminate Broad Area Traveler Information</li> <li>• Effectively Disseminate and Receive I2V and V2I Alert/Advisory Messages from the TMC</li> <li>• Improved Information to Commercial Vehicle Fleet Managers</li> <li>• Effectively Transmitted and Received V2V Messages</li> <li>• Automated Emergency Notifications of a Crash</li> <li>• Improved Speed Adherence and Reduced Speed Variation</li> <li>• Reduced Vehicle Crashes</li> </ul>	<p><u>USDOT Pilot:</u> With the close integration of the CV Pilot with WYDOT Transportation Management Center (TMC), back-office operational changes have been discussed with TMC Operations managers and the TMC software development team. These changes have been factored into our system requirements documents. WyDOT has identified the operator training needs at the TMC. WYDOT Fleets (snow plows and highway patrol vehicles) will continue operations normally but drivers of these vehicles will be trained as per the training plan to effectively understand the alerts and advisories provided by the CV pilot. From a fleet partner perspective, they will be expected to operate their vehicles normally during the pilot. Participating drivers will be trained on the CV Pilot system as defined in the training plan.</p>	<p><u>USDOT Pilot:</u> WyDOT is establishing a new CV Pilot Freight Advisory Council (FAC) to provide advisory support for the pilot. The freight advisory council will consist of representatives from WYDOT, fleet partners who are participating in the pilot, local freight stakeholders who use CVOP, Transportation Safety Council, and the Wyoming Trucking Association (WTA). The freight advisory council is a sounding board for WYDOT to discuss pilot development. As the project progresses, the advisory council will support WYDOT in the post pilot transition planning assisting in setting priorities for application updates, and supporting growth in number of fleets that have access to this technology.</p>	<p><u>USDOT Pilot:</u> The following are the stakeholders for the proposed system:</p> <ul style="list-style-type: none"> <li>• U.S Department of Transportation</li> <li>• WYDOT– Traffic, Construction, Maintenance, GIS/ITS, IT, Telecom Programs</li> <li>• Wyoming Highway Patrol</li> <li>• Fleet Managers</li> <li>• Wyoming Trucking Association</li> <li>• City managers and local traffic and law enforcement officials (Rawlins, Laramie, Cheyenne, Green River, Rock Springs, Evanston)</li> <li>• National Weather Service • County Emergency Management</li> <li>• Private Truck Parking Services</li> <li>• Adjacent State DOTs</li> <li>• Third party application developers</li> <li>• System integrators and vendors</li> </ul>
European Union: L3Pilot- Piloting Automated Driving on European Roads	NA	<p><u>International Pilot:</u> Pilot study will specifically evaluate SAE Level 3 functions, with additional assessment of some Level 4 functions. The functionality of the systems used is exposed to variable conditions with 1,000 test drivers and 100 vehicles in 11 European countries.</p>	<p><u>International Pilot:</u> The tested functions cover a wide range from parking to overtaking, and urban intersection driving. These tests will provide data for evaluation of technical aspects, user acceptance, driving and travel behavior, and impact on traffic and society.</p>	NA	NA	<p><u>International Pilot:</u> Coordinator is private sector: Volkswagen Group Research. Thirteen (13) countries are participating and 34 private sector and authorities are also participating.</p>

ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
European Union: eCall – Connected Vehicle Emergency Response	<u>International Pilot:</u> On April 28, 2015, the European Parliament voted in favor of eCall regulation which requires all new cars be equipped with eCall technology from April 2018.	<u>International Pilot:</u> ECall-equipped car automatically calls the nearest emergency center. Even if no passenger can speak, e.g. due to injuries, a 'Minimum Set of Data' is sent, which includes the exact location of the crash site.	<u>International Pilot:</u> System will be able to catalog number of incidents detected through the system.	NA	NA	<u>International Pilot:</u> Coordination with car manufactures and emergency services authorities.
United Arab Emirates: Dubai Autonomous Transportation Strategy	<u>International Pilot:</u> The strategy supports setting up legislation for development of autonomous transportation. The strategy will also identify models and means of autonomous transportation which will be allowed in the emirate, in addition to reviewing and strengthening policies to represent a global reference point for other global cities interested in the application of autonomous systems.	<u>International Pilot:</u> Autonomous metro, buses and taxis will be evaluated during the deployment.	<u>International Pilot:</u> Government will monitor public transportation costs changes during the deployment.	NA	NA	NA
Arizona: Department of Transportation	<u>Executive Order 2015-09:</u> Arizona Self-Driving Vehicles Oversight Committee was created to support research and development of self-driving vehicle technology in Arizona.	<u>Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT):</u> The ARC-IT is the merging of the National ITS Architecture and the Connected Vehicle Reference Implementation Architecture (CVRIA).	NA	<u>Organizational Structure:</u> Transportation Systems Management and Operations (TMSO) Director leads the efforts for optimizing the performance of existing infrastructure by implementing multimodal, intermodal and often cross-jurisdictional systems, services and projects, including connected vehicles and automated vehicles efforts.	<u>Executive Order 2015-09:</u> Goals align with the governor's mission of boosting economic growth, creating jobs and promoting innovation that improves the way Arizonans live.	<u>Executive Order 2015-09:</u> Committee is made up of transportation, public safety and policy experts, to advise ADOT, the Department of Public Safety, universities and other public agencies on how best to advance the testing and operation of self-driving vehicles on public roads.

ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
California: San Diego Association of Governments (SANDAG) and Metropolitan Transportation Commission (MTC)	<p><u>San Diego Forward the Regional Plan:</u> SANDAG is the San Diego region’s primary public planning, transportation, transit construction, and research agency. The plan envisions a transportation network of high-tech tools, which includes connected and automated vehicles.</p> <p><u>Catapult Bay Area:</u> MTC’s Connected Vehicle Program, branded as “Catapult Bay Area,” supports connected vehicle, automated vehicle and autonomous vehicle deployments in the San Francisco Bay Area.</p>	<p><u>Catapult Bay Area:</u> One of the goals of the program is to keep a pulse on technology and policy advancements being made at the federal, state and local levels.</p>	<p><u>Catapult Bay Area:</u> One of the goals of the program is to implement CAV projects that can help the region meet the project performance targets identified in Plan Bay Area 2040.</p>	<p><u>Catapult Bay Area:</u> One of the goals of the program is to provide technical seminars on relevant topics to help municipalities understand the technology and better prepare for this future technology</p>	<p><u>Catapult Bay Area:</u> One of the goals of the program is to provide support to local agencies interested in deploying connected vehicle projects within their jurisdictions</p>	<p><u>Catapult Bay Area:</u> One of the goals of the program is to keep local municipalities and other stakeholders engaged by providing updates at the bi-monthly Arterial Operations Committee meetings.</p>
Illinois: Department of Innovation and Technology	<p><u>Executive Order 01-16:</u> Executive Order established the Department of Innovation and Technology (DoIT), a new state agency with responsibility for the information technology functions of agencies. The DoIT delivers statewide information technology and telecommunication services and innovation, including Illinois Smart State initiatives. A Smart State is a state with a vision, a plan, and an execution road map to enact the digital transformation of government by investing in a 3rd Platform — information and communications technology (ICT) – which aids in the deployment of CAV and Smart Cities technologies.</p>	<p><u>Executive Order 01-16:</u> DoIT provides improved management of the nearly \$1B portfolio of information technology (IT) investments, greater agency oversight of IT services and more transparent rates, and greater ability to leverage the state’s economy of scale in purchasing IT</p>	<p><u>Executive Order 01-16:</u> A 3rd Platform includes mobile technologies, big data analytics, social networks, and cloud services as its foundation for a set of innovation accelerators, such as the Internet of Things (IoT), cognitive computing, and robotics, that enable potentially radical new work processes, services, and products.</p>	<p><u>Executive Order 01-16:</u> A unified IT workforce nearly 1,700 members strong provides more rapidly available innovative solutions at an industry efficient price/investment point.</p>	NA	<p><u>Executive Order 01-16:</u> DoIT delivers statewide information technology and telecommunication services and innovation to all state government agencies, boards and commissions.</p>



ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
Oregon: Department of Transportation	<p><u>Organizational Structure:</u> The Connected, Automated Vehicles and Electric Vehicles Advisor coordinates ODOT's efforts related to CAV technologies, including coordinating with other Oregon state agencies and external stakeholders at the state and national level, engaging on state and federal policy and legislation, and identifying and responding to funding opportunities. Part of the Innovative Program.</p>	NA	NA	<p><u>Organizational Structure:</u> ODOT has a Connected, Automated Vehicles and Electric Vehicles Advisor, who works out of the ODOT's Director's Office and coordinates ODOT's efforts related to CAV technologies.</p>	NA	<p><u>Organizational Structure:</u> The Connected, Automated Vehicles and Electric Vehicles Advisor coordinates with other Oregon state agencies and external stakeholders at the state and national level, engaging on state and federal policy and legislation, and identifying and responding to funding opportunities.</p>
Texas: Department of Transportation	<p><u>Bill SB 2205:</u> Bill defines a number of terms, including "automated driving system," "automated motor vehicle," "entire dynamic driving task" and "human operator." Preempts local regulation of automated motor vehicles and automated driving systems. Specifies that the owner of an automated driving system is the operator of the vehicle when the system is engaged and the system is considered licensed to operate the vehicle. Allows an automated motor vehicle to operate in the state regardless of whether a human operator is present in the vehicle, as long as certain requirements are met.</p>	NA	NA	<p><u>Transportation Systems Management and Operations (TSMO) Statewide Strategic Plan:</u> Texas Department of Transportation (TxDOT) Statewide TSMO Strategic Plan provides background information and a business case regarding the value of TSMO; provides a framework and guidance for districts and/or regions to develop a district- or region-specific TSMO Program Plan; and identifies central support available from the TxDOT divisions. Connected vehicles is addressed in the plan as a district service layer activity.</p>	NA	NA



ORGANIZATION/DEPLOYMENT NAME	BUSINESS PROCESS	SYSTEMS AND TECHNOLOGIES	PERFORMANCE MEASUREMENT	WORKFORCE	CULTURE	COLLABORATION
Germany: Various Agencies	<p><u>Ethics Commission: Automated and Connected Driving:</u> The Report was developed by a multidisciplinary Ethics Commission established in September 2016 for the purpose of developing essential ethical guidelines for the use of automated and connected car.</p> <p><u>Germany AV Bill:</u> In June 2017, Germany enacted a bill legalizing automated vehicles ("AV Bill"). The AV Bill modifies the current Road Traffic Act and defines the requirements for highly and fully automated vehicles to use public roads. The AV Bill does not change the general liability concept under German law. Therefore, both the driver and the owner remain liable even if the vehicle is in automated driving mode, with drivers able to avoid liability if they lawfully used the automated driving mode.</p>	<p><u>Germany AV Bill:</u> The bill dictates automated vehicles must be equipped with a black box to identify whether the driver or the system had control at the time of an accident. Since this will help the driver/owner (or, in practice, the "owner's" insurance company) to prove that the vehicle caused the accident, the relevance of German product liability rules and product liability insurance is likely to increase.</p>	NA	NA	<p><u>Ethics Commission: Automated and Connected Driving:</u> The Report was developed by a multidisciplinary Ethics Commission established in September 2016 for the purpose of developing essential ethical guidelines for the use of automated and connected car.</p> <p><u>Germany AV Bill:</u> The AV Bill further addresses the rights and duties of the driver when activating the automated driving mode. The AV Bill does not change the general liability concept under German law. Therefore, both the driver and the owner remain liable even if the vehicle is in automated driving mode, with drivers able to avoid liability if they lawfully used the automated driving mode.</p>	<p><u>Ethics Commission: Automated and Connected Driving:</u> The Report was developed by a multidisciplinary Ethics Commission established in September 2016.</p>

## References

1. *Connected Vehicle Pilot Deployment Program: Tampa, Florida*. Factsheet. US Department of Transportation, ITS Joint Program Office. Available at [https://www.its.dot.gov/factsheets/pdf/TampaCVPilot\\_Factsheet.pdf](https://www.its.dot.gov/factsheets/pdf/TampaCVPilot_Factsheet.pdf). Accessed August 13, 2017.
2. *Tampa Connected Vehicle Pilot*. Website. Available at <https://www.tampacvpilot.com>. Accessed August 13, 2017.
3. *Connected Vehicle Pilot Deployment Program: New York City, New York*. Factsheet. US Department of Transportation, ITS Joint Program Office. Available at [https://www.its.dot.gov/factsheets/pdf/NYCCVPIlot\\_Factsheet\\_020817.pdf](https://www.its.dot.gov/factsheets/pdf/NYCCVPIlot_Factsheet_020817.pdf). Accessed August 13, 2017.
4. FHWA Connected Vehicle Pilot Deployment (CV Pilots) Program. NYC CV Pilot Deployment Presentation 9.30.2015. Available at [https://www.its.dot.gov/pilots/pdf/02\\_CVPilots\\_NYC.pdf](https://www.its.dot.gov/pilots/pdf/02_CVPilots_NYC.pdf). Accessed August 13, 2017.
5. *Connected Vehicle Pilot Deployment Program: Wyoming*. Factsheet. US Department of Transportation, ITS Joint Program Office. Available at [https://www.its.dot.gov/factsheets/pdf/WyomingCVPilot\\_Factsheet\\_020817.pdf](https://www.its.dot.gov/factsheets/pdf/WyomingCVPilot_Factsheet_020817.pdf). Accessed August 13, 2017.
6. *Connected Vehicle Pilot Deployment Program: Wyoming (WY) DOT Pilot*. Web Site. Available at [https://www.its.dot.gov/pilots/pilots\\_wydot.htm](https://www.its.dot.gov/pilots/pilots_wydot.htm). Accessed August 13, 2017.
7. *Smart Columbus*. The City of Columbus. <https://www.columbus.gov/smartcolumbus/home/>. Accessed September 27, 2017.
8. Bezzina, D., and J. Sayer. *Safety Pilot Model Deployment Test Conductor Team Report*. Report Number DOT HS 812 171. National Highway Traffic Safety Administration and the Intelligent Transportation Systems Joint Program Office, Washington, DC. June 2015. Available at <https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812171-safetypilotmodeldeploydeltestcondrtmrep.pdf>.
9. Mcity Test Facility. Available at <https://mcity.umich.edu/our-work/mcity-test-facility/>.
10. Mcity Test Facility: An Outdoor Lab. Available at <https://mcity.umich.edu/wp-content/uploads/2017/03/Mcity-test-facility.pdf>.
11. *L3Pilot*. Website. Available at <http://www.l3pilot.eu/>. Accessed September 29, 2017.
12. *Connected Automated Driving*. Website. Available at <https://connectedautomateddriving.eu/>. Accessed September 29, 2017.
13. *Capability Maturity Frameworks Overview*. Website. Available at [https://ops.fhwa.dot.gov/tsmoframeworktool/cmf\\_overview.htm](https://ops.fhwa.dot.gov/tsmoframeworktool/cmf_overview.htm). Accessed September 13, 2017.
14. *Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation*. Website. Available at [www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx#enacted](http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx#enacted)

PENNSYLVANIA DEPARTMENT OF  
TRANSPORTATION

JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLE  
STRATEGIC PLAN

APPENDIX E

CONNECTED AND AUTOMATED VEHICLES CAPABILITY MATURITY  
MODEL EVALUATION

JANUARY 2018

## Introduction

Future transportation systems will consist of an increasing number of connected and automated vehicles (CAV). General Motors has incorporated connected technologies into select vehicles in 2017. The National Highway Traffic Safety Administration (NHTSA) is considering a ruling that will mandate connected vehicle-to-vehicle (V2V) communications in all new vehicle starting in 2023. Automotive manufacturers such as Nissan, Audi, Toyota, Volvo, and General Motors have announced that they plan to have a fully automated vehicle publicly available by 2020-2025. Mixed vehicular environments will shape the next generation transportation systems.

Vehicles with increasing levels of automation will continue to evolve leading to the introduction of fully automated vehicle operations on public roadways. While private industry is leading the implementation of vehicle automation, state, local, and private organizations responsible for safe operation on their roadways need to develop the technical, institutional, and legal framework to support this automation.

Connected and automated vehicle technologies will create a shift in the transportation decision-making process throughout Pennsylvania.

The Joint Statewide Connected and Automated Vehicle Strategic Plan will assist Pennsylvania in preparing for these technological advancements. The Strategic Plan will:

- Look at all of Pennsylvania
- Build upon existing research
- Identify the steps the departments should take to prepare for these technologies
- Define a comprehensive set of focused, reasonable and deployable applications
- Consider various levels of investment
- Provide the Department with critical missing data and information pertaining to the early deployment of connected and automated vehicles

The Strategic Plan will be used as the foundation for all policy and procedural decisions relating to connected and automated vehicles. Ultimately, the Strategic Plan will be designed to be a “living document” to account for new information and advances. In specific, the assessment of maturity of an organization in an industry that is immature suggests that the assessment will need frequent revision as the industry develops and best practices are established.

## Document Purpose

The purpose of this document is to summarize the efforts carried out under Task 4 Capability Maturity Model Evaluation, of the Joint Statewide Connected and Automated Vehicle Strategic Plan effort and document findings.

## Document Overview

To ensure that the Pennsylvania Strategic Plan aligns with national guidance and research, the Department’s connected and automated vehicle programs were evaluated using the American Association of State Highway and Transportation Officials (AASHTO) capability maturity model. The assessment of current maturity is based on input from Pennsylvania Department of Transportation (PennDOT) staff during a workshop led by staff from the Texas A&M Transportation Institute and the interviews performed by the consultant team as part of Task 1. Staff members participating in the

Capability Maturity Model (CMM) Workshop held December 15, 2017 included Mark Kopko and Jerome Frederick. For detailed interview documentation, please refer to Appendix D: Task 1 Internal Information Gathering and Investigations.

## Capability Maturity Model Overview

The Capability Maturity Model (CMM) concept was initially developed for the information technology (IT) industry and is now widely used. Using CMM has become a requirement for the provision of software to many clients with a demand for specific product quality and often involves a third-party certification process. CMM has now spread to other outcome-oriented product and service development in both the public and private sectors, especially in areas impacted by changing technology, such as customer service and manufacturing (1).

The general CMM concept described above has been adapted specifically to Transportation Systems Management and Operations (TSMO). Research conducted for the Strategic Highway Research Program 2 (SHRP 2) among transportation agencies reveals that the effectiveness of TSMO activities is closely correlated with the maturity of certain technical and business processes and institutional capacities and arrangements related to the unique features of the high-tech, real-time, collaborative characteristics of TSMO. The lessons drawn from this experience were converted into guidance, structured in terms of a CMM framework. An AASHTO-supported National Cooperative Highway Research Program (NCHRP) project was used to convert the guidance into a web-based approach (1). It combines into one single framework the key features of quality management, organizational development, and business process reengineering concepts that have long been used as strategic management tools in transportation agencies (1).

The CMM has several important features that make it a practical tool for transportation programs (1):

- It presumes that improvements in outcomes (such as reductions in delay from improved TSMO) can be managed.
- It identifies a high-level vision of capability as a target and provides a common language for discussion of how to get there.
- It focuses on a small set of specific dimensions—processes, organizational structure, and relationship capabilities—that together support the capability for higher levels of performance.
- It recognizes that improvements must be installed in evolutionary achievable levels that can be managed, with each level clearly defined by criteria.
- Priorities are identified.
- The specific actions needed to reach the next level of capability are designed to synergize towards the objective of continuous improvement as part of culture.

By understanding and using a CMM, agencies can (1):

- Develop consensus around needed agency improvements;
- Identify immediate priorities for improvements; and
- Identify concrete actions to continuously improve capabilities to plan, design and implement TSMO.

Consistent with the AASHTO Guidance, capabilities of agencies are described in the same six dimensions (1):

1. Business Processes including formal scoping, planning, programming, and budgeting.
2. Systems and Technology including use of systems engineering, systems architecture standards, interoperability, and standardization.
3. Performance Measurement including definition of measures, data acquisition, and data utilization.
4. Culture including technical understanding, leadership, outreach, and program legal authority.
5. Organization and Staffing including programmatic status, organizational structure, staff development, recruitment and retention.
6. Collaboration including relationships with public safety agencies, local governments, metropolitan planning organizations (MPOs), and the private sector.

Using the information above and the available literature on the CMM for TSMO, the consultant team developed a CMM framework for connected vehicles program and another CMM framework for automated vehicles program.

The following sections present the CMM frameworks for connected and automated vehicles programs separately, followed by a detailed explanation of each of the six dimensions provided in tabular form.

## Connected Vehicle Program Capability Maturity Model Framework

Table E-1 contains the Connected Vehicle (CV) Program Capability Maturity Model (CMM) Framework. Each level is explained for each of the six dimensions of the framework.

Table E-1: Connected Vehicle Program CMM Framework

CMM Dimension	Connected Vehicle Program Capability Level Self-Assessment Criteria			
	Level 1 Pilot Underway	Level 2 Program Initiated	Level 3 Program Integrated	Level 4 Program Mainstreamed
Business Processes: Planning, programing and budgeting, funding, project development program (PDP).	Agency is conducting initial connected vehicle (CV) pilot project (s).	Agency has conducted a pilot project and is now developing CV applications plan, program, budget project development process.	An initial CV deployment and operations plan has been developed, together with needed programming, budgeting and project develop process.	A CV program is established as the basis for continuing improvements – including plan, program, in funding updates.
Systems and Technology: Systems Engineering, and decision-support.	Agency has developed and deployed prototype CV pilot systems.	Agency is developing a CV-systems plan including back office and field components.	Standard approach to back office and field component deployment developed.	CV back office and field component development and deployment fully integrated with TSMO systems.
Performance Measurement: Use information for analytics, reporting, evaluation, management.	Performance measures and support data and analytics for pilot being developed and need for CV-relevant business case (B/C) and performance measurement approach identified.	Approach for performance measurement and management process for CV including related data requirements and support analytics and reporting is under development.	A CV-performance measurement system has been developed for CV and utilized for routine TSMO operational management and reporting.	CV is fully integrated into the agency's performance program – including both the performance of CV as well as the use of CV information regarding performance of other TSMO activities.



CMM Dimension	Connected Vehicle Program Capability Level Self-Assessment Criteria			
	Level 1 Pilot Underway	Level 2 Program Initiated	Level 3 Program Integrated	Level 4 Program Mainstreamed
Organization and Workforce: Including programmatic status, organizational structure, staff development, and recruitment and retention.	CV business case-accepted and need for changes is policy; legal protections identified – along with key organizational and staffing implications.	CV legal issues and related systems resolved and specific organizational/staffing identified including knowledge, skills and ability (KSA).	TSMO/CV business case accepted legal arrangements completed and organization-capable staff in place.	Issues associated with governance between organizations fully vetted. Workforce receives regular training related to new and developing technologies. Organizations capable of attracting and retaining top professionals. Organization have careers paths for CV/AV technologists.
Culture: Technical understanding, leadership, outreach, and program legal authority.	Participation in CV activities limited pilot deployment. Outreach focused on potential benefits of program. Outreach directed toward high-level decision makers and legislatures. Authority limited to development to pilot or test deployment.	Participation in CV activities limited to initial TSMO program. Leadership concentrated in one or two programs within organization and is focused on developing program. Authority limited to development of initial program.	Agency has well-established CV/AV technologies and actively seeks integration with other TSMO functions. Leadership and outreach focused on gaining support of other jurisdictions.	All levels within organization readily embraces CV technologies. Agency provides leadership and has fully legal authority need to make CV technologies flourish across multiple jurisdictions.
Collaboration: Relationships with public safety agencies, local governments, MPOs, and the private sector.	Pilot program arrangements informal (public-public and public-private).	Public-private and public-public partnerships needs and approaches identified.	Public-private and public-public partnerships standardized.	New partnership arrangements mainstreamed.

## Business Processes Dimension

Table E-2 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Business Processes Dimension of the CV Program Capability Maturity Model Framework.

Table E-2: CV Program CMM Framework Business Processes Dimension

Business Processes: Planning, programing and budgeting, funding, PDP			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Agency is conducting an initial CV pilot project(s).	<u>State of play:</u> Agency is developing CV-oriented plan, program, budget, and project development processes.	<u>State of play:</u> Agency has developed and is in the process of implementing CV operations plan together with programing, budgeting and project develop process.	<u>State of play:</u> A CV program is established as the basis for continuing improvement – including plan, program, and funding updates.
<u>Objective of this guidance element:</u> Utilize pilot project to identify the modifications and additions needed with regard to business processes to accommodate CV.	<u>Objective of this guidance element:</u> Develop the modifications and additions needed with regard to business processes to accommodate CV.	<u>Objective of this guidance element:</u> Implement modifications and additions to business processes to accommodate CV.	<u>Objective of this guidance element:</u> Systematically integrate CV-related business processes with TSMO activities.
<u>General strategy:</u> Identify partners in pilot project development planning.	<u>General strategy:</u> Develop a consensus-based regional approach to initial CV pilot applications and deployment regarding planning, resource allocation and project development processes.	<u>General strategy:</u> Move beyond pilots to develop an integrated CV program across priority TSMO functions.	<u>General strategy:</u> Build out and update an integrated CV program across priority TSMO functions.
<u>Relationship to TSMO:</u> No new actions with respect to addressing specific entity TSMO needs; each agency is essentially independent and automated; one or two projects that have been funded through grants such as deployment grants.	<u>Relationship to TSMO:</u> Start identifying current business processes that need to be modified to support CV applications and deployments; i.e., getting CV projects in the Transportation Improvement Program (TIP) and State Transportation Improvement Plan (STIP).	<u>Relationship to TSMO:</u> Adapt or modify existing business practices to accommodate and facilitate CV applications and deployments.	<u>Relationship to TSMO:</u> All business practices have been modified to support CV applications and deployments; public-private partnerships (PPP) are routine.
<u>Caveats:</u> CV business processes build directly on those established for TSMO.	<u>Caveats:</u> CV business processes build directly on those established for TSMO.	<u>Caveats:</u> CV business processes build directly on those established for TSMO.	<u>Caveats:</u> CV business processes build directly on those established for TSMO.

## Systems and Technology Dimension

Table E-3 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Systems and Technology Dimension of the CV Program Capability Maturity Model Framework.

Table E-3: CV Program CMM Framework Systems and Technology Dimension

Systems and Technology: Systems engineering, and decision-support			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Piloting or evaluating existing open source and/or experimental, readily available applications such as a suite of capabilities that are not necessarily connected to each other as a system. Possibly V2V safety-oriented.	<u>State of play:</u> Combine 2 or 3 applications; expand the breadth of implementation to cover a broader physical area.	<u>State of play:</u> Develop standard deployment systems and/or Concepts of Operation (ConOps) for applications; more complex vehicle-to-Infrastructure(V2I) applications.	<u>State of play:</u> Introduce PPP to incorporate more innovative and/or higher-end or cutting-edge technologies; more vehicle-to-everything (V2X) applications.
<u>Objective of this guidance element:</u> Get an agency started; build KSAs associated with the new applications and technologies; learn about the technologies and their capabilities; lessons learned.	<u>Objective of this guidance element:</u> Build public support for technologies and systems; expand in an area or address a wider scale of operational issues beyond a localized area on the network; corridor level.	<u>Objective of this guidance element:</u> Identify which best meet overall regional operational goals; expand the systems to the entire region and identify applications for specific needs in corridors.	<u>Objective of this guidance element:</u> More system coverage and to address operational needs of all facilities and complementary modes within the network.
<u>General strategy:</u> Looking at open source data application portal; pursuing readily available technologies and not developing custom applications.	<u>General strategy:</u> Start grouping applications to cover broader areas.	<u>General strategy:</u> Beginning to do a small amount of customization for specific applications and address specific needs for multiple stakeholders.	<u>General strategy:</u> Doing more customized work; building custom applications and combinations; working with private entities to develop custom systems.
<u>Relationship to TSMO:</u> Some CV applications may augment and improve existing TSMO applications, while others may provide entirely new functions.	<u>Relationship to TSMO:</u> Some CV applications may augment and improve existing TSMO applications, while others may provide entirely new functions.	<u>Relationship to TSMO:</u> Specific CV applications are implemented to augment and improve existing TSMO applications.	<u>Relationship to TSMO:</u> Specific CV applications are implemented to augment and improve existing TSMO applications.
<u>Caveats:</u> Depending on others to develop applications; implementing what others have developed which may not help you achieve your goals and objectives.	<u>Caveats:</u> The benefits will be limited to deployment corridors.	<u>Caveats:</u> Projects may not be supporting all stakeholders or mores.	<u>Caveats:</u> May become too reliant on PPP for innovation; may lose KSAs or institutional knowledge.

## Performance Measurement Dimension

Table E-4 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Performance Measurement Dimension of the CV Program Capability Maturity Model Framework.

Table E-4: CV Program CMM Framework Performance Measurement Dimension

Performance Measurement: Information for analytics, reporting, evaluation, management			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Collecting and analyzing data for specific applications; any broader benefits are simulated or extrapolated and met with low level of confidence.	<u>State of play:</u> Collecting and analyzing data for projects / corridors; less simulation needed to assess potential benefits; moderate level of confidence in performance measurements (PfM) data.	<u>State of play:</u> Using PfM to refine deployments and change operational parameters associated with applications.	<u>State of play:</u> PfM is systematic, looking a multiple applications, users, and modes and the interplay between applications.
<u>Objective of this guidance element:</u> Beginning to understand the potential benefits of the applications to address operational problems.	<u>Objective of this guidance element:</u> Beginning to understand the relationship between the CV applications and other TSMO operations and strategies.	<u>Objective of this guidance element:</u> Establish PfM that enable agency to assess both the performance of individual CV applications in concert with TSMO strategies and the interrelationship between them.	<u>Objective of this guidance element:</u> Use the complete suite of PfM to optimize overall system performance by mode.
<u>General strategy:</u> Measures will tend to be more safety-oriented.	<u>General strategy:</u> Begin to incorporate more direct measurements of mobility and safety; reactive.	<u>General strategy:</u> Starting to incorporate PfM data collection as part of the deployments; reactive.	<u>General strategy:</u> Comprehensive PfM program involving continuous data collection, analysis, and operational modifications; multimodal; approaching proactive and predictive.
<u>Relationship to TSMO:</u> Limited relationship to the broader TSMO efforts; very specific to each application to assess success	<u>Relationship to TSMO:</u> Assess whether the CV projects / deployments complement the PfM of other TSMO applications	<u>Relationship to TSMO:</u> Trying to quantify the proportion of PfM improvements are met by the CV applications and deployments	<u>Relationship to TSMO:</u> PfM elements of CV applications and deployments fully incorporated into agency-wide TSMO PfM efforts
<u>Caveats:</u> Limited to data that is already available in the deployment area and available directly from the technologies.	<u>Caveats:</u> Still limited to data available in the deployment corridors and from technologies; looking at relationships between performance measures; could have confounding factors.	<u>Caveats:</u> Need widespread and sophisticated data collection supporting a comprehensive PfM program for CV applications and deployments; establish a regional data exchange.	<u>Caveats:</u> Data sharing is essential to support mainstream PfM; regional data exchange in place with all stakeholders and modes providing appropriate data.

## Organization and Workforce Dimension

Table E-5 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Organization and Workforce Dimension of the CV Program Capability Maturity Model Framework.

Table E-5: CV Program CMM Framework Organization and Workforce Dimension

Organization and Workforce: Programmatic status, organizational structure, staff development, and recruitment and retention			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Will need to accomplish pilot project with existing workforce skill sets or specialized skill sets are contracted.	<u>State of play:</u> Begin to build in-house expertise; first areas of enhanced skill sets likely to be in maintenance to keep the system operational.	<u>State of play:</u> Beginning to build expertise in operations and management; have analysts capable of managing PFM data.	<u>State of play:</u> Employ a broad spectrum of personnel to design, operate, maintain, and analyze the systems on the network and relevant data; could be outsourced.
<u>Objective of this guidance element:</u> Begin building KSAs related to CV applications.	<u>Objective of this guidance element:</u> Enhance KSAs to understand objectives and benefits met by individual applications.	<u>Objective of this guidance element:</u> Expand KSAs to gain understanding of which CV applications support and/or complement other TSMO strategies.	<u>Objective of this guidance element:</u> Enable personnel to achieve the core competencies to design, operate, maintain, and analyze the CV systems across all modes.
<u>General strategy:</u> Become well-versed in the underlying technologies and individual applications.	<u>General strategy:</u> Understand where applications can be applied to achieve the highest level of benefits; address critical needs.	<u>General strategy:</u> Become knowledgeable with respect to how to combine applications; understand how to tie CV applications into other TSMO strategies.	<u>General strategy:</u> Able to address multimodal strategies and applications and have core competencies across the spectrum of applications.
<u>Relationship to TSMO:</u> CV operations just part of normal TSMO operations; ad-hoc.	<u>Relationship to TSMO:</u> Have a small staff (1 or 2 individuals) that are focused on CV applications.	<u>Relationship to TSMO:</u> Begin to integrate CV operations into broader TSMO organizational structure.	<u>Relationship to TSMO:</u> CV operations fully integrated into TSMO structure, including day-to-day operation.
<u>Caveats:</u> Limited by existing KSAs of personnel and FTEs of organization.	<u>Caveats:</u> Limited to the ability to fund FTEs solely devoted to CV.	<u>Caveats:</u> Ability to support CV as part of TSMO tied to business processes and TSMO programming and budgeting.	<u>Caveats:</u> Ability to support CV as part of TSMO tied to business processes and TSMO programming and budgeting.

## Culture Dimension

Table E-6 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Culture Dimension of the CV Program Capability Maturity Model Framework.

Table E-6: CV Program CMM Framework Culture Dimension

Culture: Technical understanding, leadership, outreach, and program legal authority			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> CV program is primarily an assortment of loosely related projects and strategies; only a few champions lead the efforts.	<u>State of play:</u> CV technologies are recognized as valuable and a key role of the agency. Select agency managers lead efforts for CV deployments.	<u>State of play:</u> CV technologies are recognized as a core program that coordinates with other programs on an ongoing basis.	<u>State of play:</u> CV program is highly integrated with related core functions, such as planning, design, construction, maintenance, etc. All agency staff members, from leadership to rank and file, embrace the importance and value of CV technologies.
<u>Objective of this guidance element:</u> Begin the process of entering the CV arena through individual champions and projects.	<u>Objective of this guidance element:</u> Being to expand the awareness and buy-in of CV program within the organization through targeted managers and/or leaders.	<u>Objective of this guidance element:</u> Solidify the role of CV as a tool for addressing operational problems through a core program.	<u>Objective of this guidance element:</u> Entire spectrum of organization supports and buys into CV from rank and file to agency leaders.
<u>General strategy:</u> Identify an individual who can champion the CV cause.	<u>General strategy:</u> Charge specific agency managers with leading CV efforts; provide them with tools and support to facilitate and empower that leadership.	<u>General strategy:</u> Establish a core program that is responsible for CV deployments and the coordination of those with other TSMO efforts.	<u>General strategy:</u> Empower the CV program to develop new applications, build PPP, and pursue new initiatives to advance CV program.
<u>Relationship to TSMO:</u> The CV champion could emerge from TSMO leadership.	<u>Relationship to TSMO:</u> Key leadership likely to be within TSMO program.	<u>Relationship to TSMO:</u> Rank and file within organization begins to embrace CV culture; support efforts and coordination.	<u>Relationship to TSMO:</u> Part of doing TSMO business.
<u>Caveats:</u> Takes the right person with the skills and interest and motivation to lead a CV project.	<u>Caveats:</u> Requires a successful pilot deployment to prove potential; requires champion to build other champions and interest.	<u>Caveats:</u> Tied to workforce; takes a degree of market penetration of the technologies to allow personnel to understand how to use them	<u>Caveats:</u> Technologies have to be mainstreamed.

## Collaboration Dimension

Table E-7 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Collaboration Dimension of the CV Program Capability Maturity Model Framework.

Table E-7: CV Program CMM Framework Collaboration Dimension

Collaboration: Relationships with public safety agencies, local governments, MPOs, and the private sector			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Relationships and collaboration between stakeholder organizations are informal and ad hoc.	<u>State of play:</u> Collaboration with stakeholders is more formal and related to specific CV projects.	<u>State of play:</u> Agencies collaborate on CV projects at a high level via engagement of regional stakeholders.	<u>State of play:</u> Agencies approach CV applications and deployments at the regional level and across modes. Ongoing strong partnerships.
<u>Objective of this guidance element:</u> To build a foundation of core stakeholders internal to an agency or TSMO functions specific to a project.	<u>Objective of this guidance element:</u> Work to identify core stakeholders necessary for long-term viability of a CV program.	<u>Objective of this guidance element:</u> Work to expand to external stakeholders as part of CV program.	<u>Objective of this guidance element:</u> Ensure the long-term sustainability of the CV investments in the region; commitment from all stakeholders to support a CV program.
<u>General strategy:</u> Form collaboration partners for individual projects; may be existing partners or new ones. Institutional arrangements only specific to individual projects.	<u>General strategy:</u> Begin to establish institutional arrangements for corridors, especially related to maintenance and operations.	<u>General strategy:</u> Institutional arrangements, partnerships, and agreements on a regional basis across broad spectrum of stakeholders.	<u>General strategy:</u> Ongoing partnerships across all stakeholders and modes.
<u>Relationship to TSMO:</u> TSMO stakeholders focused on the specific project and gaining trust in the technologies.	<u>Relationship to TSMO:</u> Stakeholders begin to see the benefit to incorporating CV into traditional TSMO.	<u>Relationship to TSMO:</u> Stakeholders begin to actively collaborate in more widespread deployments.	<u>Relationship to TSMO:</u> Full regional buy-in on the roles and functions of CV technologies by all stakeholders.
<u>Caveats:</u> Limited to stakeholders directly involved in the specific pilot project.	<u>Caveats:</u> Difficult to sustain interest by all stakeholders without immediate direct success.	<u>Caveats:</u> Level of involvement will not be uniform across all stakeholders.	<u>Caveats:</u> Lose the ability to influence how technology gets deployed when technology advances rapidly.



## Automated Vehicle Program Capability Maturity Model Framework

For the purposes of this framework, the consultant team has assumed the matrix matching Society of Automotive Engineers (SAE) Levels of Driving Automation with Capability Maturity Framework Levels of Capability in Table E-8.

*Table E-8: SAE Levels of Automation vs. CMM Levels*

SAE Level of Driving Automation	PennDOT CMMF Level of Capability
0-1	1
2	2
3	3
4-5	4

Table E-9 contains the Automated Vehicle (AV) Program Capability Maturity Model Framework. Each level is explained for each of the six dimensions of the framework.

Table E-9: Automated Vehicle Program CMM Framework

CMM Dimension	Automated Vehicle Program Capability Level Self-Assessment Criteria			
	Level 1 Pilot Underway	Level 2 Program Initiated	Level 3 Program Integrated	Level 4 Program Mainstream
Business Processes: Planning, programing and budgeting, funding, PDP.	Processes and resources to conduct infrastructure assessment. Implement ongoing management systems to support technologies.	Establish a statewide plan for structure for AV deployment, including functional classification of roadways.	AV plan integrated with statewide and local infrastructure development plans (TIP, STIP).	An AV program is established as the basis for continuing improvements – including plan, program, funding updates.
Systems and Technology: Systems Engineering, and decision-support.	Establish a robust sign inventory system, pavement marking management systems to support in-vehicle technologies that rely on those elements.	Agency has partnered with an original equipment manufacturer (OEM) or after-market provider to deploy prototype AV pilot systems. Involves prototype back office and field components.	Establish systems that can support cooperative communication between AV and infrastructure. Standard approach to back office and field component deployment.	Establish comprehensive operations and maintenance systems for AV-related systems. Expand with increasing levels of automation, driven either by the OEMs or governmental requirements.
Performance Measurement: Use information for analytics, reporting, evaluation, management.	Develop an understanding of the needs of the automated vehicle systems under existing conditions. Identify appropriate performance measures for current pavement markings and sign inventories.	Establish criteria that defines required level of performance for automated vehicle technologies.	An AV-performance measurement system has been developed for AV and utilized for routine TSMO operational management and reporting.	AV is fully integrated into the agency's performance program – including both the performance of AV as well as the use of AV information regarding performance of other TSMO activities.
Organization and Workforce: including programmatic status, organizational structure, staff development, and recruitment and retention.	Organization needs to be able to focus on measuring the performance assets that support AV. Work with OEMs to understand how technologies will impact systems.	AV legal issues and related systems resolved and specific organizational/ staffing identified including KSAs. Training program developed / initiated.	TSMO/AV business case accepted legal arrangements completed and organization-capable staff in place.	Workforce technology-oriented and data-driven to support AV operations. Incorporate digital assets into system to support AV operations. High level of IT involvement.

CMM Dimension	Automated Vehicle Program Capability Level Self-Assessment Criteria			
	Level 1 Pilot Underway	Level 2 Program Initiated	Level 3 Program Integrated	Level 4 Program Mainstream
Culture: technical understanding, leadership, outreach, and program legal authority.	Outreach program to educate staff, stakeholders, and decision-makers. Need for laws and programs to support pilot deployments.	Build a culture within the State Department of Transportation (DOT) with an awareness and support of AV technologies. Maintenance becomes more rigorous and designed to support AV.	Increased level of consistency across the organization with respect to AV and supporting systems.	Comprehensive understanding across organization of AV and roles and responsibilities of internal groups to support deployment.
Collaboration: relationships with public safety agencies, local governments, MPOs, and the private sector.	Communicating with OEMs and standards development bodies to understand impacts of AV on network and operations.	Partnering with OEMs to implement a pilot. Collaborate with policy makers to establish legal authority and governance. Collaborate with law enforcement agencies.	Collaborate with MPOs to integrate statewide AV plans. Partner with entities for performance measurement data collection.	Collaborate with private sector to identify how roadway design features might need to change. Collaborate with roadway builders to implement new construction practices to support AV.

## Business Processes Dimension

Table E-10 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Business Processes Dimension of the AV Program Capability Maturity Model Framework.

Table E-10: AV Program CMM Framework Business Processes Dimension

Business Processes: Planning, programming and budgeting, funding, PDP			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Existing business practices are well established for procurements and ongoing maintenance and operations.	<u>State of play:</u> Agency is identifying locations that are suitable for testing and deployment. Supported by functional classification.	<u>State of play:</u> Agency is developing processes to support broader deployments with respect to the connected elements and data capture.	<u>State of play:</u> AVs are deployed everywhere with a high market penetration. Agency needs to be able to support broad operations.
<u>Objective of this guidance element:</u> Ensure that current business practices in funding and procurement support pilot deployments.	<u>Objective of this guidance element:</u> Establish priorities for deployments using the functional classification structure.	<u>Objective of this guidance element:</u> Ensure agency has processes that can successfully support the ongoing assessment of connected elements of the AV system. Similar to an asset management system.	<u>Objective of this guidance element:</u> Ensure agency has business processes that can adapt as AV technology evolves.
<u>General strategy:</u> Review current business practices to identify any changes, enhancements, or limitations related to AV pilot deployment.	<u>General strategy:</u> Develop a consensus-based statewide approach to initial AV deployments regarding location, planning, resource allocation, and project development processes.	<u>General strategy:</u> Develop a management process to ensure long-term ongoing capabilities to support AV technologies and deployment as well as data sharing.	<u>General strategy:</u> Develop a management process that incorporates periodic assessment of business practice needs to adopt new technologies.
<u>Relationship to TSMO:</u> Helps an agency identify holes in current processes that need to be updated to support AV deployment.	<u>Relationship to TSMO:</u> Establish new or modified business processes and programmatic activities to support AV deployment, e.g., inclusion in the STIP and TIP.	<u>Relationship to TSMO:</u> The AV management process becomes routine on high priority roadways.	<u>Relationship to TSMO:</u> AV management process is routine on all roadways identified as part of the AV network.
<u>Caveats:</u> Likely to be procurement restrictions that cannot be changed as they require statewide modification.	<u>Caveats:</u> Legal authority may be limited at the pilot deployment stage to specific requests to experiment on limited number of facilities.	<u>Caveats:</u> Legal authority needs to be sufficient to support operations on high priority roadways.	<u>Caveats:</u> Legal authority needs to be sufficient to support operations on complete AV network.

## Systems and Technology Dimension

Table E-11 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Systems and Technology Dimension of the AV Program Capability Maturity Model Framework.

Table E-11: AV Program CMM Framework Systems and Technology Dimension

Systems and Technology: Systems engineering, and decision-support			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> AV technologies deployed rely heavily on infrastructure elements of the roadway (e.g., signs, markings). Driver fully engaged in the driving process.	<u>State of play:</u> Automation still relies on the driver in the decision-making process. Systems and technology play a larger role in consistent operation of AV technologies.	<u>State of play:</u> Beginning to replace physical infrastructure elements with virtual ones in high priority corridors.	<u>State of play:</u> Most physical infrastructure elements replaced with virtual ones on full AV network. Virtual maps essential.
<u>Objective of this guidance element:</u> Agency understands what elements and support processes need to be updated to support AV technology development.	<u>Objective of this guidance element:</u> Ensure agency has infrastructure elements that provide safe and reliable information to AV technologies.	<u>Objective of this guidance element:</u> Begin to develop capabilities to support virtual infrastructure elements.	<u>Objective of this guidance element:</u> Support AV technologies on full AV network with virtual infrastructure mapping.
<u>General strategy:</u> Review current sign and pavement marking inventory requirements, technologies, standards, specification and identify changes that need to be made to support AV technologies.	<u>General strategy:</u> Establish performance requirements for infrastructure elements to support AV in deployment corridors.	<u>General strategy:</u> Begin to develop high-resolution mapping of roadway network and infrastructure elements (i.e., sign inventory, markings, etc.).	<u>General strategy:</u> Agency fully develops a virtual mapping of the infrastructure and all critical elements.
<u>Relationship to TSMO:</u> Rely on upon existing systems and technologies to assess quality of signs and markings for infrastructure readiness.	<u>Relationship to TSMO:</u> Agency is more aggressive in addressing operational deficiencies of infrastructure elements in pilot corridors. Monitoring of elements is very robust.	<u>Relationship to TSMO:</u> Develop a prioritization and structured process for replacing physical elements with virtual ones. Likely to start with navigation aids, then guidance, then control elements.	<u>Relationship to TSMO:</u> Establish a process for maintaining, updating, and expanding virtual mapping as infrastructure evolves. Needs to be integrated with other systems. No longer static in nature.
<u>Caveats:</u> Do not have a good understanding of how the AV technologies function under current conditions of infrastructure elements.	<u>Caveats:</u> May not be able to predict what information new technologies will require of the infrastructure elements.	<u>Caveats:</u> Need to ensure that the virtual information can be transmitted to the vehicle. Need to be able to support multiple levels of automation.	<u>Caveats:</u> Problems could arise with jurisdictional boundaries or varying operational authorities.

## Performance Measurement Dimension

Table E-12 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Performance Measurement Dimension of the AV Program Capability Maturity Model Framework.

Table E-12: AV Program CMM Framework Performance Measurement Dimension

Performance Measurement: Information for analytics, reporting, evaluation, management			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Employ existing simulation and analyses tools to determine the impacts of AV on system operations.	<u>State of play:</u> Performance measurement primarily event-based (e.g., weather, congestion, planned special events).	<u>State of play:</u> Performance measurement likely to be trip-based rather than system-based for the high priority corridors. Some multimodal and mobility-as-a-service assessment possible for the corridors.	<u>State of play:</u> Performance measurement to be more trip-based rather than system-based. Multimodal and mobility-as-a-service assessment possible for the entire network.
<u>Objective of this guidance element:</u> Beginning to understand the potential benefits of AV on overall system performance.	<u>Objective of this guidance element:</u> Understand the impacts/benefits of AV technologies during real-world events.	<u>Objective of this guidance element:</u> Understand the impacts/benefits of AV technologies on individual trips along high priority corridors.	<u>Objective of this guidance element:</u> Understand the impacts/benefits of AV technologies across all trips, including multimodal and mobility-as-a-service trips, across the network.
<u>General strategy:</u> Measures will tend to be more safety-oriented.	<u>General strategy:</u> Collect data during events, analyze impacts, and utilize data in simulation to analyze broader impacts.	<u>General strategy:</u> Collect data throughout specific trips to analyze impacts on individual trips as well as overall system.	<u>General strategy:</u> Collect data throughout trips across modes to analyze impacts on individual trips as well as overall system. Assess impacts on VMT across network.
<u>Relationship to TSMO:</u> Limited relationship to the broader TSMO efforts. Proof of concept level at this point.	<u>Relationship to TSMO:</u> Begin to assess the extent to which automation can improve safety and mobility. Limited to specific situations and/or conditions.	<u>Relationship to TSMO:</u> Corridor-specific deployments. Be able to assess the systematic impacts of automation within high priority corridors, and to a lesser extent other facilities.	<u>Relationship to TSMO:</u> Assess total system impacts of automation. Mobility-focused, as safety should be resolved through automation.
<u>Caveats:</u> Limited to capabilities of current analysis tools. Required to make assumptions regarding AV impacts and extrapolate with market penetration.	<u>Caveats:</u> Limited to event triggers and market penetration. Privacy issues and data ownership could be a challenge.	<u>Caveats:</u> Privacy issues and data ownership could be a challenge. Mobility-as-a-service presents a challenge for trip-based assessment.	<u>Caveats:</u> Reconcile differences in trip characteristics across modes. Mobility-as-a-service presents a challenge.

## Organization and Workforce Dimension

Table E-13 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Organization and Workforce Dimension of the AV Program Capability Maturity Model Framework.

Table E-13: AV Program CMM Framework Organization and Workforce Dimension

Organization and Workforce: Programmatic status, organizational structure, staff development, and recruitment and retention			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> OEMs will be driving the development of the technology. Agencies will need to be able to express capabilities and limitations of existing systems and personnel.	<u>State of play:</u> Starting to see a shift in workforce needs that specialize in managing data and performance with complex data analytics.	<u>State of play:</u> Workforce is changing from one responsible for a physical environment to one responsible for a virtual environment.	<u>State of play:</u> Workforce transformation essentially complete. KSAs in-house or outsourced to support broad AV deployments.
<u>Objective of this guidance element:</u> Understand the roles and responsibilities of agency in supporting AV technologies and deployments.	<u>Objective of this guidance element:</u> Identify organizational/governance structure that will facilitate and support long-term AV deployment, operations, and data analytics.	<u>Objective of this guidance element:</u> Agency has qualified staff needed to support AV deployments in multiple corridors. Staff could be outsourced if necessary.	<u>Objective of this guidance element:</u> Agency has program for ongoing professional development and technology transfer to personnel in response to evolving technologies.
<u>General strategy:</u> Educate agency workforce on AV technologies capabilities and limitations.	<u>General strategy:</u> Map roles and responsibilities to existing organizational structure. Identify KSAs and map to training needs.	<u>General strategy:</u> Identify training needs and develop training program(s) to support needs and enhance KSAs for personnel.	<u>General strategy:</u> Implement comprehensive training program. Establish process to update and expand program to incorporate new technologies, processes, and applications associated with AV and agency support roles.
<u>Relationship to TSMO:</u> Examine operational practices and organizational structure to consider necessary changes to support AV.	<u>Relationship to TSMO:</u> Reduced need for specific skill sets may require retraining of personnel to support new roles and responsibilities or need to outsource.	<u>Relationship to TSMO:</u> Create new job classifications, categories, pay and promotion structures to reflect new skill sets and to be competitive in the technology workforce.	<u>Relationship to TSMO:</u> Develop pay and promotion pathways for personnel involved in AV support within an agency.
<u>Caveats:</u> Limited to existing full-time employees (FTEs) and technologies that are not mature.	<u>Caveats:</u> Agencies may have difficulty recruiting workforce with data analytic skill sets.	<u>Caveats:</u> Limitations with existing job categories. May need job categories that currently do not exist. Need for more specialized skills (e.g., data analytics, geographic information system (GIS), cyber security, etc.).	<u>Caveat:</u> Turnover of technologies likely to be rapid. Agencies need ability to keep track of advancements and respond accordingly.



## Culture Dimension

Table E-14 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Culture Dimension of the AV Program Capability Maturity Model Framework.

Table E-14: AV Program CMM Framework Culture Dimension

Culture: Technical understanding, leadership, outreach, and program legal authority			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Limited understanding of AV technologies and potential impacts on organization and transportation infrastructure.	<u>State of play:</u> Agency awareness and understanding of AV technologies is fairly common at higher levels across management groups. Engagement with pilot deployments expanded beyond initial champions.	<u>State of play:</u> Management and key support personnel actively involved in AV deployments. Teams actively engaged in establishing direction of and engagement in AV deployments and supporting operational responsibilities.	<u>State of play:</u> Personnel at all levels have comprehensive understanding of AV technologies and impacts on operations. Internal groups support AV and understand roles and responsibilities and work with counterparts effectively.
<u>Objective of this guidance element:</u> Educate staff, stakeholders, and decision-makers about AV technologies. Identify champions within organization.	<u>Objective of this guidance element:</u> Ensure agency has the ability to facilitate and support long-term AV deployment, operations, and data analytics.	<u>Objective of this guidance element:</u> Ensure messages and goals and objectives related to AV technologies, deployments, and supporting systems are consistent across the organization.	<u>Objective of this guidance element:</u> Ensure agency messages and AV understanding is comprehensive and consistent across all internal groups and from leadership to rank and file personnel.
<u>General strategy:</u> Conduct outreach activities across organization and with external stakeholders, decision-makers, and general public. Work with policy makers to pass necessary legislation so support pilot deployments.	<u>General strategy:</u> Work with team managers/leaders across organization to identify AV roles and responsibilities for staff. Expand maintenance efforts to be more rigorous to support AV technologies and deployments.	<u>General strategy:</u> Establish clear organizational goals, objectives, and messages associated with AV technologies and support systems. Work with leaders and managers to incorporate those elements into group efforts to facilitate consistency across the organization.	<u>General strategy:</u> Fully integrate AV technologies and support systems as critical components of core organizational functions. Goals and objectives related to AV complement and support overall organizational mission.
<u>Relationship to TSMO:</u> Examine organizational groups to identify those that may be directly impacted by AV deployments.	<u>Relationship to TSMO:</u> Organizational shift from traditional TSMO to incorporate AV operations helps expand awareness and involvement of more personnel.	<u>Relationship to TSMO:</u> AV technologies and supporting systems becomes more integrated into overall TSMO organizational structure.	<u>Relationship to TSMO:</u> AV technologies and support systems are fully integrated into organizational activities and serve as a data source for ongoing TSMO operations.

Culture: Technical understanding, leadership, outreach, and program legal authority			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>Caveats:</u> May be resistance to movement away from traditional TSMO to expand to AV deployments.	<u>Caveats:</u> Agencies may have difficulty recruiting workforce with data analytic skill sets.	<u>Caveats:</u> Rank and file personnel may not understand their role in the AV deployments.	<u>Caveats:</u> Personnel turnover requires continual engagement of new staff to explain AV roles and responsibilities.

## Collaboration Dimension

Table E-15 contains the state of play, objective of this guidance element, general strategy, relationship to TSMO and caveats of the Collaboration Dimension of the AV Program Capability Maturity Model Framework.

Table E-15: AV Program CMM Framework Collaboration Dimension

Collaboration: Relationships with public safety agencies, local governments, MPOs, and the private sector			
Achieving Level 1 - Pilot	Achieving Level 2 - Initiated	Achieving Level 3 - Integrated	Achieving Level 4 - Mainstreamed
<u>State of play:</u> Limited understanding of potential benefits associated with AV technologies. Hard to distinguish reality from hype.	<u>State of play:</u> AV technologies generally applied to similar type facilities. Most collaborations will be public-private. Automation generally proven reliable and safe in certain applications.	<u>State of play:</u> AV technologies are beginning to be deployed in numerous high priority facilities that cross jurisdictional boundaries. More need to collaborate across multiple public agencies.	<u>State of play:</u> AV technologies are deployed in numerous high priority facilities that cross jurisdictional boundaries. Public agency collaboration is commonplace.
<u>Objective of this guidance element:</u> Assist the OEMs to understand how current systems and technologies work to support AV deployment.	<u>Objective of this guidance element:</u> Facilitate the development of public-private partnerships for showcasing technologies.	<u>Objective of this guidance element:</u> Build relationships with private and other public entities to promote development of AV technology growth.	<u>Objective of this guidance element:</u> Maintain relationships and collaborations to utilize new advances in automation.
<u>General strategy:</u> Agencies need to be able to travel and interact with OEMs to assist in the development of AV technologies.	<u>General strategy:</u> Establish partnerships with AV developers and public safety agencies to promote testing and deployment of technologies at pilot deployments.	<u>General strategy:</u> Participate in planning activities that support and promote development and application of AV technologies.	<u>General strategy:</u> Include elements of AV technologies in long-range transportation planning. Establish data sharing policies and procedures
<u>Relationship to TSMO:</u> Examine organizational groups to identify those that may be directly impacted by AV deployments.	<u>Relationship to TSMO:</u> Identify situations and scenarios where AV technologies might address safety and operational "hot spots."	<u>Relationship to TSMO:</u> Work with other public agencies to promote use of AV technologies to address congestion issues.	<u>Relationship to TSMO:</u> Promote common vision of the role of AV technologies in communities
<u>Caveats:</u> May encounter resistance from decision-makers and public agency communities against automation.	<u>Caveats:</u> Majority of development of AV technologies will occur in the private sector. Public agencies may have little influence on types of AV technologies developed.	<u>Caveats:</u> Agencies reluctant to participate in high risk automation projects.	<u>Caveats:</u> Long range planning may not occur quick enough to keep up with evolving technologies

## Capability Maturity Model Workshop

As part of Task 4 Capability Maturity Model Evaluation, of the Joint Statewide Connected and Automated Vehicle Strategic Plan effort, the consultant team conducted a CMM Workshop December 15, 2017. The presentation materials used during the workshop to guide the discussion and the notes taken during the discussion are provided below.

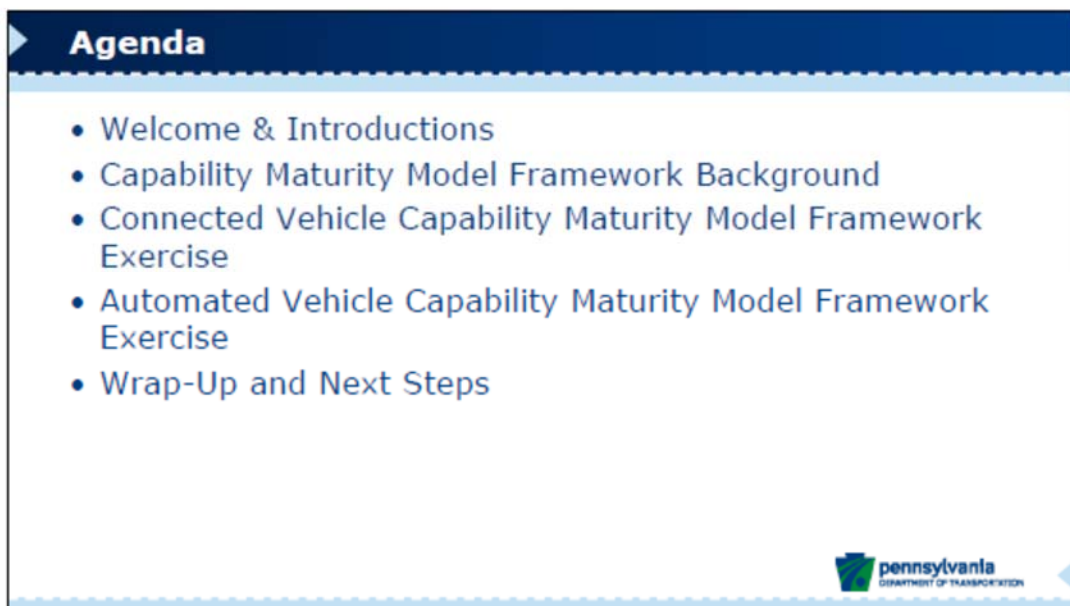


Figure E-1: CMM Workshop Presentation

## Welcome & Introductions

Laurie Matkowski, Gannett Fleming, Inc.



## Capability Maturity Model Framework Background

Beverly Kuhn, Texas A&M Transportation Institute



## Capability Maturity Model Frameworks

### Process Matters

Projects fail or do not achieve desired functionality for a variety of reasons unrelated to the technology.

### Prioritizing the right actions

Is your agency ready?  
How would you know?  
What should you do next?

### Focus on the weakest link

What is holding the agency back in becoming a leader in this area?

### Capability Maturity Model Frameworks for Connected and Automated Vehicles

#### Process

- Adapted from software development world.
- A consensus-driven consistent structured evaluation or assessment of a process.
- Guides an agency towards a higher level of implementation, standardization, and return on investment.

#### Outcomes

- Clear identification of weak links in the process.
- Prioritization of areas of improvement.
- List of process-oriented actions that an agency can implement.



## SHRP2 and AASHTO SOM Guidance

### • SHRP2 L06

- Undertook a comprehensive and systematic examination of the way agencies should be organized to successfully execute operations programs that improve travel time reliability.
- Developed a version of Capability Maturity Model for highway operations and in turn travel time reliability.

### • AASHTO

- Support the conversion of the SHRP 2 Reliability Project L06 research into a web-based tool that would be user friendly, easy to access, and updatable. (NCHRP Project 03-94, Transportation Systems Operations and Management Guide).





# AASHTO Guidance

<http://www.aashtotsmoguidance.org/>



## What is Transportation Systems Management and Operations (TSM&O)?

Transportation Systems Management and Operations (TSM&O) is a set of strategies to anticipate and manage traffic congestion, and minimize the other undesirable causes of traffic disruption, delays, and impacts. This website is providing information, best practices and best practices regarding the strategies you can use to identify the program, process, and individual project needs to achieve these effective TSM&O. [Learn More](#)

## Who Should Use the Guidance and Why?

This website and its guidance is designed for transportation agency managers whose scope of control relates to the operations and management of the roadway system, including agency leaders and program managers needed to TSM&O, who at the state, regional, local, and federal levels, as well as managers of systems operations related activities such as traffic engineering, maintenance, and public safety. The guidance can be used to evaluate agency capabilities, areas of growth and development, and identify and to prepare for future action. A technical solution customer the guidance based on current agency resources. [Learn More](#)

## Why is TSM&O Important?

Monthly travel of vehicles has significantly increased over the last 20 years. Regular congestion has continued to increase, while increasing reliability is considered by cost and impact. And, commuters have had high volatility. This has become its primary obstacle to the state and safety issues of mobility, construction, environmental, and other issues are responsible for their travel of travel delay and high office productivity.

**GUIDANCE TO IMPROVE THE EFFECTIVENESS OF YOUR TSM&O PROGRAM**

**One-Minute Guidance Evaluation**  
Based on a 60-second self-assessment.

**Customized Guidance Evaluation**  
Based on a 30-minute review of your current program.



# Capability Maturity Framework

Process Improvement Areas		Capability Levels			
Dimensions or Process Area	What is it	Level 1 Ad-Hoc, Low Level of Capability	Level 2	Level 3	Level 4 Optimized, High level of capability
Business Process	Plans, Programs, Budgets	Statement of capability	..	..	..
Systems & Technology	Approach to building systems	..	..	..	..
Performance Measurement	Use of performance measures	..	..	..	..
Workforce	Improving capability of workforce	..	..	..	..
Culture	Changing culture and building champions	..	..	..	..
Collaboration	Improving working relationships	..	..	..	..

Identify actions that you need to take to move to the desired levels of capability





## Products

- Specific agency or regional findings related to capability for various aspects of traffic management.
- Capability assessment by dimension.
- Suggested actions for improvement and advancement.



Consensus-based assessment



Dimension	Level of Capability	Level of Capability	Level of Capability	Level of Capability
Operational	High	Medium	Low	Very Low
Strategic	High	Medium	Low	Very Low
Financial	High	Medium	Low	Very Low
Human Resources	High	Medium	Low	Very Low
Information Technology	High	Medium	Low	Very Low
Legal	High	Medium	Low	Very Low
Public Affairs	High	Medium	Low	Very Low
Regulatory	High	Medium	Low	Very Low
Security	High	Medium	Low	Very Low
Other	High	Medium	Low	Very Low

Current capability



Prioritized actions for improvement



## Outcomes

- Jumpstarts the improvement process.
  - Focus is on immediate weaknesses.
  - Helps prioritize key organizational changes that can have major impact.
- Provide justification for actions.
  - Actions are based on sound rationale and a consistent assessment of capability.
- Improve consistency and collaboration.



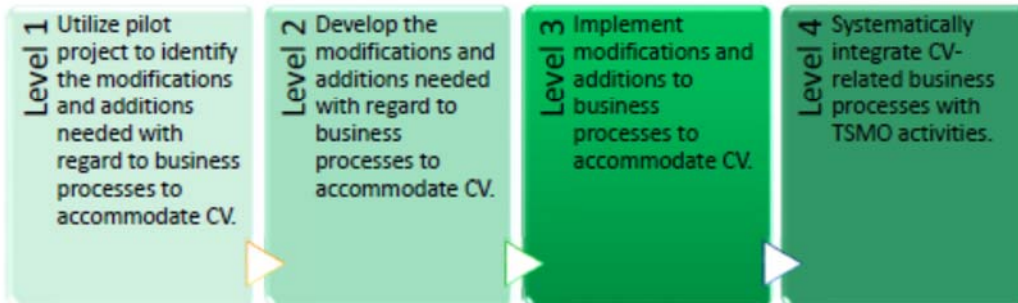
## Connected Vehicle Capability Maturity Model Framework Exercise

Kevin Balke, Texas A&M Transportation Institute

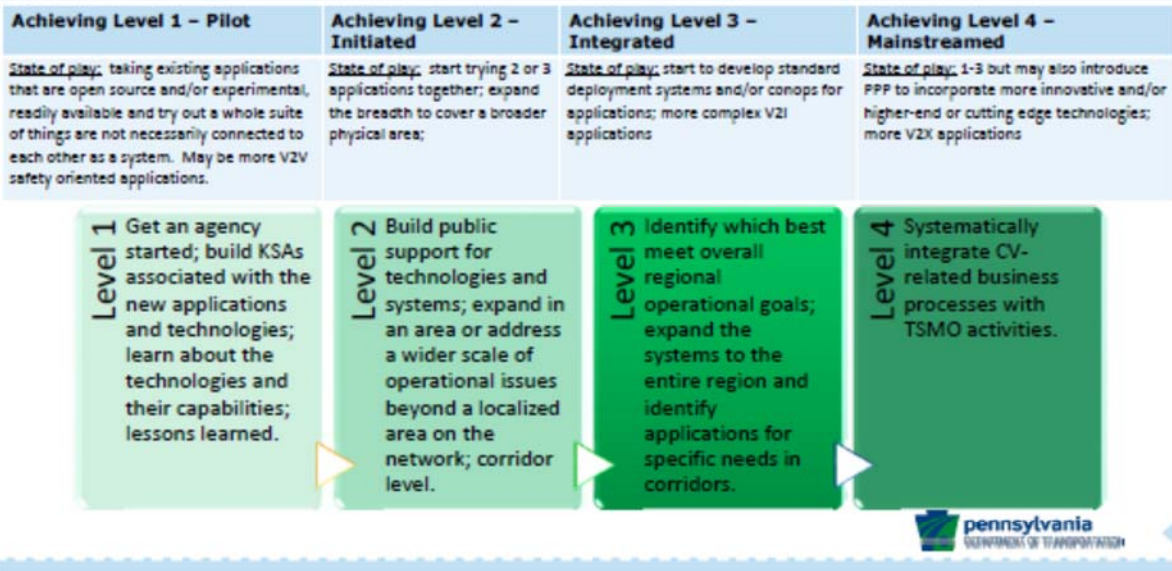


## Business Processes Dimension – Connected Vehicles

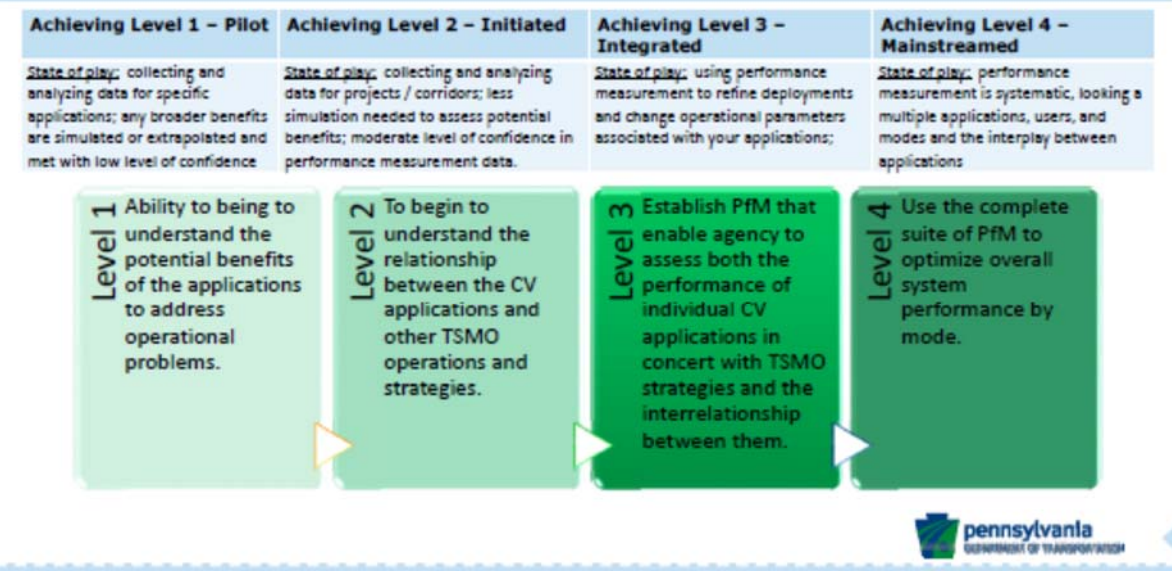
Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> agency is conducting an initial CV pilot project(s)	<i>State of play:</i> agency is developing CV-oriented plan, program, budget, and project development processes	<i>State of play:</i> agency has developed and is in the process of implementing CV operations plan together with programing, budgeting and project develop process	<i>State of play:</i> a CV program is established as the basis for continuing improvement – including plan, program, and funding updates



## Systems and Technology Dimension – Connected Vehicles



## Performance Measurement Dimension – Connected Vehicles





## Organization and Workforce Dimension – Connected Vehicles

Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> will need to accomplish pilot project with existing workforce and skill sets or specialized skill sets are contracted	<i>State of play:</i> begin to build in-house expertise; first areas of enhanced skill sets likely to be in maintenance to keep the system operational	<i>State of play:</i> beginning to build expertise in operations and management; have analysts capability of managing PFM data;	<i>State of play:</i> have a broad spectrum of personnel to design, operate, maintain, and analyze the systems on the network and relevant data; could be outsourced;

**Level 1** Begin building KSAs related to CV applications.

**Level 2** Enhance KSAs to understand objectives and benefits met by individual applications.

**Level 3** Expand KSAs to gain understanding of which CV applications support and / or complement other TSMO strategies.

**Level 4** Enable personnel to achieve the core competencies to design, operate, maintain, and analyze the CV systems across all modes.



## Culture Dimension – Connected Vehicles

Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> CV "program" is primarily an assortment of loosely related projects and strategies; only a few champions lead the efforts.	<i>State of play:</i> CV technologies are recognized as valuable and a key role of the agency. Select agency managers lead efforts for CV deployments	<i>State of play:</i> CV technologies are recognized as a core program that coordinates with other programs on an ongoing basis.	<i>State of play:</i> CV program is highly integrated with related core functions, such as planning, design, construction, maintenance, etc. All agency staff members, from leadership to rank and file, embrace the importance and value of CV technologies.

**Level 1** Begin the process of entering the CV arena through individual champions and projects.

**Level 2** Begin to expand the awareness and buy-in of CV program within the organization through targeted managers and/or leaders.

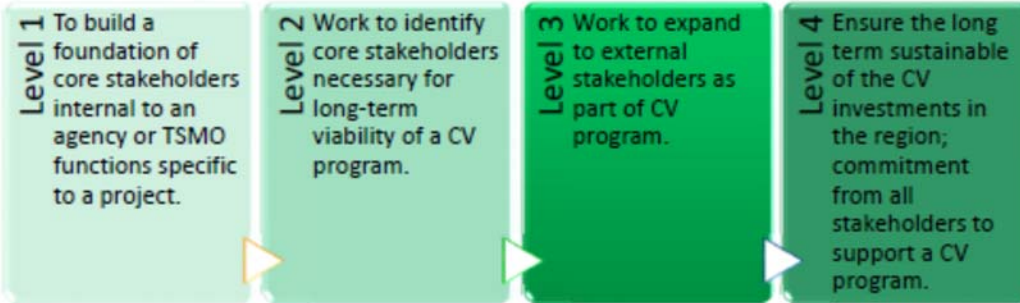
**Level 3** Solidify the role of CV as a tool for addressing operational problems through a core program.

**Level 4** Entire spectrum of organization supports and buys into CV from rank and file to agency leaders.



## Collaboration Dimension – Connected Vehicles

Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<b>State of play:</b> Relationships and collaboration between stakeholder organizations are informal and ad hoc.	<b>State of play:</b> Collaboration with stakeholders is more formal and related to specific CV projects.	<b>State of play:</b> Agencies collaborate on CV projects at a high level via engagement of regional stakeholders.	<b>State of play:</b> Agencies approach CV applications and deployments at the regional level and across modes. Ongoing strong partnerships.



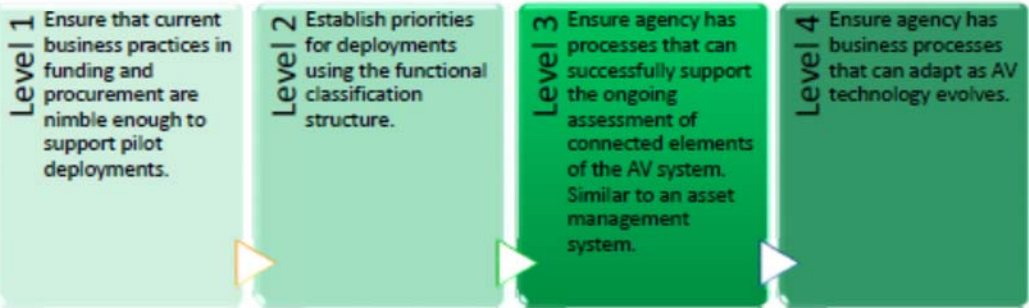
## Automated Vehicle Capability Maturity Model Framework Exercise

Beverly Kuhn, Texas A&M Transportation Institute



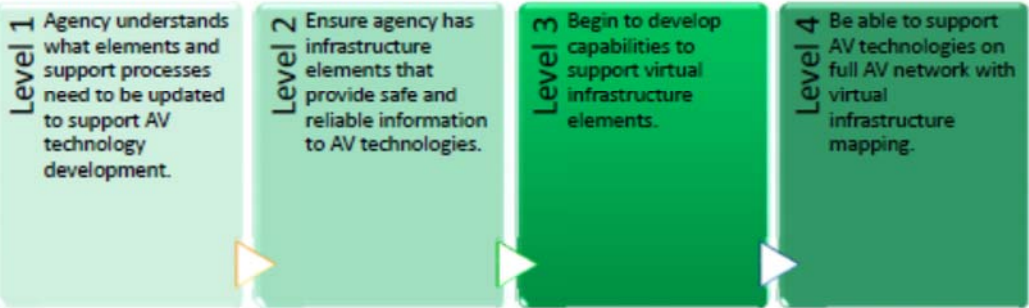
## Business Processes Dimension – Automated Vehicles

Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> Have existing business practices that are well established for procurements and ongoing maintenance and operations.	<i>State of play:</i> Agency is trying to identify locations that are suitable for testing and deployment. Supported by functional classification.	<i>State of play:</i> Agency is developing processes to support broader deployments with respect to the connected elements and data capture.	<i>State of play:</i> AVs are deployed everywhere with a high market penetration. Agency needs to be able to support broad operations.



## Systems and Technology Dimension – Automated Vehicles

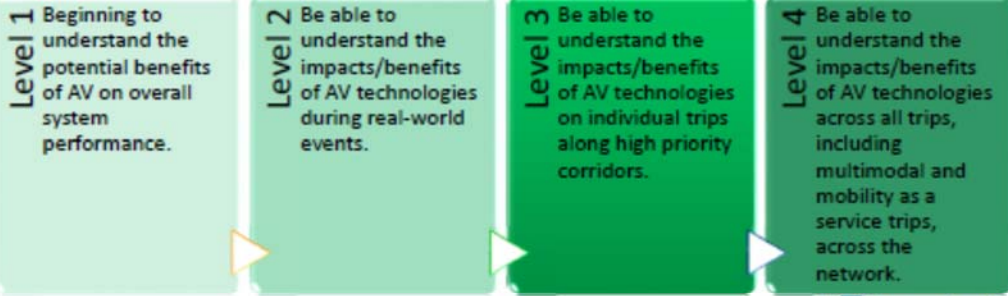
Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> AV technologies deployed rely heavily on infrastructure elements of the roadway (e.g., signs, markings). Driver fully engaged in the driving process.	<i>State of play:</i> Automation still relies on the driver in the decision-making process. S&T play a larger role in consistent operation of AV technologies.	<i>State of play:</i> Beginning to replace physical infrastructure elements with virtual ones in high priority corridors.	<i>State of play:</i> Most physical infrastructure elements replaced with virtual ones on full AV network. Virtual maps essential.





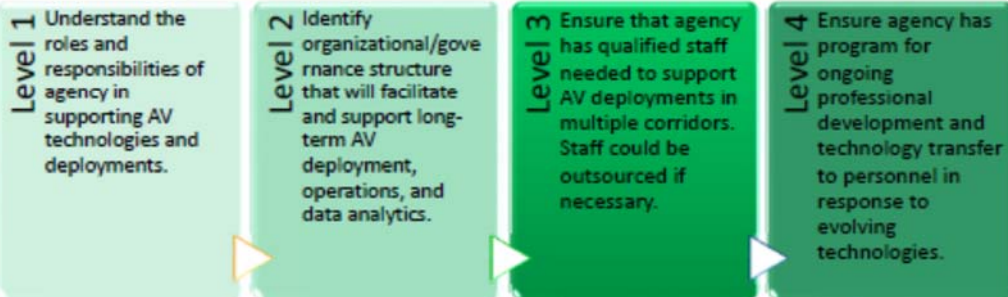
## Performance Measurement Dimension – Automated Vehicles

Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> Having to use existing simulation and analyses tools to determine the impacts of AV on system operations.	<i>State of play:</i> Performance measurement primarily event-based (e.g., weather, congestion, planned special events).	<i>State of play:</i> Performance measurement likely to be more trip based rather than system based in nature for the high priority corridors. Some multimodal and mobility as a service assessment possible for the corridors.	<i>State of play:</i> Performance measurement likely to be more trip based rather than system based in nature. Multimodal and mobility as a service assessment possible for the entire network.



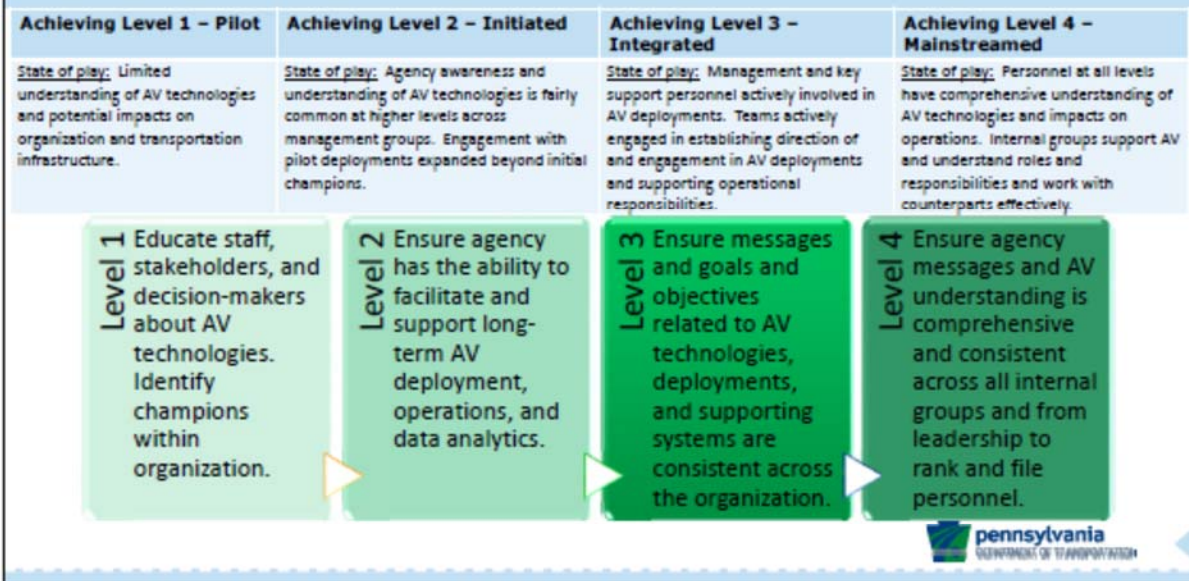
## Organization and Workforce Dimension – Automated Vehicles

Achieving Level 1 – Pilot	Achieving Level 2 – Initiated	Achieving Level 3 – Integrated	Achieving Level 4 – Mainstreamed
<i>State of play:</i> OEMs will be driving the development of the technology. Agencies will need to be able to express capabilities and limitations of existing systems and personnel.	<i>State of play:</i> Starting to see a shift in workforce needs that specialize in managing data and performance complex data analytics.	<i>State of play:</i> Workforce is changing from one responsible for a physical environment to one responsible for a virtual environment.	<i>State of play:</i> Workforce transformation essentially complete. KSAs in-house or outsourced to support broad AV deployments.

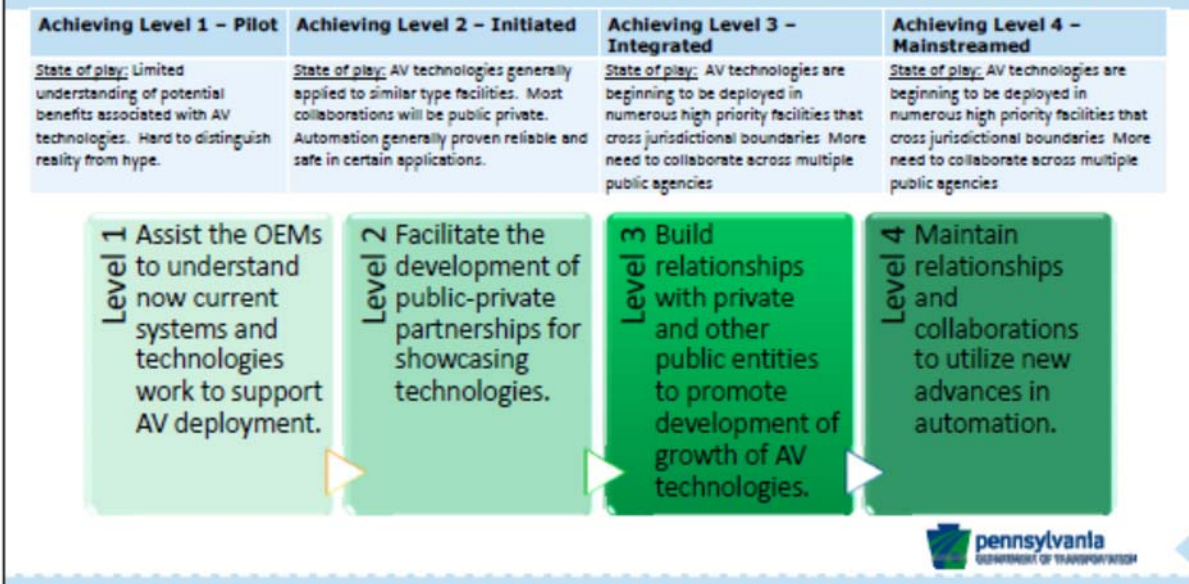




## Culture Dimension – Automated Vehicles



## Collaboration Dimension – Automated Vehicles



## Wrap-Up & Next Steps

Laurie Matkowski, Gannett Fleming, Inc.



**CAPABILITY MATURITY MODEL WORKSHOP**  
**Pennsylvania Joint Statewide Connected and Automated Vehicle (CAV) Strategic Plan**

**MEETING MINUTES**

**December 15, 2017**  
**9:00 AM – 12:00 PM**  
**WebEx**

A Capability Maturity Model (CMM) Workshop for the Pennsylvania Joint Statewide Connected and Automated Vehicle Strategic Plan was held December 15, 2017 from 9:00 AM to 12:00 PM via WebEx. The following individuals attended:

<i><b>Name</b></i>	<i><b>Title</b></i>	<i><b>Organization</b></i>	<i><b>Initials</b></i>
Mark Kopko	Manager, Traveler Information and Advanced Vehicle Technology	Pennsylvania Department of Transportation	MK
Jerome Frederick	Civil Engineer	Pennsylvania Department of Transportation	JF
Beverly Kuhn	Senior Research Engineer	Texas A&M Transportation Institute	BK
Kevin Balke	Senior Research Engineer	Texas A&M Transportation Institute	KB
Dwight E. Shank	System Engineer	Iteris, Inc.	DS
Laurie Matkowski	Director of Connected and Automated Vehicle Services	Gannett Fleming, Inc.	LM
Eric Rensel	Vice President	Gannett Fleming, Inc.	ER
Alexandra Lopez	ITS Engineer	Gannett Fleming, Inc.	AL

The following was discussed.

Welcome and Introductions:

- LM welcomed everyone and indicated that the purpose of the meeting was to review the maturity of aspects of the PennDOT related to Connected Vehicle and Automated Vehicle programs. The review is to be performed on the basis of the Capability Maturity Model developed by the Texas A&M Transportation Institute (TTI).
- Each participant in the workshop introduced themselves.
- LM transitioned leadership in the workshop to the team from TTI.

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#### Capability Maturity Framework Background:

- BK provided a brief background of CMM, as reflected in the attached slides, highlighting the following points:
  - TTI developed the CMM for highway operations and travel time reliability with support from the Strategic Highway Research Program and AASHTO projects on Transportation System Operations and Management.
  - The CMM was made available as a web-based tool to simplify access.
  - The purpose is to allow an agency to easily assess where they are regarding TSMO.
  - The results from such an assessment are very specific to each agency once you go through exercises and come up with actions.
  - The desired outcome is to enable the agency to progress in performance.
  - TTI developed a similar framework for traffic management and took the same approach to develop CV and AV frameworks.
  - This is the first use of the CV/AV CMM by TTI.

#### Connected Vehicle Capability Maturity Framework Exercise:

- KB initiated a review of Connected Vehicle Maturity by reviewing the situation at PennDOT for each dimension in the CMM.
- Business Processes Dimension:
  - KB presented the description of the dimension and related levels.
  - MK indicated the opinion that PennDOT is at a level 1.5. A lot of ad-hoc deployment has occurred. PennDOT has budgets but not dedicated line items. CV budget can be used for something else, if needed.
  - MK indicated that based on leadership, PennDOT wants to reach at least level 3 in five years. There is some support in PennDOT to reach level 4. In the next year or two, management would like to reach a solid level 2.
  - ER clarified that the secretaries and policy directors want level 4. Others (deputies) want level 3. He believes that reaching level 2 would represent a huge win.
  - KB indicated that to reach the next level, PennDOT would need to:
    - Have a set budget for CV, stable and consistent.
    - Have a comprehensive deployment and maintenance plan.
  - KB compared the progression to ITS deployment right now as tied to other initiatives. They go where there is an opportunity, rather than proceeding with ITS as a primary rationale.
  - ER emphasized there is a need for more of the non-engineering resources in order to improve. A legal framework is needed for example.
  - MK indicated that IT plays a major role for networking. Backhaul from RSUs is not always deployed on current projects, but would be advantageous.
  - KB asked if procurement practices are adequate.
  - MK related that the state procurement register of approved products does not contain roadside units. IT open-ended contracts were used to procure roadside units on previous projects, with no specifications available yet.

- DS stated that in the software development origin of the CMM, a separate organization to study progress was necessary to reach higher maturity levels.
- MK believed that currently a small staff is working on CV. Mostly engineers are involved (about 3 engineers) and not everyone proceeds consistently, but they are making their best efforts.
- Systems and Technologies Dimension:
  - KB presented the description of the dimension and related levels.
  - MK indicated that leadership wants to be in Level 4, but currently PennDOT is at level 1. There are plans to get us to level 2 in the next 3 to 4 years. Deployment in the larger Philadelphia region will integrate into the traffic management program.
  - MK stated that for resource and knowledge-base, PennDOT is in level 1. He identified weaknesses as:
    - IT has no knowledge of this currently.
    - These efforts are champion-driven.
  - KB asked about the extent that deployments are going to be dependent on IT involvement.
  - MK believes that IT will be critical as PennDOT progresses. PennDOT will need to integrate data being received into existing systems. Some states are trying to have their DOT staff who are knowledgeable about ITS handle IT, but PennDOT requires IT involvement.
  - MK believes that planning is lacking, although the Secretary and Deputy Secretary are planners.
  - JF agreed with MK, indicating a need for a set budget.
- Performance Measures Dimension:
  - KB presented the description of the dimension and related levels.
  - MK stated that PennDOT is clearly at level 1. PennDOT is not doing any performance measurement. PennDOT plans to start looking at more metrics as deployments are done. Budgets for projects are tight, with performance measurement frequently not prioritized.
  - What types of things is leadership looking for?
    - MK – From an operational perspective: pilot and quantify. From a planning perspective: a tool to measure benefit.
  - KB asked if performance measures would become critical.
  - MK stated that market penetration needs to be taken into account.
  - KB asked how benefits would be quantified or projects prioritized.
  - MK stated a desire to look at hot spots of higher market penetration and to focus there. Younger age of participants would aid in market penetration. Demographics of certain areas and willingness to adapt to newer technology would also be considered in project prioritization.
  - KB asked if typical performance measures (i.e., travel time, safety) will suffice in the future?
  - MK believes that they will still be applicable, but societal impacts will need to be looked at. Some relevant metrics may not have been developed yet.
- Organization and Workforce Dimension:
  - KB presented the description of the dimension and related levels.
  - MK stated that PennDOT is at the 1.5 level. There is some expertise in traffic ops, legal and outreach. There are no resources dedicated to CV. MK and JF work on CV, but have additional responsibilities that are unrelated.

- MK stated that staff do not know what they have to do with CV. They understand that it's coming and that they need to be prepared since technology is fast and government is slow.
- MK opined that efforts are not sufficient right now. Three of the nine PennDOT districts have CV knowledge and only one of them is strong in the area. PennDOT needs to create one location in the Department that can assist with getting prepared and establish champions within all or most business areas in the short term. PennDOT also needs someone involved at the national level in the near term.
- MK mentioned that, in the long term, PennDOT needs more market penetration. PennDOT may need to expand the overarching group and have more people in the business areas.
- Culture Dimension:
  - KB presented the description of the dimension and related levels.
  - MK indicated that PennDOT is at level 1 or 1.5. While leadership embraces it and staff doing the work embraced it, middle management has not bought into it. They see it as pie in the sky, while other more pressing issues should take priority over CV. Districts do not have the buy in; there is more buy in at the Central Office level.
  - KB asked about what is needed to get more buy in from the Districts.
  - MK indicated three separate approaches to start seeing change.
    - Projects involving the districts
    - Education and training to district staff
    - Buy in from the district executives
  - MK indicated that urban districts are more likely to embrace CV faster. One outlier is a rural district (Penn State) that is embracing technology. Acceptance is also dependent on stakeholders that are part of the District. Some rural districts have not embraced ITS yet.
  - Freight and border crossing and planning organizations.
    - MK indicated data collection falls under planning and research, which will have to become involved to incorporate freight and border crossing applications. Freight will be important for the department since I-81 and I-78 are major trucking routes. They represent the second fastest growing corridor for distribution in the world.
- Collaboration:
  - KB presented the description of the dimension and related levels.
  - MK indicated that PennDOT is at level 2.5, which is currently the highest rating of all the dimensions. Leadership wants to be at level 4. PennDOT collaborates fairly well when doing projects. Collaboration with universities, MPOs, municipalities, adjacent states including partnerships with Michigan and Ohio, and PTC. While collaboration is good, it is still regionalized, with missing stakeholders including the Philadelphia region, state police and first responders, and some of the districts.

#### Automated Vehicle Capability Maturity Framework Exercise:

- Business Processes Dimension:
  - BK presented the description of the dimension and related levels.



- MK stated that PennDOT wants to be at level 4, but most staff would be happy to reach level 3. PennDOT is currently at level 1.5.
- MK indicated that legislative issues are a limitation regarding AV.
  - Implementation of low speed automated shuttles was placed on a university facility rather than a public roadway.
  - Current laws related to both driver involvement and following distance need to change to enable automation in platooning.
- MK indicated that business practices are poorly designed to support a rapid technological advance.
  - RFP processes take time (9-12 months) and what is procured may not be the latest when built. There are always legality questions and liability questions, although PennDOT has some immunity.
  - Updates can be done faster than changing procurement processes. Lease vs. purchase shuttles – PennDOT does not do this at all.
  - AV tends to catch the attention of the public more than CV.
  - Education of procurement people is required from our legal staff. Office of General Counsel (outside PennDOT) has to approve procurements and they are not well versed on these topics.
  - MK mentioned that all data are shared unless legislation says otherwise. Data are very open currently. The open data platform is new to the Commonwealth and a lot of data requirements need to be developed.
- Systems and Technology Dimension:
  - BK presented the description of the dimension and related levels.
  - MK stated that PennDOT would like to be at level 3, but is currently at level 1. Work is underway to reach level 2.
  - MK described some of the steps underway to reach level 2.
    - Pittsburgh has some Signal Phasing and Timing (SPaT) broadcast in place, which is helpful.
    - Identify critical corridors and create LiDAR mapping and make it available for testing, etc.
    - To get to level 3, there are some items that could get digitalized and making HOT lanes in Pittsburgh available to AV is considered a possibility.
  - MK described all AV resources as currently relying on physical infrastructure. When considering electronic infrastructure for AV support, the biggest challenges will be proper up time, low latency, and reliability of communications.
  - MK mentioned that incident management and winter weather management is very important to the Department with no plan to accommodate AV.
- Performance Measurement Dimension:
  - BK presented the description of the dimension and related levels.
  - MK indicated that PennDOT wants to be at level 3 or 4 depending on the region, with the cities wanting level 4. PennDOT currently is at level 1. PennDOT is relying on partners such as CMU to do this, especially simulation.
  - MK mentioned that AV may require new metrics and may impact metrics that have not been frequently considered, such as parking revenue. This is important to locations including Pittsburgh which gets 10% of its revenue from the parking concession.



- MK also mentioned that sharing data is difficult. No one wants to share the data, which can be sensitive to competition and business models.
  - Mobility-as-a-service may not be applicable for rural areas, but is of interest in urban areas.
  - Freight transport may change significantly in rural areas.
  - Origin and destination characteristics may change requiring newer metrics for AV and increasing VMT.
  - The shared ride approach of automated vehicles may impact public transit.
- MK stated that first steps may be working with partners such as the city of Pittsburgh, evaluating real impacts, and working with academic partners. Later adjustments can be made as market penetration increases and the marketplace matures.
- Organization and Workforce Dimension:
  - BK presented the description of the dimension and related levels.
  - MK stated that PennDOT is at level 1.5 right now, and would like to reach level 3. PennDOT has done some twinning, i.e., AV Policy Task Force. The chief legal counsel is very knowledgeable as well as Driver and Vehicle Services. Stakeholder outreach events have been conducted as well as outreach to legislators.
    - There is no stable foundation in leadership - elections may change secretary and leadership. Nothing is currently formal or designed to last.
  - MK mentioned that the desire for maturity level may change with upcoming elections and the possible leadership replacement.
  - MK observed that AV is new to everyone, without much expertise in the industry. PennDOT would like to outsource AV to take advantage of current private sector resources, but PennDOT needs to gain in house public sector expertise, as well.
  - MK discussed several issues related to needed job categories and skills:
    - Data scientists will be needed, but are currently not present in PennDOT.
    - Staff members in various offices in the department are siloed. Communication between roles is difficult, e.g., traffic operations and IT.
    - Currently PennDOT requires a PE to be in upper management. With the shift from concrete and asphalt to technology, this is not applicable in certain areas and may be an impediment.
- Culture Dimension:
  - BK presented the description of the dimension and related levels.
  - MK indicated that PennDOT is currently between Level 1.5 and 2, and would like to reach level 3.
  - MK stated that AV is a priority of the Secretary. The vast majority of the Department are aware of AV, but may not be experts. Each of the nine business areas have a key stakeholder.
  - MK indicated that not all business areas are equally advanced.
    - Driver and Vehicle Services are the furthest along.
    - Legal is significantly advanced, but only the head of legal is well versed.
    - Planning is lacking.
    - IT is very interested. They tend to ramp up faster than other business areas.
    - Operations and maintenance is very well versed.
    - Design and construction is not advanced, as AV is still not real for them. They have other things to worry about.

- MK stated that actions needed to assist the business areas include:
  - Education.
  - Hands-on experiences and demonstrations.
- Collaboration:
  - BK presented the description of the dimension and related levels.
  - MK indicated that PennDOT is at level 2 and is actively working toward level 3. Activity includes:
    - A policy task force.
    - Partnerships similar to CV response.
    - Looking at AV deployment.
  - MK stated that to reach level 3, legislative changes will need to be in place.
  - MK mentioned that willingness to collaborate was at various levels:
    - Agencies were generally willing.
    - Industries are most opinionated, with significant infighting.
    - The politics side is the most difficult.
    - PennDOT and agencies can agree that safety is the primary goal.
  - MK mentioned that PennDOT is trying to foster more collaboration with locals
    - Workforce development and planning for locals with a desire to help with interoperability.
    - Local outreach.
  - BK indicated that ITE is a good place to start.
  - BK indicated that locals are interested in knowing how AV will affect them.
  - MK discussed mechanisms to fund local pilots. Funds allocated for signal enhancements with 20% match from local and 80% from PennDOT may be made available for use with CAV. Smart Cities is a potential source for pilot and deployment funding.

#### Wrap Up and Next Steps:

- Several participants mentioned that the discussion had been informed and thoughtful.
- The GF team was tasked with documenting, reviewing, and validating the discussion in the workshop.
- The results of the workshop will be used to provide input to Task 5, including developing short-term actions and long-term actions to progress each dimension of the capability model.

# Capability Maturity Model Ranking and Justification for Pennsylvania Department of Transportation

## Connected Vehicle Program

Figure E-2 presents a graphical representation of the ranking of the Connected Vehicle Program in the Pennsylvania Department of Transportation. The assessment of current maturity is based on input from PennDOT staff during a workshop led by staff from the Texas Transportation Institute and the interviews performed by the consultant team as part of Task 1.



Figure E-2: CV CMM Ranking

Table E-16 presents the justification and the desired level of CMM as assessed during the CMM workshop held December 15, 2017 and the various interviews carried out as part of Task 1 Internal Information Gathering and Investigations of the Joint Statewide Connected and Automated Vehicle Strategic Plan.

Table E-16: CV CMM Ranking and Justification

Dimension	Current Level	Justification	Desired Level of CMM
Business Processes	1.5	The current maturity level is 1, with some characteristics of level 2. Current efforts are mostly related to individual projects with champions leading to project implementation. Some work on agency planning has been initiated. To reach level 2, the state needs to establish a stable budget, develop standard specifications and practices, and gain support from organizational elements outside of CV engineers. Other organizational elements include Information Technology, Procurement, and Engineering, and Planning, among others.	PennDOT leadership would like to reach at least level 3, with some support for reaching level 4.
Systems and Technology	1	The current maturity level is 1. All technical efforts have been project based under the leadership of project champions. Projects are geographically clustered across the state, with little uniformity. Projects are rarely, if ever, able to leverage previous project infrastructure or wider PennDOT resources with CV experience. The lack of Information Technology staff with knowledge beyond individual projects is a major impediment.	PennDOT leadership would like to reach level 4.
Performance Measurement	1	The current maturity level is 1. There is no system-wide process to measure the results of CV implementations. The projects struggle to perform high-quality evaluation studies as a result of competing priorities and limited budgets.	PennDOT leadership would like to reach level 3.
Organization and Workforce	1.5	The current maturity level is 1, with some characteristics of level 2. Pilot projects in Connected Vehicles have been accomplished leading to regional expertise not only in technical implementation, but with some knowledge organizationally related to operation, outreach, and legal topics.	PennDOT leadership would like to establish a CV practice lead team, which is consistent with level 3.

Dimension	Current Level	Justification	Desired Level of CMM
Culture	1.5	The current maturity level is 1, with some characteristics of level 2. Staff involved in pilot projects as well as statewide leadership embrace use and expansion of Connected Vehicle systems. Mid-managers and staff who have not been involved in pilot projects are unprepared culturally for additional CV implementations. Most staff exposed work in urban areas or near research institutions. Freight and border crossings are areas with potential for CV expansion.	PennDOT leadership would like establish CV as widely incorporated into planning, which is consistent with level 3.
Collaboration	2.5	The current maturity level is 2, with some characteristics of level 3. Internal to PennDOT, collaboration is established. Existing partnerships cover research institutions, MPOs, and PTC. Further expansion of collaboration targets law enforcement, first responders, and planning organizations in the Philadelphia region.	PennDOT leadership would like to reach level 4.

### Automated Vehicle Program

Figure E-3 presents a graphical representation of the ranking of the Automated Vehicle Program in the Pennsylvania Department of Transportation. The assessment of current maturity is based on input from PennDOT staff during a workshop led by staff from the Texas Transportation Institute and the interviews performed by the consultant team as part of Task 1.



Figure E-3: AV CMM Ranking

Table E-17 presents the justification and the desired level of CMM as assessed during the CMM workshop held December 15, 2017 and the various interviews carried out as part of Task 1 Internal Information Gathering and Investigations of the Joint Statewide Connected and Automated Vehicle Strategic Plan.

Table E-17: AV CMM Ranking and Justification

Dimension	Current Level	Justification	Desired Level of CMM
Business Processes	1.5	The current maturity level is 1, with some characteristics of level 2. The majority of activity for Automated Vehicles has been near Pittsburgh. The state is lacking legislative and legal support for expansion of deployments including driver presence, driver capacity, and following distance laws. The ability to respond promptly to developing needs for modified roadway infrastructure, insurance coverage, and data ownership is questionable.	PennDOT leadership would like to reach level 4.

Dimension	Current Level	Justification	Desired Level of CMM
Systems and Technology	1	The current maturity level is 1. AV testing and operation rely on standard civil infrastructure. Some technical support for AV operations has been initiated, including Signal Phasing and Timing (SPaT) broadcast locally at some intersections.	PennDOT leadership would like to reach level 3. Technical hurdles to provide necessary reliability and revised physical infrastructure are already recognized.
Performance Measurement	1	The current maturity level is 1. PennDOT relies on partners to provide technical services related to Performance Measurement. Data related to performance is collected sporadically and once collected is used by the collecting agency with little sharing of the data occurring. The possibility of new metrics related to automation is acknowledged.	PennDOT leadership would like to reach level 3 or level 4, varying regionally.
Organization and Workforce	1.5	The current maturity level is 1, with some characteristics of level 2. Some areas with existing knowledge and experience. There is an AV task force operating and legal counsel has experience. Some outreach has been accomplished to stakeholders and legislature. The need for new skill sets in the work force is identified, without resources to address the anticipated need.	PennDOT leadership would like to reach level 3.
Culture	2	The current maturity level is approaching level 2, with some characteristics of level 1 still evident. The current administration has emphasized AV technology implementation, leading to wide knowledge of AV issues. Not all of the core business units are yet engaged.	PennDOT leadership would like to reach level 3, with some characteristics of level 4.



Dimension	Current Level	Justification	Desired Level of CMM
Collaboration	2	The current maturity level is approaching level 2, with some characteristics of level 1. An existing task force is addressing issues with representation from PennDOT, other government agencies, freight carriers, automotive OEMs, and standards organizations. Coordination with adjacent states for interstate issues has been initiated. Freeway issues are further advanced than those related to local operations on surface roadways. Interests of industry actors protecting their individual interests limits willingness to cooperate.	PennDOT leadership would like to reach level 3, but will need legislative and legal cooperation to proceed.

## Recommended Next Steps

The concept of a CMM is to assess the ability of an organization to perform technical work with the desired types of discipline. Increased maturity levels indicate the ability to produce improved quality of products reliably, but does not necessarily correspond to cost efficiency. As part of the CMM workshop, PennDOT staff indicated the desired level or range of levels for each dimension of maturity for both Connected Vehicles and Automated Vehicles. In all cases, PennDOT desires a greater level of maturity than is assessed as the current situation.

The progress through CMM levels is expected to move from the lowest maturity level of 1 to the highest desired level, with some time spent in each intervening level. Not all characteristics of each maturity level will be exhibited simultaneously in all cases. The following discussion presents initial steps for each CMM dimension to progress toward the desired maturity level.

### Business Processes Dimension

In the business practice dimension, both CV and AV were assessed as level 1.5, indicating that some aspects of this dimension had progressed to level 2, but some aspects were still at level 1. Both CV and AV need to take the next step to establish standard practices. For CV, standard practices involve establishing a dedicated budget to implement projects selected through a needs-based analysis. CV standard practices should also be improved by establishing procurement practices using approved hardware and common architectures. For AV, establishing standard practices include passing enabling legislation and enacting regulations that enable automated operation on public roadways. The legislation and regulations should be harmonized with other states to allow consistent interstate operation while addressing data sharing and privacy issues.

### Systems and Technology Dimension

In the systems and technology dimension, both CV and AV were assessed as level 1, indicating that only limited initial work has been undertaken. Next steps for CV should establish standard practices. This can be accomplished by broadening expertise gained in pilot projects to engineering standards to be applied throughout the state. The engineering standards should apply to CV groups in PennDOT and cooperating groups, such as Information Technology. For AV, next steps involve exploring support for automated operations, both in terms of electronic infrastructure such as SPaT and electronic signing, and physical infrastructure such as dedicated AV lanes and lane width reductions.

### Performance Measurement Dimension

In the performance measurement dimension, CV and AV were assessed as level 1, indicating that only limited initial work has been undertaken. Efforts in performance measurement are important for assessing progress in all other dimensions. For CV and AV, next steps involve initiating efforts to collect information on operations involving CV and AV technologies. A project to establish a standard method to easily transmit data from field networks and allow reliable retrieval would improve the situation.

### Organization and Workforce Dimension

In the organization and workforce dimension, CV and AV were assessed as level as level 1.5, indicating that some aspects of this dimension had progressed to level 2, but some aspects were still at level 1. Next steps should broaden the experience base from initial experience and study to full knowledge throughout the organization. While gaining awareness by the entire workforce of the topics related to CV and AV implementation can be beneficial, a more effective next step would be the education and training of

leaders within each geographic and organizational group. The education and training would address required knowledge, skills, and abilities and would be tailored to the specific needs of each group.

### Culture Dimension

In the culture dimension, CV was assessed as level 1.5 indicating that some aspects of this dimension had progressed to level 2, but some aspects were still at level 1. AV was assessed as level 2, indicating that awareness of the topic was widely established. Next steps for CV should broaden support of the use of CV tools throughout the organization. Steps to gain broader knowledge should include the publication of benefits studies for use of CV technology along with agency-wide webinars. The AV assessment level benefits from the current public emphasis on AV by technology and automotive companies, as well as support from PennDOT management. To progress toward level 3, PennDOT should establish complete awareness of AV in all business areas with targeted outreach to individual managers. PennDOT should also work to establish AV as a consideration in all future work by getting AV consideration in review checklists as a standard practice.

### Collaboration Dimension

The collaboration dimension was rated most highly in CV and AV. In CV, collaboration is an established practice with an assessment of level 2.5. The next step in CV collaboration is to make geographic collaboration more comprehensive by establishing working relationships with the Philadelphia area as well as state police, first responders, and rural PennDOT districts. In AV, significant collaboration for future deployment is apparent with an assessment of level 2. Next steps include establishing working relationships on AV with agencies responsible for surface roadways and local operation as well as passing enabling legislation supportive of AV operations.

## References

1. *AASHTO Transportation Systems Management and Operations Guidance*. Web-Based Publication. American Association of State Highway and Transportation Officials (AASHTO). Available at <http://www.aashtotsmoguidance.org/>. Accessed November 13, 2017.

PENNSYLVANIA DEPARTMENT OF  
TRANSPORTATION  
JOINT STATEWIDE CONNECTED AND AUTOMATED VEHICLE  
STRATEGIC PLAN

APPENDIX F  
CONNECTED AND AUTOMATED VEHICLES PROPOSED PILOT  
PROJECTS

MARCH 2018

## Proposed Pilot Projects

Using the information gathered during the internal and external data gathering, the review and documentation of the early successes and best practices, and the capability maturity model exercise, several connected and automated vehicles (CAV) pilots were proposed. As part of each pilot recommendation, the following was identified:

- Existing needs or issues that will be addressed by the pilot.
- Specific applications that will be tested/deployed.
- Stakeholders that will be involved in the pilot (e.g., local municipalities or MPOs).
- Existing infrastructure that will be affected by the pilot (e.g., traffic signal controller), if applicable.
- Potential industry partners.

Below is a list of the proposed pilots.

### Low Speed Automated Shuttle Pilots

- Implement Automate Paratransit Shuttles
- Implement Driverless Shuttles in Pennsylvania State Parks
- Deploy CAV technologies as First/Last Mile Connections in Communities with High Transit Ridership
- Deploy Driverless Shuttles at Airport Facilities between Gates

### CV Freight Application Pilots

- Install Advanced Curve Speed Warning Systems
- Prioritize Freight Using CAV Technologies

### Outreach Pilots

- Develop a CAV Awareness Campaign
- Develop a Community CAV Challenge
- Designate Smart Corridors

### Work Zone and Fleet Vehicles Pilots

- Deploy Automated Truck Mounted Attenuators in Work Zones
- Implement a Maintenance Plan using CAV Technologies
- Implement Response Management Connected Vehicles (CV) Technology at Work Zones

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## Pilot Category: Low Speed Automated Shuttles

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### PILOT: IMPLEMENT AUTOMATED PARATRANSIT SHUTTLES

#### Proposed Action

Fund the implementation of automated paratransit shuttles at locations where senior centers are near health care hubs such as hospitals or rehabilitation centers.

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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#### Additional Benefits

- Health benefit increase from paratransit riders who get to their appointments and may ride more frequently if shuttles are consistent and reliable

#### Partners

- Pennsylvania Department of Transportation
- Transit Agencies
- Hospitals
- Senior Centers
- Pennsylvania Department of Health
- Community Leaders
- Planning Partners
- Counties
- Cities
- Chamber of Commerce

#### Approach

- Compile a list of senior centers near hospitals or rehabilitation centers.
- Conduct a feasibility study to identify the optimum pilot location and implement electric driverless shuttles.
- Provide an evaluation of pilot sites using before/after ridership numbers.

#### Assumptions

- Legislation allows driverless shuttles.



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## Pilot Category: Low Speed Automated Shuttles

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### PILOT: IMPLEMENT DRIVERLESS SHUTTLES IN PENNSYLVANIA STATE PARKS

#### Proposed Action

Fund the implementation of electric driverless shuttles throughout parking lots, and to and from major park entry points in state parks in Pennsylvania. Study the before and after effects on parking demand and number of visitors.

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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#### Additional Benefits

- Reduce emissions in state parks while improving access.
- Reduce the amount of impervious surface area dedicated to parking in state parks.
- Support tourism by increasing the number of annual visitors to state parks.

#### Partners

- Pennsylvania Department of Transportation
- Department of Community and Economic Development
- Department of Conservation and Natural Resources

#### Approach

- Compile a list of state parks with the most restricted parking and access and identify the top three candidate locations.
- Conduct a feasibility study to identify the optimum pilot location and implement electric driverless shuttles. The optimum location would likely be located close to a nearby third-class city in a Third – Fifth class county.
- Allow implementation of other automated shared ride services to encourage use by residents and economic development for area visitors.

#### Assumptions

- Legislation allows driverless shuttles.

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## Pilot Category: Low Speed Automated Shuttles

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PILOT: DEPLOY CAV TECHNOLOGIES AS FIRST/LAST MILE CONNECTIONS IN COMMUNITIES WITH HIGH TRANSIT RIDERSHIP

### Proposed Action

Enable transit oriented design by providing first/last mile mobility-as-a-service. Provide low speed electric automated shuttles to allow mobility from a major transit hub to a community center, or other type of location quickly, safely, and efficiently with as little environment impact as possible.

Goals Addressed:	1	IMPROVE SAFETY	2	ENHANCE MOBILITY	3	PREPARE WORKFORCE	4	FOSTER AND SUSTAIN PARTNERSHIPS	5	INCREASE PUBLIC AWARENESS	6	SUPPORT ECONOMIC COMPETITIVENESS

### Additional Benefits

- Increase transit ridership.
- Decrease local area congestion.

### Partners

- Pennsylvania Department of Transportation
- Transit Agencies
- Department of Community and Economic Development
- Planning Partners
- Counties
- Cities
- Chamber of Commerce

### Approach

- Compile a list of high ridership transit hubs and identify top candidate locations.
- Conduct a feasibility study to identify the optimum pilot location and implement electric automated shuttles. The optimum location would be in a transit oriented development.
- Provide an evaluation of pilot sites using before/after ridership numbers.

### Assumptions

- Legislation allows driverless shuttles.

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## Pilot Category: Low Speed Automated Shuttles

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PILOT: DEPLOY DRIVERLESS SHUTTLES AT AIRPORT FACILITIES BETWEEN GATES

### Proposed Action

Enable electronic automated driverless shuttles on existing predetermined routes at airport facilities to take passengers to and from gates.

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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### Additional Benefits

- Increase transit ridership.

### Partners

- Pennsylvania Department of Transportation
- Airports

### Approach

- Compile a list of airports with existing predetermined routes between gates.
- Conduct a feasibility study to identify the optimum pilot location and implement electric driverless shuttles.
- Provide an evaluation of pilot sites using before/after ridership numbers.

### Assumptions

- Legislation allows driverless shuttles.

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## Pilot Category: Connected Vehicle Freight Applications

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### PILOT: INSTALL ADVANCED CURVE SPEED WARNING SYSTEMS

#### Proposed Action

Install advanced curve speed warning systems and connect them to trucks with CAV technologies. This system goes beyond static signs to warn trucks they may be going too fast for an upcoming curve. By installing CAV devices that communicate with the curve warning system, the truck will automatically slow down.

Goals Addressed:	1	IMPROVE SAFETY	2	ENHANCE MOBILITY	3	PREPARE WORKFORCE	4	FOSTER AND SUSTAIN PARTNERSHIPS	5	INCREASE PUBLIC AWARENESS	6	SUPPORT ECONOMIC COMPETITIVENESS

#### Additional Benefits

- Improve reliability of the freight network.

#### Partners

- Pennsylvania Department of Transportation
- Pennsylvania Turnpike Commission
- Fleet Vehicle Providers

#### Approach

- Create a working group of various agencies related to freight movement and determine where the advanced curve speed warning systems should be implemented.
- Work with vendors to deploy the technology needed.
- Conduct before and after studies for determination of successful implementation.

#### Assumptions

- There is a partnership with fleet vehicles for saturation to deploy.

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## Pilot Category: Connected Vehicle Freight Applications

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PILOT: PRIORITIZE FREIGHT USING CAV TECHNOLOGIES

### Proposed Action

Deploy CAV technologies within the freight network to prioritize truck movements at traffic signals, provide real-time information on parking availability, and connect freight vehicles by platooning.

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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### Additional Benefits

- Improve reliability of the freight network.

### Partners

- Pennsylvania Department of Transportation
- Pennsylvania Turnpike
- Port Facilities
- Fleet Vehicle Providers

### Approach

- Create a working group of various agencies related to freight movement and develop a set of goals for freight prioritization.
- Designate locations of ports and corridors to implement CAV technologies.

### Assumptions

- Saturation of connected freight vehicles is either sufficient or supplemented by video analytics.
- Legislation for truck platooning exists.

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## Pilot Category: Outreach

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### PILOT: DEVELOP A CAV AWARENESS CAMPAIGN

#### Proposed Action

As part of Engineers Week or other similar technology focused events, develop an outreach program that focuses on the future of transportation and the types of possible technology jobs. Encourage participation by public and private sector practicing professionals through a series of activities designed to raise awareness.

Goals Addressed:	1	IMPROVE SAFETY	2	ENHANCE MOBILITY	3	PREPARE WORKFORCE	4	FOSTER AND SUSTAIN PARTNERSHIPS	5	INCREASE PUBLIC AWARENESS	6	SUPPORT ECONOMIC COMPETITIVENESS

#### Additional Benefits

- Actively engage in programs that support STEM and expose students to technology sector job opportunities in Pennsylvania.

#### Partners

- Pennsylvania Department of Transportation
- Department of Education
- Pennsylvania Turnpike
- High Schools
- Technical Schools
- Trade Schools
- Colleges
- Universities

#### Approach

- Work with state and local universities to educate students on future transportation needs.
- Work with national groups such as the ITS Joint Program Office and National Operations Center of Excellence to be informed of the latest transportation workforce development efforts.
- Partner with state technology societies such as ITS Pennsylvania or Institute of Transportation Engineers chapters to reach out to membership, including student chapters.

#### Assumptions

- None.

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## Pilot Category: Outreach

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### PILOT: DEVELOP A COMMUNITY CAV CHALLENGE

#### Proposed Action

Engage with communities to show how implementing CAV technologies would help them address their improvement aspirations. Encourage participation in a “Challenge” to be the best community to implement CAV’s. This could be done through the existing American Association of State Highway and Transportation Officials (AASHTO) Signal, Phasing and Timing (SPaT) Challenge framework or with automated shuttles, for example. When communities are planning for redevelopment, encourage the use of AV technologies through nontraditional partnerships.

<b>Goals Addressed:</b>	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS
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#### Additional Benefits

- Increase technology penetration.
- Strengthen relationships with local municipalities.

#### Partners

- Pennsylvania Department of Transportation
- Pennsylvania Turnpike Commission
- Local municipalities
- Counties
- Regions
- Planning Partners

#### Approach

- Develop a working group to determine the framework of the challenge.
- Determine the “prize” of the challenge – financial or notoriety.
- Market and publicize the challenge.

#### Assumptions

- Some framework exists to support CAV technology in these communities.



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## Pilot Category: Outreach

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### PILOT: DESIGNATE SMART CORRIDORS

#### Proposed Action

Designate Smart Corridors to improve pedestrian, bicycle and motorist activities while planning for new CAV technologies including wireless communications, automated vehicles, and smart water and parking technologies, for example. “Smart Corridors” is generally defined as a set of complementary transportation networks connected via technologies.

Goals Addressed:	1 IMPROVE SAFETY	2 ENHANCE MOBILITY	3 PREPARE WORKFORCE	4 FOSTER AND SUSTAIN PARTNERSHIPS	5 INCREASE PUBLIC AWARENESS	6 SUPPORT ECONOMIC COMPETITIVENESS

#### Additional Benefits

- Increase technology penetration.

#### Partners

- Pennsylvania Department of Transportation
- Transit Agencies
- Department of Community and Economic Development
- Planning Partners
- County
- City
- Chamber of Commerce
- Equipment Vendors

#### Approach

- Create a diverse working group of agencies in a community to determine designation of a Smart Corridor.
- Develop a concept of operations through the working group which will contain goals and objectives, roles and responsibilities, current and future information flows and technologies, and performance measures.

#### Assumptions

- Legislation for AV exists to carry out goals of the Smart Corridor.

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## Pilot Category: Work Zone and Fleet Vehicles

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### PILOT: DEPLOY AUTOMATED TRUCK MOUNTED ATTENUATORS IN WORK ZONES

#### Proposed Action

Enable the use of automated truck mounted attenuators in work zones for increased safety of workers and the public.

Goals Addressed:	1	IMPROVE SAFETY	2	ENHANCE MOBILITY	3	PREPARE WORKFORCE	4	FOSTER AND SUSTAIN PARTNERSHIPS	5	INCREASE PUBLIC AWARENESS	6	SUPPORT ECONOMIC COMPETITIVENESS

#### Additional Benefits

- Decrease secondary crashes.

#### Partners

- Pennsylvania Department of Transportation
- Pennsylvania Turnpike
- Automated Truck Mounted Attenuator Vendors

#### Approach

- Compile a list of work zones throughout the state where there is a high frequency of work zone crashes.
- Develop a training program for workers to accept the automated vehicle as part of their fleet.
- Conduct a feasibility study to identify the optimum pilot location and implement automated truck mounted attenuators at those locations.
- Provide an evaluation of pilot sites using before/after crash data.

#### Assumptions

- Partnerships exists with automated truck mounted attenuator vendors.
- Legislation supports automated truck mounted attenuators to be used in work zones.

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## Pilot Category: Work Zone and Fleet Vehicles

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PILOT: IMPLEMENT A MAINTENANCE PLAN USING CAV TECHNOLOGIES

### Proposed Action

Deploy LiDAR on construction vehicles along with CAV compatible paint to allow for gathering of data while implementing CAV infrastructure.

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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### Additional Benefits

- Build a database of CAV paint locations.

### Partners

- Pennsylvania Department of Transportation
- Pennsylvania Turnpike
- LiDAR and CAV Paint Vendors

### Approach

- Compile a list of locations where the roadway needs to be restriped.
- Conduct a feasibility study to identify the optimum pilot locations. Work with LiDAR and paint vendors to deploy the equipment and materials.
- Develop an education campaign for workers using this approach.
- Keep a database of locations and study the long-term durability on the roadways.

### Assumptions

- Partnerships exist with LiDAR and CAV Paint Vendors.

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## Pilot Category: Work Zone and Fleet Vehicles

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### PILOT: IMPLEMENT RESPONSE MANAGEMENT CV TECHNOLOGY AT WORK ZONES

#### Proposed Action

Install after-market CV equipment on PennDOT and PA Turnpike fleet vehicles, along with workers in the work zone, and combine with enhancements to traffic management centers to improve the safety and efficiency of emergency response in work zones.

<b>Goals Addressed:</b>	<b>1</b> IMPROVE SAFETY	<b>2</b> ENHANCE MOBILITY	<b>3</b> PREPARE WORKFORCE	<b>4</b> FOSTER AND SUSTAIN PARTNERSHIPS	<b>5</b> INCREASE PUBLIC AWARENESS	<b>6</b> SUPPORT ECONOMIC COMPETITIVENESS
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#### Additional Benefits

- Reduce the number of work zone injuries, near-misses, and fatalities.
- Support improved roadway safety using this CV technology with a mission of zero deaths, as it is a core function of Pennsylvania.

#### Partners

- Pennsylvania Department of Transportation
- Pennsylvania Turnpike
- Pennsylvania State Police
- Department of Health
- Local Law Enforcement
- Local Fire Departments
- Pennsylvania Emergency Management Agency

#### Approach

- Analyze the number of injuries, near-misses, and fatalities by workers in work zones to determine location and length of area to study.
- Deploy CV technology on work zone fleet vehicles that sends messages to traffic management centers when they've been struck.
- Deploy wearable technology on work zone safety vests that alerts them when they have forgotten to wear their safety vests.
- Enhance traffic management centers with improvements to support the technology deployment and aid in collection of data that measures effectiveness.
- Develop a training program for all work zone workforce to incorporate these technologies.
- Establish trends and reporting that demonstrate return on investment.

#### Assumptions

- Agency has funding to equip vehicles and workers with appropriate technology, along with the communication system to receive information at a traffic management centers.