Maryland Transportation Authority

Planning for Connected & Automated Vehicle Readiness

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Introduction/Background

The Maryland Transportation Authority (MDTA) is committed to advancing the future of transportation and, as stated in its Strategic Plan, "supporting the delivery of innovative solutions and projects". Embracing connected & automated vehicle (CAV) technology fits squarely into that approach and provides the MDTA with an opportunity to continue enhancing its already exceptional customer service while also looking toward creating a workforce for tomorrow.

Over the last few years, the MDTA has undertaken several actions to plan for the evolution of and advancements in CAVs. As a starting point, MDTA completed a CAV roadmap in the summer of 2018, establishing a high-level approach to developing strategies and a vision for CAV readiness. To better visualize a path forward, MDTA then completed a Strategic Plan for CAV (CAV Plan) in the fall of 2018[1], establishing the following vision:

> *The MDTA will support a framework for CAV transformative technologies to improve customer experience and provide access to safe and reliable transportation solutions.*

Through the guidance of an internal CAV working group, the CAV Plan was built around five goals:

1. Maximizing customer experience with the latest vehicle technology.
2. Improving safety and travel time reliability.
3. Seeking opportunities to partner with technology providers and automakers.
4. Preparing the MDTA workforce for the technology of the future.
5. Communicating with customers on use of CAV technologies on MDTA facilities.

Since the publication of the CAV Plan, MDTA staff have continued to collaborate with entities that are interested in researching, testing, and supporting the deployment of CAV technology in Maryland. They have done so in collaboration with other state-level activities on CAVs, which is frequently coordinated by the Maryland CAV Working Group, in which MDTA has several participating representatives.

Maryland has a broader vision statement focused on safety, efficiency, and equity of transportation services that can be advanced with CAV applications with consideration of economic benefits through innovative partnering plans. The MDTA's CAV Plan and vision align with this broader vision, highlighted below[2], reinforcing our direction and providing initiative to continue advancing.

> *Maryland's Vision for Connected and Automated Vehicles (CAV) is to uphold and enhance a **safe, efficient, and equitable** transportation future by delivering collaborative and leading-edge CAV solutions. Maryland is open for business and eager to realize the life-saving and economic benefits of CAV technology, while ensuring safety for all. We are embracing CAV technology and innovation through continuing collaboration with partners interested in researching, testing, and implementing CAVs in Maryland.*

[1] https://mdta.maryland.gov/sites/default/files/Files/About/18-11-05_MDTA_CAV_Strategic_Plan_Oct_2018_w_Links.pdf
[2] https://mva.maryland.gov/safety/Pages/MarylandCAV.aspx

Other transportation business units within the Maryland Department of Transportation (MDOT) are likewise advancing their CAV planning and piloting activities. The MDOT State Highway Administration (SHA) published a CAV Strategic Action Plan in 2017 and is in the process of developing an updated CAV Implementation Plan, while the MDOT Maryland Transit Administration (MTA) is in the process of developing principles that could lead to their own agency-specific CAV Strategic Plan and conducting federal grant-supported CAV pilot projects.

Importance of Terminology

The content in this report is based upon a key understanding of terminology. Experience has shown that confusion over what CAVs are and what they can accomplish can frequently diminish the effectiveness of planning exercises such as this. CAVs come in many sizes, shapes, and functions. Besides personal cars, CAVs could include on-demand taxi services, package delivery vehicles, low-speed transit shuttles, public transit buses, and long-haul freight trucks.

Connected Vehicles (CV) "talk and listen" to infrastructure, other vehicles, and mobile devices. This communication enables applications that can warn a human driver of an impending hazard, enable a vehicle to operate more efficiently, or guide a vehicle to take appropriate action given the surroundings.

Automated Vehicles (AV) use sensors and other technologies to understand the environment to assist drivers, and eventually perform driving tasks in place of a human driver.

Connected and Automated Vehicles (CAV) leverage connected capabilities with automated features to bring the best of both worlds into one vehicle.

The foundations of CV and AV, represented in Figure 1, provide a common understanding for readers of this document.

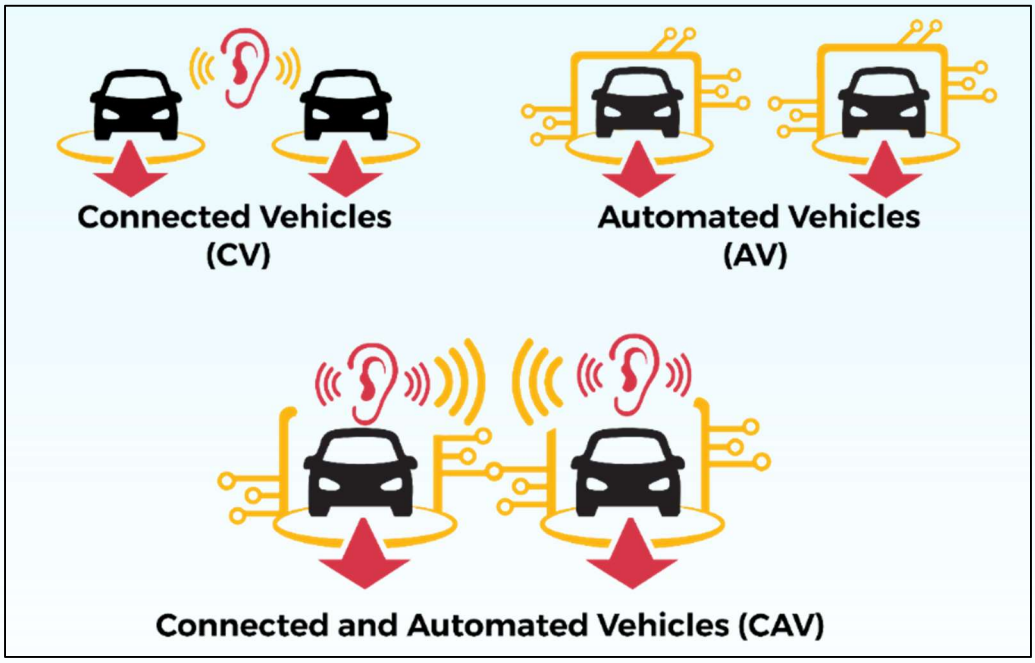


Figure 1: Graphical Representation of CV, AV, and CAV

What Is In This Report

The primary goal of this technical memorandum is to provide the MDTA with an overview of where staff believe the agency is in terms of CAV readiness and, through use of an evaluation framework, develop recommendations for several short-term "next steps".

The memorandum is divided into four key sections:

- What is a Connected Roadway Classification System?
- Attitudes toward CAVs
- Specific actions that could be taken along a key MDTA facility
- Input for prioritization and decision-making to help move CAVs forward

What is a Connected Roadway Classification System?

While Maryland and the MDTA have continued to pursue CV and AV activities, infrastructure owners and operators (IOOs) across the nation have also been working toward pursuing activities to prepare for the onset of CAVs. Evaluation of "CAV Readiness" has become a frequently-used label, although the definition of readiness and the approach to evaluating it remain, in many instances, uniquely defined efforts that each agency and organization views differently.

Common across the many different approaches is recognition that the roadway infrastructure needed for safe and efficient operation of CAVs is evolving as more knowledge is exchanged between the automotive industry and the IOOs.

In 2019, National Cooperative Highway Research Program (NCHRP) Project 20-24(112) was launched, based on the recognition that a common language and reference system about the infrastructure's role in automation would further facilitate the exchange of information. This effort was labeled the Connected Roadway Classification System (CRCS) and was presented as a framework for use in assessing the infrastructure and incorporating new knowledge that emerges on how infrastructure can support CAVs.

The CRCS framework enables IOOs to assess three possible infrastructure approaches to supporting CAV readiness: (1) talking with the road, (2) seeing the road, and (3) simplifying the road. Figure 2 shows a graphical representation of these components.

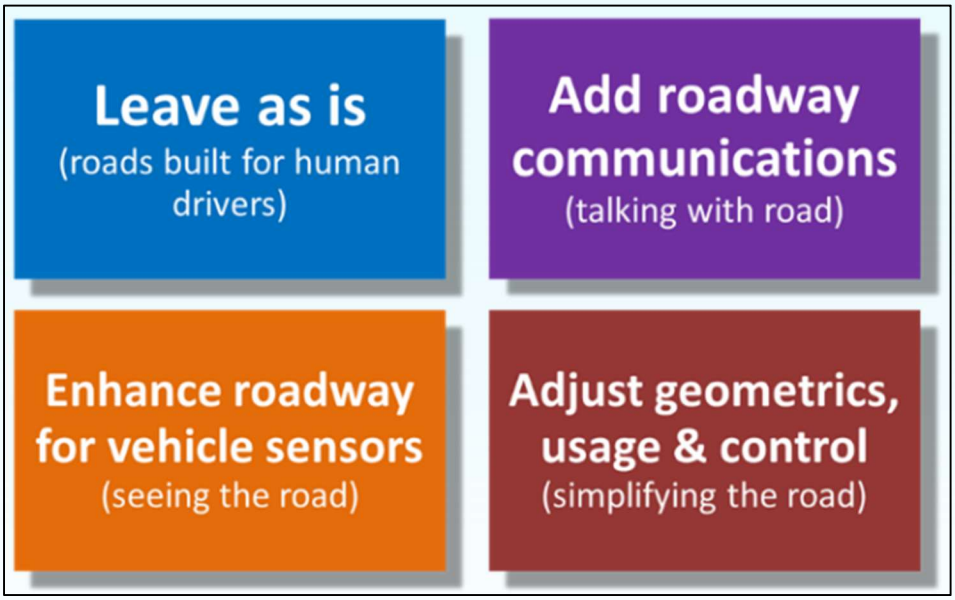


Figure 2: CRCS Framework Components

Following a classic Capability Maturity Model (CMM) exercise, these approaches can be measured against four possible classification levels:

- Needs upgrade and maintenance
- Meets current best practices
- Meets emerging markets (1–5 years)
- Meets next decade market (10 years)

The CRCS framework is designed to allow an IOO to assess their situation against previously established strategic goals and objectives, and apply that assessment during planning, project prioritization, and funding decisions.

Purpose of MDTA's CAV CRCS Exercise

Using elements of a CRCS evaluation is valuable to the MDTA by providing a consistent, interoperable, and standardized approach to viewing potential CAV advancements. Much of that value is provided through guidance on effective communication with stakeholders, decision-making strategies related to investments and policies, and navigating gaps between stakeholders. Performing this planning exercise will provide additional input to MDTA in reviewing its funding priorities, data sharing opportunities, and both internal and external communication strategies with respect to their future CAV plans.

Taking on this effort now achieves the following:

- Continues momentum from the MDTA CAV Plan and previous pilot efforts,
- Maintains a focus on the five goals agreed upon by the internal MDTA CAV Working Group and seeks ways to advance them, and
- Begins to address specific actions that might be proposed for a specific MDTA facility if the Federal Highway Administration (FHWA) or other partners wish to test CAVs on the facility

The opportunities for MDTA advancement via this exercise have been based on three key outcomes:

1. Create a living document, based on input from each MDTA division, that will help guide further prioritization and action meant to enhance MDTA's readiness for CAV,
2. Challenge every division to start thinking about at least one element of a CAV future that they can act on now, and
3. Establish an opportunity to incorporate physical CAV asset implementation, as well as update non-infrastructure elements such as standard processes, policies, and regulations, into whatever fiscal, political, or technical environment evolves post-COVID.

Approach to Information Gathering

Development of MDTA's CAV Roadmap and CAV Plan were built upon in-person meetings of various divisions and groups within the agency. Given the current staff workload, potential financial constraints, and ongoing recovery efforts from COVID-19, input for this CRCS evaluation activity emphasized optimizing time and resources from MDTA. The following activities have occurred to gather information:

1. Conduct a virtual briefing (webinar) explaining the CRCS, walking through several examples, and providing opportunities for Q&A.
2. Assign participants to discipline groups to complete an online self-assessment survey, with the goal of using the CRCS as a guide to further solicit input on needs and priorities concerning MDTA's future CAV pursuits. The discipline groups were established as follows:
    - Executive, Human Resources, and Administrative (includes Finance, Business Planning, and Procurement)
    - Engineering, Intelligent Transportation Systems, and *E-ZPass™*
    - Operations, Maintenance, and Enforcement
    - Planning and Communications
    - Information Technology

The survey was provided to designated CAV points-of-contact within each discipline group. Each group was encouraged to provide a collective team response, but individual responses were also welcomed.

General Attitudes Toward CAV

What MDTA is Doing Well, and What is Still Needed

Through the results of the CRCS self-evaluation survey, the general culture of MDTA is one that is perceived as "open to exploring and discussing potential issues and needs related to CAVs". As shown in Figure 3, staff also believe that the policies and culture, along with a commitment to emerging industry standards, also rate well. The results indicate that MDTA has made a concerted effort to study, learn, and plan for CAVs, and it is widely recognized and appreciated by staff.

Self-evaluation survey results further pointed to focus areas where the MDTA respondents felt the need for future energy or action, including the development of regulations that will enable CAV implementation. This response reflects the current lack of national standards and regulations relative to CAVs and points to the need for a more thorough review of state-level statutes to understand how they might help or impede CAV deployment.

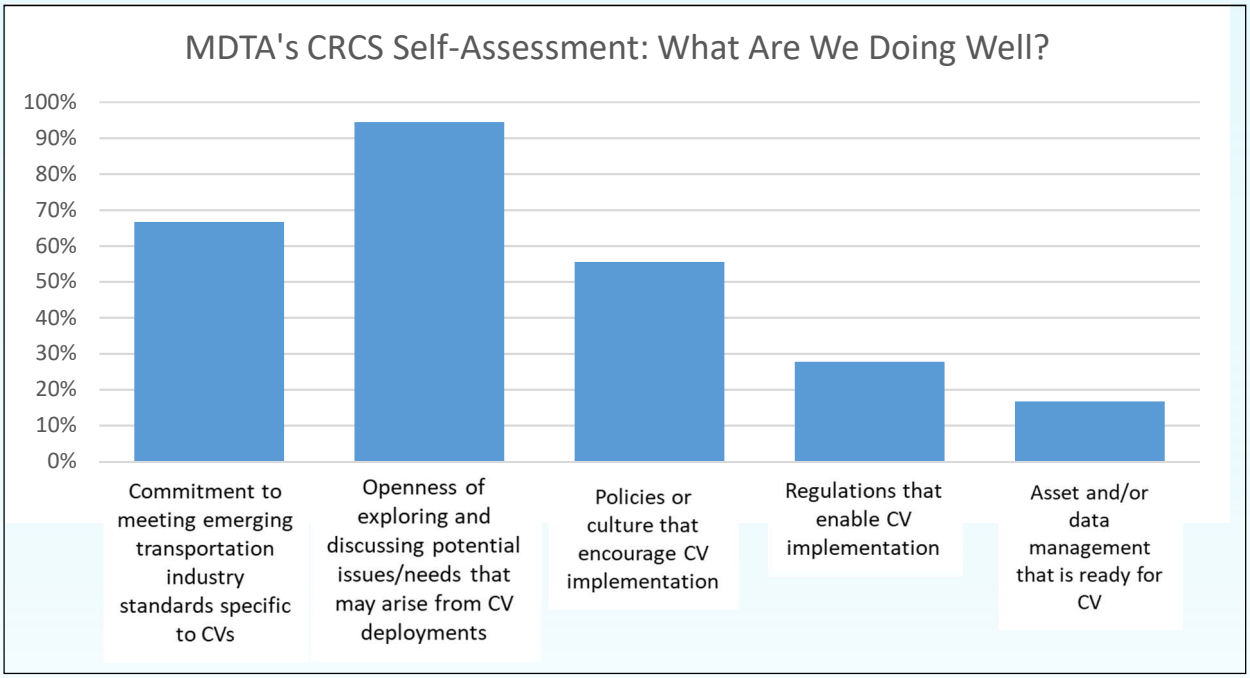


Figure 3: What Are We Doing Well? (respondents select all that apply)

Where is MDTA on the CRCS Scale?

As mentioned previously, the CRCS framework is designed to allow the MDTA to assess its status against previously-established strategic goals and objectives. In this instance, there were four key "capability levels" that are general in nature but provide a basis for measurement:

1. Needs upgrade and maintenance: Design/functionality that **falls short or marginally meets existing guidance or recommendations** for future technology accommodation
2. Meets current best practices: Design/functionality that **meets existing guidance or recommendations** for future technology accommodation
3. Meets emerging market (1-5 years): Design/functionality that **supports early adoption of CAV applications** or positions roadway elements for communication and interaction with vehicles
4. Meets next decade market (10 years): Design/functionality **that supports operation of most CV/AV applications** and/or communicates/interacts with vehicles proactively

As shown in Figure 4 below, a majority of the responses indicated a belief that the agency is still in the first stage of the CMM. Given the relative newness of CAVs and the number of still-evolving technical and policy issues, this outcome was anticipated. The two key findings from this rating, however, is that (1) further internal education might be needed to better clarify what current or emerging practices might be, and (2) there is room for MDTA to grow.

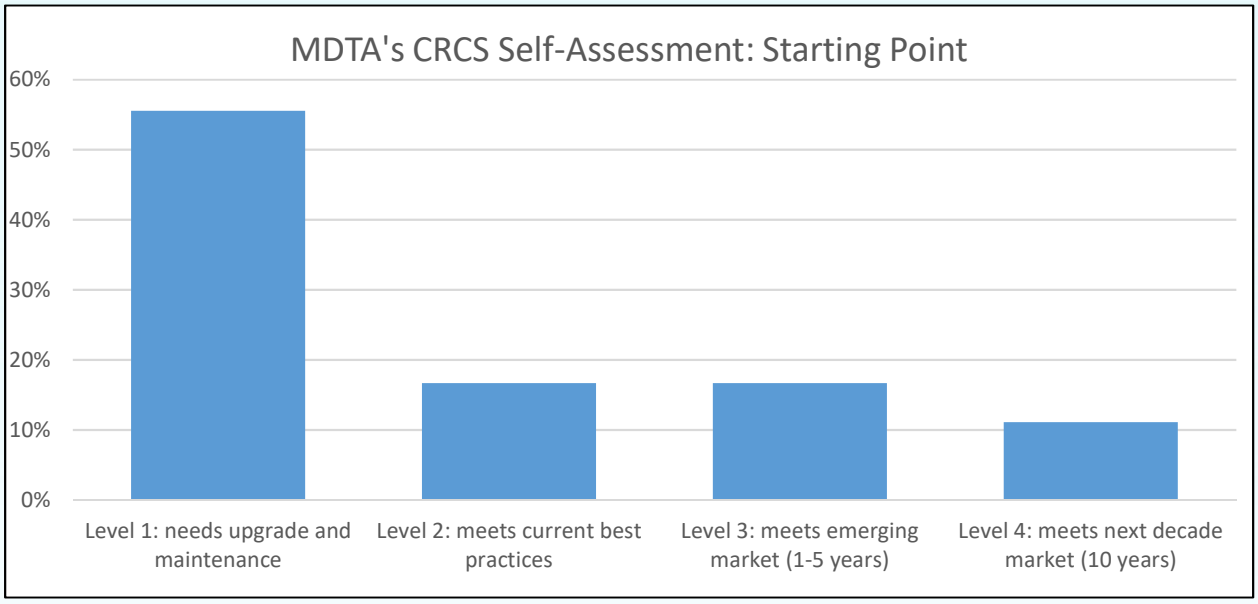


Figure 4: MDTA's CRCS Self-Assessment Summary (one selection per respondent)

As the MDTA moves forward in its pursuit of CAV readiness, it has an opportunity to set more finite goals and objectives, adjust for financial or technical changes, and react to policy issues that might arise. A key component of this effort is to identify near-term CAV opportunities that MDTA could easily act upon for its newest facility, MD 200 (Intercounty Connector; ICC).

Opportunities to Advance CAV along MD 200

Justification to Continue – Turning Attitudes Into Opportunities

Although MDTA's needs are diverse, CRCS respondents indicated that "doing nothing" is not practical. Reviewing the four CRCS assessment levels helped the respondents better recognize the importance of pilot studies and infrastructure enhancements in achieving a higher level of CAV readiness.

Although not solely related to CAVs, signing and pavement marking enhancements are often a cost-effective option for initiating CAV preparedness activities within existing maintenance programs and have the added advantage of improving Advanced Driver Assistance Systems (ADAS) performance for current customers. Benefitting current customers can be utilized as a catalyst to kick-off other CAV activities.

MDTA stakeholders also acknowledged that CV infrastructure investments are subject to uncertainties, such as technology obsolescence or spectrum uncertainty. Many agencies around the nation, however, are coping with those uncertainties by recognizing that their investment transcends key CV technologies (802.11-based DSRC and DSRC Plus[3]; or cellular-based LTE[4], C-V2X, and NR V2X[5], which relies on future 5G services) and are focusing on the infrastructure components that enable CV and AV applications, which benefit from network improvements, such as:

- Upgrading backhaul communications infrastructure, including additional fiber installation or component hubs for connectivity to the backbone
- Preparing CV back-office systems and data hubs for future vehicle-to-infrastructure (V2I) deployment
- Installing upgraded roadside Intelligent Transportation System (ITS) cabinets, controller hardware, power conditioning, and other ITS sensors (e.g., cameras, traffic detectors) with an eye toward future needs
- Developing application software specific to the agency's needs
- Investing in personnel upskilling and training

Such investments are termed "no regret" and are useful in helping agencies prepare for a future where CVs and AVs may become a routine part of the traffic stream and will strengthen their capacity to enhance existing DOT functions, such as TSMO strategies and asset management.

[3] DSRC – dedicated short-range communication. For definition of 802.11: https://www.networkworld.com/article/3238664/80211-wi-fi-standards-and-speeds-explained.html

[4] LTE – Long-Term Evolution

[5] V2X – vehicle-to-everything; C-V2X – cellular V2X; NR V2X – New Radio V2X

Why Focus on the ICC?

Recognizing that pilot tests and infrastructure investments are important elements in advancing CAV readiness, the CRCS survey exercise included several questions specific to MD 200. As the newest roadway facility on the MDTA network, MD 200 has a power and communications network available that provides a prime opportunity for advancing CAVs in Maryland. One of the considerations listed directly in the 2018 CAV Plan, mentioned below, identified the ICC as a potential target for early pilot deployment success.

> *Explore implications of permitting CAV pilot or deployment testing on the I-95 Express Toll Lanes (ETL) or Intercounty Connector (ICC) / MD 200.*

The modern nature of the ICC provides the MDTA with a facility that already features several of the "no regret" investments either started or in full operation. This allows the MDTA to focus on advancing an integrated technology platform/site that can be utilized to collect and disseminate data and information while seamlessly integrating additional devices for testing and pilot projects without having to invest a significant amount of initial capital.

The presence of periodic gantries for All Electronic Tolling (AET)[6] along the entire corridor (as shown in Figure 5) provides opportunities for simpler application of infrastructure-based technology needed for CAV activity. The ICC features a wide variety of interchange configurations, which also presents an opportunity for CAV testing with different interchange designs and helps strengthen the body of knowledge in various operational design domains, including the capability of CAVs to manage interchanges generally. The ICC presents an opportunity to test V2X for tolling and perhaps assist the industry as it wrestles with message sets for payment and tolling systems. At the same time, as cellular (LTE C-V2X) continues its evolution, an opportunity for testing what might eventually become an industry standard is readily available.

Figure 5: Sample Gantry Along the ICC / MD 200

[6] AET is now in effect statewide. In some locations, MDTA is still in the process of removing the physical toll plaza. For definition of AET: https://www.pcb.its.dot.gov/eprimer/module8.aspx

Since peak-period and overall traffic volume-to-capacity ratios on the ICC are lower than those on other MDTA facilities, existing shoulders and travel lanes can be closed for longer periods of time to conduct activities on an existing facility with a lower likelihood of operational breakdown in vehicular traffic. This also presents an opportunity to incorporate evaluations of daylight/nighttime impacts on CAV operational capabilities and reliability. There are intangibles that often get overlooked when conducting pilot tests, such as the park-and-ride lot on MD 97 near the ICC, which is ideally situated to be used as a staging area for test vehicles being serviced, test subjects being briefed, or even platoons preparing to enter the roadway.

Benefits to MDTA Staff and Customers

When looking at examples of other CV pilot programs around the country, many have a short-term focus predominantly on mobility-related benefits accruing to DOT fleets or emergency vehicles as a starting point. In the long-term, when market conditions align, the goal is to leverage much of the same infrastructure to target wider-scale mobility and safety benefits for all transportation system users.

The MD CAV Working Group and MDTA have been approached by the FHWA and numerous private companies interested in testing components of future CAVs. In addition to site-specific interchange factors, the ICC provides a unique collection of different operational design domains (ODDs) that would satisfy different test scenarios: a simulated tunnel (Olde Mill Run underpass); curve speed warnings (e.g. between MD 650 and MD 182); and, while not directly on the ICC, a nearby roundabout at Park Vista Drive and Longmead Crossing Drive that affords several unique opportunities for testing in a uniquely complex ODD. The proximity of this intersection laterally to the domain of the ICC yields an opportunity to assess reliability of communication with and response from CAVs to verify if road network and device layouts in complex design scenarios impact CAV operational viability.

The location of the ICC within Montgomery and Prince George's Counties gives it a unique advantage for planning CAV activities, as the County governments are also actively planning for and deploying CAV projects. It is also centrally located less than 10 miles from two key CAV testing grounds:

- MDOT SHA project site along US 1 being evaluated as part of the Signal Phase and Timing (SPaT) Challenge from the National Operations Center of Excellence[7]
- University of Maryland, a hotbed of connected and automated vehicle research[8]

Enhancements made to the existing facility to support testing at these (and other) locations can be leveraged to extend far beyond short-term testing. While the "no regret" CV infrastructure investments will further enable MDTA to be ready for future needs, more important is the opportunity for MDTA to engage in partnering with these organizations conducting testing and gain a stronger foothold on future data collection, analysis, storage, and security issues.

Data will be an important component of future applications that provide direct benefits to MDTA customers; will be an important factor in future workforce development needs; and could lead to quicker implementation of solutions that benefit ongoing MDTA operations and maintenance activities, primarily focused on service reliability and safety.

[7] https://transportationops.org/spatchallenge
[8] http://www.avl.umd.edu; https://mti.umd.edu; http://www.catt.umd.edu/home

Throughout the execution of this CRCS exercise, responses provided from the survey have differed noticeably between the five focus groups on policies and culture. However, getting MDTA ready for future needs remains an overall priority and points to a great opportunity to focus on additional workforce development across all agency divisions, modernizing agency-wide staff readiness.

In pursuit of expanding pilot testing and early deployment of CAV technology, responses to the survey indicated a strong belief that a focus should remain on improving messaging to customers. Additional education, outreach, and publicly-available pilot demonstrations should be made available to customers in order to clarify potential impacts of CAV advancements on customer experiences on MDTA roadways – we will better know how to explain to customers the changes they might experience at toll collection facilities, along corridors, at/near interchanges, and even when off the MDTA network. This is not only an opportunity to solicit customer input, which is of great value to both the MDTA and the organizations conducting CAV testing along the ICC, but MDTA has made it a hallmark of their operation to continuously share information with customers. This initiative provides an opportunity to improve on that already positive reputation while potentially modernizing the agency approach to customer service. As technology evolves, the way we communicate must align.

Prioritizing Actions in a Post-COVID Environment

Input from many of the survey respondents within MDTA reinforced the notion that "doing nothing" is not an acceptable option. Instead, there were clear indications that conducting pilot studies remains a priority to MDTA, in particular from survey respondents in the Executive and Administrative group; the Operations, Maintenance, and Enforcement group; and the Planning and Communications group. Respondents from the Engineering/ITS/*E-ZPass*™ and Information Technology groups took that one step further by recognizing that pilot testing would be further enabled by emphasizing communications and network upgrades, which came across as their top priority. This aligns with the previously aforementioned "no regret" investments, and the internal user groups likewise supported the need for increased budgets "for future technology deployment".

As we work to define a path forward through a COVID environment and eventually into a post-COVID one, each of the MDTA's CAV goals will play different roles at different points in time. These goals will not only shape the agency's future, but they also play a key role in influencing the bigger picture of a statewide CAV strategy by aligning with the Maryland CAV Strategic Framework Areas of Focus. Table 1 below illustrates how those two perspectives align.

Table 1: Aligning MDTA's CAV Plan and the MD CAV Strategic Framework

		Maryland CAV Strategic Framework - Areas of Focus				
		Public Education & Outreach	Planning & Policy	Early Deployment & Testing	Infrastructure	Workforce
MDTA CAV Plan - Goals	Maximize customer experience with latest vehicle technology	X	X		X	
	Improve safety & travel time reliability		X		X	X
	Seek opportunities to partner with technology providers & automakers			X	X	
	Prepare workforce for technology of the future			X		X
	Communicate with customers on use of CAV technology on MDTA facilities	X	X			

Although each goal from the MDTA CAV Plan may, in some way, support each area of focus in the Maryland CAV Strategic Framework, the items called out in Table 1 have the most direct relationships.

Opportunities exist to incorporate implementation of physical assets as part of a plan for advancing CAVs in Maryland over the coming months and years. In the context of the CRCS exercise, as shown in Figure 6 below, MDTA staff indicated through the survey that there are opportunities to enhance both "talking with the road" and "seeing the road".

Figure 6: CRCS Infrastructure Components and MDTA Focus

The project planning process should be approached as a balancing act between typical maintenance and operations (M&O) activities and capital projects. Although capital projects and M&O efforts have separate budgets and are planned somewhat independently, there may be value in incorporating CAV-related M&O items into capital projects when schedules are advantageous to more expeditiously implement improvements and consolidate work efforts. Although this could add costs to capital projects, major life-cycle benefits could be realized.

The discussion in the following sections cover suggested areas of near-term CAV activity within MDTA. As depicted in Figure 7, these concepts are intended to encourage MDTA staff to propose specific projects that will continue to advance toward the shared vision and mission of the organization.

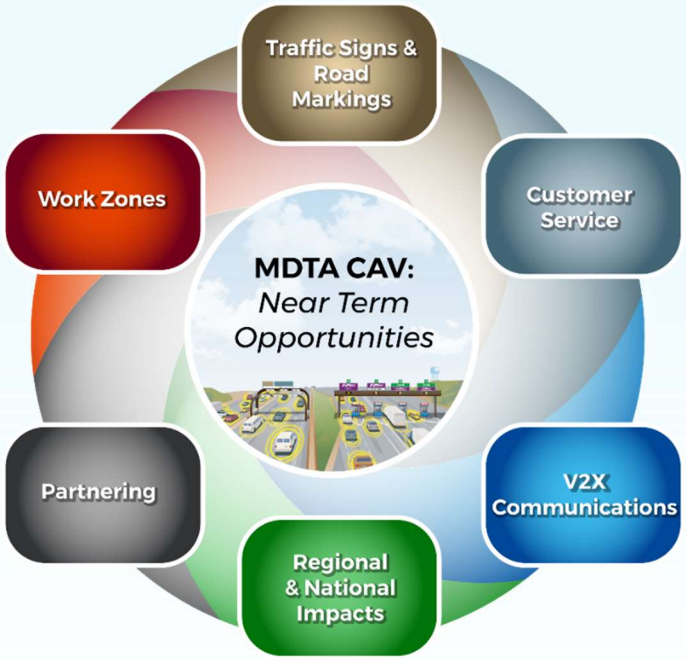


Figure 7: Primary Emphasis Areas for MDTA's CAV Activity

Primary Emphasis Areas

Traffic Control Devices – Pavement Markings: One example of an imminent need that can be implemented quickly and cost-effectively as an insert item into planned projects involves upgraded pavement markings. Incorporating upgrades such as wider markings and improved materials (retroreflectivity and life-cycle considerations) into capital projects instead of planning individual separate projects will help expedite short-term agency readiness progress. State DOTs around the country have been developing resources that MDTA can utilize to develop strategies and assess costs for implementing these measures in this way[9]. At a minimum, states must follow standard requirements in the FHWA Manual on Uniform Traffic Control Devices (MUTCD) for maintaining pavement marking quality[10]. The MUTCD is planned to be updated[11], which is expected to include reimagined standards related to pavement marking maintenance[12].

Traffic Control Devices – Work Zones: As a planning consideration for all projects, one major focus area for MDTA in maintaining a successful system for CAVs involves work zones. They have played a new role in a COVID environment based on combinations of lower traffic volumes (more opportunities for work zone activities with lesser impacts on traffic operations) yet unpredictable planning (project futures being unclear based on changes to funding availability). As approaches to project planning and implementation, including work zones, are likely to change in a post-COVID environment, so should MDTA's approaches to exploring CV-capable work zones. MDTA could take advantage of CV communication experimentations as often as possible to mitigate the anticipated unpredictable nature of road work in a post-COVID environment. Opportunities exist to test CAV relationships with work zone devices such as truck-mounted attenuators, variable message signs (permanent and portable), and even channelizing devices and static signs. Opportunities exist to learn from activities in other agencies, such as nearby Pennsylvania DOT which was recently awarded a federal grant to evaluate CAV technology in work zones[13]. Tests should be developed for assessing performance of work zones along the ICC, which can be done through simple setups of shoulder and/or lane closures along road segments away from interchanges.

V2X Communications: MDTA should also plan to continue leveraging opportunities in evaluating various communication technologies. Recent FCC decisions put into question whether or not DSRC or LTE C-V2X will be the method of choice – but the ability to test either method remains a fundamental need in terms of gaining experience with managing new data streams and gaining valuable experience in the field installations of either device type. Prince George's County has had extended experience with the installation and operation of DSRC in the National Harbor area, and other agencies across the state are contemplating V2X pilot deployments as well. AET along the entire length of the ICC will continue to provide MDTA opportunities to gain a greater foothold on installing V2X along several facilities, especially others that have corridor-wide tolling, such as the I-95 Express Toll Lanes.

[9] https://cleantechnica.com/2017/07/25/caltrans-already-modifying-californias-roads-self-driving-cars/
[10] https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part3.pdf
[11] https://mutcd.fhwa.dot.gov/mutcd_news.htm
[12] https://mutcd.fhwa.dot.gov/res-notices.htm
[13] https://www.penndot.gov/pages/all-news-details.aspx?newsid=663

Customer Service: MDTA holds a strategic advantage in leveraging and helping refine the overall MDOT CAV initiatives related to customer service. As MDTA achieves its CAV goals, it reveals to other MDOT business units the ability to meet unique and often more complex customer needs. Encouraging customers to use MDTA facilities comes with additional challenges since motorists must be willing to pay tolls on top of typical expenses associated with motorized travel, such as fuel. By meeting these compounded challenges, MDTA can provide strong justification to state leaders to continue utilizing available funding to advance CAV programs. The MDTA can also position itself as a leader nationally as managed lanes become possible early-adoption targets for CAV - enabling those customers with CAV-equipped vehicles to potentially enjoy premium service in dedicated or priority lanes.

Partnering: MDTA's role in the state and regional transportation network presents valuable opportunities to leverage partner support. With a forthcoming approach to and open dialogue on CAVs, a variety of partners, especially those in the private-sector, will hopefully be eager to invest in CAV opportunities in Maryland, with MDTA leading the way. The general approach to partnering should consider the opportunity to advertise a public-private partnership (P3) through a Request for Information (RFI). With private partners heavily involved in major elements of MDTA's CAV program, we can execute activities at a low cost, only needing to plan, approve, and monitor activities. Private partners could manage the bulk of the work, yielding a high return on state investments. Additionally, MDTA can further exhibit its industry leadership by applying lessons learned from its partners to plan differently – one example involves going further beyond minimum standard requirements for any infrastructure improvements.

Regional and National Impacts: Beyond Maryland, CAV activities in the Mid-Atlantic region abound where MDTA can apply and share additional lessons learned, iteratively modernizing approaches to CAV testing and project implementation. Lessons learned can also be applied from CAV activities around the United States occurring in drastically different operating environments. Issues identified in more complex operating environments will put our challenges into a unique perspective that would make our goals appear more achievable and more valuable to the transportation industry, exhibiting MDTA as an IOO leader amongst its public partners.

These future activities play key roles for MDTA success beyond the discussion in the earlier sections of this report. Approaches to the advancement of CAVs using this guidance will also allow for effective use of the MDTA CAV Plan as a living document. Goals, missions, and visions evolve over time, and the Plan should adapt to changing thought processes.

Secondary Priorities

Managing Risk: As we move towards a post-COVID environment, it will be more important than ever to minimize risk while maximizing customer benefits in all MDTA projects. Elements of a successful CAV program do not always require capital investments and should include the standardization of processes, policies, and regulations, which will need ample time to be drafted, reviewed, refined, and approved and should therefore be initiated immediately. Thoughtful approaches to preparing MDTA facilities for testing and pilot projects can and should include physical infrastructure investments that will continue to provide benefits after tests and pilots are completed.

Handling Data: As shown in Figure 8, stakeholders made it clear through CRCS survey input that the MDTA should require some measure of data sharing from private partners that want to test CAVs along the ICC, providing the agency with an opportunity to learn more about future data management, analysis, and governance issues in the future.

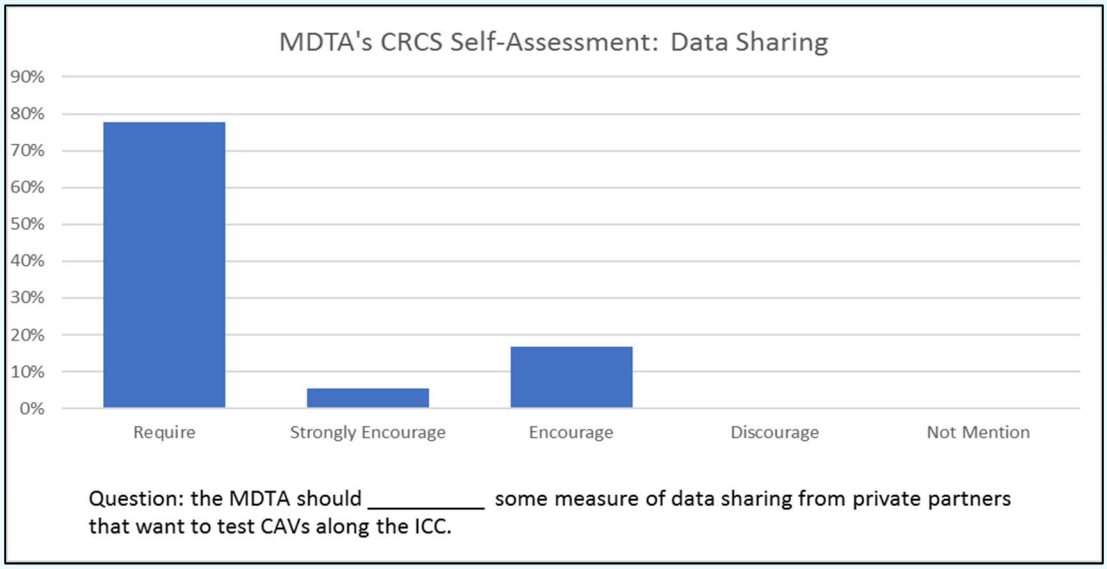


Figure 8: Data Sharing with Partners (one selection per respondent)

The first step towards making this a reality should involve drafting a data sharing agreement and governance plan that can be adapted for coordination with various private and public partners. Using that as a baseline, a collaboration plan should be discussed with MDOT SHA as a starting point for partnering efforts, as coordination between state agencies would naturally transition to and yield recommended practices for partnering with other public and private entities.

Freight: Commercial vehicle traffic has also been historically important to MDTA based on its impacts on system quality. There is value in the entire MDTA network having AET. Commercial vehicle data could be collected to investigate new methods for sharing system information with users and planning future system activities, particularly because of opportunities that exist linking AET and CAV technology. Freight has played a role in the daily lives of MDTA staff and customers in a COVID environment, as the nature of the movement of goods has changed to meet evolving community needs and will continue to do so post-COVID. Testing on freight communications could be conducted by working with one or two key freight partners to outfit vehicles with technology that can be evaluated along the ICC.

Concurrence On Common Short-Term CAV Goals

The MDTA is focused on CAV technologies where it can contribute to improving customer service and providing safe and reliable transportation solutions.

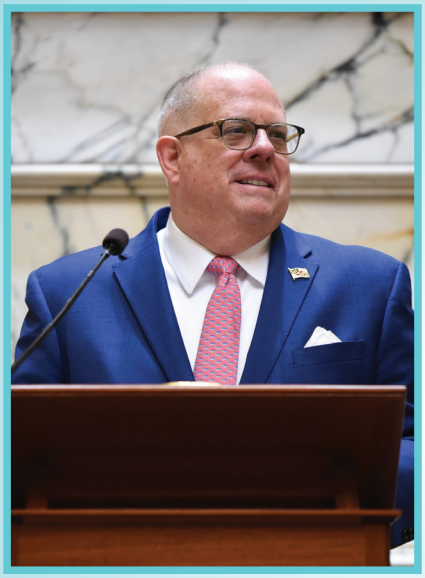
Based on the results of this exercise, it is a natural extension that system elements with which customers will directly interface – such as pavement markings and work zone upgrades – can be prioritized for investment. However, perhaps one of the most important factors in MDTA's future success with CAVs lies in rethinking procedures that will shape the agency's future culture.

> *A successful MDTA CAV program will benefit from, but may not always require, capital investments. MDTA should continue to prioritize processes, policies, and regulations that will support and encourage CAVs.*

Other important issues such as V2X communications and data management can also benefit from enhanced partnering opportunities, leveraging private investments alongside MDTA resources in pursuit of pilot demonstrations and early deployment projects.

The MDTA's efforts are also closely aligned with Maryland's recently adopted CAV Strategic Framework, and these priorities continue to reinforce that synergy.

The awareness generated by this exercise has strengthened the resolve within various disciplines across MDTA to continue to prioritize CAV opportunities wherever they may be present.



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Maryland Transportation Authority

Planning for Connected & Automated Vehicle Readiness

(MDTA Connected Roadway Classification Exercise – December 2020)

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