MARYLAND

CONNECTED & AUTOMATED VEHICLE
STRATEGIC FRAMEWORK

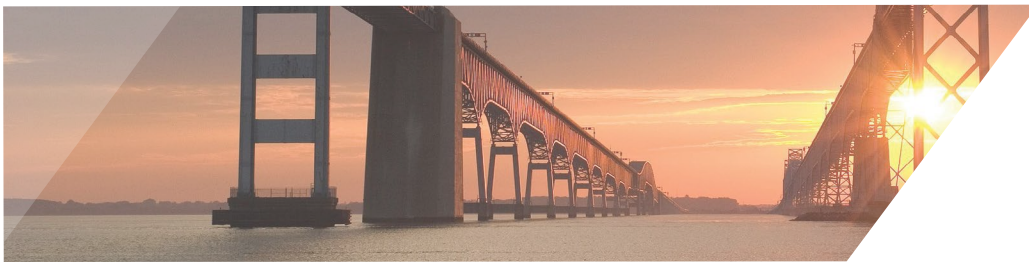### FEBRUARY 2024

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WHAT'S INSIDE

Innovation happens every single day across countless industries. In transportation, we have seen a slow but steady increase in how technological advances change lives—commuting, entertainment, and moving goods are all affected as the industry invents new ways for our vehicles to see, analyze, and react to our transportation ecosystem. Developing vehicle technology that can assist drivers with driving tasks and help cars "talk" to the roadside, and eventually drive themselves, presents challenges that Maryland must address head-on. Proactively providing clear direction to our communities and stakeholders will help effectively realize the benefits this vehicle technology can provide.

This document presents a strategic framework for Maryland that is meant to inform, guide, and empower stakeholders to build their own implementation plans for Connected and Automated Vehicles (CAV) within their work and life environments. It demonstrates Maryland's continued focus and intention to realize the many life-saving and economic benefits of CAV technology, while continuing to prioritize collaboration across the State.

For the past five years, Maryland stakeholders have explored this changing landscape and worked together to safely advance strategies that might integrate CAV technology within our transportation ecosystem. These stakeholders have prioritized the development of a strategic framework that will allow agencies and communities across the State to find common ground in advancing this transformational vehicle technology.

The **Maryland CAV Strategic Framework** (referred to as Framework throughout this document) supports planners, engineers, private entrepreneurs, researchers, policymakers, and many others within Maryland as they set about implementing tangible strategies that will enable us to reap the benefits of CAV technology in a safe, efficient, and equitable manner. It is our belief that **we can save lives** and that the real risk is lack of action: keeping the status quo will mean that hundreds of lives every year in Maryland will continue to be lost due to traffic-related crashes. Without taking calculated risks to advance CAV technology, the life-saving benefits of this ground-breaking innovation will be delayed or even non-existent.

The audience for this strategic framework is intentionally broad: lawmakers, government agencies at all levels, academia, private companies, automakers, industry associations—and most importantly, the citizens of Maryland who rely on our transportation ecosystem to work, play, and enjoy the exceptional quality of life that Maryland offers.

Through this Framework, Maryland is making **a call to action** to all State and local agencies, private and academic partners, and the public to advance CAV technology strategies that will align with the proposed recommendations within this document. Rather than detailing specific action items that could, within a year or two, result in outdated strategies, this Framework provides a unified set of high-level objectives that empower stakeholders to **work together** to deploy CAV technology safely, efficiently, and equitably in Maryland.

INTRODUCTION

A Vision for CAV in Maryland

Maryland developed the vision for connected and automated vehicles (CAV) by collaborating with many stakeholders who participate in the Maryland CAV Working Group, described in the next section. Maryland's vision for CAV is to uphold and enhance a safe, equitable, convenient, and connected multimodal transportation system for all by delivering collaborative and leading-edge CAV solutions. Maryland is 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.

MARYLAND

safe | efficient | equitable
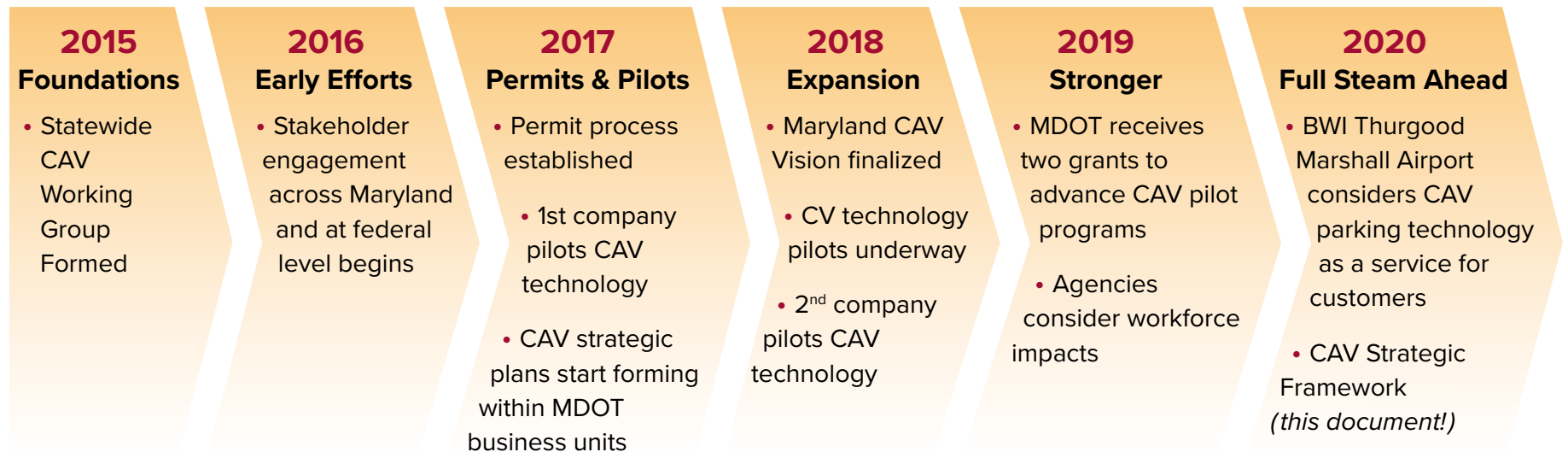*and open for business.*

Maryland Connected & Automated Vehicle Working Group

In 2015, the Maryland Department of Transportation established the Maryland CAV Working Group as the central point of coordination for the development and deployment of emerging CAV technologies in Maryland. At its inception and throughout the years, the Maryland CAV Working Group comprises a diverse membership by including elected officials, State and local agency representatives, highway safety organizations, non-transportation experts, academia, and representatives from the private sector and automotive industry—totaling engagement of over 300 people.

The Maryland CAV Working Group is critical in setting the course for the future of CAV in the State. Over the past several years, there have been informative presentations from various subject matter experts, product demonstrations from private industry, group discussions led by law enforcement, the creation of a permitting process and expression of interest form, and research explorations from various companies and academic institutions. The Maryland CAV Working Group continues to provide a one-stop-shop central point of coordination for companies or organizations seeking to test and develop CAV technology in Maryland.

CAV progress in Maryland was and continues to be facilitated by the Maryland CAV Working Group, from its initial foundation to the current environment of full stakeholder collaboration. For further details on the Maryland CAV Working Group, visit the Maryland CAV Working Group website.

Maryland across various levels of government and private investment has been steadily developing CAV technology and readying ourselves for its widespread adoption. Collaboration—across public agencies, academic institutions, and with industry partnerships—remains key to our success.

2015
Foundations

- Statewide CAV Working Group Formed

2016
Early Efforts

- Stakeholder engagement across Maryland and at federal level begins

2017
Permits & Pilots

- Permit process established

  - 1st company pilots CAV technology

  - CAV strategic plans start forming within MDOT business units

2018
Expansion

- Maryland CAV Vision finalized

  - CV technology pilots underway

  - 2nd company pilots CAV technology

2019
Stronger

- MDOT receives two grants to advance CAV pilot programs

  - Agencies consider workforce impacts

2020
Full Steam Ahead

- BWI Thurgood Marshall Airport considers CAV parking technology as a service for customers

  - CAV Strategic Framework *(this document!)*

Stakeholder Outreach

This Framework draws from input from a diverse and broad group of stakeholders, spanning the Maryland CAV Working Group, individual meetings, and most recently, a statewide online survey. It pulls inspiration from the work already underway within local jurisdictions such as Prince George's, Howard and Montgomery Counties, private-industry research and development pilots, and the Maryland agency-level CAV strategic plans generated over the past few years.[1]

Participants of this outreach have included research and academia groups, for-profit and non-profit associations, emergency responders (e.g., law enforcement and rescue), various levels of government, CAV-related service businesses or developers, vehicle manufacturers, and members of the public with a general interest in CAV technology. This Framework features stakeholder quotes and survey statistics garnered from the **over 600 anonymous responses** to the September 2020 statewide CAV survey, and one-on-one stakeholder conversations.

As we progress into this next decade, collaboration will continue to be an important foundation and component of successful CAV integration in Maryland. There must be an interest and willingness to cooperate with government, industry, academia, and public representatives in order for CAV to make a difference in our communities. Engagement through additional statewide surveys and the Maryland CAV Working Group will continue to occur.

What Are Connected and Automated Vehicles?

CAV could change all aspects of mobility—from the way we commute to how we plan and develop infrastructure for future cities and towns. However, there is often confusion on what CAV are and what the levels of automation[2] can accomplish. This Framework has established the following high-level definitions as a baseline for the recommendations proposed in this document:

Connected Vehicles "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 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 leverage connected capabilities with automated features to bring the best of both worlds into one vehicle.

> " Maryland has the expertise, infrastructure and leadership to be a national leader in CAV technology and implementation."
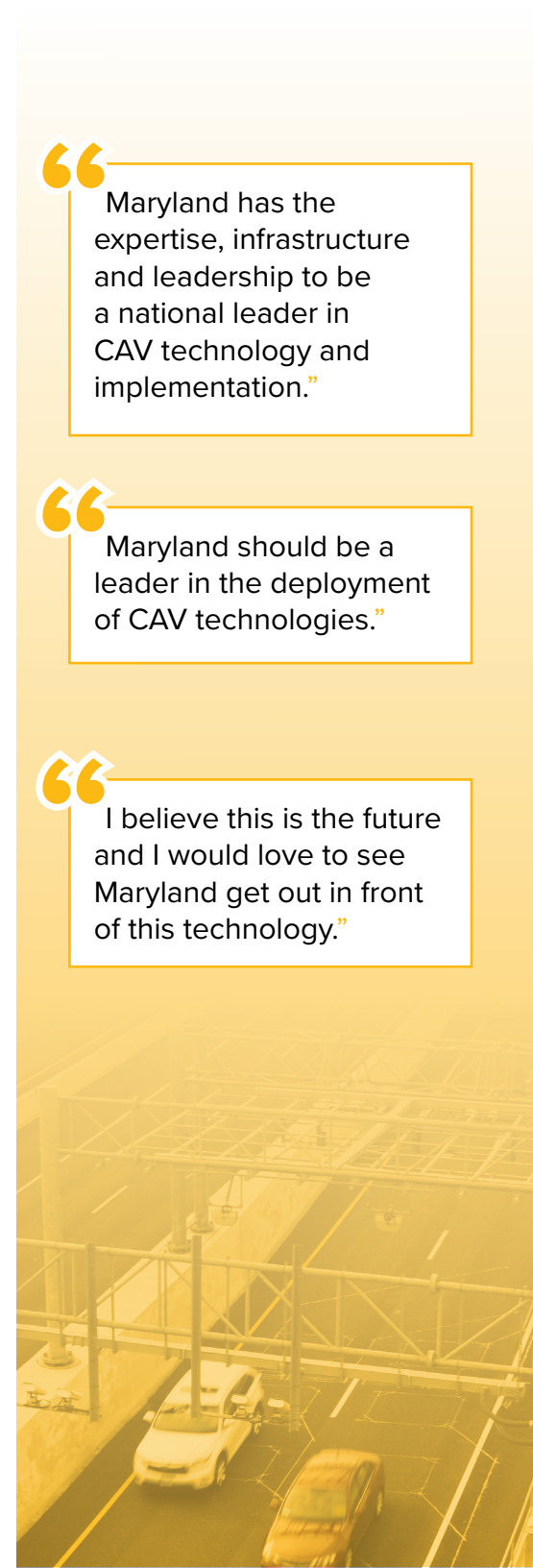
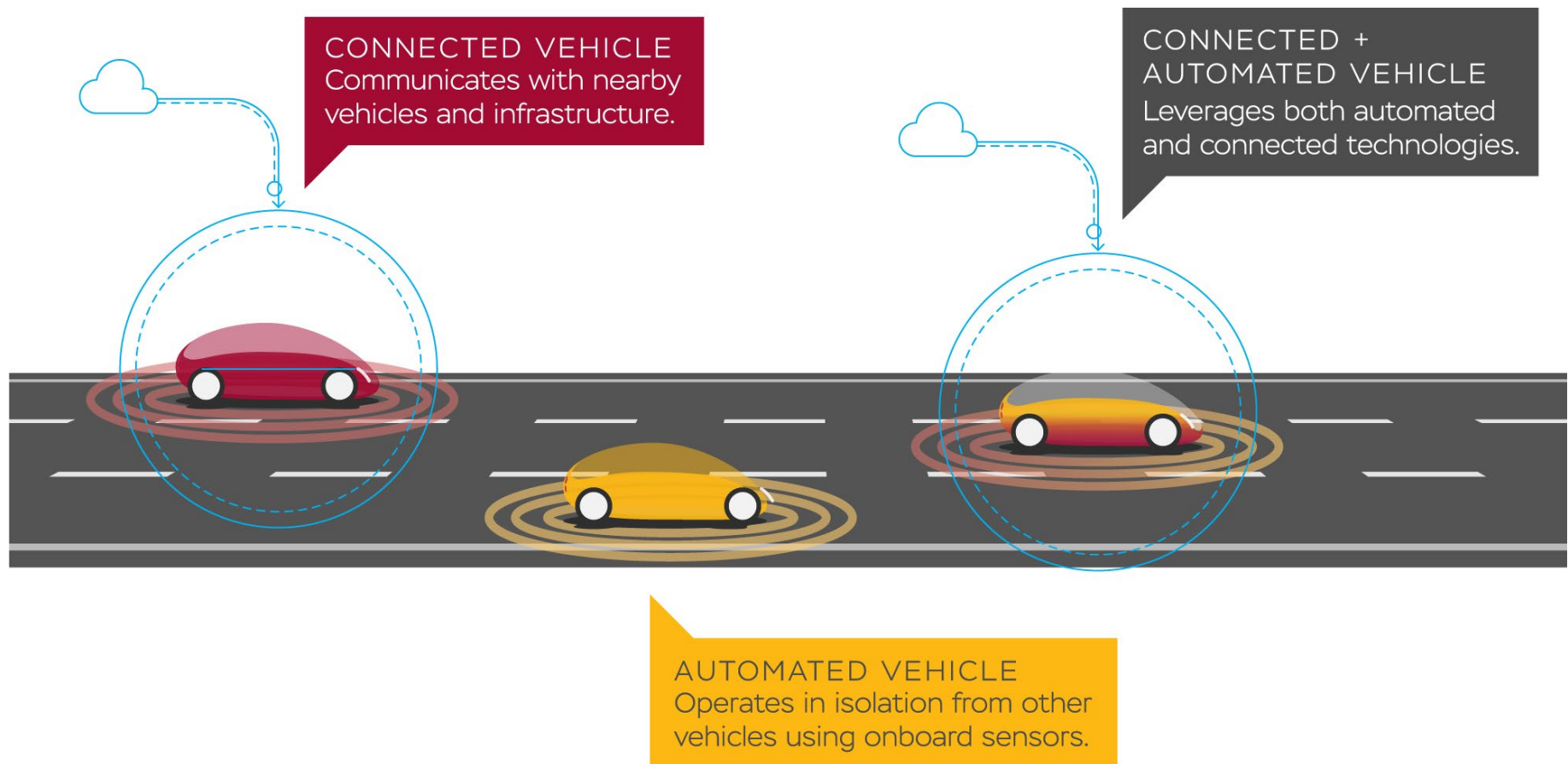> " Maryland should be a leader in the deployment of CAV technologies."

> " I believe this is the future and I would love to see Maryland get out in front of this technology."

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[1] Maryland Department of Transportation State Highway Administration's Connected and Automated Vehicle Strategic Action Plan and Maryland Transportation Authority's Strategic Plan for Connected and Automated Vehicles (CAV Plan).

[2] National Highway Traffic Safety Administration summary of Society of Automotive Engineers' Levels of Automation.

CONNECTED VEHICLE
Communicates with nearby vehicles and infrastructure.

CONNECTED + AUTOMATED VEHICLE
Leverages both automated and connected technologies.

AUTOMATED VEHICLE
Operates in isolation from other vehicles using onboard sensors.

Beyond the basic definition of a CAV, one must more importantly understand the high-level opportunities CAV technology has to offer. CAV technology could:

- **Save lives and reduce the severity of injuries,** with the possibility of nearly eliminating crashes altogether.

- **Improve reliability,** potentially reducing congestion and by extension, reducing vehicular greenhouse gas emissions and improving air quality.

- **Enable new mobility service solutions** to enhance the lives of the young, aging, people with disabilities and medical conditions, and others who choose not to drive by providing better access to employment, medical services, health care, shopping, entertainment, or all opportunities for improved quality of life.

- **Improve the movement of commodities and service providers,** thereby lowering the cost of goods and services to consumers.

> " Could have great benefits but still has significant risks. How will it be implemented, safeguarded from hacking, how will the legacy vehicle + infrastructure be integrated with the CAV infrastructure?"

In today's vehicles, new driver-assistance technologies are already becoming common and are having a positive impact on our roadways. These vehicle systems—such as automatic emergency braking, lane-keeping assistance, blind-spot warning, and adaptive cruise control—sense and monitor conditions inside and outside the vehicle to identify dangers and warn the driver and/or automatically intervene to help avoid or mitigate an incident. These automated features have already reduced crash statistics, as reported by the Insurance Institute for Highway Safety.[3]

Adopting these features is a first step in improving roadway safety as motor vehicle crashes remain a leading cause of death, with an estimated 38,000 lives lost on our nation's roads in 2019 with 534 in Maryland alone.

Even with traditional safety programs and policies that have helped make road travel significantly safer, traffic fatality and injury rates must improve—and CAV technology can help. With 94 percent of serious crashes involving human error, the U.S. Department of Transportation's National Highway Traffic Safety Administration has been clear on their belief that CAV have tremendous safety potential: "[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."[4]

CAV come in many sizes, shapes, and functions. Besides a personal car, CAV could include on-demand taxi services, package delivery vehicles, low-speed transit shuttles, micro-mobility services, public buses, long-haul freight trucks, and more. As a result, CAV might reduce transportation barriers by providing broader access and choice of where people live, work and play. They could help us re-imagine the way we plan our communities to maximize health and sustainable transportation, the environment, economy, and society.

Many aspects of our CAV future remain uncertain, but it is important to start the conversation and to work with our private industry partners as decisions are made that affect transportation for years to come. By putting Maryland on a strategic path to address the many concerns and opportunities that arise with CAV technology, we will enable our talented group of emergency responders, traffic safety, planners, engineers, industry representatives, policymakers, research and educational institutions, economic development organizations, and citizens to influence how CAV will positively affect our lives.

This Framework sets the stage for these important conversations to occur and to reach collaborative decisions on how Maryland moves forward in the deployment of CAV.

[3] Insurance Institute of Highway Safety Summary Flyer.

[4] NHTSA 'Benefits of Automation' - Automated Vehicles Safety.

> " I believe that CAV has a unique opportunity to make a difference in people's lives, especially for those who cannot drive vehicles, elderly and mobility-impaired individuals."

> " CAV's are the "Holy Grail" of mobility. Better safety, accessibility, fuel economy, emissions, commute times, and eventually cost."

> " This is a great initiative but also concerned about growing pains that go along with it."

MARYLAND FRAMEWORK

In the September 2020 survey distributed to stakeholders across Maryland, we heard loud and clear that CAV technology is an important area of emphasis for the State. Most respondents were "Very Enthusiastic" or "Enthusiastic" about deploying CAV technology in Maryland. Only 16 percent of respondents were "Worried" or "Very Worried," with the remainder taking either a "Neutral" or "Didn't Know Enough" stance to form a solid opinion.

That level of interest is an important component in developing this Framework as it sets the stage on where to go next. As we convert that enthusiasm into this Framework, feedback from stakeholders has coalesced around **five focus areas** where Maryland should draw attention and resources.

These five areas of focus guide everyone—with the encouragement to "find your place" among the recommendations and advance your very own state of the practice for CAV within your company, your agency, your institution, or your organization. These following focus areas reflect the current environment, and will evolve as additional progress, continued input, and ongoing developments shape CAV technology along a timeline influenced by many internal and external factors:

The five areas of focus in this Framework are:

1. **Public Education and Outreach**

2. **Planning and Policy**

3. **Early Deployment and Testing**

4. **Infrastructure**

5. **Workforce**

For each of the key areas, this Framework provides a brief overview of activities to date, followed by a call to action with a set of high level objectives that empowers stakeholders to work together to advance CAV strategies that align with the objectives.

Core Values

Before addressing the key areas, it is important to first address some core values for Maryland that came across very strongly through our outreach and are generally viewed as cross-cutting.

Advancing Innovation with a Safety Driven Lens

Introducing CAV technology will provide an array of benefits and bring about many new challenges, but at its core, **safety remains the number one priority.** It is essential to ensure that CAV technology is developed, tested, and ultimately used safely to realize the many anticipated benefits. Maryland supports its commitment to Vision Zero by taking proactive steps to increase roadway safety through various programs, including the Strategic Highway Safety Plan, the Highway Safety Improvement Plan, and various driver education programs among many other outreach efforts. Maryland has and will continue to pursue safety throughout its CAV technology integration activities via transparent engagement with stakeholders. That dialogue and collaboration is a foundation of Maryland's efforts to safely deploy CAV technology.

Access to Transportation Technology for All

The benefits that existing travelers and commuters can realize in safety and mobility should be **equitably available to all users** who have varying abilities and resources, including people with disabilities; users of varying ages, socioeconomic status, and demographics; and travelers across different modes, including vulnerable pedestrians, bicyclists, and new mobility users (e.g., e-scooters).

CAV technology presents a great opportunity to support all geographic areas of the State. As Maryland progresses with integrating CAV technology, stakeholders should consider the varying needs of the different regions in Maryland, as well as the differing opportunities and challenges of rural, suburban, and urban land uses.

The following pages provide extended detail on the five key areas. A summary of Future Directions for each area is shown below.

PUBLIC EDUCATION AND OUTREACH

- Increase transparency of educational CAV material and ongoing efforts.
- Ensure diverse audience when communicating initiatives.
- Leverage existing outreach avenues.

PLANNING AND POLICY

- Facilitate opportunities through the Maryland CAV Working Group.
- Establish clear goals and metrics for CAV in Maryland.
- Identify and address barriers to CAV.
- Incorporate CAV into planning and policy documents.
- Establish policies on cross-collaboration and open data sharing.
- Anonymize CAV data and safeguard from mishandling.

EARLY DEPLOYMENT AND TESTING

- Broaden use cases for early deployment and pilot projects.
- Gather public perception and adjust pilots.
- Grow the list of locations for CAV testing.
- Prioritize freight-focused CAV strategies in the short term.
- Leverage deep bench of academic excellence.
- Embrace new partnerships for non-traditional research.

INFRASTRUCTURE

- Establish baseline operation of technology infrastructure.
- Establish acceptable equipment downtimes.
- Remain engaged with national guidelines and integrate or create State-specific specifications.
- Dedicate resources and create partnerships to build out the communications infrastructure.
- Asset-management and software configuration management.

WORKFORCE

- Promote and enhance existing workforce.
- Address recruitment & retention gaps at the local level.
- Establish expectations for future staffing.
- Field training and traditional trade jobs should be encouraged.
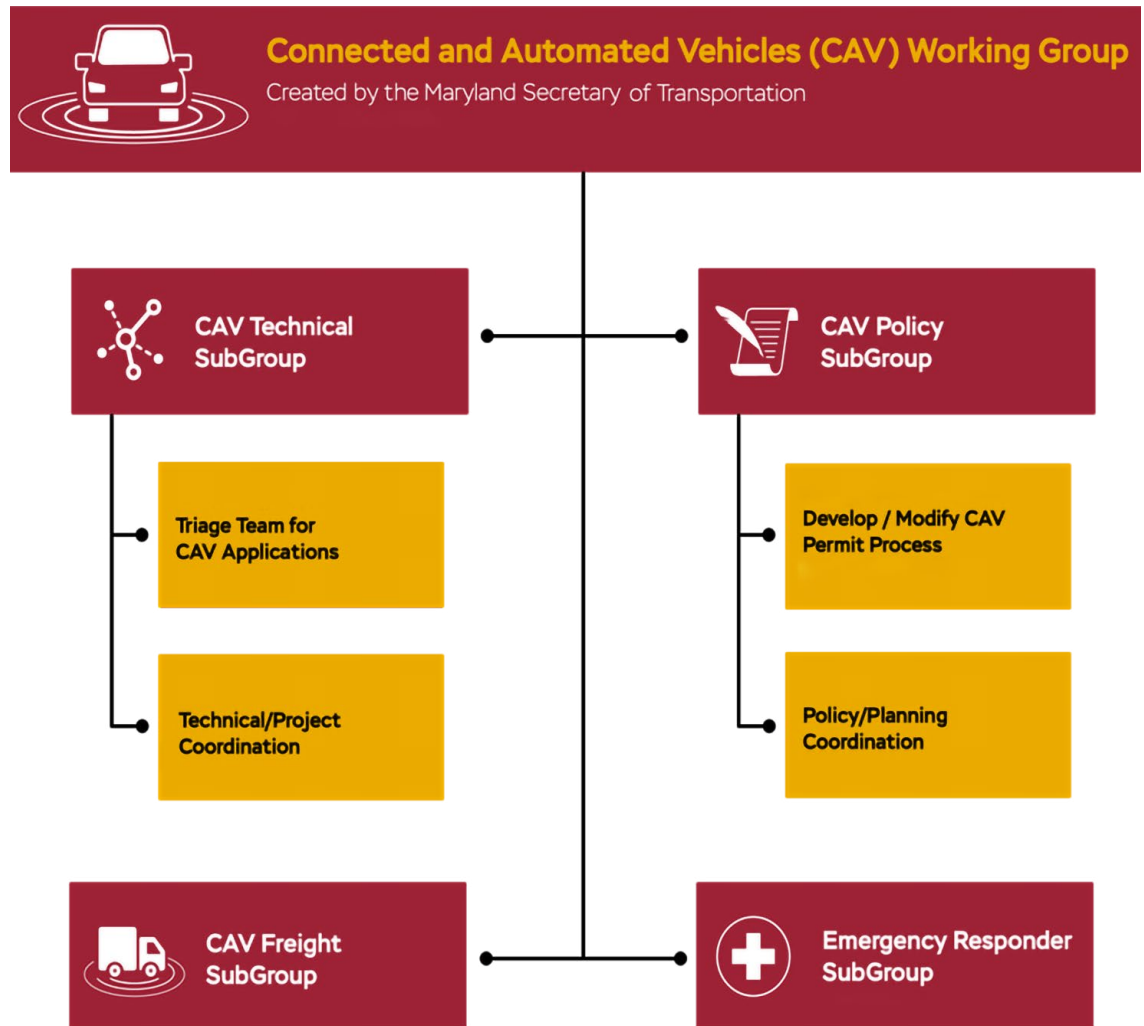
1 Public Education & Outreach

Awareness and acceptance of future technologies are intrinsically connected. As we witnessed with the personal computer, and more recently the smartphone, consumer interest and use of new devices can accelerate rapidly if there is accessibility of knowledge of what it can do. We are on the cusp of a tremendous opportunity to realize significant safety and mobility benefits through the introduction of CAV. Therefore, paying attention to public education and outreach is a critical component of our future mobility solutions in Maryland.

What Is Our Starting Point?

The Maryland CAV Working Group has been a significant contributor to increased awareness among transportation stakeholders within the State. The group has disseminated information by producing public facing material, which are meant to educate the public on the basic definitions of CAV and businesses on the advantages of partnering with Maryland.

To help drive best practices and recommend policies for action, the Maryland CAV Working Group established four subgroups: Technical, Policy, Freight, and Emergency Responders. Each subgroup is responsible for successfully researching, exchanging knowledge, and recommending where or how Maryland should engage CAV to deliver leading-edge innovative solutions.

Connected and Automated Vehicles (CAV) Working Group
Created by the Maryland Secretary of Transportation

CAV Technical SubGroup
- Triage Team for CAV Applications
- Technical/Project Coordination

CAV Policy SubGroup
- Develop / Modify CAV Permit Process
- Policy/Planning Coordination

CAV Freight SubGroup

Emergency Responder SubGroup

> " I have no idea what CAV is."

> " More public awareness to build confidence in the technology."

> " It is important to bring all levels of the community in to the conversation and show how this initiative will benefit all walks of life and how."

> " Make information more readily available."

As an example, under the direction of the Policy subgroup and with input from emergency responders, an approach to communicating with local enforcement agencies was developed to convey whenever a permit is issued for testing highly automated vehicles on public facilities.

Representatives from across Maryland have remained active in regional and national CAV and transportation activities. There has been positive press whenever companies are doing testing in Maryland, and this trend can and should continue. Sharing our CAV expertise both inside and outside Maryland's borders is an avenue for us to engage with external counterparts and industry, which is an important component to future awareness.

Survey Findings

Most respondents ranked as a high priority the opportunity that CAV represents for older and vulnerable road users and people with disabilities.

Senator Cardin with Maryland-based STEER company, testing autonomous vehicle parking (source: WBALTV) March 2019

What Is Our Future Direction?

Maryland's CAV champions should continue sharing educational CAV materials and ongoing efforts. This would ideally be done through the Maryland CAV Working Group, as the designated venue for coordination of CAV in the State. All stakeholders can use this opportunity to share language, develop and distribute outreach materials, and leverage the collective wisdom of public, private, and academic stakeholders.

As educational material and platforms are considered for the above, thought should be given to the many audiences, including the following:

- **General Public –** Education of the public and key stakeholders is critical and was raised repeatedly as a need in the survey responses and interviews conducted as part of this Framework development. Older citizens or those with disabilities should be considered important target groups for dialogue and public outreach and education.

- **Local Jurisdictions and Metropolitan Planning Organizations –** As the true experts and champions of their regions, the local jurisdictions and metropolitan planning organizations are vital to ensuring community needs are addressed as CAV technology deploys throughout the State.

- **State Agencies –** Some Maryland State agencies may be impacted by CAV that have not yet been regularly involved in the ongoing conversations. Understanding how these agencies fit into the transportation ecosystem will be important to providing a unified message across the State.

- **Legislators –** Securing one or more champions in the General Assembly and more broadly educating key legislative committees and leadership should be built around open discussion about the rapid evolution of CAV policy and technology, thus implementing appropriate laws that are neither too restrictive nor too broad.

- **CAV-Related Stakeholders –** The Maryland CAV Working Group is an effective medium for reaching key stakeholders. This group should continue on the same path and encourage additional dialogue with its diverse set of stakeholders.
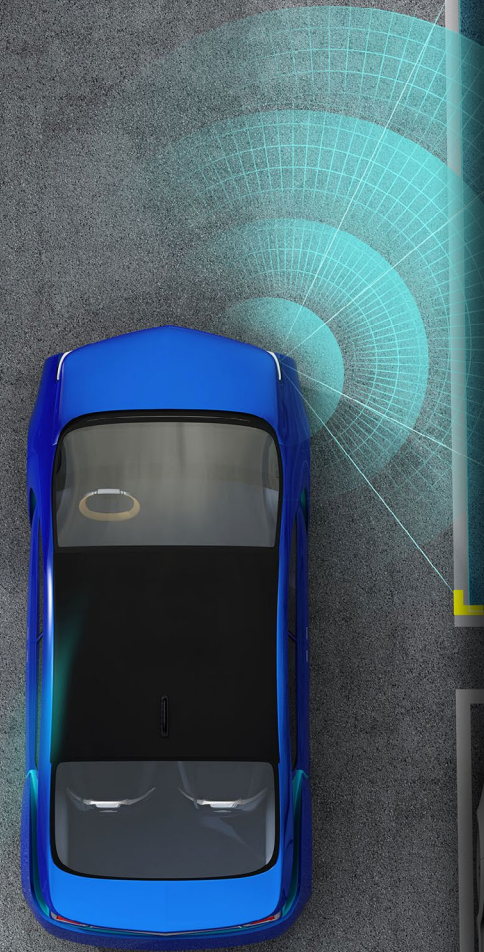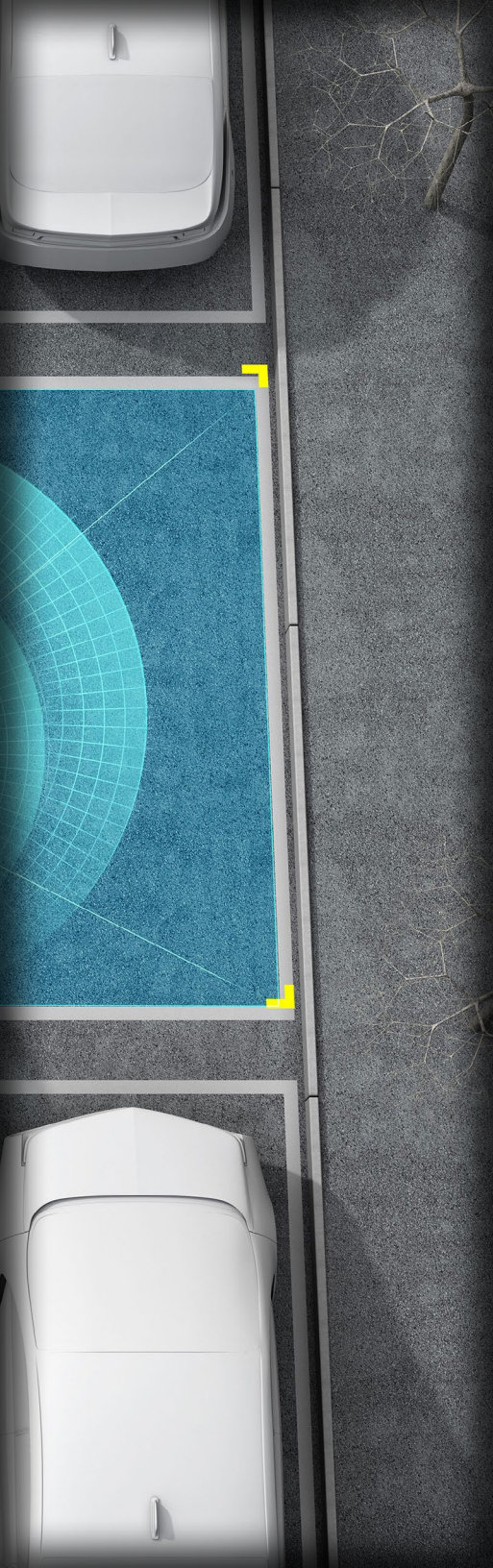
Educational outreach should leverage the many avenues for outreach available across the State. The beginnings of a list are included below but by no means cover the available resources to disseminate educational materials:

- Organizations such as AAA Mid-Atlantic regularly survey and communicate with a large population of transportation users in the region.

- Maryland Smart Growth Center reaches both local and national stakeholders for planning topics.

- Maryland Transportation Authority (MDTA) regularly conducts customer satisfaction surveys for E-ZPass® holders, which provides an opportunity to begin measuring public awareness in terms of CAV technology developments.

- The National Federation for the Blind, an early stakeholder in the Maryland CAV Working Group, engages in a wide variety of outreach such as podcasts, newsletters, and blogs.

- The Maryland Department of Transportation's (MDOT) Commuter Connections show broadcasts on cable stations across the State and brings its viewers important news and information on transit in Maryland.

- The Maryland Office of Tourism maintains a website (Maryland Office of Tourism) that offers a wide variety of information for travelers coming to the State.

- The Maryland Motor Truck Association engages in regular outreach with this target stakeholder group in Maryland and conducts compliance and safety training.

- Another early stakeholder in the CAV Working Group has been the Maryland Automobile Dealers Association, reaching buyers as they purchase new or used vehicles.

Planning in transportation often relies heavily on historical data. However, we have no historical comparison for CAV technology, which is rapidly advancing, while society's views toward mobility are evolving. More than ever, the planning task will require immense flexibility, agility in taking action, and awareness of factors outside the typical transportation field.

On the policy side, Maryland must prioritize policy solutions that embrace CAV technology while guiding the future of transportation, to realize the life-saving, environmental, and economic benefits of its potential.

What Is Our Starting Point?

Besides forming the highly successful Maryland CAV Working Group, stakeholders across Maryland have been actively preparing for a future with new mobility options, new technology opportunities, and rapidly changing transportation use.

MDOT championed the Maryland CAV Working Group since its inception, not only through administrative support but through top-level executive leadership. With input from a variety of stakeholders on the CAV Working Group, MDOT has implemented a one-stop shop for all entities interested in CAV technology in Maryland—through an expression of interest and a permitting process for CAV testing on Maryland's roadways. This process, developed collaboratively with stakeholders participating in the CAV Working Group, seeks to facilitate dialogue with potential partner companies, to better understand the needs of the entity, and to help ensure that safety is prioritized. MDOT has further performed regional travel demand modeling with CAV sensitivity, and has pursued several federal grant opportunities to fund infrastructure enhancements and CAV testing.

Survey Findings

90% of respondents felt we should "review or change Maryland laws to advance the safe integration of CAV in Maryland"

First Highly Automated Vehicle permit, issued by the MDOT Motor Vehicle Administration

> "Need to have CAV planning as part of all infrastructure projects. Difficulty may be funding it if there is not an immediate return on investment."

> "Be sure to address rural areas appropriately that may be less well-mapped, have dirt roads, not get information on closures reported as easily, etc."

> "Create legislation that encourages development of CAV. More public outreach. Demonstrate how it will work where public can see it in action."

MDOT has worked in partnership with the Maryland Department of Planning (MDP) and Maryland Insurance Administration (MIA) to begin exploring future impacts of CAV, while also reaching out to local governments and metropolitan planning organizations to better understand how CAV might provide opportunities for rural, suburban, and urban communities alike. The MDP has also incorporated CAV into its "A Better Maryland" program, recognizing that dialogue with, and guidance to, local jurisdictions is important.

Locally, the City of Rockville is one of the first municipalities in Maryland to incorporate CAV into its long-range comprehensive 2040 plan. Within the auspices of its New Mobility and Uncertain Change goal, the city has included a policy to "Monitor and plan for emerging transportation technologies and practices" with specific reference to considering changes in parking demand and other requirements based on widespread adoption of shared robotic vehicles.

What Is Our Future Direction?

Maryland should establish clear goals and visual representations of what our CAV transportation ecosystem will look like. By creating this visual through significant public outreach and stakeholder buy-in, all of Maryland would have clear goals of what they should be aiming for. This would reduce confusion, prevent "over-stepping" between agencies, and ultimately allow Maryland to accelerate the safe integration of CAV technology. This also allows Maryland to drive the conversation rather than having CAV technology innovation occur without engagement from key stakeholders.

CAV technology considerations should be incorporated into all planning and policy documents given its potentially enormous role in shaping the future of mobility. For MDOT and local transportation-related agencies, this should include incorporating CAV in long-range plans, capital plans, modal plans, and plans in specific areas like freight, vulnerable roadway user safety, and asset management. More importantly, the deployment of CAV in planning should ensure this new technology is established safely, equitably, and with environmentally sound policies to realize the full potential of benefits.

Agencies in the State know the growing potential for changes in mobility and how CAV technology could affect our communities from land use planning to hospital emergency room needs to insurance administration. Collaborative efforts among public, private, and academic partners and employing new approaches such as scenario planning are the best path forward when planning for this transformational change. This would also require incorporating quality-of-life discussions that will dramatically change the transportation landscape as work-from-home scenarios evolve in a post-COVID-19 environment.

The Maryland CAV Working Group will facilitate the following opportunities, among several others:

- Collaborate with the Department of Commerce to incorporate CAV into planning and outreach activities.

- Coordinate with the Department of Labor so that businesses and government agencies can better understand and prepare for workforce changes that might be instigated by CAV technology.

- Build stronger ties with the Department of Information Technology to create a "statewide network architect" that could help establish baseline information exchange and cybersecurity.

- Develop insurance scenarios in partnership with the Maryland Insurance Administration on how CAV technology might affect insurance—from individuals to governments to private businesses.

Many other agencies and local jurisdiction partnerships in Maryland could be leveraged to safely and equitably deploy CAV technology within the State. As technology, policy, and society all evolve at varying rates, new partnerships and new opportunities will arise to implement changes that will benefit a wide array of stakeholders. Continued engagement beyond Maryland's borders could likewise help identify additional opportunities, through ongoing engagement in the Eastern Transportation Coalition, the National Operations Center of Excellence, and many other national organizations. This will cut across varying elements of new mobility beyond just CAV technology, including electric vehicles, shared mobility and transportation network companies, and new innovations and services such as micro-mobility. Government collaboration with academia and private industry will help better understand a fast-changing environment.

Likewise, collaboration will help all Maryland stakeholders be prepared for unusual circumstances that might necessitate temporary or short-term adjustments. As demonstrated during the COVID-19 pandemic, cities around the United States utilized CAV technology for unique use-case scenarios: such as having a low-speed automated vehicle (AV) shuttle moving between a testing site and a laboratory to transport test kits, or using an AV to deliver much needed supplies to food banks. In these examples, special temporary curb-side design and other built-environment considerations could be required.
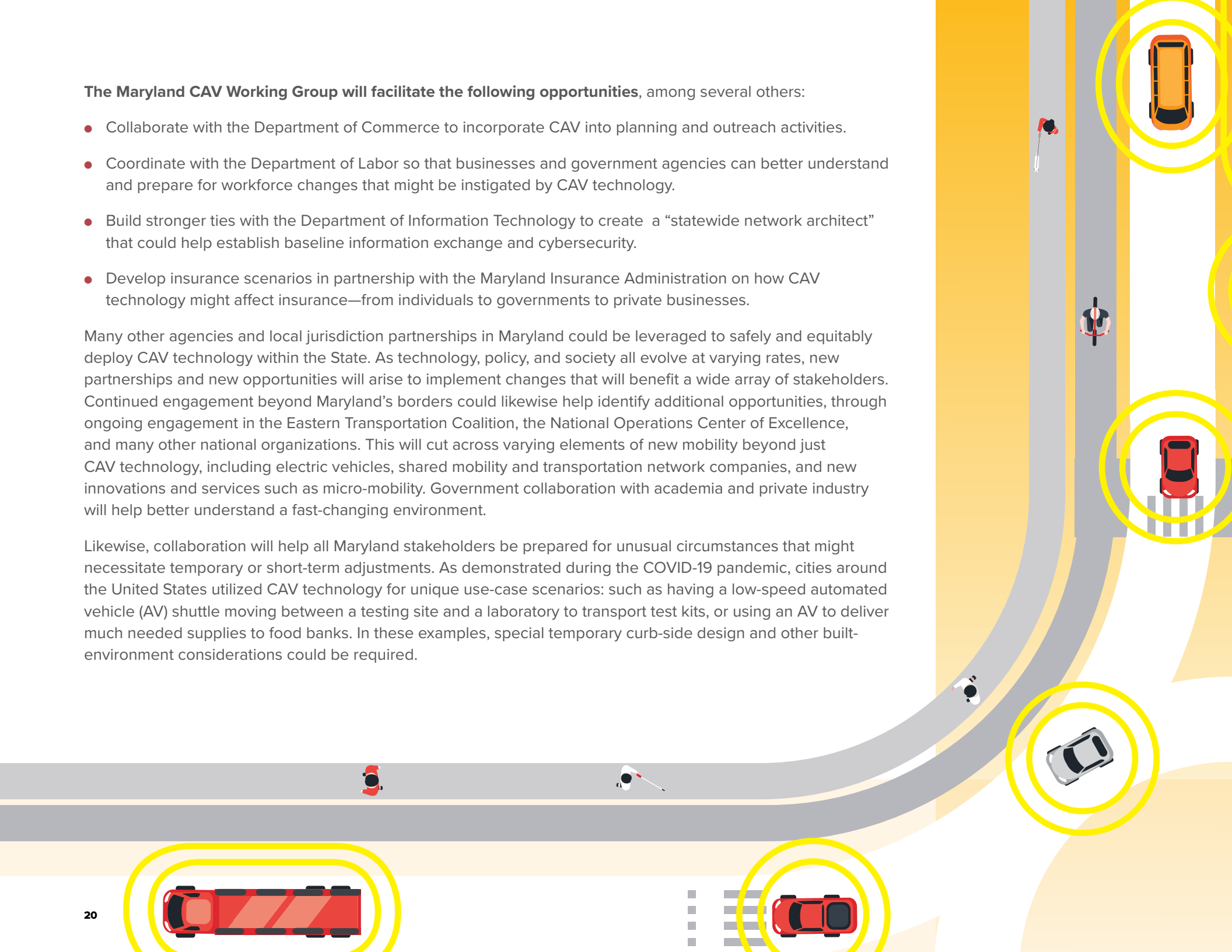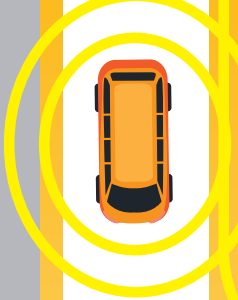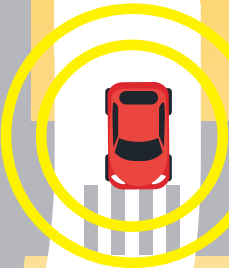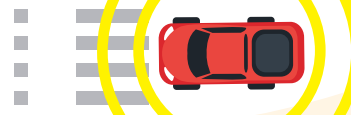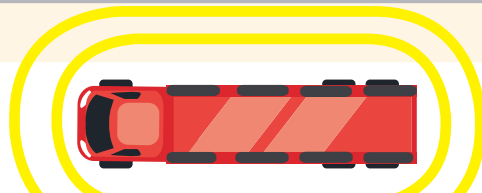
Stakeholders throughout Maryland should collectively identify and address barriers to CAV technology development and deployment. Reviewing regulatory and legal hurdles would consider typical testing and deployment requirements, identify unduly burdensome obstacles, and arrive at recommend potential revisions in critical areas. While national regulatory and legislative guidance is lacking in terms of readiness for CAV technology, many states are taking proactive approaches in partnership with private industry to better understand if and where changes could be necessary to current motor vehicle laws, registration mechanisms, and enforcement policies. Maryland should take action that both removes impediments to the safe testing and deployment of such vehicles and creates a pro-competitive and level playing field.

Maryland should establish policies on data governance to maximize the benefits of CAV technology. The development of policies on data governance among both public and private stakeholders are an important foundation of this Framework. Sharing relevant data from pilot demonstrations, fleet deployments, and research projects could lead to enhanced benefits for the end users. However, not all data is required to be shared across all stakeholders and there are opportunities to clarify who, when, and why CAV data should be shared. Specifically, milestones should be established to ensure the protection of private or confidential information, while keeping in mind transparency of data that could enhance the safety and equity of the transportation ecosystem. As an example, a private mobility service should not be permitted to use data to avoid providing accessible mobility services in certain neighborhoods.

This protection in general is an important component of data governance, **taking steps to safeguard from the mishandling of CAV data and protecting the public** from invasive data access. Maryland should help guide the conversation on how personally identifiable, proprietary, or otherwise sensitive data should be retained, stored, or shared on an individual user basis – if at all. The State should learn from policies explored or enacted in other states, and gather feedback from stakeholders as to key elements to focus on or exclude.

In a survey targeted only at local agencies in early 2020, MDOT asked about key priorities. Over two-thirds of respondents suggested that open data portals or data feeds "for the exchange of roadway information" such as work zones, plow locations, or other instances is something they considered important. As we gather and obtain more and more data from CAV technology, it is critically important that we seek opportunities to share such data for mutual benefit, while not over-demanding access to proprietary information without clear benefits.

As new technology and strategies form around CAV, it is important for all stakeholders to gain experience and anticipate future needs. Pilot programs are an excellent opportunity to build experience with next-generation technology, new partners, and future operational scenarios. On-road testing and early deployments are important to improving CAV performance and allowing them to reach their full performance potential. Careful real-world testing allows developers to identify and rapidly fix system shortcomings, not just on individual vehicles but across fleets.

For those new to the State, Maryland's critical Baltimore-Washington Corridor has unique benefits for testing and deploying CAV technology, including proximity to the National Capital Region—the backbone of eastern seaboard goods movement—and vital academic institutions with strong entrepreneurial spirit. Beyond its metropolitan center, Maryland offers a plethora of beaches on its eastern shore, to lakes and mountains on its western panhandle, wrapped in weather that ranges from hot, humid summers to cold, snowy winters.

In short, Maryland's landscape is a microcosm of the entire United States, offering urban, suburban, and rural areas with diverse weather and geographic conditions to conduct real-world tests for CAV technology, and both freight and passenger intermodal scenarios.

What Is Our Starting Point?

Numerous public and private pilot programs are underway or planned across the State, as illustrated and summarized in the following table.

Completed

In Progress

Planned

Bullet Number	Text Description
1	MDTA has tested multiple pilot deployments of dedicated short range communications (DSRC) roadside units and on-board units.
2	Howard County based STEER Tech has worked with several agencies in pursuit of testing its AV-focused parking valet application that will be featured on automobile manufacturing platforms soon.
3	The US Army's Aberdeen Test Center has been an active participant in the CAV test arena, working with the USDOT and others to test and develop future driver assist applications and new test protocols.
4	MDOT SHA is in the process of completing an infrastructure to vehicle deployment in the detection and warning of vulnerable users in the crosswalk at MD 214 and Addison Road-Street Pleasant Metro in Prince George's County.
5	MDOT MTA was awarded the first-ever CAV pilot under the TRB IDEA Transit program and is working with STEER to test AV technology at a MARC Station Parking Lot.
6	Prince George's County has an active CV pilot deployment in National Harbor, with several intersections and vehicles equipped to communicate with infrastructure.
7	Local Motors has piloted a low-speed AV shuttle dubbed "Olli" at multiple locations around the state, including National Harbor.
8	Maryland-based Robotic Research has been testing automated trucks, buses, and shuttles, in partnership with private and public entities, at their Montgomery County facilities.
9	The University of Maryland's Center for Advanced Transportation Technology is testing vulnerable user detection and notifications and has worked with the MDOT SHA and MSP on incident scene data transfers for in-vehicle notifications.
10	Howard County has procured the STEER technology for select government vehicles for automation within their county offices.
11	MDOT SHA is preparing a comprehensive pilot deployment of DSRC along US 1 in Howard County, supporting the national Signal Phase and Timing (SPaT) challenge.
12	Montgomery County is deploying connected vehicle solutions at several intersections for Signal Phasing and Timing (SPaT) testing.
13	The Work Group to Study Advanced Technology Center in Western Maryland is pursuing strategies to build a scalable, partner-driven facility for workforce development, testing, and education for connected and automated vehicles.

What Is Our Future Direction?

Projects and progress are constantly evolving. Given the incredible collaboration already in place and the government commitment established by MDOT and local agencies, it is no surprise that Maryland remains an attractive destination for future CAV testing and development:

- We are a microcosm of the United States in an accessible (i.e., smaller) state.

- We have a strong and highly educated workforce with ties to government agencies and leading-edge technology research.

- Our proximity to the nation's capital offers many possibilities to work with national legislators and federal agencies along our Baltimore–Washington corridor.

As we look to the future, Maryland's leadership has supported the notion of pursuing pilot opportunities that will benefit the State. This experimentation, when done to promote Maryland's core values, can help the CAV community within Maryland to thrive and grow.

Government and industry together should take great care to establish use cases for early deployment and pilot projects that not only help an individual organization or company, but can further the state of the practice and consider an equitable distribution of benefits to different regions to the extent possible. This is an important stage in considering both vertical and horizontal equity.

Focusing on *vertical equity* means that the broadest possible cross-section of Marylanders experiences the expected CAV benefits, demonstrations, and challenges—allowing them to see, touch, and understand firsthand the impacts of CAV technology. Beyond the anticipated safety, mobility, and environmental benefits, this focus also provides government and industry insight into diverse needs and key measures such as cost, geographic access, and personal mobility.

When selecting locations for early deployments or pilot activities, *horizontal equity* acknowledges that each agency in Maryland is at a different level when it comes to system capabilities, and each agency has different challenges they are facing in terms of providing predictable and reliable multimodal options. This is a natural condition, and these differences should be viewed as strengths that agencies in Maryland can lean on to leverage each other's investments in infrastructure, workforce development, and policy evolution.

Maryland has already designated several sites that can be used for the testing of CAV technologies. **There are opportunities to grow this list** by partnering with other State and local agencies, taking care to always look for opportunities to provide benefits beyond just testing. This one-stop-shop is available for viewing on MDOT's website and can be a gateway for companies or agencies looking for a closed-course location to continue development of CAV systems and components.

Survey Findings

84% of respondents felt we needed to do small pilots across "all vehicle types."

" Test cost-effective ways to enable real-time communication between CAV's and emergency vehicles, tow trucks, incident responders, and maintenance vehicles - i.e., vehicles that use lights and sirens to get driver's attention today."

> " Test, test, test! Increase testing all over the state, including all public roads, both urban and rural."

> " Due to its proximity to our nation's capital, demonstrating CAV technology in Maryland will be a critical factor in acceleration CAV adoption nationwide."

> " Continue to initiate pilot programs to showcase technologies and pique the interests of corporations."

All Maryland stakeholders have an opportunity to promote emerging technology "sandboxes" within their districts or along major corridors that can be transitioned to become successful multimodal, mixed-use, and CAV-friendly areas where testing of new technologies is agreed upon by the communities. In making this determination, agencies might encounter new issues not considered "mainstream," such as landscaping maintenance that will not interfere with CAV sensors, multimodal drop-off or holding CAV zones, and large-scale data governance and data management.

Private companies have a tremendous opportunity to incorporate CAV technology into their planning and policy efforts, recognizing that how their employees use transportation will change. This is not limited to how they get to or from work, but in general there could be changes in where these employees choose to live if afforded an opportunity to be more productive while all or some of the driving tasks are now being handled by driverless systems.

Deployment of freight-focused CAV strategies can and should be prioritized. The freight industry has already begun investigating and deploying CAV technology to support the vitality of their businesses. Several major freight corridors cross through Maryland, both east-west and north-south, carrying nearly $300 billion in value annually. Our global presence is dependent on the Port of Baltimore and Baltimore/ Washington International Thurgood Marshall Airport to move international cargo rapidly through the supply chain, making this type of pilot program an important component of our economy and likewise an attractive opportunity for CAV testing and implementation. Ensuring that both government and industry are working together during the early stages of planning these pilot programs is critical to exploring potential benefits and challenges up front.

Maryland should leverage its deep bench of academic excellence with pilot testing, data analysis, and a source for research acumen. Not only do our colleges and universities provide a campus setting for testing certain applications on private roads, but they also provide a treasure-trove of data analysis experience. The University of Maryland's Center for Advanced Transportation Technology has a long history in partnering with governments and industry toward data collection and analysis, and the Maryland Transportation Institute (MTI) has become a core source of innovation, with its recent experience leading to the development of a national COVID-19 impact tool that has been nationally recognized by many— including Amazon's own technology services.

Pilots deployed in Maryland can and should be viewed as an opportunity to gather insight into public perception and the use of CAV technology. No effort should ever be done in a vacuum, and organizations should take advantage to partner with local interest groups to gain insight into user input on CAV technology testing. Additional steps could involve focus groups and public meeting forums, and include targeted user groups such as single parents, the disabled, and aging population, ensuring a broad cross-section of equity considerations are factored into the evaluation. Pilots should incorporate feedback, perform evaluations for all CAV technology tests, especially those that engage the general public and use the opportunity to promote CAV technology testing to expose the general population to emerging technologies. Government and industry together should also evaluate if their existing or future pilot projects have adequately met local needs and document unexpected or unintended consequences.

Pilot programs can and should embrace the opportunity to establish new partnerships to fund and conduct research in fields beyond traditional transportation focus, to include but not limited to insurance and liability, cybersecurity needs, and workforce impacts. They can even address longer-term research needs including technical inspections of Advanced Driver-Assistance Systems (ADAS) and more general enforcement issues that span the federal/state roles, and remain unclear given the rapid evolution of technology. Pilot programs and research don't always need to emanate from a single agency, and in fact could just as easily be organized by many State and local government agencies. This type of collaboration would be better to leverage and build on federal, think-tank, and peer State research regarding key implementation issues such as liability, cybersecurity, workforce impacts, and demands. We have tremendous lessons-learned from the E-ZPass® implementation across regions and should take care to follow that lead. This is an area where multidisciplinary engagement will be necessary, bringing expertise from government agencies that might oversee information technology and private companies that are specialists in cybersecurity or security credentialing.

To realize the full potential benefits of CAV technology, a true partnership between the vehicles—small or large as they may be—and the infrastructure they operate on, will be necessary. The old model where vehicles and infrastructure were designed and operated independent of each other is no longer sustainable; instead, we must look at cooperative automation collectively.

What Is Our Starting Point?

Transportation infrastructure can be defined as roadway or transit facilities that vehicles operate on, and those that operate and manage the facility or service are called Infrastructure Owner Operators (IOO). In Maryland, MDOT is the main IOO, and is working with local jurisdictions like Montgomery and Prince George's Counties to explore various infrastructure needs for CAV. These include additional signing, lane striping, and reporting of real-time road conditions. MDOT considers both wireless and fixed communication systems as the backbone over which CAV technology will exchange such information. MDOT recognizes that CAV technology will benefit most from a fast, reliable, secure, private, and interoperable communications network. This includes understanding how newly adopted communication technologies, computing developments, and data security policies tie into the network.

Survey Findings

More than **3/4** of survey respondents felt it was important or urgent to "build more communication infrastructure that would help connected vehicles operate safely (e.g., fiber or wireless)"

" We should design, deploy, operate and maintain an Automated Transportation Corridor."

Within MDOT, the State Highway Administration (MDOT SHA) completed in 2020 a comprehensive technology communications plan to adapt to emerging transportation needs. Both MDOT SHA and MDTA (the tolled facilities IOO) have completed CAV strategic plans and continue to advance CAV readiness within their organizations to prepare the infrastructure for the future.

Prince George's County has been an early adopter IOO within the CAV space, having equipped a half dozen intersections in and around National Harbor with DSRC roadside units (RSU), and is conducting pilot demonstrations of CV applications such as traffic-signal phase awareness and work zone awareness. Montgomery County is preparing to equip several intersections with DSRC RSU for a CV pilot deployment.

There is considerable research underway both nationally and internationally to better understand the impacts that CAV technology might have on road markings, signage, Intelligent Transportation Systems (ITS), and sensors among many others. Maryland has been and continues to participate in these national dialogues, including but not limited to the National Committee on Uniform Traffic Control Devices, Cooperative Automated Transportation Coalition, Connected and Automated Vehicle Pooled Fund Studies, ITS America Advocacy Groups, Transportation Research Board, National Cooperative Highway Research Program, American Association of State Highway Transportation Officials, and Institute of Transportation Engineers.
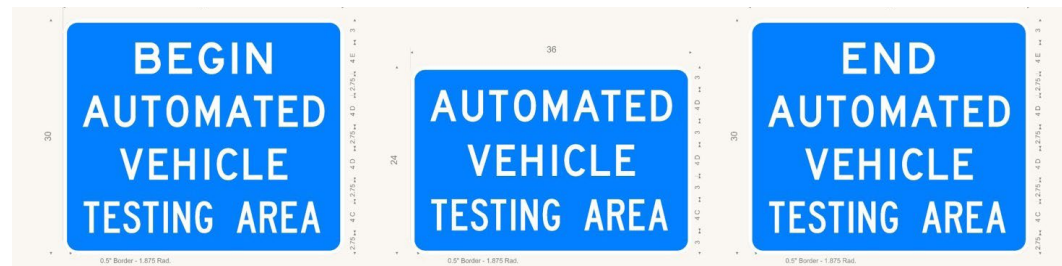
Example signage recommended within automated vehicle testing areas

What Is Our Future Direction?

The IOO in Maryland can review and update the transportation infrastructure to support CAV technology. Working with other government agencies, academia, and the private sector, this update can be broad statewide or specific by corridor—but in all instances, must be done with future benefits in mind.

IOO across Maryland should establish a baseline assessment of their physical infrastructure. Much of this begins with an assessment to determine if the current design and maintenance of traditional control devices (e.g., pavement markings and signage) are compatible with CAV needs. This should include recommendations from CAV manufacturers and consideration of regional and national practices to allow for interoperability.

MDOT and local agencies should remain engaged with national infrastructure guidelines as new and evolving CAV standards are created, to determine if they are enough for everyday needs as well as for special cases (such as inclement weather), especially for evacuation route applications. Although many of these guidelines are still being developed, maintaining relationships with national committees will allow Maryland to receive notice when standards or guidelines might be changing, and to take early steps to ease the resource burden that change often brings or to voice opinions on how the standards may diverge from IOO needs.

Maryland should develop State specific technical specifications, best practice guidelines and procedures on different infrastructure-centric CAV technologies, applications, communication procedures (e.g., 5G and DSRC), and operations. Guidance and specifications that cross jurisdictional borders will increase the likelihood of seamless transitions for a vehicle, which ultimately must operate on all facilities, and in both urban or rural environments. The efforts should leverage existing resources such as including empty conduit or dark fiber in future construction or rehabilitation projects, and provide long-term benefits that are considered best practices among IOO in other states. Maryland is already benefiting from engagement nationally such as with the Cooperative Automated Transportation Coalition, a partnership among IOO and OEM stakeholders.

Backhaul communications may need to be high bandwidth to accommodate still-unknown levels of data, reliable in their exchange to avoid lapse in critical messaging, and as close to real time as possible. That means latency, reliability, and switching are all critical functions in the network architecture. Similarly, there will need to be robust connections in all geographic areas (both urban and rural), potentially triggering varying levels of resource needs for different corridors. **This requires not only dedicated resources from government agencies, but a willingness and emphasis on exploring resource sharing possibilities with the private sector**, especially to incentive in regions where they currently opt out of building infrastructure (e.g., rural regions of Maryland).

Communications will be enabling CAV technologies that will be used for safety applications, and as such, they will become labeled as critical roadway infrastructure. **State and local agencies should establish acceptable communications and roadside equipment downtimes, and share lessons learned** regarding the need for redundant systems to provide a backup if the CAV technology in place fails.

CAV technologies will usher in a new era of network architecture and cybersecurity needs. Agencies should understand and set baseline network thresholds for all field devices to more easily detect anomalies. For network protocols and routing, agencies should standardize Internet Protocol (IP) assignments and ensure enough IP addresses are available to each agency and promote the sharing of fiber-optic cable where feasible. More than ever, a cooperative engagement between MDOT, the Department of Information Technology, local agencies, academia, and business is necessary to establish a clear network architecture.

Fortifying security is important to ensuring public safety and accepting CAV technology. Protecting devices in the field might require normalizing more traditional strategies such as using physical locks or barriers that restrict access or expand to more complex strategies such as cyber locks and password protection. For CV installations, the use of a security credential management systems to validate authorized users and verify the authenticity of messages transmitted between vehicles and roadside equipment is recommended for pilot deployments and will be required for longer-term deployments.

All this new technology will bring with it **a need to maintain or increase Maryland's emphasis on asset-management.** Future implementations will need to include, at minimum, an inventory of devices along with approximate age, procurement cost, life expectancy, regular maintenance needs, and notes such as frequency and impact of failures.

As technology rapidly evolves, configuration management is a necessity. Keeping track of software and firmware versions, upgrade needs, and firewall or connectivity issues will be just as important as the physical characteristics of the devices. Such information will be useful not only to manage equipment, but also to make a business case for assigning resources for a more robust maintenance program.

Rapidly evolving technology requires an equally rapid evolving workforce. Creating and supporting the CAV technology ecosystem will require transportation professionals who have expertise in computers, communications, physical deployment, maintenance, and cybersecurity as well as traditional skills such as civil engineering. Preparing for the future will mean developing a work force capable of pioneering change.

What Is Our Starting Point?

Maryland is a State where technology development and innovation are flourishing. Maryland is home to 14 of America's top 25 aerospace companies and 70 of the top 100 defense contractors. Additionally, Maryland is a hotbed of software services, electronics, telecommunications firms, and a critical mass of cybersecurity organizations, many of which are already engaged in automation development. Skills across these fields have expanded and are built around a culture of innovation, with a touch of entrepreneurial spirit. After all, Maryland can proudly proclaim itself the home State of big-name innovators such as Under Armour and the Allegis Group, and home-grown AV small-business pioneers like STEER, who is advancing AV solutions locally and nationally.

Survey Findings

90% felt it was important to work with industry and vehicle manufacturers to "help streamline existing automated features."
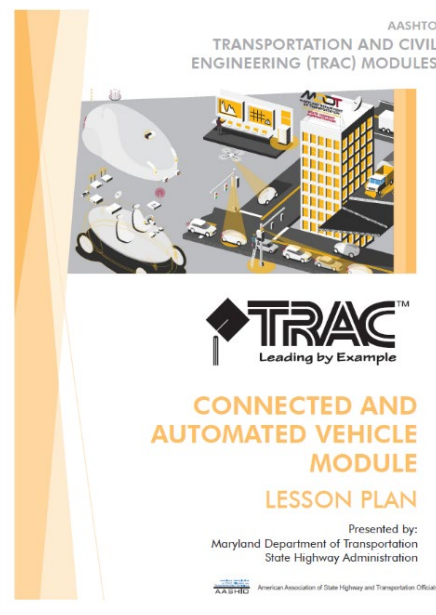
Maryland is a leader in data analytics and visualization and is experimenting with big-data through academic, private-sector, and military partnerships. Institutions across the State are testing the interface of CAV with our infrastructure and investigating the potential benefits of CAV on the way we operate and manage our transportation ecosystem. The benefits of collaboration has meant Maryland institutions have real-time data and agreements in place with the University of Maryland Center for Advanced Transportation Technology, Johns Hopkins Applied Physics Laboratory, Morgan State University's Urban Mobility and Equity Center, the Maryland Emergency Management Agency, among many others, providing unparalleled support for data-driven decision making and training the next generation of data scientists.

AASHTO
TRANSPORTATION AND CIVIL
ENGINEERING (TRAC) MODULES

TRAC
Leading by Example

CONNECTED AND
AUTOMATED VEHICLE
MODULE

LESSON PLAN

Presented by:
Maryland Department of Transportation
State Highway Administration

American Association of State Highway and Transportation Officials

Strategic planning documents from both MDOT SHA and MDTA pay great attention to workforce and data implication, and progress has been made toward exploring future workforce needs across the MDOT Maryland Transit Administration as transit operators begin conversations of what it might mean to have autonomous shuttles in Maryland. Multiple for-profit and non-profit agencies across the State support and actively promote educating our next generation of experts through Science, Technology, Engineering, Arts and Mathematics (STEAM). The Work Group to Study Advanced Technology Center in Western Maryland is still actively pursuing strategies to build a workforce training center near Frostburg that could train in CAV technology, and and the University of Maryland, College Park, is planning for a new state-of-the-art CAV lab that will be capable of accommodating passenger vehicles and buses as part of the construction of a new building on campus that will primarily house the Department of Civil Engineering and Maryland Transportation Institute.

What Is Our Future Direction?

Maryland is staring down an opportunity to build on its foundation, protect our workforce, and inspire leadership in the workplace of tomorrow. The widespread adoption of CAV technology is expected to have varying impacts on public- and private-workforce needs, including the already emerging challenge of finding, attracting, and retaining employees with the right skillsets needed to operate, maintain, manage, and plan the next-generation transportation ecosystem.

Agencies across Maryland should collaborate with the Department of Labor and perhaps the Governor's Workforce Development Board (GWDB) to protect and enhance Maryland's workforce. While MDOT and local transportation agencies will be heavily affected, there is no question that CAV could have wide-ranging impacts on all facets of Maryland life. This will be important especially to industrial and labor workforces, which have a higher potential for being impacted by autonomous vehicles (e.g., taxi or truck fleet drivers). Meeting this challenge will require incorporating lessons learned from other regions and parts of the country, including investing in local training programs and technical schools, promoting staff engagement and growth, and exploring new ways to hire qualified applicants.

Local agencies can address recruitment challenges for attracting and retaining qualified data scientists and other high-salary positions by reviewing existing limitations and exploring the possibility for joint hires or shared resources between jurisdictions.

Academia should take the lead and bring public and private industry together to establish expectations for future staffing needs. Besides some of the obvious needs for the future—electrical and computer engineering, software development and information security, systems engineering and applied analytics—new job categories not even contemplated are likely to arise. Job titles like "data ethicist" or "emerging technologies modeler" will join a host of other new careers in public and private enterprises.

Universities have a unique opportunity to "keep the cabinet stocked" with talent and fresh ideas, at both the government and industry levels. This will require sitting down with executive leadership at academia, government, and businesses to explore new curricula that might be required, exploring new research needs, and managing the reality that technology and policy are evolving at a break-neck speed.

Field training and traditional trade jobs should be celebrated and encouraged. Maryland's education should leverage all opportunities for learning to develop new training and education programs to populate tomorrow's trade workforce alongside STEAM careers. Workforce needs will transcend engineering science, math, and technology, and will require a work force with field experience in construction, maintenance, and operations to ensure our signals remain functional, our communications do not lapse, and other emerging technology continues to operate to the maximum of its capabilities.

> " We need to redouble our efforts to train and position computer science and robotics engineering teachers in K-12 education, and we need to increase the number of students in computer science at our State universities."

> " Get as much data, analysis and feedback from as many sources as possible to mitigate as many obstacles are possible."

> " Support colleges and universities to conduct research, collaborate and produce workers who can support the industry."

CLOSING THOUGHTS

Maryland is advancing CAV technology while prioritizing the safety, equity, and betterment of our society for all Marylanders.

Maryland has taken significant strides in fostering CAV collaboration through its Maryland CAV Working Group, which comprises a diverse group of public- and private-sector agencies, academia, advocates, and members of the public. The group remains a central point of collaboration for all CAV solutions to support the recommendations proposed within this Framework.

Building on this progress, individual agencies, companies, universities, and interested **stakeholders are encouraged to remain active** in the Maryland CAV Working Group; to bring ideas, challenges, and opportunities for deployment or collaboration; and to meet the proposed recommendations within this Framework. Likewise they should represent Maryland's interests in national committees, organizations, and industry coalitions, and bring the most current knowledge and lessons learned to bear in our home State.

This document empowers State and local agencies, the private sector, and the public to **become part of the conversation** and of the change that CAV technology can bring to our State.

The CAV environment is extremely fluid, new technologies, strategies, and challenges will arise every single day. How society utilizes the transportation ecosystem will evolve dynamically, unexpected changes like the COVID-19 pandemic will appear, and parallel discoveries will influence how CAV are integrated within our lives. The best method for dealing with uncertainty is to develop strategic frameworks, like this one, to provide all stakeholders with the ability to proactively prepare for multiple eventualities.

We ask everyone in Maryland to **take action** and work with the Maryland CAV Working Group so that CAV technology is advanced across the State with your needs in mind.

We look forward to the discussion!

Contact the
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