

# Connected & Automated Vehicle Toolkit for Maryland Local Jurisdictions

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**Disclaimer:** this document is for informational purposes only and is subject to change as Connected & Automated Vehicle technology evolves. If you have any questions about this document please contact the Maryland CAV program team at [CAVMaryland@mdot.maryland.gov](mailto:CAVMaryland@mdot.maryland.gov)

## Introduction

Through local outreach efforts, the Maryland Department of Transportation (MDOT) and the Maryland Department of Planning (MDP) recognize that there is a desire from local jurisdictions to seek guidance on preparing, planning, and implementing **Connected & Automated Vehicle (CAV)** technologies. This document includes a list of recommended actions as a resource for local jurisdictions when considering CAV technologies for their regions. Jurisdictions should use these recommendations as guidance to advance initial steps to meet their own unique needs and goals. This list is not comprehensive and is subject to change as CAV technologies advance and new regulations are implemented; however, this document provides a solid foundation for local jurisdictions to begin understanding CAV technology impacts within their communities.

These recommendations are also intentionally geared towards local jurisdictions, which play an integral role in achieving [Maryland's CAV vision](#) and help to implement [the Statewide Maryland CAV Strategic Framework](#). It is important to note that, while there may be some overlap with actions that can and should be taken by Metropolitan Planning Organizations (MPOs), an MPO-focused list would include different strategies and considerations. Ultimately, coordination across local jurisdictions, MPOs, and state agencies is also highly encouraged, as CAV will cross jurisdictional boundaries – collaboration will be a key factor to the success of CAV in Maryland.

This document begins with baseline knowledge that all jurisdictions should be made aware of, followed by a menu of possible actions that could be undertaken. The menu of actions attempts to identify and categorize actions based on various levels of responsibilities.

## Why Consider CAV Now?

CAV technology is operational on our roads today, making involvement at all levels of government timely and important to establish a balanced approach to the technology's deployment. As outlined in the Maryland CAV Strategic Framework, CAV technology has the potential to:

- **Save lives and reduce the severity of injuries**, with the possibility of nearly eliminating crashes altogether. The Insurance Institute for Highway Safety already recorded real-world crash savings<sup>1</sup> anywhere from 7% to 78% through existing automation.
- **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.

<sup>1</sup> IIHS [Real-world Benefits of Crash Avoidance Technologies](#)

## Menu of Possible Actions

The below outlines three main categories of actions: (1) baseline, (2) medium investment, and (3) high investment. Depending on the jurisdiction's current roles and responsibilities one or more category may apply.

### *Baseline*

The below provides baseline actions local jurisdictions should take to advance their understanding of CAV. It is recommended that all jurisdictions read and understand items 1, 2, and 3, while action 4 expands involvement to the national arena.

#### 1. Know the definitions and trends of Connected & Automated Vehicles (CAV)

- Read definitions in the Maryland CAV Strategic Framework ([link](#)).
- Review the Glossary of Connected and Automated Vehicle Terms ([link](#)).
- Track trends in the news about CAV & attend webinars (free or otherwise) to remain current on the latest available information. Online searches are a quick way to sign up for newsfeeds (e.g., PAVE) and to read up on the latest news.
- Be cognizant that CAV will have impacts to infrastructure, such as lane markings, sensors used for detection of vehicles or pedestrians, among others. See item 4 for additional resources regarding infrastructure impacts.
- Understand that integrating CAV technology into our communities will require a balanced approach. A common misconception is that CAV technology only applies to single occupancy vehicles. Companies and software developers today are involved in new mobility solutions across multiple mobility solutions, which include transit, freight, wheelchairs, pods, fresh food delivery vehicles, shared mobility options, etc.

#### 2. Read & familiarize yourself with the Maryland CAV program resources

- Review the Maryland CAV Strategic Framework ([link](#)), which includes:
  - » The Maryland CAV Vision.
  - » State guidance on key focus areas to consider when preparing for CAV.
- Visit the Maryland CAV Program page ([link](#)) to find:
  - » What has been done in Maryland for CAV.
  - » Links to additional resources for CAV research, testing, & implementation.
- Contact the Maryland CAV Program at [CAVMaryland@mdot.maryland.gov](mailto:CAVMaryland@mdot.maryland.gov) to coordinate directly with a program manager.
  - » This action is highly recommended for those who wish to join subgroups, share knowledge and learn about statewide goals and initiatives.
- Review national/state legislation on CAV ([link](#)) to understand national perspectives.

### 3. Clearly establish roles and responsibilities for & within your local jurisdiction

- Evaluate where and how the actions recommended within this document fit based on your jurisdiction's current resources and responsibilities. **Not all actions outlined in this document are realistic to be implemented by all jurisdictions within Maryland.** We recommend understanding how your current roles and responsibilities might be affected by preparing action plans, implementing, and/or monitoring/operating the proposed actions.
- Reach out to other stakeholders within your communities, bordering jurisdictions, and statewide, to broaden baseline knowledge and encourage dialogue. Collaboration is a key component to the success of CAV and this step will go a long way to adopting the technology within the state. This action can take the form of participating in the statewide CAV subgroups ([link](#)).
- Understand the level of awareness of your decision-makers and staff about CAV technologies and pursue consistent outreach so that when turnovers occur, the knowledge about the impacts of CAV technology is not lost.

### 4. Consider expanding your participation to the national dialogue (Optional)

This action item provides resources to those who want to expand their knowledge to the national platform. The national dialogue for CAV spans across many agencies, groups, committees, and academic institutes from across the nation. The below list is by no means comprehensive but provides some insights on the many ongoing national efforts related to CAV.

- USDOT Automated Vehicle activities ([link](#)) and related USDOT efforts:
  - » US DOT ITS JPO Connected Vehicle Pilot Deployment Program ([link](#))
  - » US DOT CARMA ([link](#))
  - » US DOT Work Zone Data Exchange ([link](#))
  - » US DOT NHTSA Technology & Innovation ([link](#))
  - » US DOT NHTSA Levels of Automation ([link](#))
  - » US DOT NHTSA AV Test Tracking Tool ([link](#))
  - » USDOT's Accessibility & Inclusive Design ([link](#))
- Cooperative Automated Transportation (CAT) Coalition ([link](#))
- Connected Vehicle Pooled Fund Study Research Findings ([link](#))
- National Association of City Transportation Officials ([link](#))
- National Association of Counties ([link](#))
- American Planning Association AV Resources ([link](#))

- Association of Metropolitan Planning Organizations (AMPO) Regional Planning for CAV ([link](#))
- Center for Automotive Research (CAR) Group ([link](#))
- ITS America policy resources related to ITS and autonomous vehicles ([link](#))
- Partners for Automated Vehicle Education ([link](#))
- NCHRP research reports on planning for CAV (20-102, 08-117, among others) ([link](#))
- Examples of local CAV plans/strategies ([link](#))
- Past research done within or impacting Maryland that might be of interest:
  - » Fehr & Peers AV impacts using the MWCOG model ([link](#))
  - » Michael Baker International VTrans2040 Scenario Analysis ([link](#))

### *Medium Investment*

The below outlines a menu of actions local jurisdictions could take to prepare for CAV. Please note that **not all the items outlined in this menu of actions are realistic to be implemented by all jurisdictions within Maryland**. The below also does not cover all possible actions a jurisdiction could take, but together with the guidance provided in the Maryland CAV Strategic Framework, serves as a starting point for actions to increase CAV activity to address mobility and safety needs.

### *Community Vision & Needs*

- Develop a vision for the future of your communities & the next generation transportation ecosystem.
  - » Creating a visual representation of the future of your community is an exciting and momentum generating exercise that brings communities together. These can be done through community meetings, online brainstorming sessions, surveys, etc. and push the boundaries of what is needed now, versus what is desired in the future for the next generation.
  - » When developing these visions, identify and articulate how they affect safety, efficiency, sustainability, equity, and reliability. These can then be documented directly in local transportation, comprehensive, or CAV strategic plans.
  - » Using the vision of the future, define goals and policies to demonstrate how CAV technologies can contribute to achieving the overall transportation vision and goals.<sup>2</sup> Tying to transportation goals aligns your needs with future funding opportunities that often have predetermined categories at both state and federal levels, such as Every Day

<sup>2</sup> AMPO [Regional Planning for CAV and APA: Preparing Communities For Autonomous Vehicles](#)

Counts ([link](#)), Maryland Highway Safety Office ([link](#)), US Department of Transportation federal grants such as RAISE, INFRA, and the ATCMTD, among others.

- Identify barriers to achieving current needs and the above vision of the future through CAV solutions.
  - » Consider timeline of needs, for example long term community needs or one-time projects.
    - Example of a long-term community need: expanding the mobility of aging community to improve their quality of life.
    - Example of a one-time project: an automated shuttle service deployed for a few months only.
  - » For jurisdictions that include multiple population densities, consider that needs will vary across urban, suburban, and rural communities.
  - » Tie needs to existing CAV solutions to accelerate adoption, such as:
    - Need for healthy food can be tied to automated food delivery systems, such as Personal Delivery Devices (PDD) and freight delivery solutions (e.g., Udelv, Nuro, Gatik, FedEx, and Amazon).
    - Need for increased accessibility to mobility constrained communities can be tied to automated shuttles, ride-hailing, automated wheelchairs, etc.
    - Desire to reduce single-occupancy vehicles can be tied to shared automated mobility solutions (e.g., “robo-taxis”).
  - » Intentionally broach equity and social justice barriers.
    - Consider role of CAV in closing the gap on food deserts – i.e. let the vehicle do the work of bringing food to areas currently unable/limited in access to healthy, fresh, and nourishing food.
    - Use CAV solutions for mobility constrained populations, to include people with disabilities and aging/youth.
- Identify CAV strategies and programs that fit your jurisdiction based on the needs identified above.
  - » Consider the use of scenario planning to understand fiscal impacts & what policies and programs are most aligned with your community.
  - » Consider how to message out to the public, including through public workshops, web resources, tying to the larger Maryland CAV program, among other strategies.
  - » Plan for CAV deployments as a regional or local transportation policy issue alongside safety enhancements, signal synchronization, goods movement, economic development, and incident response (among others).

### *Multimodal Strategies*

The advent of CAV without clear expectations on what vehicle types are permitted is likely to skew the vehicle mix toward single-occupancy vehicles (SOV) and in the longer term zero-occupancy vehicles (ZOV), which in turn may significantly increase vehicle miles traveled and the congestion within communities. The actions outlined in the following list are geared towards jurisdictions who wish to manage the mix of vehicles within their communities to reflect a more multimodal approach. These actions are entirely the decision of the jurisdiction and in no way reflect MDOT or MDP opinions on these mobility solutions.

- Adopt language in planning documents, leadership briefings and materials, and other documents that clarify your stance on shared and high capacity CAV mobility within your community.
  - » Address multimodal priorities up-front and clearly to help manage the mix of vehicles, rather than react to the situation after it has affected you.
  - » Consider the complete streets and walkable communities<sup>3</sup> approach when implementing this strategy.
- Develop strategies and programs to broaden the availability of automated ride-sharing services to all segments of the population within your communities.
- Future-proof for potential reduced parking demand by creating redevelopment strategies for existing parking facilities and new parking regulations for other developments with required parking.
- Consider first/last mile public-private-partnerships (P3) solutions that enable jurisdiction to reallocate funds to the main trunk of transit routes. This will allow jurisdiction to maintain core transit routes while deploying more 'custom' CAV solutions for first/last mile that increase transit use. See the Fehr and Peers<sup>4</sup> analysis showing the increase in transit use when communities had more first/last mile vehicle solutions.
- Consider the impact to any taxi commissions over microtransit, ride-hail services, and other mobility provider service models in your community (e.g., existing agreements that might be violated by new mobility solutions). Parallels exist with Transportation Network Companies (TNCs) and e-scooter services that could be applied to CAV services.
- Determine if you will use single vendor or multi-vendor business models across the different automated vehicle solutions (e.g., allow exclusive vendor all rights or require mix of vendors).
- Consider how CAV can enhance just-in-time delivery services. Greater travel time reliability can enable businesses and others to expand their use of just-in-time services, thus improving economic vitality and resiliency.

<sup>3</sup> NACTO [Blueprint for Autonomous Urbanism 2<sup>nd</sup> edition](#)

<sup>4</sup> Fehr and Peers [MWCOC CAV Scenarios](#)



- Freight CAV solutions have demonstrated potential economic savings to private industry and increased safety benefits. Consider how you want freight and logistics to move within your communities, how delivery packages through automated vehicle solutions might benefit access to services to communities or if restrictions are needed.
- Consider an emphasis on overnight delivery services: automated delivery vehicles could be deployed during the evening to make overnight deliveries, reducing the need for them to be on the road during the day or at peak travel times and taking advantage of greater roadway capacity during the overnight hours.

### *Land Use and Zoning*

- Assess existing land use and development policies and regulations affecting or being affected by CAV deployment and CAV infrastructure building.
  - » Assess site design and development to accommodate and promote positive outcomes of CAV.
  - » Address potential land use changes resulting from CAV and other emerging technologies (e.g., electric vehicles and e-commerce) such as increased warehousing/distribution uses and CAV staging/service sites.
- Assess local regulations and policies that affect public property or right-of-way access and pole attachment for CAV infrastructure.
- Consider implications to parking and related revenue streams.
  - » A vehicle may no longer need to park if the user can simply call it over when they need it (rather than parking it to make sure they can then get home).
  - » The fiscal implications might be a loss of revenue for that jurisdiction if no vehicles park at designated parking spots, or parking violations no longer occur.
  - » If a CAV no longer needs to park, a jurisdiction may also intentionally choose to remove all parking areas to allow for other uses, such as open-air parks, or lane utilization for vulnerable roadway user lanes (e.g., bicycle lanes).
  - » Automated Vehicles have a tendency towards being electric vehicles (EV). Consider that parking infrastructure may need to adjust to allow for the charging of a CAV/EV. For more information about EV initiatives in Maryland please see this [link](#).
- Identify current revenues and understand which ones will be affected by CAV, leading to a better understanding of how to mitigate, or benefit, from the impacts.
- Increase the dialogue around accessibility, ADA compliance, and inclusive design to improve quality of life for all mobility constrained communities. This could come as ordinances to include metrics related to accessibility within your permits or traffic impact studies.



- Make a policy on use of curb space and/or implement land use requirements to enforce how the curb will be managed within your jurisdiction for CAV, and other human driven vehicles.
  - » Consider designating load/unload curb space within land use/zoning process to begin the build out of systematic locations for vehicle drop off/on. Questions that can help with this decision: How will the curb space be designated? Will the curb be used for loading/unloading of people and/or goods? If so what types of vehicles would be permitted to load/unload (e.g., only shared vehicles, ride hailing vehicles, delivery vehicles, etc.)? What times of day can they be present?
  - » Will there be appointment times where only goods deliveries are permitted so that services continue to optimize their profits and return revenue to your region? Consider research and other pilots done on appointment systems, such as the Washington DC 12-week pilot<sup>5</sup>.
  - » Will you implement policies to generate revenue from the use of curb space?
  - » Update access management design guides and reference materials to acknowledge the impacts of CAV and suggest ways in which they can be accommodated, e.g., replacement of parking requirements in a zoning ordinance with drop-off/pick-up zones.<sup>6</sup>
- Consider developing designated CAV and/or ZOV “holding zones”, or corridors, where vehicles can be kept but be easily accessible when called upon to drive someone to their destinations.
  - » These could be tied to main arterials where traffics enters or exits your community, thus reducing vehicle mileage on low speed regions and allowing flexibility of movement to/from your community.
  - » Consider whether they park and “wait” or whether they continue to drive around the city for immediate/short times for pick up.

### *Workforce Readiness*

- Review current skill sets for agencies running city/communities to consider whether they can address CAV needs, such as maintenance of the vehicles, sensors, etc. and then establish a plan on how to improve those skillsets.
  - » This may include partnerships across jurisdictions who have training centers.
  - » Consider 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 between jurisdictions.
- Engage local emergency responders on their ability to react to CAV.

<sup>5</sup> [DC Curbed Article](#)

<sup>6</sup> [AMPO Regional Planning for CAV](#)

- Promote inclusion of CAV topics in Science Technology Engineering Art & Mathematics (STEAM), school, and educational events, which has a consequence of attracting businesses while preparing the next generation for the future transportation ecosystem.
- Engage tech companies within your jurisdiction to determine if they are working on CAV issues.

### *Attract CAV Deployment*

- Engage with vendors early to start understanding each vendor's limitation and benefit.
- Consider incentivizing CAV deployment, which might include:
  - » Granting multimodal CAV solutions access to parking at reduced costs.
  - » Granting high-occupancy CAV access to dedicated lanes or facilities.
  - » Promoting P3 solutions, while exercising caution about utilizing a single vendor for too long.
- Develop fleet transition plans to identify opportunities for zero electric vehicles and CAV.
- Identify districts or corridors that can be transitioned to become "innovation sandboxes" for CAV pilots, testing curb loading/unloading, ride hailing for communities, etc. where restrictions are officially designated as more flexible.

### *High Investment*

The below actions are attached to physical and digital infrastructure to support CAV. Both menus of action are high cost and time consuming, though provide a significant return to the CAV ecosystem. The actions below are recommended to jurisdictions who manage larger systems and have resources meant to deal with both physical and digital needs. Jurisdictions that do not invest heavily in either should read and understand the below to recognize how they fit in the bigger picture transportation ecosystem.

### *Physical Infrastructure*

Infrastructure considerations for a local jurisdiction can result in significant cost and are not a requirement for CAV at this time. The below actions may not be appropriate for all jurisdictions, and several actions relate directly to how much maintenance and operations a jurisdiction can manage. We do not recommend the below for jurisdictions that do not currently, or in the future wish to, control signals, radios, or other electronic devices within their roles and responsibilities.

- Assess infrastructure needs to support CAV deployment such as road marking and signages, smart-signals, dedicated lanes, electric vehicle charging stations, communication radios (e.g., dedicated short range communications or cellular), high-speed broadband, and wireless networks.
  - » This action will have long term impacts on your community. The assessment of your current assets, where you want to deploy, how you will maintain, and possibly

expand to new automated services can be a large endeavor, but also an important first step that is strongly encouraged across all jurisdictions.

- » Create a detailed asset map and maintain it to be as up to date as possible. This should also include tracking of software updates.
- Collaborate with your neighboring jurisdictions and statewide groups to promote interoperability across jurisdictions. CAV technology is more likely to succeed if they are able to operate seamlessly across jurisdictions. Several efforts are already underway (i.e. statewide working group), allowing you to save time and cost. This is also more attractive to businesses as they do not need to change their systems significantly for every town, city, county, or state they operate in, thus increasing economic vitality.
- Invest in connected vehicle (CV) infrastructure that enables applications that matter to your jurisdiction. Examples include but are not limited to:
  - » Work zone data (e.g., lane closures, detailed lane shifts etc.).
  - » Signal Phase and Timing and MAP (i.e., intersection geometry) data to support red light violations, departure on green, eco-driving, and other smart signal applications. An example jurisdiction applying these applications includes National Harbor, through the Prince George's County Department of Public Works & Transportation.
  - » Vulnerable roadway user (e.g., pedestrian) in roadway warnings. Once such deployment exists through the MDOT State Highway Administration at MD 214 in Prince George's County.
  - » Signal priority systems for shared mobility, transit, and freight, where appropriate to facilitate their movement in/out of the city and reduce their financial burdens (thus making your region more attractive for businesses).
  - » Communications infrastructure such as fiber and wireless systems.
- Consider how to fund the maintenance of control devices (e.g., stop sign, lane markings, etc.) to the best of your ability. CAV can “see” most of these control devices, but if they are in poor condition, they may not recognize them, resulting in subpar and possibly unsafe operations.
- Confirm that communication infrastructure policies are comprehensive and up to date; for example, whether the city is currently including a “dig once” policy which reduces the cost of a comprehensive fiber network.

### *Digital Infrastructure*

Similar to physical infrastructure, digital infrastructure actions are a heavy lift both in cost and time for any jurisdiction, but result in a more efficient CAV ecosystem and savings to the jurisdiction on the long term. The below actions should not be invested in without an understanding of how the jurisdiction will manage these assets over time.

- Consider each project, policy, and opportunity as a piece of a “system” that must fit into a larger system in order to generate benefits and be sustainable and equitable. Local jurisdictions should be investigating how their piece of the “system” fits into the larger picture as soon as possible.
- Establish channels and platforms for data exchanges to allow for a broad and interoperable CAV ecosystem of information. Interoperability is critical to CAV adoption, so jurisdictions should implement in their procurements and standard operating procedures that software platforms with CAV capabilities have the capability of exchanging information across various platforms (e.g., Application Programming Interfaces).
- Create a fully digitized map of your jurisdiction so CAV have a redundant map to confirm infrastructure placement and routing.
  - » This does require constant updates should a road infrastructure project add turn lanes, change signs, etc. and can be costly to maintain.
  - » Consider that currently, vendors are more likely to create their own maps so they have more control over the information and details they need to operate their vehicles.
  - » Alternatives to this include a crowdsourced based platform validated by the jurisdiction on a monthly, weekly, or even daily basis.
- Prioritize open data formats, platforms, and systems during procurement so jurisdictions can take advantage of the best technologies without getting locked into proprietary vendors.
- Begin considerations of a system-wide transportation management system (TMS) that can incorporate artificial intelligence to manage the future transportation ecosystem. This digital transportation infrastructure should not only include the ability to enable CV data in the future but also support multi-modal systems and programs like real-time travel-time sharing.
  - » Determine how the information flow integrates with 3<sup>rd</sup> parties and statewide systems.
  - » Define how large amounts of data will be received, stored, and reshared, if at all.
  - » Utilize increased deployment of sensors to improve the system’s situational awareness.
  - » This means an increased annual operational cost to maintain functional sensors.

- » While the use of “big data” removes physical maintenance costs, it does raise privacy concerns and the potential for cybersecurity threats if not managed properly.
- Identify, enhance and expand cybersecurity protocols to cover operational technologies such as field devices, like traffic signals.
- Develop a standard data-sharing agreement for ride-hail, micro-transit operators, and any CAV platforms interacting with the jurisdiction’s transportation ecosystem. This could be done across, or in partnership, with multiple jurisdictions and/or with state agencies.
  - » If piloting a CAV solution, ask for valuable data such as the number of crashes, near misses, take overs, etc.
  - » Long-term, consider the impacts of single vendor agreements over diversified teams of vendors.

- End of document -