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Connected and Automated Vehicle (CAV) Planning Guide: Recommended Actions for Local Agencies to Prepare for CAVs

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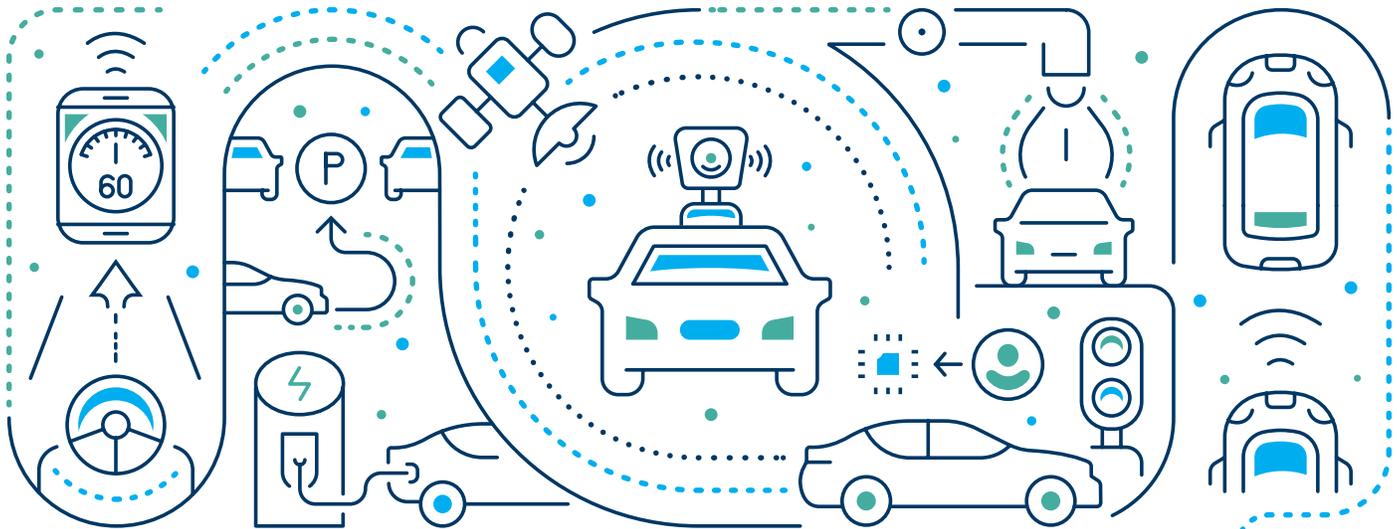
Introduction

Now is the optimal time for federal, state, and local governments and agencies to start planning and preparing for connected and automated vehicles (CAVs). Agencies can learn as the technology continues to evolve and be tested before CAVs make up more of the vehicles in operation.

The Connected and Automated Vehicles (CAV) Integration for Local Governments project provides an overview of potential CAV impacts and recommends actions local agencies can take to prepare for the safe, efficient, and equitable adoption of CAVs in the Baltimore region.

This guidance was based on a literature review of best practices at the national, state, and regional levels. The best practices were tailored to create recommendations specific to the Baltimore region. A user guide compliments this document to help agency staff understand and implement the recommendations.

The following sections outline:

- Potential positive and negative impacts of CAVs, which may vary by technology.

- Strategies to leverage positive impacts and to limit and mitigate negative impacts of CAVs.

- Specific, customized, realistic actions BMC and its partner agencies can take to prepare for CAVs including, planning, pilot programs, evaluation, deployment, operations, and maintenance.

What are CAVs?

Connected vehicles (CVs) use wireless communications to share and receive information from other vehicles, the infrastructure, or other users interacting with vehicles within the roadway (e.g., a pedestrian). Communicating with infrastructure could help CVs move more efficiently through signalized intersections (such as Transit Signal Priority) or share travel and safety information with drivers (like upcoming work zones, crashes, or weather events using in-vehicle messaging).

Automated vehicles (AVs) perform some or all driving tasks for a human using sensors, cameras, automated driving systems, or other technology.

Connected and automated vehicles (CAVs) combine the information sharing of connected vehicles and the "brain" of automated driving systems. Combining connectivity and automation enables a CAV to know what is happening multiple vehicles ahead (like slowing down, hard braking, or a traffic signal changing). Communication between vehicles could enable Cooperative Adaptive Cruise Control (CACC), speed harmonization, shorter following distances, and reduced delay at traffic signals. The recommended actions in this document focus on preparing for vehicles that are both connected and automated. However, it is important for local agencies to also plan for connected vehicles and supportive communications infrastructure that local agencies can control (like signal controllers, traffic management centers, and roadside units).

CAV is an umbrella term for a variety of technologies and use cases. This CAV Planning Guide provides recommendations specifically for roadway applications. However, agencies should monitor other use cases for transportation automation, including rail transport, urban air mobility, and drone deliveries.

Key Near-Term Actions for Local Agencies

Over the next 1-2 years, local agencies should take the following key actions to begin preparing for CAVs:

Cross-Cutting

- **Coordination.** Coordinate all CAV planning efforts with the State and BMC. Follow state guidance on CAVs. Share your vision, goals, plans, policies, and other actions with the State and with your surrounding jurisdictions. Partner with local, regional, and state partners to secure funding and to avoid siloed, localized CAV planning efforts. Regularly meet with critical partners and local champions. BMC will play a key role in coordinating efforts among local governments; sharing and documenting best practices; and conducting outreach to the public, policymakers, and other partners.

- **Safety.** Identify safety partners and define safety goals. Engage the Emergency Responder Subgroup of the MD CAV working group and include a Safe System Approach as an underlying priority throughout the recommended actions, visioning, and goal setting.

- **Freight & Goods Delivery.** Consider different needs and use cases for CAVs used for freight and goods delivery, which might be adopted earlier than widespread passenger movement applications of CAVs.

Planning

- **Organizational Readiness.** Define your agency's vision for CAVs, tied to existing local goals. Identify partners and nominate a CAV champion(s) in your agency who will participate in partnerships and working groups (like the Maryland CAV Working Group) to learn about national trends and news, advocate for your agency's CAV vision, and work across internal offices to coordinate CAV planning and investments.

- **Equity and Accessibility.** Include equity and accessibility partners in all projects and develop requirements for CAV service to underserved communities. Include groups and partners from vulnerable and underserved populations on all project partner lists, steering committees, and advisory committees. Local agencies should share with BMC their equity and accessibility goals and needs as they develop policies and infrastructure enhancements. BMC can champion those needs at the state level with the Department of Disabilities and the Maryland CAV Working Group. Local agencies can also develop procurement policies requiring accessible and equitable service for underserved communities.

- **Planning and Land Use.** Integrate desired outcomes of CAVs and other emerging technologies (such as needs for loading/unloading zones or electric vehicle charging stations) into land use and transportation plans, regional travel demand models, building and zoning codes, and design manuals.

- **Funding, Financing, and Fiscal Health.** Plan for the impact of CAVs on local fiscal health including impacts to transportation revenue; land use fees; and procurement, operations, and maintenance costs.

- **Travel & Mobility.** Continue to prioritize multimodal mobility and Complete/Slow Streets policies. Focus on safely accommodating all travelers, including people with disabilities, pedestrians, bicyclists, transit riders, and drivers. Placemaking, walkability, and accessible transportation options are critical to serve today's travelers and prepare for a CAV future.

Workforce Development

- **Workforce & Education.** Invest in people and the future of the workforce. Advocate and champion policies with the State training and education programs.

Infrastructure

- **Physical infrastructure.** Maintain infrastructure in a state of good repair and advocate for adequate funding to serve today's users and to facilitate the transition to CAVs. Begin with improvements that benefit all travelers today. Examples include high quality and consistent crosswalk markings, pavement markings and striping, and signage. Supplementary improvement may also include flex posts, raised pavement markings, and speed calming measures. This approach provides benefits regardless of CAV deployments by re-orienting public space with all users in mind.

- **Data Privacy & Security.** Follow guidance or industry standards for collecting, storing, and securing CAV data. To reduce privacy risks, request only processed and aggregate data to measure success against performance measures and practice good cyber hygiene.

More specific actions are provided in the following sections. A summary of these key near-term actions is also provided at the end of the document.

CAVs in Maryland

CAVs are emerging and, in some cases, are already here. Numerous efforts are underway in Maryland to collaborate, plan, and prepare for CAVs. The Maryland Connected and Automated Vehicle Program provides a central location for activities around the state.

The Maryland Department of Transportation (MDOT) and the Maryland Department of Planning (MDP) have prepared guidance for local jurisdictions on how to prepare for, plan for, or implement CAVs and their supporting technologies. Their Connected & Automated Vehicle Toolkit for Maryland Local Jurisdictions outlines three levels of action jurisdictions can take: Baseline actions, Medium Investment, or High Investment. Jurisdictions can do more than one.

- *Baseline actions* are to get smart on terms and resources, to clearly establish roles and responsibilities for and within the agency, and to join the national dialogue on CAVs.

- *Medium investment* includes understanding the community vision and needs, multimodal strategies, land use and zoning, workforce readiness, and attracting CAV deployment.

- *High investment* includes actions related to the physical or digital infrastructure.

Other state-wide plans for CAVs include:

- MDOT CAV Strategic Framework provides overarching strategic direction for Maryland, meant to inform, guide, and empower partners to build their own CAV implementation plans.

- SHA CAV 2021-2025 Implementation Plan focuses on SHA's area of responsibility, including non-tolled State arterials and highways.

- MDTA Planning for CAV Readiness describes Maryland Transportation Authority's current CAV readiness and next steps.

- MDTA 2018 CAV Strategic Plan focuses on a near-term action plan from 2019-2024.

The **Maryland CAV Working Group** meets several times yearly (established in 2015) to provide opportunities for partners to collaborate, learn what's happening across the state, and hear directly from industry leaders. The CAV Working Group has four subgroups focusing on Emergency Responders, Freight, Policy, and Technology. The subgroups each meet 3-4 times per year in addition to the overall Working Group. For more information, reference the Working Group Charter on the Maryland CAV website.

BMC's Resilience 2050 Emerging Technologies White Paper (2022) provides an overview of recent and expected advances in transportation technologies across a range of modes.

Maryland's CAV website tracks all current activities happening in the state. Key 2022 state, regional, and local accomplishments in Maryland included:

- Updating the Motor Vehicle Administration's Drivers Manual to include Advanced Driver Assistance Systems (ADAS), the first state in the U.S to do so.

- Deploying Kiwibot Personal Delivery Devices (PDDs) at Morgan State University.

- Updating the state's Emergency Response Plan to include recommendations for appropriate procedures for testing and deploying truck platooning and personal delivery devices.

- Continuing the next phase of Westminster's Autonomous Corridor project. Westminster's Mid-Atlantic Gigabit Innovation Collaboratory (MAGIC) is creating public-private partnerships to develop autonomous and smart city technologies.

- Receiving 7 additional (total of 46 since 2017) expressions of interest from companies to test CAV technology in Maryland.

- Establishing collaboration between Johns Hopkins University and Howard County to plan and implement a smart and connected community concept within Howard County's Gateway Innovation District.

- Continuing deployment of connected vehicle roadside units across the state, including in the Baltimore region.

- Expanding automated vehicle technology capabilities at the Aberdeen Test Center (ATC).

- Researching and testing automation at the Army Research Laboratory Robotics Research Collaborative Campus (R2C2).

The recommendations in this plan provide specific actions for local jurisdictions in the Baltimore region to continue to expand existing efforts to prepare for CAVs.

State and Local Partner Engagement

A **Steering Committee** representing diverse perspectives from across the Baltimore region provided insights on the needs, gaps, and opportunities for CAV impacts on transportation in the region. The steering committee also reviewed and provided feedback on the recommendations and user guide. Steering Committee members represented:

- Local Transportation, Public Works, and Planning agencies.

- Emergency Responders.

- Baltimore Metropolitan Council (BMC).

- Local Planning Departments.

- Maryland Department of Transportation (MDOT).

- Maryland Transportation Authority (MDTA).

- Maryland Transit Administration (MTA).

- Maryland Port Administration (MPA).

- State Highway Administration (SHA).

- Motor Vehicle Administration (MVA).

- Maryland Department of Disabilities (MDOD).

Additionally, the project team held **Interviews** with a wide range of transportation agencies, users, service providers, and emergency responders who have some knowledge or experience with CAVs. Input from the interviews was also used in the development of the CAV recommendations.

Interviews were conducted with representatives from the following organizations:

- State Highway Administration.

- Maryland Port Administration.

- Baltimore City DOT.

- Baltimore County.

- Carroll County.

- Howard County.

- Maryland Department of Disabilities.

- Morgan State University.

- Kiwibot.

- Emergency Responders (State Police, County Fire Departments).

Key opportunities and challenges for CAVs identified by the Steering Committee and Partner Interviews included:

- **Equity.** Access for underserved communities, including people with disabilities, older adults, and people living in food deserts.

- **Safety.** Impacts on overall system safety, including speeds, crashes, congestion, enforcing rules of the road, and data privacy.

- **Built Environment & Infrastructure.** Land use and potential infrastructure needs such as communication networks, dedicated lanes, parking, roads, electric vehicle charging stations, and sidewalks.

- **Collaboration.** Partnering with new companies, service providers, and other agencies.

- **Community Education.** Identifying key champions and local partners to be involved in planning, education, outreach, and support.

- **Emergency Response.** Updating first responder training, enforcement procedures, and response plans, and improving vehicle predictability (e.g., moving over for emergency vehicles or responding to human traffic control).

CAV Impacts

CAVs could potentially reduce crashes, increase roadway capacity, improve travel time reliability, enable new mobility service solutions, and improve the movement of goods. On the other hand, CAVs might increase vehicle miles traveled and exacerbate inequities in the transportation system.

The equity impacts of CAVs on the transportation system and industry will be influenced by policies at the federal, state, and local levels to ensure the widespread use of CAVs doesn't leave behind underserved communities.

To help agencies prepare, Table 1 outlines potential CAV benefits and challenges as they relate to BMC's Resilience 2050 goals.

Table 1. Potential Impacts of CAVs Compared to BMC's Resilience 2050 Goals

Resilience 2050 Goal	Potential CAV Benefits to Help Achieve Goal	Potential CAV Challenges to Reaching Goal
Improve Accessibility *Identify and support multimodal options and systems that enable all individuals to reach their destinations safely and seamlessly.*	• Reduced travel time if CAVs reduce congestion. • Reduced vehicle ownership costs if CAVs are shared. • Reduced vehicle maintenance costs if CAVs are electric due to fewer fluids such as engine oil that require regular maintenance, reduced brake wear due to regenerative braking, and parts needing maintenance relative to internal combustion engine. • Reduced labor costs if no drivers/operators in vehicles and potential for new job creation/training opportunities.	• Unknown sustainable price point (cost) for CAV trips. • Unknown real-world consumer use and acceptance of CAVs. • Availability and costs of CAVs sufficiently equipped to aid older adults or people with mobility, sensory, or cognitive disabilities. • Availability of human assistance for people with disabilities entering/exiting vehicles or attaching lap/shoulder belts.
Improve Equity *Identify and support multimodal options and systems that promote equity for all individuals.*	• Opportunities to meet transportation and safety needs of persons with disabilities, underserved populations, and older adults. • Opportunity to reduce cost of deliveries (food or otherwise) thus increasing opportunities for underserved populations to receive goods and food.	• Specialized policy or legislation might be needed to ensure disadvantaged and rural communities, unbanked travelers, and those without a smart phone can access and benefit from CAVs. • Costs may need to be subsidized to make CAV technologies affordable for all users. • On-demand CAV deployment areas may not provide access to underserved communities without policy or legislation.
Increase Mobility *Help people and freight move reliably, equitably, efficiently, and seamlessly.*	• New mobility options for travelers who do not drive or own personal vehicles. • Improve transit connections by reducing first-/last-mile trip costs or increasing accessibility in lower-density or other areas with gaps in the transit network. • Increased roadway capacity and throughput.	• Competition with high-occupancy public transit. • Potential for reduced capacity if AVs cannot communicate with other vehicles and are more conservative or leave more space between vehicles than human drivers. • Traffic and safety risks from unresponsive CAVs in rights-of-way. • Increased competition for limited curb space, including induced demand for e-commerce in underserved areas from reduced freight delivery costs. • Reduced occupancy in short-term if seats are unavailable due to on-board computer storage requirements.

Resilience 2050 Goal	Potential CAV Benefits to Help Achieve Goal	Potential CAV Challenges to Reaching Goal
Improve System Safety *Reduce the number of crashes, injuries, and fatalities experienced by all users of the system toward meeting Zero Deaths Maryland.*	• Faster reaction times than humans. • Not distracted, impaired, or drowsy. • More predictable around emergency responders or work zones. • Ability to geofence speed limits in designated slow zones (or disable a vehicle by law enforcement in emergencies or restricted areas). • Additional safety features with low-level automation features like Advanced Driver Assistance Systems. • Personal security benefits for travelers preferring driverless service over taxis and ridehailing services due to fears of physical assault.	• Crash risks might increase. • Exposure rates increase if Vehicle Miles Traveled (VMT) increases. • Drivers and other travelers might not understand the technology. • CAVs might not detect vulnerable road users. • CAVs might not know how to react to edge cases. • New personal safety risks might occur for riders with no driver.
Improve and Maintain the Existing Infrastructure *Improve conditions of facilities; systematically maintain and replace assets as needed.*	• Opportunity to invest in roadway improvements that benefit all users today (ex: Complete Streets/ Slow Streets, enhanced crosswalks, smooth pavements, and clear striping and signage) while also preparing operational environment for successful adoption of CAVs.	• Some functions of CAV are limited due to poor or non-existent high-speed communications networks. • Maintaining and upgrading roadside technologies might not be feasible, practical, or cost effective and could create interoperability challenges. • Poor sidewalk condition or pathway conflicts might obstruct personal delivery devices (PDDs). • Maintenance costs could increase due to heavier vehicles on roads or personal delivery devices on sidewalks. • Additional infrastructure costs to install charging stations.
Create an Environmentally Responsible Transportation System *Pass on the healthiest natural and human environment possible.*	• Reduced emissions and noise pollution from reduced congestion and zero-emission CAVs. • Reduced VMT compared to ridehail if robotaxis are stored in central locations (compared to taxi or ridehail drivers that have to commute to / from service areas).	• Increased VMT from zero-occupancy trips. • Increased VMT from travelers willing to move further away from urban center and travel longer distances due to less onerous and more productive travel in a CAV. • Increased VMT if robotaxi companies over-supply vehicle fleets to minimize passenger wait time. • Increased pollution from increased VMT if CAVs are not ZEV. • Addressing potential environmental impacts of battery manufacturing, replacement, and end-of-life recycling.
Promote Prosperity and Economic Opportunity *Support community and business vitality, worker opportunities, and the movement of goods and services.*	• Reduced driver stress. • Repurposed auto-centric land uses. • New partnerships between local educational institutions, agencies, and industry to provide technology workforce training. • Reduced freight costs could bring more affordable delivery options to food deserts and serve other essential needs. • New service modes increase competition, allowing for reduced monopoly and more affordable price points for services. • New jobs for maintenance and operations of CAVs, especially in S.T.E.M. fields.	• Potential job displacement due to automation. • Need for workforce retraining.
Promote Informed Decision Making *Ensure adopted transportation policies and performance measures guide the regional decision-making process.*	• Real-time & historical information about traffic, safety, pavement, construction, or weather conditions from CAVs and roadside equipment.	• New skills and cloud resources needed to manage big data from CAVs. • New training needed for maintenance, operations, and emergency responders (ex: installing and repairing infrastructure, pulling over a CAV, responding to a crashed or disabled CAV, or manually directing traffic). • Technologies change more quickly than public sector can react to. • New performance measures and analysis tools to support data-driven decision making.

Functional Roles in CAV Planning

Multiple entities must collaborate to develop policies and governance elements for planning and operating CAVs. Each entity has different roles and responsibilities. The key functional roles are summarized below and detailed in **Table 2**.

- The **Federal government** sets minimum performance safety standards for new vehicles and issues overall guidance and education materials. Key agencies for CAVs include the U.S. Department of Transportation (USDOT) and the Federal Communications Commission (FCC).

- **State and Local Governments** set statewide, regional, and local CAV strategic direction that impacts planning, design, operations, and maintenance of roadways; land use planning; and other traffic laws, regulations, and policies. Local governments can set and enforce rules of the road as permitted by the state, such as speed limits and curb management. States oversee driver training and vehicle registration. In 2021, Maryland updated state laws to allow personal delivery devices to operate on public roads, sidewalks, etc. and to allow truck platooning. In 2021, Maryland lifted the state's prohibition on "following too closely" for electronically connected trucks to facilitate the deployment of truck platooning in the state.

- **Private industry** drives CAV development and deployment. This includes original equipment manufacturers (OEMs) making vehicles, vendors providing sensors and algorithms, and fleets operating CAVs.

- **MPOs / Other organizations (including non-transportation entities)** inform policy, operations, and workforce development by partnering on projects and participating in working groups to provide feedback on CAV opportunities and barriers (including commerce, labor, etc.).

Role of Champions

Local agencies that have successfully implemented emerging technologies have one thing in common—a champion. An **emerging transportation technology champion** is:

- An individual or group.

- Well-networked throughout the local jurisdiction(s).

- Passionate about implementing new technologies.

- Motivated to push for a project's success.

- Pragmatic about how technology can be realistically used to support local goals.

Pilot deployments and sustainable services take years to implement. These champions need to be dedicated and committed to the long-term efforts in the region.

Even if a local jurisdiction will not lead a deployment of its own, the champion can help decision makers understand how CAV applications could impact transportation and public investment and support local goals.

Role of Partnerships

Partnerships are critical to win funding for CAV pilots and deployments. BMC and local agencies can lead workshops with regional partners to refine ideas that may be candidates for a grant application and to identify potential partners before notices of funding are released.

Table 2. Key Roles and Responsibilities in CAV Planning

Private Industry	Federal Government	State Government	Local Government	MPO / Other Organizations
• Manufactures vehicles and equipment and develops CAV technology. • Self-certifies regulatory compliance (such as with Federal motor vehicle safety standards and Federal communications standards). • Manages operations of the vehicle and fleet. • Writes and shares Emergency Responder Interaction Plans to communicate with and educate first responders and local agencies and to meet state permitting requirements (during pilot and testing phase). • Applies first-hand knowledge of what customers want and need out of services they provide (ex: learning how to safely attach lap / shoulder belts for different wheelchair types; or learning boarding/de-boarding processes for people with different disabilities before developing trip performance metrics).	• Sets minimum performance safety standards for new motor vehicles and motor vehicle equipment. • Enforces compliance with safety standards. • Investigates safety-related defects and non-compliances and manages recalls or remedies. • Issues guidance, such as the Federal Automated Vehicles Policy. • Educates the public about motor vehicle safety issues. • Sets national priorities through grant funding and transportation budgeting. • Sets national infrastructure standards.	• Registers motor vehicles. • Licenses human drivers. • Issues permits for automated vehicle operations. • Educates and trains human drivers. • Develops training for older adults and people with disabilities on how to access and use available transportation systems. • Sets and enforces traffic laws and regulations. • Regulates motor vehicle insurance and liability. • Conducts safety inspections, as appropriate. • Updates state street and highway design standards and complies with national requirements. • Sets statewide regulations, policies and guidance through legislation and adopted planning documents. • Monitors revenue impacts to the state Transportation Trust Fund	• Sets and enforces traffic laws and regulations as permitted by the state, such as speed limits. • Updates land use plans, codes, and land development regulations. • Updates building codes. • Updates local street design standards and complies with state and national requirements. • Sets local regulations, policies, and guidance through legislation and adopted planning documents.	• Communicates specialized community needs for safe, acceptable customer services. • Participates in educational outreach. • Advocates for policies that further goals. • Participates in workforce training. • Coordinates planning and funding decisions with the State and local governments.

Table 3 outlines characteristics for a strong partnership between a local agency and a CAV provider. Jurisdictions can leverage these characteristics to achieve local goals and incentivize safe, productive, and sustainable CAV implementations, even if the jurisdiction is not a contractual partner.

Table 3. Characteristics of Strong CAV Partnerships

Characteristic	Local Agency	(C)AV Provider
Clear expectations	Define and be transparent about the challenge to be addressed, goals and desired outcomes.	Showcase how their technological solutions can achieve desired outcomes.
Long-term perspective	Understand that transportation decisions made today can have effects on private industry, both good and bad.	Long-term working relationships can be mutually beneficial and avoid the need to repeat start-up processes in multiple new jurisdictions.
Trust	Set communications expectations, verify outcomes through regular performance reporting.	Set expectations for making adjustments to pilots based on field experiences, work through established agency processes to build community trust.[1]
Nimbleness	Adopt flexible approaches to working with (C)AV providers funding their own pilots, empower agency staff to adjust regulations and fees within limits to adapt to evolving knowledge and technologies.	Be ready and willing to adjust pilots to adapt to lessons learned, have a plan for scaling up the pilot if the desired outcomes are met.
Data sharing and project support	Maintain and provide agency datasets used by the (C)AV technology, prioritize maintenance activities supporting the technology (e.g., refreshing pavement markings).	Provide processed data that can help support agency functions and monitor project outcomes.

Table reproduced from: Ryus, et al., 2022, Automated Vehicle Hosting Handbook for North Central Texas Communities. North Central Texas Council of Governments, Arlington, TX.

1   National League of Cities, April 2017. Autonomous Vehicles: A Policy Preparation Guide.

Recommended Actions for Local Jurisdictions

MDOT created a CAV Toolkit for Local Jurisdictions, which outlines possible actions local agencies could take under baseline, medium, or high levels of investment.

This section builds off MDOT's existing guidance and outlines actionable recommendations specific to the Baltimore region to prepare for emerging technologies. The recommendations in this section are based on the assumption vehicles are both connected and automated.

Now is the time for local governments in the Baltimore region to start preparing for potential impacts of CAVs and learning how public policies can steer CAV adoption to support public goals. The recommendations are based on CAV impacts and are made under these overall categories of impact areas.

Cross-Cutting

- **Coordination:** ensure coordinated plans with other local jurisdictions, BMC, and the State.

- **Safety:** ensure overall safe operations of CAVs.

- **Freight & Goods Delivery:** prepare for impacts on delivery, logistics, and trucking.

Planning

- **Organizational readiness:** identify key actions to improve an agency's readiness for CAVs.

- **Equity and Accessibility:** ensure all travelers in the region have convenient, safe, and equitable access to mobility options.

- **Planning and Land Use:** consider impacts to the public realm, right of way allocation, and curb space.

- **Funding, Financing, and Fiscal Health:** examine impacts of CAVs on traditional transportation revenue sources and potential costs of CAV technology installation and maintenance for local agencies.

- **Travel & Mobility:** consider the role of CAVs in a multimodal transportation system.

Workforce Development

- **Workforce & Education:** train, retrain, and upskill workers.

Infrastructure

- **Physical Infrastructure:** identify physical infrastructure investments needs to support CAVs.

- **Data Privacy and Security:** prepare for an influx of new CAV data; build capabilities to securely collect, manage, and store data; or build partnerships to measure system performance.

Reference Sheets

On the following pages, a 2-page reference sheet is provided with recommended near-term local actions for each impact area. These reference sheets include:

- Overview of the topic area.

- Specific actionable recommendations for local government agencies in the Baltimore region.

  – Each recommendation includes a timeframe such as short (1-2 years), medium (3-5 years), and long (5+years);

  – Estimated level of staff effort (low, medium, high); and

  – Primary local government agency responsible.

- Links to additional resources for more information.

- Example case studies of agencies taking innovative actions.

Preparing for CAV Impacts on Safety

Local governments want CAVs to operate safely and to protect the public from crashes or malfunctions. CAV performance could be different if there is a backup safety driver in the vehicle or not. Local agencies will need to work closely with the State on specific proposals, regulations, and policies to govern CAV testing and deployment. Local agencies might also need to develop procedures for responding to CAV crash events or other incidents.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Coordinate with MDOT to develop **operational readiness performance** measures for CAVs to meet before proceeding from testing to deployment to ensure safety.	Medium	Medium	Transportation Department coordinating with BMC and MVA
Monitor and advocate for safety performance measures of CAV deployments (crash and personal safety metrics). Example performance measures may include: • Number of reported crimes, crashes, and severe injuries. • Number of hard braking events (location, time, date). • Number of false-positive hard braking events (location, time, date). • Number of crashes involving a CAV (this may require new reporting procedures and training).	Low	Short	Transportation Department coordinating with BMC, SHA, and CAV deployers
Include **emergency responders on advisory committees and inter-agency working groups**.	Low	Short	BMC and Transportation, Police, and Fire Departments
Participate and **engage the Emergency Responder Subgroup** of the MD CAV Working Group to learn best practices and provide feedback on needed research or next steps.	Low	Short	Transportation Department and BMC
Require Emergency Response Plans from vendors operating in your jurisdiction. Collaborate with mobility providers and local emergency responders to develop these plans. Coordinate emergency responder policies and plans with MDOT who permits the deployments. Coordinate with Emergency Responder Subgroup of the MD CAV Working Group to include the Safe System Approach in their activities.	Low	Short	State or Local Transportation Department
Incorporate the USDOT's Safe System Approach (safer people, roads, vehicles, and speeds; and post-crash care).	Low	Short	All agencies

Where can I learn more?

The [Automated Vehicle Safety Consortium (AVSC)](#) provides best practice documents, including:

• First Responder Interactions.

• Interactions with Vulnerable Road Users.

• Safe testing and Evaluation.

Safety Case Studies

Updated Emergency Response Plan: The Maryland CAV Emergency Responder Subgroup updated the state's Emergency Response Plan to include recommendations for appropriate procedures for testing and deployment for truck platooning and personal delivery devices. BMC staff maintains a site of [CAV Resources for Emergency Responders](#) for the Subgroup.

National Highway Traffic Safety Administration (NHTSA) Reporting: In June 2022, NHTSA published the [initial round of crash data](#) for Advanced Driver Assistance Systems (ADAS) and Automated Driving Systems (ADS). In 2021, NHTSA began to evaluate whether the manufacturers of ADS and ADAS systems and the vehicles equipped with them, including manufacturers of prototype vehicles and equipment, are meeting their statutory obligations to ensure that their vehicles and equipment are free of defects that pose unreasonable risks to motor vehicle safety.

Preparing for CAV Impacts on
Automated Freight & Goods Delivery

CAV applications for freight and goods movement could include truck platooning, fully automated trucks, personal delivery devices (PDDs, or sidewalk robots), or even drones for small package delivery. There are a variety of road, rail, air, and even water transportation CAV applications that could provide automated freight and goods delivery service. The recommendations in the CAV Planning Guide focus specifically on roadway applications. Non-automated emerging freight/goods movement technologies include electric delivery vehicle fleets, cargo e-bikes, on-demand delivery services, and internet-based e-commerce applications. The demand for e-commerce and on-demand deliveries is moving warehouse and distribution centers closer to urban areas.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Meet early and often with private developers to understand needs and plans for access, loading/unloading, truck parking, electric vehicle charging, and broadband. This is important for freight-specific developments and technology parks, as well as mixed-use developments.	Low	Short	Planning Department
Build well-connected, ADA-compliant networks of sidewalks and bike lanes for people as well as personal delivery devices (PDDs, or sidewalk delivery robots). Coordinate with residents and businesses to maintain (and potentially pay for) the sidewalks in front of their property. Fees to offset costs could also be used to fund the sidewalk network (see previous fiscal health section).	High	Long	Transportation and Planning Departments

Where can I learn more?

- MDOT created a Personal Delivery Devices webpage with guidance on operating in Maryland.

- Mapping the Future of Autonomous Trucking (October 2022) by Boston Consulting Group created a dashboard of prioritized potential automated truck routes across the US.

- The AV TEST Tracking Tool is a dashboard where states and companies can voluntarily report their AV testing in the US. It includes heavy trucks (Aurora, Embark, Gatik, Kodiak Robotics, TuSimple, and Waymo) and small goods delivery robots (Nuro).

- The Federal Motor Carrier Safety Administration (FMCSA) provides short summary presentations from the annual Analysis, Research, and Technology (ART) Forum.

Automated Freight & Goods Delivery Case Studies

There are several freight-related pilot projects in the US that will offer new insights into freight and goods automation needs. Many of these pilots are new, so there aren't clear lessons learned to share yet. Pilots include:

- Texas Connected Freight Corridors.

- Freight Vehicle Intersection Optimization Project (planned by North Central Texas Council of Governments (NCTCOG)).

- Truck Ports for automated trucks are being tested in Atlanta and North Texas by Kodiak Robotics and highway travel center operator pilot.

- Wyoming Connected Vehicle Pilot Integrates Connected Vehicle Data into Traffic Management and Information Dissemination.

- Locally, Kiwibot is testing food delivery using personal delivery devices (PDDs, or sidewalk robots) to serve a food desert on the Morgan State University campus.

Preparing for CAV Impacts on
Organizational Readiness

Local jurisdictions can get the expertise they need through training, partnerships, engagement, and organizational changes.

Local policies on emerging technologies need to promote equitable access to technologies so all communities can benefit from CAVs. Policy development should also be flexible to adapt to changes in technology adoption and development. Agencies should proactively plan to continually update policies as we learn more about how CAVs impact our communities.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Define the **agency's vision for emerging technologies** relative to agency goals. Set clear priorities and goals for multimodal transportation (like complimentary service for high-capacity transit), micromobility, electrification, broadband, and data management. Agencies should plan for applications of technology, rather than specific technologies, which may change over time.	Medium	Short	Transportation and Planning Departments
Nominate **champions** among agency management and elected officials who will support funding and decision making (vision, staff allocation, departmental responsibilities).	Medium	Short	All departments
Get a seat at the table and learn by attending the Maryland CAV Working Group meetings.	Low	Short	All departments
Invite **diversity of experts to serve on advisory committees** (ex: legal, data managers, electric utilities, emergency responders, micromobility vendors, microtransit providers, private developers, and accessible transportation experts).	Low	Short	Planning and Transportation Departments, BMC
Establish **inter-office or inter-agency working groups** to break down silos and work across offices or departments to share information, data, staff resources, and project updates.	Medium	Short	BMC, Transportation, Public Works, Information Technology (IT), Emergency Responders, Utilities, and Legal Departments
Use **memoranda of understanding (MOUs) and other partnership strategies** to accelerate technology deployment (like bringing ridehail to rural areas or building a public broadband network).	Medium	Medium	Transportation Department and their partners
Plan for **multiple possible future scenarios** during long-range planning. Monitor trends on how CAVs are being deployed, adopted, and used to understand regional impacts and which ones align with your goals.	Medium	Medium	BMC and Transportation Department
Facilitate regular meetings with deployers, agency staff, first responders, and community advocacy groups to share concerns and lessons learned. (Ex: City of Baltimore meets weekly with micromobility vendors and holds monthly meetings open to the public).	Medium	Short	BMC and Transportation Department

Where can I learn more?

- NACTO Blueprint for Autonomous Urbanism, 2nd Edition outlines actions for local agency offices and departments to prepare for CAVs in Section 1.3.

- NCHRP Report 924: Foreseeing the Impact of Transformational Technology on Land Use and Transportation provides guidance in Chapter 8 on how to hire or train agency staff and how to form partnerships with other departments or agencies, with the private sector or outside experts, and with educational institutions.

- Automated Vehicle Hosting Handbook is a guidebook created by the North Central Texas Council of Governments for their local agencies. See Chapter 4 on building partnerships.

- Some conferences held in the region to learn more about CAVs include:

  – Pennsylvania Automated Vehicle Summit held each Fall is the largest annual AV-focused conference in the Northeast.

  – Transportation Research Board (TRB) Annual Meeting brings professionals across the transportation industry together in Washington, DC each January. There are a number of TRB Committees focused on CAV planning, policy, and integration.

- Other national conferences include:

  – Automated Road Transportation Symposium (ARTS) is an annual, international conference on CAV research and policy development held each Summer.

  – ITS World Congress held every other year and the ITS America Annual Meeting sponsored by ITS America focus on intelligent transportation systems (ITS).

  – Consumer Electronic Show (CES) is the largest technology event in the US and is the home to many industry announcements and technology unveilings each January in Las Vegas.

Organizational Readiness Case Studies

City Transportation Technology Policies and Actions. Los Angeles, California developed a Transportation Technology Strategy that identified goals, policies, and actions for planning for transformational technologies related to data-as-a-service (DaaS), mobility-as-a-service (MaaS), and infrastructure-as-a-service (IaaS). The city identified policies and actions (short-, medium-, or long-term) for each of their goals.

Westminster, MD / Ting Public-Private Partnership. CAV communications, intelligent roadway infrastructure, and smartphone mobility apps will rely on cellular communications or high-speed internet access. The Westminster Fiber Network is the Mid-Atlantic's first community-wide gigabit fiber network, creating a competitive local marketplace for Internet services and providing community access to affordable gigabit Internet speeds. The City of Westminster constructs, owns, and maintains the dark fiber network. Under a lease agreement, a private partner (Ting Internet) installs equipment, lights the network, and provides service to customers. Westminster's approach to public-private partnership is detailed in Successful Strategies for Broadband Public-Private Partnerships and example Request for Proposal (RFP) language for the PPP can be found on the City of Westminster website.

Preparing for CAV Impacts on Accessibility & Equity

Local agencies need to take action to promote accessible and equitable CAV technology adoption. Local governments should consider how they can ensure that CAVs are accessible to all members of the community, including those with disabilities, the elderly, and underserved populations. They may also need to develop policies to promote the use of CAVs in areas that are currently underserved by public transit and ensure that the deployment of CAVs does not lead to increased congestion or decreased accessibility in these areas. These strategies support BMC's Resilience 2050 long-range planning goals to:

- Identify and support multimodal options and systems that enable all individuals to reach their destinations safely and seamlessly.

- Identify and support multimodal options and systems that promote equity for all individuals.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Engage with **regional champions from vulnerable and underserved populations and organizations** like the Maryland Department of Disabilities (MDOD) and advocate for underserved populations with state agencies.	Low	Short	Planning Department and BMC
Include **underserved community and disability advocacy groups** and partners on all project partner lists, steering committees, and advisory committees to include equity and accessibility perspectives early in the planning process.	Medium	Short	All
Distribute updated material and **conduct outreach** to local organizations performing travel training. Travel training program curriculum can be updated by MDOT to include CAV technology education for riders and drivers.	Medium	Medium	Transportation Department
Develop local policy requiring all mobility companies operating in a jurisdiction to provide: • **Multilingual options**. • **Accessible** mobile applications. • **Accessible vehicles** for people with visual, auditory, cognitive, or physical disabilities and older adults. • **Alternative forms of booking and payment** for unbanked people or those without smartphones. • **Minimum level of service** in equity zones.	High	Medium	Transportation and Legal Departments
Invest in providing accessible **signage, pathways, and stop amenities** at CAV pickup/drop-off locations.	High	Long	Transportation and Public Works Departments

Where can I learn more?

- [Maryland CAV Strategic Framework](#) lists example avenues for outreach across the state in Chapter 1 Public Education and Outreach.

- [USDOT ITS4US Program](#) has awarded four projects with a specific focus on solving mobility challenges for underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers. The Transportation Data Equity Initiative, one of the Complete Trip deployment projects, is being led by the University of Washington, and spans three states: Washington, Oregon, and Maryland. The project aims to create the foundational data tools necessary for both public and private entities to collect, share, manage, and use transportation data. The effort includes updating existing standards OpenSidewalks, GTFS-Flex, and GTFS-Pathways. A second Notice of Funding Opportunity for new projects is expected in Fall 2023.

- [Inclusive Design Challenge](#) awarded projects to develop hardware and software solutions addressing a wide range of physical, sensory, and cognitive disabilities, all aimed at integrating with Automated Driving System-Dedicated Vehicles (ADS-DVs).

- [Accessible Transportation Technology Research Initiative (ATTRI)](#) was a joint USDOT initiative to develop and implement transformative applications that improve mobility options for all travelers, particularly those with disabilities. ATTRI research, including a user needs report, focused on removing barriers to transportation for people with visual, hearing, cognitive, and mobility disabilities.

Accessibility & Equity Case Studies

[Baltimore's Standards for Equitable Dockless Vehicle Access](#) require vendors to provide cash payment plans, non-smartphone plans, and low-income plans as a condition of their permit. The city's policy also sets Equitable Distribution Requirements within [Equity Zones](#), which requires permit holders to deploy at least 3 or 4 dockless vehicles in each Dockless Equity Zone by 8:00am each day of service. The city is regulating through incentive and could revoke the permit if the vendor does not comply with these equity requirements. Similar approaches could be used for CAV companies wanting to enter the Baltimore region.

[Via](#) currently [offers automated ridehail services](#) with the goal of making transportation accessible for all by creating products that can be used by everyone. To accomplish this, Via offers multiple payment method options, including cash, and provides multiple booking methods, including phone, web, and booking kiosks to better accommodate all users.

Chicago's updated [city ordinance](#) requires at least one EV Supply Equipment-ready space be accessible to people with disabilities per applicable property.

Preparing for CAV Impacts on
Planning & Land Use

The widespread use of CAVs has the potential to change the way cities are designed and used. Local governments need to consider the impact of CAVs on land use, transportation planning, and parking, and develop plans for how they will integrate CAVs into their existing transportation systems. For example, local governments may need to plan for the potential reduced demand for parking spaces and increased demand for pickup/drop-off areas as more people use shared CAVs instead of personal vehicles. They may also need to consider the impact of CAVs on public transit and develop plans for how CAVs can complement existing transit systems.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Monitor **and update zoning ordinances with an emphasis on parking codes** to anticipate potential reductions in parking demand and increases in curbside pickup/drop-off space from shared CAVs.	High	Short	Planning and Transportation Departments
Update roadway and sidewalk design standards or manuals to facilitate retrofitting existing infrastructure (like reallocating lane space) and reusing and repurposing rights of way to transition space to bicyclists, pedestrians, transit, shared vehicles, and drop-off zones. Update design and maintenance standards to include signing, marking, and street lighting to accommodate CAVs, if needed.	High	Medium	Planning and Transportation Departments
Monitor shifting land use patterns and integrate CAVs and other emerging transportation technologies into regional travel demand models and land use and transportation plans.	Medium	Ongoing/ Long	BMC and Local Planning and Transportation Departments
Develop a Development CAV Readiness checklist for your region's specific needs to educate developers and help future-proof developments as part of project/building permit reviews process.	Low	Short	Planning and Transportation Departments
Monitor state and federal regulations, trends, and best practices to determine if you need to update **local building/zoning codes** to accommodate smart lockers for e-commerce, automated delivery, or aerial delivery.	Medium	Medium	Legal, Planning, and Public Works Departments

Where can I learn more?

- American Planning Association (APA) Autonomous Vehicle Resources.

- Parking Reform Now – Municipal parking reform policy database.

- NCHRP Report 924 on Foreseeing the Impact of Transformational Technologies on Land Use and Transportation.

- NCHRP Project 20-102(29) is developing new guidance for integrating new mobility options into travel demand forecasting and modeling.

- BMC's 2023 CAV Literature Review (Page 18-24) provides best practices for writing policies, case studies and model code language.

Planning & Land Use Case Studies

Curb Zone to Flex Space: The city of Seattle has identified the area between the travel lanes and sidewalks as a "flexible space" where people catch their bus, park a car, hail a cab, drop off a passenger or make a delivery. This space is also transitioning into a place to socialize or do business in parklets and streeteries. As its uses have grown more complex, Seattle has moved away from using curbside spaces for parking only. Seattle's Flex zone priorities are based on the surrounding built environment context. Flex zone functions include mobility, access for people, access for commerce, social spaces, greening, and storage. For example, flex zone uses like plantings or bike parking are more valuable in residential areas, while others, like taxi zones, public art, or short-term parking are more valuable in commercial, mixed-use, or industrial areas.

Parking Reform: More and more cities around the country are eliminating or reducing parking mandates—like Buffalo, New York; Hartford, Connecticut; Santa Monica, California; Raleigh, North Carolina. Both California and Oregon recently passed laws limiting a city's ability to impose parking minimums for development in certain areas. For more information, visit: https://parkingreform.org/resources/mandates-map/

Preparing for CAV Impacts on
Funding, Financing, & Fiscal Health

CAVs could impact transportation revenue, land use fees, procurement costs, operations costs, and maintenance costs. Local agencies should plan for these impacts and identify alternative ways to fund or finance their transportation costs.

CAVs could have significant effects on transportation funding at all levels of government, including:

- Reduced motor fuel tax revenue from more electric vehicles and fuel-efficient vehicles.

- Reduced traffic violation revenue if CAVs are programmed to comply with traffic laws (including parking fines).

- Reduced parking revenue if parking patterns or usage change.

- Reduced transit revenue if CAVs compete with public transit OR increased revenue if CAVs enhance first/last mile connections.

- Reduced vehicle registration and sales tax revenue if vehicles become shared OR increased revenue if new vehicle types join the market.

- Increased tolling revenue if drivers travel farther due to lower travel costs and driver stress.

The private sector and the public both may have expectations with regards to the funding and financing of CAV infrastructure and upgrades. However, their goals for returns on investment may differ. The private sector may be more willing to invest in CAV infrastructure if there is a clear return on investment, while the public sector may be more supportive of public expenditures if they believe that the community benefits of CAVs will outweigh the costs. Local governments need to understand these expectations, encourage public dialogue, and identify alternative ways to fund or finance the transportation system.

Local governments need to consider the impact of CAVs on their fiscal health and develop plans for balancing the benefits and costs of CAVs. The deployment of CAV infrastructure and the necessary upgrades to transportation systems will have an impact on the fiscal health of local governments. For example, the installation of smart traffic signals and dedicated lanes may be expensive, and the cost of maintaining these systems will need to be considered. Additionally, the cost of deploying and maintaining CAV infrastructure may have an impact on available funding for other important public services, such as schools and safety.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Conduct a transportation revenue study to **document current local revenue sources and trends** for local fuel tax revenue, parking revenue, traffic fines, and tolling. Coordinate with regional and state organizations to identify state revenue sources and trends.	Medium	Short	Planning Department
Develop a toolkit guide outlining a **process for local jurisdictions to evaluate revenues** and set thresholds for developing potential **alternative revenue streams**.	High	Medium	BMC
Explore new pricing strategies for curb management, parking, vehicle registration, including: • Dynamic curbspace pricing (potential for reduced revenue from on-street parking). • Charging fees. • Local transportation tax (gauge public support first). • Usage-based fees (VMT fees). • Congestion charging. • Public private partnerships. • Development impact fees.	High	Long	Elected Officials, BMC, MVA
Assess **infrastructure** costs (installation, operations, and maintenance) associated with increased adoption of CAVs. Evaluate opportunities for development fees and other fees to offset costs. Assess the benefits and costs of CAV technology and engage the private sector and the public on funding options.	Medium	Medium	Transportation Department, Elected Officials

Where can I learn more?

Local agencies should participate in the Maryland CAV Policy Subgroup meetings to learn more about policy levers in the state and bring the potential revenue impacts to the group for consideration.

Potential grant programs included in the Bipartisan Infrastructure Bill (BIL or IIJA) include:

*   FTA Mobility Innovation programs.

*   Strengthening Mobility and Revolutionizing Transportation (SMART) Grant Program.

*   Electric vehicle infrastructure.

*   Broadband expansion.

To help communities understand the best ways to apply for grants and to plan for innovative projects:

*   USDOT Navigator Tool is a new resource to help communities understand the best ways to apply for grants, and to plan for and deliver successful projects.

*   Bipartisan Infrastructure Law Overview provides key areas of funding, providing details on ways to prepare, total funding amounts, contacts, and resources for each.

*   MDOT Summary of USDOT Discretionary Grant Programs provides an overview of the 2021 IIJA.

*   Shared-Use Mobility Center Funding Strategies Learning Module.

Funding, Financing & Fiscal Health Case Studies

Vehicle Miles Traveled (VMT) fees are road user charges based on the number of miles traveled by a vehicle. VMT fees may be applied to all vehicles or may be applied in different ways to certain vehicle types (like trucks) or to certain operating conditions (like an AV or rideshare vehicle not carrying any passengers). VMT fees are being explored in several states to address the issue of declining revenue from fuel taxes as fuel economy increases. In Oregon, for example, the OReGO program is voluntary with participants paying 1.9 cents for each mile they drive on Oregon roads.

North Central Texas Council of Governments (NCTCOG), the MPO for the Dallas/Fort Worth Metropolitan Area, recently completed a financial report high-level assessment of how automated transportation may affect local entity finances. The report is an example of a study local governments or BMC could undertake.

Florida Department of Transportation (FDOT) conducted a study projecting market penetration rates of CAVs and used it to assess the impact of projected substantial loss in state and local tax revenue on Florida's transportation revenues.

Preparing for CAV Impacts on Travel & Mobility

Advanced technologies like self-driving cars and trucks, e-commerce, micromobility, and telework (to name a few) introduce opportunities to improve mobility. They can help people, freight, and information move more reliably, equitably, efficiently, safely, and seamlessly. Agencies need to monitor and prepare for impacts to travel and mobility from CAVs and other emerging transportation technologies.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Support existing **multimodal mobility** deployments (like personal delivery devices, scooters, e-bikes, etc.). Consider new or additional implementations, if feasible. Develop local regulations for operation.	Low	Short	Transportation Department or Roadway Facility Owner Agency
Implement **Complete Streets / Slow Streets** policies to safely accommodate all transportation system users, including pedestrians, bicyclists, transit riders, drivers, passengers, and goods delivery. This approach provides benefits regardless of CAV deployments by re-orienting public space with all users in mind.	Medium	Medium	Transportation Department or Roadway Facility Owner Agency
Share planned work zone and road closure data with Waze to improve safe navigation for CAVs and human drivers.	Medium	Short	Transportation Department, MDOT
Monitor data to identify new travel trends and ways to improve system efficiency. Execute **data sharing agreements** with local vendors to report and track total vehicle miles traveled (occupied and unoccupied) on a regular basis.	Medium	Medium	Transportation, IT, and Legal Departments (likely within facility owner agency)
Monitor local CAV registrations (fleets or privately owned) to inform market penetration, availability, use, and potential congestion management. May also monitor funding and revenue sources for transportation infrastructure for potential revenue reductions that could affect travel and infrastructure investments (see fiscal health recommendations for more details).	Medium	Medium / Long	BMC
Invest in and **incentivize sustainable modes today and in a CAV future** (transit, vanpool, carpool, micromobility, etc.).	Medium	Long	Transportation Department (with coordination on regional level)

Where can I learn more?

The Shared Use Mobility Center (SUMC) provides an automated vehicle learning module to provide best practices for incorporating CAVs into a multimodal transportation system and the potential impacts of CAVs on pedestrians, bicyclists, transit, public space, and more.

Travel & Mobility Case Studies

Waze for Cities data program: This program is a two-way data sharing partnership between local governments, the Waze database, and travelers. Information can be shared about slowdowns, crashes, construction, road closures, and special event traffic management. Sharing planned road closures and construction zones with automated vehicles will help pre-trip navigation planning.

Mobility hubs are locations where different modes (walking, cycling, transit, shared mobility, electric vehicles, and potentially CAVs) come together to provide convenient mobility options for people. Several cities are using mobility hubs including:

- San Diego Associated of Governments (SANDAG).

- City of Minneapolis.

- City of Portland.

- Broward Metropolitan Planning Organization.

- City of Boston.

Preparing for CAV Impacts on
Workforce & Education

CAV technology and its applications will impact the workforce by replacing some existing jobs with automation and requiring new skill sets or retraining. Workforce development is an important aspect of CAV preparation.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Hire, train, and retrain staff. Obtain new skills by hiring staff or consultants or training staff (ex: data science, programming, deployment planning). Retrain staff displaced by automation (ex: retrain bus drivers to become CAV operators). Plan for specialized and continued on-the-job training as specific technologies are developed or applied.	High	Medium	All Departments
Partner with **local trade schools or colleges** on local pilot projects.	Medium	Medium	Trade Schools, Colleges, Universities, Transportation Department
Partner with CAV vendors through **RFIs or RFPs to identify and understand potential applications** of CAVs. Identify appropriate equipment necessary to support AVs in support of agency goals.	Medium	Medium	Transportation and Public Works Departments
Invest in developing **transferable skills for students and staff** to keep up with technological advancements.	Medium	Long	Trade Schools, Universities, School Districts, Transit Agencies, IT, Public Works
Excite children early. Encourage private industry to partner with local public and private schools to **teach about STEM careers and new technology applications** in classrooms.	Low	Long	School Districts, Jurisdictions, BMC
Incentivize **hiring workers displaced by AVs** (contracting selection, regulatory preference, tax/fee reductions).	Low	Long	All Departments
Procure and **maintain necessary equipment** to accommodate and support AV technologies.	Medium	Long	Transportation Department and BMC

Where can I learn more?

NCHRP Report 924: Foreseeing the Impact of Transformational Technology on Land Use and Transportation outlines how to hire or train agency staff and how to form partnerships with other departments or agencies, with the private sector or outside experts, and with educational institutions. (See Chapter 8.) Local partners might include:

- Montgomery Community College, Morgan State University, and Johns Hopkins University.

- Aberdeen Proving Ground.

- University of Maryland Autonomous Vehicle Laboratory.

- University of Maryland Center for Advanced Transportation Technology (CATT).

- Review available lesson plans to introduce students to transportation and CAVs:

- Institute of Transportation Engineers (ITE) technical resources for transportation education.

- Center for Advanced Automotive Technology (CAAT) connected vehicle demonstration lesson plan for grades 9-12.

- NCTCOG K-12 lesson plans on emerging transportation technologies.

- Maryland CAV Working Group Ideas for CAV & Workforce Preparations in MD.

Attend conferences to learn more about CAVs:

- Free virtual panels sponsored by Partners for Automated Vehicle Education (PAVE).

- Consumer Electronic Show (CES) is the largest technology event in the US and is the home to many industry announcements and technology unveilings each January in Las Vegas.

- Automated Road Transportation Symposium (ARTS) is an annual, international conference on CAV research and policy development held each Summer.

- ITS World Congress held every other year and the ITS America Annual Meeting sponsored by ITS America focus on intelligent transportation systems (ITS).

- Pennsylvania Automated Vehicle Summit held each Fall is the largest annual AV-focused conference in the Northeast.

- Transportation Research Board (TRB) Annual Meeting brings professionals across the transportation industry together in Washington, DC each January. There are a number of TRB Committees focused on CAV planning, policy, and integration.

Workforce & Education Case Studies

Florida State College at Jacksonville (FSCJ) has the first accredited certificate for an Advanced Driver Assistance Systems (ADAS) Technician.

The Tampa CV Pilot Deployment Program partnered with Hillsborough Community College to train students to install on-board units in the test vehicles.

Howard University's College of Medicine received a five-year National Science Foundation grant for its "STEM Opportunities in Prison Settings (STEM-OPS)" project to provide internships to formerly incarcerated people as a part of the university's "Prison to College Pipeline" program.

Preparing for CAV Impacts on
Physical Infrastructure

Local governments should assess the state of their transportation infrastructure and may need to update or upgrade some infrastructure to support the safe deployment of CAVs. Exactly how and when CAVs will impact the built environment will depend on many factors including technology advancement, use cases, vehicle sizes, and private or shared ownership. The transformation will be iterative—local agencies will need to continually fine tune their approach by evaluating and adapting to keep pace with industry developments.

Begin with improvements that benefit all transportation system users (like clear crosswalk markings, striping, and signage). Future-proof your investments by requiring procurements that are interoperable (like traffic signal controllers). Consider how infrastructure improvements can enhance a multimodal transportation system. For example, personal delivery devices (PDDs) need ADA-accessible sidewalks and curbs to operate—infrastructure that also benefits people not in vehicles.

CAVs are likely to be electric, so local governments will also need to consider charging and electrical grid needs for the EVs on the road today and CAVs tomorrow.

How can local agencies prepare?

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Maintain infrastructure in a state of good repair to serve today's users and to facilitate the transition to CAVs. However, the needs of CAVs will be different than other vehicles. For example, CAVs will likely need [2]: • Greater uniformity and quality in road markings to support lane awareness and during approaches to pick-up/drop-off and on-/ off-ramps. • Consistent signage and traffic signal placement across jurisdictions improves the operating environment for both human drivers and CAVs. • Consistent data on work zones and work zone traffic control devices. Maintaining infrastructure, including devices in the roadway like flex posts, raised pavement markers, and speed calming measures, will provide benefits regardless of CAV adoption.	Medium	Short / Ongoing	Roadway Facility Owner Agency maintains. BMC could facilitate coordination across jurisdictions and facility owners
Develop a **Curb Use and Street Space Allocation Master Plan** that includes a framework for right-of-way allocation decisions. In the future, this could include real-time parking or delivery scheduling mechanisms, and pick up/drop off activity.	High	Medium	Planning and Transportation Departments
Develop a sidewalk demand management plan to proactively plan for spaces for all physical abilities, freight delivery, and robot delivery.	Medium	Medium	Planning and Transportation Departments
Monitor electric vehicle (EV) registrations to make data-driven decisions for placing charging infrastructure, modeling emissions, and monitoring adoption data and trends (See Maryland Zero Emission Vehicle Infrastructure Council (ZEEVIC)).	Medium	Short	BMC and Planning, Permitting, Transportation, and IT Departments
Invest in communications infrastructure, such as fiberoptic and wireless communications. Communications infrastructure will support future CAV deployment, as well as existing traffic management and communication needs.	High	Long	Public Works, Planning, and Transportation Departments
Upgrade intersection (signalized and unsignalized) control infrastructure, including: • Advanced signal timing (current best practices). • Additional space in signal controller cabinets for new communications equipment (future proofing). • Installation of Vehicle to Infrastructure communications (CAV readiness).	High	Long	Public Works, Planning, IT, and Transportation Departments

2   Shared Automated Vehicle Toolkit: Policies and Planning Considerations for Implementation (2022)

Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Coordinate infrastructure improvements across agencies and interest groups. Discuss new development plans, opportunities for coordinated policies to expand high-speed communications infrastructure. For example, coordination across city agencies or departments can maximize the amount of conduit installed as part of Dig Once/Dig Smart to enable future fiber connections.	High	Medium	Transportation Department, MDOT, and BMC
Collaborate with CAV industry. Facilitate mutually beneficial information to assess current infrastructure and identify potential future physical and digital infrastructure requirements. BMC can promote guidance to be released in 2023 for Infrastructure Owner Operators (see below).	Low	Short	MDOT, BMC, Transportation and Planning Departments

Where can I learn more?

• The National Cooperative Highway Research Program (NCHRP) 20-24(112) Connected Roadway Classification System (CRCS) project developed a framework that can be used to classify infrastructure readiness for connected and automated vehicle deployments.

• Guidance for Infrastructure Owner Operators (IOOs): Maryland is one of eight states participating in a national Pooled Fund Study on Automated Vehicles. The group released an IOO Roadmap in 2021 and is currently developing a free and national online forum for public and private sector entities to engage and partake in discussions around AV technologies, to be released in 2023.

• The American Association of State Highway and Transportation Officials (AASHTO), ITS America, and Institute of Transportation Engineers (ITE) released guiding principles for IOOs for cooperative automated transportation.

• The Lessons Learned from USDOT's Connected Vehicle Pilots report shares successes and lessons learned from the three CV sites (Wyoming, Tampa, and New York City) with the deployer community for faster and more cost-effective CV deployments.

• The Maryland CAV Strategic Framework provides additional guidance from MDOT, the main IOO in Maryland, on various infrastructure needs for CAVs.

Physical Infrastructure Case Studies

Monitor EV registrations: The Dallas-Fort Worth Clean Cities Coalition's Electric Vehicles North Texas (EVNT) dashboard provides electric vehicle registration data by vehicle model, county, and city in North Texas. The tool is a regional effort to gain insight on EV trends. EVNT provides a central location for the region to educate and spread awareness of EV technology and applications and provide resources and technical assistance to help reduce the barriers of EV adoption. This approach can help monitor EV registrations to inform charging locations on a regional level. A similar tool could monitor AV registrations.

EV Charging: The City of Alexandria, Virginia's EV Charging Infrastructure Readiness Strategy includes recommended locations for public charging and audits of zoning and building codes to ensure support for developing charging stations.

Dig Once/Dig Smart policies to expand high-speed communications infrastructure: These policies require conduit installation during local construction projects, such as repairing pipes or building roads, and enable the jurisdiction or future providers to install fiber more easily and cheaply by threading it through existing conduits. Coordination across city agencies or departments can maximize the amount of conduit installed as part of Dig Once/Dig Smart. Engaged champions are key to this communication.

(NCHRP) 20-24(112) Connected Roadway Classification System (CRCS) project: Colorado Department of Transportation (CDOT) classified its roadways according to the classifications systems:

• Needs upgrade and maintenance: unpaved roads, roads with little to no communication or traffic control devices, and roads with degraded physical and digital infrastructure.

• Meets best practices: roads that meet current American Association of State Highway and Transportation Officials (AASHTO) and Manual on Uniform Traffic Control Devices (MUTCD) guidance and have mature Intelligent Transportation Systems (ITS).

• Meets emerging market: roads with connectivity to support vehicle to infrastructure communications.

Preparing for CAV Impacts on Data Privacy & Security

CAVs generate large amounts of data, including sensitive personal information. Local agencies should follow guidance or industry standards for collecting, storing, and securing any CAV data they obtain. Consider what performance metrics are important for your agency to monitor. Request summary statistics from CAV operators, rather than raw data with potentially sensitive information.

How can local agencies prepare?

| Recommended Actions for Local Agencies	Staff Effort	Timeframe	Local Responsible Organization
Consider requesting **processed and aggregate data** to measure success against performance measures. This is likely the best option for local jurisdictions with limited data management capabilities. Raw data with personally identifiable information (PII) should stay out of the public agency's control.	Low	Short	Transportation Department
Follow State and Federal guidance on using **standard data specifications** when integrating data sources from different agencies and operators. Local ordinances can include requirements for private mobility providers to use standard data specifications. For example, the Mobility Data Specification (MDS) is a data specification to streamline micromobility data sharing. MDS provides a standard data-sharing format to give cities valuable access to real-time data and gives private providers consistent data formats across different cities.	Low	Short	Guidance: FHWA, NHTSA, FCC, and MDOT Application: Local Transportation Department
Invest in hiring or training new staff in **data management expertise** to securely manage CAV data.	Medium	Medium/Long	Transportation Department
Leverage data collected by public agencies as a bargaining chip to obtain other data from vendors. Data sources that could be useful to industry include: • Roadway mapping and inventory data. • Curb usage data. • Construction zone data.	Medium	Medium	Transportation Department
Coordinate data sharing agreements across jurisdictions, negotiating as one unified region, instead of negotiating different individual data sharing agreements between various regional agencies and jurisdictions.	Medium	Medium	BMC, MDOT
Practice good cyber hygiene, such as updating passwords, using multifactor authentication, and updating antivirus software, to maintain the security of users, devices, networks, and data	Low	Short	All state, regional, and local agencies

Where can I learn more?

- **NCHRP Web-Only Document 355: Cybersecurity Issues and Protection Strategies for State Transportation Agency CEOs** presents high-level direction to agency CEOs on how to assess their organization's degree of vulnerability and risk to cyber threats, how to prepare for, prevent, and manage cyber incidents, and how to link transportation asset classification with cyber risk.

- Chapter 2.3 of **NACTO's Blueprint for Autonomous Urbanism** provides best practices for public agencies collecting, managing, protecting, and storing data.

- **NCHRP Report 952 Guidebook for Managing Data from Emerging Technologies for Transportation** provides data management guidance, and tools, and it lays out a roadmap for transportation agencies on how they can begin to shift – technically, institutionally, and culturally – toward effectively managing data from emerging technologies.

- A review of **cyber security best practices for inclusion in CAV safety cases** recommended intrusion detection, encryption of data, verifying the identity of all users, and securing systems by design to be resilient to any attacks.

- **Transportation Systems Sector Cybersecurity Framework Implementation Guide** (2020) by the Cybersecurity & Infrastructure Security Agency (CISA) helps transportation systems sector owners assess their cybersecurity needs, identify resources, and communicate risk management issues with partners. CISA has other resources for agencies, such as a **cyber hygiene scanning service** which provides regular scanning of internet-accessible systems.

- **NCHRP 08-119: Data Integration, Sharing, and Management for Transportation Planning and Traffic Operations** provides tools, methods, and guidance for improving data integration, sharing, and management practices to enable transportation agencies, in collaboration with private-sector and public-sector partners, to make better planning and operations decisions.

- **NCHRP Web-Only Document 266: Developing a Physical and Cyber Security Primer for Transportation Agencies** provides transportation managers and employees with an introductory-level reference document containing essential security concepts, guidelines, definitions, and standards.

Data Privacy & Security Case Studies

Data sharing: Many cities, including Baltimore, have adopted the Mobility Data Specification (MDS) to standardize communication and data-sharing between cities and private mobility providers (like e-scooter and bike share companies). As additional modes and new technologies like CAVs become more established, cities will need data standards to easily use data from different public and private mobility services.

Ransomware attacks: In 2019, hackers digitally seized about 10,000 Baltimore government computers and demanded around $100,000 to free them back up. It's a so-called "ransomware" attack, where hackers deploy malicious software to block access to or take over a computer system until the owner of that system pays a ransom. Similar ransomware attacks have occurred in local jurisdictions across the country.

Cybersecurity & Infrastructure Security Agency (CISA): After a cyberattack on a natural gas compression facility, CISA provided an overview of threat actor techniques and recommended corresponding mitigations for all asset owner operators.
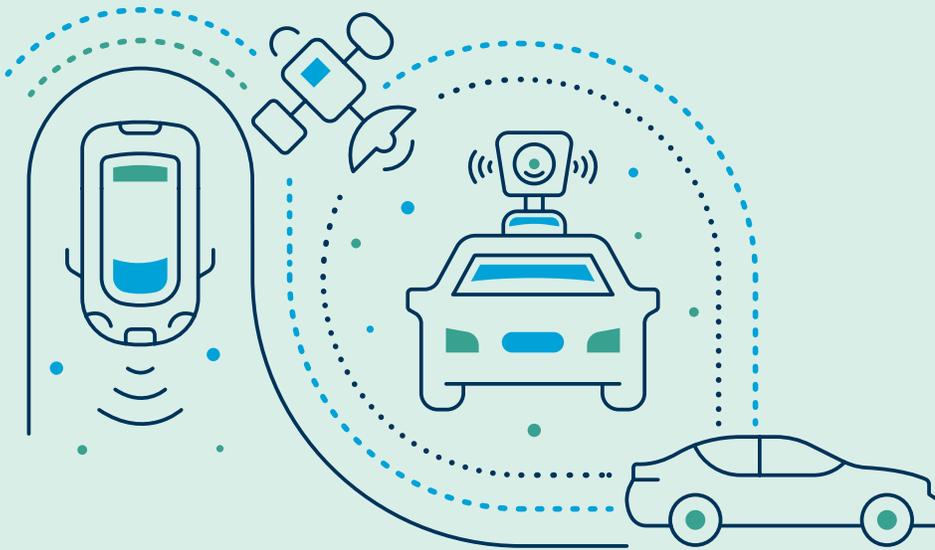
Key Near-Term Actions for Local Agencies to Prepare for Connected and Automated Vehicles (CAVs)

Now is the time for local agencies to start preparing for connected and automated vehicles (CAVs). Proactive planning will help agencies maximize the potential benefits of CAV technology and minimize the potential negative impacts. The previous sections provide details on the near-term, mid-, and long-term actions local agencies should take to prepare.

Over the next 1-2 years, local agencies should take the following key actions to prepare for CAVs.

Cross-Cutting

1

Coordination. Coordinate all CAV planning efforts with the State and BMC. Follow state guidance on CAVs. Share your vision, goals, plans, policies and other actions with the State and with your surrounding jurisdictions. Partner with regional and state partners to secure funding and to avoid siloed, localized CAV planning efforts. Regularly meet with critical partners and local champions. BMC will play a key role in coordinating efforts among local governments; sharing and documenting best practices; and conducting outreach to the public, policymakers, and other partners. (This is a cross-cutting recommendation. See individual section topics for specific recommended coordination actions)

2

Safety. Identify safety partners and define safety goals. Engage with the Emergency Responder Subgroup of the Maryland CAV working group and include a Safe System Approach as an underlying priority throughout the recommended actions, visioning, and goal setting. (See: Safety page 14; Organizational Readiness page 18)

3

Freight & Goods Delivery. Consider different needs for automated freight and goods movement. CAV applications may be first adopted for freight and goods delivery, instead of passenger movement. Throughout the recommended actions, include needs and plans for these use cases. (See: Freight & Goods Delivery page 16)

Planning

4

Organizational Readiness.

- Define your agency's vision for CAVs tied to your goals for safety, efficiency, sustainability, equity, and reliability. (See: Organizational Readiness)

- Identify partners and nominate a CAV champion(s) in your agency who will participate in partnerships and working groups (like the Maryland CAV Working Group) to learn about national trends and news, advocate for your agency's CAV vision, and work across internal offices to coordinate CAV planning and investments. (See: Organizational Readiness)

5

Equity and Accessibility. Include

equity and accessibility partners in all projects and develop requirements for CAV service to underserved communities. Include groups and partners from vulnerable and underserved populations on all project partner lists, steering committees, and advisory committees. Local agencies should share with BMC their equity and accessibility goals and needs as they develop policies and infrastructure enhancements. BMC can champion those needs at the state level with the Department of Disabilities and the Maryland CAV Working Group. Local agencies can also develop procurement policies requiring accessible and equitable service for underserved communities. (See: Accessibility & Equity)

6

Planning and Land Use. Integrate desired

outcomes of CAVs and other emerging transportation technologies (such as needs for loading/unloading zones or electric vehicle charging) into land use and transportation plans, regional travel demand models, building and zoning codes, and design manuals. (See: Planning & Land Use)

7

Funding, Financing, and Fiscal Health. Plan for impacts of CAVs on local fiscal

health, including impacts to transportation revenue; land use fees; and procurement, operations, and maintenance costs. (See: Funding, Financing, & Fiscal Health)

8

Travel & Mobility. Continue to prioritize

multimodal mobility and Complete/Slow Streets policies. Focus on safely accommodating all travelers, including people with disabilities, pedestrians, bicyclists, transit riders, and drivers. Placemaking, walkability, and accessible transportation options are critical to serve today's travelers and prepare for a CAV future. (See: Travel & Mobility)

Workforce Development

9

Workforce & Education. Invest in

people and the future of the workforce. Advocate and champion policies with the State on training and education programs. (See: Workforce & Education)

Infrastructure

10

Physical Infrastructure. Maintain

infrastructure in a state of good repair and advocate for adequate funding to serve today's users and to facilitate the transition to CAVs. Begin with improvements that benefit all travelers today. Examples include clear crosswalk markings, striping, and signage. Supplementary improvement may also include flex posts, raised pavement markings, and speed calming measures. This approach provides benefits regardless of CAV deployments by re-orienting public space with all users in mind. (See: Physical Infrastructure)

11

Data Privacy & Security. Follow guidance

or industry standards for collecting, storing, and securing CAV data. To reduce privacy risks, request only processed and aggregate data to measure success against performance measures and practice good cyber hygiene. (See: Data Privacy & Security)