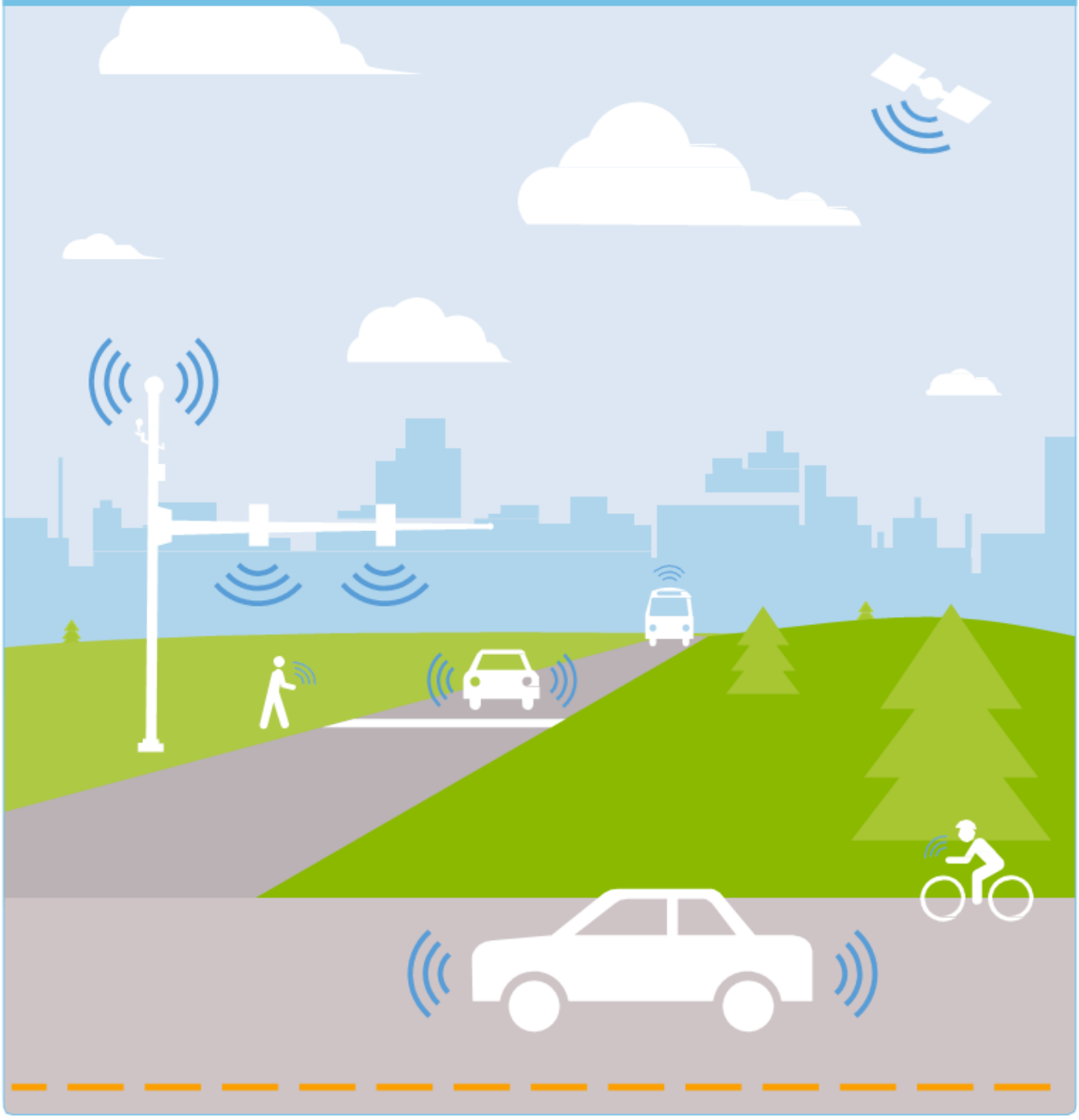
2020 VDOT Connected and Automated Vehicle Program Plan

VDOT Virginia Department of Transportation

September 2020



Revision History

This document shall be reviewed and updated on an annual basis, or more frequently if required, and protected from unauthorized disclosure and modification.

Revision	Date of Release	Owner	Summary of Changes
Full document update	09/11/2020	CAV Program Manager	Revision based on *2017 VDOT CAV Program Plan*

Approvals

Name	Initials	Date
Director of Office of Strategic Innovation		
Chief of Technology & Business Strategy		
Director of Research and Innovation		

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I. Purpose

This document provides direction to Virginia Department of Transportation (VDOT) in preparing for the deployment of connected and automated vehicle (CAV) technologies and solutions, which are expected to bring transformative change to the safety and efficiency of surface transportation.

II. Vision

VDOT owns and operates roadways with diverse urban, suburban, and rural characteristics, including more than 128,000 lane miles and 10,000 traffic signals. VDOT's current $6.4 billion budget for 2020 supports road maintenance and operations, construction, funding for local and regional transportation projects, and agency support operations.

VDOT's CAV Program vision is to prepare Virginia's roadways for the deployment of CAVs in a manner that leverages the *safety, accessibility, economic, and operational benefits of CAVs.* When integrating CAV technologies, VDOT must adapt its infrastructure and programs to increase the efficiency and safety of the transportation system. VDOT expects that CAV deployments will:

- Impact safety and mobility for drivers and the traveling public
- Create opportunities for economic development, including through a growing workforce dedicated to CAVs, and through more efficient exchange of goods across roadways
- Increase freight throughput and transportation of goods

III. CAV Program Overview

A. Introduction

The development and adoption of CAVs is moving at a rapid pace. As these vehicles begin to appear on publicly owned roads, those who own and operate the roads should be prepared for their impacts. These emerging technologies will affect many of VDOT's day-to-day functions, including operations, traffic engineering, construction, maintenance, and information technology.

Preparing for a future with CAVs will require VDOT to develop new policies, programs, and partnerships to address rapidly changing technologies. In recognition of this, the agency created the CAV Program and the position of CAV Program Manager to coordinate the preparation of Virginia's roadways for the deployment of CAVs. The CAV Program Manager serves as VDOT's subject matter expert on integrating advanced vehicle technologies into VDOT's business functions, and as a champion to promote the program internally and externally. Additional VDOT CAV Program Manager responsibilities include:

- Serve as the first point-of-contact for any CAV-related inquiries
- Serve as the administrator of VDOT CAV Working Group
- Facilitate coordination and communication across CAV stakeholders
- Encourage innovative partnerships to better prepare for the deployment of CAVs

The *2020 VDOT CAV Program Plan* (the *Plan)* outlines the CAV Program's current near-term efforts related to CAVs, long-term possibilities, and near-term actions supporting VDOT's goal of preparing Virginia's roadways for the deployment of CAVs. The structure of the *Plan* was based, in part, on guidance from the *VDOT CY 2018-2021 Business Plan*.

The *VDOT CY 2018-2021 Business Plan* identified nine agency goals in order to plan, deliver, operate, and maintain a transportation system that is safe, enables easy movement of people and goods, enhances the economy, and improves Virginian's quality of life. One of these nine agency goals directed the agency to be innovative, with a focus on taking advantage of technological advances such as CAVs. To achieve coordination across the agency, and to address the multitude of impacts CAV technology will have, VDOT's CAV Program has organized VDOT's efforts into five workstreams. These workstreams categorize VDOT's efforts across multiple business functions.

B. Workstreams

The *Plan's* five parallel workstreams are as follows:

Workstream 1: Governance

The purpose of this workstream is to form the necessary organizational bodies and committees needed to support the *Plan* and other VDOT CAV-related initiatives. By having adequate leadership and a governance structure in place, VDOT will successfully support CAV projects and efforts. VDOT will undertake projects and ongoing efforts within this workstream to:

- Establish and maintain the governance structure necessary to support VDOT's CAV efforts
- Support statewide, regional, and national efforts to coordinate CAV-related activities

Workstream 2: Legal

The purpose of this workstream is to ensure VDOT is aware of, and aligned with all laws pertaining to CAVs. As CAVs and technology continue to rapidly evolve and change, legislation will likely also evolve. VDOT will monitor the CAV industry, as well as local, state, and federal legal developments to ensure compliance. VDOT will undertake projects and ongoing efforts within this workstream to:

- Monitor ongoing local, state, and federal CAV deployments to understand potential statutory and regulatory changes
- Monitor ongoing local, state, and federal statutory and regulatory legal changes in preparation for CAV deployments
- Assist VDOT in updating legal documents, such as memorandums of understanding and contracts, to address CAV testing and deployment

Workstream 3: Education

The purpose of this workstream is to establish effective communication concerning CAV developments and education between VDOT's workforce, partner agencies, industry stakeholders, and the public. VDOT will need to communicate with its employees, partner agencies, industry stakeholders, and the public about VDOT's preparations for CAVs and changes in CAV technology. Further, successful CAV deployments will require public and stakeholder support, including VDOT employees familiar with, and trained in, CAV-related technology. VDOT will undertake projects and ongoing efforts within this workstream to:

- Participate in local, state, federal, and industry CAV discussions and deployments related to workforce training
- Monitor regional and national discussions regarding workforce needs and certifications
- Provide guidance and training to VDOT workforce
- Create communication channels between VDOT and the public regarding CAV technologies, specific VDOT CAV projects, and CAV-related education

Workstream 4: Physical and Digital Infrastructure

The purpose of this workstream is to ensure VDOT possesses the necessary physical and digital infrastructure to prepare Virginia's roadways for CAV deployments. The advent of CAV technologies will require foundational infrastructure, both physical and digital, to be added or upgraded and maintained across Virginia's transportation system. VDOT will undertake projects and ongoing efforts within this workstream to:

- Catalog VDOT physical and digital infrastructure relevant to CAV deployment
- Assess existing VDOT infrastructure as to its capacity to support CAV deployments
- Inform VDOT business functions as to potential CAV deployment opportunities and risks associated with CAV deployments
- Provide guidance and information to VDOT business functions whose infrastructure assets may be impacted by the deployment of CAV technologies

Workstream 5: Data

The purpose of this workstream is to position VDOT to take advantage of the influx of additional CAV-related data as CAV deployments increase throughout Virginia. CAVs will create large amounts of new transportation data for use and analysis. Moving forward, VDOT will ensure the additional CAV-related data is managed in compliance with the agency's security standards and will utilize this data to improve business functions. VDOT will undertake projects and ongoing efforts within this workstream to:

- Participate in, learn from, and disseminate information on state, regional, and national discussions concerning data standards, data governance, and data privacy
- Assist VDOT's agency-wide cybersecurity efforts in addressing CAV impacts on security
- Inform VDOT business functions as to potential CAV data needs and uses
- Discuss the need to develop tools and staff expertise to store and analyze data

C. Integrating CAVs into VDOT Functions

In conjunction with developing the *Plan*, the CAV Program developed the *Integrating CAVs into VDOT Functions Report* (the *Report*), which describes how CAVs will impact each of VDOT function's people, processes, and technology and tools.

In developing the *Report*, the CAV Program fostered conversations across the agency in preparation for CAVs on Virginia's roadways. Similar to the *Plan*, the *Report* is designed to be updated on an as-needed basis to reflect each function's current efforts and future needs. The two documents are designed to work together, with the *Plan* providing structure and vision for VDOT's CAV-related efforts and the *Report* providing a more granular review of impacts to specific agency responsibilities. As the CAV ecosystem evolves, the CAV Program will update the *Plan* and the *Report* to reflect the critical feedback provided by VDOT's functions.

IV. VDOT Near-, Mid-, and Long-Term Efforts and Possibilities

VDOT is focused on preparing for the deployment of CAVs and CAV-related technology. To achieve this goal, the agency has undertaken multiple initiatives related to CAVs. The current efforts lay the groundwork for additional near-, mid-, and long-term possibilities. As CAV technology is fast-evolving, VDOT will remain flexible and adapt to new technologies and accompanying possibilities, as appropriate. In all its efforts, VDOT will remain diligent in coordinating with national and regional efforts to create standards related to the deployment of the CAV ecosystem, so as to assist in the creation of a cohesive future transportation system.

A. Near-Term VDOT CAV Efforts

VDOT is currently working on foundational efforts that will prepare Virginia's roadways for CAVs. The following describes the efforts VDOT has already begun and will continue to develop and expand upon to prepare for CAVs in the near-term:

Workstream 1: Governance

In order to provide guidance on CAV deployments, governing structures and bodies will need to be established to successfully implement CAV initiatives. Some of the current governance-related initiatives underway include:

- **Establishing VDOT CAV Working Group and Executive Steering Committee:** Establishing the CAV working group and executive steering committee to provide leadership structure and guidance on future CAV deployments

- **Implementing the *VDOT of Tomorrow* Program:** Implementing the *VDOT of Tomorrow Program* includes ten strategic initiatives around three key goals:
    - Supporting all VDOT employees to prepare for the future through the acquisition of new skills through reskilling efforts
    - Refreshing the way VDOT does business and updating processes to meet future workforce and transportation industry needs
    - Harnessing the power of VDOT employees to create new ideas and tools to move VDOT forward and ensure it remains a premier DOT

Workstream 2: Legal

Legal changes as a result of CAV deployments across the US will need to be monitored to ensure successful VDOT CAV initiatives and programs. Some of the current legal related efforts underway include:

- **Monitoring local, state, and federal developments related to CAVs -** Monitoring local, state, and federal CAV deployments for legal changes and guidance VDOT should be aware of

Workstream 3: Education

VDOT staff, stakeholders, related agencies, and the public will need to effectively communicate regarding CAV education to ensure successful CAV deployments. Some education iniatives currently underway include:

- **Updates to the *Virginia Travel Demand Modeling Policies and Procedures Manual* –** Updating the *Virginia Travel Demand Modeling Policies and Procedures Manual* to incorporate guidance on the CAV component development process provides the agency with accurate travel demand models as CAVs are deployed

- **Test and Verify CAV Assumptions in Travel Demand Models** – Testing and verifying CAV assumptions in travel demand models to ensure the agency incorporates changes to the volume and location of CAV deployments as appropriate

- **CAV Research Efforts** – Researching the possible impacts of CAVs to ensure the agency is well-informed as to emerging technologies and how to best integrate them into Virginia's transportation system. Some research projects currently underway include:
    - Virginia Connected Corridors (VCC)
    - Connected Worker Vest
    - VCC Cloud
    - VCC Monitor
    - Automated Truck Mounted Attenuator
    - 2-Way Communications Process and Security Research
    - Wide-area network (WAN) Protocols [LORA Protocols]
    - Connected Vehicle Pooled Fund Study (CV PFS)

- **Partnerships with Universities to Conduct CAV-related Research** – Partnering with research institutions across Virginia expands VDOT's capacity to undertake research efforts

Workstream 4: Physical and Digital Infrastructure

Physical infrastructure plays a critical role in ensuring Virginia's transportation system is best equipped to handle a rapidly developing CAV industry. Some of the physical infrastructure changes currently underway include:

- **Roadways with Connected Traffic Signals** – Upgrading traffic signals with the latest approved hardware to create a centralized traffic signal system that can communicate and respond to changing conditions

- **Roadways Outfitted with Emerging Mobility Technology Infrastructure** – Implementing multi-use road sensors that can identify, detect, and communicate a variety of data back to the traffic operations center (TOC)

- **Robust, High-Speed, High-Capacity Communications** – Expanding VDOT's fiber network to provide high-speed, low-latency communications

- **Innovative Public-Private Partnerships** – Identifying opportunities to develop innovative partnerships to enable beneficial CAV deployments

- **Work Zone Broadcasting and Communication** – Combining the utility of mobile applications for designing work zones, equipping field workers with broadcasting work vests, automating truck-mounted attenuators and pursuing work zone API connections with federal efforts. VDOT is preparing a digital work zone program to become part of the digital communications and infrastructure strategy.

- **Innovative Roadway Design Tools (3D and 4D format) –** Developing roadway design in 3D and 4D formats using time as the fourth dimension to enable integration of roadway plans and as-builts with the CAV ecosystem, as well as enable the development of safer roadways and Maintenance of Traffic (MOT) zones

Digital infrastructure will be essential to realizing the full capability of the CAV ecosystem. Some of the digital infrastructure changes currently underway include:

- **Predictive Traffic Operations and Artificial Intelligence (AI) Solutions for Commuter and Freight Traffic Management** – Implementing predictive traffic management and AI solutions to optimize multi-modal traffic while allowing the use of existing infrastructure

- **Next-Generation Asset Management** – Connecting all assets to monitor asset health from a TOC continually and deploying resources as needed for repairs

Workstream 5: Data

Software and data management will be critical for VDOT to utilize the full potential of CAV solutions as CAV technology produces an influx of transportation-related data. Some of the software and data management changes currently underway include:

- **Data Lake and Edge Computing** – Exploring methods to store, share, and analyze data efficiently

- **Highway Maintenance Management System (HMMS) Integration –** Integrating HMMS to provide CAVs with real-time geo-spatial maintenance information

- **Cybersecurity Upgrades and Security Management –** Implementing a Security Operations Center, implementing an Identity and Access Management solution, and upgrading the network

B. VDOT CAV Deployment Near- to Mid-Term Possibilities

VDOT is considering and discussing numerous possibilities related to CAVs to implement in the near- and mid-term. As CAV-related technology continues to develop and transform over time, VDOT will continue to explore different avenues to integrate CAVs and related technology into Virginia's transportation system.

Physical Infrastructure:

- **Infrastructure Geared for Truck Mobility** – Setting up platooning and traffic signal priority for trucks would involve additional hardware and simulation modeling along with communication networks, both wired and wireless. This infrastructure could then be coordinated with the manufacturers of the specific platooning equipment.

- **Safer Streets for Pedestrians and Bikers** – Emerging micro mobility options would likely result in higher percentages of bikers, e-mobility, and pedestrians in the urban parts of the state. CAV compatible infrastructure would support these users to provide safe multi-modal travel.

- **Corridor Wide Tolling Infrastructure** – Setting up innovative tolling scenarios would allow VDOT to increase revenue, something which is currently not feasible due to the cost and enforcement issues around tolling booths. VDOT could upgrade toll corridors with highly reliable fiber networks and roadside units (RSUs) to support hardware and communication with integrated CAV equipment. This infrastructure could then be coordinated with CAVs and onboard vehicle unit (OBU) manufacturers.

- **State Vehicle Infrastructure** – Procuring or upgrading current state vehicles and contractor construction vehicles with CAV technology may help VDOT to implement safe construction and MOT zones for patrolling vehicles. New specifications would need to be developed to mandate such procurement.

- **Corridor with Enhanced Data Sharing to Traffic Operations Centers** – Sharing of enhanced CAV-related data along a corridor would involve coordination between manufacturers, VDOT, and public and private agencies. VDOT could act as a central coordination figure guiding policy, specifications, and standards.

- **Region and Corridor that Supports Creative Financing** – Creative financing as a result of CAV technology and deployments would involve the implementation of new software and workflows.

- **Infrastructure Capable of Operating in Emergency Situations (e.g., a hurricane)** – Equipping roadways with different technologies and infrastructure may be key to operating seamlessly when emergency situations arise. Corridors would be capable of operating remotely, automatically, and autonomously periodically when human influence and input is minimal. This may also involve the implementation of AI. CAV technology implemented on roadways may help VDOT prepare and respond to any emergencies that arise.

Digital Infrastructure:

- **TOC with Advanced Signal Management Capabilities** – Connecting signals using a central software system and implementing innovative techniques would allow vehicles to communicate directly with the signal system. Some benefits may include improving signal progression using AI-based signal timings and reducing carbon footprints using freight priority systems.

- **Last Mile Services –** Supporting private partners to provide last mile solutions by integrating VDOT infrastructure and information in real-time would allow vendors to adjust their availability.

- **Real-Time Roadway Communications Systems –** Developing digital systems to support real-time communications to road users concerning road closures, work zones, incidents, and other developments on the roadways would allow road users to travel more safely and efficiently.

Data:

- **Data Harvesting, Edge Computing, and Data Sharing** – Implementing CAV would potentially result in enhanced operations and performance due to efficient data sharing and computing.

C. VDOT CAV Deployment Mid- to Long-Term Possibilities

Due to rapidly changing CAV technologies, VDOT has identified mid- to long-term opportunities, as opposed to specific projects. With this flexibility, the agency will be better prepared to adapt to CAV deployments. This section approaches possible mid- to long-term CAV outcomes from two perspectives: how users could interact with Virginia's transportation system and how CAVs could be deployed.

User Profiles

Users would interact with Virginia's transportation system in novel ways as CAVs are deployed. Below are some of the ways users' day-to-day activities could change due to CAV deployments.

Travelers

Travelers could enjoy a wide variety of benefits due to CAVs. For instance, vehicles equipped with an OBU could receive in-vehicle notifications and safety alerts for pedestrian crossings, construction zones, wrong-way driving, and dangerous road conditions due to ice or stormwater. Smart traffic signals could reduce greenhouse gas emissions by allowing for better traffic flow conditions. CAV applications that prioritize and route traffic could reduce congestion. CAV technologies could make public transportation, shuttles, and vanpool options increasingly accessible. New toll lane options could be available to travelers, and payment could be integrated into each vehicle's OBU unit.

Commercial Vehicle Operators

Commercial vehicle operators could benefit from the same traveler information services, such as receiving safety and mobility notifications. In addition, commercial vehicle operators could identify parking options and locate contact information and directions. CAV technology could allow commercial vehicle operators to receive in-vehicle information regarding weight restrictions on bridges. This technology could be paired with priority lanes to enable platooning and signal priority traffic management.

Transportation Managers (ITS, Construction, Operations, and Maintenance)

Transportation managers could use newly automated, connected, and shared tools to better measure the performance of the transportation system and monitor acitivity on Virginia's roadways. CAV technologies may enable safer construction and MOT zones by employing CAV-enabled work vehicles.

Public and Private Transit Providers

CAV technology could allow for the implementation of innovative transit options. Public and private transit providers could provide on-call services and also run longer schedules.

Traffic Engineers

Traffic engineers could devise and implement advanced traffic strategies to reduce congestion and increase throughput for commuters and freight. The real-time nature of feedback from CAV technologies could further validate the approach and improve field response.

Transportation Planner

CAVs could provide transportation planners with real-time, granular data to make better policy decisions that support transportation initiatives and communities.

Data Managers

Data managers at VDOT and respective partner agencies could be designing, operating, and maintaining systems that store, archive, transmit, and analyze CAV data. Data managers would ensure data is organized, protected, and secure, and is available to internal and external stakeholders, as appropriate.

Researchers

Researchers could continue to study and provide recommendations as to CAV impacts on real-time safety, proactive traffic management, road safety integration, and transportation planning, highway safety analysis, simulation, big data and data analytics, and intelligent transportation systems (ITS).

Scenarios

The benefits of CAV ecosystems would likely expand beyond individual users, as the entire transportation system could be optimized for efficiency across multiple modes of transportation through the deployment of CAVs. VDOT-led initiatives and projects would aim to create CAV ecosystems that benefit all aspects of the transportation network. Below are possible future scenarios depicting the deployment of CAVs.

Scenario 1 – Smart Connected Intersection

Vehicles utilizing CAVs would interact with smart connected intersections to improve traffic flows and safety on Virginia roadways. Vehicles equipped with lower levels of automation, or those without OBUs, would still be able to interact with connected intersections and other vehicles through specific cellular devices and low-latency applications. Several applications may be implemented at a smart connected intersection to improve traffic flow and safety, some of which include:

Enhanced Signal Optimization

CAVs would communicate with signals for each approaching leg of an intersection. The signal would perform edge computing of CAV data received and communicates with adjacent signals

both upstream and downstream on a fiber optic network. AI algorithms would adjust signal timing for traffic needs in real-time for the corridor. Multi-modal expandable RSUs installed at the intersections would provide signal phasing and timing (SPaT) back to vehicles equipped with OBUs to adjust their speed to optimize travel time and fuel consumption based on the fluctuating demand of the corridor.

Advanced Weather Detection

Non-invasive sensors would detect hazardous road conditions, such as ice or flooding on a roadway, and send alerts to approaching vehicles via the OBU display to enable them to avoid the hazard. Using supplemental sensor data in conjunction with CAV data would allow CAVs to navigate safely in adverse weather conditions.

Sensors would detect atmospheric conditions such as air temperature, precipitation, wind, and relative humidity. This information could be transmitted back to the Public Safety and Transportation Operations Center (PSTOC) and the National Weather Service (NWS) to assist with weather predictions and with monitoring real-time conditions to assist with maintenance of the corridor.

Pedestrian Safety

Smart connected intersections would detect approaching pedestrians via signal video analytics and automatically actuate the signal, and also inform CAVs to slow down to account for pedestrian movement.

Freight Signal Priority

The cross-pollination of vehicle types entering an intersection would induce a different dynamic for a corridor. Larger freight vehicles have increased stopping and starting distances from which to operate. Smaller vehicle interaction with freight traffic increases safety concerns and greenhouse gas emissions, especially in stop- and- go traffic. In order to minimize safety concerns and reduce emissions, freight signal priority would be initiated by smart connected intersections where passenger vehicles communicate to freight vehicles and signal timings. Based on the information received from the signal, freight vehicles would be able to adjust their speeds to stay in green progression.

Emergency Vehicles

Emergency vehicles would alert vehicles within their proximity that they are approaching. Connected intersections would make signal changes to allow the emergency vehicle to pass through the intersection safely. An emergency signal pre-emption code would also trigger a message to nearby vehicles to make lane changes and reduce speed to allow for the emergency vehicle to respond safely.

PSTOC would receive data and video surveillance from the smart connected intersections to be able to adjust system thresholds for increased performance and provide notification to internal and external organizations. Through the implementation of smart connected intersections, all types of vehicles would be able to communicate to more efficiently and safely traverse Virginia roadways.

Scenario 2 - Connected Infrastructure

As CAV technology advances, VDOT project designs may be developed in a new time-lapse format that would allow VDOT, contractors, and the general public to view projects in 3D with time as the fourth dimension. MOT plans and permits could utilize a 3D format to precisely capture information on every lane closure and opening time. Once MOT plans are approved, CAV users could be updated with the plans to enable users to make the right travel choices when crossing through MOT zones.

Installation of a redundant and reliable fiber and communications network along interstates with RSU would allow construction vehicles and construction workers to communicate quickly with CAV users. For example, when construction vehicles enter or leave a construction zone, construction vehicles would communicate to oncoming traffic to adjust speed accordingly to allow for safe passage of the vehicle. Additionally, connected personal protection equipment (PPE) would improve safety for construction workers by alerting workers to safety hazards. For example, a connected safety vest would vibrate to alert a worker when they leave the protected MOT zone while also communicating with nearby CAVs to prevent potential accidents.

Scenario 3 – Data Management and Analytics Platform

Numerous ITS devices and emerging mobility solutions may be integrated into the VDOT network. All TOCs would be outfitted with software that allows for the command, monitoring, and control of field devices (e.g., multi-sensors, Road Weather Information System). Through a high-speed fiber optic network, maintenance staff would be able to monitor all devices remotely. VDOT's data storage solution would offer seamless Application Programming Interface (API) connectivity with data, no limits on transactions and low-latency to implement real-time solutions.

RSU infrastructure and networks installed by VDOT would collect real-time data that can quickly be provided to cities and counties, contractors, and startups via VDOT's data portal. The data portal would allow users to filter to obtain necessary data, including clear visualizations of vehicle flows and plotting of data in a user-friendly manner. For example:

- A transportation planner could procure data about parking times and vehicle usage to assist in developing new parking policies, thus eliminating the often-lengthy process of data collection
- A consultant working to improve pedestrian safety at a signalized intersection could obtain data received by signal controllers from CAVs about pedestrian sightings and sudden slowdowns by car cameras. The data would provide the blindspot locations of pedestrians to identify where signal improvements need to be made to provide safer pedestrian crossings.
- Startups working on new hardware and software applications for connected vehicles (CVs) would have access to real-time data to develop and test new products that would bring new business and jobs to Virginia.

V. CAV Program Near-Term Workplan

VDOT's CAV Program coordinates and facilitates VDOT's efforts to prepare Virginia's roadways for CAV deployments. The Program is tracking and supporting projects throughout the agency related to CAVs. In order to achieve the mission of supporting these efforts, the CAV Program identified a number of near-term projects within the five workstreams. These efforts have been put into the following workplan. While the *Plan* is subject to regular review, this section may be updated more frequently, as appropriate.

CAV Program Near-term Workplan Summary:

- **Workstream 1: Governance**
  - 1.1 Establish a VDOT Executive Steering Committee
  - 1.2 Maintain the VDOT CAV Working Group
- **Workstream 2: Legal**
  - 2.1 Inform VDOT Business Units of Possible CAV Impacts to Standard Legal Documents
  - 2.2 Monitor Ongoing State and Federal CAV legal developments
  - 2.3 Prepare for Potential Statutory and Regulatory Changes
- **Workstream 3: Education**
  - 3.1 Create a CAV communications strategy
  - 3.2 Prepare VDOT's workforce for CAVs
  - 3.3 Collaborate with CAV Ecosystem Partners
- **Workstream 4: Physical and Digital Infrastructure**
  - 4.1 Inventory and visualize CAV-related physical and digital infrastructure
  - 4.2 Develop CAV readiness framework
  - 4.3 Review and Update Relevant VDOT Specifications and Standard Operating Procedures
  - 4.4 Create a Roadmap of Physical and Digital Infrastructure Investments to Prepare for CAVs
  - 4.5 Monitor and Support National Standards Concerning Physical and Digital Infrastructure for CAVs
- **Workstream 5: Data**
  - 5.1 Manage and Govern CAV Data
  - 5.2 Monitor and Support National Standards Concerning Data Management in Preparation for CAVs

Workstream 1: Governance

1.1 Establish VDOT Executive Steering Committee

The VDOT Executive Steering Committee is one of two primary governance structures of the *Plan*. Technology and systems are a key component of CAV deployments, and there is a need to apply strong governance practices to address:

- Internal coordination and information sharing
- Project planning needs
- Changes in technology or industry product offerings
- Outside influences (e.g., legislative mandates, industry shifts)
- Desired enhancements

Purpose:
A VDOT CAV Executive Steering Committee will guide the program to maximize the benefits of existing and emerging CAV technologies to meet VDOT's goals and objectives. The Committee's scope is intentionally limited to focus on CAV topics and decisions to which VDOT can apply resources, including operations improvements, maintenance, infrastructure investments, and long-range transportation planning.

Meeting Schedule:
The VDOT Executive Steering Committee will meet two-three times a year. Meetings will likely occur in the early spring prior to budget decisions, mid-summer near the beginning of the fiscal year, and/or late fall to review the year's accomplishments.

1.2 Maintain VDOT CAV Working Group

The VDOT CAV Working Group was established in the fall of 2019 and is one of two primary governance structures of the *Plan*.

Purpose:
The VDOT CAV Working Group is responsible for providing feedback to the CAV Program Manager on CAV projects, addressing issues that arise within the CAV Program, and disseminating CAV-related information amongst business functions across VDOT.

Meeting Schedule:
The VDOT CAV Working Group meets quarterly. Additional meetings to address specific issues may occur on an as-needed basis.

Workstream 2: Legal

2.1 Inform VDOT Business Units of Possible CAV Impacts to Standard Legal Documents

The CAV Program Manager will coordinate with the Governance and Legislative Affairs Division (GALA) to ensure VDOT's business units are informed and aware of any impacts to standard legal instruments as a result of increased CAV deployments throughout Virginia.

2.2 Monitor Ongoing State and Federal CAV Legal Developments

The CAV Program will monitor ongoing projects within Virginia and across the country to better understand potential legal changes resulting from past and current CAV initiatives. Additionally, the CAV Program will work with GALA to monitor any state or federal legal changes anticipated to impact the deployment of CAVs and CAV technologies.

2.3 Prepare for Potential Statutory and Regulatory Changes

Currently, there are no laws specific to CAVs in Virginia. At some point, this will likely change. In preparation for this, the CAV Program will conduct the following activities:

- Document statutory and regulatory requirements for CAVs from across the country
- Participate in ITS America, American Association of State Highway and Transportation Officials (AASHTO), and other relevant organization committees that focus on federal CAV legislation
- Coordinate with Division points of contact concerning existing policies that may relate to, or be impacted by, CAV technologies

Workstream 3: Education

3.1 Create a CAV Communications Strategy

The CAV Program will develop an in-depth CAV communications strategy in order to facilitate discussion between VDOT stakeholders, external stakeholders, and the general public. The communications strategy will:

- Identify opportunities for public outreach
- Identify potential partnerships with similar innovative efforts
- Identify CAV-related educational opportunities for relevant stakeholders

3.2 Prepare VDOT's Workforce for CAVs

As part of its *VDOT of Tomorrow* effort, VDOT is identifying future workforce needs across the agency. To assist the agency-wide effort, the CAV Program Manager will monitor, participate in, and disseminate information from state, regional, and national discussions on CAV workforce needs.

Employee education is also critical for the success of the CAV Program. As such, the CAV Program Manager will:

- Work with industry stakeholders to identify and catalog available courses and publish them internally
- Evaluate sources, document available training opportunities, and work with the entities listed below for VDOT-wide access to these training opportunities, including:
    - U.S. Department of Transportation (USDOT)
    - Society of Automotive Engineers
    - National Electrical Manufacturers Association (NEMA)
    - Virginia colleges, universities, and community colleges
    - Private sector hardware and software suppliers

- Encourage employee participation in the national and local forum for CAV discussions, such as ITS America, ITS Virginia (ITSVA), American Public Transportation Association (APTA), International Bridge, Tunnel, and Turnpike Association (IBTTA), and the Institute of Transportation Engineers (ITE)
- Encourage peer-to-peer knowledge transfer internally to provide a better understanding of opportunities and risks across the agency

3.3 Collaborate with CAV Ecosystem Partners

In an effort to build partnerships with private and public organizations at the local, regional, and national level, the CAV Program will identify avenues for collaboration and understanding with multiple stakeholders, including; Virginia agencies, other state DOTs, law enforcement, highway safety advocates, and industry entities. In addition, the Program will lead, participate in, or support Virginia-based CAV pilot programs, as appropriate.

Workstream 4: Physical and Digital Infrastructure

4.1 Inventory and Visualize CAV-Related Physical and Digital Infrastructure

As CAVs arrive on highways and arterials, the current physical and digital infrastructure might not be well-positioned to take full advantage of the technology. The CAV Program will develop an interactive, user-friendly Geographical Information System (GIS) map to catalogue and visualize information related to current and planned CAV resources. The GIS map will contain, but is not limited to, the following:

- Virginia population and demographics
- Virginia roadways, major arterials, commuter routes, truck parking facilities, park and ride lots, and permitted facilities (e.g., fiber and small cell)
- VDOT-controlled ITS and communications infrastructure
- VDOT-controlled physical infrastructure and traffic control assets

The GIS map will serve as a living document and be updated regularly as CAV deployments move forward.

4.2 Develop CAV Readiness Framework

The CAV Program will create a CAV Readiness Framework for Virginia, which will include a breakdown such as:

- Meets Next Decade Market (10 years)/CAV Ready
- Meets Emerging Market (1-5 years)/CAV Adequate
- Meets Current Best Practices/CAV Preparations Need Work
- Needs Upgrade and Maintenance/CAV Inadequate

The CAV Readiness Framework will be based on national and federal standards related to preparing for CAVs. The CAV Readiness Framework will include a maturity model, such that an annual review and update process is outlined. The Framework will be based on regional and national Connected Vehicle (CV), Automated Vehicle (AV), and CAV readiness frameworks and the GIS map, as described in *Section 4.1.*

4.3 Review and Update Relevant VDOT Specifications and Standard Operating Procedures

Over the years, VDOT has developed policies and Standard Operating Procedures (SOP). These procedures are combined with feedback from various stakeholders and integrated into best practices. The CAV Program will assist stakeholders in updating existing policies and SOPs in preparation for CAVs, as appropriate.

4.4 Create a Roadmap of Physical and Digital Infrastructure Investments to Prepare for CAVs

VDOT will develop a Roadmap of Physical and Digital Infrastructure Investments to Prepare for CAVs (Roadmap) that takes into consideration the CAV-readiness of Virginia's 1,118 miles of interstate, 8,111 miles of major primaries, 48,305 miles of secondary roads, and private toll roads across the nine districts. Prior to the development of the Roadmap, the CAV Program will conduct a review of CAV use cases' needs, costs, benefits, and adverse impacts. The CAV Program will also identify and document the most important factors the agency should consider when planning CAV-related investments. The Roadmap will include:

- An expansive understanding of investments, including investments the agency should make in people, processes, technology, tools, and roadway infrastructure
- Direction as to how CAVs impact current investment plans for infrastructure improvements
- Guidance on future physical and digital infrastructure needs related to preparing for CAVs
- A prioritization plan for current and future investments; could be organized by roadway type, improvement costs, benefits, etc., or some combination thereof

Finally, the Roadmap will take into consideration and align with national and regional CAV preparedness efforts to assist in a cohesive response to CAVs. The CAV Program will also develop a process as to how the Roadmap will be reviewed and updated, if needed, on an annual basis. Input will be gathered from internal and external sources via workshops with partner agencies, VDOT employees, CAV stakeholders, and the general public.

4.5 Monitor and Support National Standards Concerning Physical and Digital Infrastructure for CAVs

The CAV Program will monitor the development of national, regional, and local efforts to prepare physical and digital infrastructure for CAVs, particularly any standards, regulations, or frameworks designed to create a cohesive CAV environment. Where possible, the CAV Program will assess the standards and provide feedback to the national CAV community as to VDOT's lessons learned.

Workstream 5: Data

5.1 Manage and Govern CAV Data

The CAV Program Manager will assist VDOT's Planning, Information Technology, Traffic Engineering Operations Divisions, and others in preparing to govern and manage the collection, storage, integration, security, and usage of data generated from CAVs. This effort will include:

- Generating an overview of the types and potential uses of data that CAV could generate at VDOT and partner agencies
- Identifying data needs and gaps that could be met, replaced, or strengthened through CAV data

- Assessing the state of practice for CAV technologies, including the Security Credential Management System (SCMS)
- Participating in agency-wide data governance discussions

5.2 Monitor and Support National Standards Concerning Data Management in Preparation for CAVs

The CAV Program will monitor the development of national, regional, and local efforts to prepare DOT data management for CAVs, particularly any standards, regulations, or frameworks designed to create a cohesive CAV environment. Where possible, the CAV Program will assess the standards and provide feedback to the national CAV community as to VDOT's lessons learned.

Appendices

Appendix A: Acronyms

Acronym	Definition
AASHTO	American Association of State Highway and Transportation Officials
API	Application Programming Interface
APTA	American Public Transportation Association
AV	Automated Vehicle
CAV	Connected and Automated Vehicle
CV	Connected Vehicle
CV PFS	Connected Vehicle Pooled Fund Study
GIS	Geographical Information Systems
IBTTA	International Bridge, Tunnel, and Turnpike Association
ITS	Intelligent Transportation System
ITSVA	Intelligent Transportation Society of Virginia
ITE	Institute of Transportation Engineers
MOT	Maintenance of Traffic
NEMA	National Electrical Manufacturers Association
NWS	National Weather Service
OBU	Onboard Unit
PPE	Personal Protection Equipment
PSTOC	Public Safety and Transportation Operations Center
RSU	Roadside Unit
SCMS	Security Credential Management System
SOP	Standard Operating Procedure
SPaT	Signal Phasing and Timing
TOC	Traffic Operations Center
USDOT	U.S. Department of Transportation
VDOT	Virginia Department of Transportation