MNDOT CONNECTED & AUTOMATED VEHICLES
ANNUAL REPORT

March 2024

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This report was prepared by the Minnesota Department of Transportation's Office of Connected and Automated Vehicles.

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MESSAGE FROM THE DIRECTOR

The last year has been exciting for the CAV team at MnDOT. With new projects and new people on our team, we continue to work on advancing technologies to address transportation challenges for Minnesotans. We continue to strive for improved safety, equity, access, and mobility in all the work we currently do, while also keeping an eye on future challenges.

Some of our team's accomplishments in 2023 include major project work, national awards, and new publications. We wrapped up testing and demonstrations for BearTracks, the automated vehicle shuttle deployment in White Bear Lake; continued testing and learning from the Automated Truck Mounted Attenuator system to maximize operational benefits for future maintenance use; completed research that garnered national interest regarding the indirect impacts of low-speed automated shuttles on pedestrians and other roadway users; and advanced several other projects. Our work received two Best of ITS Awards from ITS America for our partnership to advance LiDAR and camera technology and deploy the goMARTI automated shuttle project. We also launched our new website and had an article published in TRB News.

Our work wouldn't be as valuable to the people of our state if not for the involvement of our diverse stakeholders. We look forward to continued and new partnerships through our CAV Challenge program, the Governor's Council on CAV, and the Innovation Alliance committees. If you are interested in getting more involved in the state's work to help prepare and advance technology for the transportation system, please consider joining one of the Innovation Alliance committees in 2024.

TARA OLDS, PE
DIRECTOR OF CONNECTED AND AUTOMATED VEHICLES

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CAV community pop-up event

1. CAV VISION AND GOALS

Background

Formed in 2018, MnDOT's CAV Office works actively to plan and prepare for how technology will impact Minnesota's transportation future. Connected and automated vehicles (CAV) will be part of that future. Basic levels of CAV technology are already on Minnesota roadways. However, vehicles that are fully automated in all settings are still years away. Infrastructure that accommodates connected vehicle technology, such as fiber optic cable, sensor networks, and smart traffic signals, is currently being tested and is in use.

Minnesota is at the forefront of testing and understanding connected and automated vehicle technology, with a particular focus on safety and winter weather. MnDOT's CAV Office and our CAV partners are advocating for not just testing the technology, but also making sure it supports how people live, work, and play.

This report highlights the work done in 2023 by MnDOT's CAV Office to help prepare Minnesota for the future of transportation.

Figure 1: *MnDOT CAV Office values: safety, equity, innovation, reliability, and livability*

Minnesota's CAV Goals

Equity, Mobility, and Accessibility
CAVs may reduce transportation barriers for people with disabilities, older adults, and low-income families. They could also provide better access to jobs, health care, and other transportation modes.

Economic Development and Small Business
Advancing CAV policy could grow Minnesota businesses, attract new ones, and expand opportunity for small businesses.

Jobs and Workforce Development
CAVs present opportunities to reskill and upskill workers, attract new talent to the STEM field, and develop jobs of the future while protecting the jobs of today.

Public Health and Sustainability
CAVs could help reshape the way we plan communities to maximize health and sustainable multimodal transportation. Because many CAVs are electric, they could reduce emissions to advance sustainability goals.

Safety and Efficiency
CAVs could reduce congestion and crashes, eliminating some aspects of human error that contributed to the roughly 400 lives lost on Minnesota highways in 2023.

Autonomous Truck Mounted Attenuator

2. WHAT IS CAV?

Connected and automated vehicle technology encompasses a broad range of connectivity and automation, sometimes operating independently and sometimes cooperatively. These technologies are designed to enhance and improve the transportation experience—making it safer, more efficient, and more accessible.

Connected Vehicles

Connected vehicles use technology to communicate with each other; connect with traffic signals, signs, and other road items; and/or obtain data from the cloud. This information exchange will enhance safety and improve traffic flow.
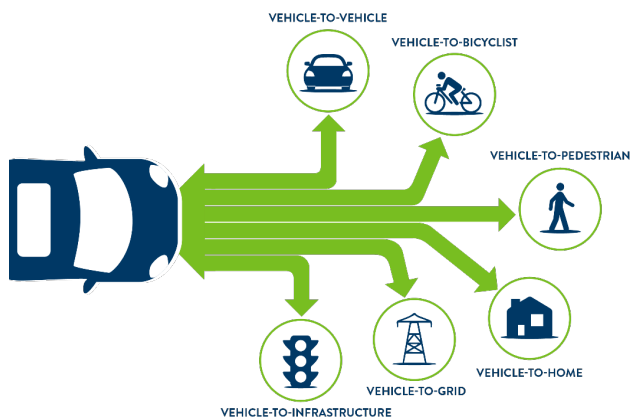
Automated Vehicles

Automated vehicles use technology to do driving tasks, like steering, accelerating, and braking, with little to no human input. Some vehicles still require a human to monitor the roadway, while other vehicles require no human intervention.
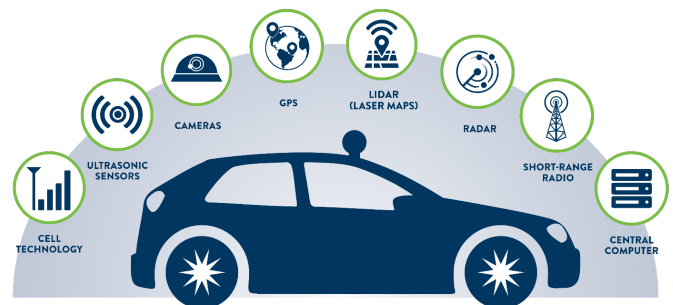

Figure 2: Example interactions that connected vehicles can make

Figure 3: Example technologies used for automated vehicles

Tara Olds (CAV) and Nichole Morris, PhD. (UMN) presenting at WTS International in Atlanta, GA

3. CAV STRATEGIC PLAN

The MnDOT CAV Strategic Plan is now four years old and we have started the process of updating it. In this update, the CAV Plan will be integrated into MnDOT's Transportation System Management and Operations Strategic Plan as a Tactical Plan. We are currently assessing the previous plan and progress made and identifying future focus areas for the next five years.

The CAV team has been operational for over six years, and we look forward to incorporating all the knowledge and experience gained over this time to redefine our mission and identify our role within TSMO and MnDOT. With this, we intend to refocus our objectives and direction, building on our accomplishments and identifying areas for future growth opportunities to better support forthcoming changes to our transportation system.
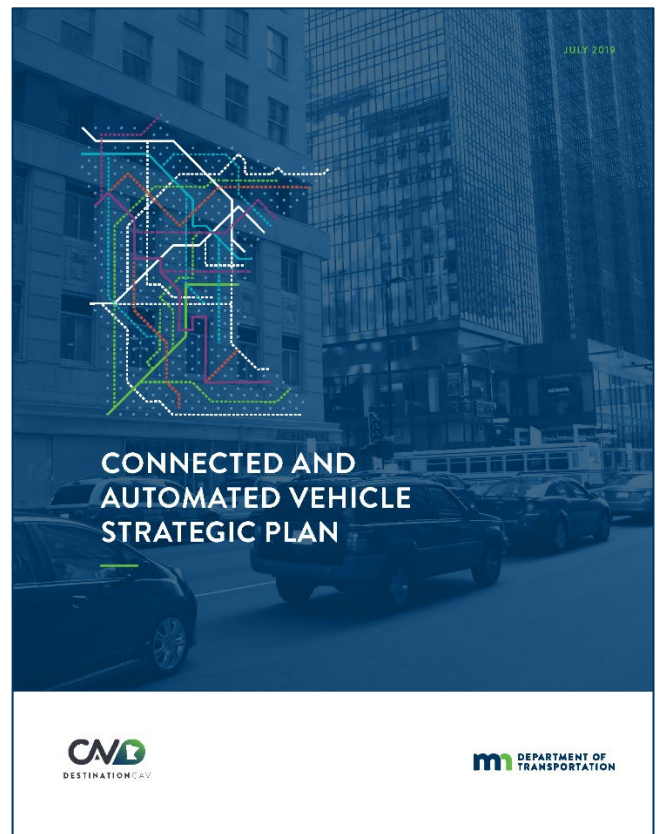

Figure 4: MnDOT's 2019 CAV Strategic Plan

goMARTI self-driving shuttle

4. HOW MnDOT IS PREPARING FOR CAV

Minnesota continues to prepare for CAV and transportation technologies by observing trends and advances in vehicle automation, connected vehicle technology, and other emerging areas. Below are some examples of work done by MnDOT's CAV Office in 2023 in the areas of testing, research, engagement, and partnerships.

Testing and Research

Bear Tracks

Beginning in August 2022, the Bear Tracks autonomous shuttle operated on a 1.5-mile route in White Bear Lake, Minnesota, with the goal of increasing transportation options and access for people facing transportation barriers, while also educating people and creating awareness on connected and autonomous vehicles. The shuttle, which concluded service in spring 2023, operated during all four seasons, in all weather conditions, and successfully demonstrated an autonomous connected vehicle application with a Ramsey County traffic signal. Some of the lessons learned during snow events will allow us to improve on our future autonomous vehicle projects.

goMARTI

Launched in fall 2022, the goMARTI self-driving shuttle project is the result of a unique partnership among several groups with a shared goal of increasing accessibility and transportation options for residents and visitors of Grand Rapids and testing self-driving technology in rural, winter conditions. The operation covers nearly

17 square miles and includes more than 70 pickup and drop-off points using five autonomous vehicles, including three wheelchair-accessible vehicles. The free, on-demand rides can be requested through a smartphone app or by calling the local First Call 211 service, which can help individuals download and navigate the app and place ride requests. While the vehicles are considered self-driving, there is always an autonomous vehicle operator on board who verifies the vehicle's safe operation and aids passengers as needed.

After beginning as an 18-month demonstration project led by MnDOT, goMARTI received federal funding submitted by the Department of Iron Range Resources and Rehabilitation to extend the project at least another three years and expand operations to the neighboring communities of La Prairie and Cohasset. To learn more about the project, go to goMARTI.com.

Automated Truck Mounted Attenuator (ATMA)

Over the winter, several modifications to the ATMA trucks were incorporated based on operator comments to improve the ruggedness and ease of operations of the system. Additionally, this year, the

CAV team provided staffing using mobility positions and performed statewide testing to support district operations. The approach of dedicating staff for the summer resulted in significantly more opportunity to test the ATMA system in the field. Though the system continued to encounter issues, the dedicated crew was generally able to work with the vendor to identify and correct them quickly. The CAV team plans to continue testing the ATMA system in 2024.

Lane Boundary Guidance System

Snowplow operators are often tasked with clearing snow from roadways under challenging conditions. One such situation is low visibility due to falling or blowing snow that makes it difficult to navigate, stay centered in the lane, and identify upcoming hazards. University of Minnesota researchers developed a snowplow driver-assist system that provides the operator with visual and auditory information that is suitable for low-visibility situations. This lane boundary guidance system uses a high-accuracy Global Navigation Satellite System (GNSS) and maps of the roadway, along with a forward obstacle detection system using radar, to detect potential hazards in the roadway. Currently, one truck in each of the eight districts is equipped with this system. The feedback from maintenance staff has been overwhelmingly positive. We will continue to improve this technology each year and look to expand the system to more MnDOT snowplows.

Connected Traveler Alert System

The Connected Traveler Alert System has been operating since November 2020 and remains in operation. This research project was created with the aim of increasing safety for roadway workers and the traveling public by informing motorists via Dynamic Message Signs (DMS) of slow-moving or stopped maintenance vehicles along the roadway. The 138 DMS display safety messages informing motorists that they will encounter a slow or stopped vehicle in their path. These alerts are produced without operator intervention. Our next steps are to increase the number of signs and improve the messaging.

Assessment of Pedestrian Safety and Driver Behavior Near Automated Vehicles

As more automated vehicles (AV) enter shared roadways, an essential aspect of AV safety is understanding the interactions between these vehicles and other road users. Anecdotal reports about aggressive following and overtaking behaviors at crosswalks near the Med City Mover (MCM), a low-speed automated shuttle (LSAV) pilot demonstration in Rochester, MN, suggested the need for a scientific study of the behaviors of drivers of manual vehicles near the LSAV. The human factors research project, titled "Assessment of Pedestrian Safety and Driver Behavior Near an Automated Vehicle," was launched to study these behaviors and is nearing completion.

The research team conducted a series of laboratory and field studies aimed at better understanding the safety relationship between LSAVs and the humans with whom they share the road. Overall, the study found an increased risk of overtaking and multiple-threat passing near the MCM, which may increase the risk of pedestrian-involved crashes, sideswipe crashes, and rear-end crashes.

The study findings suggest that poor human-machine interfaces, exceptionally slow vehicle speeds, and resultant large queues behind the MCM contribute to these risks. Improved communication interfaces, speeds more consistent with the surrounding traffic, and smaller queue size are all important factors that AV developers and future pilot demonstrations must consider to enhance pedestrian safety near AVs. The final report for the project is scheduled to be published in early 2024 on the project website.

Connected Work Zones

The CAV team is working with MnDOT's 511 vendor, Castle Rock, to develop a system to incorporate information from connected work zone devices into our traveler information systems (511 and other work zone feeds). The system being developed provides automated event generation and updates based on information from field devices to ensure that MnDOT publishes the most accurate information. Additionally, the CAV team developed and piloted a construction specification on a metro project this year. The pilot project is a first step to incorporating connected work zone devices on construction contracts.

Newly updated CAV website shown across various platforms

The CAV team has also been working with MnDOT's Office of Maintenance to identify a solution to retrofit and integrate connected work zone devices into the MnDOT vehicle fleet.

Engagement

CAV Website

MnDOT's Destination CAV website has received a long overdue upgrade. The new website is divided into two sub-sites; one is targeted toward the general public looking for basic information on CAV and what is happening in Minnesota, and the other is targeted toward partners already involved with CAV or those interested in getting involved. Check out the new website at http://www.dot.state.mn.us/automated/destination cav/

CAV Messaging and Engagement Guidance Documents

The MnDOT CAV Office and several partners developed high-level guidance documents designed to help shape CAV messaging and engagement in Minnesota. This multi-year effort culminated in a variety of resources focused on CAV messaging and engagement guidance. The documents can be used by anyone preparing CAV-related communications and engagement as they plan and implement CAV projects or look to include CAV messaging and engagement in related projects. Included in the documents is information related to messaging goals, identifying audiences, core messaging themes, talking points, and CAV-specific guidance for engagement.

The following resources were developed and are available on MnDOT's CAV Resources website:

- **Minnesota CAV Messaging and Engagement Guidance Document:** A high-level guidance document to help include CAV messaging and engagement in CAV and other related projects

- **Minnesota CAV Messaging and Talking Points Toolkit**: A compilation of specific messages and talking points for project managers and other practitioners

- **Minnesota CAV 10 Talking Tips**: A quick guide that highlights 10 tips for talking about CAV in Minnesota

- **Med City Mover Case Study**: A real-world example of this guidance in action and lessons learned from messaging and engagement on the Med City Mover CAV demonstration project in Rochester, Minnesota

- **Minnesota CAV Messaging and Engagement Strategic Recommendations**: Next steps for how Minnesota CAV partners can elevate messaging and engagement programmatically over the next one to five years

Community Driven CAV

Technologies are often developed by select companies and universities, and then tested in communities. Instead of leading with a solution, the Community Driven CAV project, focused in St. Paul's Creative Enterprise Zone, started by understanding community needs and assets, and then creatively explored ways that connected and automated technologies could address them. The result of many community listening sessions, events, and workshops was a Demonstration Action Plan describing the top potential CAV demonstrations that the community could pursue. A Community Driven

Planning Framework was also created that outlines innovative community engagement strategies and processes used and is a tool for other communities that are interested in community-driven CAV planning efforts.

Partnerships

Pooled Funds

Automated Vehicles

Highlights from the Automated Vehicle Pooled Fund Study (AV PFS) include creating and publishing the [Accelerate AV](#) website, which is an online forum where public- and private-sector AV stakeholders can share ideas, network, and discuss challenges and opportunities for the industry. Additionally, a new RFP was released last fall, titled Guidance for Sustainable Integration of Automated Transportation Technologies. It focuses on how state and local governments can integrate technologies to improve safety, mobility, and accessibility by exploring best practices, identifying issues and resolutions, and reviewing regulations and policies.
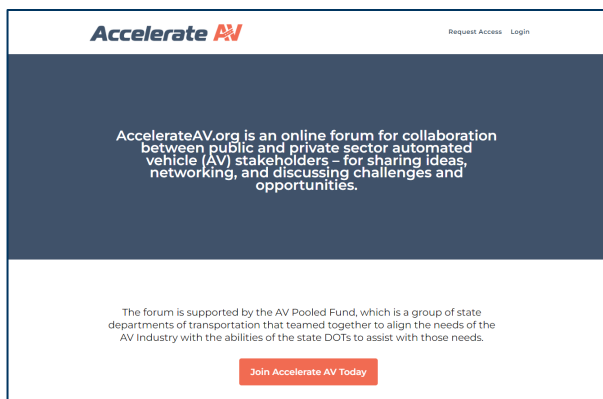
Figure 5: New Accelerate AV website

Automated Maintenance Technology (AMT)

Highlights from this year's AMT pooled fund activities include continued focus on automated truck mounted attenuator systems and development of related technologies, creation of a steering committee to ensure stability as staffing changes at Colorado Department of Transportation (CDOT), and visiting Virginia Tech to learn about the ATMA system the university is developing at low cost.

MAASTO CAV Committee

Two major highlights for the Mid America Association of State Transportation Officials (MAASTO) CAV Committee in 2023 include the committee's annual meeting and the establishment of the MAASTO CAV Pooled Fund Study.

The annual meeting was held in Iowa City, Iowa in June. Committee members and industry partners had the opportunity to tour the Driving Safety Research Institute and learn about the ADS for Rural America project, both at the University of Iowa. The meeting also included presentations and in-depth discussions about research and demonstration projects, legal issues, and challenges and opportunities for the region in the coming year. MnDOT CAV staff presented during the fireside chat session, sharing lessons learned from state deployments, research highlights regarding safety around low-speed automated vehicles, and IIJA grant awards for Minnesota. CAV staff also participated in roundtable discussions to help identify MAASTO CAV priorities.

The committee established a pooled fund study to help support research and initiatives identified in the MAASTO CAV 10-year Regional Strategy to advance CAV technology for member states. Projects are expected to kick off in early 2024.

Figure 6: MAASTO CAV Committee's 2023 annual meeting in Iowa City, IA

ITS Minnesota (ITS MN)

ITS MN fosters grassroots participation and public-private partnerships to inspire, educate, and support the use of intelligent transportation technology that improves safety, equity, and mobility for all Minnesotans. MnDOT has continued its longstanding membership in ITS MN. In the last year, Adam Wellner has served as a Director and Scott Meier has served on the Program Committee.

Partners for Automated Vehicle Education (PAVE)

Tara Olds, CAV Director, was named chair of PAVE's Public Sector Advisory Council. She serves as the liaison for PAVE to share national and state work and help identify future areas for collaboration with PAVE and other organizations.

Traffic Engineering Organization (TEO)

The CAV team continued its engagement with MnDOT's Traffic Engineering Organization. Adam Wellner chairs the TEO ITS committee. Additionally, Scott Meier sits on the Work Zone subcommittee and the statewide Work Zone Safety committee. CAV staff members also participate in various TEO subcommittees as CAV topics are discussed, continuing a close working relationship with TEO and MnDOT's Office of Traffic Engineering.

5. 2023 MnDOT CAV TEAM

The CAV Team in 2023 was made up by a number of people from different disciplines and backgrounds which allowed to move work forward in areas including engineering, maintenance equipment and operations, engagement, policy, and planning.

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Director of Connected and Automated Vehicles

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Project Management Engineer

CHRIS MARTELL
CAV Technician

DAN ROWE, PE
Project Manager

CURT SULLIVAN
ATMA Operator

SCOTT MEIER
Project Manager

JEN WILTGEN
CAV Planner

MnDOT CAV's ITS America award acceptance

6. AWARDS

CAV team projects have received local and national awards in recent years, including the following:

ITS America

MnDOT projects were recognized as two of the five finalists for the 2023 Best of ITS Awards. MnDOT was also recognized as a key partner, along with VSI Labs, for the first place recipient, AEye, for its LiDAR and camera testing and validation on I-94, which exceeded industry expectations. MnDOT was also recognized as a key partner of the third place recipient, The Plum Catalyst, for the goMARTI AV demonstration project.

Northern Lights Awards

The CAV messaging and engagement guidance documents won the Silver Award in the Marketing or Communications Plan category for the Northern Lights Awards, which are presented by the Minnesota Association of Government Communicators.

Robert C. Johns Research Partnership Award

The Snowplow Driver-Assist project was awarded the University of Minnesota Center for Transportation Studies Robert C. Johns Research Partnership Award, which is presented annually to a team of individuals who have collaboratively drawn on their diverse expertise to achieve significant impacts on transportation.

Bear Tracks Automated Shuttle

7. WHAT'S NEXT?

The CAV team has exciting plans for 2024, which will include continuing many existing projects and starting new projects to research and help advance transportation technologies to address transportation challenges for people in Minnesota. Priorities include testing and advancing winter-weather capabilities of technologies, using ITS and CAV technology to enhance work zone safety, exploring opportunities to incorporate technology into MnDOT's fleet, and focusing on all roadway users to ensure that our outcomes create a safer, more equitable, and more accessible transportation system.

New programs and events are already being developed and planned and the next Governor's Council on Connected and Automated Vehicles will kick off in early 2024. Be sure to check out the MnDOT CAV website for updates throughout the year on our work and ways to get involved.