Connected and Automated Vehicles and New Technology White Paper

Introduction

The Michigan Department of Transportation (MDOT) continues its tradition of being a cutting-edge state transportation department and a leader among transportation agencies around the country. Two of the State Long-Range Plan goals are the driving influence behind MDOT's leadership in new technology: promoting safety and security, and operating an efficient and effective transportation system.

This white paper provides summaries of a few of the exciting advancements MDOT has made in fostering new transportation technology. The department is preparing for the potentially paradigm-shifting technologies of connected and automated vehicles (CAV) that have the potential to provide the citizens of Michigan with safer and more efficiently managed roads. In addition, advancements in operations and intelligent transportation systems (ITS) have already created a safer and more efficient transportation network, ensuring the effective movement of goods and people around the state.

Connected and Automated Vehicles

Many new vehicles already have systems that warn the driver to stay in their lane, or even stop the vehicle, if the driver is distracted before an incident occurs. These systems exemplify the early stages of CAV technology. Whether mandated by the government or demanded by consumers, MDOT must be ready for the changes these technologies will bring to the use and maintenance of the road network.

The technology currently exists, or will exist soon, to allow CAVs to become a part of the public vehicle fleet. As a state transportation agency, MDOT is planning and preparing for the changes required to support and take advantage of CAV technology.

What's the Difference?

Connected vehicles and automated vehicles are two different technologies that are both developing and will have fundamental impacts on transportation. A connected vehicle is a car or truck that is equipped with dedicated short-range communication devices, primarily two-way radio frequency reserved by the federal government for transportation safety purposes. This allows the car to either communicate with other vehicles on the roadway or with roadway infrastructure, such as traffic lights. This communication is often referred to as vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I), and is already being incorporated into new vehicles and roadway infrastructure. MDOT is focused primarily on V2I testing and implementation, as this technology is dependent on infrastructure outfitted with sensors and communication devices.

Examples of MDOT efforts in this field, which involve infrastructure communicating to the vehicle or operator, include:

- Signal Phase and Timing
- Truck Parking Availability
- International Border Delay

Initiatives the department is using to improve operations internally include:

- Pavement Condition Monitoring
- Road Weather Information Systems (RWIS)
- Work Zone Management

Automated vehicles, also known as autonomous vehicles, are cars or trucks that sense their surroundings with such techniques as radar, light detection and ranging technology, global positioning systems (GPS), and computer vision. The vehicle uses these technologies to identify its location in the environment, thereby determining an appropriate navigation path and keeping itself on the road while avoiding obstacles. This potentially can allow the passenger in the car to be just that, a passenger, and not an operator, although this technology is still in its very beginning phases.

CAV Technology Strategic Plan

MDOT's mission is to "Provide the highest quality integrated transportation services for economic benefit and improved quality of life." This mission has been applied to CAV and ITS in the Connected and Automated Vehicle Technology Strategic Plan, a high-level guidance document that MDOT uses to incorporate CAV/ITS technology department-wide, which can be found at www.michigan.gov/its. The Strategic Plan lays out the design for aligning MDOT's long-term transportation plans with recent advances in technology and policy regarding CAV. A core element of the plan centers on the inclusion of rapidly developing technologies in the digital communications and vehicle-embedded automated systems. MDOT strategies must account for changes in these important technologies, in addition to traditional communication and ITS technologies. The document is divided into six strategic focus areas that are directly related to the department's Strategic Plan:

- Leadership
- Safety
- Customer Service
- Partnerships
- System Linkages
- Efficiency

Implementation and Test Facilities through Planet M

Planet M represents the collective mobility efforts across the state of Michigan around the technologies and services that enable people and goods to move around. Michigan has always been the leader of the automotive industry, and as vehicle and transportation technologies continue to evolve in amazing ways, Michigan is continuing to lead the way. The entire state and the auto industry are transforming into the global center for mobility. Working in partnership with automobile manufacturers and suppliers, universities, local agencies and a number of others in the public and private sectors, MDOT has set a vision for a connected vehicle environment encompassing a large segment of southeast Michigan, centered along the freeway and surrounding arterial network in Metro Detroit. The connected vehicle environment is envisioned to encompass the four basic foundations of any connected vehicle system: supporting infrastructure, equipped vehicles and/or motorists, data and applications, and the communications network needed to support the system. For information, please visit the Planet M website.

Examples of test projects include:

- Mcity: An automated vehicle testing center at the University of Michigan's (U of M) Transportation Research Institute. Developed in partnership with U of M, MDOT, and Michigan's automotive industry.
- Ann Arbor Connected Vehicle Test Environment: This started as a pilot project to test the effectiveness of connected vehicle technology in a real world environment around the city of Ann Arbor. It is now being transitioned from a test deployment to an operational deployment. The project is also being transitioned away from government funding to more sustainable long-term funding.
- Southeast Michigan Connected Vehicle Environment: A project consortium to create a Connected Vehicle Environment, including MDOT, General Motors, Ford, and U of M. The project will be developed primarily along I-96/I-696 and I-94, and will also include part of US-23 and the Connected Vehicle Pilot site in Ann Arbor. MDOT has identified 400 to 470 locations where roadside units could be located. The project includes numerous applications, both V2V and V2I, such as emergency electronic brake lights, forward collision warnings, left-turn assist, work zone warnings, signal phase and timing, and border wait time applications. Although a recent $20 million pilot site application submitted to the U.S. Department of Transportation to further support the development of the project was unsuccessful, development of the Connected Vehicle Environment will continue.
- Truck Platooning: The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) and MDOT have partnered to test communications technology for Army vehicles along I-69. This technology will increase safety and efficiency and address the looming shortage of truck drivers. This also has the potential to increase capacity of the freeways and reduce fuel consumption, saving money and reducing emissions.

New Technology

e-Construction: MDOT's e-Construction process is the collection, review, approval, and distribution of construction contract documentation in a paperless environment. e-Construction involves the integration of various digital technologies into business/construction operations so that cost savings, efficiency gains, and other benefits are realized. MDOT began by piloting the e-Construction process in 2013 on four major highway contracts worth a combined $140 million in construction costs. In order to go completely paperless, other processes also had to be automated. Document management software was made accessible to all stakeholders, including contractors, engineers, suppliers, fabricators, testing personnel, inspectors, and the Federal Highway Administration (FHWA). All parties were required to use digital signatures, and training was required to bring people up to speed on the new technology.

Having completed the pilot projects, MDOT is now implementing e-Construction across the entire construction program. Statewide implementation began in the 2014 construction season as e-Construction staff conducted training in every MDOT field office throughout the state. Full implementation on MDOT highway and bridge projects started in October 2014, when the requirement to be paperless and use digital signatures became part of all MDOT jobs bid after that date. As of 2015, Michigan is the first and only state DOT in the nation to fully implement e-Construction on all state highway and bridge contracts.

Stringless Concrete Paving: This method of preparing a construction site involves scanning the existing pavement, sub-base, aggregate base, and other roadway components, collecting very precise measurements. These highly accurate computer-aided measurements decrease the number of hours construction crews spend staging a construction site. The data helps guide the construction equipment, ensuring a more consistent and efficient construction by minimizing error and waste.

Intelligent Transportation Systems (ITS): ITS is a combination of electronics, telecommunications and information technology for the transportation system. It is not only for highways, but includes all modes of transportation. The concepts included within ITS also are evolving, although there are now a number of them established that are giving definition to the discipline. Examples include systems for traffic management, public transportation management, emergency management, traveler information (dynamic message signs), advanced vehicle control and safety (red light warning systems), commercial vehicle operations (truck parking information system), and railroad grade crossing safety.

Transportation Operations Centers (TOC): MDOT has four TOCs, in Detroit, Grand Rapids, Lansing, and Port Huron. These centers collect real-time information on state roadways using ITS devices, traffic technology, and communications. Two-way communication and data exchange through partnerships with the Michigan State Police, local emergency responders, the National Weather Service, a variety of MDOT staff, traffic information providers, and many others is utilized to gather and share information focused on optimizing transportation safety, mobility, sustainability, and the Michigan economy. The TOCs collect real-time information, monitor freeway mobility, dispatch Freeway Courtesy Patrol (FCP) drivers, manage incident and

emergency response, coordinate information for planned events, and provide traveler information. Technology tools and strategies utilized at the TOCs include Advanced Traffic Management System (ATMS) software, RWIS, Maintenance Decision Support Systems (MDSS), and an ITS infrastructure. Traffic operation strategies and ITS devices are employed to provide public traveler information, via roadside message signs, to the MDOT Mi Drive website and social media accounts, provide e-mail and text notifications to the public that have signed up to receive these, and enhance partnerships with local media by providing added value content to their services.

Mid America Association of State Transportation Officials (MAASTO) Truck Parking Information Management System (TPIMS): To address the safety issues associated with driver fatigue and illegal truck parking, MDOT developed the TPIMS. TPIMS currently assesses truck parking availability along 130 miles of the I-94 corridor in southwest Michigan, one of the busiest truck corridors in the state. TPIMS identifies available truck parking and shares that information with commercial vehicle drivers in real time.

The TPIMS segment of the I-94 corridor contains five public rest areas with maximum truck parking capacity of less than 160 spaces, and more than 1,000 additional spaces at private truck stops. At the public truck parking locations, MDOT uses pavement sensors to gauge parking space availability and communicates that information to MDOT's ATMS. At private truck stops, MDOT contracts with a private-sector firm, Truck Smart Parking Services, to interface with truck stop owners, and install cameras and traffic counters at access points; this data is then used to gauge the number of parking spots available based on an "in-out" analysis. TSPS then communicates that information to MDOT for rebroadcast through ATMS.

MAASTO submitted and was awarded a TIGER grant in 2015 to expand TPIMS to corridors throughout the Midwest. The goal is to implement TPIMS on the busiest truck routes on as many miles as funding will allow. Multiple routes were selected across eight of the 10 MAASTO states. The intent is for the signs and technology to have a consistent "look and feel" across states, so that commercial drivers can easily identify the information. The project was awarded $25 million in 2016.

Active Traffic Management (ATM): ATM encompasses a broad range of techniques and approaches to improve roadway efficiency and safety, and to reduce traffic congestion. Examples of ATM strategies that MDOT is currently implementing include adaptive traffic signal control, dynamic shoulder use, dynamic lane use, dynamic advisory speeds, and queue warning. Other ATM strategies include transit signal priority, adaptive ramp metering, dynamic junction control, and dynamic merge control. MDOT plans to place an ATM system along US-23 between the US-23/M-14 west interchange and M-36 in the greater Ann Arbor area beginning in 2016. This system will utilize the upgraded median shoulders on US-23 to help improve traffic flow and increase safety along the corridor. Lane control signs will let drivers know when the system is active. The ATM will be monitored by MDOT's Statewide Transportation Operations Center through the use of expanded ITS technology and with assistance by the FCP.

Road Weather Information System (RWIS): The vision of the MDOT RWIS program is to have a robust system that provides stakeholders useful information about road weather conditions around the entire state of Michigan using an array of existing and next generation technologies. RWIS is one element of ITS, consisting of remote sensing locations that together form an information system that gathers and transmits road-related weather information. The information may include atmospheric (temperature, wind, precipitation, etc.), roadway (temperature, pavement conditions), and sub-surface (frost depth) characteristics. The impact of snow and ice events is one of the most influential factors affecting transportation operations and maintenance during the winter months, and has significant cost and safety implications. Implementing RWIS provides safer highways, improved road maintenance decision-making, improved traveler information, and data for review of historical weather events to enhance transportation planning.

Transportation Systems Management and Operations (TSM&O): This is an integrated program to optimize the performance of existing multimodal infrastructure by implementing systems, services, and projects to preserve capacity and improve the security, safety, and reliability of the transportation system. TSM&O can help address transportation challenges by leveraging technology to:

- Enhance safety
- Preserve and maximize existing capacity
- Promote mobility and customer outreach
- Improve reliability for commuters and freight
- Enhance sustainability and livability
- Monitor performance
- Help achieve regional safety and mobility goals
- Quicker and less costly implementation compared to adding lanes, etc.

Global Positioning Systems (GPS) and Maintenance Decision Support Systems (MDSS): MDOT has installed GPS and other weather sensors on all 300 MDOT snowplow trucks and some fleet maintenance vehicles. This system provides a comprehensive fleet tracking and mobile weather system for MDOT snowplow trucks and maintenance fleet vehicles. It includes, but is not limited to: GPS hardware/software, installation support, communication/data transfer, training support, a secure website for displaying mapped assets in near real-time (snowplow trucks can be seen on MDOT's Mi Drive website when actively managing a weather event), vehicle sensing of atmospheric conditions and in-vehicle controllers, data management, data reporting and data storage, and ongoing technical support for implementing the GPS fleet tracking solution on MDOT fleet vehicles. Other initiatives in this area include, but are not limited to:

1. Assessing the need, potential benefit, and participating in a state transportation department Pool Fund Study (PFS) for the MDSS;
2. Continuing to define functional and user requirements for the operation of the MDSS;
3. Building and evaluating software changes to MDSS that will meet the defined functional needs of the state PFS.

MDSS is the visual tool provided by a third party vendor that gives a forecast and treatment recommendations to the snowplow truck driver and the maintenance garages. MDSS provides important information to help those managing a weather event with more localized atmospheric conditions so they have better awareness as to what is needed for roadway treatment to maintain a given level of service to MDOT's customers.

The University of Michigan (U of M) Mobility Transformation Center, **Mcity:**
The Michigan Mobility Transformative Center is intended to improve the safety, sustainability, and accessibility of the ways that people and goods move from place to place. Through this program, the Mcity test site was developed, in partnership with U of M, auto manufacturers, and MDOT, to conduct research and testing of automated and connected vehicle technologies, supporting three "pillars" of transformation: expanding connected vehicle deployments in the Ann Arbor area, supporting MDOT's connected vehicle environment in southeast Michigan, and providing for the deployment of automated vehicle systems in the Ann Arbor area. Mcity is recognized as a world-class, forward-thinking and unique facility, supporting the development and testing of this new transportation technology.

The American Center for Mobility (ACM):
A joint initiative with supporters including MDOT, Michigan Economic Development Corporation, the University of Michigan, Business Leaders for Michigan, and Ann Arbor SPARK. The center, located in Ypsilanti Township, will help accelerate advanced mobility vehicle development safely and support the development of a potentially transformative industry in Michigan. ACM offers an opportunity for larger-scale research, development, and testing due to both the size of the facility and more diverse infrastructure.

Smartphone Apps: MDOT is also making use of the prevalence of smartphones by creating applications to enhance customer service and to operate efficiently. For example, new apps are being used to collect the locations of invasive species and digitizing that information on maps. This allows maintenance crews to address, to the extent possible, the treatment and potential elimination of invasive species that can impact safety and function of the roadway by disrupting the intended plant life in the area.

Additionally, through the MDOT Mi Drive App, MDOT is providing its customers with truck parking information, travel speeds, and a variety of roadside amenities, such as rest areas and carpool lots.

Conclusion

MDOT continues to develop new and more efficient methods to manage Michigan's transportation system. At a time when demands on the existing network are ever increasing, it is important to continue looking for new ways to innovate and use resources wisely. The new technologies described in this paper are only a few examples of how MDOT is working hard to provide safe and efficient systems for Michigan.