

# RESEARCH UPDATE

OCTOBER 2011

## Using Data to Improve Safety, Manage Traffic and Manage Assets

The technology that keeps us connected is everywhere—from our cell phones to the Internet and the Global Positioning System (GPS) devices that tell us where we are with pinpoint accuracy at any given moment.

### In This Issue: Leading the Way with Connected Vehicle Technologies

In this issue of *Research Update*, we highlight MDOT's leadership role in connected vehicle research that will be critical to the transportation system of the future.

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### A coordinated effort

Federal and state transportation agencies—with participation by private industry partners—are investigating how the connectivity we take for granted in our daily lives can be applied to transportation. The technologies in development—referred to as “connected vehicle” technologies—use an interoperable network of wireless communication among 1) vehicles; 2) the transportation infrastructure (roadways, traffic signals and sensors); and 3) personal communication devices to enable vehicles to obtain and share information with each other and the community at large. For example, vehicles slowed by traffic congestion may automatically transmit messages about the location and extent of the congestion to other vehicles, a traffic operations center and a 511 Web site.

While still in their infancy, connected vehicle technologies show great potential to improve safety and reduce congestion. The data generated and shared within the connected vehicle information network can:

- Inform drivers about congestion and suggest alternative routes.
- Prevent collisions or run-off-the-road crashes.
- Process tolling transactions.
- Deliver other travel-related messages.

### Leading the way

MDOT's vision is for Michigan to be the home of connected vehicle research,



*MDOT's investment in connected vehicle technologies holds the promise of a safer, smarter and greener transportation system.*

development and deployment in the United States. A national expert in the field and the driving force behind MDOT's involvement in connected vehicle research, MDOT Director Kirk T. Stuedle oversees a program that, with the benefit of nontraditional public-private partnerships and significant investments, is developing and deploying several connected vehicle initiatives.

### Managing the data

At the heart of connected vehicle technology is data—lots of it, from many different sources. In 2008, MDOT initiated a wide-ranging research effort—“Data Use Analysis and Processing (DUAP)” —that is the first independent evaluation of the uses and benefits of the wealth of data generated through connected vehicle technologies.

The DUAP effort began with identification of the data-driven processes within MDOT. Researchers considered how more robust data gathered with

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## Using Data to Improve Safety, Manage Traffic and Manage Assets

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connected vehicle technologies could provide significant improvements in the road network, drivers' situational awareness, congestion management, asset management and safety.

Data are gathered in near real time at any time and place where vehicles are using the infrastructure—not just when specially equipped vehicles are in use. The project gathers data from a variety of sources, including GPS devices that provide vehicle location, specially equipped vehicles that obtain data about road surface conditions, and sensors that monitor weather, traffic and bridge stresses. Wireless communication services transmit data back to a server, where the DUAP system caches the data and makes it available for dissection by various software applications.

### Generating new information

DUAP stores this raw data, and over time uses it to build a consistent set of traffic, environmental and asset-related data that merge with other data generated and managed by MDOT. Computations using DUAP data generate new information about real-time traffic and historic traffic patterns, incident detection and location, and weather, road and bridge conditions.

When appropriate, DUAP generates messages and sends them back to the infrastructure, vehicle or personal communication device in real time. For example, messages sent from the DUAP system to affected vehicles may include travel times, event descriptions and recommended routing to minimize travel time.

Data and outgoing messages are archived by the DUAP system to allow for replaying events or future analysis. DUAP also adds value to existing processes by supporting and enhancing current data collection systems for asset management and planning. Data gathered from in-vehicle systems such as GPS devices and accelerometers help MDOT staff identify and locate roadway roughness, potholes and general pavement distress.

## Building on the Success of DUAP

Lessons learned from the initial DUAP project stand ready to be applied as the project transitions to its next phase—DUAP 2.

Beginning this fall, researchers will seek to expand the range of partner organizations and the sources from which DUAP data is drawn. This user-centered project will also focus on:

- Capturing MDOT's data collection needs through facilitated workshops using a systems engineering process.
- Reviewing current applications for possible enhancement with richer, more comprehensive data sets.
- Exploring ways to retrieve more connected vehicle data to conduct system evaluations and develop prototypes. Simulation will be considered to augment actual data.

- Equipping MDOT and other public fleets with new types of aftermarket devices that will generate the specific data needed to power user applications. Of particular interest are devices that will gather data to improve operations and asset management.
- Determining how DUAP data can be used to support current data sources used for asset management and planning, and to enhance current methods of data collection.

The continuation of DUAP research is expected to provide MDOT with the ability to reduce departmental costs and optimize resources. DUAP 2 is scheduled to conclude in summer 2014. Contact Project Manager Steve Cook at [cooks9@michigan.gov](mailto:cooks9@michigan.gov) to learn more about this project.

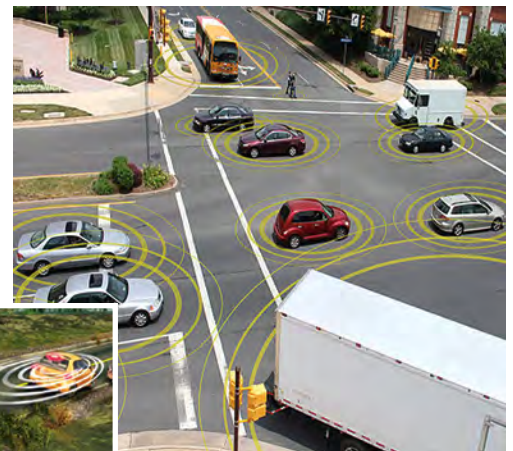
*“As we dig deeper into the connected vehicle world, we’re finding that the benefits that support safety, mobility and a greener environment are virtually limitless.”*



—Steve Cook, P.E., MDOT Operations Engineer

### For more information

Much of the research described in this issue of *Research Update* feeds into MDOT's DUAP project in some way. Learn more about the DUAP project and other MDOT initiatives at [www.michigan.gov/cv](http://www.michigan.gov/cv). Read more about the work that continues on DUAP in the sidebar above.



Connected vehicle technologies allow for vehicle-to-vehicle and vehicle-to-infrastructure communication. (Courtesy of U.S. DOT.)

# New Contract to Test Connected Vehicle Technologies

The recent awarding of a \$14.9 million research contract to the University of Michigan Transportation Research Institute (UMTRI) keeps Michigan at the forefront of connected vehicle research. UMTRI will use the federal research funds, in addition to \$3.7 million in cost share, to conduct a model deployment of connected vehicle safety applications beginning in July 2012. MDOT will work closely with UMTRI and other key stakeholders to monitor and evaluate the results of the model deployment.

## The testing protocol

To set the stage for the yearlong testing program, researchers will develop a real-world multimodal test site in Ann Arbor that allows for wireless communication among vehicles. Specially designed roadside equipment installed at the test site will generate data that feeds into safety and mobility applications.

The research program will test connected vehicle systems that communicate wirelessly with other vehicles and the roadway infrastructure to generate warnings to drivers of potential threats, hazards and delays on the roadway. Over 2,800 vehicles, including passenger cars, commercial trucks and transit buses, will be equipped with a mix of connected vehicle systems, including:

- Broadcast-only devices that send a single type of safety message to other vehicles. This type of device identifies vehicle location,

direction, speed and other information, and broadcasts it in a basic safety message.

- Aftermarket devices installed in the vehicle that broadcast and receive safety messages. These devices have the capability to process the received messages to generate audible or visual warnings and alerts for the driver.

The proposed devices may generate warnings specific to each type of vehicle, including warnings based on messages broadcast by other vehicles and by roadside equipment, and warnings for curve speed, blind spots, no-pass areas, forward collisions and more.

## Applying the results

During the 12-month model deployment, researchers will test the effectiveness of the safety applications installed in the test vehicles and the overall effectiveness of the driver safety warning system. The data generated will be used by the U.S. Department of Transportation (U.S. DOT) to estimate safety benefits and to develop additional safety, mobility and environmental applications using wireless technologies.

MDOT's Steve Cook and other key stakeholders will work with UMTRI staff and the city of Ann Arbor to coordinate installation of the test site's roadside equipment. For more information about this project, contact Steve Cook at [cooks9@michigan.gov](mailto:cooks9@michigan.gov).



*Wireless connectivity allows cars to tell other vehicles where they are located at all times. (Courtesy of U.S. DOT.)*

## MDOT Research in the National Spotlight

Two national meetings this month will showcase Michigan's role in advancing connected vehicle technologies.

- Detroit—the city that revolutionized transportation—is hosting the Annual Meeting of the American Association of State Highway and Transportation Officials (AASHTO) October 13 to 17. MDOT Director Kirk T. Steudle will describe MDOT's connected vehicle research at a session on Sunday, October 16: "The Vehicle of the Future: Greener, Safer, Smarter."
- The Intelligent Transportation Society of America, a non-profit organization established to foster the use of advanced technologies in surface transportation systems, is sponsoring the 18th World Congress on Intelligent Transport Systems in Orlando, Fla., October 16 to 20. Researchers and MDOT staff will demonstrate new technology slated for testing in a model deployment that will examine connected vehicle safety applications. See the article on this page to learn more about this research.



*"MDOT's leadership in developing, testing and deploying connected vehicle technologies serves both the state and nation. Application of connected vehicle research will bring economic benefits to Michigan and make the national transportation system safer and more reliable, while contributing to a cleaner environment."*

—Kirk T. Steudle, P.E., MDOT Director

# Monitoring the Health of Michigan Bridges

Most state DOTs gather data about bridge health during the biennial field inspections required by federal regulations. MDOT researchers were interested in learning if an installation of sensors could generate real-time data about the effect of traffic on bridge stress levels. Adding this real-time data to data from required biennial inspections has the potential to improve scheduling and deployment of maintenance resources, improve current decision support systems, and increase safety through early detection of structural problems.

## Monitoring the Bridge Walk

A much-loved annual event in Michigan's Upper Peninsula provided the opportunity to test connected vehicle technologies. The annual Labor Day Mackinac Bridge Walk, the once-a-year exception to the rule prohibiting pedestrians on the Mackinac Bridge, closes the east lanes of the bridge to vehicles to make room for the thousands of walkers participating in the five-mile walk. Before the September 2007 Bridge Walk, MDOT placed four vibrating wire strain gage sensors on the bridge to monitor traffic conditions—in this case both foot and vehicular traffic.

Connected vehicle technologies collected data sent through a wireless communication network; laptops in the Mackinac Bridge Authority's office and vehicles specially equipped with onboard systems monitored data gathered by the sensors. Researchers compared the data collected every eight seconds from the bridge before, during and after the Bridge Walk to the structure's original design allowable stresses.

## Expanding the pilot system

The success of the pilot system in gathering, delivering and processing high-speed, real-time data led to the permanent installation of eight strain gages at critical locations near the south



*The annual Labor Day Mackinac Bridge Walk provided researchers with an opportunity to test data collection through a wireless network.*

tower of the Mackinac Bridge. The monitoring program also expanded to a second location—the Cut River Bridge, just 24 miles to the west of the Mackinac Bridge.

Five solar panels provide power to the Cut River system, with a battery charge that can hold up to 16 days of reserve power supply. In addition to 16 fiber-optic strain gages installed to monitor and detect strains and stresses in primary load-carrying members, the Cut River monitoring system also includes:

- Environmental sensors installed in the bridge deck to detect bridge moisture content, deck temperature, chloride content and icing conditions.
- Detectors installed in the travel lanes just before the bridge to detect traffic speed, volume and occupancy of vehicles passing over the bridge.
- Closed circuit television (CCTV) cameras to verify surface conditions,

traffic flow and vehicle type. This visual evidence will aid in the quality control of data retrieval.

An environmental sensor station installed near the bridge provides additional weather data. A weigh-in-motion (WIM) station one mile east of the bridge collects additional data on vehicles crossing the bridge. Sensors transmit the data to a common server for storage, archiving, analysis and display.

## Managing the data

Data collected over the course of two years will include vehicle data (speed, volume, classification), bridge video images, strain gage data, WIM data, and environmental sensor station data (wind speed and direction, temperature and humidity).

In addition to providing supporting data for current MDOT methods of monitoring the structural performance of the bridges, the data collected will be used to compare historic design practices with current calculations that use AASHTO specifications for design service loads. Weather, traffic and deck sensor data will be used in traveler information programs, and all data will be organized and formatted for use in the DUAP 2 project.

## For more information

This research project—“Infrastructure Monitoring Data Management”—is expected to conclude in spring 2012. Contact Project Manager Steve Cook at [cooks9@michigan.gov](mailto:cooks9@michigan.gov) to learn more about this ongoing project.



*The Cut River Bridge, site of one of the bridge monitoring locations, is one of only two cantilevered deck truss bridges in Michigan.*

## Communicating Movable Bridge Status in Real Time

It can be frustrating for drivers who must wait for river traffic to pass under an open bascule—or movable—bridge. Frustration can turn to greater concern for emergency responders, when every minute counts. MDOT recognized the need to provide better information about the opening and closing of bascule bridges to 911 operators, fire and emergency medical responders, and the traveling public.

Bascule bridges in Bay City (Liberty and Lafayette Avenue bridges) and on US-131 in Grand Haven provided the sites for a pilot project to investigate the feasibility of a statewide bridge monitoring program. The monitoring systems include CCTV that delivers live streaming video and other equipment that receives bridge closure in-

formation directly from the bridge gate circuit and transmits the bridge status via a point-to-point wireless connection.

Local agencies obtain information about bridge status through a direct server connection. The public sees bridge status in real time on MDOT's Mi Drive Web site, an online resource for Michigan traffic and roadway construction information. On the Mi Drive site at [www.michigan.gov/drive](http://www.michigan.gov/drive), bridge icons change colors



Completed in 1938, the Lafayette Avenue Bridge over the Saginaw River is one of the state's three bascule bridges equipped with monitors.

to signify bridge status (open to traffic, closed to traffic, status unknown); the time of closure and duration are also noted.

## National Trends

### In-Vehicle Messaging for Safer, More Efficient Roadways

In 2013, the National Highway Traffic Safety Administration (NHTSA) expects to make a decision on whether to establish rules for automakers to introduce crash-avoidance technology in new vehicles by the end of this decade. The U.S. DOT Research and Innovative Technology Administration (RITA) is supporting a number of connected vehicle initiatives to test technologies and develop best practices in support of NHTSA's 2013 rulemaking decision.

#### A testing "sandbox"

RITA's connected vehicle program includes a range of projects that address safety, mobility and the environment. Among the projects is a national interconnected test bed system that provides a real-world laboratory for the public and private sectors to test and certify connected vehicle technologies.

Michigan is home to one of the country's six test bed sites. Built in Oakland

County, with support from RITA and in cooperation with the Road Commission for Oakland County and MDOT, the Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Technology Test Bed covers 45 square miles of interstate, divided highway and arterial roadways.

#### How it works

The test bed's communications network includes 55 roadside equipment (RSE)



Researchers use Michigan's test bed to evaluate the wireless communication that has the potential to connect all transportation modes. (Courtesy of U.S. DOT.)

units that can broadcast advisory and basic safety messages, transmit data from

## In-Vehicle Messaging for Safer, More Efficient Roadways

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vehicle probes that monitor road surface conditions and simulate tolling transactions. The RSEs are connected to a data center, where servers receive requests to post in-vehicle messages from other applications and forward those messages to the appropriate RSE. Onboard equipment stores messages when a vehicle enters a particular geographic area, tracking the vehicle's position to display messages at the appropriate time.

### For more information

Learn more about the V2V and V2I Technology Test Bed project at the RITA Web site at [www.its.dot.gov/connected\\_vehicle/technology\\_testbed2.htm](http://www.its.dot.gov/connected_vehicle/technology_testbed2.htm).



*A variety of V2I messages are delivered for display as vehicles travel through the test bed. (Courtesy of U.S. DOT.)*

Information about RITA's other connected vehicle projects is available at [www.its.dot.gov/connected\\_vehicle/connected\\_vehicle.htm](http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm).

## The Bottom Line...

*The benefits of connected vehicle technology extend beyond developing a safer and more efficient transportation system. The Center for Automotive Research estimates that MDOT's leadership role in advancing connected vehicle systems has the potential to contribute:*

- More than 16,000 full-time jobs in Michigan.
- \$177 million in state income tax revenues.

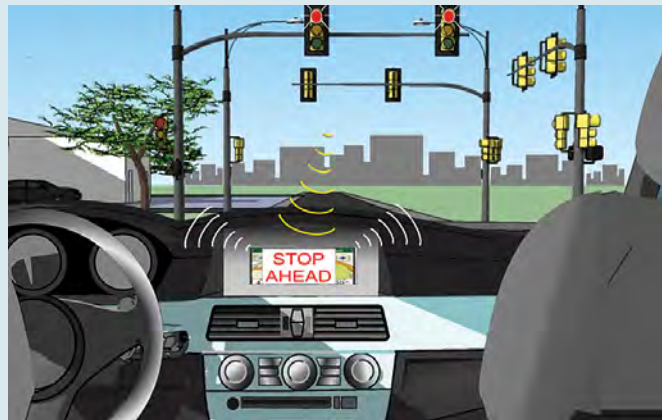
*The center's report about the economic impacts of connected vehicle research in Michigan is available at*

[www.michigan.gov/documents/mdot/MDOT\\_Research\\_Report\\_RC1513\\_244198\\_7.pdf](http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1513_244198_7.pdf).

## Broadcasting Signal Timing

The U.S. DOT test bed in Michigan was recently expanded with the addition of 22 specially equipped traffic signal controllers. The installation along Telegraph Road in suburban Detroit is the largest of its type in the United States. These specialized traffic signal controllers, combined with in-vehicle displays of the intersection, provide drivers with almost real-time information about signal phase and timing (SPaT).

The system works through a dedicated short-range communications (DSRC) service that manages communication between the traffic signal controller and the vehicle. DSRC systems have the advantage of providing secure, high data transfer rates using an open-source protocol for wireless communication similar to Wi-Fi.



*V2I communication forms the basis for SPaT technology. (Courtesy of U.S. DOT.)*

When a vehicle is within 1,000 feet of a SPaT intersection, a display screen inside the vehicle presents a green, amber or red indicator with a countdown in seconds to the signal change and a recommended speed for passing safely through the intersection without stopping.

In a complementary project, MDOT recently installed SPaT technology at two intersections on Telegraph Road to the north of the U.S. DOT test bed to investigate

extending the reach of signal phase messaging with cellular technology.

The SPaT signal controller uses cellular communication to send status information about the signal (green, amber or red) to the in-vehicle display every three to five seconds. Researchers will explore the feasibility of communicating this information over distances of up to two miles and across multiple intersections. The cellular communication would then hand off to the almost real-time DSRC service when a vehicle is within 1,000 feet of the intersection.

Why broadcast signal timing to drivers? By adjusting or maintaining their speed through intersections, drivers can avoid stopping at red lights and starting up again on green. Less braking and acceleration makes for a greener transportation system by reducing fuel consumption and vehicle emissions.

# Research in Progress

## Detecting Slippery Roads in Real Time



This project will help determine the potential for a full-scale deployment of probe vehicles to monitor winter driving conditions.

The tools in state DOT arsenals for fighting winter storms continue to improve—from better-designed snowplows to more effective, environmentally-friendly deicing chemicals. A research project under way at MDOT seeks to develop another tool for MDOT’s snow-and-ice-fighting toolbox.

### Gathering road surface data

In this effort—another that will feed data into the DUAP project—MDOT researchers are equipping vehicles with wireless onboard instrumentation that automatically measures and transmits data about pavement conditions. With real-time information about slippery conditions, managers can more effectively deploy winter maintenance treatments and keep roadways safer for the traveling public.

Data collection will begin with the 2011-2012 winter season and continue through the following winter. Among the data collected are vehicle statuses such as speed, activation of antilock brake systems, traction control and GPS position. External sensors provide data on road surface roughness, temperature and humidity. Data are collected almost continuously by a smart cellular phone communicating with various devices in the vehicle. Data are transmitted to a back-end server for evaluation and merging with other DUAP data.

While the focus is on slippery road detection, the system also provides segment-by-segment travel time data in real time to monitor the impacts of weather conditions on travel time.

### For more information

Research results will be available after the project concludes in spring 2013. Contact Project Manager Steve Cook at [cooks9@michigan.gov](mailto:cooks9@michigan.gov) to learn more about this ongoing project.

## Current MDOT Connected Vehicle Technologies Research

Project Title	Start Date	End Date
MDOT Vehicle Infrastructure Integration Data Analysis Documentation and Research Support Program	Summer 2006	Spring 2012
Infrastructure Monitoring Data Management	Fall 2009	Spring 2012
Signal Phase and Timing (SPaT)*	Spring 2010	Spring 2012
Slippery Road Detection and Evaluation	Fall 2010	Spring 2013
Advanced Applications of IntelliDrive Data Use Analysis and Processing 2 (DUAP 2)	Fall 2011	Summer 2014
Vehicle-Based Information and Data Acquisition (VIDAS)*	Fall 2011	Winter 2014

\* Not supported with State Planning and Research, Part II, funding

*“Research conducted through MDOT’s Office of Research and Best Practices is an important complement to the agency’s other connected vehicle technologies research.”*

—Michael Townley  
MDOT ORBP

# Program News

**Transportation Research Board brown bag lunch:** This fall, ORBP will host a lunch-and-learn session for all MDOT staff. Come learn about the Transportation Research Board (TRB) and the cutting-edge transportation research TRB sponsors through its National Cooperative Highway Research Program. Watch for the date and time of this event or send an e-mail to [mdot-research@michigan.gov](mailto:mdot-research@michigan.gov) to request details.

**Strategic priorities for the next biennium:** This November, MDOT's Research Executive Committee (REC) will set the strategic research priorities for the 2014–2015 research program. In the coming months, ORBP will ask MDOT staff and other members of the research community to submit research ideas for applied research projects that address the REC's strategic priorities.

**Research Summit:** May 10, 2012, is the date of MDOT's biennial research summit at the Kellogg Hotel and Conference Center in East Lansing. The summit will bring together members of Michigan's transportation research community to share information and expertise as participants examine and refine proposed research ideas that address critical MDOT challenges. Save the date and plan on attending to provide input on the topics that will be part of the 2014-2015 research program.



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**VISION:** *To be a recognized leader in coordinating applied research and implementing results by identifying cutting-edge research topics, implementing research results and coordinating development of research projects. Our core strength results from a highly integrated network of dynamic partnerships among transportation professionals.*

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