IntelliDrive℠ Initiatives in Michigan: Leading the States Forward

White paper prepared for the Michigan Department of Transportation

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I. Introduction

The United States Department of Transportation (USDOT) has launched a national program to enhance vehicle transportation through the applications of communication technologies. This program, known as IntelliDrive[SM] (succeeding the USDOT's VII, for Vehicle-Infrastructure Integration, program), targets safety, mobility, and environmental improvements through a combination of vehicle-to-vehicle and vehicle-to-infrastructure communications. Already, these technologies have been demonstrated in the State of Michigan and elsewhere. Led by the Michigan Department of Transportation (MDOT), Michigan has committed itself to playing a leadership role within the overall national IntelliDrive[SM] effort.

IntelliDrive[SM] allows vehicles to communicate with each other and the roadway to enhance situational awareness and ultimately enable cooperative, active safety systems. Rather than defining a specific technological solution, IntelliDrive[SM] consists of multiple in-vehicle and roadside communication technologies, along with data processing and applications, that enable vehicles to obtain and share information with each other and the world, including transportation infrastructure operators. Thus, IntelliDrive[SM] leverages existing 3G, 4G, and other communication networks where and when they make sense (such as for mobility applications).

Every year, 40,000 Americans lose their lives in motor vehicle crashes. Every year, we lose millions of hours stuck in traffic. And every year, we waste billions of dollars in fuel caught in traffic congestion. Technology can change this. Today, the U.S. DOT, state DOTs, the American Association of State Highway and Transportation Officials (AASHTO), and private industry are working together to implement IntelliDrive[SM], a system that allows vehicles to communicate with each other and the roadway. Vehicle to infrastructure (V2I) involves communication of the vehicle with the roadway, traffic signals, and other pieces of infrastructure such as bridges. Vehicle to vehicle (V2V) entails vehicles equipped with communication devices that can speak to each other. Each has different benefits which are described below.

IntelliDrive[SM] will help drivers bypass congestion, and it will reduce crashes by providing advanced safety warnings. It will even be able to take over the vehicle when there is not enough time for the driver to react. IntelliDrive[SM] will also help us manage traffic, alerting drivers to upcoming congestion, advising them of alternative routes, and altering the timing of traffic signals to improve traffic flow. It can even help owners with vehicle maintenance by reporting pending problems, keeping small repairs from becoming larger and more expensive.

The system will achieve all these benefits using a variety of technologies, each with its own advantage that lends it to specific applications.

- Dedicated short-range communication (DSRC) is primarily used for safety applications, and can complement cellular communications and provide secure, high data transfer rates at low latencies in relatively small communication areas.
- 3G (Third Generation) is the general term of the current generation of mobile, telecommunication networks. It is helpful, because since most people own mobile devices, if the devices are equipped to receive transportation and other data, these devices can serve as a vehicle's external communication device.
- 4G (Fourth Generation) is the next step in mobile technology after 3G, and Long Term Evolution (LTE) is seen as the final step toward reaching that. LTE is designed to increase both speed and data transfer capacity of wireless networks.

Strong leadership will be required for IntelliDrive[SM] to achieve its promise. A leader can guide connected vehicle innovation by providing much needed direction, and the IntelliDrive[SM] community has recognized this need. In CAR's 2009 survey of experts in the connected vehicle industry, an early leader or champion of the technology was cited as the one of the most important items that would help IntelliDrive[SM] deployment. A leader can help set technological standards, dedicate funding sources for infrastructure, and help devise a plan to coordinate the technology between vehicles and the infrastructure.

The State of Michigan is well positioned to play the role of the IntelliDrive[SM] leader and is willing and able to take on that mantle. As the home of the nation's automotive industry, Michigan is a logical choice to take on the leadership role. Furthermore, Michigan has much to gain from assuming this leadership role. In this way, the state can make its own vision of IntelliDrive[SM] become a reality, instead of letting others define it. Leadership also promises economic development benefits, because it will bring jobs and other investment into the state as the IntelliDrive[SM] industry takes root and grows in Michigan.

II. IntelliDrive[SM] Deployments and Roadside Test Facilities

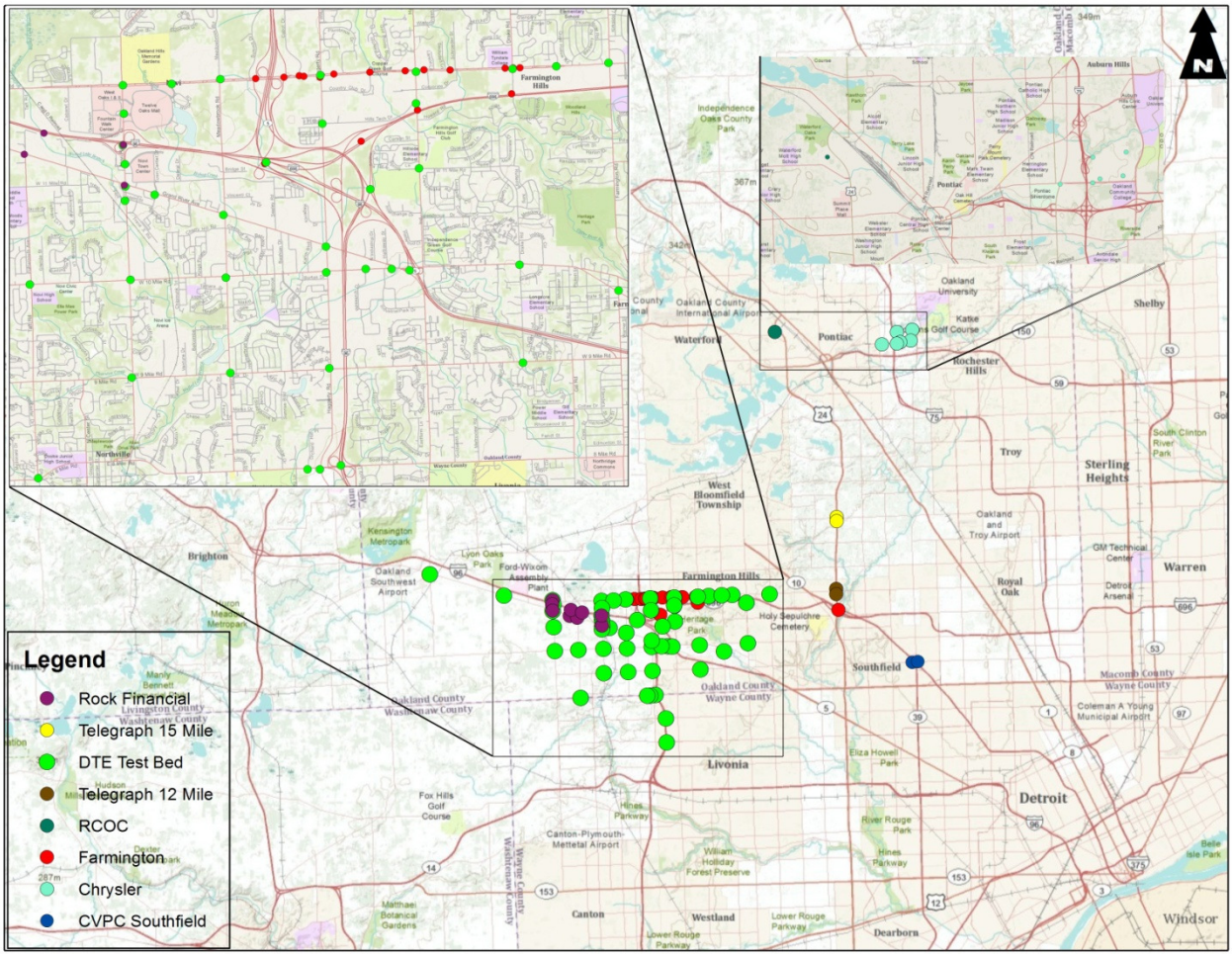
Development and eventual deployment of IntelliDrive[SM] will ultimately depend on the availability of facilities that can be used to test and develop hardware, software, standards, interoperability, and more. Michigan is home to more of these facilities than is any other state. MDOT has invested in numerous test facility locations, including Chrysler Tech Center in Auburn Hills, Telegraph Road, Farmington Hills, Rock Financial Showplace in Novi, CVPC Southfield Road, and the Michigan International Speedway (MIS, forthcoming). In addition, the USDOT has built and deployed the IntelliDrive[SM] Developmental Test Environment (DTE) in southeast Michigan. The DTE stands as the single largest deployment of DSRC-based roadside equipment in the U.S. Finally, a small, privately developed deployment is underway in Owosso, Michigan, and it currently boasts one signalized intersection broadcasting signal phase and timing (SPaT) information via DSRC, with six more planned. Maps of these asset locations are presented in Figure 1 and Figure 2, and these facilities are described in more detail below.

Chrysler Tech Center in Auburn Hills

The Chrysler Tech Center in Auburn Hills is home to six roadside IntelliDrive[SM] locations. Each of these sites contains 5 GHz and 2.4 GHz mesh radios that communicate with properly equipped vehicles (front-end communications), 2.4 GHz 12.5 dBi omni antennas, and 5 GHz 21dBi backhaul antennas. Three of these locations also have DSRC capability. These six sites were installed in June 2005 by Azulstar (with help from the Road Commission for Oakland County), use Proxim equipment, and may be replaced soon. Chrysler used these sites along with in-vehicle devices to retrieve real-time diagnostic data. While the fleet originally entailed 25 vehicles, it eventually totaled 1,500 vehicles communicating on the network.[1]

[1] ITS Michigan Brochure. *Past, Current, and Future ITS Efforts in Detroit and SE Michigan.* 2010.

Figure 1: Michigan Department of Transportation IntelliDrive[SM] Asset Inventory



Farmington Hills

The IntelliDrive[SM] roadside deployment area in Farmington Hills (and parts of Novi), largely along 12 Mile Road, is more complex than the previously mentioned areas due to both the number of units deployed and the types of technologies deployed. These locations primarily use Rauhorn and Motorola equipment, and the deployment area includes two large radio towers and 17 roadside equipment locations (see Figure 5). Of the roadside equipment locations, ten provide canopy service using either 5.7 GHz or 5.2 GHz frequencies. The remaining seven locations have 2.4 GHz WiFi and Mesh, 4.9 GHz Wi-Fi, and Mesh IAP6300 equipment. This deployment area, which dates from March 2007, was not operational as of January 2009. This is because the two radio towers, which are critical components of the overall deployment, where not operational and slated for replacement. The roadside units, however, are in working order.

Rock Financial Showplace (Novi)

MDOT has deployed roadside IntelliDrive[SM] units at nine locations in the vicinity of the Rock Financial Showplace, and these use Motorola equipment. These locations were originally deployed in 2007, but the sites were completely rebuilt in 2008. These assets are not currently in use, but they have been tested and are in good condition. Aside from the one site that served as a Virtual Traffic Management Center (VTMC) at 12 Mile and Beck, the remaining eight sites use 2.4 GHz Wi-Fi and Mesh, 4.9 GHz Wi-Fi, and either Mesh IAP6300 or Mesh MWR6300 for front-end hardware. Three of these sites also have

backhaul hardware of 5.8 GHz radios. The VTMC was removed after the ITS Michigan conference in May of 2008.

CVPC Intersection (Southfield)

The Connected Vehicle Proving Center, which is part of the University of Michigan-Dearborn, operates two roadside equipment sites in Southfield. These are located at 9 Mile Road and Southfield Road and 9 Mile Road and Northwestern. These sites have front-end communication hardware consisting of both WiFi and DSRC antennas, as well as a Motorola/Canopy Ethernet antenna for backhaul. These units were set up with assistance from Econolite, and use Motorola technology. They are available for testing through the CVPC.

Michigan International Speedway

In January of 2009, MDOT joined the MIS in a unique partnership for research, development, and safety innovation utilizing IntelliDrive[SM] technologies. The speedway has two 1.9-mile road courses that will be used for testing, and a two-mile oval, currently used for NASCAR events, that also can be used. The current plan is to deploy one or two DSRC locations on the MIS property and one along an adjacent public road. MIS is already marketing the racetrack and its road course to organizations involved in testing new vehicle technology, and the facility has hosted several (non-DSRC) demonstrations and tests to date, perhaps most notably serving as the home of the Progressive Automotive X-Prize[2] (competition to develop a 100 MPG or equivalent vehicle) finals in spring and summer 2010.

USDOT Developmental Test Environment

With 55 roadside units, the IntelliDrive[SM] Developmental Test Environment (DTE) deployed by the USDOT in the Novi area is by far the largest single deployment of IntelliDrive[SM] assets in Michigan. The DTE roadside units were produced by Technocom (now part of Kapsch), installed by the Road Commission for Oakland County, and managed and operated by Booz Allen Hamilton (BAH) as part of a proof of concept test in 2004. The front-end hardware consists of 5.9 GHz DSRC, while the backhaul varies between 3G, WiMAX, and T1. The USDOT currently is reviewing proposals to operate and maintain this facility for ongoing testing and demonstration activities.[3]

Telegraph Road Corridor

Currently, the Telegraph Road corridor includes two intersection deployments of WiFi, one at 12 Mile Road and the other at 15 Mile Road. The goal of this test facility is to encourage research on the use of signal phase and timing (SPaT) data for intersection safety and other IntelliDrive[SM] applications that make use of SPaT. When necessary funding is identified, MDOT has plans to upgrade and extend this deployment to include DSRC at twenty-two signalized intersections between 8 Mile and 14 Mile roads, all broadcasting SPaT. With this deployment, the goal is to improve safety and mobility along signalized intersections.[4]

Owosso

Dave Acton, formerly of GM's OnStar and a very active member of the Michigan IntelliDrive[SM] community, has developed a proof-of-concept test in Owosso, Michigan. He has partnered with Michigan-based DGE Inc., Kapsch, and the City of Owosso to make this happen. Kapsch has equipped one intersection with a DSRC-based communication device, and DGE developed five in-vehicle units that have been installed in five vehicles. The in-vehicle units are small circuit boards with GPS and DSRC

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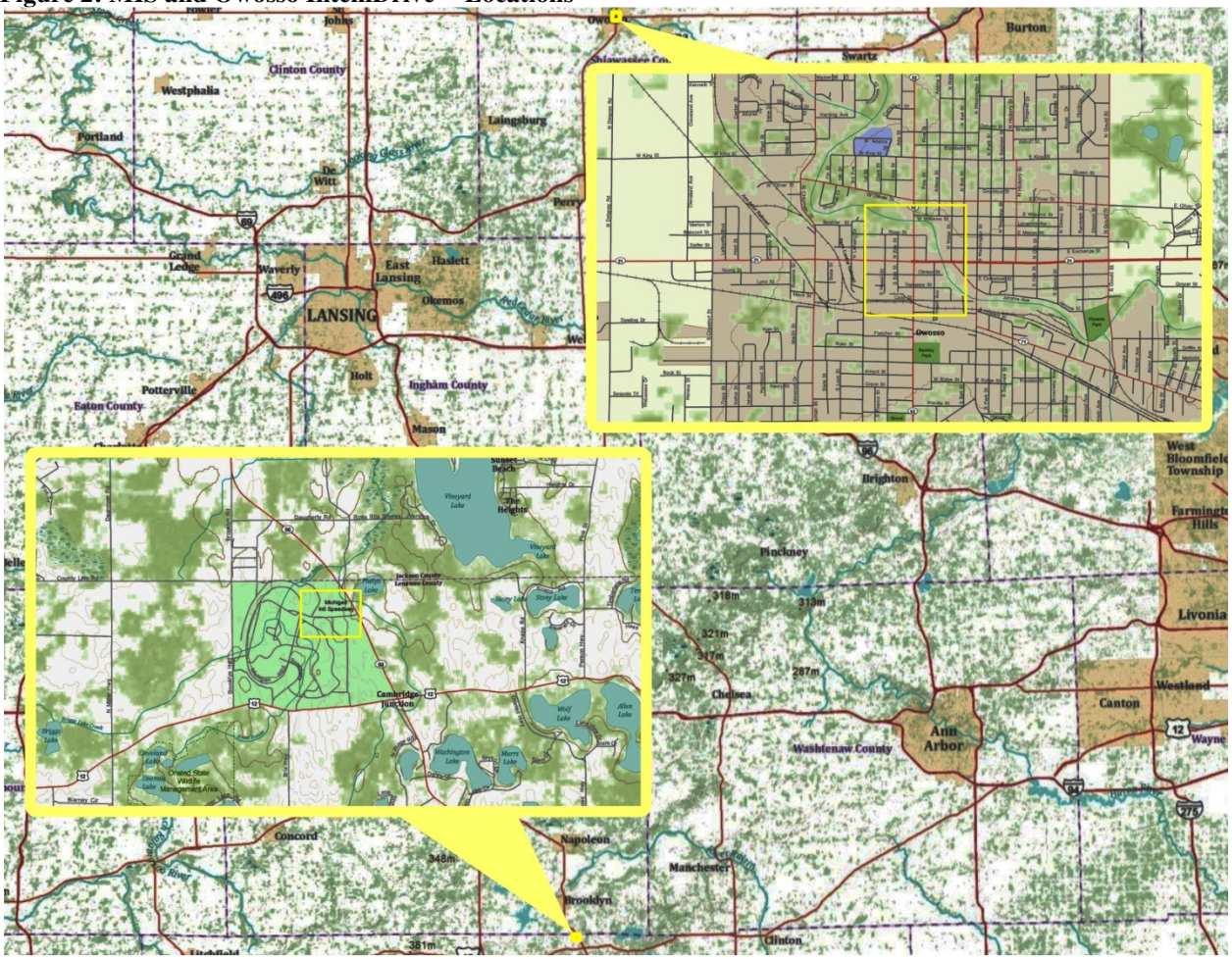
[2] See http://www.progressiveautoxprize.org/

[3] Federal Business Opportunities Website. 25 March 2010. <https://www.fbo.gov/index?s=opportunity&mode=form&id=a63fcca8a74cd3d9968fde93b7b8eaf7&tab=core&_cview=1>

[4] ITS Michigan Brochure. *Past, Current, and Future ITS Efforts in Detroit and SE Michigan.* 2010.

sensors, and offer a touch-screen display. They alert a driver of the signal's current state, as well as when the signal will change (SPaT). The project's goal is to have a total of seven intersections in Owosso equipped with these vehicle communication devices.

Figure 2: MIS and Owosso IntelliDrive[SM] Locations



III. IntelliDrive[SM] Programs and Research

Michigan boasts significant federal, state, and local efforts in the IntelliDrive[SM] sphere. Many of these efforts are spearheaded by MDOT, but other organizations in the state also are playing leading roles.

Programs with MDOT Involvement

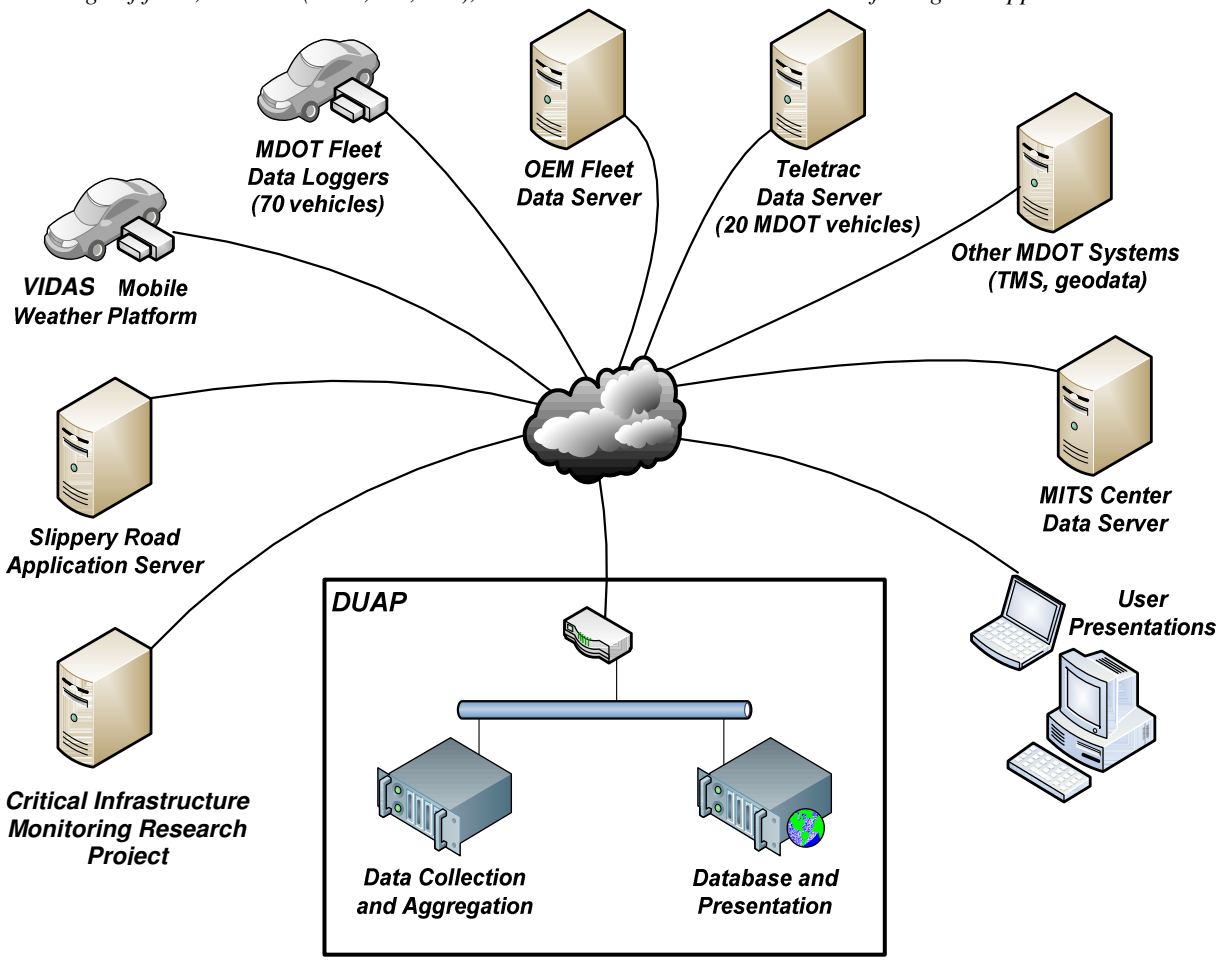
The following programs are either completely administered by MDOT or MDOT is a partner with other organizations.

Data Use Analysis Processing Project

MDOT is leading the way among state agencies in IntelliDrive[SM] technology and has produced a plan that describes the institutional relationships, outreach, and technical developments that will be needed to develop and deploy it. The Data Use Analysis Processing (DUAP) project brings together much of the technical development called for in the plan. The specific purpose of the DUAP project is to support MDOT and its partners in evaluating uses and benefits of IntelliDrive[SM]-related data in transportation

agency management and operations (see Figure 3). The DUAP project builds on the work previously done to investigate how the availability of data from IntelliDrive[SM]-equipped vehicles throughout the road network may impact the ways transportation agencies do business. DUAP specifically focuses on data uses to enhance safety, improve traffic flow and better manage transportation assets. The work will also support the other IntelliDrive[SM] activities, technology development for MDOT, and economic growth for the state. Building on the successes of the original DUAP project, MDOT is now pursuing a follow up effort known as DUAP 2.

Figure 3: Data Linkages That Compose DUAP. *Note that DUAP is agnostic to mode of data flow and will take advantage of fiber, wireless (WiFi, 3G, etc.), etc.—whichever channel works best for a given application.*



Current DUAP initiatives include the following:

- Chrysler Tech Center – Continue previous testing of fleet vehicles
- Michigan Intelligent Transportation Systems Center – Project focuses on looped and wireless traffic detectors
- Teletrack Sensors - on 10-15 vehicles
- Regional Weather Information Station (RWIS) – weather data is pulled into Clarus.[5] Michigan has several stations located in both the Upper and Lower Upper Peninsulas.

[5] The U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA) Road Weather Management Program, in conjunction with the Intelligent Transportation Systems (ITS) Joint Program Office

- OnBoard Diagnostic (OBD)-II – partnered with Motorola, who has provided OBD devices for 70 MDOT fleet vehicles, and uses WiFi to test physical conditions of the vehicle and the environment in which it is operating.
- Cut River Bridge and Mackinac Bridge – remotely monitoring the structural conditions of each bridge
- Slippery Roads Detection and Evaluation –The project will equip vehicles with telemetry equipment to monitor driving conditions while operating on winter roads and other potentially slippery situations and road surface quality issues. MDOT has a contract with the University of Michigan Transportation Research Institute to install IntelliDriveSM technology on a minimum of two vehicles.

IntelliDrive^{SM} Technology Incubator

MDOT is pursuing the idea of an IntelliDrive^{SM} technology incubator project. This project would support both infrastructure and vehicle deployment, eventually leading to self-sustaining, permanent deployment. Such an incubator would include outreach and education components, as well as a business incubator, all of which would play key roles in making this technology sustainable.

Critical Infrastructure Monitoring Research Project

MDOT recently partnered with Michigan State University, Michigan Technological University, and the University of Michigan to work on research grants that advance remote sensing and sensor technology for infrastructure monitoring and data collection[6]. It builds upon a previous MDOT project that utilizes communication, sensor, and collection technology to monitor the Cut River and Mackinac Bridges. In 2007, four sensors were installed on the Mackinac Bridge as was a wireless broadband network, and a pilot test was completed to ascertain how well data transmission functioned. It was determined that use of these technologies was an excellent way of monitoring stress on the bridge, which can be used for asset management, planning, maintenance, and emergency response. In light of this success, MDOT decided to install similar devices to monitor the Cut River Bridge in the Upper Peninsula. While similar broadband and sensor technology will be used, new elements will be also tested such as data delivery, power sources, system security, and weather-related issues.[7]

Vehicle-based Information and Data Acquisition System

Vehicle-based Information and Data Acquisition System (VIDAS) is an MDOT project intended to use visual observations to determine the accuracy and reliability of test mobile data relating to road conditions. It will also compare visual observations to determine the accuracy of RWIS data (see Figure 4). The project also seeks to ascertain how this information can be enhanced by fleet vehicles' gathering of road surface data and other situational information to accurately determine surface conditions. By determining whether RWIS data corresponds to vehicle probe data and visual observations, MDOT can hopefully expand the VIDAS service to the rest of the state to help with safety, mobility and planning. MDOT has released a request for proposals for a company to assist with this project.[8]

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established the *Clarus* Initiative in 2004 to reduce the impact of adverse weather conditions on surface transportation users. *Clarus* is a research and development initiative to demonstrate and evaluate the value of "Anytime, Anywhere Road Weather Information" that is provided by both public agencies and the private weather enterprise to the breadth of transportation users and operators.

[6] MDOT Press Release. *MDOT partners with Michigan Universities on infrastructure monitoring research.* 17 May 2010.

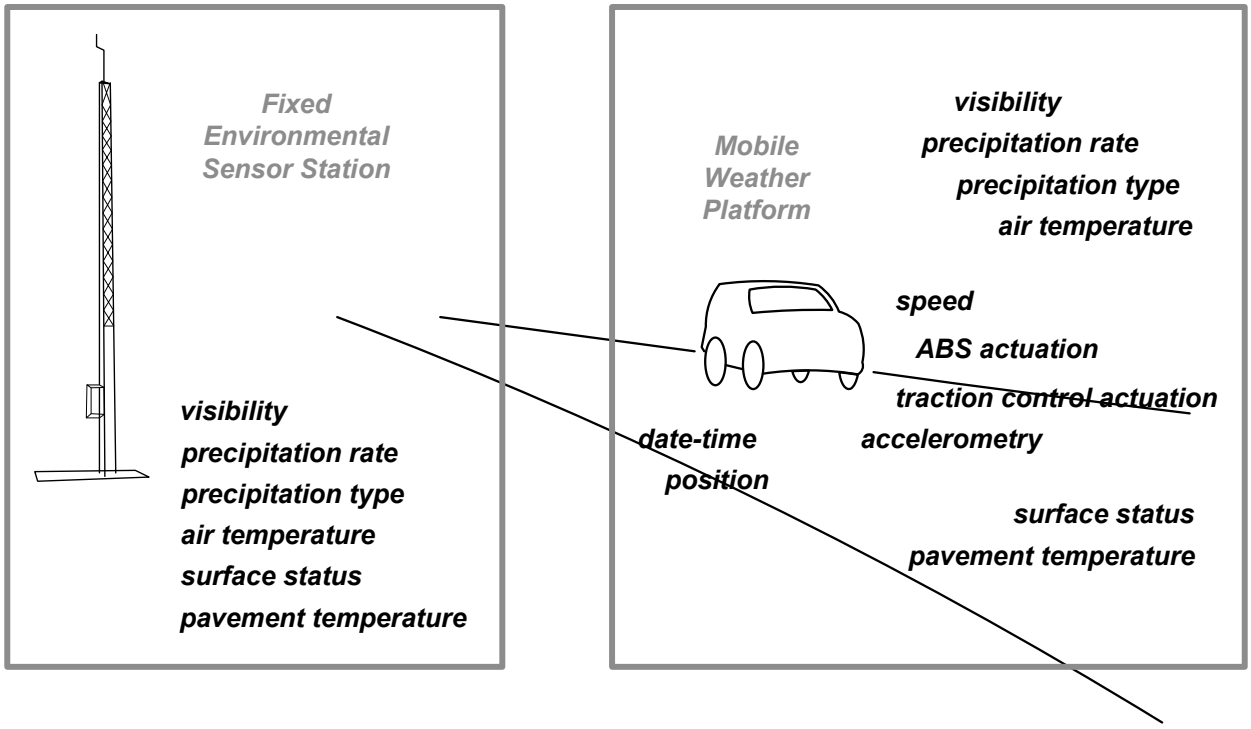
[7] MDOT Document. Critical Infrastructure Monitoring Research Project. Provided to CAR by Steve Cook.

[8] MDOT RFP. Scope of Service for VIDAS Project. Provided to CAR by Steve Cook.

Great Lakes Intelligent Transportation System

The Great Lakes Intelligent Transportation System (GLITS) consists of several intelligent transportation systems technologies deployed across the region to enhance the Great Lakes International Economic Corridor. It includes improving corridor traffic flow along I-75 (with the Road Commission for Oakland County assisting MDOT), deploying a new traffic operations center in Macomb County, expanding the Road Commission of Macomb County's Advanced Traffic Management System, and extending the Road Information Management System to Wayne County's Department of Public Services.[9] With these projects, GLITS intends to make a safer and more efficient transportation system that will help make the region known on a national scale as a center for transportation technology.

Figure 4: VIDAS Project Links Fixed and Mobile Data Collection Platforms



Traffic Incident Management in Metro Detroit

The Metropolitan Detroit Incident Management Coordinating Committee has joined ITS Michigan because of the high use of ITS technology among first-responders. The committee has developed an incident management program called "The Blueprint for Action," of which four major improvements have been undertaken. These include combining Michigan State Police dispatch operations with the MDOT ITS Center, expand Closed Circuit Television camera and dynamic message sign coverage, establishing a Freeway Courtesy Patrol, and revising the abandoned vehicle law.[10]

Other Michigan Programs and Research

In addition to the programs described above, Michigan is home to several other IntelliDrive^{SM} and ITS-related efforts that deserve mention. These are described below.

[9] ITS Michigan Brochure. *Past, Current, and Future ITS Efforts in Detroit and SE Michigan.* 2010.
[10] Ibid.

Southeastern Michigan Snow and Ice Management
Southeastern Michigan Snow and Ice Management (SEMSIM) is a multi-jurisdictional project including the Road Commission for Oakland County, Wayne County Department of Public Services, the City of Detroit Department of Public Works, and the Suburban Mobility Authority for Regional Transportation (SMART). The goal of the initiative is to improve the efficiency of winter road maintenance using vehicle communication technology. Over 400 fleet vehicles are equipped with satellite tracking devices and sensors that send data relating to speed, direction, and weather conditions to a central server via a radio system. Road agencies can also monitor vehicle locations on a web-based map, and can show supervisors which roads have and have not been salted. This technology will make winter road maintenance much easier for local departments of transportation.[11]

Integrated Vehicle-Based Safety Systems
The University of Michigan Transportation Research Institute's (UMTRI) Integrated Vehicle-Based Safety Systems (IVBSS) program is a four-year research effort to develop and test an integrated crash-warning system. The system is made up of a suite of advanced technologies that warn drivers when they are about to leave the roadway, are in danger of colliding with another vehicle while attempting a lane change, or are at risk of colliding with the vehicle in front of them.[12]

Cooperative Intersection Collision Avoidance System
Sponsored by USDOT, the Cooperative Intersection Collision Avoidance System (CICAS) is a $30 million cooperative effort between automotive manufacturers and public transportation agencies at all levels. Using new wireless communications technologies, it pursues an optimized combination of autonomous-vehicle, autonomous-infrastructure and cooperative vehicle-infrastructure technology to develop systems that prevent crashes at intersections. MDOT is one of the primary state DOTs that participates in the program, and much proof-of-concept testing will occur in Michigan, particularly for CICAS-V, a primarily vehicle-based system that warns drivers of any impending stop-sign or red-light violations.

Developmental Test Environment Proof-of-Concept
The USDOT Developmental Test Environment (DTE) Proof of Concept (POC) for several IntelliDrive^{SM} applications officially began in 2007. It was supported by nine vehicle manufacturers, including General Motors, Ford, Chrysler, Mercedes-Benz, BMW, Nissan, Volkswagen, Honda, and Toyota, and the original test fleet consisted of 25 vehicles.[13] These vehicles were equipped with the following:

- On-Board Equipment (OBE) module
- 5.9 GHz Dedicated Short Range Communication (DSRC) radio with Linux drivers and an antenna
- Controller Area Network access and a display

In addition, prototype applications were developed to exercise the network, such as probe data collection, off-board navigation, in-vehicle signage, and payment applications. The USDOT's contractor for roadside units was Booz Allen Hamilton (BAH), and they have deployed roadside units around the Novi, Michigan area. This area includes 45 square miles and about 75 miles of roadway.[14] The initial phase of the POC has been completed and proved the technical feasibility of IntelliDrive^{SM} technology. As of spring 2010, the USDOT had issued an RFP for the continued operation and maintenance of the DTE and to transfer it out of federal control. Furthermore, proposals had been received and were under review.

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[11] Ibid.
[12] UMTRI Website. 17 February 2010. <http://www.umtri.umich.edu/news.php?id=2452>
[13] Frank, Randy. "Exploring Vehicle-to-Vehicle Communication and Vehicle Infrastructure Integration." *Auto Electronics*. 1 July 2008
[14] Ibid.

IV. Michigan-Based Consortia

Michigan is home to numerous multi-organizational consortia that focus on IntelliDrive[SM]-related activities. These contribute to the State's overall leadership in *IntelliDrive,* and the most prominent of these are described below.

Vehicle Infrastructure Integration Consortium

The Vehicle Infrastructure Integration Consortium (VII-C) is a collection of representatives from nine (eight prior to the Daimler-Chrysler split) light-duty vehicle manufacturers. These include Ford, General Motors, Chrysler, Toyota, Nissan, Honda, Volkswagen, Daimler, and BMW.[15] In December of 2005, the U.S. DOT signed an agreement with the VII-C to develop the POC for the DTE described above. The VII-C was therefore the organization that oversaw all the testing for POC.

Crash Avoidance Metrics Partnership

The Crash Avoidance Metrics Partnership (CAMP) was formed by Ford Motor Company and General Motors Corporation in 1995.[16] The objective of CAMP was to accelerate the implementation of crash avoidance countermeasures to improve traffic safety. They sought to achieve this by defining and developing necessary pre-competitive enabling elements of future systems. As such, CAMP was the technical lead for the CICAS project.

ITS Michigan

ITS Michigan is the state's chapter for the national group, ITS America. Its goal is to improve the safety, security and efficiency of the nation's transportation system for the traveling public through deployment of Intelligent Transportation Systems (ITS).[17] ITS Michigan is comprised of members of vehicle and product manufacturers, consulting firms, transportation engineering firms, non-profit organizations, universities, public transit agencies, and state and local DOTs. One of their biggest events is their ITS Michigan Annual Meeting, usually held in May. The event includes speakers knowledgeable in ITS and IntelliDrive[SM] technology, booth areas for companies to show off products, and vehicle demonstrations which allow attendees to experience the technology first-hand.

Connected Vehicle Trade Association

Connected Vehicle Trade Association (CVTA) is a non-profit organization based in Plymouth, Michigan. The goal of CVTA is to advocate effective communication, collaboration, and consensus-building amongst companies, organizations, and governments involved in the use of vehicle communications. Membership in CVTA is open to any qualified individual or organization involved in the use or development of vehicle communications. The CVTA Board of Directors consists of an industry representative from each business sector involved in vehicle communications.[18]

CVTA performs a variety of functions, such as promoting the benefits of vehicle communications, advocating quick implementation of these technologies, providing educational programs, and identifying business opportunities.

Society of Automotive Engineers

The Society of Automotive Engineers International (SAE) is a professional organization comprised of engineers, business executives, educators, and students. SAE is based in Warrendale, Pennsylvania, with three U.S. satellite offices and two international offices; London, UK and Shanghai, China. SAE members primarily work in the aerospace, automobile, commercial vehicle, and motorsports industries.

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[15] Reed, John. "Full Speed Ahead for Intelligent Car Design." *Financial Times.* 20 February 2007.
[16] Deering, Richard. *Crash Avoidance Metrics Partnership Annual Report, 2001-2002.* NHTSA, December 2002.
[17] ITS Michigan Website. 23 February 2010. <http://www.itsmichigan.org/whatis.html>
[18] CVTA Website. 5 March 2010. <http://www.connectedvehicle.org/aboutus.aspx>

Services and products offered by SAE include conferences, seminars, publications, networking events, and career development resources.

SAE actively compiles research and policy papers on intelligent vehicles systems and their various applications. In addition, SAE has numerous workshops on IntelliDrive[SM], with topics focusing on the standards of this technology and its future in ground transportation. SAE sponsored an IntelliDrive[SM] Standards Leadership Workshop at the Michigan International Speedway in September of 2009.[19] The purpose of the workshop was to develop industry standards for IntelliDrive[SM] systems that could be agreed upon by those with a vested interest.

Specialty Equipment Market Association

The Specialty Equipment Market Association (SEMA) is a diverse trade association based in Diamond Bar, California, whose members include manufacturers, distributors, and retailers to car enthusiasts and racing teams. A primary function of SEMA is protecting rights of consumers to drive specialized and accessorized vehicles. In order to protect these rights, SEMA is actively engaged in monitoring state and federal legislation concerning these issues.[20] SEMA's marquee event is an annual trade show held in Las Vegas which the latest offerings in specialized automotive equipment are unveiled.

SEMA's role in IntelliDrive[SM] technology may be growing. As the U.S. DOT tries to encourage deployment, it will need to embrace the aftermarket to make this happen given the present slow down of new vehicle sales.[21] Since the technology will not be deployed in new vehicles as quickly as those in the industry would like, the changes of deployment are much greater if technology is developed for aftermarket installation. SEMA is working to make this happen. They have recently partnered with Detroit-based American Expedition Vehicles to accelerate integration and interoperability of consumer electronic products into automobiles.[22]

In October of 2009, SEMA hosted a "Driving Connected" technology seminar that discussed the integration of automotive and electronic devices. The driving force behind this seminar was to highlight the ways in which smart technology can improve the safety of driving. A broad array of interests attended the seminar, such as representatives from Microsoft, Gartner, the Michigan Department of Transportation, Clemson University, and the U.S. Department of Transportation.[23]

Center for Automotive Research

The Center for Automotive Research is a non-profit, research organization specializing in the mechanical, labor, environmental and economic development aspects of the automotive industry. Located in Ann Arbor, Michigan, the organization has four research divisions: Automotive Analysis, Labor and Industry, Manufacturing, Engineering and Technology, and Sustainable Transportation and Communities. CAR researchers in the Sustainable Transportation and Communities group work with the MDOT IntelliDrive[SM] team on several fronts. They have completed Delphi studies to gauge expert opinions on the future of IntelliDrive[SM] technology, categorized MDOT IntelliDrive[SM] assets in the region, and worked with MDOT employees to develop MDOT's IntelliDrive[SM] strategic plan. They continue to work with MDOT on a variety of IntelliDrive[SM]-related initiatives.

[19] SAE Website. 8 March 2010. <http://www.sae.org/events/idsl/overview.pdf>
[20] SEMA Website. 8 March 2010. <http://www.sema.org/about-sema>
[21] Barlas, Stephen. "Smart Driving, Sales Push." *Aftermarket Business.* 11 March, 2010
[22] Ibid.
[23] SEMA Website. 8 March 2010. <http://www.sema.org/?q=node/6632>

V. Automotive Industry Investment

Michigan is the proud home of the North American automotive industry, and IntelliDrive[SM] requires significant commitments from the automotive industry to be successful. As described above, Michigan-based vehicle manufacturers have played leading roles in the VII-C, CAMP, and other industry consortia developing and testing IntelliDrive[SM] systems. In addition to these significant efforts, individual manufacturers and suppliers have made significant investments in vehicle communications and related systems for many years. These include investments in products and services such as GM's OnStar and Ford's Sync, as well as ongoing research and development at the many automotive research and development centers located in Michigan. Highlights of these efforts and investments are described below.

General Motors and OnStar

General Motors is the parent company of OnStar, one of the leading providers of vehicle communication services in the nation. In 2007, OnStar became standard equipment in all GM vehicles, and the first year of service is offered free of charge. One of the most significant services that OnStar provides is an automatic crash response. In the event of a crash, sensors indicate what has happened to the vehicle, and that information is transmitted to an OnStar center where representatives can alert emergency response teams. The technology uses Global Positioning System (GPS) satellite and cellular technology to link the vehicle to the OnStar Center.

In addition to crash response, OnStar offers other features, including Vehicle Diagnostics, Turn-by-Turn Navigation, Emergency and Crisis Assistance, Stolen Vehicle Assistance, Remote Door Unlock, Information/Convenience Services, Remote Horn and Lights to Locate Vehicle, and Driving Directions.[24]

Ford and SYNC

SYNC is a voice activated wireless connectivity system now available in select automobiles. The SYNC technology is a Windows-based operating system which was introduced in January 2007 at the North American Auto Show. The technology was developed as a collaboration between Ford and Microsoft. It offers features such as hands-free calls and receipt of audible text messages with Bluetooth enabled phones, voice activated use of MP3 players, traffic reports and navigational assistance with simple voice commands, diagnostic checks, and emergency alerts to 911 operators if an airbag deploys and/or the driver is unable to verbally communicate. Sync is currently included in all 2010 Lincoln models and several Ford and Mercury models, and is available in three languages; North American English, Spanish, and French.[25]

Other Vehicle Manufacturers

In addition to GM and Ford, Toyota, Nissan and Chrysler have research centers in Michigan that are engaged with IntelliDrive[SM] research.

Suppliers

Continental Automotive Systems, located in Auburn Hills, MI, has been working on efforts to further research and development into IntelliDrive[SM] through its Active Passive Integration Approach (APIA) as well as its Telematics project. The company has considered integrating dedicated short-range communication technology into its APIA. Continental also has experience with its Car-to-X project which is related to connected vehicle work in Europe.[26] Last year at the Frankfurt International Motor Show, Continental listed intelligent and optimally interconnected road traffic as among its three mobility

[24] Onstar Website. 15 March 2010. <http://www.onstar.com/us_english/jsp/explore/onstar_basics/services.jsp>
[25] Ford SYNC Website. 15 March 2010 <http://www.fordvehicles.com/technology/sync/about/>
[26] Day, John H. (2007). "1-2-3 Red Light!" Auto Electronics. November 1, 2007.

goals.[27] In 2006, Continental acquired Motorola's automotive electronics business which is located in Farmington Hills, MI. Motorola's automotive work included projects related to IntelliDrive[SM] such as telematics (embedded wireless vehicle communications), occupant detection electronics, sensors, and stability control. Motorola participated in IntelliDrive[SM] proof of concept demonstrations by providing systems to allow communication between roadside equipment and backhaul servers.[28]

Delphi, located in Troy, Michigan, has worked in partnership with other firms to demonstrate the ability to download files to vehicles using dedicated short-range communication technology. In its Electronics & Safety Division, Delphi has developed both in-vehicle hardware and software and its products have also been used in proof of concept testing.[29]

Bosch, located in Farmington Hills, Michigan, has been researching ways of linking active and passive safety systems, driver assistance systems, and driver information systems together to improve overall vehicle safety. The combined active and passive safety system utilizes predictive sensors to help identify potentially dangerous situations and alert drivers.[30]

Other Michigan suppliers include DENSO, Hitachi, Visteon, Panasonic, and Vector CANtech. DENSO's facility is in Southfield and its work on IntelliDrive[SM] is related to telematics systems and electronic display and information systems. Hitachi's research facilities are in Farmington Hills and involve testing and product development of sensors and vision systems among other projects. The Visteon Technical Center of Van Buren Township is responsible for applied research, testing, engineering and product development and has worked on integrated circuits as well as audio and in-vehicle entertainment systems. Panasonic's research facility is located in Southfield and focuses on engineering and product development, focusing on numerous automotive electronics products. Vector CANtech is a Vector Group subsidiary located in Novi, Michigan and has years of experience with development and measurement tools for communication systems in vehicles and mature software components.[31]

VI. University-based Activities

Universities have traditionally played leading roles in basic and applied research in the U.S. They have been and are playing significant roles in IntelliDrive[SM] research, as well. In Michigan, several university-based efforts are underway, and many of these are highlighted below.

University of Michigan Transportation Research Institute

The University of Michigan Transportation Research Institute (UMTRI) is a diverse research center comprised of research scientists, academic faculty, graduate students, and technical personnel. There are six research divisions within UMTRI; Biosciences, Engineering Research, Human Factors, Automotive Analysis, Social and Behavioral Analysis, and Transportation Safety Analysis, as well as the Research Information and Publications Center, which is responsible for the dissemination of research results.[32] The institute operates through funds received primarily from automotive manufacturers, parts suppliers, and the state and federal government.

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[27] Pflug, Enno. (2009). "Frankfurt International Motor Show 2009: Innovations for Tomorrow's Safe, Sustainable and Continuously Connected Mobility." Continental Press Release. August 17, 2009.
[28] Ibid. Day, John H. (2007).
[29] Ibid. Day, John H. (2007).
[30] Ibid. Day, John H. (2007).
[31] Vector Website. 15 March 2010. <http://www.vector.com/vi_car2x_solutions_en,,223.html>
[32] UMTRI Website. 9 March 2009. <http://www.umtri.umich.edu/about.php>

Within the Human Factors Division, research is being conducted on intelligent transportation systems to improve the overall quality of transportation networks and improve safety. In October 2009, the Transportation Systems Group at UMTRI gave a presentation entitled "Evaluation of Generation and Usability of IntelliDrive[SM] Probe Vehicle Data."[33] The group highlighted research results being conducted on IntelliDrive[SM], and the effectiveness of data being collected by this system under the currently recommended methodology/framework. These results were based on observations of traffic flows and vehicle movements. A major goal of this research was to test the data collection feasibility from vehicles equipped with IntelliDrive[SM]. UMTRI has a number of other IntelliDrive[SM] research initiatives on which it continues to present its findings.

Connected Vehicle Proving Center

The Connected Vehicle Proving Center (CVPC) is a research facility located at the University of Michigan-Dearborn campus, and is funded through a conglomeration of public (primarily the Michigan Economic Development Commission) and private financial resources. The CVPC is a testing center for wireless communication technologies in transportation systems. It is dedicated to testing and evaluating various connected-vehicle technologies, one of which is transportation infrastructure technology. By testing these intelligent transportation systems, the center hopes to find ways to alleviate traffic congestion, thereby reducing the number of accidents and improving safety. This also improves environmental quality and increases the efficiency of transportation infrastructure spending.

Although located at UM-Dearborn, the CVPC interacts with industry and the public sector through both projects and advisory groups. Initially, the main participants involved with the operations of the center were the Connected Vehicle Trade Association, University of Michigan-Dearborn, and the Michigan Department of Transportation.[34] Since its inception, the Center has developed additional partners and has acquired laboratory space through its location within the College of Engineering at UM-Dearborn.

In March 2010, CVPC co-sponsored a Wireless Access in Vehicular Environments (WAVE) Seminar to discuss the direction and challenges facing connected vehicles. Participants at this seminar included academics, government representatives, and engineers and managers from the automotive industry. Some of the topics discussed were technical and development challenges, advances by the research community and future research directions, projects other companies are working on, and an update of the state of the connected vehicle market.[35]

Michigan-Ohio University Transportation Center

The Michigan-Ohio University Transportation Center (MIOH UTC) is a regional organization comprised of five universities, as well as private and governmental interests. The universities included are University of Detroit Mercy, Bowling Green State University, Grand Valley State University, University of Toledo, and Wayne State University. The MIOH UTC is headquartered at the University of Detroit-Mercy and funded by the U.S. Department of Transportation.[36] The transportation center is focused on areas such as improving existing infrastructure, reducing energy dependence, increasing supply chain logistics, and increasing the use of alternative fuels and vehicles. Another major focus of the center is the use of intelligent transportation systems to reduce traffic congestion.

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[33] UMTRI Website. 9 March 2009 <http://www.umtri.umich.edu/news.php?id=2416>

[34] CVPC Website. 10 March 2009 <http://www.cvpc.com/about/overview-44-35.html>

[35] University of Michigan-Dearborn Website. 10 March 2010. <http://groups.engin.umd.umich.edu/hpceep/wave.seminar/index.html>

[36] MIOH Website. 14 March 2010. <http://www.udmercy.edu/stay-connected/news-events/newsletters/ces/2006/02/articles/mioh-utc/index.htm>

The center has conducted a vast amount of research focusing on intelligent transportation systems. This research includes the development of real-time methods, procedures, and software to reduce traffic congestion, the use of water hovercraft for mass transit in Detroit, and improving paratransit services in the Toledo area. These are just a few of the research projects the center has undertaken in recent years to improve transit by utilizing intelligent transportation systems.

Other University Activities

In addition to the above university activities, advanced transportation technologies are part of the research agendas at other Michigan universities, as well. Both Western Michigan University and Michigan State University have researchers that are engaged with IntelliDrive^{SM} technology. Furthermore, Michigan Technological University is actively engaged in transportation research within several domains, including those involving advanced transportation technologies.

VII. Public Sector Leadership

Michigan's public sector is actively engaged with IntelliDrive^{SM} technology, and several government representatives participate on committees relating to the technology. For example, the Director of MDOT participates in the American Association of State Highway and Transportation Officials IntelliDrive^{SM} committee. Additionally, the MDOT ITS Program Manager chairs the ITS America IntelliDrive^{SM} task force and is currently on loan to the USDOT RITA Joint Programs Office (JPO). And the Managing Director of the Road Commission for Oakland County is a past president of ITS America and ITS Michigan, and has supervised deployment for the USDOT DTE.

Public sector agencies are also actively involved with the technology. The Michigan Economic Development Corporation has provided significant funding to the CVPC, as well as MIS as they pursue their IntelliDrive^{SM} activities. The Ann Arbor Transportation Authority offers real-time route guidance, so riders can see if the bus is on-time or delayed to avoid long waits at bus stops. Similarly, the Suburban Mobility Authority for Regional Transportation (SMART) in the Detroit region employs a variety of ITS-related technology, such as Automated Vehicle Location technology, Geographical Information Systems for trip generators, and SEMSIM, the winter road maintenance partnership.

VIII. Opportunities for and Benefits of Michigan Leadership

Given all of Michigan's activities in the IntelliDrive^{SM} realm as described above, the state has a great opportunity to be the leader in this technology. This will encourage research, testing, and development to occur in the state, potentially spurring job creation in advanced automotive technologies. Michigan should continue to devote resources toward this developing field, given its current investments and the potential for those investments to become beneficial to the state.

IX. Conclusions

Through both private- and public-sector activities, Michigan has established itself as a national leader in IntelliDrive^{SM} technology. For this technology to achieve widespread deployment, the State of Michigan and the automotive manufacturers and suppliers who call Michigan home, will need to continue to play a valuable, leading role in terms of:

- Testing and development of new hardware and software
- Establishing industry standards

- Designing and building vehicles equipped with IntelliDrive[SM] on-board
- Conducting early deployment trials
- Making the investments needed for this technology to mature
- Challenging industry and DOTs to push the limits of the technology

In short, for the safety, mobility, environmental, and personal convenience benefits of IntelliDrive[SM] to be realized, the roadmap for deployment leads through Michigan, and Michigan leads deployment.

By continuing to play a leading role in the national efforts to develop and deploy IntelliDrive[SM] technology, Michigan will have a significant role in shaping the future of IntelliDrive[SM] and be well-positioned to reap the benefits of becoming the recognized home of this technology. These benefits could include early deployment and associated lives saved, as well as thousands of jobs in the IntelliDrive[SM] industry.