

TEAM MICHIGAN: CONNECTING VEHICLES AND PARTNERS

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This paper provides an overview of Michigan's unique approach to moving ahead on the vision of technical and relationship integration and on building a connected vehicle system that meets shared public and private objectives. The transformation of the automotive industry from mechanical to electronic engineering is critical to the Michigan economy as the dramatic reduction in automotive industry jobs has placed Michigan at the forefront of what appears to be a recession of the U.S. economy. The Michigan economy lost 75,000 jobs in 2007 and appears to be headed in a similar direction in 2008. Connected vehicle technology development offers Michigan a growing high-tech industry where Michigan companies have a competitive advantage. Michigan is also home to the MDOT and other public-sector agencies that have demonstrated national leadership in connected vehicles. "Team Michigan" is pursuing a strategy for testing and developing VII providing all the players necessary for further developing vehicle communication systems that keep drivers connected, save lives, improve mobility, protect the environment, and employ Michigan residents.

Road transportation is undergoing a significant technological transformation with wireless communication enabling vehicles to communicate with other vehicles and with the infrastructure. This has multiple benefits, including improved safety, mobility, personal convenience, and economic development. To make the most of this opportunity, a number of public and private interest groups must collaborate to develop a system that actively engages the automotive, telecommunications, and consumer electronics industries. This effort involves the integration of vehicle and infrastructure-based communication systems across the nation, and it also requires that public agencies and companies overcome competitive forces and cooperate to achieve an "integrative" outcome. This challenge is enormous, because the vision and benefits are difficult to achieve from a technical perspective and the amounts of effort and overall trust that will be required in building relationships among participating contributors is large. In the

State of Michigan, we are working hard to establish this multi-sector collaboration, and we call it, simply, "Team Michigan."

This technical paper provides a brief overview of Team Michigan's unique approach to moving ahead on the vision of technical and relationship integration and on building a connected vehicle system that meets shared public and private objectives.

In his presentation at the 2008 Consumer Electronics show, Rick Wagoner, Chief Executive Officer, General Motors, captured the revolutionary vision of technology transformation the automotive industry is undergoing over the course of the next few decades:

- From mechanically driven, to electrically driven...
- Energized by petroleum, to energized by electricity...
- Powered by internal combustion, to powered by electric motors...
- Mechanically and hydraulically controlled, to electronically and digitally controlled...
- Operated in isolation, to fully connected...

According to Wagoner, "the electronics content of the typical automobile has increased by almost 50 percent over just the last five years." Furthermore, the automotive industry is keenly aware that the content of the automobile is expected to grow to between 35 and 40 percent of a car's cost by 2010. Electronics and software will represent 80–90% of vehicle innovations over the same period.

This transformation of the automotive industry is critical to the Michigan economy as the dramatic reduction in automotive industry jobs has placed Michigan at the forefront of what appears to be a recession of the U.S. economy. The Michigan economy lost 75,000 jobs in 2007 and appears to be headed in a similar direction in 2008. Job losses are predicted to taper off over the next few years, because of the restructuring of the automotive industry.

Despite the challenges that it faces, The State of Michigan is committed to playing a key role to ensure the successful transformation of its economy and that this transformation results in sustaining the new, electronically oriented, automotive industry in Michigan. Total U.S. employment in automotive electronic equipment was 80,200 in 2005 and is growing rapidly. This number does not include content developers, location based service providers, and application programmers, nor sales, marketing, and technical personnel. Given that the anticipated marginal increase in Michigan employment resulting from technology developments in connected vehicles is in the tens of thousands, the Michigan economy will most likely benefit from developing a home for such technology in the State.

Currently, automotive electronics are enabling a quantum leap in automotive performance, safety, comfort, efficiency, and environmental impact, and these changes are only just beginning. Modern improvements to both active and passive safety, such as airbags, anti-lock brakes, traction control, electronic stability control, and lane-departure and blind-spot detection, owe their existence to electronics. Moreover, electronics provide automotive manufacturers with high-end, integrated entertainment, navigation, power, and safety features, with the electronic content in automobiles increasing by almost 50 percent over the last five years. Last November, the Defense Advanced Research Projects Agency (DARPA) sponsored a contest for autonomous vehicles in an urban environment, and this DARPA Urban Challenge showed that there is a future for autonomous vehicles. The vehicles will drive themselves.

Currently, 42,000 people die annually on our roadways nationwide. Traffic accidents are the leading cause of death for people between ages 4 and 33. Fifty percent of the deaths occur from intersection collisions and vehicles leaving the roadway. Annual traffic crashes cost the American economy \$230 billion, and traffic congestion cost \$63 billion while wasting 56 billion gallons of fuel. Improving vehicle safety is part of the critical path to improving road transportation and the health and welfare of the traveling public.

Vehicle-to-vehicle and vehicle-to-infrastructure communications are prime examples of how wireless technologies are increasing safety. Vehicles communicate their locations, speeds, and other information with one another and provide warnings and controls to avoid collisions. Vehicles can also communicate with remote service centers to get information and to provide vehicle performance data. Furthermore, these vehicles will have the potential to serve as probes of incidents and general traffic conditions that will help both public and private responses to bottlenecks and emergency conditions. The connected vehicle is a central component in the public-private partnership in sustaining technological development in the Michigan automotive sector. Consumers are connected in almost every domain of life, from home to work, or any other location where there is access to cell phones and Wi-Fi communication. The driver wants to be as connected while on the road as in any other part of life, but connectivity in the car or any other vehicle has been limited because of the differences in the production cycle between commercial electronics and the vehicle.

Connected vehicle technology development offers Michigan a growing high-tech industry where Michigan companies have a competitive advantage. Michigan is the center for global research engineering expertise in the automotive sector with a concentration of nearly 70% of the North American research and development activity. Michigan is unquestionably the top state for automotive research and development employing more than 70,000 high-tech workers. Michigan ranks second among the 50 states in total private spending on research and development activity. Michigan is also home to the MDOT and other public-sector agencies that have demonstrated national leadership in connected vehicles.

The general strategy is to create and attract new information technology (IT) jobs to Michigan by leveraging the unique automotive design and engineering resources already located in Michigan and expanding the IT jobs that will benefit from collaborating with an existing technology resource base. New jobs will come from the design of new products and services that take advantage of the new Vehicle Infrastructure Integration system. New jobs will be attracted to the engineering and design core with the expansion into consumer electronics and wireless communications. The intent is to make Michigan the birthplace and rightful home of an emerging industry in telematics and wireless mobile communication linked to the automobile.

The VII Program in Michigan impacts the lives of Michigan citizens beyond transportation and will have economic development impacts as well including:

- New information technology industries form in Michigan as a result of the VII development effort and are implemented as a result of coordinated efforts with State of Michigan economic development partners.
- Improved mobility for automaker related activities through coordination between MDOT and the automakers on VII and other transportation related issues.

- Improvements in safety, security and traffic flow provide a positive impact on quality of life, encourage private sector investment in Michigan, and improve tourism.

In order to accomplish these things, MDOT must pursue this opportunity using a process that involves extensive collaboration and partnership with organizations not traditionally involved in the infrastructure design process, including automotive companies with vehicles that will communicate with the system and with telecommunications and consumer electronics companies with devices and technologies that support electronic communication. The VII strategy focuses on describing what needs to be achieved and how to accomplish these goals over the course of the next five years. At the forefront of the MDOT Vehicle Infrastructure Integration (VII) strategic plan is the creation of an executive level partnership between the State of Michigan and its automotive OEMs. This partnership includes Chrysler, Ford, General Motors, Hyundai, Nissan, and Toyota. All have a major presence in the state. The purpose of this partnership is to provide a high level strategic approach to addressing new opportunities for transportation innovation and economic development in the State of Michigan.

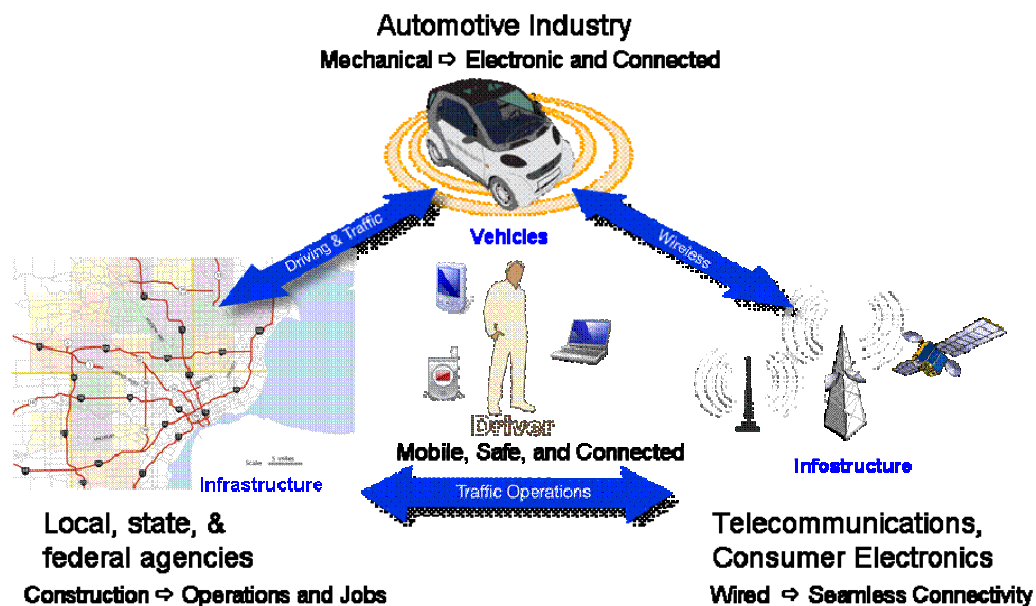


Figure 1. Synergies among Sectors in Transition

Michigan has taken the lead in pulling together a coalition of public private, for-profit and non-profit entities, as well as academic institutions and leveraging resources, combining capabilities, and working collectively to advance the participants interests for mutual growth, technology advancement, and other synergies. What pulls these organizations together is the shared interest in vehicle safety as a critical and addressable public health need that is clearly tied to customer demand for automobiles, road transportation, and consumer electronics used in vehicles. The other force that draws these organizations together is the growing demand for accessibility influenced by the cultural changes tied to increasing use of consumer electronics. Everyone is expected to be connected, entertained, and safe at all time including while driving. In response to this demand and the transition in government and industry illustrated in Figure 1, members of the automotive, telecommunication, and consumer electronics industries have come together with government to address safety, mobility, and seamless connectivity. The way this has

emerged in Michigan is that organizations have formed advisory groups with shared membership that formulate and coordinate industry, public policy, and university research needs in the area of advanced transportation technology; for example:

Center for Automotive Research Policy Advisory Committee addressing the industry-government connection for automotive and telecommunications economic development
Intelligent Transportation Society of Michigan addressing the public-private research and development, education and showcasing, and
University of Michigan Transportation Research Institute External Advisory Board addressing long-term research needs in transportation including safety and efficiency.

Center for Automotive Research has put a Policy Advisory Committee (PAC) in place to guide the efforts on industrial development in the area of connected vehicles and automotive electronics and wireless communication. The PAC brings together the key leaders from the automotive industry, state and local government, and the telecommunications industry to forge ahead on activities that draw on the strengths of each sector in times of dramatic change. For example, as mentioned above, the automotive industry is transforming from designing a product of mechanical origins to integrating electronic systems. The telecommunication companies are providing the infostructure at a time when they are transitioning from wired communication to wireless communication within vehicles and between vehicles and the infrastructure. This is happening at a time when the state and local transportation agencies are transitioning from an emphasis on expanding the road network to operating and managing the infrastructure more efficiently. The PAC includes director level representation from MDOT, RCOC, Ford, Chrysler, General Motors, Toyota, and the Connected Vehicle Trade Association. All of these organizations can see the synergies of working together in new and creative ways to address safety, mobility, and over accessibility issues shared by the drivers, citizens, and customers for their services. This committee was essential in the formulation and promotion of the plan that started the Connected Vehicle Proving Center where a test environment is under construction for the development of advanced wireless safety and mobility products.

Michigan's forum on public policy and support of Intelligent Transportation Systems (ITS) is ITS Michigan. ITS Michigan is a state chapter under ITS America, which was established in 1991 as a not-for-profit organization to foster the use of advanced technologies in surface transportation systems. Since then, ITS America has become a national advocate for the development and deployment of intelligent transportation systems in the U.S. Members include private corporations, public agencies, academic institutions and research centers. The national organization and the state chapters share a common goal: to improve the safety, security and efficiency of the nation's transportation system for the traveling public through the deployment of ITS. The Intelligent Transportation Society of Michigan is an organization of leaders, a central point of contact where industry can be in touch with leaders of transportation and education. ITS Michigan is a forum that allows a diverse group of people to provide insight on current ITS projects, as well as develop ideas for the future. ITS Michigan members are involved in research at outstanding Michigan universities and institutional research organizations, and is an advocacy group, promoting the importance of ITS at business meetings and other forums. This organization was the catalyst in generating Michigan's initial funding and conceptual plans for VII testing and deployment.

The University of Michigan Transportation Research Institute (UMTRI) Executive Advisory Board (EAB), which consists of about thirty members who represent business, industry,

government, and academia, helps shape transportation research in an era of rapidly changing technology that will ultimately connect vehicles and the infrastructure. EAB members play a key role in advising UMTRI and the University on transportation issues and research priorities, as well as assisting UMTRI in maintaining leading-edge research capabilities that will serve emerging research challenges. They provide guidance on high-level transportation issues, including safety and efficiency, and a context for UMTRI's future direction and development. With input and guidance from the EAB, UMTRI has been the lead organization in the Integrated Vehicle Based Safety Systems (IVBSS) program for NHTSA. This is a particularly a good example of UMTRI's investigation in to how four warning applications, filtered and prioritized, can be combined into a single system that communicates to the driver through a single human-machine interface. In a field operational test with drivers going about their normal business, UMTRI has tracked measurable changes in driver behavior, based on driving scenarios identified by poring over many miles of naturalistic driving data from previous field operational tests. Again, coordination and integration of university research efforts is facilitated by cross-cutting membership in the PAC, ITS Michigan, and UMTRI's EAB.

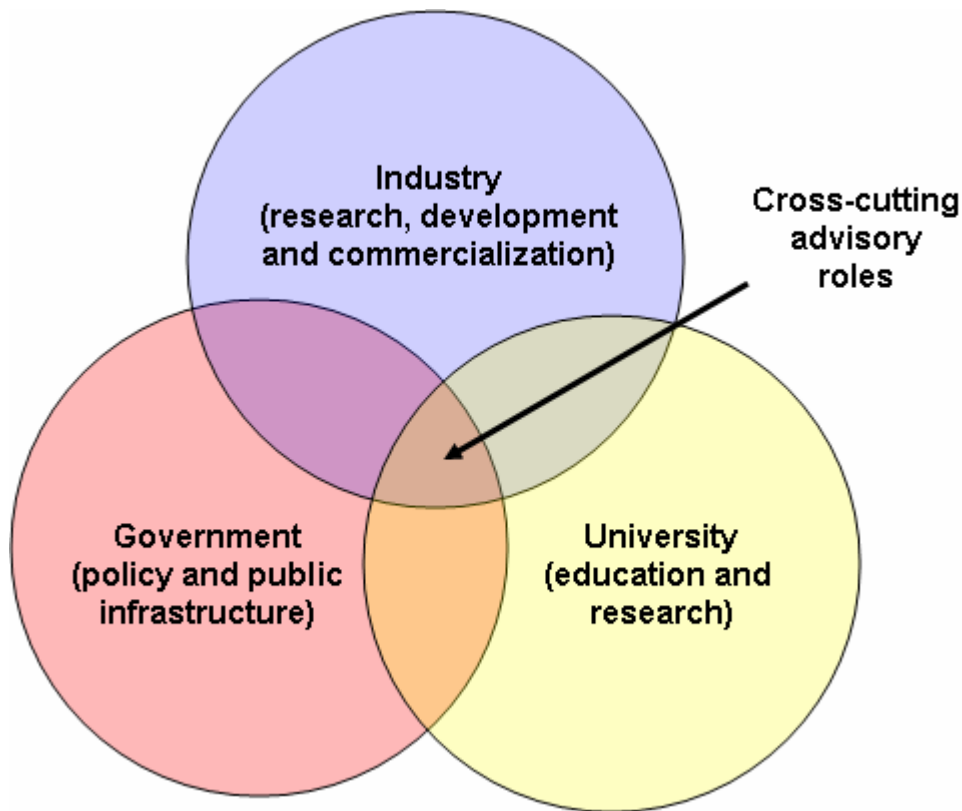


Figure 2. Cross-cutting Advisory Committee Membership

The State of Michigan is uniquely poised to form the first innovation-oriented state-industry partnership to support VII. Michigan has been the home of the Chrysler Group's Technology Center, the Ford Scientific Research Labs, and General Motors R&D Center since their inception. These automakers have formed strong partnerships with Michigan's major research universities in powertrains, structural optimization, occupant protection, human factors and safety systems. The additions of the Toyota R&D Center, Nissan Design Center, and the Hyundai R&D Center demonstrate an evolving automotive R&D innovation cluster that is supported by

the multitude of resources within Michigan. The challenge for growth is that strategic mechanisms are lacking to foster synergies between all of these R&D centers and direct state and federal resources to meet collectively determined OEM needs. TEAM Michigan provides some new opportunities for these organizations to cooperate on pre-competitive R&D and sharing of connected vehicle infrastructure, backhaul, data storage, testing, evaluation, and showcasing facilities.

Furthermore, Michigan has been home to more than \$117 million in current USDOT funding for VII and related activities that provide a jump-start for the Michigan and national VII program. This promises to continue as the connected vehicle research and development efforts move to an open systems platform. Michigan is participating in and is the home of:

- The Vehicle Infrastructure Integration Consortium (VIIC) of automotive manufacturers, which was awarded \$44 million in federal dollars, along with a \$12 million match, to design, test, evaluate, and assess deployment feasibility by the end of 2008; VII proof-of-concept (POC) testing is underway at the time of this writing. . MDOT's Data Use Analysis and Processing (DUAP) project is supporting the VIIC on the public side by looking into data sources from which traveler information can be.
- Integrated Vehicle-Based Safety Systems (IVBSS) program, which includes \$25 million awarded to the University of Michigan Transportation Research Institute (UMTRI) to create a \$31 million program to accelerate the successful integration and deployment of safety systems addressing rear-end, lane change and roadway departure collisions into the light-vehicle and heavy commercial vehicle fleets.
- Cooperative Intersection Collision Avoidance Systems (CICAS) program, which provides \$30 million to the Crash Avoidance Metric Partnership (CAMP), located in Michigan, to develop and demonstrate prototype systems that save lives and prevent injuries at the most hazardous roadway intersections and assess their value and user acceptance.

MDOT has also been working in partnership with the Road Commission for Oakland County (RCOC) and Chrysler for the past two years to pull in real-time information from vehicles. To date, Chrysler has instrumented over 1,100 vehicles for testing of VII communication in and around their Auburn Hills campus. The data from this deployment has been used by Chrysler to improve many dimensions of vehicle performance, ranging from safety and traffic optimization to fuel efficiency to reliability. Over the next 3-6 months a program will be implementing at MDOT to evaluate the data from these vehicle systems and determine how they can improve the departmental operations on efforts ranging from traffic operations to asset management and pavement condition to weather tracking and monitoring. Instrumented naturalistic test vehicles developed by UMTRI are being used to collect data on the effectiveness of VII systems being exercised in the VII POC testing.

No other state can offer the geographic concentration of potential test vehicles with the thousands of automotive leased vehicle that arrive at automotive company parking lots daily. This concentration of potential will provide the necessary traffic densities to test the effectiveness and benefits of traffic management and safety systems and offers the automotive companies an exceptional opportunity to monitor the performance of a large number of vehicles remotely. One could speculate that even without national deployment, a Michigan deployment of a wireless infrastructure that would support close-to-continuous broadband remote diagnostics would have continuing appeal to the automotive companies.

The study and development of connected vehicle systems provides a new opportunity to collect data that can be used to evaluate vehicle performance, driver behavior, and network and traffic conditions. Such data include vehicle location, speed, and direction; throttle position; air bag activation; braking actions; traction control activation; road condition; and more. The connected vehicle opens the door for remote vehicle diagnostics and probes for traffic and road conditions. To create an environment in which to develop, test, and showcase these emerging connected vehicle systems, the Michigan Economic Development Corporation (MEDC), with support from the Michigan Department of Transportation (MDOT), provided the Center for Automotive Research (CAR) and the Connected Vehicle Trade Association (CVTA) with a grant for developing the Connected Vehicle Proving Center in Michigan, and the CVPC is another critical component of Team Michigan.

The CVPC was launched in 2007 and is now set up to test, evaluate, and showcase connected vehicle systems by integrating connected vehicles, smart roadway infrastructure, and a broad range of telecommunication technologies, as well as provide expertise in evaluation design, data storage and analysis, and information sharing to be used in product development, remote diagnostics, and vehicle probe applications. Again, this involves partnership. In many cases, MDOT and local governments will own much of the roadside infrastructure used by the CVPC, while the Center will partner with other organizations to gain access test tracks and other key facilities. While these facilities will be available to automotive and telematics companies, as well as universities and government organizations, through contractual and other arrangements, the CVPC will offer protection for data and intellectual property, as well as liability protection. The CVPC's Policy Advisory Committee includes representatives of public organizations like MDOT and RCOC as well as the automotive industry including General Motors, Ford, Chrysler, Toyota, and BMW, along with representation of the connected vehicle industry through CVTA. This further demonstrates the value of collaboration among the automotive, telecommunications, and consumer electronics industries, along with support from public agencies, to ultimately address customer transportation and information system needs.

Michigan's commitment to supporting connected vehicle development is clear:

- The US automotive industry is concentrated in southeast Michigan. All the major manufacturers have R&D facilities here.
- The automotive supply base, as well as key wireless infrastructure, application, and services companies, also have R&D facilities and offices in southeast Michigan.
- Southeast Michigan is home to several major universities, including the University of Michigan, Michigan State University, and Wayne State University, as well as Oakland University and the University of Detroit-Mercy. In addition, the region is also home to Lawrence Technological University and Kettering Institute, two of the best of technological institutions.
- The State of Michigan is committed to supporting VII, as evidenced by MDOT's partnership with RCOC, the funding of test-bed infrastructure, and MEDC funding of the CVPC.
- The VII proof of concept test-bed is located in Michigan, and the VII Consortium, comprised of all the major automakers, meets weekly to provide oversight to the development and prove-out of new technologies.

In summary, “Team Michigan” provides all the players necessary for further developing vehicle communication systems that keep drivers connected, save lives, improve mobility, protect the environment, and employ Michigan residents. The automotive, telecommunications, and consumer electronics industries are all engaged with the State of Michigan and other partners like the RCOC, UMTRI, VII-C, CVTA, and CAR to assure that Michigan takes a leadership role as a catalyst for the connected vehicle industry as a cornerstone for the transformation of the automotive industry as it transitions from mechanical to electronic. The teaming is motivated by shared interests in consumer demand for vehicle safety and continuous connectivity.