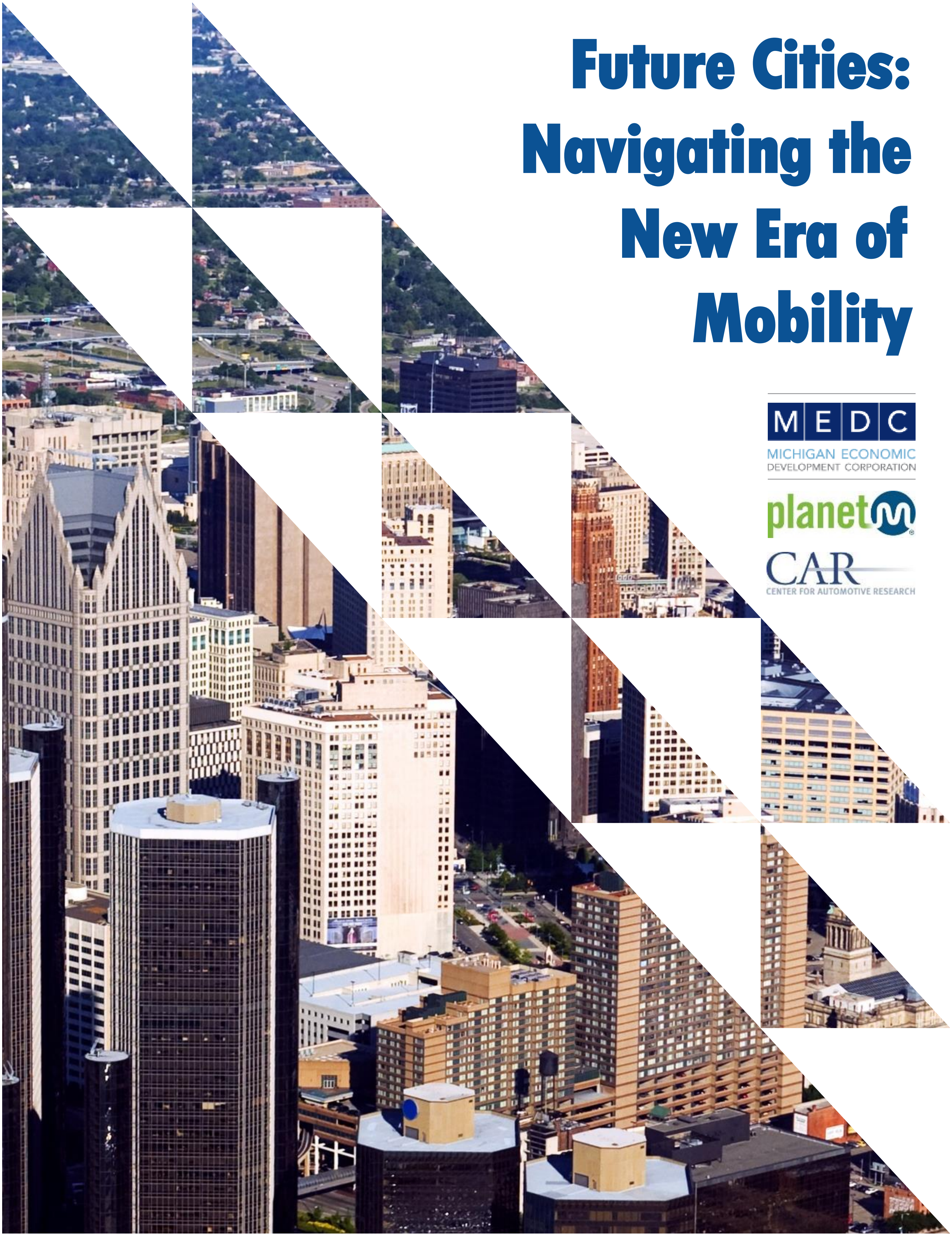

Future Cities: Navigating the New Era of Mobility

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MICHIGAN ECONOMIC DEVELOPMENT CORPORATION

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CAR's mission is to conduct independent research and analysis to educate, inform and advise stakeholders, policymakers, and the general public on critical issues facing the automotive industry, and the industry's impact on the U.S. economy and society.

Introduction

Michigan has long been a world-wide automotive hub, not just for manufacturing, but for research, engineering, design, and testing. As innovative mobility services (IMS) proliferate and connected and automated vehicle (CAV) technologies develop, Michigan has stayed on top of the ever-evolving technology race as well as the economic development opportunities that come with it.

The Michigan Economic Development Corporation (MEDC) wants to ensure Michigan remains a leader in CAV development, and a large part of accomplishing this means bringing its communities up-to-date on the impacts of CAVs and innovative mobility services. With this knowledge, Michigan communities will be well-positioned to take advantage of various technology advancements and make sound decisions on infrastructure investments, transportation plans, and strategic master planning.

To help achieve this goal, the MEDC Automotive Office commissioned the Center for Automotive Research (CAR) to assess the potential impacts of CAVs and innovative mobility services on local communities in Michigan. These technologies and services promise many benefits for local Michigan communities, but in many cases, new infrastructure or policies are required to maximize their societal benefits and overall effectiveness. This policy development and infrastructure deployment will often require an innovative and collaborative approach between local (city, township, county, charter township, and village) units of government, state agencies, in partnership with private organizations.

Communities that understand the potential challenges and benefits of IMS and CAVs and make wise capital investments based on that knowledge will be more attractive to both companies and residents. Communities that best adapt to these new mobility technologies and services will be best positioned to manage this investment.

This report first defines connected and automated vehicle technologies and various innovative mobility services. It also discusses the potential impacts these vehicles and mobility services will have on communities and transportation systems. To better position Michigan as a leader, the report concludes with guidelines for communities to maximize the benefits of CAVs and IMS for their residents, businesses, visitors and governmental entities.

As these guidelines show, there will be opportunities for returns on the significant public and private investment needed for the creation of innovative mobility services and, especially, the deployment of connected and automated vehicles. These returns on investment relate particularly to mobility efficiency, property utilization and quality of life. This deployment warrants future work to develop a set of financial tools to assess the level of investments, change in public sector revenue flows, and factors contributing to the return of these investments.

Methods

The project consisted of four broad tasks: literature review, expert interviews, community workshops, and final report and dissemination.

CAR researchers performed a thorough literature review of available information on the subject, including activities both nationally and internationally that relate to CAVs, IMS, and communities.

Researchers then identified experts in CAR's extensive network of researchers, economic developers, municipal leaders, planners, automotive and transportation engineers, and others to interview and glean further information, especially in communities that have participated in U.S. DOT and other pilot tests of CAV technology, or where innovative mobility services have been deployed.

Based on information acquired during the literature review, CAR researchers developed a survey to understand better participants' experience and concerns with the technologies, potential CAV and IMS impacts, current or planned activities linked to CAV or IMS deployment. The survey also solicited respondent's ideas for how CAVs and IMS can integrate with and potentially improve the overall well-being of their community.

CAR then used the literature review and responses from the survey to assess the potential impacts of CAVs and IMS on local communities and highlight experiences of a few communities that already have taken steps to support CAV and IMS deployment.

To ensure the results of this effort were as impactful and useful for Michigan communities as possible, CAR organized a series of workshops with local municipal leaders, transportation planners, researchers, industry representatives, and others across the state. These workshops consisted of two parts: the first offered attendees a thorough description CAVs and IMS and solicited their questions; the second provided specific recommendations for action items communities can take and offered supporting information and examples of policies other communities have enacted.

Each wave of workshops consisted of four meetings, with locations selected across the state to encourage as much local participation as possible. Approximately 160 planners, economic developers, municipal and county elected officials, municipal managers, transportation engineers, and others took part in the events. The workshop locations were:

- East Michigan – Ypsilanti (Round 1) and Plymouth (Round 2)
- West Michigan – Grand Rapids
- Northern Michigan – Gaylord
- Upper Peninsula – Marquette

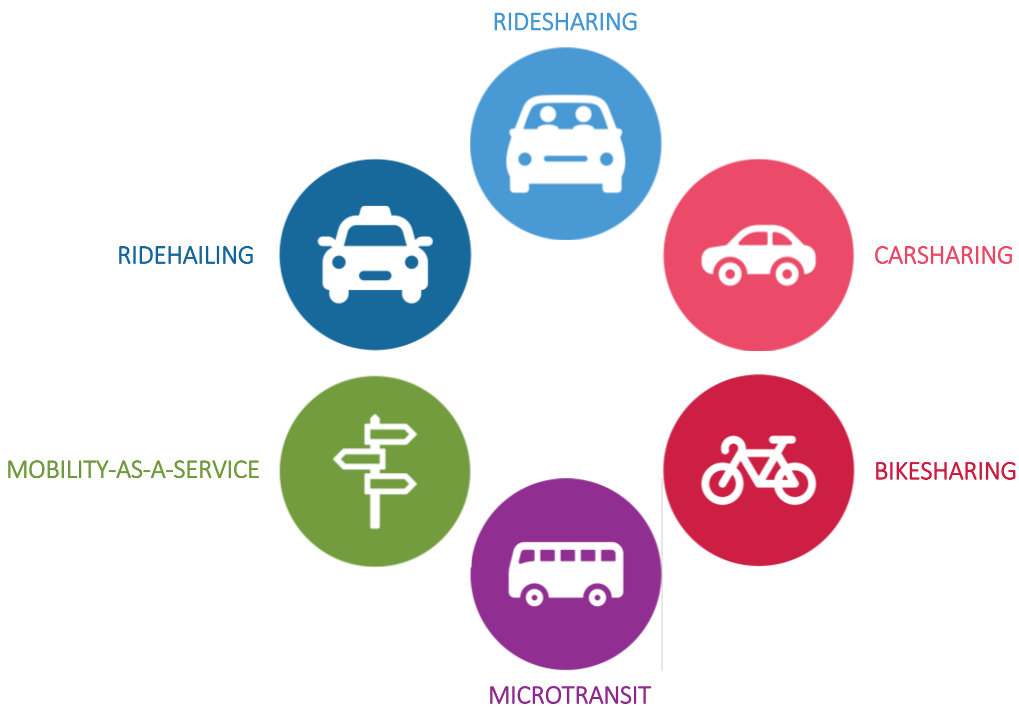
Based on the literature review, the survey results, and the workshops, CAR researchers developed this report on the potential impacts of CAVs and IMS on Michigan communities.

Innovative Mobility Services

Numerous new passenger transportation options, collectively called innovative mobility services (IMS), have been introduced in the past fifteen years – and some have seen significant growth.

Innovative mobility services are transportation solutions enabled by emerging technologies and wireless connectivity that allow for more convenient, efficient, and flexible travel. Carsharing, ridehailing, ridesharing, microtransit, bikesharing, and mobility-as-a-service are among the most noteworthy innovative mobility services currently in development.

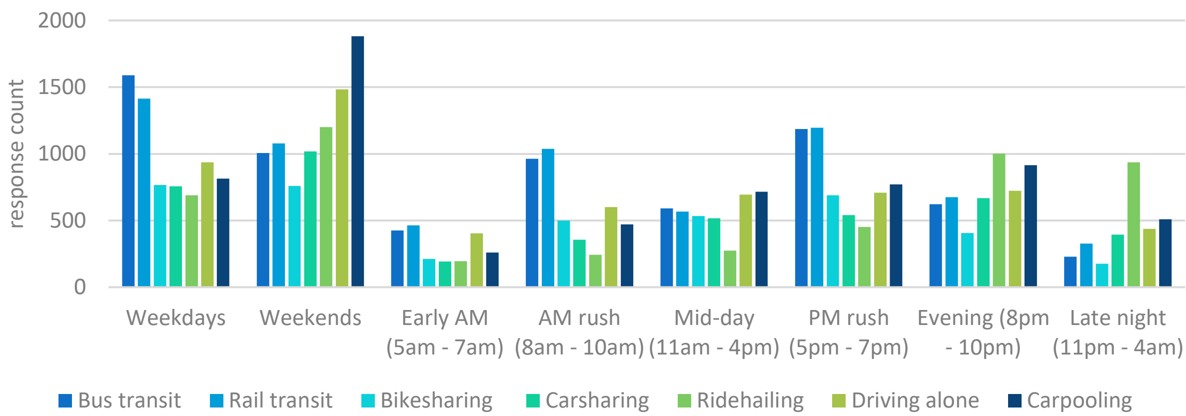
Figure 1: Innovative Mobility Services



Innovative mobility services provide entirely new solutions or reshape existing transportation modes with technology. Each has a unique business model and underlying service characteristics, but all services enable users to have access to – or shared-use of – transportation modes (passenger vehicle, bicycle, motorbike) for a short-term, on-demand, and as-needed basis. The growth of these services proves they are filling transportation gaps in local offerings. Additionally, many IMS share the common values of promoting mode choice in transportation, as well as encouraging multimodal connectivity and system interoperability.

Among innovative mobility services, ridehailing, carsharing, ridesharing, bikesharing, and microtransit services are widely used globally and domestically (Figure 1), and each service has its predominant use cases (Feigon, S. et al., 2016). For example, carsharing is used more often on weekends for shopping or leisure purposes. However, for ridehailing, peak time is in the evening and late night, as these services are a top choice when people go out. Finally, bikesharing is used most during the afternoon rush, but there are no differences between weekend and weekday usage. Figure 2 represents responses to a transportation survey addressing mode preference in seven big U.S. cities – Austin, Boston, Chicago, Los Angeles, San Francisco, Seattle and Washington, DC (Feigon, S. et al., 2016).

Figure 2. Mode Preference by Time of Day and Week (Average of Seven U.S. Cities)



Source: (Feigon, S. et al., 2016)

The increasing adoption of innovative mobility services is changing travel behavior and has various implications for other transportation modes such as public transit and private vehicles. Many studies based on surveys of members of IMS programs have been conducted to understand the changing habits of these individuals and their future intentions towards different transportation modes. Despite the limitations of insights deduced from survey data, these studies provide early-stage information on transportation trends. As IMS become more widely adopted, it is important to include questions about these services in statewide and nationwide surveys like the American Community Survey – the California Household Travel Survey started including questions related to IMS in 2010. Also, transportation analysts could mine more reliable data from shared vehicles and bikes for insights about changing travel behaviors.

Overall, innovative mobility services both complement and compete with public transit and private vehicles. Half of U.S. innovative mobility users walk or bike more, and fifteen percent of them use transit more often than they did before signing up for a mobility service (Feigon, S. et al., 2016). Inversely, almost a third of them drive less than before they started using a mobility service (Feigon, S. et al., 2016) and in some cases give up owning a vehicle entirely (Feigon, S. et al., 2016). Because IMS lower their users' reliance on personal cars, this group of individuals tends to decrease their vehicle miles traveled (VMT), defined as the number of miles traveled by motor vehicles. This reduction in VMT could contribute to reducing traffic congestion and air pollution.

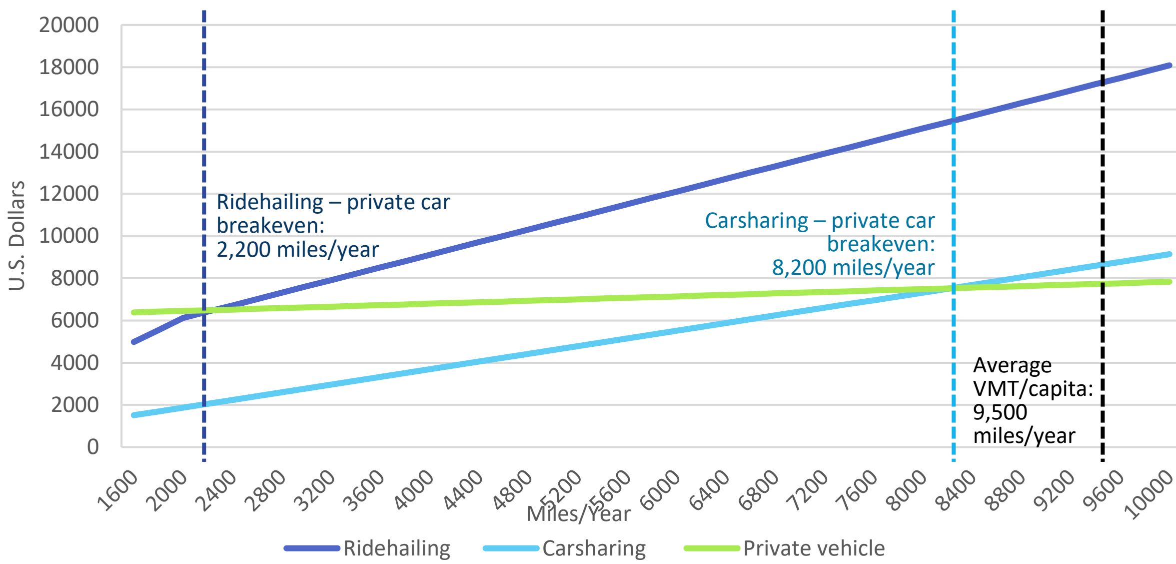
Age wise, IMS users tend to be younger than the users of traditional transportation modes. For example, 28 percent of Americans between 18 and 29 years have used ridehailing, but only 4 percent over 65 have used this service (Smith, 2016). On average, IMS users own 1.05 light vehicles per household (Shared-Use Mobility Center, 2016), compared to the national average of 2.06 vehicles per household, and IMS users also have shorter commutes.

Lower-income households make less use of innovative mobility services such as carsharing and bikesharing. Among the notable causes is the very limited availability of these services in low-income neighborhoods. Also, these transportation options are more expensive than public transit and require users to have credit cards, Internet access, and smartphones.

Innovative mobility services are making progress accommodating people with disabilities, but the accessibility of these services is still quite low compared to public transit or even specialized taxi services. In the past, ridehailing companies have argued not having to comply with the Americans with Disabilities Act (ADA) because they are technology companies. They are changing their stance and multiplying pilot programs in partnership with public agencies to introduce new paratransit services or improve existing ones**.**

The cost dimension of innovative mobility services is complex. When these services are used in combination with public transit, biking and walking, IMS can reduce household transportation costs, especially compared to costs associated with owning and using a private vehicle. However, exclusively using ridehailing or carsharing is less expensive than a private car only for people with shorter commutes (Spulber, et al., 2016). With carsharing, for example, the breakeven point is 8,200 miles, still less than the average annual VMT per capita of 9,500 miles (Figure 3). Like any other disruptive technology or service, however, the price of innovative mobility services will decrease as they become more popular and accessible.

Figure 3. Annual Transportation Cost by Mode (National Average)



Source: (Spulber, et al., 2016)

Ridehailing

Ridehailing services rely primarily on smartphone apps to connect passengers with drivers who offer rides for a fee in private vehicles. Transportation Network Companies (TNCs) design and operate these online platforms. TNCs have deployed a variety of operating models, partnering with self-employed drivers holding a commercial driver’s license or those with a standard driver’s license.

The two biggest ridehailing operators in the United States are Uber (founded in 2009, available in 200 urban areas in the United States), and Lyft (in the market since 2012, available in 300 U.S. urban areas). These fast-growing ridehailing services are currently operating in more than ten urban areas in Michigan, including Detroit, Ann Arbor, Lansing, Grand Rapids, Saginaw, and Kalamazoo.

Like other IMS, ridehailing services thrive in the largest cities, especially in denser population areas. Uber, for example, makes most of its revenue in a few big U.S. cities, like New York City, San Francisco, and Chicago (Hall & Krueger, 2015). Ridehailing is also available in suburban areas but tends to be less profitable, as there are fewer potential customers than in more densely-populated urban cores. Some ridehailing companies are specifically expanding in small urban and rural communities that were previously unserved by ridehailing companies. One example is Liberty Mobility Now, a for-profit company launched in 2015 offers ridehailing services as well as a mobility-as-a-service platform. By partnering with existing transportation options, such as public transit, taxi, and shuttle services, Liberty Mobility Now can provide a one-stop shop for mobility information, booking, and payment options.

Fifteen percent of all Americans have used ridehailing (Smith, 2016), especially for shopping or recreation purposes, and less for commuting to work. There is a clear urban-rural gap in ridership, given that 28 percent of urban Americans under 50 years have used this type of service, compared to only 4 percent among those in rural areas.

Despite its short history compared to other transportation modes, ridehailing has already had a significant impact on travel patterns in some areas. A comparison between 2013 and 2016 reveals that ridehailing has increased New York City's total VMT by 3.5 percent (Schaller, 2017). The same study showed that ridehailing both substitutes and complements public transit, is displacing taxi and personal car trips, but also attracts users that would not have traveled otherwise.

Michigan Public Acts 345, 346, 347, and 348 of 2016 revised the rules that apply to limousines, taxis, and TNCs. The laws define TNCs and the criteria under which drivers can be considered independent contractors, require that TNCs register with the Department of Licensing and Regulatory Affairs and pay a fee – they also prohibit local governments from imposing a fee and allow airports to do so, establish insurance requirements, and require that TNCs conduct drivers criminal history checks.

Carsharing

Carsharing is a short-term car rental, often by the hour. Electronic systems allow customers direct access to the vehicles. This type of service includes fuel and insurance costs. These characteristics distinguish carsharing from traditional car rental. In the last few years, however, the distinction between the two models is increasingly blurred, as car rental has become more similar to carsharing.

Carsharing vehicles can be owned by a company (business carsharing), such as Zipcar or car2go, or by private individuals (peer-to-peer carsharing). Turo and Getaround are two of the platforms that organize peer-to-peer carsharing by connecting car owners with renters. Some operators provide round-trip carsharing, in which case the vehicle must return to its initial parking location (e.g., Zipcar, Enterprise CarShare), while others offer one-way rentals, meaning the vehicle reservation can end in another parking area (e.g., car2go).

More than 50 U.S. cities and regions have one or more carsharing services. In Michigan, peer-to-peer (Turo) and business carsharing (Zipcar, Maven) are available in seven urban areas, including Ann Arbor, Detroit, and Lansing.

Table 1. Characteristics of Neighborhoods with Carsharing Programs

Demographics	
One-person households	51.8%
Households with children	12.5%
Rental households	71.5%
Means of Transportation to Work	
Drive alone	33.0%
Carpool	6.6%
Public transit	30.8%
Bicycle	2.1%
Walking	21.9%
Neighborhood Characteristics	
Housing units per acre	21.7

Source: (Millard-Ball, et al., 2015)

As Table 1 shows, the characteristics of neighborhoods with carsharing programs are unique: high transit and walking mode shares, and higher than average housing density. Such environment offers carsharing services enough customers to stay profitable. For that reason, cities with lower population densities or with a seasonal population (tourists, seasonal recreational activities enthusiasts) are less attractive for carsharing operators.

Several studies have shown overall, people who use carsharing services will tend to reduce automobile ownership rates. Because they have access to a carsharing vehicle, some people decide to sell a vehicle and others refrain from buying one. The impact on vehicle ownership varies significantly from city to city. Studies on North American carsharing programs show that 2 – 32 percent of carsharing users sell one or more personal vehicles and 7 – 71 percent of carsharing users avoid a vehicle purchase (Martin & Shaheen, 2016; Shaheen, et al., 2016). By reducing vehicle ownership in operation areas, carsharing programs can contribute to sustainable urban development by reducing overall parking demand (especially in residential and mixed-use areas), VMT, and greenhouse gas emissions.

The impact of carsharing on travel demand is complex and needs further research. By reducing vehicle ownership, carsharing also can contribute to a reduction in VMT. Also, carsharing vehicles tend to have a higher occupancy than private ones (Cervero, et al., 2007). A survey of members of the Car2go programs in five North American cities (San Diego, Seattle, Washington DC, Calgary and Vancouver) estimated that members' VMT had dropped by 6 to 16 percent (Martin & Shaheen, 2016). Another study on the San Francisco City CarShare program showed that members' mean mode-adjusted VMT fell by 67 percent, between 2001 and 2005 (Cervero, et al., 2007).

Carsharing also impacts the use of other modes of transportation. One study shows that carshare members decrease their use of public transit slightly and they walked, biked, and carpooled significantly more (Martin & Shaheen, 2011). Carsharing is changing the customer base of public transit**.** Carless households gaining vehicle mobility through carsharing may ride public transit less. Conversely, households that own vehicles and reduce their car dependency because of carsharing may use transit more. Finally, the impact of carsharing on mode choice in dense areas is different from those in suburban areas. One study specifically targeted Zipcar programs on college campuses and revealed that members of carsharing programs used public transit, walked, and biked much less in suburban and rural college campuses than in urban ones (Stocker, et al., 2016).

Ridesharing

Ridesharing is a type of carpooling that uses private vehicles, arranging shared rides on short notice between travelers with either a common origin or destination. This service can be for short-or long-distance trips. Travelers share trip costs through ridesharing platforms that charge a fee for making the connection. Carpooling has existed for decades, but real-time ridesharing started in the mid-2000s. While ride-matching programs have easy success connecting passengers in densely populated areas with insufficient transportation options, areas with lower population densities represent a challenge.

One of the most prominent recent ridesharing programs is Waze Carpool, currently available in the San Francisco Bay Area. There are many other ridesharing services, as well as vanpool and carpool programs enabled by smartphone apps or web platforms. In Michigan, the MichiVan vanpooling program is sponsored by Michigan Department of Transportation and operated by Enterprise Rideshare. There is also a Guaranteed Ride Hope program associated with MichiVan (Michigan Department of Transportation, 2017). One of the hurdles in preventing ridesharing programs from becoming more pervasive is the challenge of matching rides and meeting at centralized locations – such as a shopping mall, grocery store or carpool lot – which is not always convenient.

Microtransit

Microtransit is a broad category encompassing various private transit services that use vans or small buses and develop flexible routes and schedules based on customer demand. Microtransit resembles current route-deviation services and bridges the gap between single-user transportation and fixed-route public transit.

Microtransit services provided by companies such as Via and Chariot started operating around 2012 in several U.S. cities. They work similarly to jitney services and city-operated paratransit or flexible route services. What sets them apart are wireless connectivity and data analytics. Better data on mobility patterns and broad smartphone access have made flexible, on-demand transit more convenient for the users, and more profitable for providers.

Microtransit can be a useful option for communities to provide the proper response to travel demand when and where it is needed, without large investments in material or transportation infrastructure. It can eliminate the problem of empty buses in some areas or during specific hours and can operate within both fixed and dynamic routes and schedules. With such nimbleness, microtransit services can eliminate the need for feeder buses in areas with limited demand for public transit, and can also provide more convenient transit options for those who have longer commutes with multiple connections.

Although no microtransit companies operate in Michigan, several cities operate paratransit or demand-response shuttles that are similar to microtransit. The Ann Arbor Area Transportation Authority is launching a FlexRide service that will provide connections to the fixed-route transit network and other destinations in southeast Ypsilanti Township. Users will be able to reserve a same-day ride by calling AAATA, whereas microtransit companies like Chariot and Via allow reservations over a smartphone app and pick up riders in a matter of minutes.

There is inadequate information on the impact of microtransit on communities. An evaluation of the six-month 2016 pilot partnership between Kansas City and Bridj – a company that ceased operations in April 2017 – found that most used the service for commuting and work-related travel. The alternative mode analysis indicated that Bridj mostly substituted single occupancy vehicles and bus transit.

Bikesharing

Bikesharing is a system that provides free or affordable access to bicycles for short-distance trips, mostly in urban areas. Bikesharing programs can be created and managed by local community groups or non-profit organizations (Community Bike programs) or by public-private partnerships involving municipalities or transit agencies (Smart Bike programs). More than 120 U.S. cities have bikesharing programs (Shared Use Mobility Center, 2017), and over ten Michigan cities – including Ann Arbor, Detroit, Dearborn and Battle Creek – have such programs.

Studies have shown bikesharing is best suited for dense, urban areas where the bikes connect riders to other modes of transportation, especially public transit. According to a recent study, 77 percent of bikesharing stations in the United States are within a block's distance of public transit (Firestine, 2016). Similarly, when suburban points of interest like commercial centers or office parks are available, bikesharing may also be viable. The success of bikesharing programs will also depend on the quality of the bike and road infrastructure.

The impacts of bikesharing may differ depending on the size of cities. In smaller cities, people tend to employ bikesharing for recreational purposes. In these cases, bikesharing increases access to transit, so bus and rail use increases among bikeshare users. In larger cities, people more often use bikesharing for commuting, thus making it an alternative to transit and reducing overall bus and rail use among bikeshare users (Martin & Shaheen, 2014; Shaheen, et al., 2014).

Bikesharing has several implications on other modes; one study shows 39 percent of bikeshare users have reduced their use of public transit (Shaheen, et al., 2012). Similar studies also indicate bikeshare users reported a reduction in the use of personal cars by 25-53 percent (DeMaio, 2009; Shaheen, et al., 2014), which can have a role in reducing VMT and alleviating congestion in the long term.

Mobility-as-a-Service

Mobility-as-a-Service (MaaS) is a mobility distribution model in which a person satisfies his or her transportation needs over a single interface. In general, multiple transportation options (mass transit, carsharing, ridehailing, among others) are bundled together in an integrated solution. That solution then is presented to the user through a smartphone app and the service is paid via a single account. MaaS aims to provide end-to-end transportation by linking different transportation modes and make better use of the existing transportation options in a given area. In the United States, companies like TransLoc, Xerox, and moovel N.A. are developing transportation aggregator apps, including employee commute benefits, and are developing partnerships with local authorities.

Urban regions with at least two or three transportation modes other than private cars can benefit from a MaaS program. Additionally, MaaS is highly data-driven and powered by information technology improvements including precise Global Positioning Systems (GPS), widespread penetration of smartphones on high speed cellular network (3G, 4G or 5G), high level of connectivity, real-time travel option schedules and cashless payment systems. One important item of note is that MaaS implementation requires strong local and regional cooperation between public agencies and private providers. Each of these stakeholders may bring their innovative ideas and strengths into the transportation planning sphere to change the future of urban mobility.

Connected and Automated Vehicles

The general concept of "connected and automated vehicle" can encompass a variety of vehicle technologies currently being used or still in development. These technologies may work at the level of the vehicle, the transportation system, or both.

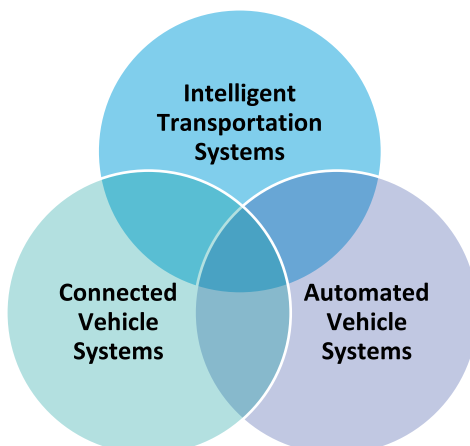
Connected Vehicle (CV) Systems - Any system enabling the exchange of digital information between a vehicle and the world (e.g., another vehicle, infrastructure). Vehicles can connect in multiple ways: vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-everything (V2X).

Automated Vehicle (AV) Systems - Any electronic system that influences the lateral or longitudinal operation (or both) of a ground vehicle.

Intelligent Transportation Systems (ITS) - Electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system (Code of Federal Regulations 940.1).

Vehicle connectivity, automation, and intelligent transportation systems intersect on multiple vehicle features and system applications (Figure 4).

Figure 4. Advanced Transportation Technologies



Although some vehicles could be connected without being automated, and possibly others could be automated without being connected, automotive manufacturers are increasingly aiming to develop vehicles that are both automated and connected. To be fully self-driving, vehicles will need to integrate connectivity technology and applications, such as digital maps or traffic data. Also, a combination of engineering, operational, regulatory, and marketing factors, are making some companies consider using electric vehicles for their self-driving models.

The term connected and automated systems is often conflated with intelligent transportation systems (ITS), and while ITS may include connected and automated vehicle systems, ITS is a much broader concept involving a variety of advanced applications that go beyond vehicle systems. Connected and automated vehicle technologies may or may not be integrated into ITS, depending on the particular application.

Connected Vehicle Technologies

Among the many different connected vehicle networks and standards, cellular 4G LTE, 5G, and 5.9 GHz Dedicated Short-Range Communication (DSRC) are the most likely to affect how transportation systems function in the future. Whereas cellular 4G LTE exists today, DSRC devices have not been installed yet on vehicles or infrastructure beyond limited pilot deployments. 5G is still in development and industry is expected to agree upon standards for 5G and have the technology ready for deployment somewhere after 2020.

U.S. DOT and industry partners have been researching and developing connected vehicle technology for nearly three decades. Some work involved cellular technologies, but the overall vision is to establish a nationwide connected vehicle environment based on DSRC. U.S. DOT has proposed a mandate that would require DSRC connectivity on all light vehicles five years after its adoption (NHTSA, 2016) to ensure a critical mass of the technology. Additionally, U.S. DOT and state DOTs are planning to deploy the required infrastructure for DSRC-based V2I communication. The latest program to deploy, test, and operationalize CV applications is the U.S. DOT Connected Vehicle Pilot Deployment Program. The program began in 2016 and supports three pilot sites – Wyoming, New York City (NYC), and Tampa – each testing specific CV applications.

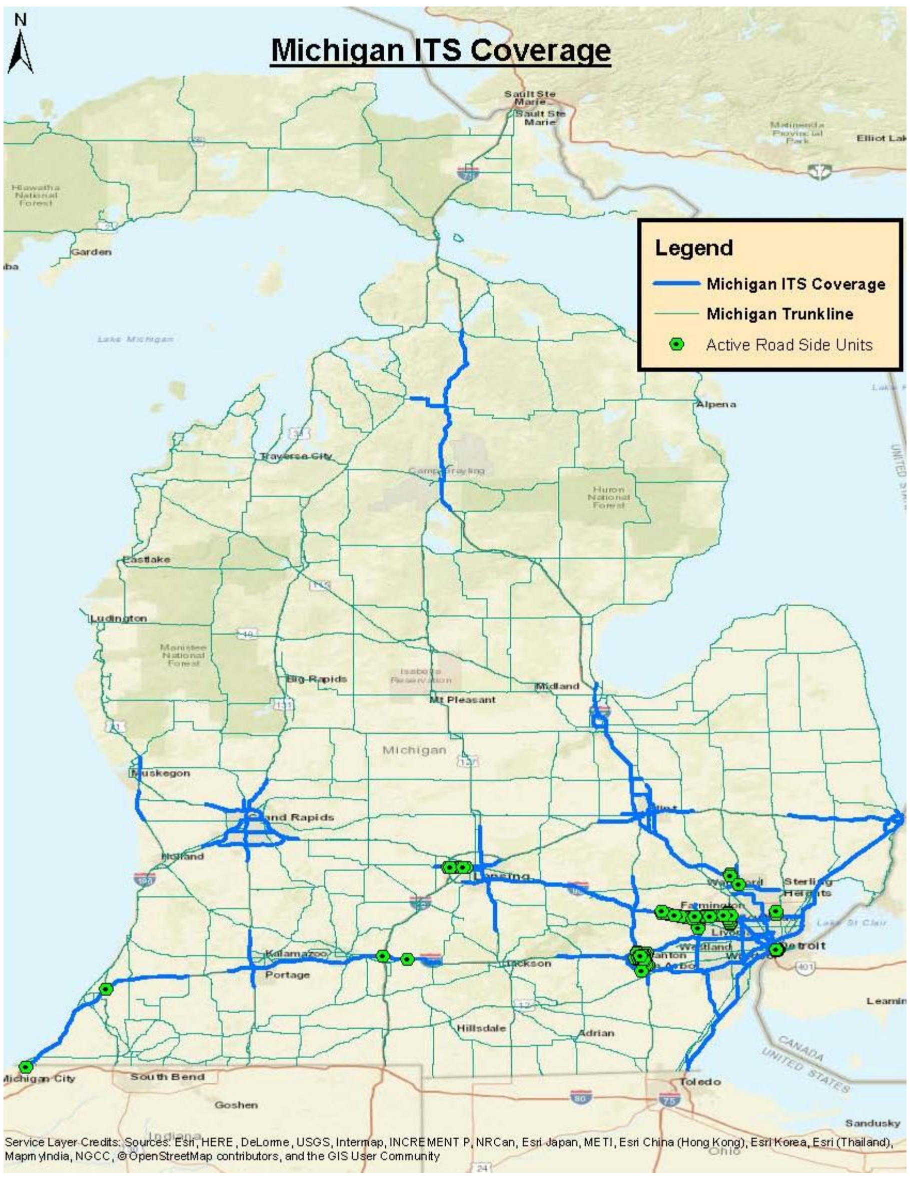
Michigan has been the site of significant state- and federally-supported CV research and testing initiatives. Starting in 2005, U.S. DOT conducted a CV Proof of Concept (POC) in the Novi/Farmington Hills area. A few years later, the Ann Arbor Safety Pilot Model Deployment (SPMD) – led between 2012 and 2015 by University of Michigan Transportation Research Institute (UMTRI) with support from the Michigan Department of Transportation (MDOT) and MEDC– equipped 3,000 vehicles and 29 roadside locations with CV technology. This project allowed U.S. DOT to collect data to evaluate and improve communications equipment interoperability. UMTRI is currently conducting the Ann Arbor Connected Vehicle Test Environment (2015-2018), a project that builds on the SPMD and aims to implement and further test CV technologies on vehicles and infrastructure such as traffic signals.

MDOT has been leading several connected vehicle tests and pilot deployments aimed at enabling DSRC communication. MDOT is focusing its efforts on four initial CV applications: red light violation warning, work zone warning, road weather management, and pavement condition monitoring (Planet M website, 2017). To that effect, for example, MDOT has equipped 15 vehicles from its fleet with sensors capable of collecting and transmitting information on pavement condition, as part of the Vehicle-Based Information and Data Acquisition System (VIDAS) project. MDOT has also created a Data Use, Analysis, and Processing (DUAP) Program to integrate CV data, mobile data, and data from fixed sensors into a unified system and make it accessible to MDOT personnel.

There are currently 115 DSRC roadside units deployed across Southeast Michigan (Figure 5 and Figure 6) in Ann Arbor, Farmington Hills/Novi/Lyon Charter Township, Detroit, Southfield, Lansing/Delta Charter Township, Warren, and I-94 corridor between Battle Creek and Benton Harbor.

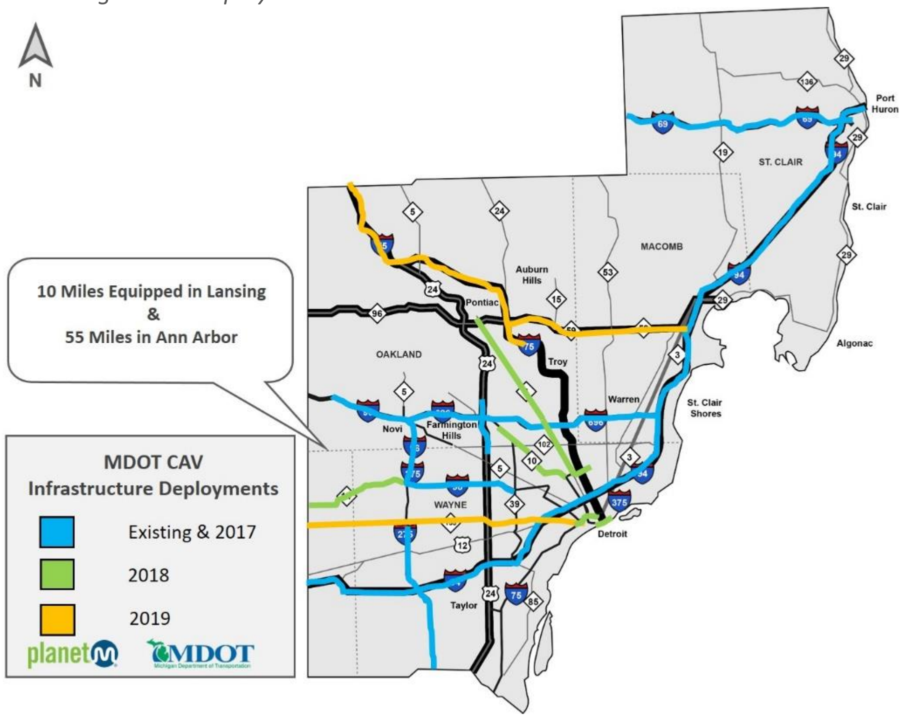
The expected benefits of connected vehicle applications are diverse. They promise to increase road safety, mitigate congestion and generate fuel savings and the environmental benefits that come from them. NHTSA estimates this technology could prevent between 439,000 to 615,000 crashes, 305,000 to 418,000 injuries, and 987 to 1,366 fatalities (roughly 3 percent of annual fatalities) each year at full adoption around the year 2060 (NHTSA, 2016). Furthermore, a decrease in crashes will also reduce congestion caused by these incidents. Specific connected vehicle applications promise to increase throughput, such as dynamic routing – choosing a route based on live traffic data – and connecting vehicles to traffic signals so the driver may adjust speed or the signal may be better timed to traffic. U.S. DOT has estimated that connected vehicle applications could potentially reduce travel time by up to 27 percent on urban corridors, and 42 percent on highways (FHWA, ITS JPO, 2015). Those estimates assume that nearly every vehicle is connected and coordinated, though, and ignores the phenomenon of induced demand where increased throughput encourages more people to drive, and the system returns to roughly the same previous level of congestion. This phenomenon is common in areas with a robust or growing regional economy. Finally, connected vehicle technologies could also make tolling – an effective way to address congestion – more efficient by lowering transaction costs and potentially making dynamic congestion pricing easier to implement.

Figure 5. Michigan ITS and CAV Deployments



Source: MDOT

Figure 6. Southeast Michigan CAV Deployments

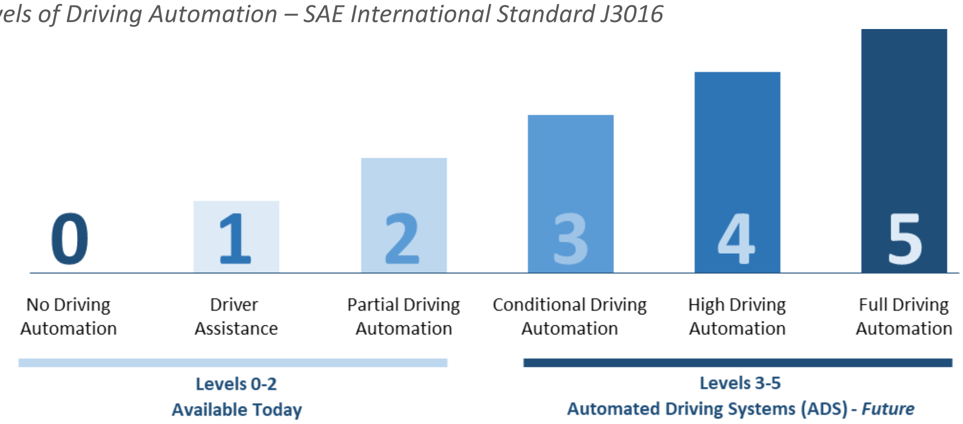


Source: MDOT

Automated Vehicle Technologies

Automated vehicle systems perform three functions: monitoring (cameras, radar, lidar), agency (information processing), and action (physical actuation systems). The automotive industry and regulators are currently using a taxonomy of six levels of driving automation, defined in the SAE International J3016 standard (SAE International, 2016). This standard defines vehicle capabilities, how people can use them, and to what extent they can rely on the technologies (Figure 7).

Figure 7. Levels of Driving Automation – SAE International Standard J3016



The highest level currently available to consumers is Level 2 (e.g., Tesla's Autopilot 8.0). Audi has announced its 2019 A8 model will have a Level 3 capability. Other companies, such as GM, Ford, Waymo, Volvo, Audi, are developing testing Level 3 and 4 systems. Most automakers promise to launch Level 4 vehicles around 2020, initially as part of ridehailing services to better control deployment.

Automated vehicle technologies promise to increase road safety significantly. Because 94 percent of all crashes are caused by human error (NHTSA, 2008), taking the human driver out of the equation could, in theory, eliminate those crashes (Mosquet, et al., 2015). Lower levels of automation between 0 and 2 have already started proving some safety benefits (Kuehn, et al., 2009). Nevertheless, because fully automated vehicles do not exist yet, there is no data to estimate their safety benefits reliably.

MDOT, MEDC, and other Michigan public and private organizations are also supporting automated vehicle technology development and testing in various capacities. Mcity, a 32-acre site on University of Michigan's campus opened in 2015, was the first purpose-built CAV test facility with simulated urban and suburban driving environments. The American Center for Mobility (ACM), a larger test and development facility of more than 500 acres, will be completed in 2018 at the historic Willow Run site in Ypsilanti. ACM is a partnership between MDOT, MEDC, and other public and private organizations.

In 2013, Michigan became the fourth state to regulate the testing of automated vehicles. Public Acts 231 and 251 allowed manufacturers, suppliers, and upfitters to test prototype automated driving systems on public roads when registered with a special license plate (an 'M-plate') provided by the Michigan Secretary of State. In 2016, Public Acts 332, 333, 334, and 335 refined key definitions, removed a prohibition on AV deployment, specifically allowed platooning of connected vehicles, introduced a regulatory framework for an "on-demand motor vehicle network," and added other various AV-related language to the legal code. One provision of Michigan's law limits local authority to impose restrictions and fees on automated vehicles.

Impacts of Connected and Automated Vehicles on Transportation Systems

Vehicle automation and connectivity applications will have significant effects on transportation systems, land use, and infrastructure investments. Community impacts will vary depending on the levels of driving automation, market penetration, and the types of vehicle connectivity and applications. The magnitude of impact will depend on how people use connected and automated vehicles, public and private infrastructure investment decisions, public policy and regulation, level of adoption of the technology and overall transportation costs.

There is a growing body of research on the future impacts of CAVs on transportation systems, vehicles miles travel, parking, and land use, and most of these early studies use travel model simulations, hypothetical street grids and generated trips. While these simulations do not represent accurate predictions, they are important tools in understanding how cities and regions can modify their travel models in the coming decades. A few studies are starting to create simulations based on actual travel data and models based on real street grids. Going forward, these will become more sophisticated, but for a complete understanding of the implications of CAVs, planners will require real-world data once CAVs are deployed.

Travel Demand Implications

When the majority of vehicles are fully automated and thus do not require a human driver, how people travel by car or other transportation modes could change significantly. While it is premature to definitively state the overall effects that highly automated vehicles (e.g., SAE levels 4 and 5) will have on travel patterns, it is possible to identify the factors will likely increase or decrease VMT, many of which could have an amplified effect when taken together (Table 2).

Table 2. Factors Contributing to CAVs Influencing VMT

Factors contributing to CAVs increasing VMT	***Factors contributing to CAVs decreasing VMT***
▪ Increased travel demand due to a lower value of travel time ▪ Zero occupancy VMT ▪ Reduced trip chaining ▪ Shift away from mass transit and non-motorized modes ▪ Sprawling development patterns ▪ Remote CAV parking locations ▪ Increased mobility of non-drivers ▪ Private ownership of automated vehicles	▪ Shared automated vehicle programs ▪ Reduced vehicle ownership ▪ Increased vehicle occupancy ▪ First-and-last-mile solutions combined with mass transit ▪ Reduced parking demand

Based on previous research on VMT by vehicle age, CAVs could have a significant impact on VMT in their first five years of operation. Nearly a quarter of all light vehicle miles traveled are from vehicles in their first three years of operation; vehicles ages five and under account for 42.6% of VMT (CAR research based upon data from FHWA, and IHS Markit).

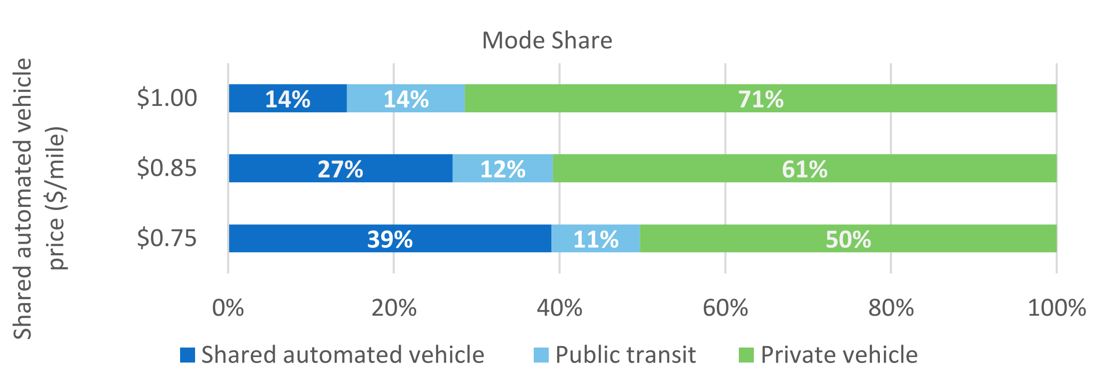
Currently, research based on travel demand simulation of local case studies or hypothetical cities predict an increase in overall VMT, due in large part to a predicted increase in zero-occupancy travel, defined as vehicles driving without passengers after dropping one off and before picking up the next one. Researchers estimate that zero occupancy travel from shared automated vehicles would account for 7.7 to 11 percent of VMT in travel demand simulations (Chen & Kockelman, 2016; Fagnant & Kockelman, 2014; Zhang, et al., 2015). Simulations are interesting because of the assumptions and scenarios they test, such as CAV adoption rate, the value of travel time, the cost of CAV rides, and what other transportation modes available.

One study using Seattle's activity-based travel model showed private CAVs could increase overall VMT anywhere from five percent (if only high-income households purchase CAVs to replace their conventional cars) to 19.6 percent (if all households that own manually-driven cars replace them with CAVs). The same study also examined how the price of a shared automated vehicle influences the adoption of this new transportation option. For example, if all CAVs are shared and cost $1.56 per mile, VMT could drop by 35.4 percent (Childress, et al., 2015). Other studies looked at the potential effect of shared automated vehicles on vehicle ownership. These studies estimate one shared automated vehicle could replace 12-14 personal vehicles (Fagnant & Kockelman, 2014; Zhang, et al., 2015).

Transportation Mode Choice Implications

Several studies have looked at how the adoption of CAVs, either shared or privately owned, would change transportation mode choices across different modes. One simulation based on Austin, TX – a city with a relatively low population density – showed that shared automated vehicles would reduce the percent of the population using conventional private vehicles (Chen & Kockelman, 2016), as shown in Figure 8.

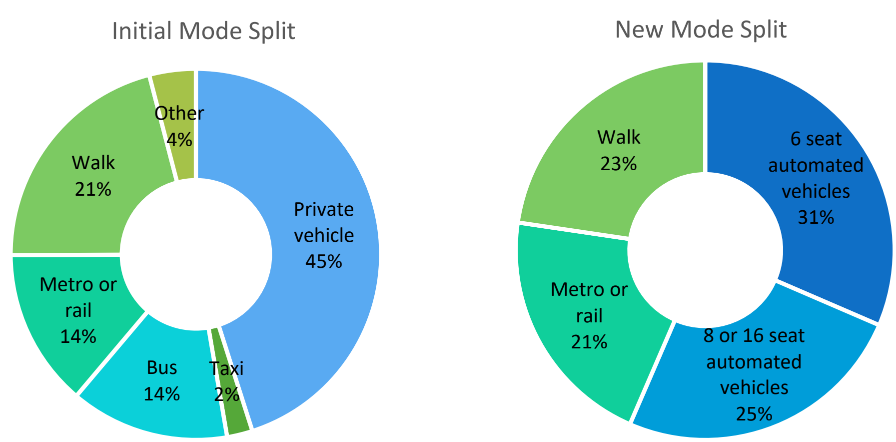
Figure 8. Mode Split Simulation – Austin Example



Source: (Chen & Kockelman, 2016)

The Seattle-based study mentioned earlier found that if everyone who owns a car now replaced it with a CAV, the transit share would decrease by 9 percent and the walk share by 21 percent (Childress, et al., 2015). However, a study based on an agent-based model that simulates the daily mobility of Lisbon, Portugal explored a different scenario where six-, eight-, and sixteen-passenger automated vehicles replaced private vehicles and buses (Figure 9). The research results showed that the percent of people walking, using metro, or rail would slightly increase after the introduction of automated vehicles (ITF Corporate Partnership Board (CPB), 2016).

Figure 9. Mode Split Simulation – Lisbon Example



Source: (ITF Corporate Partnership Board (CPB), 2016)

More research based on improved simulation models and actual travel data is needed to refine the potential impacts of CAVs on VMT and take into account different types of landform, demographic groups, and other metrics.

Non-motorized Travel Implications

Automated driving promises many benefits for pedestrians and cyclists, but it also has the potential to impose costs. Improved safety due to CAV technology is the biggest potential benefit; crashes involving pedestrians and cyclists would likely be avoided by CAVs, as these will be more effective than human drivers in identifying and acting in time to protect these vulnerable traffic participants. CAVs will likely make possible more reductions in parking space and road diets, also called lane reductions and which reduce either the number of travel lanes or the road width (or both) to achieve systemic improvements. Thus, some of the space gained could be used to widen sidewalks or create or improve bike lanes. Prioritizing CAV traffic flow means that walking and biking could become more challenging. For example, poorly designed CAV loading areas could intersect bike lanes too many times or force deviation of bike routes. Pedestrians and cyclists might have extended wait times to cross an intersection optimized for CAV traffic.

Mass Transit Implications

Vehicle automation and connectivity pose complex challenges for public transit services and providers, but they also offer many potential benefits. Automated vehicle technology promises to make passenger vehicles more convenient for everyone, and should expand the range of user groups that can "operate" vehicles. The expanded range of mobility consumers includes people younger than age 16, elderly that are unable to drive, and persons with disabilities. Ultimately, automated vehicles might enable certain users to give up mass transit in favor of automated vehicles, through either a shared or an owned automated vehicle. If the mode shift is significant, it could negatively affect transit's financial balance and lead to reduced service, especially in lower density areas. If affluent people increase their use of automated vehicles, the transit-using population may become even more skewed toward economically-disadvantaged groups, CAVs may exacerbate economic and societal equity issues and further widen the digital divide.

On the other hand, automated driving could also be an opportunity for mass transit evolution. Semi-automated transit vehicles could improve safety, and fully-automated transit could be more affordable if human drivers are not needed. In the latter scenario, transit service could be improved by extending lines, increasing frequency and offering on-demand services with shorter wait times. In low-density areas, automated transit could act as a feeder service to rail or bus rapid transit. Connectivity applications also present many potential benefits for mass transit. V2V and V2I communication could improve the priority of transit in mixed traffic or of bus rapid transit, reduce collisions, optimize the efficiency and effectiveness of transit operation, and contribute to the reduction of transit's environmental impacts. For users, V2V and V2I could improve travel time predictability and access to transportation information. Automated transit could represent a threat for transit drivers, though not all jobs will be lost since transit personnel are still necessary for tasks other than driving, such as assisting people with disabilities, providing information, and surveilling fare payment.

Parking Implications

Various CAV technologies will impact parking regarding use, location, and design. Vehicle-to-vehicle and vehicle-to-infrastructure communication will enable more efficient use of existing parking supply. Vehicles will identify nearby empty parking spots and choose the best one according to passenger preference, allowing for better distribution between areas with high demand and insufficient spots and the opposite scenario. These vehicles will no longer waste time searching for a parking spot, and because shared automated vehicles will have higher utilization rates, they will spend less time parked, especially in commercial and office areas. If more people, especially urban dwellers, forego car ownership in favor of automated taxis, this effect could be even larger. One study found that if shared automated vehicles were used by two percent of the population in a city, these users would reduce their parking demand by 90 percent (Zhang, et al., 2015). A simulation based on Atlanta, GA showed that the overall parking land use of the city could be reduced by 5 percent if shared automated vehicles would serve 5 percent of the trips (Zhang & Guhathakurta, 2017).

Automated vehicles will be able to park by themselves after dropping off passengers, thus reducing the need for on-site and on-street parking in high-demand areas and opening up parking alternatives that are currently viewed as less desirable (in the rear of lots, for example). Automated vehicles also will enable significant changes in parking design, because parking facilities no longer will need to be designed and built for human use. Parking spaces could be smaller because, with no need to open doors, automated vehicles could park closer together. Also, turning radii on alleys could be reduced, and in parking structures, human-oriented amenities like lighting and elevators could be reduced or eliminated.

Land Use Implications

If CAVs lower transportation costs and travel times and allow people to use travel time for other activities, commuters could be more willing to travel further distances to and from work. Therefore, households and businesses may be encouraged to locate farther from urban cores, ultimately leading to low-density land-use patterns, more urban sprawl, and greater infrastructure costs.

Nevertheless, a phenomenon known as Marchetti's constant has observed that the majority of people wish to commute no more than one hour. This phenomenon is likely to continue to be true even after the introduction of CAVs.

On the opposite side, CAVs could foster more density. If CAVs reduces parking demand and enables road diets, then valuable, urban-core space could be freed up for redevelopment. The result would be more space for human occupancy and other non-parking uses. Fleet operators of shared automated vehicle programs will likely target markets offering large potential customer bases, specifically dense urban areas. The availability and efficiency of shared automated vehicles in these areas will make dense neighborhoods more attractive and more people may seek to relocate there. In this scenario, the number of denser, more walkable developments that encourage a less car-centric life could increase.

Decision-Making Guidelines

Innovative mobility services have already impacted cities in transformational ways. (Cohen & Shaheen, 2015). Connected and automated vehicles will also contribute to substantial changes in urban, suburban and rural areas. These new services and technologies will transform how people move, and where they work and live. There will be large changes in travel patterns, land use decisions, social ecosystem and environmental sustainability in the coming years and decades. Citizens, municipal governments, transit agencies, counties, and regional entities must plan for and adapt quickly to many of these changes. Michigan communities can use the decision-making guidelines below to help them navigate the modifications their planning processes, policies, and investment decisions will require.

Include Tomorrow's Mobility in the Planning Process

Many CAV and IMS impacts on cities and regions remain uncertain. Multiple alternative futures are still possible, and which becomes a reality depends to a large extent on market penetration and user behavior. Given this level of flexibility, communities can influence services and technology adoption by planning, policies, and regulations. Communities must begin defining their ideal scenarios for mobility systems and those they wish to avoid and then design policy to achieve their desired goals. Very few communities currently take into account the potential impacts of CAVs and IMS in their planning processes (DuPuis, et al., 2015). In the next years, cities and regions in Michigan need to make sure they consider the implications CAV and IMS deployment in all stages of their planning processes.

Existing trends do not fully inform the transformative role of CAVs and IMS on cities and regions. Communities need a process to plan for unknown yet impactful effects these technologies may have. To build such a plan, communities can collaborate with state agencies like Michigan Department of Transportation (MDOT) and Michigan Economic Development Corporation (MEDC); work cooperatively with other communities and regions, metropolitan planning organizations (MPO), and councils of government (COG); and partner with universities, industry, or within associations such as the Michigan Association of Planning (MAP), Michigan Municipal League (MML), and Michigan Transportation Planning Association (MTPA).

Develop and Maintain Expertise Within Public Agencies on Connected and Automated Vehicles, and Innovative Mobility Services

The first step towards planning for tomorrow's mobility is to gain IMS and CAV expertise within municipalities, transit agencies, MPO, and COG. In-house expertise will be essential for communities when considering a variety of issues, such as whether to partner with a private provider to support a bikesharing program or when and how to invest in infrastructure enabling connected vehicles. Communities need to increase their IMS and CAV knowledge related to planning, service design and operation, infrastructure design, and data management. Through training and hiring, communities can add much-needed new skills in programming, computer science, and data science, as well as knowledge about the mobility and CAV industries.

To make the right investment decisions at the right time, public agencies also need to monitor the CAV timeline of development and deployment by engaging with industry. One way to do that is to attend the quarterly meetings of the Michigan Connected and Automated Vehicle Working Group that CAR coordinates on behalf of MDOT (Center for Automotive Research, 2017; Michigan Department of Transportation , 2017).

Pursue Public Engagement, Outreach, and Education

Public engagement is a classic planning exercise that is especially important during deployment of innovative mobility services and technologies. Communities are ideally positioned to educate constituents on the changes in mobility, to communicate the potential benefits and drawbacks of CAV technology and innovative mobility services, to show residents how a new service fits into the existing transportation offerings, and how to combine CAVs with public transit and other existing transportation modes. Communities can also solicit feedback from residents, businesses, and actual or prospective users of IMS and CAVs to shape policy, address concerns about new services and technology (e.g., storefronts adjacent to a bikesharing kiosk), and make sure as many residents and neighborhoods as possible can benefit from these innovations in transportation.

Develop a Vision for Tomorrow's Mobility

Municipalities and regions need to develop a vision for tomorrow's mobility, encompassing their transportation needs and offerings for the short, medium, and long term. Communities should determine how innovative mobility services and connected and automated vehicles fit into that vision, and how they may help achieve or hinder the ability to reach those goals. IMS and CAVs can potentially improve a variety of issues:

- Safety and security via reduced crashes, especially through CAVs
- Efficient and reliable mobility via mitigation of road congestion
- Increased mobility for seniors, minors, disabled, and low-income residents
- Climate change and sustainability via reduced vehicle ownership or single-occupancy vehicle mode share and reduced vehicle emissions
- Sustainable development via reduced parking demand, dense land development

Vehicle connectivity and automation, as well as innovative mobility services, can be a solution to contemporary problems such as congestion and crashes, but they can also create new, unexpected problems. Michigan communities need to explore both hypotheses. CAVs and IMS will not solve all transportation problems, and planners should continue with the goal to improve biking and walking infrastructure, and transit services.

This vision for tomorrow's mobility – and how IMS and CAVs fit into that – can be part of a variety of planning documents, such as master plans, long-range transportation plans, and neighborhood plans.

As communities develop this vision and subsequent plans, it is essential to adopt clear definitions for the various mobility services, connected and automated vehicle technologies, and use them consistently in order to avoid confusion (e.g., 'ridehailing' and 'ridesharing' being used interchangeably to define the services provided by transportation network companies like Uber and Lyft, 'connected vehicles' being used as a blanket term for a variety of technologies and applications).

EXAMPLES

In 2016, Los Angeles County developed a Shared Mobility Action Plan aimed at reducing the number of vehicles in the county by two percent within the next five years by supporting a significant scaling up of innovative mobility services in concert with public transit, which remains the backbone of the system (Shared-Use Mobility Center, 2016).

The City of Boston led the Go Boston 2030 initiative that produced a Vision and Action Plan in 2017 with specific projects and policies to be implemented over the next 5, 10, and 15 years. The plan includes an Autonomous Vehicle Policy, supports on-street testing of CAVs, and encourages shared electric automated vehicle business models (Boston Transportation Department, 2017).

When the City of Southfield, MI updated its master plan in 2016, it included a section acknowledging the need to monitor and understand the impacts of CAVs and IMS in the next years to make sound investment decisions (City of Southfield, 2016).

Analyze the Impact of Innovative Mobility and Connected and Automated Vehicles on Cities and Regions

When dealing with IMS and CAVs, communities will want to use flexible planning tools, such as visioning plans, scenario planning, SWOT analysis, and brainstorming sessions. For example, scenario development is instrumental in exploring the potential CAV impacts on travel demand and then in proposing changes to existing travel models. Communities can develop various scenarios for CAV deployment, such as mixed traffic conditions, the operation of CAVs in limited locations, synergies between CAVs and IMS, different adoption rates. Large cities and regions should undertake tailor-made scenario planning, whereas smaller ones could do a pooled study. The end goal is to develop performance measures and targets to measure how policies and investments related to IMS and CAVs serve to achieve the overarching community goals.

Having access to the right data is crucial for this analysis phase. Data collected from IMS or CAVs can include useful dynamic information on high-demand trips origins and destinations, wait time and in-vehicle time, cost of trips, modal choice, average speed and vehicle occupancy. This real-time data can help evaluate impacts on system performance (congestion, pollution), calibrate microsimulation models, evaluate the effectiveness of CAV/IMS policies in achieving city goals, analyze travel behavior, preferences, and transportation needs. Most carshare and bikeshare operators share data with cities as part of public-private partnerships. Ridehailing operators are becoming more open to providing some data than they once were, though they remain reticent.

EXAMPLES

Capital Bikeshare in Washington D.C. provides anonymized rider data – trip history, including location and timestamp of the trips' origin and destination, bike ID and membership type (Capital Bikeshare , 2016).

Southeast Michigan Council of Governments (SEMCOG) is a member of the Association of Metropolitan Planning Organization's (AMPO) Connected and Autonomous Vehicles (C/AV) Working Group. The

Group's goals include providing MPO and ultimately communities with support in planning for CAVs. The member MPO aims to develop different scenarios on the deployment of CAVs and the related implications for cities (Association of Metropolitan Planning Organization, 2017).

Communities should use existing standards for data collection and architecture, collect the same data from all providers of the same type of service, and allow open access to data (shared on websites or through APIs) as much as possible to reinforce transparency and innovation.

Communities can include data reporting requirements in policy or partnerships. During negotiations, they can leverage what private companies need and work with mobility providers to satisfy their concerns about user privacy and competitiveness. Some examples are for carsharing, companies need parking; for bikesharing, they need kiosk space on sidewalk or parking; for ridehailing, they require access to roads and loading areas; and for CAVs, they need parking, loading zones, and access to roads.

Use Incentive Zoning to Encourage or Enable the Use of Innovative Mobility Services and Shared Automated Vehicles

Incentive zoning can be an effective tool to encourage or enable the adoption of IMS and shared automated vehicles if communities wish to include that in their mobility vision. Municipalities should consider adopting policies that enable reduced parking, such as eliminating minimum parking requirements, reducing the number of required parking for developments incorporating IMS or shared automated vehicles, substitute general-use parking with carsharing parking, bikesharing kiosks, or ridehailing loading zones. These provisions work best in urban areas with high housing and parking construction costs and high-density areas with public transit service. In the long term, cities will also need to develop design specifications for CAV parking and loading areas.

EXAMPLE

In May 2016, Indianapolis-Marion County updated its zoning ordinance to permit reductions in minimum off-parking parking requirements if a development provides parking for shared vehicles, carpools or vanpools, extra bicycle parking, and electric vehicle charging, or if the development is close to public transit (City of Indianapolis, 2016).

Innovative mobility services and dense cities are in a virtuous circle of mutual reinforcement. Cities that want to attract mobility providers or help ensure their success can allow increased density in their zoning ordinances, such as allowing greater floor-to-area ratios, more dwelling units permitted per acre, and higher building heights.

Provide New or Improved Transportation Services

Connected and automated vehicle technology and innovative mobility services have the potential to improve public transit networks and offer more reliable, convenient, and relevant transportation options for residents. Communities can bring innovation to their transit systems by partnering with private companies or by adopting new technologies and concepts for services to expand their overall effectiveness.

Though the impacts of vehicle automation and mobility services are uncertain, Michigan communities should take an "experiment and measure" approach to improving public transit and transportation options in general. Agencies at the local and regional level can engage in pilot projects, make small, initial investments and take limited risks.

Innovative mobility services expansion and connected and automated vehicle deployment will enrich transportation offerings, but will not negate the need for public transit. Public transit helps achieve some community goals in a much more efficient manner and remains the best way to serve densely populated areas. Therefore, communities should support mobility solutions and technologies that complement and enhance transit, as well as walking, biking, and reduce reliance on single-occupancy vehicles.

Partner with Innovative Mobility Providers to Develop or Enhance Transportation Services

Municipalities in Michigan should consider partnerships with innovative mobility providers to develop or enhance transportation services. Communities can start evaluating these opportunities right now by exploring the benefits and business opportunities for IMS in their regions. Free tools such as the opportunity and benefits analysis offered by the Shared Mobility Center are a good initial resource (Shared Use Mobility Center, 2017).

After evaluating partnership opportunities, cities have a variety of options: experiment with pilot projects, incorporate concepts from innovative mobility into public transit, give grants or low-interest loans, or even become a risk-sharing partner in a mobility program. Communities can consider a variety of funding sources such as the Federal Transit Administration's Mobility on Demand Sandbox Program (Federal Transit Administration, 2016), CMAQ funds, health and insurance companies, developers, or private operators depending on the type of partnership and its goals, be they safety, health, environmental or other.

EXAMPLES

The Pinellas Suncoast Transit Authority (PSTA), FL was the first public agency to sign a partnership with a ridehailing company to expand access to its public transit network. Through the Direct Connect program, which now includes Uber and Lyft, PSTA subsidizes up to $5 per ridehailing trip to and from designated transit stops (PSTA , 2017).

Many cities have partnered with private providers to set up bikesharing programs. Communities can choose to purchase the equipment (e.g., Ann Arbor and Battle Creek contracted with BCycle) or to rent it (e.g., Dearborn and Midland rent material from Zagster – which also operates programs for private companies in other cities including Detroit and Warren). Cities can choose a single equipment provider and operator or collaborate with separate entities (e.g., PBSC Urban Solutions is the equipment provider, and Shift Transit is the operator of the Detroit MoGo program) (BCycle, 2017; Zagster, 2017; MoGo, 2017).

Communities can support ridesharing programs – like the MDOT sponsors MichiVan – or engage in more informal collaborations by encouraging residents to use ridesharing apps like Scoop or programs like SEMCOG's MiRideshare (Scoop, 2017; SEMGOG, 2014).

Cities can choose to sponsor carsharing programs (e.g., the City of Indianapolis is one of the funders of the BlueIndy program), to provide dedicated parking for free or for a fee, or simply to encourage residents to use carsharing programs by explaining the benefits of this service. Peer-to-peer carsharing (e.g., Turo) can be more relevant for low-density and suburban areas than regular carsharing (Turo, 2017). Because peer-to-peer relies on private individuals renting their vehicles when they are not using them, there is a lower pressure to have a high vehicle use rates – a challenge for communities with lower densities.

Host Pilot Tests of Connected and Automated Vehicles on Public or Private Roads

The next five to ten years are crucial in the development of connected and automated vehicles. Michigan is one of the regions at the forefront of this revolution in the automotive industry, with so many of the relevant companies located here. There is an opportunity for communities to reach out to industry or academia to host CAV tests or public or private streets. Companies require a state-level authorization to test on public roads in Michigan. However local and regional agencies can informally engage with automakers that are testing or wish to test in their region. Communities should get involved for three main reasons: to make sure their concerns are taken into consideration, to assess the potential of this technology, and to understand what changes in public policies and infrastructure are needed.

Communities can work with companies, MDOT and the local MPO to define a test perimeter and parameters. Cities can also discuss whether infrastructure improvements – such as lane markings, signage, or traffic signals – are necessary to ensure the safety of other traffic participants. Finally, it is important to negotiate access to data from these tests, or at least key results. The goal is to understand better if and when CAVs need specific infrastructure changes for safe operation, and what type of infrastructure changes such as lane width, curve radius, loading zones, and parking.

These vehicles technology advances can also affect public services and fleets. In the coming years, it will be important to assess automated transit opportunities, for example (Figure 10). The earliest applications will likely be in controlled environments like exclusive roadways, BRT lanes, and campus-like environments. Mixed traffic solutions are more complex and will reach technological maturity later. Additionally, municipalities and counties can start using CAV technology for their fleets, such as giving priority for emergency vehicles, asset tracking, pavement monitoring, routing, lane departure, blind spot warning, and emergency braking.

EXAMPLES

The City of Gothenburg and the Swedish Transport Agency are partners of the first large-scale test of automated passenger cars under real-world driving conditions that is open to the general public. Through the 2017 public launch of the Drive Me project, Volvo will allow drivers to use 100 Volvo XC90 in automated mode on a 31-mile preselected route on divided highways (Volvo, 2017).

MDOT and the U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC) is conducted truck platooning and V2I communication tests on the I-69 Corridor in 2016 and 2017 (Planet M website, 2017).

Pilot projects of automated transit already exist in Europe and some North American cities. Companies like Navya, Easymile, and Local Motors produce automated shuttles to be used at low speeds on fixed routes with limited conflicts. Mcity is launching an automated shuttle pilot service in fall 2017 using two

Navya vehicles to transport students, faculty and staff inside the Ann Arbor University of Michigan campus (Snavely, 2017).

MDOT is partnering with the Suburban Mobility Authority for Regional Transportation (SMART) and Macomb County to provide transit signal priority to SMART buses using CV technology units along key routes within the county (M-53), to provide improved travel time reliability and reduce travel delays (Michigan Department of Transportation, 2017).

Figure 10. Examples of Automated Shuttles

Easymile EZ10

Navya Arma

Local Motors Olli

May Mobility

Ridecell (Auro)

2getthere

Update Transportation Policies

Transportation policies will need to keep up with the ever-evolving mobility landscape and technology advancements. Some policies will become outdated as transportation systems, and the adoption of new mobility services and technologies will make them obsolete. As a cross-cutting principle, communities will want to design policies that maximize the expected benefits of IMS and CAVs like safety and minimize potential undesirable effects like increased travel or urban sprawl. For example, communities can strengthen policies to manage travel and urban sprawl by using congestion pricing schemes, by encouraging shared deployment of automated vehicles, by managing transportation facilities regarding people throughput as opposed to vehicle throughput, and by consolidating transportation markets at the regional level.

Develop Policies for Multimodal Integration

Both IMS and CAVs will bring more transportation options for people, and implementing multimodal integration policies will become increasingly important so people can use multiple transportation modes more frequently. Communities with public transit services should develop and experiment with ways to integrate transit with innovative mobility services and shared automated vehicles when they become available. Cities and regions should develop policies relating to multimodal integration, such as infrastructure, information, and payment integration.

Infrastructure integration involves physical modifications that facilitate transfer from one mode to another and can take many forms.

EXAMPLES

Many cities have coordinated with bikeshare and carshare operators to locate bike kiosks and carshare parking at public transit hubs, major stops, or park-and-ride lots to facilitate the transfer between the two modes (e.g., Ford GoBike, formerly Bay Area Bike Share in San Francisco). Many airports have designated loading zones or staging areas specifically for ridehailing or allowed these companies to use existing taxi areas (e.g., Detroit Metropolitan Airport, Chicago O'Hare International Airport). Some communities also provide some integration with microtransit or private shuttle services. For example, the San Francisco Commuter Shuttle Program allows private company shuttles to use MUNI bus stops for a fee equivalent to the operating cost of the program.

Other cities are taking comprehensive approaches. The Los Angeles County Metropolitan Transportation Authority has developed a First Last Mile Strategic Plan that guides its efforts to extend the reach of its transit system and improve multimodal connections between mobility services, transit, and private cars (LA Metro and SCAG, 2014).

Information integration seeks to improve knowledge of how best to connect transportation modes. Multimodal trip-planning apps are becoming more pervasive, but many cities are also investing in wayfinding signs, joint marketing and awareness campaigns. As access to mobility through smartphones continues to increase, trip-planning apps are ideally positioned as one-stop information points for transit (e.g., routing, real-time information, timetables, maps, fares), as well as ridehailing, bikesharing, or carsharing, depending on the city.

EXAMPLES

Depending on their needs and resources, cities can choose different approaches. Free apps like Transit, Moovit, and Citymapper integrate publicly available transit schedules and real-time data sources into their platforms. The simplest action cities can take is to provide transit systems data in a compatible format that these apps can use. Agencies can also encourage residents to use these free apps and collaborate with app developers to provide with additional data and gain more data insights in return. Cities with more sophisticated transportation systems and greater transportation budgets can choose to develop custom user apps with companies like TransLoc and Xerox. Finally, cities can also work with companies like Swiftly that develops enterprise software that analyzes transit data to improve transit system performance, service reliability, and real-time passenger information.

Cities and regions have also moved towards fare integration to develop payment systems incorporating several modes, either on the technology side (single fare card, smartphone or user account used to pay for multiple modes) or the policy side (fares aligned across modes, sometimes including free or discounted transfer).

EXAMPLES

Los Angeles County Metropolitan Transportation Authority's TAP fare card passengers can use it for the bus, light rail, subway, or bikesharing since 2016 – modes which are all operated by the Transportation Authority (LA Metro, 2016). Since 2015, thanks to a partnership between Twin City Metro Transit and

HOURCAR, carsharing members can use their transit Go-To cards to access carshare vehicles in the Minneapolis-Saint Paul area (Metro Transit , 2015).

Update Parking Policies to Capitalize on the Benefits of Innovative Mobility and Automated Vehicles

The widespread adoption of IMS and CAVs is likely to change parking demand, with early estimates indicating a decrease in demand. Innovative mobility already appears to be lowering parking demand in some cities like San Francisco (San Francisco Municipal Transportation Agency, 2017) and CAVs are likely to do the same in the future. Communities should assess this reduction in future parking demand when evaluating their parking offering and especially when considering whether to invest in new public parking structures or to allocate land to street-level parking. It is possible that in some areas, in a decade or two, lower parking demand will render new structures unnecessary. Where cities do decide to build new parking structures, they should choose retrofit-capable designs. These designs include at a minimum floor height compatible with residential or commercial uses and level floors.

Widespread use of CAVs will also have an impact on parking location. Because CAVs will be able to drop-off their passengers and park elsewhere, less parking will be needed on-site. Some on-street parking could be converted into bike lanes, wider sidewalks, or green spaces. In the long term, cities can relocate some CAV parking in areas with lower land values outside core downtown areas and redevelop land previously occupied by parking for more valuable commercial or residential uses. Larger CAV parking areas outside the densest cores could be used for off-peak hours servicing and storage. Downtown areas can have smaller CAV parking zones, used mainly during peak hours for charging or fueling. When deciding on the future locations of CAV parking, it is crucial to consider zero-occupancy CAV travel, because locating CAV parking too far can contribute to an increase in VMT. During the transitional phase of coexistence of CAVs and conventional cars, some on-site parking could be maintained for the latter category, and off-site parking could be provided for automated vehicles.

Communities will need to update parking policies to capitalize on the benefits of innovative mobility and automated vehicles. Innovative mobility services like carsharing and connected vehicle technologies can generate real-time, highly-accurate data on parking utilization and demand. These data enable cities to fine-tune parking policies much more than before. For example, it makes implementing a variable market-rate on-street parking policy much easier from a technical point of view.

Prepare the Road Infrastructure for Tomorrow's Mobility

In the long term, widespread CAV adoption, and to a lesser extent, IMS, may render obsolete some infrastructure projects currently in the pipeline, such as roadway capacity expansion, corridor upgrades, or new roadways. Conversely, IMS and CAV adoption may increase the need for ITS and other infrastructure deployments, traffic signal updates, bicycle and pedestrian improvements, and transit investments. Michigan communities should start integrating the implications of CAVs and IMS in program and project selection. They should consider a range of CAV and IMS scenarios when determining the robustness of investments, especially a potential increased roadway capacity thanks to

CAVs. As communities accumulate more data on the impacts of CAVs and IMS, they can make periodic reassessments of projects in the pipeline.

Most automotive manufacturers expect the first automated vehicles to be publicly available after 2020-2025 (Smith, et al., 2017). Pending a future mandate, all new U.S. light vehicles will have V2V communication after 2025. According to some estimates, automated vehicles will represent more than half of the vehicle fleet after 2050 (Litman, 2017). The consequences of the increase in CAV availability is that for several decades to come, human-driven vehicles will share the road network with CAVs.

Allocate Public Right-of-Way to Innovative Mobility Providers and Connected and Automated Vehicles

Communities that find that encouraging the use of innovative mobility services and connected and automated vehicles helps achieve community goals such as increased safety or reduced fuel emissions may choose to allocate right-of-way to these new modes to support their adoption. Then cities need to develop a formalized process for allocating public right-of-way that defines the amount of public space allocated, determines whether to assess fees or permits, manages competition between operators, determines whether to permit custom signage and markings and defines enforcement mechanisms to prohibit unauthorized activities. Naturally, this process should involve the public, residents, and local stakeholders.

For example, cities can consider giving access to IMS with high-occupancy on transit-only lanes, or they can allocate parking or bike docking space. In the long term, cities and regions also need to discuss and decide whether CAVs should get special or privileged access to the roadway (e.g., dedicated highways, dedicated lanes, access to transit lanes or HOV lanes, and signal priority).

Allocation of public right-of-way to specific modes or operators can be controversial. For example, CAV-only lanes could raise debates about fairness and cost efficiency, and some designs such as grade separation could create accessibility problems and disrupt the urban fabric. Communities should, therefore, seek to justify policy based on expected results, collect data from programs, and evaluate policy outcomes to see whether those policies helped achieve mobility, social, safety, or environmental goals.

EXAMPLES

Many cities have allocated on-street or off-street parking to carshare operators. San Francisco's first such policy dates back to 2011 when the city launched a small-scale pilot. That was followed by a 2013-2017 the large-scale On-Street Car Sharing Pilot Program (200 spaces allocated to City CarShare, Getaround, and Zipcar). After the success of the pilot in lowering overall parking demand in the city, the SFMTA's Board of Directors approved in July 2017 a permanent On-Street Shared Vehicle Parking Permit Program to be launched at the end of 2017 (SFMTA, 2017). Up to 1000 permits will be available to carshare operators with dedicated fleets (non-peer-to-peer) for a fee (three fee categories based on location). Exact parking location will be determined with input from carshare operators, but also from the general public via a crowdsourcing website.

Similarly, cities have also allocated space for bikesharing stations, like Ann Arbor (Arbor Bike Share) and Detroit (MoGo).

On the medium to long term, communities can convert some on-street parking, turn lanes, or service roads into loading zones for ridehailing and CAVs or designate waiting zones. In the long term, these loading areas will be needed not only airports and train stations, but also near office buildings, commercial areas, cultural and sports venues, and apartment buildings.

EXAMPLE

In 2016 San Diego converted parking on Fifth Avenue in the Gaslamp Quarter into a 3-minute loading zone on Friday and Saturday between 8PM – 3AM, to increase pedestrian safety and improve traffic by clearing the street of drivers circling in search of parking, reducing double-parking, and promoting the use of ridehailing and taxi services *(Gaslamp Quarter Association, 2016).*

Build Infrastructure that Enables Innovative Mobility Services

Communities committed to encouraging the use of IMS should consider building infrastructure using principles that enable the use of these new services. Complete Streets design principles enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities with sidewalks, bike lanes, accessible public transportation stops, frequent and safe crossing opportunities, median islands, curb extensions, narrower travel lanes, and roundabouts. Using Complete Streets designs will encourage the use of IMS, and policies that encourage density will also make the use of IMS more attractive.

Update Infrastructure to Enable Connected and Automated Vehicle Technology

To date, road infrastructure has been designed to suit the needs of human drivers, but CAV proliferation may mean human drivers will be less of a consideration in the future. Thus, wide-scale deployment of computer-driven vehicles might require changes to road markings, signage and signalization, lane width, and access management. The timing and nature of these modifications will depend on the level of adoption of CAVs.

With the arrival of CAVs, Michigan communities will need to shift their priorities from expanding roadways to modernizing them even more than before, because CAVs promise to increase road throughput. Communities should also protect infrastructure for non-motorized modes, by keeping walking and biking a priority and ensuring that infrastructure adaptations for CAVs do not discourage walking and biking by fragmenting sidewalks and bike lanes. Based on the expected benefits of CAVs, such as safety and congestion relief, communities need to assess the need to make design changes that either enable the adoption of CAVs or capitalize on the benefits of CAVs. In the long term, roadway design manuals will need to take CAVs into account. Communities will need to take a multi-phased approach because CAVs will share the road with conventional vehicles for decades and it is impossible to currently determine whether CAVs will one day be the only form of motorized transportation.

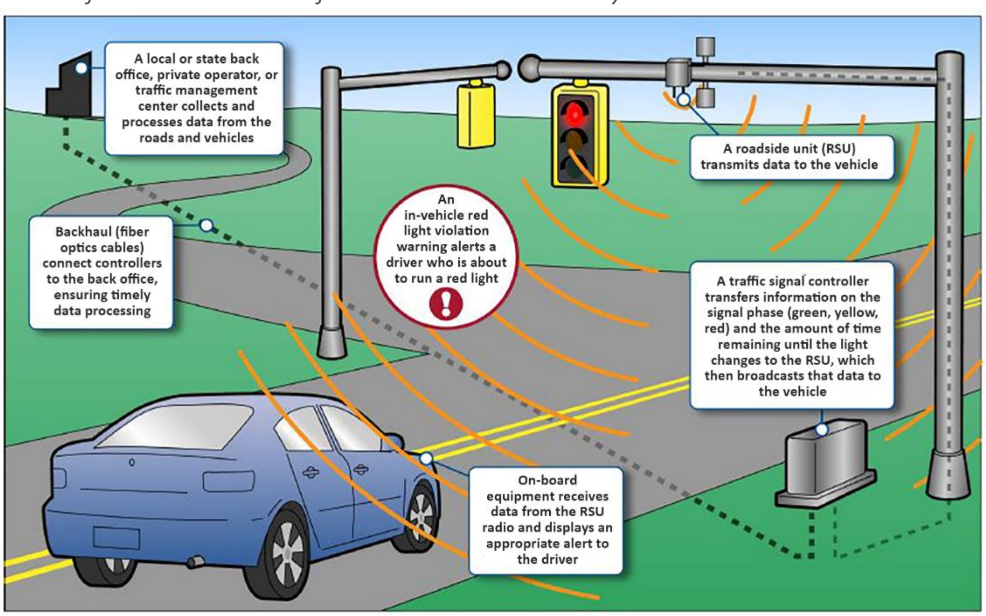
Cities should understand that companies are developing automated vehicle technologies able to function reliably on today's roads, even with their imperfections and specificities. Thus, municipalities should not overestimate the magnitude of investments needed for the deployment of automated vehicles, especially in the short to medium term. Close monitoring of the technology development and capabilities will give cities a better idea of which investments are imperative for the deployment of automated vehicles and the optimal timing. Nevertheless, maintaining and improving road infrastructure, could speed up CAV deployment and especially increase the reliability and safe operation of automated vehicles. In particular, communities will want to maintain reflective lane markings and rumble strips, as well as replace signs and maintain their visibility. These improvements would be useful for human-driven vehicles, cyclists, and pedestrians as well.

More infrastructure investment is needed to enable vehicle connectivity – vehicle-to-infrastructure communication in particular. The deployment will be voluntary and occur over the next decades. The cost will likely be borne by local and state authorities but will be eligible for federal aid highway funding. By emphasizing the benefits of V2I applications, governments will be able to tap into funding programs set up to reach particular goals such as air quality and safety. Communities should prioritize infrastructure deployment decisions to areas with issues that can be addressed by V2I applications, to the locations of equipped vehicles today, and locations most likely for early fleet penetration.

Federal, state, and local public agencies are already working with the automotive industry and research community to develop, test, and deploy the infrastructure needed to support V2I applications, as well as the technical standards. As a general principle, local communities and counties, but also states and federal agencies, need to monitor the development of CAV technology, to invest wisely and avoid investing and installing technologies that become obsolete fast.

The infrastructure needed to support DSRC-based V2I communication includes both road structures like roadside units (RSU), traffic signal controllers, and traffic management centers, and user or vehicle-related equipment such as on-board equipment and nomadic devices. Deployment costs will likely to drop over time, and where fiber backhaul exists, RSU deployment would cost less. Traffic signs could be updated with Advanced Signal Controllers to enable V2I applications. New models should include Internet protocol (IP)-ready ports National Transportation Communications for ITS Protocol (NTCIP) compliance

Figure 11. Scheme of Installation Needed for DSRC-based Connectivity



Source: (U.S. Government Accountability Office, 2015)

Fast internet connections are highly important for V2I applications using DSRC. One of the most effective ways for communities to support broadband deployment by private companies is to have a "dig once" policy that recommends laying a single tube in the ground through which various wires could pass (Office of Transportation Policy Studies, 2013). Once the tube is there, any new company can route their fiber through that existing conduit, thus cutting the cost of broadband deployment by up to 90 percent (Zografos, 2014).

Construction and work zones represent another consideration for CAVs and signage. To limit error risks, construction workers could have wireless beacons that give automated vehicles instructions. That could complement the efforts of automotive companies to interpret gestures of road workers correctly. The same could apply to law enforcement and emergency workers.

EXAMPLES

MDOT plans to deploy DSRC RSUs along I-94 in Southeast Michigan to support weather-related V2I applications that could warn drivers of micro-level weather conditions to reduce associated crashes. MDOT is also planning an RSU deployment on I-275 at key mainline and ramp curve locations to broadcast to vehicles curve geometric and advisory speed data *(Michigan Department of Transportation, 2017)*.

MDOT is deploying RSUs as part of the I-75 modernization in Oakland County to support construction activities and long-term operational needs in the corridor. Temporary RSUs will broadcast work zone messages to support testing of work zone information and safety applications. Also, 3M is providing MDOT with advanced all-weather lane markings, retroreflective signs with smart sign technology and DSRC devices for V2I communications (Michigan Department of Transportation , 2017).

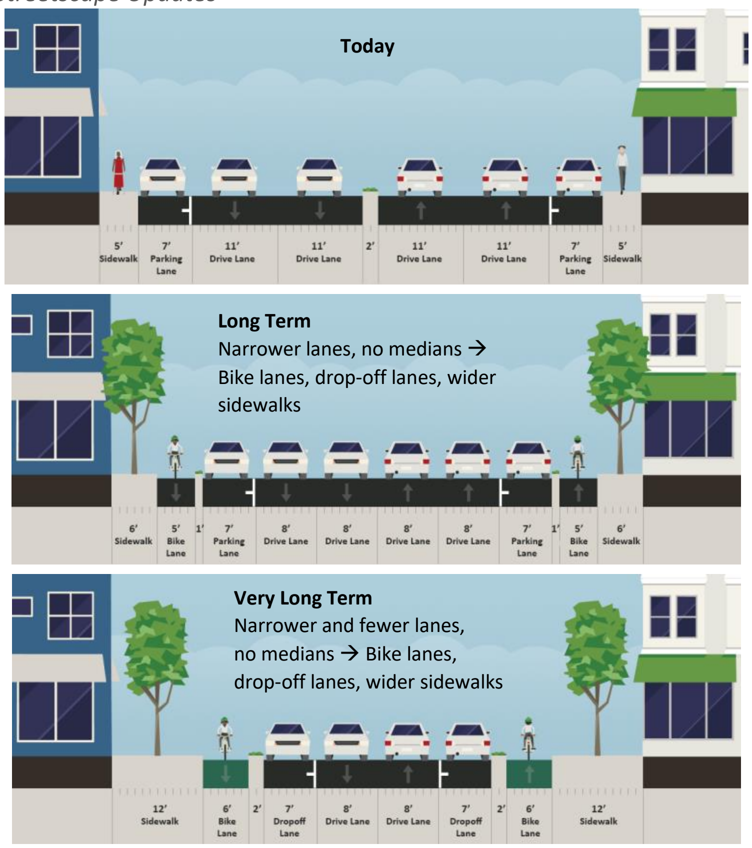
With the development of V2V and V2I application and automated driving, the collection, management, and analysis of transportation data are becoming increasingly important. Local public agencies could collect and publish online pertinent data on lane closures, work zones, and weather. They could also partner with private organizations to exchange data for existing ITS applications, as well as connected and automated vehicles; many agencies have already partnered with Waze, Here, or INRIX.

Make Infrastructure Changes that Capitalize on the Benefits of Connected and Automated Vehicles

Connected and automated vehicles promise to increase road throughput and efficiency, therefore accommodating the same amount of traffic on fewer road lanes. Cities and regions should reevaluate road capacity needs, because some road expansion projects may become unnecessary in the long term. Also, the increased performance of CAVs and lower parking demand strengthens the arguments for performing road diets in some areas. Reducing the number and width of lanes could save space that could then be repurposed for sidewalks, bike lanes, and green space.

Lanes dedicated to automated vehicles will not require additional width to accommodate for human error. Lane width could be closer to actual vehicle width and be reduced by as much as 20 percent – to a width of about eight feet – if vehicle dimensions remain roughly constant (Chapin, et al., 2016). For mixed traffic situations, reductions to ten feet could also benefit conventional cars, pedestrians, and bicyclists, because they discourage risky driving behavior, lower vehicle speeds, and improve safety (Karim, 2015).

Figure 12. Example of Streetscape Updates



Source: Streetscape created using the RESTREET tool (https://app.restreet.com/)

Assess how Connected and Automated Vehicles May Impact Public Budgets

The broad-scale adoption of CAVs will have an impact on public budgets at all levels of government. Public agencies, including those at the local and regional level, should start estimating that impact and reassess it regularly, as more data on the adoption curves of CAVs is available.

For example, according to NHTSA, seven percent of vehicle crash costs are paid for by public revenues – four percent by federal entities and three percent by states and localities (Blincoe, et al., 2015). If the use of CAVs will bring about a significant drop in crashes, then those funds could be reallocated to maintain or improve road infrastructure, for example. If the deployment of CAVs, especially as a part of shared-use programs, causes a decrease in vehicle ownership, vehicle registration fees, and vehicle sales tax might decrease. Whether vehicle miles traveled increase or decrease because of CAVs will have an impact on impact on gas tax revenue – if these vehicles will have internal combustion engines. If the widespread use of CAVs causes a drop in transit ridership, transit fare revenue and the allocation of federal funds for transit that is tied to ridership will decline. Having CAVs that make less moving violations is a societal benefit overall, but that will also bring about a drop in moving violations revenue on which many municipalities and police departments depend. Likewise, the prospect of a lower parking demand generated by CAVs represents an opportunity to create denser communities with more valuable land-uses, but that will also lead to a decline in municipal parking revenue.

Advocate for Legislative Changes at the State and Federal Level

Cities and regions should follow closely the development of future state and federal legislation and regulation related to CAVs and IMS. Transportation and planning leaders should give legislators and agencies feedback on proposed bills, voice their concerns, and propose changes on aspects of CAV or IMS legislation that will affect their residents and businesses. Michigan communities can reach out to state and federal legislators, MDOT, and U.S. DOT, as well as the Federal Committee on Automation (two mayors are part of this committee, Mayor of Los Angeles, CA, and Mayor of Oklahoma City), the Vehicle to Infrastructure Deployment Coalition (MDOT is a key member), and the Michigan Council on Future Mobility (a representative of the Grand Rapids region is part of this group).

Communities can voice their position on the issues that will impact them. For example, cities could request that CAV companies be required to give the state anonymized and private raw data and that MDOT shares some of that data with communities. Cities could also ask to have a greater role in regulating and managing CAV testing and pilot deployment on public streets.

Cities could reflect on advocating for and experimenting with new systems of infrastructure funding, such as road pricing, a VMT-based fee for all vehicles, a VMT-based charge on CAVs, a surcharge when the CAV is empty, or a lesser charge for higher occupancy vehicles to incentivize a reduction or slower growth of VMT.

Cities could encourage the State to expand pre-tax employer transportation benefits to high-occupancy CAVs or vehicles used for IMS. Communities could also voice support for extending income tax exclusions to carsharing, bikesharing, and other mobility services used for commuting that delivers demonstrated climate benefits, alongside similar existing provisions for commuter parking and public transportation.

Resources

Many public agencies and research organizations have published useful reports or are maintaining resource websites. A few of the most relevant for Michigan cities and regions are listed below.

Innovative Mobility Services

- American Association of Planning: Cohen, A. and Shaheen S, *Planning for Shared Mobility*, 2016 - publication available at https://www.planning.org/publications/report/9107556/
- Federal Transit Administration: Mobility on Demand Sandbox - information available at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.html
- Institute for Transportation and Development Policy: *The Bike-Share Planning Guide*, 2013 - publication available at https://www.itdp.org/the-bike-share-planning-guide-2/
- Michigan Department of Transportation: Mi Commute, Guaranteed Ride Home Program, Rideshare Program - information available at http://www.michigan.gov/micommute
- Shared-Use Mobility Center: Mobility Toolkit, Opportunity analysis, and Policy database - web tools available at http://sharedusemobilitycenter.org/tools/
- UC Berkeley - Transportation Sustainability Research Center: *Innovative Mobility Carsharing Outlook* - collection of publications available at http://tsrc.berkeley.edu/search/node/

Connected and Automated Vehicles

- Association of Metropolitan Planning Organizations: Connected and Autonomous Vehicles Working Group – information available at http://www.ampo.org/resources-publications/ampo-work-groups/connected-and-autonomous-vehicles-working-group/
- Columbus Smart City website https://www.columbus.gov/smartcolumbus/home/
- Florida Department of Transportation: Florida Automated Vehicle Program – information available at http://floridaav.hntb-tsc.com/
- ITS America website https://www.itsa.org/
- ITS Michigan website http://www.itsmichigan.org/
- Michigan Department of Transportation: Connected Vehicle Technology – information available at http://www.michigan.gov/mdot/0,4616,7-151-9621_11041_38217---,00.html
- NACTO: *Policy Statement on Automated Vehicles*, 2016 – document available at https://nacto.org/2016/06/23/nacto-releases-policy-recommendations-for-automated-vehicles/
- Planet M website http://www.planetm.com/
- Transportation Research Board: Impacts of Connected Vehicles and Automated Vehicles on State and Local Transportation Agencies (NCHRP 20-102 Project) – information available at http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3824
- United States Department of Transportation – Intelligent Transportation Systems Joint Program Office (ITS JPO) website https://www.its.dot.gov/
- V2I Deployment Coalition website https://www.transportationops.org/V2I/V2I-overview

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