Addressing the Impact of Autonomous Transportation on Individuals with Disabilities in Michigan

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Abstract

Having limited or no access to regular, reliable transportation can have a significant impact on many areas of a person's life including health, employment options, income level, education, and community connectedness (Bascom & Christensen, 2017). For individuals with disabilities, the negative effects can be profound and greatly limit independent living. A study was conducted in Michigan to gain an understanding of how Autonomous Vehicles (AV) could be used to meet the transportation needs of individuals with disabilities. The study's goals were to identify current transportation gaps, assess how AVs could bridge these gaps for persons with disabilities, and determine what transportation officials, AV designers, and automobile developers need to do to ensure that AVs are accessible and available to all future users. To address these goals, a combination of statewide focus groups and a Delphi Panel of experts was used to gather data and arrive at final recommendations. Eight focus groups with individuals with disabilities and family members were conducted to learn about transportation needs, knowledge of AVs, and ideas for ensuring accessibility and availability. This data was used to build a survey that was completed by a 10-person Delphi Panel that rated the priority level of each survey item. A set of 10 final recommendations was developed from the Delphi Panel's results. The recommendations outline what focus group and Delphi Panel participants identified as strategies and best practices that should be followed to ensure that AVs provide individuals with disabilities greater mobility and independence and do not ultimately present yet another barrier to accessing much needed transportation options. Recommendations and other findings were written into a White Paper that was distributed to stakeholders throughout Michigan.

Purpose of Study and Paper

This project outlined in this paper was funded by the Michigan Developmental Disabilities Council (Grant # 2020071, awarded pursuant to Public Law 106-402, as amended, the Developmental Disabilities Assistance and Bill of Rights Act, through the Michigan Department of Health and Human Services, the Council's designated state administering agency). Project activities were completed between April 2019 and September 2020 by the Michigan Developmental Disabilities Institute (MI-DDI) at Wayne State University (WSU). MI-DDI is the state of Michigan's University Center for Excellence in Developmental Disabilities (UCEDD) and part of the national Association of University Centers on Disabilities (AUCD). The Institute's mission is to contribute to the development of inclusive communities and quality of life for people with disabilities and their families through a culturally sensitive, statewide program of training and education, community support and services, research, and sharing of information.

The primary aim of the project is to explore the potential impact of the use of autonomous vehicles (AV) by individuals with disabilities. There is a desire to more fully understand the current transportation needs and experiences of Michigan's individuals with intellectual, developmental, and physical disabilities, how AVs can be used to meet these needs, and which strategies and actions should be prioritized in order to ensure these transportation needs are met in Michigan and beyond.

Impact of Transportation

Access to regular, reliable transportation is an aspect of modern living that has a profound impact on many areas of daily life. The ability to travel within and outside of one's community can affect health outcomes, employment, income level, number and quality of social connections, education, and the ability to obtain goods and services (Bascom & Christensen, 2017). Greater mobility enables individuals to live more active lives within their communities, leading to more social capital, networking opportunities, job prospects, independence, and improved quality of life (Darcy & Burke, 2017).

For many of the millions of Americans with disabilities, lack of accessible, reliable transportation is a significant barrier to living fully inclusive, self-determined lives in their communities (Wasfi, Steinmetz, & Levinson, 2017). According to the Centers for Disease Control and Prevention (2015), 22.2% (53,316,677) of U.S. adults reported experiencing some form of disability (e.g. mobility, cognitive, independent living, vision, self-care). In Michigan, this figure jumps to 24.6% of adults 18 and over experiencing any disability (2013 Behavioral Risk Factor Analysis Surveillance System (BRFSS) Survey). Of those in Michigan, 14.8% reported a disability primarily affecting their mobility and 12.0% report experiencing cognitive disabilities. It is estimated that there are as many as 15 million Americans that have trouble securing the transportation they need, with an estimated 40% of these being individuals with disabilities (Bezyak, Sabella, & Gattis, 2017; U.S. Department of Transportation & Bureau of Transportation Statistics, 2003).

Employment. According to the U.S. Census Bureau's American Community Survey data (2018 estimates), of working age adults (21-64 years) reporting one or more disabilities, 37.8% are gainfully employed nationally. This number for Michigan residents is 35.7%. This stands in stark contrast to the 80.0% employment rate for adults without disabilities nationally and 79.2% in Michigan. If only those individuals who have full-time, full-year employment are considered, the number of individuals with disabilities in this category drops to 24.3% nationally and 21.5% in Michigan, compared to 61.1% and 58.9%, respectively, for individuals without disabilities.

A major factor affecting an individual's ability to get and keep a job is ready access to transportation (da Costa, 2018). For Americans with and without disabilities, access to reliable personal or public transit influences the type, quality, and location of where a person can work. For individuals with disabilities in particular, the issue becomes more complicated when income level is considered. How much a person makes is found to be significantly correlated with the modes of transit they typically use to meet their mobility needs (Bascom & Christensen, 2017). In other words, individuals who make less money tend to rely more on public transportation to get to work (e.g. dial-a-ride service, public

and private door-to-door paratransit). Those who make more money report using personal automobiles. This points to the perpetuation of a cycle where income and transportation together have the potential to continue to limit a person's community inclusion and upward mobility. In another study examining the transportation experiences of rural communities, only 11% of respondents reported having access to public transportation options near their homes (The Walsh Center, 2018). Clearly, there is a need to explore how to better connect individuals with their communities and more employment options.

Health. Several studies (Darcy and Burke, 2017; National Academies of Sciences, Engineering, and Medicine, 2005; Wallace, Hughes-Cromwick, Mull, & Khasnabis, 2005) have examined the needs and outcomes of individuals who fall into the group of "transportation disadvantaged". Millions of Americans who find themselves in this category are characterized as not having the ability to provide or purchase their own transportation (i.e. owning a personal automobile). Hence, these individuals rely on other options like public transportation, friends, family, and ride-sharing to get to work, attend school, make and keep medical appointments, and run errands. Because of a heavy reliance on others, this group frequently misses work and other important appointments, including healthcare visits, due to a lack of independence and personal automobility.

In 2005, a National Academies of Sciences, Engineering and Medicine report estimated that 3.6 million people in this transportation disadvantaged group missed or delayed medical appointments due to their difficulty in securing regular, reliable transportation. Individuals with disabilities make up a considerable portion of this group which is also found to have a relatively lower income on average and are less likely to have earned a college degree, further limiting their ability to earn more income and ultimately own their own vehicles. Wallace and colleagues (2005) also estimate that these 3.6 million Americans experience transportation difficulties when seeking nonemergency transportation in order to attend medical appointments. Compounding this issue is the

fact that many public transportation routes, in both urban and rural settings, do not provide direct access to healthcare facilities.

In a study looking at the types of transportation used within an urban setting to arrive at clinical office appointments (Sipe, Wei, Roth, Chi, Naidu, and Samuels, 2004), patients of a pediatric clinic (n=82) were surveyed. Results showed that:

- Sixty-six percent (66%) of participants reported using **a personal car**
- Twenty-seven percent (27%) used **public transportation** options
- Average time for a one-way trip when using **a personal car** was 45 minutes
- Average time for a one-way trip when using **public transit** was 81 minutes
- Twenty-seven percent (27%) of patients using **private cars** reported missing a previous appointment and 43% had arrived late due to transportation-related issues
- Eighty-six percent (86%) of patients using **public transportation** reported missing a previous appointment and 95% had arrived late due to transportation-related issues

These disparities highlight the significant barriers that those dealing with transportation disadvantages face when attempting to access regular healthcare services. For individuals with disabilities and other chronic conditions in this group, the inability to make and keep regular healthcare visits leads to poorer health outcomes overall. Worsening health outcomes further increase the cost of healthcare nationally which is felt by all Americans. The evidence here suggests that there is a need to address the transportation options of individuals with disabilities as barriers to automobility appear to have an ongoing, growing role in the negative health outcomes of this group. Policy makers and transportation officials must assess how the transportation needs of persons with disabilities can best be met by examining existing infrastructure and resources and by turning to emerging technologies for safe, creative, cost-effective solutions.

Independence and Community Inclusion. Having accessible, reliable transportation is an essential element for individuals with disabilities to live independent, self-determined lives. Being active in one's community is not only key to feeling included and valued, but also contributes to success and happiness in other areas of one's life. For instance, in a study examining the transportation dependence of aging adults, those reporting greater access to transportation reported a higher quality of life and less social isolation overall (Christiansen & Byrne, 2014; Cvitkovich & Wister, 2001). Though this particular study focused on aging populations, there are many parallels that can be drawn between aging individuals with mobility barriers and individuals with lifelong disabilities. Ready access to the community often hinges on the ability to access transportation.

The impact that wider access to transportation can have on a person's independence and employment options have been well documented (Bascom & Christensen, 2017; Wasfi et al., 2017). Access to transportation continues to touch practically every aspect of a person's life, whether it's getting to work, accessing healthcare, shopping for groceries, socializing, or simply enjoying time out in the community for leisure purposes (Darcy & Burke, 2018). Connecting with neighbors and community members builds a person's shared sense of community and identity. Socializing more can lead to relationships that have the potential to lead to employment and enhanced community connectedness. All of these factors contribute to a person's overall quality of life, employment outcomes, and health (Samuel et al. 2013).

What are Autonomous Vehicles (AV)?

AVs - also referred to as self-driving or driverless vehicles - have one or more of their driving functions controlled by the car itself. For instance, many AVs will typically control the steering, acceleration, braking, and navigation duties so the "driver" does not have to. There are, however, different levels of autonomy that a vehicle can be classified under (Raza, 2018). It is important to make a distinction between fully and partially autonomous vehicles. For the sake of the current discussion, the types of vehicles that

hold the greatest promise for increasing independence for individuals with disabilities are vehicles that are highly and fully automated.

The Society of Automotive Engineers (SAE) (2018) defines five levels of vehicle automation, with a vehicle having no automated driving functions being at Level 0. The five levels are:

- **Level 1: Driver Assistance.** A single driver assistance system can help control steering OR acceleration. Vehicles at this level offer assistance such as adaptive cruise control, brake assist, or parking assistance. The driver still needs to maintain full control while driving.
- **Level 2: Partial Automation.** At this level, two aspects of driving (steering and acceleration) are controlled simultaneously by the vehicle. An example of Level 2 automation would be radar regulated cruise control and lane assist working as a person drives. The human driver still needs to control all other aspects of driving at this level (e.g. Tesla's autopilot function).
- **Level 3: Conditional Automation.** All driving functions can be controlled by an automated driving system at this level. Drivers can turn their attention to other activities but will be prompted to intervene if needed. There are very few, if any, publicly operating Level 3 autonomous vehicles currently on the road.
- **Level 4: High Automation.** These vehicles can steer, accelerate, brake, and navigate roads on their own. There are limitations on Level 4 vehicles when road conditions change drastically, such as in the event of a traffic jam or accident. An example of testing being done on this is the Google Waymo Project (https://waymo.com/).
- **Level 5: Full Automation.** The vehicle is fully automated and passengers are not required to do anything to assist in vehicle function. These vehicles are controlled by Artificial Intelligence (AI) and very high level computing systems. There are not currently any Level 5 vehicles in production (Shift Mobility, 2020).

Project Overview

The project discussed in this paper was developed by MI-DDI in response to a call for proposals released by the Michigan Developmental Disabilities Council (MDDC) in late 2018. The Council's mission is to support people with developmental disabilities to achieve life dreams. One way this is accomplished is by supporting research on best practices and emerging issues that have potential to affect individuals with disabilities. MI-DDI and MDDC work together, along with Disability Rights Michigan, to form the core of disability research, training, advocacy, and support in Michigan.

As mentioned, the MI-DDI Autonomous Vehicle Project was launched with the primary goal of ensuring that the voices of individuals with intellectual, developmental, and physical disabilities were heard, and their participation solidified, as AV technology is developed and made available across the state of Michigan. To accomplish this, the study focused on three objectives:

1. Establish a baseline understanding of the typical experience of individuals with disabilities as they use both private and public transportation to engage with their communities and live self-determined lives.
2. Assess people's current knowledge and expectations of how AVs may impact their lives by holding focus groups throughout Michigan with individuals with disabilities and family members.
3. Identify the top priorities that need to be considered by those who design, build, and sell AVs, those who create and enforce transportation policies, and others who make transportation decisions that affect the lives of individuals with disabilities.

In the end, the aim of the project was to evaluate and address the potential impact of the adoption and use of autonomous, self-driving vehicles by individuals with disabilities. The possibility for positive outcomes (e.g. increased mobility, independence, and inclusion) appears high. However, care must be taken to minimize the potential for harmful or exclusionary consequences (e.g. legal impact, financial exclusion, accessibility of the technology by users with disabilities).

Timeline. The MI-DDI AV project was facilitated from April 1, 2019 to September 30, 2020. The project was designed to be executed in two distinct phases as is shown in [Table 1](#). The first phase took place between April 1 and September 30, 2019. The focus of phase 1 was to plan and convene focus groups with individuals with disabilities and family members throughout Michigan. Information gathered from focus groups was then used to inform the next phase of the project.

During this Phase 2, a Delphi Panel of experts was brought together. Data gathered during Phase 1 was analyzed and used to build a survey that was completed by the Delphi Panel. The Panel was tasked with prioritizing the issues and ideas identified by the focus groups. The results of the Delphi Panel were used to put forth the final recommendations of the project and inform the writing and dissemination of this paper.

Project Advisory Council (PAC). To guide the project, a Project Advisory Council (PAC) was formed. The PAC was composed of ten individuals with different lived experiences and perspectives on disability, transportation, and inclusion. The input of individuals and family members is vital as it ensures that project activities and goals remain person and family-focused. This aligns with MI-DDI's mission and keeps the focus on the voices of those directly affected by the outcomes of the project. The PAC also provided accountability for project staff. The group met regularly with the Principle Investigator to discuss project progress and timelines. This kept all activities on track and focused on project goals. The importance of the PAC was highlighted as the COVID-19 pandemic unfolded in 2020. PAC meetings had already been conducted using Zoom. The meetings were essential to keeping the project on track to be completed within the original timeframe. The PAC had a direct, significant impact on the success of the AV project.

Focus Groups. Eight focus groups were scheduled in different regions of the state. This was done strategically in order to gain a balanced representation of those who experience different transportation opportunities and barriers. [Table 2](#) shows the focus group locations and dates. AV Project staff worked with local Michigan Arc chapters to

schedule dates and conduct outreach to people in each region. The Arc is a network that supports and advocates on behalf of individuals with I/DD and their families. The Arc network was instrumental in reaching out to focus group participants. Additionally, the Disability Network in Flint was also very helpful in identifying participants and hosting a focus group.

Each focus group included 6-10 participants and lasted up to 90 minutes. The Project Director facilitated all focus groups in-person and led participants through a series of questions related to the following:

- Current transportation-related challenges
- Frequency of travel outside of the home
- Types of transportation used
- Adequacy of currently available transportation
- How transportation has impacted their lives over the years
- How current transportation options could be improved
- Current knowledge of what autonomous, or driverless, vehicles are
- Thoughts and feelings about using/being driven in an AV
- What excites them about potentially using AVs
- Concerns and/or fears related to using AVs
- How often they would use AVs to travel if they were available
- What features and functions public and private AVs would need in order to be accessible to them and other users with disabilities
- What they deemed the most important factor or design feature that an AV would need to ensure equitable use/access

Focus Group Findings. In total, n=43 individuals took part through eight focus groups. Of the participants, 28 identified as having a disability, 10 were family members, 2 were caregivers, and 3 worked in the disability field. Following the conclusion of the focus groups, responses were combined across groups and initially organized according to the focus group questions found in Appendix 1. Responses were then examined for

common themes. Following this analysis, focus group responses were grouped under five overarching themes found in Table 3.

Emerging themes were fairly consistent across the eight groups. First, participants indicated that dependency upon others, difficulty and limitations of scheduling transportation, and the time it takes to travel in the community were the top obstacles they commonly faced. These barriers agree with existing literature (Bascom & Christensen, 2017; Darcy & Burke, 2017; Sipe et al., 2004), indicating that a person's reliance on others to meet their transportation needs is an ongoing issue that tends to have adverse effects on individuals with disabilities. Several focus group participants also identified the inaccessibility of vehicles as an ongoing issue affecting their ability to utilize public and door-to-door transportation. A trend also emerged showing that those living in rural areas relied heavily upon friends, family, and staff to drive them to appointments. Whereas, those in urban centers had more public transportation options available to them. This aligns with previous work (The Walsh Center, 2018) identifying a lack of public transportation in rural communities, forcing transportation disadvantaged individuals to find other options.

The majority of focus group participants (21 of 22 who voiced their opinions to the question) stated that the transportation options they use to meet their travel needs are inadequate. This is telling as it shows that, despite being able to arrange rides through public transit or with family members, friends, and staff, these individuals still felt that they did not have the transportation they needed to live as independently as they would like to.

Another area that received a majority agreement was that transportation in general had negatively impacted their lives over the years. Examples given included:
- The excessive amount of time it takes to schedule door-to-door services and the use of public transit - take away the ability to be spontaneous;

- Time restrictions of public or private options; "no pick-up after 9:30 PM"; can't change pick-up times when something comes up"; "if you are late (to be picked up) 3 or more times, you are on probation and can't use service";
- "Paying staff to drive can be expensive";
- "County Connect service won't cross county lines", hence restricting travel distance;
- "Need more transportation options!"

When asked about how current transportation could be better, responses included:
- Better accessibility of all vehicles, privately owned and public options; needs to be improved and more widely available;
- Scheduling and the time it takes to use public options needs to be improved, overhauled; would like to live more "in-the-moment";
- Owning a car is cost prohibitive and the cost of private ride-sharing is too high; somehow make current options more cost-effective for everyone!
- Include people with disabilities in the design of these vehicles and in how public transportation is offered and ran;
- Public transportation and door-to-door services need to be reliable and accountable;

In general, participants would like the transportation options available to them to be more accessible, reliable, and cost-effective. These feelings are shared by all people using transportation to get to work, doctor's appointments, and engagements in their communities. Equitable availability and use of transportation is a theme that can also be found throughout the literature.

Participants were asked how they thought they would feel being driven in an AV:
- Many believed they would feel worried, nervous, or concerned initially
- Others were excited at the thought of AV options becoming available
- Of those who had AV experiences already, they felt "nervous at first, but comfortable by the end of the ride"

These comments speak to the need to roll this technology out to potential users incrementally (Ferati et al., 2018). Providing more opportunities for individuals with disabilities to access and use these vehicles as they become available will help remove the mystery and the anxiousness some feel about adopting this technology.

The potential for AVs to offer individuals with disabilities increased freedom and independence was acknowledged as the greatest potential benefit. This emerged as a universal theme across all focus groups. A deeper level of personal autonomy could open up other areas of one's life such as access to more employment options, wider social circles, and richer community inclusion.

Safety, control, and accessibility emerged as primary concerns for individuals with disabilities and family members. Individuals with various disabilities worried about how safe they would be travelling alone in a personal AV. They also raised concerns about how much control they would have over the vehicle's functions in an emergency situation. Another concern was how individuals would be able to interact with the vehicle's controls. For example, if a person were unable to speak, or hear, or move, or understand the vehicle's commands, how would they interact with the vehicle? Would the passenger be able to control functions of the vehicle with their smartphone? Or would there be other ways that they would be expected to control the technology to fix a problem or to change navigation mid-ride? Wheelchair lifts and ramps were also mentioned as features that will need to be made standard with the introduction of AVs. People currently face barriers to using public transportation as many vehicles are not fully accessible or are in need of repair. Multiple modes of interaction will also need to be considered as an accessibility feature in AVs. Voice and gesture commands, touch, visual, and auditory alerts should all be considered so that AV technology is universally accessible to the widest array of users.

These concerns were echoed when discussing autonomous public transportation. In the event of an emergency, would there be an attendant or someone of authority on board

the shuttle or bus? How would a passenger with an intellectual or developmental disability handle a situation where an autonomous public bus was in an accident with another car? All of the concerns raised by focus groups require legitimate and deeper discussions at the levels of designers, developers, transportation authorities, and governments.

Overall, feedback received from the focus groups was both enlightening and familiar. Long known barriers to transportation such as lack of consistent accessibility, scheduling difficulties, unrealistic restrictions on travel, a growing dependence on others, and increasing costs that prohibit regular use of public transit and ride share options still affect many individuals with disabilities in Michigan. These individuals devote a significant amount of time and money to simply travelling within their communities. This creates stressors that negatively affect other areas of life that can lead to problems with employment, financial stability, and health. These are all areas that need to be addressed by local and state governments, transportation authorities, and AV designers and developers. Despite these current barriers, there is much excitement about the promise that AVs hold for increasing independence and inclusion for individuals with disabilities. To ensure the delivery of this promise, care needs to be taken to include the voices of these individuals at all levels of AV development and implementation. This is a charge that is passed to the next phase of the project as the Delphi Panel was given the opportunity to weigh in on how these concerns and ideas should be prioritized and addressed.

Delphi Panel Process. The second phase (Year 2) of the project involved convening a Delphi Panel of experts tasked with reviewing information gathered from Phase 1 focus groups. The Delphi Method is a research technique that seeks to gain consensus judgements on one or more topics by a group of experts (Hallowell & Gambatese, 2010; van Vliet et al., 2016; Klein et al., 2019). The panel of informed experts is given the chance to consider information through multiple rounds of questionnaire administration. In between each round, a summary of findings and more information is presented for use when reconsidering items. Survey rounds continue until consensus is reached on

all items or until there is no more change in Panel members' survey responses. This approach incorporates both quantitative and qualitative methods and works to elicit honest group opinions, with little to no pressure or influence from other Panel members. It has been shown that the most accurate results for a Delphi Panel approach are seen after two rounds and begin to drop off after that (Hallowell & Gambatese, 2010). Two survey rounds were completed for the current project. There were no items that needed a third round to be reconsidered by the group.

Baker, Lovell, and Harris (2006) explored the criteria that are necessary for a person to be considered "expert" on a topic or within a field. It is evident that there are different criteria that can be used to deem a person an expert. For the purpose of this project, individuals were sought that had clear professional (i.e. working in a field related to transportation) or lived (i.e. a person with a disability that uses transportation) experiences. The impact that transportation in general - and autonomous technology specifically - have had and will have, respectively, on individuals and systems is diverse and far reaching. Similar to previous research involving Delphi techniques, this study assembled a Panel made up of diverse individuals having different professional and personal experiences with disability, transportation, design and development, and social and political policies (Baker et al., 2006; Darcy & Burke, 2018; Hallowell & Gambatese, 2010; Phadraig, et al. 2014). By using a Panel of people with varied points of view, achieving consensus on topics related to autonomous vehicles, transportation, and disability will be representative of those affected by these topics in different ways.

Project staff and PAC members reached out to various organizations, industries, and partners throughout the state to identify individuals who would be interested in serving as Delphi Panel members. Previous research (Hallowell & Gambatese, 2010) indicated that the typical size of a Panel tends to be between 8 and 16. In the end, ten individuals agreed to serve on the Delphi Panel. The group represented various professional fields, areas of expertise, and lived experiences found to be pertinent to the topic of autonomous vehicles and transportation access for individuals with disabilities. Panel members represented the following:

- Personal experience with disability
- Disability supports and services
- Engineering
- Computer science
- Advocacy
- Disability law and policy
- Public transportation management
- Autonomous vehicle development and management
- Autonomous vehicle design

For this project, information gathered from focus group participants during Phase 1 was used to construct the survey that was sent to Panel members. The survey can be found in Appendix 2.

The themes identified by focus groups (Table 3) were used as a structure to write and organize survey items.The survey included 70 items that were written as statements. Panel members were asked to prioritize each statement on a scale of 1 to 5 (1 = No Priority, 2 = Low Priority, 3 = Not Sure, 4 = High Priority, and 5 = A Top Priority). For example, under the first theme, *Current Transportation Barriers*, one statement read "Lack of consistent public transportation options in rural Michigan communities". Panel members then ranked this statement as either a high or low priority item to be addressed by policy makers, automobile companies, public transportation authorities, and other systems that could affect change. The goal was to have Delphi Panel members arrive at a consensus on each item as to the level of priority they felt each topic should be given moving forward.

On April 6, 2020, a Zoom session was facilitated to introduce the project objectives to the Delphi Panel members. The Panel was informed of the project's timeline and what their responsibilities would be throughout the process. The first survey link was sent to all Panel members by email on April 10, 2020. They were given two weeks to complete the 70-item survey. All ten members completed the survey in the time allotted. Initial item-level analysis was done by project staff to establish the extent to which consensus

was reached on all items. Each section of the survey also included an open-ended item for Panel members to provide further feedback, offer insights, or to request clarification.

Following analysis, it was found that all but six items had achieved consensus ratings by the group during round one. These six items were included in a second survey round. Feedback from the Panel and additional information regarding the items were also written into the new survey. A link to the six-item survey was sent to Panel members on May 8, 2020. Once again, they were given two weeks to complete the survey. Another item-level analysis was done to determine the extent to which Panel members achieved consensus on the remaining six items.

Results

Consensus Criteria. There is no single definition for what consensus looks like (Jorm, 2015). Considering previous research (Berk, et al. 2011) employing Delphi Panel techniques, and keeping in mind the goal of arriving at a set of recommendations, consensus for the current study is defined as 80% agreement on the importance of a given item. This means that for an item to achieve consensus as a "high" or "top priority", eight out of ten Panel members would have to designate the item as such. This definition was also used for items deemed by the Panel to be of "low" or "no priority".

An additional factor used to determine consensus was the amount of item variance. For example, if an item achieved 70% consensus but also had a variance of 1.50 or higher, the item was included in the next survey round for reconsideration. The rationale for this factor was to ensure Panel members were fully informed about an item. For instance, if 3 people had a greater level of expertise on a topic and scored the item related to that topic as a top priority while the rest of the group scored it as a low priority, the variance of the item would be high, denoting a large spread in ratings. This could indicate that the item needed to be reconsidered in a subsequent survey round when more information could be provided to all Panel members. Items that achieved a consensus rating of 70%, placing it on the cusp of consensus, were also considered for deeper analysis and reconsideration by the Panel.

High and Top Priority Items. As a result of the Delphi Panel process, 53 items achieved group consensus as high or top priorities. The 11 items that received 100% consensus can be found in Table 4. Each item that received 100% consensus as a high or top priority achieved this during the first round of survey administration. These items represent a mix of concerns and ideas. For example, all Panel members believed that the involvement of individuals with disabilities during autonomous vehicle development and testing phases is essential. Another area considered by the Panel to be of great importance is ensuring that financial equity is considered when autonomous vehicles are offered through public and private transportation services (e.g. city buses and shuttles, ride sharing options). Also considered a priority is the accessibility of a vehicle's technology. This was also a primary area of discussion throughout the focus groups facilitated during Phase 1 of the project.

Table 5 lists survey items that achieved 90% consensus from the Panel. Twenty-one items achieved this level of consensus as a high/top priority. One of the 21 items in the 90% consensus group achieved consensus during the second round of survey administration. This item states *"Autonomous vehicles should have the ability to identify and park in accessible parking spaces if passengers require it."* In the first survey round, this item achieved 60% consensus as a high/top priority. However, the item's response variance was 1.656, indicating a significant degree of disagreement by the Panel. The item was presented again during round two along with further descriptive information. After round two, the item achieved 90% consensus as a high/top priority and with a lower level of variance (.400).

All items achieving 80% consensus are listed in Table 6. The 21 items at this level represent a mix of technical, physical, and financial accessibility concerns, existing policies and practices, and larger outcomes for individuals as a result of increased mobility and independence. Of the 21 items, two achieved consensus in the second survey round.

Low and No Priority Items. A total of 17 items failed to achieve Delphi Panel consensus as a high/top priority. These items are listed in Table 7. Items in this group range from statements reflecting technical "wish list" items ("*Ability to have the vehicle automatically come to the person using a remote control or smartphone app*") to things that changes in policy or practice would not be able to significantly affect ("*Weather conditions during the Winter months in Michigan*"). There were, however, 3 items that were marked for consideration during the second survey round. These are denoted in Table 7. Although these items did not gain consensus during round two, it can be argued that these, along with other items in this group, may arise in the future as points that need to be reconsidered.

Emerging Categories. After examining the items reaching consensus as high/top priorities, and considering how these items will influence recommendations going forward, three overarching themes emerge. The first theme involved items impacting policy and practice. Focus group and Delphi Panel participants identified areas that they felt needed to be addressed to ensure equitable access to, and use of, autonomous transportation. Examples include the following:

- Existing public transportation policies that negatively affect patrons with disabilities (e.g. lack of fixed routes connecting urban and rural areas)
- Rules related to the use of transportation vouchers
- The current scheduling options and practices of public and private transportation companies (e.g. City busses and shuttles, paratransit, door-to-door services)
- Training for AV developers, manufacturers, and transportation authorities (local, regional, and state) on the transportation needs of individuals with disabilities
- General availability of public and ride-sharing transportation options for persons with disabilities
- How laws governing drivers licenses and insurance impact individuals with disabilities who want to own a personal AV

Questions to consider here include how increased advocacy efforts could help change transportation policies and practices. And how could updated policies improve the

experiences of individuals with disabilities on local, regional, and statewide levels? Another area to explore would be how current research efforts happening in Michigan could be harnessed to address and improve access to, and successful use of, public transportation options? For example, the Wayne Mobility Initiative at Wayne State University brings together researchers, experts, and advocates from various domains and fields to address every aspect of mobility.

The second theme to emerge involved AV technology and design. These items relate to the accessibility of the design, development, manufacturing, and implementation of AVs for public and private use. Questions to consider here include:

- How can concepts of Universal Design be included from the start to ensure AVs are made accessible to the widest range of users, including users with disabilities?
- How can more individuals with disabilities be involved in the design, development, and testing of new AV technology?

Universal Design is not a new concept and is regularly employed within many industries, including automotive design. A natural way to work toward designs that enable ready access for all users is to include diverse groups of individuals at all steps of the research and development process. How can individuals with intellectual and developmental disabilities, for example, be involved in the design and testing of AVs? Are there existing programs or initiatives in place that can be proliferated to encourage both manufacturers and individuals with disabilities to seek each other out for mutually beneficial outcomes? Who are the key players that should be brought together to bolster efforts to encourage diverse stakeholder engagement and idea sharing?

The third theme to emerge focuses on larger outcomes for individuals with disabilities as a result of access to AVs. Items that fall under this theme touch on potential outcomes for individuals with disabilities if AVs are made available and accessible on a wider scale. Potential outcomes include:

- Increased independence and enhanced connections between rural and urban communities
- Improved transportation overall

Questions arising here include how AV availability could be prioritized for individuals who would benefit most from its use? This could include individuals with disabilities and others (i.e. aging populations) who do not have the ability to either operate a traditional vehicle or access public transportation routes where they live (i.e. rural communities). How can these larger potential outcomes be realized through advocacy, research, and information sharing?

Recommendations

Ten recommendations have been developed that call for action in areas identified by our focus group participants and put forward by the Delphi Panel. Though there is current work being done in many of these areas, the recommendations reinforce a growing need to bolster advocacy efforts in areas related to transportation and mobility for persons with disabilities in Michigan. The recommendations are listed below and also in Table 8. They are not listed in any order of importance but simply presented for consideration as a group.

Recommendation #1: Focus transportation advocacy efforts on current scheduling practices and related policies affecting how individuals with disabilities can effectively and realistically use existing public transportation options in their communities (e.g. busses, shuttles, door-to-door services, paratransit).

There is much work that needs to be done to improve the current transportation experiences of individuals with disabilities in Michigan. The feedback from our focus group participants showed that there is a need for advocacy and discussion around scheduling practices and policies as they apply to persons with disabilities. Public transportation and door-to-door/para-transportation services vary widely in their scheduling practices. Individuals with disabilities report being regularly late for

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appointments, left stranded, or unable to schedule transportation when it is needed. Addressing and finding realistic solutions for these service gaps is essential prior to the introduction of AVs as a public option. Otherwise, individuals with disabilities will remain at a disadvantage despite the presence of this new technology.

Recommendation #2: Harness mobility research and collaborative work being done by universities, organizations, and companies throughout Michigan to address the transportation needs of individuals with disabilities in both rural and urban settings.

The transportation experiences of individuals with disabilities have both commonalities and differences when looking at Michigan's rural and urban settings. While urban residents tend to have more public transportation options, accessibility and scheduling issues are still commonly reported. Rural residents report having fewer publicly available options and tend to rely more on friends, family and direct care staff to meet their transportation needs. This increased reliability on others often results in missed appointments and inconsistent availability of needed transportation. There is a wealth of research and collaboration happening across Michigan's academic settings. Companies focused on AV development, such as May Mobility and Navya, along with groups from the State of Michigan, are collaborating with universities to address the mobility needs of Michigan's diverse citizenship. There is promising potential to address the transportation needs of rural and urban residents through these efforts as the role that AVs will play is examined and tested.

Recommendation #3: Engage individuals with disabilities, service providers, employment specialists, advocates, state legislators, and other key stakeholders to brainstorm solutions to the growing need for Direct Support Professionals (DSP) to provide essential care, including transportation, for individuals with disabilities.

Michigan, along with several other states, is facing a critical shortage of DSPs. These essential workers provide day-to-day care for many individuals with disabilities. This care regularly involves providing transportation in the form of using their personal

vehicles to bring individuals to healthcare appointments, grocery shopping, and other activities in the community. Advocacy and education on the need for increased pay and benefits for these essential workers and their impact on the lives of those they care for is important. Not only are DSPs a lynchpin for the transportation needs of individuals with disabilities, but they will be vital to linking individuals to emerging technologies and services related to AVs as they become more available in the future. A knowledgeable DSP workforce will help pave the way toward quicker adoption of autonomous transportation for the people who need it most.

Recommendation #4: Connect individuals with disabilities with AV designers, developers, and manufacturers to facilitate idea sharing and training opportunities throughout the research, development, and testing phases of this emerging technology.

The importance of having everyone at the table cannot be overstated. In the case of product design and development, having the input of end-users is a common practice in many industries. The Delphi Panel was unanimous in deeming the involvement of individuals with disabilities in the design, development, and testing of AVs as very important. Connecting automotive companies, engineers, and mobility experts with individuals with disabilities can open a larger dialogue on the ultimate impact of transportation in general, and the vast potential autonomous transportation holds for these and other individuals who are transportation disadvantaged. The lived experiences of persons with intellectual, developmental, and physical disabilities can be valuable teachers for developers and designers as they look to make AVs and driverless technologies accessible and open to everyone.

Recommendation #5: Facilitate opportunities for individuals with disabilities to directly use and/or engage with existing autonomous transportation while providing a platform for them to give feedback and ask questions.

In past years, AVs have been made available to consumers to try out during events such as the North American International Auto Show. At the time of this paper, a

collaboration between AV manufacturer Navya, NextEnergy, Bestmile, Flagstar Bank, IXR Mobility, AARP, DTE, and Michigan's Office of Future Mobility and Electrification (PlanetM) is piloting an autonomous shuttle service in Midtown Detroit. The shuttles offer transportation for area senior citizens and individuals with disabilities to local hospitals and doctors' offices. These types of opportunities will be more essential as AVs become common in our communities. It is vital to test the accessibility of the vehicles, the scheduling process, and the practicality of these services in the lives of those who need them. Future collaborations should target diverse regions (rural and remote communities), users (individuals with different types of disabilities), and destinations (employment, grocery shopping, social/leisure outings). Finally, those participating in these opportunities will need to be provided with platforms by which to provide their feedback and ideas to enable a cycle of constant improvement and innovation.

Recommendation #6: Create an ongoing dialogue between persons with disabilities and local, county, and state transportation authorities to ensure the voices of individuals are heard as AV technology is integrated into the current transportation landscape.

One of the primary goals of this project is to ensure that the voices of individuals with disabilities are heard prior to the wide-scale adoption of AVs in Michigan. An effective method for accomplishing this is to connect individuals with the local and state sources that make many of the transportation decisions that affect us all. Entities like Disability Rights Michigan, the MDDC, and MI-DDI are instrumental in bridging these gaps and connecting Michigan's individuals with disabilities with offices such as the Michigan Department of Transportation. Sustaining these connections will be paramount to keeping the interests of individuals with disabilities front and center as AVs are introduced to city streets.

Recommendation #7: Create awareness and advocacy focused on ensuring that there is financial equity regarding the cost to own and/or use autonomous vehicles as they become more available to the public.

For people with disabilities, a long standing, significant barrier to owning an automobile has been not having the financial means to do so. Mentioned earlier, lack of reliable transportation commonly affects a person's ability to get and maintain full-time employment. In turn, not having adequate employment leads to financial shortfalls which make owning a vehicle next to impossible. The cycle is compounded when a person is discouraged from earning above a certain income level due to state and federal limitations related to Social Security benefits, for example. Creating greater awareness of these scenarios amongst transportation authorities and AV manufacturers is a first step toward a larger conversation about equity and access to reliable transportation.

Recommendation #8: Review how funding sources such as transportation vouchers and Social Security benefits can be applied to diverse transportation options such as ride sharing programs (e.g. Uber, Lyft) and how this will work with AVs.

A transportation future will look very different when autonomous vehicles of different shapes, sizes, and purposes are introduced. One aspect of future transportation that will need serious consideration is how individuals pay for public and private transportation options. Whether it is a city bus route, door-to-door or curb-to-curb paratransit service, or a private company like Uber, how we pay to use these services will likely look very different than they do now. Will persons with disabilities be able to use things like transportation vouchers or alternative forms of payment to utilize these resources? It is important to begin looking at how transportation services are paid for now and creatively address how this will look when AVs are commonly available.

Recommendation #9: Work with autonomous vehicle manufacturers and transportation authorities to create a priority for them and others to make publicly operating AV bus and shuttle services available to individuals who would be most immediately impacted by their use (e.g. individuals with disabilities, aging adults, transportation disadvantaged).

Disability focused organizations and advocacy networks should create partnerships with mobility companies and transportation authorities across Michigan. Through this synergy, work can be done to create a statewide priority for making autonomous mobility options directly available to individuals with disabilities, aging adults, and others who are transportation disadvantaged. Through these partnerships, the impact that these resources can have on the lives of different groups will be made evident, further propelling innovation that can meet the transportation needs of people across the state. Some of this work has been mentioned already and is taking place in Midtown Detroit and Grand Rapids. Increasing the number of partnerships and involving more people with disabilities will enable these technologies and opportunities to be offered more widely, beyond Michigan's urban centers. These partnerships can also lead to work addressing other areas of need such as how to encourage healthcare equity, increase employment options, and better connect individuals with disabilities to their communities.

Recommendation #10: Through information sharing and advocacy efforts, create awareness of the potential positive impact that AVs could have on the independence, community connectedness, and overall quality of life of individuals with disabilities and their families.

In the end, the potential impact that AVs could have on the lives of persons with disabilities is significant. There is, however, the danger for these technologies to introduce more barriers if delivered to communities in ways that prevent equitable access and use. Information sharing and advocacy will be key to ensure that the introduction of AVs has the positive impact that is hoped for: greater independence, more community connectedness, access to meaningful employment, and a better overall quality of life for persons with disabilities and their families. The information and recommendations offered in this paper are meant to provide ideas and spark action. Research and development in the area of autonomous mobility is accelerating quickly. Several important projects and collaborations are happening throughout Michigan. It is

important that the skills, lived experiences, and expertise of individuals with disabilities and their families are included in this work. Only through the inclusion of all people can a better future through AV technology be truly realized.

Current Work, Policies, and Future Advocacy

Considering the recommendations outlined above, the question becomes how can people take action now to ensure equitable access to accessible AVs in the future? A good place to start is to look at what work is currently being done in Michigan around the design, development, and use of AV technology. The next step is to connect with these groups to explore how individuals with disabilities and advocates can be part of the process and not just watch from the sidelines. The same approach can be used to ensure that the voices of individuals with disabilities are heard as policies and laws are crafted and passed by local, state, and federal legislators.

Work Happening in Michigan. Michigan has long been a worldwide leader in the automotive industry. In recent years, work being done throughout the state has established its leadership position in the design and implementation of cutting-edge mobility solutions, including AVs. Dozens of Michigan-based organizations, companies, and Universities are designing, developing, and testing AVs in laboratories and on city streets. Wayne State University in Detroit is one such leader in both AV research, collaboration, and advancement of emerging technologies.

In 2020, the Wayne Mobility Initiative (WMI) was formed. Under the guidance of Dr. Weisong Shi, the WMI's mission is to better understand and connect the work being done across WSU departments in the area of improving mobility and developing solutions in this space. MI-DDI is also located on the campus of WSU and has partnered with different departments and faculty on these mobility initiatives. MI-DDI's role is to ensure that the voices of individuals with disabilities are heard as this important work is carried out.

Wayne State also hosts the annual Metro Detroit Workshop on Connected and Autonomous Driving (MetroCAD). This event brings leaders in the AV community together to present and share their research and ideas. In 2019, Wayne State was part of a team, which included the State of Michigan, City of Detroit, University of Michigan, American Center for Mobility, the City of Grand Rapids, and Ford Motor Co., that received a $7.5 million federal grant for self-driving car development (Crain's Detroit Business, 2019).

Ann Arbor-based May Mobility Inc. has focused their efforts on developing and mastering smaller roadways with their electric GEM e6 shuttles. The shuttle can hold up to six people and travel at 25 miles per hour on fixed routes (mLive, 2018). The Michigan Economic Development Corporation (MEDC) recently announced plans to support May Mobility to expand its work to develop safe, reliable autonomous urban transport (May Mobility's expansion in Ann Arbor underscores Michigan's leadership position in autonomous and connected vehicle technology, 2020).

Another Michigan mobility effort involving MEDC and May Mobility is the Grand Rapids Autonomous Vehicle Initiative, known as AVGR. The AVGR initiative involves May, MEDC, the city of Grand Rapids, and nine other Michigan companies with the goal of better understanding how AVs can and will be used in urban settings. This work exemplifies the collaborative efforts that continue to emerge throughout Michigan.

Further evidence of the State of Michigan's commitment to advancing and leading in the mobility space was the creation of The [Michigan Council on Future Mobility](#) in 2017. A public-private partnership, the Council's mission is to guide statewide policy changes and to make recommendations to the Governor, the state legislature, and other state agencies (Michigan Council on Future Mobility Annual Report, 2019). One of the goals of this group is to promote "equitable access to future mobility options, especially for those who are economically disadvantaged, persons with disabilities, and seniors" (p. 4). The Council is also involved in reviewing current law and how future mobility, and in particular AVs and other highly automated vehicles, will be affected by these laws. The

work of this group is vital to paving the way for Michigan's mobility future. Advocates and individuals can connect with the Council and take part in the movement toward equitable access.

A collaborative effort is happening in Midtown Detroit that involves a partnership between several entities, including AV developer Navya. The group was awarded a grant in 2019 to develop and implement an autonomous, ADA compliant and accessible, electric paratransit shuttle. The shuttle currently operates on a fixed route that serves aging residents and individuals with disabilities in the Brush Park Manor and Brewster Homes areas by transporting them to one of many healthcare facilities along the route (PlanetM, 2020). For this pilot project, an attendant rides along and helps to monitor rider safety and also works to inform passengers about the shuttle and its features. One of the collaborative's partners, Bestmile, is contributing their mobile application technology for use by those using the shuttle service.

Finally, in May of 2020, Ford Motor Company released self-driving vehicle data that they have been collecting through the operation of multiple AV-ready cars in the city of Detroit (DigitalTrends, 2020). Ford's intention is that the data helps to drive others conducting research and development in the AV space.

With the wealth of work being done across the state, it is important for advocates and individuals to reach out to the people and companies engaging in this work. Disability advocacy groups such as the MDDC, The Arc Michigan, and Warriors on Wheels of Metro Detroit can be places to start for those interested in getting involved.

Policies and Legislation. As AVs are pilot tested on Michigan roads and technology continues to advance toward wide-scale use, national and state legislatures are reviewing existing laws and putting new laws and regulations into place to ensure safe and equitable adoption of self-driving cars. The Michigan Council on Future Mobility continues to address how the emergence of AVs will affect, and be affected by, existing laws. Another area that the Council is tasked with is addressing the way car insurance

is administered and how this may present barriers and potential opportunities for change with the introduction of AVs.

In 2017, Congress passed the SELF DRIVE Act (H.R.3388). This bill established the federal government's role in:

"...ensuring the safety of highly automated vehicles by encouraging the testing and deployment of such vehicles. A 'highly automated vehicle' is a motor vehicle, other than a commercial motor vehicle, that is equipped with an automated driving system capable of performing the entire dynamic driving task on a sustained basis."

This piece of legislation sets the standard for ensuring safe development and use of AVs on roadways in the U.S. In 2013, the Michigan legislature passed Senate Bill 0169 (Public Act 231, 2013) and subsequently Senate Bill 0995 in 2016 (Public Act 332, 2016) which amended Public Act 300 of 1949 to establish initial guidelines for the operation and insuring of AVs. The law also established the Michigan Council on Future Mobility to be the guiding body for laws and regulations related to future mobility options such as AVs on Michigan roads.

In 2017, the National League of Cities (NLC) published a policy preparation guide focused on AVs for city leadership. In it, the NLC sets forth recommendations for city planners, engineers, and other leadership on how to prepare for the inevitable presence of AVs in their cities (National League of Cities, 2017). The guide encourages cities to prepare plans to enact policies and guidance for integrating AVs into existing infrastructures, specifically public transportation systems and roads where autonomous personal and ride-share vehicles will eventually operate together.

These are but a few key examples of how federal, state, and local policy is being created to address the coming of AVs to our streets. There is still much work that needs to be done to review existing laws that may negatively affect the adoption and equitable use of these technologies by all members of our communities, especially individuals

with disabilities and others who are currently transportation disadvantaged. It is important that more individuals and advocates become involved in these conversations at all levels. Contacting local government officials and city councils is a good first step in ensuring that the voices of individuals with disabilities are heard and considered when the topic of AVs is on the table.

References, Tables, and Appendices

Please use the links below to access and download this paper's references, tables, and appendices in PDF format.

Table 1. Autonomous Vehicle Project Work Plan: Years 1 and 2

Table 2. Focus Group Locations, Dates, and Participants

Table 3. Focus Group Response Themes

Table 4. Survey Items Reaching 100% Consensus as a High or Top Priority to Address in Michigan

Table 5. Survey Items Reaching 90 Consensus as a High or Top Priority to Address in Michigan

Table 6. Survey Items Reaching 80 Consensus as a High or Top Priority to Address in Michigan

Table 7. Survey Items Considered Low or Non-priorities to Address in Michigan

Table 8. Recommendations for Future Action in Michigan

Appendix 1. Autonomous Vehicle Project Focus Group Questions

Appendix 2. Autonomous Vehicle Project Delphi Panel Survey Phase 1

References