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OPPORTUNITIES AND CHALLENGES FOR DEPLOYING CONNECTED AND AUTOMATED VEHICLES TO ADDRESS TRANSPORTATION DISPARITIES IN URBAN AREAS

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I. INTRODUCTION

As the development and testing of connected and automated vehicles (CAV) accelerates, it is important for government stakeholders, planners, and policymakers to have a better understanding of the challenges and opportunities CAVs will bring to infrastructure, communities, and lifestyles. There is general consensus among scholars and transportation practitioners that CAV will “disrupt” transportation systems, land use patterns, and socioeconomic power structures as they exist today.¹ The implications of CAV on transportation infrastructure have been the subject of numerous academic and professional studies, suggesting both positive and negative effects may occur. Furthermore, in an American context, transportation planning has historically contributed to the vast socioeconomic and racial inequities still seen today, so particular emphasis should be given to the potential for CAV development to compound equity issues. Regardless, the rapid development of CAV technology has led to a compressed timeline for planners and policymakers to put policies, plans, and infrastructure into place to prepare for the mainstreaming of CAVs, and the evolution of the current transportation system.

In order to identify strategic ways to leverage CAV to best support communities of all scales, researchers at the University of Minnesota have gathered information from community members and stakeholders across the state. Building on previous research and community discussions surrounding CAV opportunities in Greater

¹ A. Lari et al., *Self-Driving Vehicles and Policy Implications: Current Status of Autonomous Vehicle Development and Minnesota Policy Implications*, 16 *Minnesota J. of L., Sci., & Tech.* 735, 735–769 (2015).

Minnesota, this project sought to understand the needs of transportation disadvantaged communities that have limited access to transportation due to level of income, ability, or service extent, and explores whether CAV could be an appropriate solution. This research particularly focused on such communities in the “East Metro” of the Twin Cities, with particular focus given to the east side of Saint Paul, downtown, and Frogtown areas. Much of the equity-related research conducted in the Twin Cities metropolitan area is focused on Minneapolis, and there is a relative gap in the literature for evaluating transportation challenges of the East Metro. Transportation is undoubtedly an issue for everyone, but these challenges are most difficult for individuals with limited access to transportation due to income, ability, or extent of service area. CAVs have the potential to mitigate some of these transportation challenges, but the policy measures discussed in this paper should be considered to ensure that CAV deployment does not recreate or exacerbate the inequities of today's transportation system.

II. LITERATURE REVIEW

Transportation challenges have persisted throughout numerous transportation system evolutions. Many transportation challenges are well documented in the literature, spanning from traffic congestion in urban areas to issues of rural mobility. However, there is a need to scrutinize urban mobility gaps, especially in a CAV context. While much of the literature on CAV technology revolves around the scientific and mechanical details of the technology, there is a growing body of research surrounding policy development and the urban planning response to the impending initiation of CAV technology into mainstream society. This literature review will first provide an overview of transportation challenges, then summarize the state of CAV technology in planning, and finally discuss some of the CAV-related equity issues identified in the literature.

III. TRANSPORTATION CHALLENGES

The immense number of transportation challenges identified in the literature ranges from technical measures of congestion and mobility to studies on race, income, and gender and mode choice. In other words, transportation challenges are very well documented in the literature. In terms of geography, rural transportation options are generally fewer and less well-resourced than urban transportation

options. Most people in rural areas rely on cars, while residents of urban areas usually have access to more transportation options.² Because public transit systems, bicycle and pedestrian networks, and other non-car-centric modes of transportation are typically more robust in urban areas than rural areas, rural areas have often been designated as having more mobility challenges than urban areas. However, urban areas still face numerous transportation challenges, of which the focus has historically been on traffic congestion, and the shortcomings of the multimodal transportation network.³ While more and more people migrate to urban areas from rural and suburban areas, transportation challenges are expected to become exacerbated. In recent decades, CAV technology has been described as a potential way to address urban transportation challenges.⁴ Although CAVs have the potential to ease transportation challenges, such as congestion, under a private ownership scenario, CAVs may contribute to other challenges, like the acceleration of urban sprawl. Travelers' willingness to travel further distances may increase with the ability to repurpose commute time to more productive activities, or due to the potential to travel at higher speeds on roadways exclusive to CAVs.⁵ If travelers' tolerance for travel distance increases, CAVs may encourage population dispersal from urban areas to suburban and exurban areas. Whether CAVs may exacerbate or alleviate these issues depends on the policies adopted.⁶

IV. CAV PLANNING EFFORTS

While many cities are aware of CAV technology, relatively few are actively planning for it. Freemark et al. provide an overview of how various cities are preparing for CAV technology.⁷ The authors use a combination of existing plan analysis (of the top 25 largest U.S. cities) and a web-based representative survey of

² J. Pucher & J. Renne, *Rural mobility and mode choice: Evidence from the 2001*, 32 *TRANSP.* 165 (2005).

³ *Id.*

⁴ A. Lari et al, *supra* note 1; L. Butler et al., *How can smart mobility innovations alleviate transportation disadvantage? Assembling a conceptual framework through a systematic review*, 10 *APPLIED SCI.* 6306 (2020).

⁵ Daniel Sperling, *Three Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future* (Island Press 2nd ed. 2018).

⁶ A. Lari et al, *supra* note 1; Todd Litman, *Autonomous vehicle implementation predictions 28* (Victoria, Canada: Victoria Transport Policy Institute 2022).

⁷ Y. Freemark, A. Hudson, & J. Zhao, *Are Cities Prepared for Autonomous Vehicles? Planning for Technological Change by U.S. Local Governments*, 85 *J. OF THE AM. PLAN. ASS'N* 133, 133–151 (2019).

planning and transportation practitioners (of cities with populations greater than 100,000) to evaluate the trends and levels of preparedness of cities.⁸ Overall, the study found that the majority of the top 25 largest U.S. cities (64 percent) do not include CAV-related policies in their comprehensive or transportation plans.⁹ Those that do include CAV policies use relatively vague and flexible language.¹⁰ The authors report that the survey of cities with populations over 100,000 were relatively more prepared, having less than 9.9 percent of cities not having assigned policy responsibility to a department.¹¹

Although few cities and planning agencies are actively planning for CAV technology, even fewer are discussing the equity implications of CAV technology. Kuzio's 2019 review of regional transportation plans from 20 different metropolitan planning organizations substantiated this relative lack of planning and policy language on emerging technologies.¹² While 70 percent of the regional transportation plans mentioned emerging technologies, only 20 percent considered equity implications of emerging technologies.¹³ The lack of consistency in CAV policy development at the municipal level poses great uncertainty for the ways in which CAV technology will be regulated upon its introduction. Of course, policy development will vary by local context, but the general lack of preparation on the municipal level brings to light the importance and urgency for politicians, planners, and transportation practitioners to further contemplate the role of CAV technology in the future.

V. CAV TECHNOLOGY AND EQUITY

Much of the literature on CAV technology revolves around safety, efficiency, and costs, with only a small, yet growing, body of research focused on CAV technology and equity.¹⁴ In much of the

⁸ *Id.*

⁹ *Id.*

¹⁰ *Id.*

¹¹ *Id.*

¹² J. Kuzio, Planning for social equity and emerging technologies 2673 *Transp. Rsch. Rec.* 693 (2019).

¹³ *Id.*

¹⁴ TIERRA Bills, On Transportation Equity Implications of Connected and Autonomous Vehicles (CAV) A Review of Methodologies. Final Report (USDOT CCAT Project No. 5. 2020); J. Cohn et al., *Examining the Equity Impacts of Autonomous Vehicles: A Travel Demand Model Approach*, 2673 *TRANSP. RSCH.*

literature relating to CAVs and equity, CAVs are lauded for their potential to expand mobility options to those who cannot drive due to age or ability level.¹⁵ This capacity would certainly improve the lives of many across the country and the world. However, the potential for CAVs to improve mobility for low-income and historically disadvantaged populations has been somewhat overlooked and deserves equal attention in the discussion on CAVs and equity. However, pilot projects such as “Complete Trip Deployment” based in Buffalo, New York, are beginning to expand CAV technology not just for the elderly and disabled communities, but for low-income communities as well. The project is working to deploy electric Automated shuttles to connect these communities to public transit and the greater transportation network.¹⁶ Given the drastic racial and economic disparities driven in part by the development of the automobile and related discriminatory transportation planning decisions in the twentieth century, the development of CAV technology provides an opportunity to address these harms to work toward a more equitable transportation network for all.¹⁷

It is clear that the development of CAV technology will pose changes for transportation systems. Levinson 2015 summarizes the history of transit and the automobile, with the summary that transit use has declined as automobile use has increased.¹⁸ The author goes on to suggest that there is the potential for CAVs to kickstart a mode

REC. 23 (2019); Karel Martens, *Grounding transport planning on principles of social justice*, 19 BERKLEY PLAN. J. 1 (2006).

¹⁵ David Levinson, *Climbing Mount Next: Effects of Autonomous Vehicles on Society*, 16 MINN. J. OF L., SCI., AND TECH. 787 (2015); A. Lari et al, *supra* note 1; Corey Harper et al., *Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions*, 72 Transp. Rsch. Part C 1 (2016); Laura Fraade-Blonar et al., *Older Adults, New Mobility, and Autonomous Vehicles*, AARP PUB. POL’Y INSTIT. (2021).

¹⁶ Peter Murphy, *UB, partners receive \$8.2 million to help vulnerable populations with transportation issues*, UNIV. OF BUFFALO SCH. OF ENG’G & APPLIED SCI. NEWS (2021).

¹⁷ Stuart Cohen & Sahar Shirazi, *Can We Advance Social Equity with Shared, Autonomous and Electric Vehicles?*, UNIV. OF CAL. DAVIS INSTIT. OF TRANSP. STUD. (2017); Fahimeh Golbabaie, Tan Yigitcanlar, & Jonathan Bunker, *The role of shared autonomous vehicle systems in delivering smart urban mobility*, Int’l J. of Sustainable Transp. (2020); Andrea Ricci, *Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium*, In Transportation Research Board Conference Proceedings (No. 56) (2019).

¹⁸ Levinson, *supra* note 15.

shift away from non-automobile modes, such as transit, especially if the travel and service costs of CAV trips decline.¹⁹ This mode shift would constrain already limited bicycle, pedestrian, and transit resources, which would have negative ramifications for those who do not have access to a car.

Along these lines, Sperling 2018 posits that transportation practitioners can envision a spectrum of positive and negative futures as CAV technology evolves. For transit systems specifically, Levinson's characterization may lead to what Sperling describes as an emergent chasm between the "mobility haves and have nots".²⁰ In other words, this chasm would form between those able to quickly adopt CAV technology and those who are unable to financially or geographically access self-driving vehicles, instead remaining reliant upon walking, rolling, cycling, or using a deteriorating transit system. However, there is also the opportunity for CAV technology to supplement multimodal transportation systems. Sperling suggests potential options such as creating partnerships among shared CAV operating organizations and transit agencies to solve first and last mile connections, as well as the potential to automate buses and rail vehicles themselves.²¹

VI. METHODS

The research team used a combination of interviews and roundtable discussions to gather a range of stakeholders' perspectives on transportation challenges and CAV technologies, as well as a qualitative analysis to identify key themes and takeaways. The methods were structured to sequentially build off of one another, with the interviews and qualitative coding structure informing the framework of the roundtable discussions. It should be noted that several interviews and both roundtable discussions occurred in the midst of the COVID-19 pandemic. Any modifications or comments related to the COVID-19 pandemic are discussed where noted.

Interviews were conducted by phone with a selection of human service providers, government agencies, and transportation practitioners. Based on previous research and a review of literature,

¹⁹ *Id.*

²⁰ SPERLING, *supra* note 5; Levinson, *Climbing Mount Next: Effects of Autonomous Vehicles on Society*, (2015).

²¹ SPERLING, *supra* note 5.

these stakeholders were assumed to have the most familiarity with transportation challenges faced by transportation disadvantaged individuals. The research team targeted interview participants either located in or serving urban areas within the East Metro and used snowball sampling to expand the list of interviewees. The objective of the interviews was to assess transportation challenges and opportunities as well as potential CAV implications on participants' specific realms of influence. Questions centered around the type of clients served, the identified transportation needs (for example, appointments needed and frequent origins/destinations), the organization's familiarity with CAV technology and what benefits CAVs might provide as well as policy implications, potential challenges and opportunities, and equity implications for the groups of people needing these services. Participants were encouraged to ask questions of the research team, and were asked if they were interested in attending a future roundtable for further discussion surrounding transportation disadvantaged groups and CAV.

Following the interviews, members of the research team used organized notes from the interviews into a qualitative coding structure to capture the key perspectives and themes of the discussion. The coding structure used both descriptive and analytic codes to respectively provide context about a point that was made, and to identify themes that arose in the discussion.²² The use of a spreadsheet assisted in the organization of the responses to the focus group questions against the coding structure. The themes from the interviews were then used to inform an activity used in the roundtable discussions. This qualitative coding analysis helps to apply the literature review framework to the Twin Cities regional context. The synthesis of these components will help to decipher the key takeaways of transportation disadvantaged groups and CAV issues through an equity lens that should be prioritized as CAV policy develops.

In order to provide a forum in which interview participants and other stakeholders could exchange thoughts and ideas, the research team planned two multi-sector roundtable discussions. Due to the COVID-19 pandemic, these roundtable discussions had to be modified to a virtual setting. The first roundtable, held in May 2020, targeted human service providers and nonprofit organizations, while the second roundtable, held in October 2020, targeted government

²² Meghan Cope, *Coding Qualitative Data*, in *QUALITATIVE METHODS IN HUMAN GEOGRAPHY 3* (Ian Hay ed., 2010).

officials and transportation practitioners. Stakeholders were identified through the interview participants themselves, snowball sampling suggestions, and research on prominent organizations in the East Metro. During the research team's recruitment process, the stakeholders naturally broke out into the groups reflected in the two roundtable events. A list of the organizations represented in each roundtable event is listed in Exhibit 1.

Roundtable 1: Human Service Providers and Non-Profit Organizations	Roundtable 2: Government Officials and Transportation Practitioners
Casa de Esperanza	City of Saint Paul - Mayor's Office
East Metro Strong	City of Saint Paul Mayor's Advisory Committee for People with Disabilities
Metropolitan Council	City of Saint Paul Department of Planning & Economic Development
Minnesota Department of Human Services - Aging and Adult Services Division	Dakota County
Minnesota Department of Transportation - Connected and Automated Vehicle Office	Minnesota Council on Transportation Access
Mobility 4 All	NewTrax
	Payne/Phalen District Council
	Ramsey County Workforce Solutions
	Scott County
	Washington County

Exhibit 1. Participant Organizations Represented in the Roundtable Discussions

The structure of the roundtable events involved an introductory presentation by the research team, short presentations by three guest speakers, and a facilitated questions and answer activity which facilitated the actual roundtable discussions. Guest speakers were selected based on interviews and phone conversations to represent a range of issues and perspectives related to this research.

The roundtable discussion included an interactive question and answer activity, building on the insights and themes from the interviews, to further the discussion of CAVs and equity. This activity was designed to allow participants to discuss transportation and equity challenges, and potential implications of CAVs among people of diverse backgrounds. The activity involved asking participants to list key challenges or opportunities for each interview theme, which would then be documented as a virtual sticky note on Google Jamboard in either the “existing” or “future” area, with specific CAV recommendations included in a “CAV potential” area. The activity lasted approximately 45 minutes and concluded with some high-level takeaways from the discussion. While a deep knowledge of CAVs was not required to attend and participate in the roundtable, participants were primed with contextual information about CAVs through presentations given at the beginning of the roundtable by transportation practitioners and experts in CAVs that provided a baseline knowledge for participants to provide meaningful insights.

VII. FINDINGS AND DISCUSSION

The literature review demonstrated that CAV technology is a rapidly evolving field that holds many unanswered questions for the risks and opportunities that CAVs present to current transportation networks, especially regarding urban transportation system access and equity. While planners are beginning to include CAV considerations in municipal and regional planning, there is a relative lack of attention given to CAV technology, and even less thought given to equity implications of CAV technology.

The literature findings were substantiated in the interviews and roundtable discussions. The overarching themes discussed in the interviews can be summarized in two questions: will CAVs be able

to address existing issues *and* new and unforeseen issues? Or will CAVs recreate existing issues as efforts are focused on new and unforeseen issues? Exhibit 2 summarizes the interview themes identified as either existing issues or future issues. Building on the interview themes, the roundtable discussions presented further investigation of how various transportation-disadvantaged groups experience mobility challenges, and how CAVs could change the landscape of transportation options and accessibility. While no fully conclusive answers could be identified, findings indicated that there is potential for CAV to fill a constructive role in improving the transportation system, while broader equity concerns remain. Overall findings from the literature review, interviews, and roundtable discussions can be organized into three categories: 1) issues CAV can solve, 2) issues that require partnerships, and 3) remaining concerns. These themes will be further explored in the following sections.

Theme	Existing Issues	Future Issues
Reliability and Reliance	The “transportation disadvantaged” do not have reliable access to a car, and are reliant on transit and other modes of transportation that have limitations (network extent, service hours, etc.)	Will CAVs provide a reliable transportation mode to address unmet transportation needs?
Equity	Limited income, ability level, language barriers, employment made more challenging by limited transit network/service hours	Cost considerations; inequities from poorer access to transportation

Accessibility	Spatial mismatch of residents and jobs, physical accessibility	Same as existing, plus technology access
Vehicle ownership	Structural barriers - Drivers License documentation restrictions; limited financial capacity to buy a car	Private ownership vs. shared ownership reiterating existing socioeconomic/spatial disparities?
Safety	Vehicle crashes, policing	Pedestrian detection, trust without drivers

Exhibit 2. Key Themes from Interviews

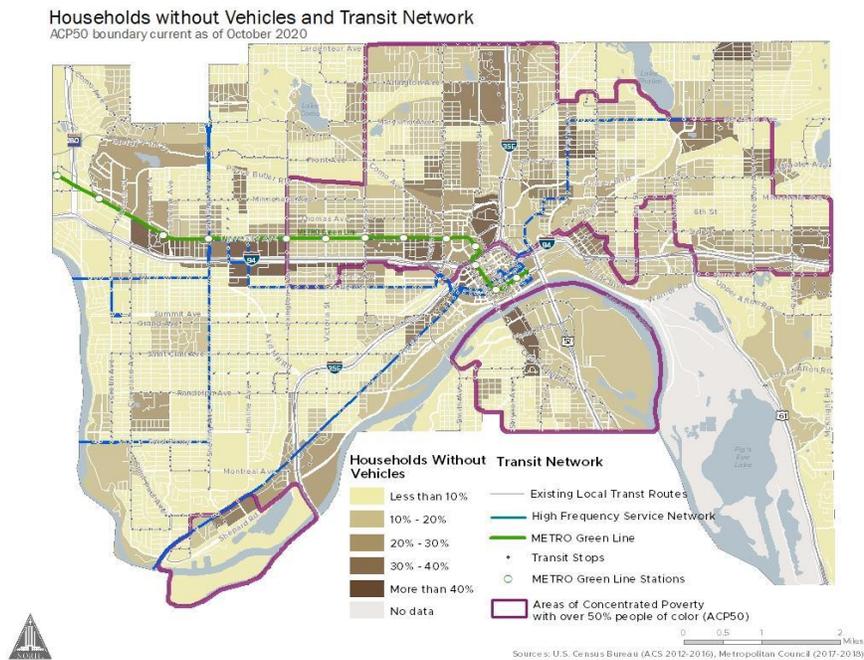
VIII. ISSUES CAV CAN SOLVE

The ability for CAV to solve some transportation issues remains unknown. However, based on interviews and roundtable discussions, it seems as though there are a couple areas where CAV could have a productive and positive impact on transportation trends, including closing transportation gaps in the East Metro, and facilitating non-passenger uses.

IX. TRANSPORTATION GAPS IN THE EAST METRO

Interview and roundtable participants emphasized that compared to other parts of the Twin Cities metropolitan area, there is a relative lack of transit accessibility in the East Metro. Among many things, the lack of transit accessibility limits access to jobs, human services, and health care. One of the roundtable guest speakers from the City of Saint Paul noted that the transit system in Saint Paul is not as robust as Minneapolis, and even transit service in west Saint Paul is better than east Saint Paul due to its proximity to Minneapolis, where job density is higher. Furthermore, the speaker described the connectivity across Saint Paul, which is limited by the

general hub-and-spoke layout of the transit system. Interview and roundtable participants further described the spatial mismatch throughout the East Metro. While transit access is generally concentrated in downtown Saint Paul, job growth has occurred further and further out from the urban core, necessitating long commutes that are not well served by transit today. Notably, the transportation gaps in Saint Paul are focused in areas where there is low car ownership. As seen in Exhibit 3, census tracts where there are high percentages of households without vehicles also tend to lack transit service.



**Exhibit 3. Households without Vehicles and Transit Network
(Source: City of Saint Paul)**

One story that is emblematic of gaps in existing land uses involves the limited transit access from the Sun Ray Transit Center to the Woodwinds Health Campus. This health facility is both a major employer and a health care service provider, including the only hospital in the southeast metro area, doctors' offices supporting approximately 15 specialties, outpatient services, among other

services.²³ Although there is technically transit access to Woodwinds Health, it is a very large campus and not particularly easy to navigate by walking or rolling. This area has been talked about as a first mile/last mile CAV pilot opportunity, discussed in a subsequent section.

Interview and roundtable participants frequently brought up the spatial mismatch of workers' home locations and attainable jobs as a challenge. In addition to accessibility in terms of spatial mismatch, both physical and technological accessibility were found to pose challenges in the existing transportation system. While some interview participants talked about accessibility in the physical ADA sense with regard to the ability to drive, or the need for an attendant to accompany passengers on transit, others described challenges relating to access to a smartphone, credit card, or bank as a limiting factor in accessing transit, rideshare, and other modes of transportation. While CAV cannot solve spatial mismatch issues alone, there is a case to be made for CAV to supplement the existing transportation system to close gaps in connecting residents to their jobs. However, it will be crucial for CAV to mitigate accessibility challenges, which may involve solutions ranging from including a caretaker or attendant on board to ensuring that technology involved in CAV supports multiple languages, is visually and audibly accessible, and offers technological support to accommodate unbanked riders and/or riders without a smartphone.

X. NON-PASSENGER USES

While CAV is often considered as a way to modernize passenger transportation, it could also be a constructive tool for non-passenger uses. Roundtable participants specifically noted the use of CAV technology for delivery and maintenance in addition to passenger transportation as an additional means of increasing accessibility. One specific example a participant offered was the potential for automated snowplows to clear sidewalks and bus stops. Utilizing CAV technology for maintenance would have tremendous potential for making multimodal infrastructure more accessible, especially during the winter months in Minnesota. Despite having a "snow removal arsenal", Metro Transit has noted that snow removal

²³ *Woodwinds Health Campus*, M HEALTH FAIRVIEW, <https://mhealthfairview.org/locations/woodwinds-health-campus> (last visited Aug. 4, 2022).

takes a significant amount of time. Metro Transit's Public Facilities Manager has noted that during heavy snows in January and February, it is relatively normal for maintenance staff to work for 12 hours a day.²⁴ Automated snow plows could effectively supplement not just Metro Transit's, but other public agency's snow removal efforts. In fact, efforts to automate snow removal tools are already underway. There is an annual Autonomous Snowplow Competition hosted by Dunwoody College that demonstrates this particular utilization for CAVs, illustrated in Exhibit 4. One of the objectives of this competition is to demonstrate the capabilities of CAV technology and promote its real-world applications.²⁵ Advancing CAV technology in such a way could provide solutions to long-standing challenges like maintenance.



Exhibit 4. Autonomous Snowplow Competition 2020 (Source: Kathy Helgeson)

Over the course of the COVID-19 pandemic, deliveries have taken on an increasingly important role as in-person errands have been replaced by online services and deliveries. The Department of Human Services (DHS) has provided more flexible grant funding to allow mobility providers to start doing grocery and prescription

²⁴ Drew Kerr, *Snow removal pros' goal this winter: collaboration*, METRO TRANSIT: RIDER'S ALMANAC BLOG (Nov. 11, 2019, 1:55 PM), <https://www.metrotransit.org/snow-removal-pros-goal-this-winter-collaboration>.

²⁵ *Objectives*, ION AUTONOMOUS SNOWPLOW COMPETITION, <https://www.autosnowplow.com/objectives.html> (last visited Aug. 4, 2022).

deliveries.²⁶ There is an opportunity for CAV technology to contribute to delivery services, which has been a subject of recent media attention. However, it is important to focus not only on younger populations but on seniors and other communities that need to get essential goods through these deliveries. As one roundtable guest speaker mentioned, there is an opportunity to create a marketplace for essential deliveries in the East Metro. Serving seniors is one place to start, as seniors that are already familiar with mobility services such as Mobility4All and the pricing mechanisms could become used to CAV deliveries provided through a similar marketplace. Another mobility provider, NewTrax, transitioned to food distribution during the COVID-19 pandemic, partnering with Washington and Ramsey Counties to provide food to people in need. Further CAV development could continue and expand delivery services even after the COVID-19 pandemic subsides.

XI. ISSUES THAT REQUIRE PARTNERSHIPS

Some transportation issues for which CAV is proposed as a solution may require partnerships or policy interventions to yield beneficial outcomes. Discussions during interviews and roundtables suggested that with the appropriate partnerships and policies in place, CAV could act as a supplement to transit, and could mitigate transportation costs to ensure equitable access to CAV technology.

XII. CAV AS SUPPLEMENT TO TRANSIT

Generally speaking, there is significant potential for CAVs to supplement transit systems. While transit routes typically serve the most well-used “trunk” lines in a region in order to maximize ridership, there are invariably gaps in the system in areas not well served by trunk lines. Levering CAVs to supplement the transit system and connect underserved areas to the broader transit system could prove beneficial for communities and transit systems alike. While none of the interviews or roundtable discussions were focused on transit specifically, the potential for CAVs to change transit was frequently discussed. Much of the discussion among interviewees and roundtable participants focused on how CAV could supplement transit rather than compete with and replace it. Participants’ concerns

²⁶ John Doan, Presenter, Mobility4All, University of Minnesota Roundtable Human Service Providers and Non-Profit Organizations (May 2020).

over maintaining equity suggest that planners should place greater emphasis on deploying CAV in a way that enhances trunk line service, so as not to encourage a mode shift leading to deterioration of the transit system.

One of the roundtable guest speakers noted an example of how CAV could potentially support transit. The speaker, a representative from NewTracks, described the organization's participation in a CAV pilot project in White Bear Lake, Minnesota. The pilot project is operating on the planned Rush Line Bus Rapid Transit corridor and could potentially become a first mile-last mile solution for access to and from the Rush Line. As part of the pilot project, NewTrax plans to staff the CAV with an attendant, per Minnesota state statute. Additionally, an interview participant described efforts underway to create a shuttle/circulator pilot program that connects the Creative Enterprise Zone in the midway area of Saint Paul with the Green Line light rail. A shuttle program could serve areas outside the walking distance of stations, in effect making transit a more realistic commuting option for those living or working just out of reach of the Green Line. While the community group behind this idea has not yet had luck finding funding, they are continuing to refine the idea. Discussions about such examples of CAV supplementing transit indicate that there is both interest and impetus for establishing partnerships among CAV developers and transit agencies to actualize first-last mile solutions.

XIII. CAV TECHNOLOGY COSTS

The cost of using CAV technology is a major topic of consideration for CAV planning, especially in terms of equity. Some roundtable participants expressed concern over the ability for low-income individuals to pay for technology - such as smartphones, data plans, and internet services - in today's transportation system, as well as the expectation that these individuals may also have a limited ability to pay for CAV services. Other participants noted that CAV technology has the potential to decrease costs so that transportation is accessible to people of all income levels. Specifically, one roundtable participant described the ability to own a vehicle as a way to "buy" transportation reliability. In other words, the spectrum of an individual's ability to pay affects one's opportunity to get where one needs to go. As such, it seems as though planners may need to consider establishing partnerships or policy interventions to avoid

inequitable “tiers of access” from emerging in a CAV system.²⁷ These reforms can be focused on price progressivism to ensure that lower-income riders are not priced out of CAV access. Such reforms can include price discounts and progressive pricing structures.²⁸

Another concern that surfaced during roundtable discussions entailed whether CAV technology would continue the current obligation for individuals who need a higher level of service to pay higher costs. Specifically, Metro Transit’s Transit Assistance Program allows eligible low-income riders to pay a reduced fare of \$1 per ride for Metro Transit service, yet there is no similar program for Metro Mobility despite having comparatively higher fares.²⁹ In order to ensure that CAV remains accessible for people of all ages, income levels, and ability levels, participants noted that some kind of partnership or policy solution would need to be arranged to provide affordable door-to-door service. Conversely, it could be possible for CAV to actually enhance service rather than continue providing existing services at a lower cost.

XIV. REMAINING CONCERNS

While CAV could potentially solve or benefit some transportation issues, there are undoubtedly issues that CAV cannot address. These remaining concerns, including social and structural barriers to transportation, equity considerations, and accessibility and safety concerns were brought up during the interviews and roundtable discussions as being outside of the scope of CAV’s capability to address.

XV. SOCIAL AND STRUCTURAL BARRIERS TO TRANSPORTATION

Aside from the physical constraints of the transit system and bicycle and pedestrian networks, social barriers also play a major role in transportation-disadvantaged groups’ ability to access transportation. Social and structural barriers noted by interview and roundtable participants include limited income, ability level, language barriers, as well as restrictions on Driver’s License

²⁷ Todd Litman, *Evaluating transportation equity*. Victoria Transport Policy Institute (2014).

²⁸ *Id.*

²⁹ Metro Transit, Transportation Assistance Program, (2021).

documentation, and discriminatory policing. According to the City of Saint Paul's analysis of areas of concentrated poverty within the city limits, at least 40 percent of residents live at a threshold below the poverty line, half of which are people of color.³⁰ As seen in Exhibit 3, many of these areas surround downtown, including the East Side, North End, West Side, Frogtown, and areas along Shepard Road. Some of those we interviewed emphasized that many of these communities face structural barriers to owning a vehicle beyond having a constrained income. For example, the immigrant and refugee communities in these areas must contend with restrictions on who can apply for a Driver's License, leaving undocumented immigrants out of the opportunity to own a vehicle in addition to the financial limitations that can prevent individuals from buying a car. One interview participant noted that transportation gaps and social barriers can compound immigrants' abilities to find and keep jobs, stating:

Language is a common barrier to transportation, particularly for the region's immigrant and refugee communities. It is not uncommon for an immigrant new to the Twin Cities to have a job lined up but miss a training or orientation due to transportation limitations and lose the employment opportunity as a result. Making language a key consideration in CAV technology development could help.³¹

Social and structural barriers to transportation such as poverty, immigration legal barriers, discriminatory policing, among many others require substantive systemic changes outside of the transportation system alone. Any CAV technology planning and implementation should center these issues and prioritize ways for CAV to dismantle barriers rather than cause further harm to communities that continue to face systemic oppression. Such considerations will likely require both forward-thinking planning leadership as well as public policy interventions to prioritize CAV implementation strategies that result in equitable outcomes.

³⁰ City of Saint Paul (2018).

³¹ Transp. Policy and Econ. Competitiveness Program, Humphrey Sch. of Pub. Affairs, Univ. of Minn., Connected and Automated Vehicles: Opportunity for Equity, Accessibility, and Safety (2020).

XVI. TRANSPORTATION DISPARITY CONSIDERATIONS

Transportation disparities, while related to social barriers to transportation, specifically arise out of discriminatory transportation planning decisions. Among the most prominent themes in the interviews and roundtable discussions was the potential for CAVs to reiterate existing transportation disparities. Interview and roundtable participants expressed concerns about the private manufacturers driving CAV development and emphasized that public policy must be created to encourage - or force - manufacturers to address equity issues. Participants indicated that planners and policymakers need to ensure that they don't inadvertently recreate the disparities of today's transportation system. At the same time, participants stressed that it is also important for planners and policymakers to consider how future transportation system conditions could be different than they are today.

As one of the roundtable guest speakers noted, the Metropolitan Council has worked to connect the development and implementation of CAV technology to regional goals outlined in Thrive MSP and 2040 Transportation Policy Plan. Rather than allowing the development of CAV technology to lead governmental actions, the regional goals should be leading the development of CAV technology. One of the Metropolitan Council's goals is equity, defined as follows: "equity connects all residents to opportunity and creates viable housing, transportation, and recreation options for people of all races, ethnicities, incomes, and abilities, so that all communities share the opportunities and challenges of growth and change."³² One roundtable guest speaker highlighted that a primary way to advocate for equity in transportation planning is to center people's experiences and their needs rather than just thinking about modes and vehicles.

This speaker also discussed the potential benefits and challenges of CAV technology, noting that in terms of equity, there is a need to broaden the conversation from solely looking at the benefits and challenges of CAV to considering decisions made within the overall public right-of-way. Some considerations include:

- Which modes are being prioritized in transportation investment decisions?

³² Metropolitan Council, *Thrive MSP 2040 Plan*, (2014).

- In terms of cost, how are the decisions planners make impacting system level vs. individual level costs?
- CAV passenger and delivery services may not be affordable to those with a fixed income, so how can CAV technology be made available to people of all income levels, people who are unbanked, people who do not have a smartphone, etc.?

In order to mitigate further transportation disparities, CAV planners will have to remain intentional about the communities they engage, how to define performance measures, and to avoid shying away from bold planning goals and objectives.

XVII. ACCESSIBILITY AND SAFETY CONSIDERATIONS

While CAV technology has the potential to address many of the existing transportation system's accessibility issues, safety remains a key concern. From a conventional accessibility standpoint, roundtable participants questioned the degree to which CAVs would be wheelchair accessible. Because non-CAV wheelchair-accessible vehicles are both limited in number and cost more than wheelchair-inaccessible vehicles, participants expressed concern that CAVs may complicate accessibility to people of varying ability levels. Some of the interview participants mentioned that technology access poses additional accessibility challenges, as the technology interface may have limitations for those who have visual or hearing impairments, speak languages not included in the software, as well as cause issues for those without a smartphone, credit card, or bank account. One interviewee in particular noted that as automated interactions become more common, and human drivers become less common, CAV technology will have to better account for language to ensure that all users get the service and assistance they need. Additionally, a roundtable participant noted that CAVs will likely improve access to transportation for people who are hearing impaired, with the ability for screen readers to substitute for humans that do not use sign language.

In another vein of accessibility discussion, participants considered the need for caregivers to be able to accompany riders, and the need for someone to be present if CAVs respond to emergency situations. The requirement for an attendant to staff a CAV raises the question of labor and operating cost. Participants both discussed the potential for driverless vehicles to save operating

costs yet have also noted that attendants may simply replace the labor costs of operators. A shift in skills will likely accompany a shift toward caregiver or attendant staffing a CAV rather than an operator. However, another participant noted that such a labor shift could expand the job pool, since the current transit operator shortage excludes people who have received a ticket for speeding, driving under the influence, or some other driving infraction on their background check.

XVIII. CONCLUSIONS AND RECOMMENDATIONS

Based on the literature and the interview and roundtable discussions, despite being part of a relatively robust transportation system, the East Metro still faces transportation gaps and barriers to mobility. Additionally, it is clear that planners and policymakers need to better prepare for CAVs to disrupt today's transportation system in terms of funding, infrastructure, equity, safety, and other concerns. While policy discussions are indeed taking place, many metropolitan areas, including Minneapolis-St. Paul, are less prepared than they could be to regulate CAVs.

One basic yet fundamental finding has been that transportation is an issue for everyone. Most people face some sort of challenge in getting from point A to point B, yet these challenges are more severe for transportation-disadvantaged communities that have limited access to transportation due to level of income, ability, or service extent. In the context of CAV planning, one roundtable participant emphasized that “[w]e need to think about how implementation of CAVs might reiterate existing transportation disparities. We might consider individual barriers, but we need to make sure we don't inadvertently recreate disparities in our current system”.³³

In general, equity is a peripheral topic in policy discussions, and there are few tangible policies that pertain to promoting equity in CAV development. Planners and other stakeholders in the East Metro seem open to eventually incorporating CAV technology into the transportation system to fill transportation gaps, resolve first mile-last mile issues, and mitigate transportation service restrictions and other barriers to using the current transportation system. Further,

³³ Heidi Schallberg, Presenter, Metropolitan Council, University of Minnesota Roundtable Human Service Providers and Non-Profit Organizations (May 2020).

the interviewees and roundtable participants seem adamant about encouraging planners and policymakers to center equity in CAV planning efforts.

Perhaps the most notable takeaway is that policy needs to take a stronger role in guiding private development to address equity issues as CAV technology develops. This can take several forms both from a CAV design and deployment perspective. First, policy makers can mandate CAV design technologies, such as Vehicle-to-others technologies that can sense and communicate with those inside and outside the vehicle. From a deployment perspective, policymakers can encourage shared ownership for those needing to use automotives by increasing regulatory control over licensing and insurance.³⁴ In addition, policymakers can insist that transit and transportation infrastructure that emphasizes accessibility is implemented to avoid a total “free market” approach to CAV deployment.³⁵ Further, however, policymakers can leverage the fact that CAVs will need to operate on public right-of-ways which are governed by the public sector and can thus insist that automakers follow enacted policies and legislation.

While the interviews and roundtable discussions yielded numerous ideas to address transportation challenges, a few stand out as tangible ways CAVs can solve issues. These include improving language access, encouraging CAV deployment as a supplement rather than replacement of transit, and deploying CAV in maintenance and delivery capacities. Among the recommendations of ways CAV can solve issues in partnership with public entities is to develop policy that ensures attendants and caregivers staff CAV as needed, so those with higher service needs are not left driverless and without assistance. Additionally, CAV service models and equitable cost structures must be part of the discussion for CAV implementation. Although CAV alone cannot solve systemic inequities, planners and policymakers must work to prevent CAV from continuing and reinforcing the same disparities of past planning decisions. Ultimately, the implications of CAVs on equity and transportation issues require further discussion, as there is ample

³⁴ X. Wu, J. Cao, & F. Douma, *The impacts of vehicle automation on transport-disadvantaged people*, 11 *Transp. Rsch Interdisciplinary Perspectives*, 100447 (2021).

³⁵ K. Emory, F. Douma, & J. Cao, *Autonomous vehicle policies with equity implications: patterns and gaps*, 13 *Transp. Rsch. Interdisciplinary Perspectives* 100521 (2022).

room to elevate equity in transportation planning and public policy decisions.