NCHRP Project 20-113F

Preparing for Automated Vehicles and Shared Mobility: State-of-the-Research Topical Paper #5

PRIORITIZING EQUITY, ACCESSIBILITY AND INCLUSION AROUND THE DEPLOYMENT OF AUTOMATED VEHICLES

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Transportation Research Board
500 5th Street NW
Washington, DC 20001
www.trb.org

Prepared by:

Stantec

ARA

For:

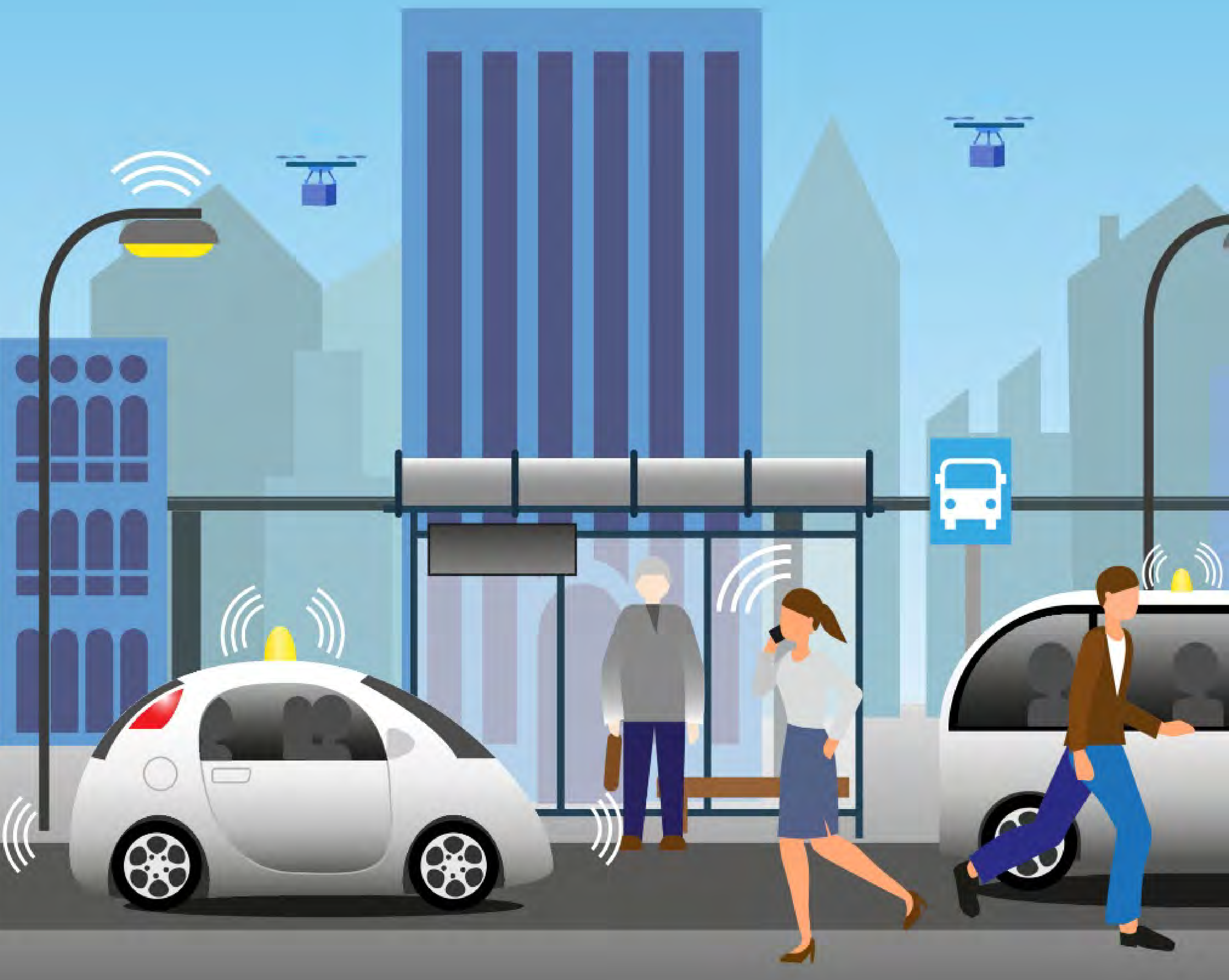
TRB AV/SM FORUM
AUTOMATED VEHICLES + SHARED MOBILITY

1 Introduction

1.1. Background

In coordination with the National Cooperative Highway Research Program (NCHRP), the TRB Forum on Preparing for Automated Vehicles and Shared Mobility (Forum) has developed nine (9) Topical Papers to support the work of the Forum (Project).

The mission of the Forum is to bring together public, private, and research organizations to share perspectives on critical issues for deploying AVs and shared mobility. This includes discussing, identifying, and facilitating fact-based research needed to deploy these mobility focused innovations and inform policy to meet long-term goals, including increasing safety, reducing congestion, enhancing accessibility, increasing environmental and energy sustainability, and supporting economic development and equity.



The Topical Areas covered as part of the Project include the following:

- Models for Data Sharing and Governance
- Safety Scenarios and Engagement during Transition to Highly Automated Vehicles
- Infrastructure Enablers for Automated Vehicles and Shared Mobility
- Maximizing Positive Social Impacts of Automated Vehicle Deployment and Shared Mobility
- Prioritizing Equity, Accessibility and Inclusion Around the Deployment of Automated Vehicles
- Potential Impacts of Highly Automated Vehicles and Shared Mobility on the Movement of Goods and People
- Impacts of Automated Vehicles and Shared Mobility on Transit and Partnership Opportunities
- Implications for Transportation Planning and Modeling
- Impacts and Opportunities Around Land Use and Automated Vehicles and Shared Mobility

For this Project, the important goals of the papers are to provide a snapshot of all research completed to date for a Topical Area and within the proposed focus areas identified below. The papers are intended to provide a high-level overview of the existing research and to make recommendations for further research within a Topical Area. The Project establishes a foundation to guide the use of resources for further development and support of more comprehensive research that tracks the identified research gaps noted in each Topical Paper and to support the Forum.

The research reviewed varies by paper, but generally, only published research was included as part of the Project. For clarity, the scope of the project is to report on research that has been done without judging or peer reviewing the research conducted to date and referenced herein. While considered for background purposes, articles, blog posts, or press releases were not a focus for the work cited in the Topical Papers. Also, in consideration of the focus of the Forum and the parameters of the Project, the research was narrowed to publications focused on the intersection between automated vehicles and shared mobility. Materials reviewed and cited also include federal policy guidance and applicable statutes and regulations.

Each of the papers is written to stand on its own while recognizing there are cross over issues between the Topical Areas. If desired, readers are encouraged to review all nine Topical Papers for a more comprehensive view of the Project and the points where topics merge.

The goals of the Topical Papers are the following:

Snapshot of research completed under a particular topic area

Summary of research completed to date

Identification of gaps in research

Recommendations for additional research

1.2. Approach to Topical Paper Development

The approach to development of the Topical Papers and their focus included the following:

- Meetings with the Chairs of the Forum
- Engagement with the Members of the Forum, including during the Forum meetings in February and August of 2020
- Feedback from Chairs and Forum Members during the development of focus areas for the Topical Papers and receiving comments to the draft versions of the papers

During the meetings with the Forum in February 2020, the research team discussed the Project with the Forum over two days in two separate sessions. On Day 1, the research team presented the proposed scope for each Topical Paper and broke out into groups to further refine the focus of each paper to match the interest and goals of the Forum and its Members. During Day 1, the Forum also heard from different organizations highlighting previous and ongoing research. These organizations[1] included the following:

- Brookings Institution
- The Eno Center for Transportation
- National Governors Association
- Future of Privacy Forum
- AARP
- American Public Transportation Association

On Day 2, the research team reconvened with the Forum to summarize the break-out discussions on Day 1 and to receive final comments on the focus for each Topical Paper.

In August 2020, the draft papers were presented to the Forum for review and feedback. Comments were received in writing and verbally during a virtual Forum meeting. The final papers incorporate the comments and feedback received as part of the review process. This paper identifies a large body of research regarding this topic area associated with shared and automated vehicles. As reviewer comments pointed out, there remains considerable uncertainty regarding if and when highly automated vehicles will be deployed on a large scale. This is reflected in much of the research that has been completed to date. Consequently, this paper summarizes common themes from the research available to date as much as possible, while acknowledging that various scenarios may impact the issues, recommendations, and areas for future research. Many of the issues addressed in this research are forward-looking and anticipate an environment where fully automated vehicles (SAE Level 5) are a ubiquitous part of the transportation system.

[1] The research team and the Forum thank these organizations for their time in sharing their work and insights in support of the development of the Topical Papers.

2 Paper Areas of Focus

This Topical Paper reviews research conducted and published as of July 10, 2020, unless specific papers were identified as part of the final review and comments process. In approaching this topic, the paper focuses on the following issue areas:

1. Examine opportunities and challenges to affordability, accessibility and equity in the development and deployment of smart mobility strategies in support of automated vehicles and shared mobility.
2. Examine how issues like complete streets, building codes, universal design, and the Americans with Disabilities Act relate to vehicular design and the built environment, and how to ensure enhanced mobility for all current and potential users of the transportation system.
3. Evaluate existing smart mobility policies that seek to incorporate equitable and balanced deployments and how to maximize success and achieve important goals of equity, access, and inclusion around automated vehicles and shared mobility.
4. Consider the expected integration of artificial intelligence and facial recognition technologies into automated vehicles.

3 Summary of Findings

While HAVs and smart mobility strategies offer opportunities to increase accessibility and equity, there is also the potential to increase inequities depending on how this technology is rolled out. HAVs can increase access to efficient, affordable travel for at-need populations. However, issues such as physical accessibility and the digital divide pose challenges to meeting the needs of all users. Appreciating this, government, the research community, and the private sector wish to understand AVs' implications on accessibility and equity, as well as strategies that can be used scale up AV technology in an equitable way.

Through review of the existing body of literature within the context of the focus areas for this Topical Paper, several common themes emerge:

- **AVs have the potential to increase access to transportation.** Much of the research identifies the opportunity for AVs to provide needed mobility for the elderly, those with disabilities, and lower-income individuals. Shared AV services can also improve spatial and temporal equity by filling transit gaps in underserved areas. This in turn would improve health and economic outcomes for these at-need populations.

- **Barriers around equitable and accessible deployment must be addressed.** Researchers also consider challenges that must be overcome to make sure these services are truly equitable and accessible. Barriers to use include: affordability, service provision in less profitable areas, physical accessibility considerations, and access to information in an increasingly digitized world.

- **AVs on the road to date, do not currently meet the needs of all users.** A key theme of the research is both the opportunities and challenges for AV services to meet the needs of people with varying disabilities. While some localities have enacted policies to spur equity, it is also important to consider implications of national polices such as the Americans with Disabilities Act (ADA) in light of private mobility service provision. Some manufacturers are working with stakeholders to design more accessible vehicles, although accessible AV standards do not currently exist.

- **The potential use of artificial intelligence combined with the expected increased reliance on digital applications raises new issues around potential discrimination.** With the potential use of technologies like facial recognition for AVs, particularly for subscription and shared formats, concerns are raised around the ability to make sure algorithms are developed in an unbiased manner that do not purposefully or inadvertently discriminate against travelers. Further, ensuring access to devices that allow for universal use of digital applications will be important to consider moving forward.

Additional research and outreach in the Forum will be needed to address these discussion trends. The great deal of uncertainty surrounding the development and ultimate implementation of these new technologies provides strong challenges for transportation leaders.

4 Summary of Research Reviewed

The research reviewed included papers from academic research publications, federal agencies, and nonprofit organizations. This points to a cross-sector interest in equitable and accessible deployment of AVs. The following is a summary of the research reviewed.

4.1 Examine opportunities and challenges to affordability, accessibility and equity in the development and deployment of smart mobility strategies in support of automated vehicles and shared mobility

New mobility strategies such as TNCs, carsharing, and AVs offer many opportunities for more equitable access to reliable transportation. Current research notes that these services can provide important mobility services for people in transit-poor areas, for those who cannot afford personal vehicles, or for people requiring additional services such as paratransit. However, these mobility solutions can increase inequities if not rolled out in a conscientious way. The research shows that access to services and information, as well as the nature of services offered, can be challenging for many potential users.

4.1.1 Increased Access to Mobility, Especially for Disadvantaged Groups

Several authors note that a key opportunity of smart mobility strategies is the ability to increase mobility for groups that have previously faced transportation barriers.[2] First, this could help populations who cannot or do not wish to drive or own a car, such as older adults, youths under the age of 16, and individuals with disabilities.[3] This would improve the ability to reach critical destinations such as jobs and medical care.[4] Claypool, Bin-Nun, and Gerlach found that mitigating transportation-related obstacles for people with disabilities would result in new employment opportunities for approximately 2 million individuals with disabilities and would save $19 billion annually in healthcare expenditures from missed medical appointments.[5]

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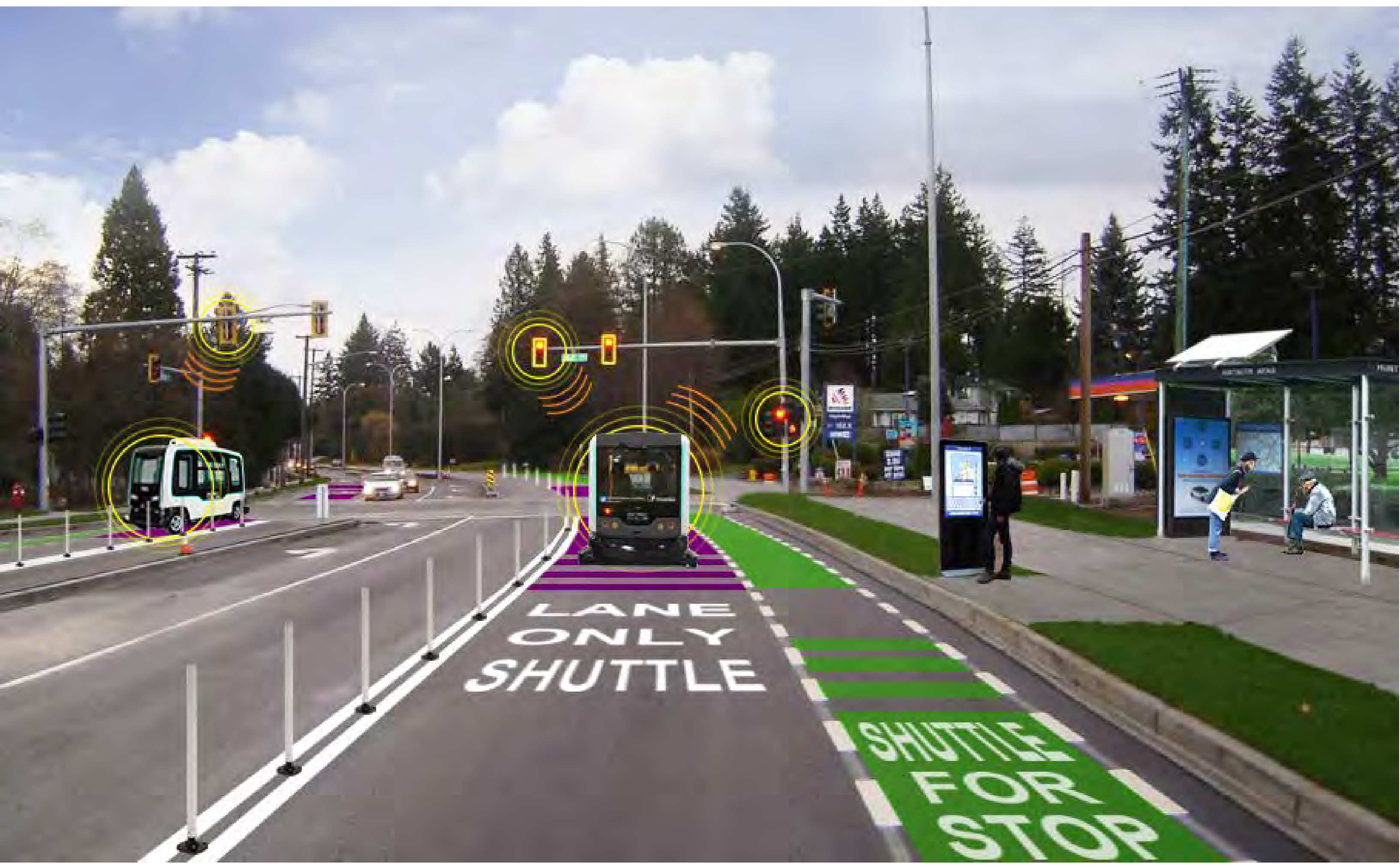
[2] Andrea Ricci, "Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium," in *Transportation Research Board Conference Proceedings*, 2019; Johanna Zmud et al., "Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies," 2017; Susan Shaheen et al., "Mobility on Demand Operational Concept Report" (United States. Department of Transportation. Intelligent Transportation …, 2017); David J. Eaton, "Autonomous Rural Transportation Challenges and Opportunities in Iinan-Cho, Shimane, Japan," 2020, https://repositories.lib.utexas.edu/handle/2152/81242.
[3] Zmud et al., "Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies"; Matthew Lynberg, "Automated Vehicles for Safety," NHTSA, n.d.; Susan Shaheen, Elliot Martin, and Apaar Bansal, "Peer-to-Peer (P2P) Carsharing: Understanding Early Markets, Social Dynamics, and Behavioral Impacts," 2018, https://escholarship.org/uc/item/7s8207tb.
[4] "USDOT Comprehensive Management Plan for Automated Vehicle Initiatives," US Department of Transportation, n.d., https://www.transportation.gov/policy-initiatives/automated-vehicles/usdot-comprehensive-management-plan-automated-vehicle; Ricci, "Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium"; Richard Ezike et al., "Where Are Self-Driving Cars Taking Us?," 2019, https://www.ucsusa.org/resources/where-are-self-driving-cars-taking-us.
[5] Henry Claypool, Amitai Bin-Nun, and Jeffery Gerlach, "Self-Driving Cars: The Impact on People with Disabilities," *Newton, MA: Ruderman Family Foundation*, 2017.

Smart mobility strategies – including services provided by both public and private operators – can also improve mobility for people in areas that are poorly served by transit.[6] Shaheen, Cohen, and Martin write that shared AVs or other mobility services can provide key first- and last-mile connectivity and provide increased routes, travel speed, and reliability.[7] Lynberg notes that AVs and smart mobility strategies can increase efficiency and convenience, leading to time savings benefits (see Section 4.1.2).[8] Eaton describes the mobility opportunities that HAVs could pose in a rural area of Japan, where an aging population and few mobility options can make transportation difficult.[9] Shared HAV deployments have successfully been demonstrated or are in the planning stages to provide first/last mile connections to transit. A 2020 study on AV



[6] Ricci, "Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium."
[7] Susan Shaheen, Adam Cohen, and Elliot Martin, "The US Department of Transportation's Smart City Challenge and the Federal Transit Administration's Mobility on Demand Sandbox: Advancing Multimodal Mobility and Best Practices Workshop," *Transportation Research Circular*, no. E-C219 (2017).
[8] Lynberg, "Automated Vehicles for Safety."
[9] Eaton, "Autonomous Rural Transportation Challenges and Opportunities in Iinan-Cho, Shimane, Japan."

deployments provides a description of several case studies.[10] In Denver, the 61AV Shuttle served as a successful AV pilot to provide first/last mile connections to transit via public roadways. The CCTA GoMentum Station project currently in testing phase (as of September 2020) is designed to eventually provide AV shuttles for first/last mile connections between a business park and transit connections in San Ramon, CA.

To experience these benefits, smart mobility strategies such as AVs and TNCs must be deployed in the areas that need them the most. An opportunity for more equitable access exists through subsidies. In South Bend, Indiana, the Commuter Trust program helped subsidize ride-hailing to address long, irregular commutes for factory workers.[11] However, the research notes that incentives do not always compel TNCs to adequately serve underserved areas.[12]

4.1.2 Reduced Cost of Transportation

Feen, Bin-Nun, and Panasci note that AV transportation services could reduce the inequitable burden of transportation costs among American households. Currently almost two-thirds of American households live in neighborhoods where housing and transportation costs exceed 45% of their incomes, a level that is difficult to sustain over time. In their report, the authors note that shared, electric AV services could cost less per mile than traditional services such as buses. Their analysis shows that AVs could reduce household transportation costs by up to $5,600 per household and reduce the burden of transportation costs on millions of households, especially those in urbanized neighborhoods.[13] Rodier's study of AVs' travel effects agree with these findings, stating that AV use could reduce transportation costs from insurance and fuel.[14] Greenblatt and Shaheen note that AV technology prices are projected to drastically reduce by 2025, making these services more affordable to a larger number of people[15].

Aside from monetary costs, HAVs and shared mobility strategies also have the potential to reduce the time burdens associated with transportation. Passengers can take advantage of their liberation from driving by turning AVs into moving offices, bedrooms, or dens, thereby eliminating time previously occupied at the wheel.[16] Lynberg notes that AVs and smart mobility strategies can increase efficiency and convenience, leading to time savings benefits.[17]

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[10] Kelley Coyner, "Low-Speed Automated Vehicles (LSAVs) in Public Transportation," 2020, http://intranet.trb.org/TRBNet/ProjectEdit.asp?ProjectID=4438.
[11] Stephen Goldsmith and Betsy Gardner, "Prioritizing Public Value in the Changing Mobility Landscape," 2020.
[12] Goldsmith and Gardner.
[13] Gidon Feen, Amital Bin-Nun, and Anthony Panasci, "Fostering Economic Opportunity through Autonomous Vehicle Technology," 2020, https://secureenergy.org/wp-content/uploads/2020/07/Fostering-Economic-Opportunity-through-Autonomous-Vehicle-Technology.pdf.
[14] Caroline Rodier, "The Effects of Ride Hailing Services on Travel and Associated Greenhouse Gas Emissions," 2018.
[15] Jeffery B Greenblatt and Susan Shaheen, "Automated Vehicles, on-Demand Mobility, and Environmental Impacts," *Current Sustainable/Renewable Energy Reports* 2, no. 3 (2015): 74–81.
[16] Jacques Leslie et al., "Will Self-Driving Cars Usher in a Transportation Utopia or Dystopia?," 2018, http://e360.yale.edu/features/will-self-driving-cars-usher-in-a-transportation-utopia-or-dystopia; Rodier, "The Effects of Ride Hailing Services on Travel and Associated Greenhouse Gas Emissions."
[17] Lynberg, "Automated Vehicles for Safety."

4.1.3 Potential to Increase Inequities

Despite their potential benefits, a theme in the literature is that smart mobility strategies have the capability to increase existing inequities. Privatization of services could compel companies to provide more or better service in areas based on their potential for profit, to the exclusion of underserved areas and disadvantaged populations such as the unbanked.[18] Fleming writes that this could exacerbate both spatial and temporal equity of services, as some communities would have fewer mobility options and less frequent service.[19] Shaheen et al. explain equity barriers in terms of a framework incorporating five types of equity barriers: spatial, temporal, economic, physiological, and social.[20] Several authors observe that the potential to increase inequities would affect low-income areas as well as rural areas where service could be less profitable.[21] Transportation inequities could be exacerbated both in terms of people and goods. One study notes the potential for "delivery deserts" if residential areas are underequipped for automated delivery.[22]

Without proper planning and policies, certain groups could see little benefit from smart mobility strategies while at the same time bearing the brunt of its negative effects such as congestion and pollution.[23] Ezike et al. note that people living in low-income neighborhoods and communities of color could be subjected to substantial increases in exposure to congested driving in a variety of HAV scenarios, with exposure in these neighborhoods being about 50% higher than in the region as a whole.[24] Study results show that exposure to congested driving to be highest in a 'no pooling' scenario, with almost eight times the amount of congested VMT compared to 2040 baseline values. The 'pooling, better transit' scenario had the lowest increase, with four times the baseline congested VMT. AVs and smart mobility strategies could worsen sprawl and gentrification and increase housing prices: those who could afford AV technology and high-priced housing could move outside of expensive urban areas, in turn driving up the cost of living in those areas and marginalizing lower income community members who may already live

Without proper planning and policies, certain groups could see little benefit from smart mobility strategies while at the same time bearing the brunt of its negative effects

[18] Ricci, "Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium"; David C Rouse et al., "Preparing Communities for Autonomous Vehicles," 2018; Goldsmith and Gardner, "Prioritizing Public Value in the Changing Mobility Landscape."
[19] Kelly L Fleming, "Social Equity Considerations in the New Age of Transportation: Electric, Automated, and Shared Mobility," *Journal of Science Policy & Governance* 13, no. 1 (2018).
[20] Susan Shaheen et al., "Shared Mobility Policy Playbook," 2019.
[21] Garrett Fitzgerald and Richard Lee, "Driving a Shared, Electric, Autonomous Mobility," 2019, https://rmi.org/insight/driving-a-shared-electric-autonomous-mobility-future/; Rouse et al., "Preparing Communities for Autonomous Vehicles"; Shaheen et al., "Mobility on Demand Operational Concept Report"; "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session," 2018, https://autoalliance.org/wp-content/uploads/2019/05/ODEP_AVInfoGatheringReport2Final.pdf.
[22] Ricci, "Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium."
[23] "The Transition Toward Shared Automated Vehicles," 2019, http://onlinepubs.trb.org/onlinepubs/circulars/ec252.pdf; Ezike et al., "Where Are Self-Driving Cars Taking Us?"
[24] Ezike et al., "Where Are Self-Driving Cars Taking Us?"

there.[25] It could also result in “rebound distancing,” in which education and employment opportunities recede farther from residential areas and people who need them.[26]

4.1.4 Challenges for Physical Accessibility

Additional challenges exist for people with disabilities or others who need accessible transportation options.[27] Several reports note that a lack of drivers in fully automated vehicles could hinder those needing assistance to board or otherwise navigate mobility services.[28] Fewer disabled and wheelchair-accessible services would also negatively affect mobility: this is already seen among TNC services, where customers experience issues with reliability, estimated response times, and higher prices for wheelchair-accessible vehicles.[29] Hwang et al. write that, aside from in-vehicle requirements for disabled passengers, a lack of appropriate built environments such as level boarding platforms could add additional challenges for people navigating new mobility solutions.[30] Herderson and Golden and also Glennie-Smith consider regulatory challenges regulatory challenges to disabled users owning and operating private AVs if drivers’ licenses are required for HAV operation.[31]

Driverless vehicles could also pose challenges for people outside of the vehicles. The CNIB Foundation produced a report on the impacts of fully automated vehicles on pedestrians with sight loss.[32] The report uses existing literature and a survey of people experiencing sight loss to better understand the issues and propose recommendations to ensure the safety of pedestrians with sight loss.

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[25] Fleming, “Social Equity Considerations in the New Age of Transportation: Electric, Automated, and Shared Mobility”; Ricci, “Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium.”

[26] Ricci, “Socioeconomic Impacts of Automated and Connected Vehicle: Summary of the Sixth EU–US Transportation Research Symposium.”

[27] “Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session”; Steven H Bayless and Sara Davidson, “Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities,” 2019.

[28] Rouse et al., “Preparing Communities for Autonomous Vehicles”; Ben Pierce, Eric Plapper, and Jodi Rizek, “Accessible Transportation Technologies Research Initiative (ATTRI): User Needs Assessment: Stakeholder Engagement Report.” (United States. Department of Transportation. Intelligent Transportation …, 2016); Bayless and Davidson, “Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities.”

[29] Joanna Moody, Scott Middleton, and Jinhua Zhao, “Rider-to-Rider Discriminatory Attitudes and Ridesharing Behavior,” *Transportation Research Part F: Traffic Psychology and Behaviour* 62 (2019): 258–73; “Still Left Behind,” 2019, https://nylpi.org/wp-content/uploads/2019/05/Still-Left-Behind-Report—Updated.pdf.

[30] Jinuk Hwang et al., “A Focus Group Study on the Potential of Autonomous Vehicles as a Viable Transportation Option: Perspectives from People with Disabilities and Public Transit Agencies,” *Transportation Research Part F: Traffic Psychology and Behaviour* 70 (2020): 260–74.

[31] Susan Henderson and Marilyn Golden, “Self-Driving Cars: Mapping Access to a Technology Revolution,” 2015; Caroline Glennie-Smith, “Loopholes, Licensing, and Legislation: Considering the Needs of People with Disabilities in the Autonomous Vehicle Revolution,” *Loy. LA Ent. L. Rev.* 38 (2017): 187.

[32] “Advance Connectivity and Automation in the Transportation System: Understanding the Impact of Connected and Automated Vehicles for Pedestrians Who Are Blind or Partially Sighted,” 2019, https://tcdocs.ingeniumcanada.org/sites/default/files/2020-05/CNIB - Understanding the Impact of Connected and Automated Vehicles for Pedestrians who are Blind or Partially Sighted.pdf.

4.1.5 Digital Equity & Access to Information

Access to information is key to accessing new mobility services including AVs. However, the research reveals that this could prove challenging for certain groups. Digital accessibility issues currently exist around apps and other technologies that need to be designed for a number of different users, whether these users are blind, developmentally challenged, or require other accommodations – if not addressed, these issues will serve as barriers for future AV services.[33] Fleming adds that it is also necessary to address language barriers by providing information in languages other than English, while some populations such as older adults may be resistant to app-based platforms.[34] She also notes that some, (such as low-income populations), may lack access to the required smart phones or computers needed to use shared mobility strategies. Several reports and studies note that access to mobility information is difficult for those without internet access or smartphones.[35] Additionally, Feigon and Murphy write that the unbanked may have difficulty paying for mobility services with cash, especially as fare payment integration systems are deployed.[36]

4.1.6 Affordability

Affordability is a current challenge to equitable use of smart mobility technology that could also affect AV service delivery. Issues with unpredictable or expensive fares can hinder widespread use.[37] Research by Goodin, Baker, and Taylor and the National League of Cities write that road user charges, if employed in a non-equitable way, could disproportionately affect lower income or rural users as these drivers are more likely to drive non-fuel-efficient vehicles or to travel longer distances.[38] The National League of Cities writes about challenges for several user groups. First, the unbanked or people without internet access could face additional challenges with electronic billing systems. Second, wheelchair users may be also burdened by a lack of insurance coverage for accessible transportation. Furthermore, wheelchairs are defined by the

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33 Rouse et al., "Preparing Communities for Autonomous Vehicles"; "The Transition Toward Shared Automated Vehicles"; Scott Baker et al., "Accessible Transportation Technologies Research Initiative (ATTRI) Institutional and Policy Issues Assessment: Task 6: Summary Report" (United States. Dept. of Transportation. ITS Joint Program Office, 2017); Henderson and Golden, "Self-Driving Cars: Mapping Access to a Technology Revolution"; Bayless and Davidson, "Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities"; Hwang et al., "A Focus Group Study on the Potential of Autonomous Vehicles as a Viable Transportation Option: Perspectives from People with Disabilities and Public Transit Agencies."

34 Fleming, "Social Equity Considerations in the New Age of Transportation: Electric, Automated, and Shared Mobility."

35 Rouse et al., "Preparing Communities for Autonomous Vehicles"; Goldsmith and Gardner, "Prioritizing Public Value in the Changing Mobility Landscape"; Moody, Middleton, and Zhao, "Rider-to-Rider Discriminatory Attitudes and Ridesharing Behavior"; Shaheen et al., "Mobility on Demand Operational Concept Report"; Fleming, "Social Equity Considerations in the New Age of Transportation: Electric, Automated, and Shared Mobility"; Sharon Feigon and Colin Murphy, *Shared Mobility and the Transformation of Public Transit*, 2016.

36 Feigon and Murphy, *Shared Mobility and the Transformation of Public Transit*.

37 Shaheen et al., "Mobility on Demand Operational Concept Report."

38 Ginger Goodin, Richard T Baker, and Lindsay Taylor, "Mileage-Based User Fees: Defining a Path Toward Implementation; Phase 2: An Assessment of Institutional Issues" (Texas Transportation Institute, 2009); "Fixing Funding by the Mile: A Primer and Analysis of Road User Charge Systems," 2019, https://www.nlc.org/sites/default/files/2019-03/Fixing Funding by the Mile.pdf.

Centers for Medicare and Medicaid Services as “durable medical equipment” meant for in-home use only and so there is no insurance reimbursement for wheelchairs designed for transit.[39]

4.1.7 Safety & Discrimination

The research notes that certain users may face safety concerns or discrimination that would discourage their use of smart mobility services. Such concerns relate to the potential deployment of automated vehicles in a subscription and shared format; these can be used as a proxy for future AV concerns. Studies by Brown and Ge show that African American riders, especially males, experience higher cancellation rates and longer wait times for TNC services than other users.[40] Moody, Middleton, and Zhao note that personal safety concerns can be a barrier for women.[41] Ge’s study adds that women can also face discriminatory treatment; it found that women using TNC services in Boston were more likely than men to be driven using longer, more expensive routes.[42] Shaheen et al. note that language and cultural barriers are additional social considerations that can inhibit a user’s comfort with using certain transportation modes.[43] More research is needed around the concerns posed to other at-risk groups such as LGBTQ or indigenous populations.

Equitable access must be considered at all stages of mobility service rollout, from design of new vehicles to the underlying policy regulating how services can operate

4.2 Examine how issues like complete streets, building codes, universal design, and the Americans with Disabilities Act relate to vehicular design and the built environment, and how to ensure enhanced mobility for all current and potential users of the transportation system

As mentioned above, people with disabilities face unique challenges when dealing with mobility in general and smart mobility strategies in particular. Research in this area focuses not only on accessible design for users with disabilities but also on the issue of ensuring access to the app-based platforms needed to utilize these services. Current research shows that equitable access must be considered at all stages of mobility service rollout, from design of new vehicles to the underlying policy regulating how services can operate.

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39 “Fixing Funding by the Mile: A Primer and Analysis of Road User Charge Systems.”
40 Anne Elizabeth Brown, “Ridehail Revolution: Ridehail Travel and Equity in Los Angeles,” 2018, https://escholarship.org/uc/item/4r22m57k; Yanbo Ge et al., “Racial and Gender Discrimination in Transportation Network Companies” (National Bureau of Economic Research, 2016).
41 Moody, Middleton, and Zhao, “Rider-to-Rider Discriminatory Attitudes and Ridesharing Behavior.”
42 Ge et al., “Racial and Gender Discrimination in Transportation Network Companies.”
43 Shaheen et al., “Shared Mobility Policy Playbook.”

4.2.1 Universal Design

Universal design is "the *design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design*.[44]" This concept recognizes that different users have different needs and incorporates this into the design process.[45] Broad universal design guidelines feature seven principles by which to evaluate products: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use. As Bayless and Davidson write, a universally designed HAV would enable all users to independently get in and out of the vehicle, use occupant and mobility aid restraint systems, and communicate with and operate the vehicle.[46] The Disability Rights Education and Defense Fund's Fully Accessible Autonomous Vehicles Checklist provides guidance on designing AVs that can be used by all with a focus on human-machine interface, hardware, and policy and legislation.[47] Claypool, Bin-Nun, and Gerlach found that some industry experts have noted that developing a universally accessible AV will be nearly impossible. Rather, they recommend a "dispatch" model of TNCs

[44] "Principles of Universal Design," United States Access Board, 1995, https://www.access-board.gov/guidelines-and-standards/communications-and-it/26-255-guidelines/825-principles-of-universal-design.
[45] Pierce, Plapper, and Rizek, "Accessible Transportation Technologies Research Initiative (ATTRI): User Needs Assessment: Stakeholder Engagement Report."
[46] Bayless and Davidson, "Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities."
[47] "Fully Accessible Autonomous Vehicles Checklist," Disability Rights & Education Defense Fund, 2018, https://dredf.org/wp-content/uploads/2018/04/DREDF-Fully-Accessible-Vehicle-Checklist-3-5-18.pdf.

that would meet the individual needs of a rider using vehicles that are designed appropriately for various needs.[48]

While universally accessible smart mobility strategies do not yet exist, progress is being made to accommodate users with various challenges. Lyft and Aptiv are collaborating with the blind community to include HAV features for vision-limited passengers such as braille guides in vehicles.[49] May Mobility has designed an HAV prototype that is wheelchair accessible.[50] The Local Motors Olli is another HAV that is designed as a “cognitive vehicle” to communicate on passengers’ terms and can be used by passengers with varying abilities.[51] While these are mainly prototypes, they represent inclusionary practices towards the implementation of more universally designed mobility solutions.

[48] Claypool, Bin-Nun, and Gerlach, “Self-Driving Cars: The Impact on People with Disabilities.”
[49] “Lyft Partners with the National Federation of the Blind and Aptiv in Las Vegas,” Lyft, Inc., 2020, https://www.lyft.com/blog/posts/lyft-aptiv-nfb-low-vision-riders.
[50] Darrell Etherington, “May Mobility Reveals Prototype of a Wheelchair-Accessible Autonomous Vehicle,” TechCrunch, 2019.
[51] “Transforming Transportation for the World’s Aging Population and People with Disabilities,” IBM, 2018, https://www.ibm.com/blogs/age-and-ability/2017/01/06/transforming-transportation-for-the-worlds-aging-population-and-people-with-disabilities/.

4.2.2 Built Environment & Complete Streets

Outside of vehicles, the built environment must be addressed in order to ensure that new mobility services, including AVs, can be enjoyed by all. NACTO's Blueprint for Autonomous Urbanism includes built environment features such as near-level curbs that must be available to ensure accessible boarding.[52] It notes that this can be an issue when TNCs do not have designated drop-off areas and vehicle and curb heights are not standardized. At an information gathering session hosted by the U.S. Department of Labor's Office of Disability Employment Policy[53], a key finding was that accessible sidewalks and bus stops are vital for passengers to get to vehicles comfortably and safely. The session concluded that the built environment must be considered so that people with various disabilities can comfortably navigate to mobility services.[54] Bayless and Davidson add that this includes specific issues for the blind, deaf, hard of hearing, and mobility impaired.[55]

4.2.3 Apps & Information

The research to date notes that apps or other web-based platforms must be accessible for all in order for equitable use. There is a need for an accessible and supportive user interface, including adaptive software.[56] Within HAVs, technology such as automated passenger support and voice command can allow for users with disabilities to operate vehicles in the absence of a driver.[57] The USDOT's Accessible Transportation Technologies Research Initiative (ATTRI) has identified five focus areas that are vital for access to transportation technology: (1) wayfinding and navigational solutions, (2) assistive technologies, (3) automation and robotics, (4) data integration, and (5) enhanced human services transportation.[58] These areas have significant potential to address many of the specific user needs and barriers to improved mobility.

Like universal design for vehicles, the Office of Disability Employment Policy states that universal design principles for learning can be incorporated to make information easily understood by all. Components include plain language and audio/visual cuing for people on the autism spectrum and people with intellectual disabilities.[59] Subryan and Bayless and Davidson discuss accessible wayfinding features such as tactile maps and a Nearby Explorer app that can help the sight impaired navigate to and from mobility services.[60]

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[52] "Blueprint for Autonomous Urbanism – Second Edition," 2019, https://nacto.org/publication/bau2/.
[53] https://www.dol.gov/agencies/odep
[54] "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session."
[55] Bayless and Davidson, "Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities."
[56] "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session."
[57] Bayless and Davidson, "Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities"; Pierce, Plapper, and Rizek, "Accessible Transportation Technologies Research Initiative (ATTRI): User Needs Assessment: Stakeholder Engagement Report."
[58] Pierce, Plapper, and Rizek, "Accessible Transportation Technologies Research Initiative (ATTRI): User Needs Assessment: Stakeholder Engagement Report."
[59] "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session."
[60] Heamchand Subryan, "DR-22 Tactile Maps as Navigational Aids," 2019, http://idea.ap.buffalo.edu/wp-content/uploads/sites/110/2019/08/22.pdf; Bayless and Davidson, "Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities."

4.2.4 ADA Regulations

Under the ADA, people with disabilities legally have a right to access the same transportation opportunities as people without disabilities.[61] However, this does not cover all transportation options. Private TNC companies that claim to be "technology companies" are not subject to ADA rules[62], and the ADA contains exemptions to wheelchair-accessible rules for taxi companies.[63] A forthcoming research paper on LSAVs discusses additional considerations around AVs and physical accessibility.[64] AVs must abide by all applicable requirements under the ADA if they are used to provide public transit services. However, thus far no definition of an ADA-compliant AV exists. Early adopters of LSAVs have prioritized vehicles designed to accommodate users with limited mobility, but none yet meet transit ADA-type standards. Some localities have introduced their own requirements to ensure accessible deployment of AVs and other smart mobility services. Arlington, Texas requires LSAVs to have ramps for deployment, while Jacksonville, Florida included wheelchair users in its assessment of accessibility and LSAVs on its fixed guideway.

Research should be participatory in order to include the voices of those who are directly affected by physical or cognitive accessibility concerns

As noted below, future research around service delivery, design, and policy can help ensure enhanced mobility for all. This research should be participatory in order to include the voices of those who are directly affected by physical or cognitive accessibility concerns.

[61] Claypool, Bin-Nun, and Gerlach, "Self-Driving Cars: The Impact on People with Disabilities."
[62] This is currently being contested in court. See Douglas O'Connor v. Uber Technology, Inc: https://skift.com/wp-content/uploads/2015/07/OConnor-v.-Uber-Technologies.pdf
[63] Bayless and Davidson, "Driverless Cars and Accessibility: Designing the Future of Transportation for People with Disabilities"; Jocelyn K Waite, "Legal Considerations in Evaluating Relationships between Transit Agencies and Ridesourcing Service Providers," 2018.
[64] Coyner, "Low-Speed Automated Vehicles (LSAVs) in Public Transportation."

4.3 Evaluate existing smart mobility policies that seek to incorporate equitable and balanced deployments and how to maximize success and achieve important goals of equity, access and inclusion around automated vehicles and shared mobility

Some of the equity and accessibility challenges previously noted in the current research can be overcome through policy measures. Key findings in the current research show that smart mobility policies have the potential to increase equity and accessibility in a holistic way, from ensuring that services are available and affordable to mandating accessible design of vehicles. While such policies have not yet been widely implemented, they are worth considering as a means of developing best practices for inclusion in mobility services. Current research discusses examples of policies regulating TNCs and other micromobility services that can shed light on best practices for future AV policies.

4.3.1 Public Engagement

Engagement with the public is key to ensure equitable access to services. In New York City, CitiBike deployment included a multi-lingual public engagement effort to determine station siting and allow for public feedback.[65] Inclusionary engagement such as this can also be used for shared mobility services that are not based on service stations. Successful approaches should involve and educate leaders at all levels of government.[66] A number of options for partnerships exist at the city level, such as experimenting with pilot projects, incorporating concepts from innovative mobility into public transit, giving grants or low-interest loans, or becoming a risk-sharing partner in a mobility program.[67] In San Jose, for example, the CIO developed a collaborative pilot process via roundtables and a Request for Information with the City's goals to ensure that new mobility positively impacted the community.[68]

4.3.2 Affordability & Pricing

Subsidies and pricing policies are strategies to obtain more equitable pricing of smart mobility services. Subsidies can particularly benefit low income and rural populations that may not otherwise be able to access services.[69] Several reports stress that subsidies should be used specifically to encourage use of shared options. Zmud et al. and Shaheen et all. recommend subsidizing shared AVs or other shared services, either by pricing lower-occupancy modes or

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[65] Shaheen et al., "Mobility on Demand Operational Concept Report."
[66] "Autonomous Vehicle Policy Framework Summit," 2018, http://www.transpogroup.com/assets/autonomousvehiclepolicyframeworksummit_finalproductreport.pdf.
[67] Center for Automotive Reseach, "Future Cities : Navigating the New Era of Mobility," *Center for Automotive Research. Retrieved from Http://Www. Cargroup. Org/Wpcontent/Uploads/2017/10/Future-Cities_Navigating-the-New-Era-of-Mobility. Pdf*, 2017, 1–40.
[68] "Issue Overview: Economic Development," n.d., https://www.hks.harvard.edu/sites/default/files/Taubman/AVPI/Economic Development Basic.pdf.
[69] "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session"; Susan Shaheen et al., "Travel Behavior: Shared Mobility and Transportation Equity," 2017; Eaton, "Autonomous Rural Transportation Challenges and Opportunities in Iinan-Cho, Shimane, Japan."

through other means.[70] The Office of Disability Employment Policy notes that subsidies or discounts can be used to offset any negative costs associated with accessing new mobility solutions.[71] Shaheen et al. further opine that linking smart cards to digital accounts can help to expand access and allow for multiple fare payment methods .[72]

Funds for such subsidies can be raised in several ways. Goldsmith and Gardner note that curb sharing agreements can be established to charge TNCs for loading and unloading and use the resulting funds to subsidize rides for low-income or disabled residents.[73] NACTO and Goodin, Baker, and Taylor write that user fees can also be used to improve equity, for example by supporting transit improvements or other projects benefitting populations that are negatively affected.[74] The National League of Cities recommends instituting policies devoting a percentage of revenues from road user charges towards the development and improvement of rural transit options.[75]

The research agrees that any user fees must be rolled out equitably. For example, the National League of Cities suggests that road user fees could be charged based on rural and urban zones to recognize that rural drivers must often drive farther to get to their destinations.[76] It also suggests that road user charges could be structured in a progressive manner or even be eliminated for drivers who live in households under a specified income level. Shaheen et al. recommend that affordability should be a key performance measure for smart mobility strategies such as shared automated vehicles.[77]

4.3.3 Equitable Service Delivery

Aside from being affordable, services must be equitably available for all that need them. Incentives and requirements can be used to ensure equitable service distribution. Goldsmith and Gardner and Shaheen et al. suggest that shared use mobility operators could be incentivized to operate in potentially less profitable areas by offering higher vehicle caps or risk sharing partnerships with municipalities.[78] Shared use mobility agreements could require that operators locate their services in transit-poor neighborhoods as a condition for operating in the public right-of-way.[79] However, Goldsmith and Gardner note that such provisions do not always compel companies to adequately serve underserved areas.[80]

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70 Zmud et al., “Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies”; Shaheen et al., “Travel Behavior: Shared Mobility and Transportation Equity”; Susan Shaheen et al., “Mobility on Demand: A Smart, Sustainable, and Equitable Future,” *Transportation Research Circular*, no. E-C244 (2019).
71 “Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session.”
72 Shaheen et al., “Travel Behavior: Shared Mobility and Transportation Equity.”
73 Goldsmith and Gardner, “Prioritizing Public Value in the Changing Mobility Landscape.”
74 “Blueprint for Autonomous Urbanism – Second Edition”; Goodin, Baker, and Taylor, “Mileage-Based User Fees: Defining a Path Toward Implementation; Phase 2: An Assessment of Institutional Issues.”
75 “Fixing Funding by the Mile: A Primer and Analysis of Road User Charge Systems.”
76 “Fixing Funding by the Mile: A Primer and Analysis of Road User Charge Systems.”
77 Shaheen et al., “Mobility on Demand: A Smart, Sustainable, and Equitable Future.”
78 Goldsmith and Gardner, “Prioritizing Public Value in the Changing Mobility Landscape”; Shaheen et al., “Travel Behavior: Shared Mobility and Transportation Equity.”
79 Shaheen et al., “Travel Behavior: Shared Mobility and Transportation Equity.”
80 Goldsmith and Gardner, “Prioritizing Public Value in the Changing Mobility Landscape.”

Policies can be put in place to ensure that services reach the unbanked and people without internet access. Shaheen et al. suggest that telephone concierge service, SMS text access, and shared mobility access kiosks can all be used by people without smartphones.[81] In Washington, DC, DC Capital Bikeshare assisted the unbanked by connecting them to financial institutions that could provide banking and debit card access.[82]

Policies can be put in place to ensure that services reach the unbanked and people without internet access

4.3.4 Physical and Cognitive Accessibility

Policies can increase accessibility of new mobility solutions in several ways. In terms of physical access, the Office of Disability Employment Policy writes that Department of Transportation AV regulations could include requirements for full accessibility for all types of common and public-use AVs and should ensure the safety of wheelchair users traveling accessible vehicles.[83] Shaheen et al. suggests that service can be expanded for users with special needs by defining multiple tiers of accessible vehicles.[84] The Office of Disability Employment Policy further notes that policies can also be put in place to ensure accessible infrastructure, such as curb cuts, sidewalks, and bus stops, so that users can access vehicles.[85]

Some policies are already in place to ensure equitable service for users with special needs. Austin, Texas prohibits TNC drivers from refusing to serve or charging higher prices for riders with disabilities.[86] Seattle and Chicago, meanwhile, have used fees to improve wheelchair accessibility services in for-hire vehicles such as taxis.[87] Glennie-Smith notes that the law is trending towards requiring that private TNCs comply with Title III of the ADA as private entities performing a public service or if purchasing new vans for their fleets.[88]

As mentioned above, AV operator licensing requirements can be a barrier for users with disabilities. Several researchers recommend that operator licensing should not be required for HAVs, and states should be prohibited from discriminating on the basis of disability in licensing for their use.[89] Further, in 2016, the USDOT and National Highway Traffic Administration policy guidelines stated that a licensed operator need not be present in a fully automated vehicle once that technology becomes available. Claypool, Bin-Nun and Gerlach recommend that states should align with this federal policy and not impose such a requirement.[90]

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81 Shaheen et al., "Travel Behavior: Shared Mobility and Transportation Equity."
82 Shaheen et al.
83 "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session."
84 Shaheen et al., "Travel Behavior: Shared Mobility and Transportation Equity."
85 "Autonomous Vehicles: Driving Employment for People with Disabilities Information Gathering Session."
86 Shaheen et al., "Mobility on Demand Operational Concept Report."
87 So Jung Kim and Robert Puentes, "Taxing New Mobility Services: What's Right? What's Next?," *Eno Brief*, 2018.
88 Glennie-Smith, "Loopholes, Licensing, and Legislation: Considering the Needs of People with Disabilities in the Autonomous Vehicle Revolution."
89 Claypool, Bin-Nun, and Gerlach, "Self-Driving Cars: The Impact on People with Disabilities"; Henderson and Golden, "Self-Driving Cars: Mapping Access to a Technology Revolution."
90 Claypool, Bin-Nun, and Gerlach, "Self-Driving Cars: The Impact on People with Disabilities."

As vehicles are being developed with higher levels of autonomation, policies can be used to guide this development towards increased accessibility for users with various needs. Henderson and Golden write that requests for proposals providing federal funding for development of AVs should include a requirement incorporating accessibility for people with a range of disabilities. They also write that all technology products such as digital applications should be required to comply with Section 508 of the Rehabilitation Act, which mandates that federal agencies' electronic and information technology must be accessible to people with disabilities.[91] The AV START Act as proposed in Congress, but not passed, sought to codify this.[92] Additionally, it would mandate the involvement of both people with disabilities and AV manufacturers in policymaking decisions at the federal level.

Future research can promote policy best practices to achieve equity and accessibility. Particularly, case studies to standardize definitions around equity, protected classes, and ADA compliance for AVs can spur future regulations for accessibility. Best practices around equity and accessibility metrics would help create targets for successful policy implementation.

4.4 Consider the expected integration of artificial intelligence and facial recognition technologies into automated vehicles

As stated above, discrimination can be a challenge to equity in smart mobility strategies, especially around shared mobility options. In this vein, artificial intelligence and facial recognition must be considered as more automated and algorithm-focused technology features are integrated into mobility services. While they have the potential to remove human biases, current research shows that these technologies are only as equitable as they are programmed to be. Policy makers, system developers, and end users can use these findings to be more aware of barriers to equity in order to improve future performance. Further, there are questions around how and if the underlying programmed code can be regulated, especially when trade secret considerations may exist.

4.4.1 Discrimination in TNCs

Discrimination in TNC services has already been documented: the research shows that this can be by riders towards drivers, by drivers towards riders, or among passengers in a TNC situation.[93] Discrimination against passengers can affect service quality, Ge et al. noted that African American passengers experienced longer wait times and more cancellations for TNC services.[94] It is unclear whether the incorporation of artificial intelligence in AVs would decrease discrimination by removing human bias or exacerbate it by encoding these biases into operating systems: more research is needed regarding this topic.

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[91] Henderson and Golden, "Self-Driving Cars: Mapping Access to a Technology Revolution."
[92] Glennie-Smith, "Loopholes, Licensing, and Legislation: Considering the Needs of People with Disabilities in the Autonomous Vehicle Revolution."
[93] Moody, Middleton, and Zhao, "Rider-to-Rider Discriminatory Attitudes and Ridesharing Behavior"; Scott Middleton and Jinhua Zhao, "Discriminatory Attitudes between Ridesharing Passengers," *Transportation*, 2019.
[94] Ge et al., "Racial and Gender Discrimination in Transportation Network Companies."

4.4.2 Facial Recognition Accuracy

Grother, Ngan, and Hanaoka have shown that technology can be biased against certain groups of people. In their study of facial recognition algorithms, they found that various algorithms had difficulty recognizing faces of people from different races, genders, and ages.[95] Another study by Wilson, Hoffman, and Morgenstern found that pedestrian detection systems are worse at detecting people of color compared to Caucasian people.[96]

In the event that facial recognition is incorporated into AV systems, especially through a fleet subscription format, these systemic biases must be considered and improved upon to ensure equitable, safe service for all. Additionally, there should be considerations around standards for programming such algorithms and the ability to enforce such requirements as such systems become more prevalent.

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[95] Patrick J Grother, Mei L Ngan, and Kayee K Hanaoka, “Face Recognition Vendor Test Part 3: Demographic Effects,” 2019.

[96] Benjamin Wilson, Judy Hoffman, and Jamie Morgenstern, “Predictive Inequity in Object Detection,” *ArXiv Preprint ArXiv:1902.11097*, 2019.

5 Further Research Opportunities

The suggestions below identify topics for future research to inform and focus the important discussion around *Prioritizing Equity, Accessibility, and Inclusion Around the Deployment of Automated Vehicles*. These topics will be evaluated by the Forum in coordination with the appropriate TRB Committees and staff to determine which topics can be expanded into more detailed research statements and proposals. Where possible, crossover to other Topical Papers has been identified to assist with the development of more robust and cross-issue research statements.

Subtopic	Research Opportunity	Crossover to Other Topics
4.1	Develop strategies for using AVs to increase service in underserved areas including rural geographies and best practices for facilitating fare subsidies.	*Social Impacts*
4.1	Compile case studies on approaches to addressing digital access and unbanked in fare payment including Mobility as a Service / Mobility on Demand approaches for AVs and shared mobility.	*Social Impacts*
4.1	Assess impact of AVs and shared mobility on costs, travel time, and reliability for paratransit service.	*Social Impacts, Land Use*
4.1	Investigate equity implications of HAV service including effects related to land use (e.g. charging, storage, density, housing) and strategies to maximize access and mitigation inequities.	*Land Use*
4.2	Create model standards and/or identify best practices in wayfinding including signage, haptics, AV/augmented reality and pick-up and drop-off for AVs and other shared mobility applications (including transit). Assess practices and technologies developed and deployed in projects in federally funded grant programs including ATTRI, Integrated Mobility Innovation, Accelerating Innovative Mobility, and advanced driving system programs, as well as the Small Business Innovation Research program and National Science Foundation-funded research.	*Social Impacts, Infrastructure*
4.2	Identify barriers to access to AVs for persons with disabilities including design, licensing, safety operator specifications, and the like as well as infrastructure considerations including facilities.	*Social Impacts, Transit, Infrastructure*
4.3	Develop ADA guidance for all types of AV vehicles including purpose built, electric, and light duty vehicles (vans and sedans).	*Social Impacts, Transit*
4.3	Identify best practices for community and stakeholder outreach for deployments with focus on equity and accessibility.	*Social Impacts, Safety*
4.3	Identify best practices in participatory design by persons with disabilities in both creation of standards for shared mobility and AVs.	*Social Impacts, Safety*
4.3	Establish metrics for inclusion, equity, and access to AV and shared mobility service.	*Social Impacts*
4.4	Identify discriminatory practices within TNC services, include engagement with LGBTQ and indigenous communities, and identify metrics for assessing bias or discrimination.	*Data Sharing*

6 Appendix

A. Definition of Terms

ADA	Americans with Disabilities Act
ADS	Automated Driving System
AV	Automated Vehicle
EV	Electric Vehicle
FTA	Federal Transit Administration
HAV	Highly Automated Vehicle
LSAV	Low-Speed Automated Vehicle
MaaS	Mobility as a Service
NHTSA	National Highway Traffic Safety Administration
ODD	Operational Design Domain
OEDR	Object and Event Detection and Response
SAE	Society of Automotive Engineers
TNC	Transportation Network Company
USDOT	US Department of Transportation
VMT	Vehicle Miles Traveled

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Principal Research Manager: Greg Rodriguez, Stantec, Mobility Policy Principal
Principal Research Coordinator: Pamela Bailey-Campbell, Stantec, Senior Transportation Strategic Advisor
ARA Research Lead: Jason Bittner, Principal and Practice Area Lead
Researcher: Jennifer Shriber, Stantec, Transportation Planner
Researcher: Sophia Constantine, Stantec, Researcher
Principal Investigator: Kelley Coyner, Innovation4Mobility

Subject Matter Expert for this Topical Paper: Frank Domingo, Stantec, Senior Project Manager