The Road to Transport Equity: Automated Driving and the Pursuit of Inclusive Urban Mobility

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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To improve transportation efficiency, sustainability, health, and equity, planners can better accommodate pedestrians, cyclists, and public transit passengers. Engineers can optimize vehicles to reduce greenhouse gas emissions and energy consumption, while policymakers can pursue measures that improve transport equity, by considering time, affordability, safety, accessibility, and health for all. Transportation accounts for about 64 percent of global oil consumption, 27 percent of all energy use, and 23 percent of world CO2 emissions (Mead 2021). These burdens exacerbate health effects, climate change, and inequality.

Some experts contend that automated vehicles, including so-called "autonomous" vehicles, can make important contributions to these needs. Though highly automated vehicles are often called "autonomous vehicles" (AVs), they are more accurately termed robotic vehicles. A truly autonomous vehicle would have a will of its own, but a successful AV acts only under the intentions of its human occupants, programmers, and supervisors.

As technology companies develop vehicle automation, social groups compete to determine how automated vehicles (AVs) will fit into mobility systems, and how or if AVs can contribute to a more equitable mobility future. Social groups disagree about robotic vehicles and their capacity to promote equitable urban mobility. Some argue that robotic cars can promote equitable mobility, but others contend that they are a grave threat because they divert research attention, money, and other resources away from the best means available to us to improve transport equity. Equitable mobility offers practical means of mobility for all, taking into account affordability, safety, and accessibility. Historical cycles of racism and discrimination in urban planning have caused disparities in transit, exacerbating inequities associated with income, sex,

age, race, disability, and migrant status (Hidayati, et. al.). If these factors are not adequately considered and planned for, the technology cannot be equitable.

While some participants claim AVs can promote equitable mobility, robotic vehicles can not significantly contribute to equitable mobility, especially with the current infrastructure and regulations in place. To better contribute to a more equitable urban mobility future, emphasis should be placed on promoting current public transit systems and potentially using robotic vehicles to augment existing sustainable transport.

I. Review of Research

Researchers have evaluated robotic vehicles' capacity to contribute to equitable mobility. Specifically, it is essential to determine how AVs will affect transport-disadvantaged people, such as low-income people, racial minorities, immigrants, women, people with disabilities, seniors, teenagers, and rural residents (Wu, Cao, & Douma 2021). Emory, Douma, and Cao (2022) found that policies addressing accessibility and economic impacts are the most common, while there is little emphasis on low-income communities, people of color, rural communities, and interpersonal security. They further state that without proper policy interventions, AVs generate serious equity concerns.

Some researchers claim that robotic vehicle technology could improve urban transportation mobility. Rahman & Thill (2023) claim that the "main anticipated strengths associated with AVs include delay and congestion reduction, increased accessibility and mobility, travel cost savings, and revenue generation for ride-sharing companies." However, they also acknowledge that some potential downsides could include "higher vehicle purchase costs and higher VMT, while critical threats would consist in an increase in travel demand and a reduction

in public and active transportation," but overall they claim that the benefits outweigh the downsides. Claypool, Douma, & Cao (2021) contend that autonomous vehicles offer significant potential for reducing transportation obstacles for people with disabilities. They contend that the disability community needs "to organize, learn more about the [AV] technology, and enhance its advocacy efforts." These researchers focus on the potential benefits of robotic vehicle technology for equitable mobility, but they fail to consider how the technology will work with current infrastructure and policies, and they do not provide a reliable timeline for how long it could take for the technology to be sufficiently developed and incorporated into society.

Many researchers claim that AV technology could benefit urban mobility but only if incorporated into existing urban transportation systems. Wen (2019) contends that AVs should augment existing modes of sustainable transport, such as public transportation, since they are "more acceptable to all the stakeholders and respects the social-purpose considerations such as maintaining service availability." Fulton, Mason, & Meroux (2017) examined the three revolutions (3R) in urban transportation- automation, electrification, and, ride-sharing- and claimed that "... a 3R scenario … of shared vehicle trips, public transport, and active travel use can provide high quality and sufficient urban mobility." Petrovic, Mijailovic, and Pesic (2022) examine how AVs are perceived by persons with physical disabilities and conclude that many people in the community believe the best solution is "introducing AVs in the public transport system following accessibility, reliability, and safety principles". According to Wadud, MacKenzie, & Leiby (2015), a "shift over time from privately owned, privately used vehicles to a shared-use system with some automation might decrease energy, vehicle travel, and emissions in several ways." These studies realistically address the lack of infrastructure necessary for AVs to beneficially impact mobility and offer possible approaches to further existing transit options,

but they do not adequately consider any possible alternatives that would better equitable mobility.

Other researchers doubt that current robotic cars can contribute to equity in urban mobility. Sparrow and Howard (2020) examined AVs' economic implications for road transport and their consequences for mobility equity and concluded that introducing robotic cars to the current market will only "reproduce and/or exacerbate existing inequalities." Creger et al. (2019) examine how the "autonomous vehicle revolution could lead us to transportation hell, with a growing mobility divide between haves and have-nots." Wadud, MacKenzie, & Leiby (2015) analyzed the wide range of impacts AVs could have on energy consumption and carbon emissions and found that "vehicle automation may increase travel by specific user groups not actively driving, increasing demand beyond that captured by the response of current drivers." The analysis contends that robotic vehicle technology will increase travel and energy demand, creating a Jevons paradox, which occurs when the pursuit of increasing efficiency actually increases the overall consumption of resources, instead of saving them (Jevons 1865). These studies contend that AVs will not satisfactorily benefit urban mobility and that the technology will even perpetuate existing inequalities.

II. Technology Companies and Industry Perspective

From an industry perspective, technology companies advocate for the benefits of robotic vehicles to equitable mobility. The National Association of City Transportation Officials, a professional association, claims to support "an autonomous future that enhances all aspects of cities' transportation systems, from improving safety for all road users, re-balancing the use of the right-of-way, and expanding mobility for all" (NACTO 2020). Cruise and its parent

company, General Motors, develop vehicles capable of automated driving and have a business interest in promoting them. In its public relations, Cruise claims it seeks to "build a better, more accessible product for our riders," (Lee 2023). The Coalition for Safe Autonomous Vehicles and Electrification (SAVE), a professional association, states that "AVs can provide a new, affordable mobility option for those who are unable to drive" and that they "can reduce transportation barriers in underrepresented communities." Likewise, Partners for Automate Vehicle Education (PAVE), another professional association, states "Mobility experts see automated vehicles as an important new opportunity for [those with disabilities, seniors, and those who can't afford a personal vehicle], many of whom could, enjoy the same freedom and economic opportunity that most of us enjoy." PAVE does not identify any sources for the "mobility experts" however.

These participants claim to advocate for AVs but fail to address concerns regarding associated costs adequately. Also, much of the focus of these groups is addressing accessibility, but they fail to consider other prominent factors affecting equitable mobility, like race or socioeconomic status. Robotic vehicle technology companies continue to pander to communities, like people with disabilities or the elderly, but they do not provide realistic implementations of the technology, nor do they provide concrete evidence on whether AVs will actually improve mobility for these groups. Without adequately considering all factors when designing or endorsing robotic car technology, it cannot contribute positively to a better equitable mobility future.

III. Social Groups on Accessibility

From an accessibility perspective, participants have varying claims regarding whether robotic cars will promote or negatively affect equitable urban mobility. Some participants claim

that robotic vehicles will improve accessibility and thus equitable mobility. The National Federation of the Blind, an advocacy, states that it supports “the transformative capabilities fully autonomous vehicles can and will have on the lives of the blind,” (Riccobono 2022). The U.S. Department of Transportation’s Federal Highway Administration (2024) claims that “people who are disabled, unable to drive to work or have other barriers will be able to travel in a much safer way” with automated driving systems. Anni Chung, the president and CEO of Self-Help for the Elderly, supports AVs as “one of the great equalizers when it comes to safety benefits and transportation access for our senior communities.” Similarly, From the Blind and Visually Impaired, San Francisco CEO Sharon Giovinazzo asserted that "Waymo has offered me, as well as many other individuals with visual impairments, unparalleled independence and safety," (Kelly 2024).

Participants raise concerns about robotic vehicle technology further perpetuating accessibility inequities in transportation. The Disability Rights Education and Defense Fund contends to be concerned with “bias within pedestrian detection and collision behavior algorithms, lack of disability representation in the datasets used to train and test AVs, and the need for ethics frameworks that give full recognition to disabled people’s humanity and fundamental rights,” (Moura 2022). The Urban Institute (2022), a think tank, endorses AVs as vehicles that “could improve transit access for people with disabilities if regulated appropriately,” but warns that “if deployed haphazardly with inadequate oversight and regulation, they could produce even worse inequities than those caused by the current system.”

IV. AVs and Socioeconomic Status

Participants contend that robotic vehicle technology cannot satisfactorily alleviate financial barriers, especially without the proper social equity policies in place to reduce AV costs. An analysis of robotic vehicle-related infrastructure investments will be necessary to examine the fiscal impacts of widespread AV adoption, like parking structures, high-occupancy toll lanes, congestion pricing, gasoline taxes, and similar strategies (APA 2018). Robotic vehicle technology also cannot adequately benefit rural communities, which face distinct transportation challenges due to a lack of accessible and affordable transit. AVs raise equity concerns regarding the rural-urban divide and the increasing suburbanization of poverty, requiring more research to determine how these issues will be impacted or perpetuated (APA 2018). Urban Institute contends that "inequality could worsen because of the prohibitively high cost of purchasing autonomous vehicles" and that "increased access to self-driving cars might reduce demand for public transit… [which] could increase overall transit costs for low-income households" (Stacy & Meixell 2018). Austin Russell, CEO of lidar sensor company Luminar, stated "People think that they'll go and buy autonomous cars. That's not going to reflect reality. Current lidar systems simply aren't reliable enough, and making them more reliable will drive up costs." Russell asserts that the first generation of truly autonomous vehicles could cost anywhere from $300,000 to $400,000 apiece (Edelstein 2018).

V. Safety Concerns

Many participants state that robotic vehicle technology presents severe safety concerns, resulting in poorer mobility. Advocates for Auto and Highway Safety (2024) contend that "currently [AVs] are being developed and deployed in a way that is insufficient to protect those in AVs and other road users." The Network for Safety in Our Streets & for Working People, a

coalition of San Francisco residents, safety advocates, and workers, demands an immediate ban on self-driving taxis, accusing the companies that operate them of endangering public safety (Kelly 2024). The organizer of the group, Edward Escobar, stated “We cannot afford another catastrophe by these vehicles. We demand that Governor Newsom remove all Waymo self-driving taxis from the streets of San Francisco and California immediately.” The group was also backed by the Alliance for Independent Workers and United Front Committee for a Labor Party who stated “We believe that self-driving cars are a threat to the public interest and the common good” (Kelly 2024).

VI. Public Distaste & Protest

Some social groups have asserted their dislike and distrust of robotic vehicle technology through activism. Los Angeles protestors gathered outside Google headquarters in October 2023 to denounce AVs, chanting and holding signs with phrases like “Waymo? Hell No!” and “No drivers, no peace” (Sharp 2023). Safe Street Rebel, an anonymous activist group in San Francisco, has been gaining traction for protesting AVs through “coning”. The group disables as many AVs as they can by placing a cone on the hood of the robotic vehicles, putting them into panic mode, and thus shutting down the vehicle until an employee manually fixes it. According to Safe Street Rebel (2024), the group “fight[s] for car-free spaces, transit equity, and the end of car dominance. People, community, and park space must be prioritized over polluting, dangerous & murderous vehicles.” An extreme case was seen in February 2024, when a Waymo robotaxi was vandalized and set on fire by a crowd of people in San Francisco. While this drastic form of protest does not address the majority of social groups opposing robotic vehicle technology, this does show evidence of controversy and disapproval of AVs.

VII. Integration of AVs with Current Mass Transit Systems

Given the current infrastructure and regulations, the evidence shows that AV technology cannot sufficiently address the systemic inequities present in urban mobility. The American Planning Association, a professional organization representing urban planners, claims that AVs are "a disruptive, society-changing technology, not just for planning and placemaking, but for employment; social engagement; mobility; and a range of physical, social, and economic factors" (APA 2018). Advocates for Highways & Auto Safety, a professional association, states that "currently [AVs] are being developed and deployed in a way that is insufficient to protect those in AVs and other road users." A more effective approach involves integrating AVs into current bus and shuttle services to better equitable mobility without being unrealistic or increasing congestion. NACTO (2019) claimed that cities should engage with technology companies to incorporate robotic vehicles into existing urban transit systems, thus decreasing vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions.

Many AV policies recommend a "Mobility as a Service" (MaaS) model, which integrates various forms of transport into a single, comprehensive service. This includes public transit, walking and biking routes, ride-sharing services, and more. MaaS emphasizes convenience and flexibility for users by allowing users to choose the most suitable and cost-effective modes for their journey. The MaaS Alliance (2022), a professional association, claims to be "dedicated to creating and advancing the foundations for a common approach to MaaS." With the "advent of on-demand autonomous vehicles, [which] requires a rapid and responsive app-based system" and thus a "big opportunity for travelers with disabilities", the MaaS Alliance (2021) asserts that this directly correlates to "the core principles underpinning MaaS, that of customization and

personalization based on user preferences and habits." Toyota Motor North America (Toyota 2022) has begun to modify their 2022 Sienna minivans by "adding a vehicle control interface, to create a new vehicle platform compatible with third-party autonomous driving kits and sensors ("Autono") for use in Mobility-as-a-Service (MaaS) applications" resulting in the new Toyota Sienna Autono-MaaS.

Prototype AV shuttle services have begun testing on college campuses and in cities to provide first or last-mile connections to other public transportation in the area. Local Motors Industries, the parent company for Olli, an AV shuttle bus company in the Washington D.C. area, claims that "... Olli isn't a replacement of one specific type of transportation, but an enhancement of a multimodal transportation system," (Zaleski 2019). Navya, another self-driving shuttle company states that their "Autonom Shuttle Evo guarantees autonomous transport performance as well as a comfortable trip for the first and last mile, thanks to its gentle navigation." Delaware Department of Transportation (DelDOT) has begun to pilot test DelDOT AV Shuttles " to understand its function in the larger transportation network and to gauge the public's response to the shuttles."

VIII. Robotic Vehicles vs. Current Public Transit Systems

It is necessary to determine if robotic vehicle technology is even the best approach to bettering mobility equity. As seen above, some participants contend that the integration of AVs with current mass transit systems is an adequate approach to bettering equitable urban mobility. However, compared to public transit, ride-shared AVs only provide equal or lesser access to jobs on average compared to other high- or middle-fare modeled scenarios (Kovalski et al 2023). Thus, employment accessibility would only expand if riders were willing to pay more, which is

not feasible for those of lower socioeconomic status. Also, comparing ride-hailed AVs with human-driven ride-hail, AV ride-sharing fares are projected to be similar to or even more expensive than current options (Kovalski et al 2023). This analysis asserts that current ride-sharing options with human drivers are more beneficial for equity than AV ride shares.

Rather than focus on cars, social groups maintain that public transit, walking, and biking are the most sustainable forms of transportation, and thus the best approach to bettering equitable mobility due to the interconnectedness of sustainability and other factors. NACTO (2020) claims "Pooled ride-hail trips still pollute more than even private cars do. What works? Designing streets that prioritize people walking, biking, and taking transit." The Active Transportation Alliance (2016) asserted that despite claims that AVs will be "deployed like an extensive, flexible transit system that results in people owning fewer cars", communities "worry about exacerbating car-dependent land use patterns that make it more difficult to walk and bike places, and an erosion of public transit ridership caused by competition from autonomous cars."

Denver Streets Partnership (2021), advocating for people-friendly streets, asserts that "America's car-based transportation system erects barriers to mobility that reinforce long-term social inequities. Transit investment must remove these barriers and prioritize the needs of Black, brown, and low-income people who stand to gain the most from better service." Another advocacy, Pittsburghers for Public Transit (PPT) claims to "organize for an expanded, affordable, and accessible public transit system that meets all needs, with no communities left behind." In 2021, the group successfully prevented the Mon-Oakland Connector, an AV micro-transit project. Laura Wiens, executive director of PPT, stated "The City claims that the Connector will enhance the mobility options and transportation for the working class and underserved

community within that corridor. But they will see very little benefit from a micro-transit shuttle project pilot" (TransitCenter 2021).

IX. Conclusion

Despite claims that robotic vehicle technology can promote equitable mobility, the evidence proves that AV technology alone cannot sufficiently address the systemic inequities present in urban transportation. The emphasis on robotic vehicles overlooks existing sustainable modes of transportation, such as public transit, walking, and biking, which have been advocated for by many social groups as more equitable alternatives. Proponents of robotic vehicle technology continue to pander to marginalized communities by claiming advancements to transit equity, but evidence shows that AV technology can not satisfactorily improve urban mobility and that it could even perpetuate existing disparities. Prioritizing improvements and expansion in public transit infrastructure and possibly integrating AVs into current mass transit systems is the most promising approach to enhancing mobility equity. To address the issues of equitable urban mobility, policymakers, planners, and engineers must adopt an interconnected approach that considers not only technological advancements but also social, economic, and environmental factors. This approach should prioritize investments in public transit, pedestrian-friendly infrastructure, and policies that promote equitable access to transportation for all members of society. Further work is needed to better understand the implications of robotic vehicle technology on equity, through policy innovations, community engagement, infrastructure investments, and feasibility studies.

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