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“Don’t Keep Us Out of the Revolution!”: Accessibility and Autonomous Rideshare in California

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16. Abstract

Robotaxi services, or rideshare operated by autonomous vehicles, present an opportunity for independent and convenient transportation for people with disabilities. The proliferation of robotaxis in California has been met with mixed reactions from the disability community. To better understand perceptions of and expectations for robotaxis, this report uses semi-structured interviews with representatives from disability advocacy organizations. For many people with disabilities, especially for people with intellectual, developmental, and/or physical disabilities, robotaxis are inaccessible. Given the intricacies of accommodating a wide audience, not all interviewees were confident that robotaxi design and programming will be inclusive. Some interviewees trusted that autonomous vehicle companies will independently pursue accessibility features in their robotaxis. Other interviewees regarded statewide accessibility standards as essential to ensure accessibility. Overall, interviewees shared that people with disabilities want to be included in the process of designing, testing, and regulating robotaxis.

Implications for accessible robotaxi governance in California is presented, with an emphasis on wheelchair access, considering impact on public transportation service, and centering people with disabilities. Interviewees also discussed ideal accommodations that would allow a broad audience to request a ride, board the robotaxi, communicate with the operation system, and exit the vehicle. These findings may be useful to AV companies as they consider how robotaxis can accommodate people with a variety of disabilities.

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About the Pacific Southwest Region University Transportation Center

The Pacific Southwest Region University Transportation Center (UTC) is the Region 9 University Transportation Center funded under the US Department of Transportation's University Transportation Centers Program. Established in 2016, the Pacific Southwest Region UTC (PSR) is led by the University of Southern California and includes the following partners: California State University, Long Beach, Northern Arizona University, Pima Community College, University of California, Berkeley, University of California, Davis, University of California, Irvine, University of California, Los Angeles, University of Hawaii, and University of Nevada, Las Vegas.

The Pacific Southwest Region UTC conducts an integrated, multidisciplinary program of research, education and technology transfer aimed at *improving the mobility of people and goods throughout the region.* The program is organized around four themes: 1) technology to address transportation problems and improve mobility; 2) improving mobility for vulnerable populations; 3) Improving resilience and protecting the environment; and 4) managing mobility in high growth areas.

US Department of Transportation Disclaimer

Disclosure

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My work with the San Francisco Municipal Transportation Agency inspired this research. I am very appreciative of the Accessible Services staff and the valuable learning opportunity provided to me during my internship.

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Executive Summary

People with disabilities frequently experience discrimination, harassment, inaccessibility, and inconvenience in transportation, and on average, they make fewer trips per day than able-bodied people (Bureau of Transportation Statistics, 2022). As autonomous vehicle (AV) technology advances, the disability community, researchers, industry experts, and government agencies are discussing robotaxis – rideshare operated by autonomous vehicles (AV) – as the ultimate mobility solution for people with disabilities. Robotaxis can be called immediately, provide door to door transportation, and do not require interaction with another person. They have the opportunity to improve safety and quality of life for people with disabilities.

Several AV companies are operating robotaxi services in California, and as these operations have expanded, several questions are brought to light: Who is able to ride in a robotaxi? How safe are robotaxis for disabled people? The future of accessible robotaxis is uncertain for two reasons. First, people with disabilities have a variety of body shapes, body sizes, abilities, and mobility aids that need varying methods of accommodation. Second, there are no enforceable federal or state requirements for robotaxis to be accessible. As AV companies continue to work on robotaxi design, it is uncertain if or how the diverse needs of people with disabilities will be accommodated.

People with disabilities face ableism and exclusion, and robotaxis may be no different unless disabled people are actively included in vehicle and policy design. We continue to oppress this marginalized group if their needs and identities are not considered. In an effort to better understand the perceptions of and expectations for robotaxis and as inspired by my work at the San Francisco Municipal Transportation Agency, I spoke to representatives from disability advocacy organizations in California and in the US. Interviews reveal several hopes and fears for the future of autonomous transportation, and they had differing opinions on the role of accessibility regulation. A short summary of interview findings are in Table 1.

Table 1. Short Summary of Interview Findings

What is the outlook for the future of robotaxis and accessibility?	Some interviewees spoke about accessible robotaxis as an inevitability in the future; this confidence may be attributed to their existing relationships with AV companies or a general positive outlook. Other interviewees were skeptical or even fearful of the future of robotaxi access without government-set standards for accessibility.
Who can use a robotaxi?	Current robotaxi design is inaccessible for a lot of the disabled population, especially those with intellectual, developmental, and/or physical disabilities. The cost of a robotaxi ride is another barrier to people with disabilities, who face disproportionate rates of poverty.

Why do some interviewees support accessibility regulation for robotaxis?	Interviewees with concerns about safety, access, and affordability were more likely to be supportive of accessibility requirements for robotaxis. Priorities for regulation are (1) requiring wheelchair-accessible robotaxis (or equivalent service) and (2) including people with disabilities during robotaxi development, testing, and regulation.
Why are some interviewees against accessibility regulation for robotaxis?	Interviewees that were against regulation for robotaxis demonstrated trust in AV companies to pursue accessibility independently. Many of these interviewees have had positive experiences working with AV companies or anticipated that AV companies will realize that serving people with disabilities can be financially successful.
How can robotaxis normalize disability?	If robotaxis are accessible, disabled people will be able to leave the house more often, and able-bodied people will have more interactions with people with disabilities, thus normalizing having a disability.
How did interviewees compare robotaxis to public transportation?	Interviewees anticipate that robotaxis will not present some of the common issues experienced on public transit by people with disabilities. Some interviewees were concerned that robotaxis will take away ridership from transit, which is an extremely valuable resource for the disability community.
How did interviewees compare robotaxis to paratransit?	If robotaxis accommodated people who use wheelchairs, it could be a viable alternative to paratransit, though robotaxis will not be able to help riders board or exit the vehicle or provide social interaction as paratransit staff do.
What are some elements of a completely accessible robotaxi?	A completely accessible robotaxi would have visual, audible, and tactile options to initiate the ride, find the vehicle, and communicate with the system. The vehicle must have an automatic ramp and wheelchair securement system that can be used without an attendant.

While the 8 subjects interviewed do not fully represent disabled people in California, lessons from their interviews provide valuable insight for the future of accessibility and robotaxis. Based on these findings, I present five recommendations for the future of accessible robotaxis, as summarized in Table 2.

Table 2. Short Summary of Recommendations

Pursue Wheelchair Access (Or Equivalent Service)	Wheelchair access is a priority for the disability community, and this shared desire points to potential widespread political support for a statewide requirement for wheelchair access. Any AV company that provides quality wheelchair access will be very popular with the disability community.
Identify Initial Target Audience	If industry experts, researchers, policymakers, and people with disabilities established a target audience to initially design for, it would help AV

	companies focus accessibility efforts. The target audience should later be expanded to include a broader range of riders.
Include People with Disabilities in Vehicle and Policy Design	Waymo and Cruise work with the disability community, but interviewees desired more involvement. Given that the needs of disabled people vary wildly, AV companies should ensure they are hearing from many different individuals. The state should consider measures that invite people with disabilities to actively participate in rulemaking that supports their needs.
Consider Impact To Public Transportation And Paratransit	Many people with disabilities depend on public transportation, and their mobility is threatened if public transportation is defunded and robotaxis do not serve their needs. The CPUC could pursue a program similar to TNC Access for All to fund accessible robotaxis and public transportation. Robotaxi operations may be more supported if their operations are maximized to fill gaps in existing public transit and paratransit.
Educate and be Transparent with the Public	Public information campaigns can help to demystify the highly technological aspects of robotaxis. The public also deserves information on robotaxi regulation that is easy to understand and to access, and with this knowledge, people with disabilities will be empowered to know when they are being appropriately served or lacking accommodations.

Introduction

More than 7 million Californians live with a disability (Center for Disease Control, 2023). For many, transportation is a barrier to accessing jobs, school, healthcare, and their social circle. Though transportation agencies are legally obligated through federal legislation to make their systems accessible, people with disabilities have poorer mobility choices compared to able bodied individuals (Taylor et al., 2010). Many struggle to use public transportation, are unable to drive, and face inconsistent or inconvenient service from paratransit. Poor transportation access is part of the reason why disabled adults face higher poverty rates and lower employment rates than adults with no disability (Goodman et al., n.d.), and improved transportation options could radically improve quality of life for this population.

Robotaxis – rideshare operated by autonomous vehicles (AVs) – may revolutionize how people with disabilities travel. In theory, a person with a disability can ride in a robotaxi at any time without fear of discrimination or needing to depend on someone else. Robotaxis are serving communities in the Bay Area and Los Angeles, but there are no federal or state standards that require AV companies to make their vehicles accessible. Thus, the majority of California's disabled population currently cannot use this transportation mode. While the future of accessible robotaxis is uncertain, robotaxis will play a significant role in the future of transportation, and people with disabilities deserve to have similar access that able-bodied people have. As said by Teresa Favuzzi of the California Foundation for Independent Living Centers, "don't keep us out of the revolution!" (Bizjak, 2016).

Robotaxi technology is a polarizing topic within the disability community. Media headlines demonstrate this controversy: "How Passengers With Disabilities Can Drive The Autonomous Vehicle Revolution" versus "Are Wheelchair Users being Thrown Under the (Autonomous) Bus?" (Alexiou, 2021; Ho, 2023). I also witnessed this controversy throughout my internship at the San Francisco Municipal Transportation Agency in the summer of 2023. As a member of the Accessible Services group, part of my role was to speak with disability advocacy organizations about the California Public Utility Commission's decision to allow two AV companies to operate paid robotaxi trips throughout San Francisco. Some people believed that robotaxis are the true mobility solution, while others believed the technology is unsafe and will not serve the diverse needs of those with disabilities. There is limited research that seeks to understand this controversy and how people with disabilities perceive robotaxi technology, especially people who have interacted with robotaxis themselves. This report uses semi-structured interviews with representatives from disability advocacy organizations to better understand how the disability community is thinking about robotaxis, with a lens on AV companies Waymo and Cruise.

In the first section of this document, I discuss the value of this research, existing policies on AVs and accessibility, and current robotaxi operations in California. The following section is a

review of academic and gray literature on people with disabilities, transportation, and autonomous vehicles. The Methodology section discusses my approach to interviews. I then discuss themes that emerged from the interviews and present implications for policy and vehicle design.

Context

This section begins with an explanation of the motivation behind my research and possible uses for my findings. I follow this with a brief discussion of AV policy at the federal and state levels and relevant accessibility policy. This discussion includes California's TNC Access for All Program, which relates to rideshare and accessibility. Finally, I discuss robotaxis in California, which started operating paid trips during all times of day in August 2023.

Research Impetus

Like any new technology, robotaxis have sparked excitement and hope. Many people with disabilities have difficulties with transportation and struggle to find modes that are accessible, convenient, and inexpensive. Much of California is auto-oriented development, so granting a person with a disability access to a vehicle could allow them to more fully participate in society. Robotaxis may be a transportation option that can be used with complete independence. Hypothetically, a person with a disability can call a ride and it will arrive in a timely manner. They will not need to rely on a family member or friend. They will not need to schedule far in advance, as with paratransit. They will not need to interact with a human driver, who may harass, abuse, or discriminate against them.

The disability community has also responded to robotaxis with skepticism and fear. People with disabilities share concerns with the general public about safety, cost, privacy, and impact on the environment. In addition, people with disabilities are concerned if they will be able to ride in robotaxis at all. Given the lack of accessibility regulation and limited accessibility features for current robotaxi design, people disagree if or how robotaxis will benefit people with disabilities. Discussions around access bring up issues of mobility justice: does everyone have the right to ride in these vehicles? Do AV companies have the responsibility to develop vehicles that cater to those with disabilities? How much should the federal and state governments regulate these vehicles? My research takes the approach that people with disabilities should not be left behind, and this skepticism and fear of the future is valid.

There is limited research on the disability community's understanding and expectations of AVs. Troublingly, the majority of existing research on perceptions of robotaxis looks at people with disabilities as a monolith, rather than recognizing the diversity of experiences and identities within the community. There is also limited research on how disabled people who have ridden or interacted with robotaxis perceive the technology.

Thus, my research seeks to understand these differences in hope and expectations for robotaxi design and policy. This report also investigates what accessibility features within robotaxis are a priority for the disability community. If robotaxis are to be sold as a mobility service for people with disabilities, government entities and AV companies must incorporate their perspectives in both regulation and vehicle design. This information may be useful to

policymakers in California and in other states, as they consider accessibility-related robotaxi regulation. Findings will be useful for public information campaigns to demystify technical aspects and address misconceptions. This report will also be a resource for AV companies as they consider how their vehicles will respond to mounting concerns over accessibility.

Existing Policies on Autonomous Vehicles

At the federal level, AVs are regulated by the National Highway Traffic Safety Administration (NHTSA) and the U.S. Department of Transportation (USDOT). NHTSA and the USDOT issued the Federal Automated Vehicles Policy in 2016, which served as guidance but not binding policy. It outlines responsibilities at the federal and state levels. The 2016 policy encouraged AV manufacturers to consider the wide variety of users and their needs, as well as recommending state agencies that represent the aging and disabled communities to work on AV issues (Glennie Smith, 2018). In 2020, NHTSA published "Ensuring American Leadership in Automated Vehicle Technologies: Autonomous Vehicles 4.0," another guidance document that established the U.S. government's three core interests surrounding AVs: Protect Users and Communities, Promote Efficient Markets, and Facilitate Coordinated Efforts. This document discusses freedom of mobility, and says that inclusive design is needed to ensure that AVs serve people with all types of disabilities (National Science & Technology Council & U.S. Department of Transportation, 2020). In 2021, NHTSA issued the Standing General Order that required manufacturers and operators to report crashes that involved AVs.

California is the third state to pass legislation related to AVs (Glennie Smith, 2018). According to state law, the Department of Motor Vehicles (DMV) and the California Public Utilities Commission (CPUC) have permitting authority over AVs. The DMV is tasked with establishing regulations for testing and public use of AVs, and companies must obtain a permit from the DMV to operate robotaxis on public roadways. The CPUC establishes the terms and conditions of these permits. The CPUC also is responsible for establishing accessibility requirements and has adopted an accessibility-related goal: "expand the benefits of AV technologies to all of California's communities, including people with disabilities" (Decision 20-11-046, p. 38). However, the CPUC has declined to officially define "accessibility" and does not enforce any requirements for AV service providers. As a result, AV companies are not required to provide comparable wheelchair accessible service, share timelines for wheelchair-accessible vehicle testing and deployment, engineer robotaxis to drop off and pick up at the curb, or other key services for people with disabilities. The CPUC's AV Accessibility Working Group was established to discuss issues related to people with disabilities using AVs, but this group is no longer active.

Existing Policies on Accessibility

The 1990 Americans with Disabilities Act (ADA) ensures people with disabilities have equal rights and opportunities as able-bodied people. The law prohibits discrimination on the basis of disability. Under the ADA, public transit agencies must provide paratransit services to qualified individuals with disabilities who are unable to use the agency's fixed-route service. While the ADA does not cover robotaxis, we can refer to how the law treats taxis. Title III addresses private entities that provide transportation services such as taxi companies. First, sedan taxis are not regulated by the ADA, and private transportation providers are not required to purchase sedans that are accessible. If the provider purchases a new van, bus, or other vehicle, it must be accessible – which usually means there are wheelchair lifts – unless they can demonstrate that equivalent service is provided. Equivalent service may look like a different vehicle that provides the same services "to the same traveling points for the same cost within the same time frame as a regularly scheduled trip" (Wheel the World, 2023). At the time of writing, Waymo and Cruise only operate sedan robotaxis, and Waymo provides equivalent service through a third party.

The ADA does not specifically cover rideshare, and several court cases involving alleged discrimination have been presented against Transportation Network Companies (TNCs) Uber and Lyft on the basis of the law. In 2020, Lyft reached a settlement agreement with the United States regarding allegations that some of its drivers refused rides to people with foldable wheelchairs and walkers (U.S. Department of Justice, 2020). In November 2021, the Department of Justice filed a lawsuit against Uber, which alleged that the company violated the ADA by charging wait time fees starting two minutes after the vehicle arrived at the pickup location (U.S. Department of Justice, 2022). The Department of Justice argued that Uber did not modify this policy to accommodate people who need more time to get to the vehicle due to a disability. In its settlement, Uber was required to waive wait time fees for riders who certified that they need additional time because of their disability. Additional litigation against TNCs is likely as the applicability of the ADA is not well defined.

The State of California has pursued measures to incentivize the availability and quality of on-demand transportation for people with disabilities. Senate Bill 1376, authored by Senator Jerry Hill (D) and sponsored by Assemblymember Lorena Gonzalez Fletcher (D), established the TNC Access for All Program. The program is administered by the CPUC and requires TNCs to collect a 10 cent fee for every rideshare ride. Part of the funds from this fee are used to reimburse rideshare companies if they demonstrate they are improving access to wheelchair-accessible rides. Any remaining funds are distributed to transportation carriers that provide on-demand wheelchair-accessible rides. Since the Access for All program's implementation in 2019, TNCs have invested $54.9 million into wheelchair-accessible service and outreach, of which 90% went towards costs associated with partnering with a third party that provides wheelchair-accessible service (California Public Utilities Commission, 2024). The CPUC

reimbursed TNCs with $28.1 million for trips within counties that meet certain performance thresholds. More than $23 million has been awarded to regional or local carriers to provide wheelchair-accessible service (California Public Utilities Commission, 2024). The TNC Access for All Program program does not apply to robotaxis.

Robotaxis on Californian Streets

In August of 2023, the CPUC granted Waymo and Cruise permission to operate commercial robotaxis across San Francisco at any time of day. Prior to this decision, both companies operated robotaxi services in the city with certain limitations, such as geographic and time restrictions, conditions during which a safety driver is present, and conditions dictating when fares could be collected (California Public Utilities Commission, 2023). This vote followed a 5-hour hearing during which many members of the disability community submitted comments against and in favor of this expansion of services. Several companies, advocacy organizations, and government entities submitted letters to the CPUC as well.

This was a landmark decision, and robotaxi operations have been expanding across the state since then. In addition to San Francisco, Waymo now operates in 22 cities in San Mateo County and parts of Los Angeles (see Figure 1) (Curry, 2024). Waymo is also allowed to operate robotaxis up to 65 mph on certain highways. Today, several other AV companies have been issued “drivered pilot” permits, and Zoox has been issued a “driverless pilot permit” by the CPUC. The CPUC’s decision and the subsequent events also highlighted disagreements among governing bodies of how robotaxi deployment should progress. In two letters to the CPUC, the San Francisco Municipal Transportation Agency, the San Francisco County Transportation Authority, and the Mayor’s Office on Disability expressed excitement for the technology but shared concerns about rapid expansion of AV service. Instead, the three parties supported incremental deployment to lessen the impact on San Francisco’s transportation network. The letters also raised concerns about transparency of documents and data and the need to monitor robotaxi performance. The three parties also raised several accessibility concerns, including the need to require equivalent service for wheelchair users.

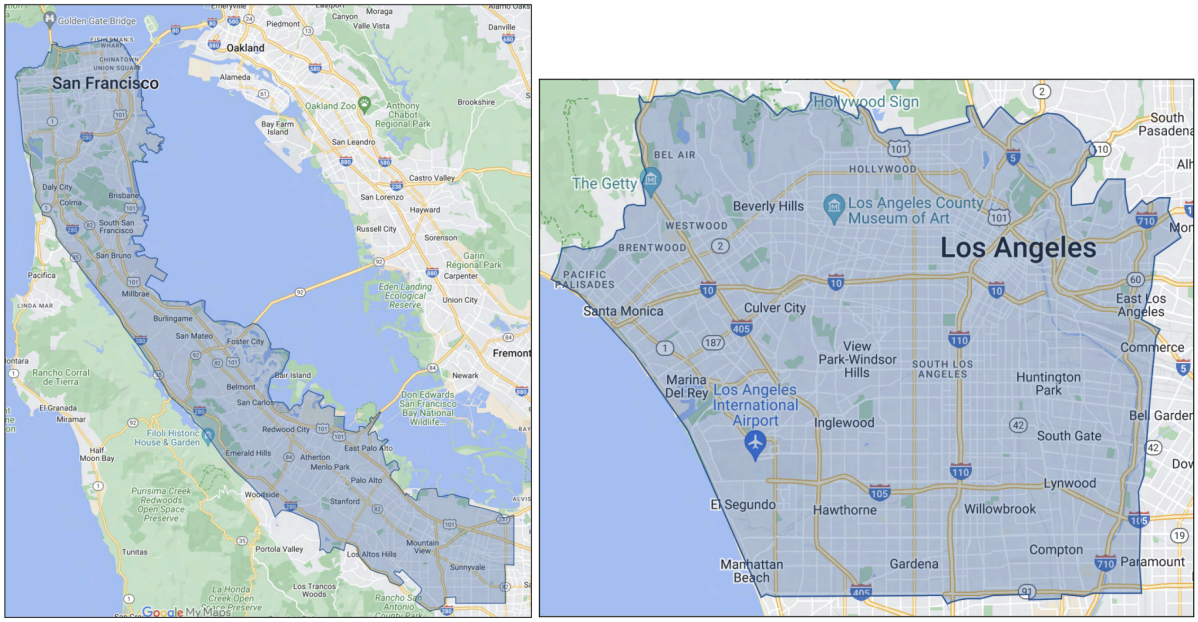

Figure 1. Current operational domain of Waymo (Source: Waymo LLC)

While not required, Waymo and Cruise have taken steps to serve people with disabilities. Waymo provides equivalent service to wheelchair users in non-autonomous vehicles. Cruise has been developing their own wheelchair-accessible vehicle, the Cruise Origin (Figure 2), though this has been put on pause. Both companies have sought feedback from people with disabilities: Waymo partners with disability advocacy organizations through their Accessibility Network, and Cruise has a similar program called the Cruise Accessibility Council.

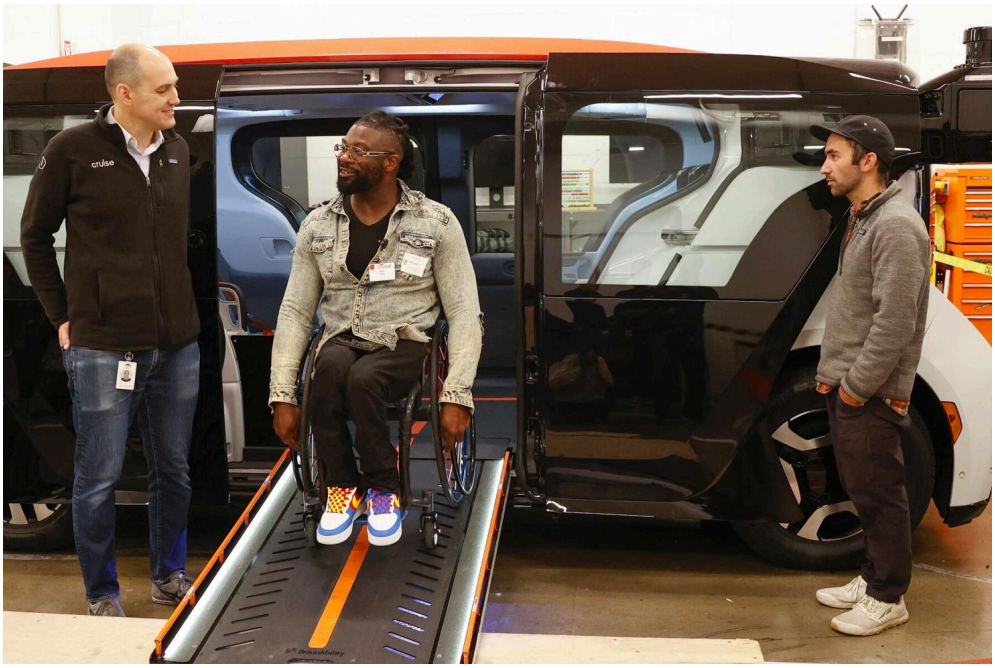

Figure 2. Cruise's wheelchair-accessible vehicle (Source: Craig Lee, The Examiner)

One day after the August 2023 decision, a dozen Cruise robotaxis stalled in the middle of the roadway, blocking traffic for approximately 20 minutes during the Outside Lands music festival in Golden Gate Park. On October 2, 2023, a Cruise robotaxi was involved in a crash with another vehicle and a pedestrian in downtown San Francisco (Cano, 2024). The pedestrian was pinned underneath the robotaxi and dragged several feet. As a result of the crash and Cruise's subsequent response, the DMV suspended all Cruise operations and the CPUC suspended their permits. Cruise halted development on the wheelchair-accessible Cruise Origin and stopped all robotaxi services across the country, though the company is returning to Phoenix streets in human-driven robotaxis in Phoenix in April 2024.

Literature Review

Transportation and Disability

People with disabilities face many barriers to reach their destination. Many are unable to drive and face inconsistent or inconvenient service from paratransit and rideshare. While transportation agencies have made significant strides towards accessibility since the adoption of the ADA, many people with disabilities struggle to use public transportation. Still, people with disabilities are more likely to use public transportation than able-bodied people (Kassens-Noor et al., 2021). People with disabilities often pay more for transportation services and have to plan far in advance (Claypool et al., 2017). People with disabilities may be limited to living in certain locations because accessible transportation options relevant to their needs are not available everywhere (Cordts et al., 2021). Transportation-related social tasks, like asking others for help or a ride, can cause stress or perceived social isolation, which negatively affect travel behavior (Cochran, 2020).

These transportation barriers can lead to a poor quality of life for many people with disabilities. The disability community often speaks of facing a lack of independence and feelings of helplessness, as people with disabilities often need the support of a caretaker to get around (Cordts et al., 2021). Access to healthcare is a high priority for many people with disabilities, but limited mobility can mean that they arrive late or have to cancel appointments (Cordts et al., 2021). Transportation obstacles also significantly impact access to employment opportunities. According to Claypool et al., reducing transportation obstacles could provide new employment opportunities for 2 million people with disabilities in the U.S. (2017). People with disabilities often feel isolated from their communities because they cannot easily travel, which can negatively impact relationships and their social life.

Value of Rideshare for People with Disabilities

Taxis and TNCs constitute a large proportion of daily travel for people with disabilities (Cochran & Chatman, 2021). They use TNCs less than people without disabilities on a monthly basis. There are many reasons for this difference, including concerns of cost, driver discrimination, smartphone access or use, living in a rural area, concerns of navigating pick up and drop off, and inaccessibility of cars (Cochran & Chatman, 2021). People in wheelchairs/scooters cannot ride in standard vehicles which make up the majority of a TNC fleet (Cochran & Chatman, 2021). Wheelchair users and people with service animals may use rideshare services less than people who use white canes and crutches, likely due to driver discrimination. This also shows a latent demand for wheelchair-accessible transportation services.

Potential Benefits of AVs

People with disabilities anticipate that AVs will grant the freedom to travel independently. Riders will not need to own a car, have a driver's license, or be able to physically drive. People with disabilities also look forward to getting around without needing to plan far in advance. Safety improvements are also highly anticipated for both riders and pedestrians, with automated driving technology leading to fewer vehicle crashes (Hwang et al., 2020). The general public expects that robotaxi services will be a cost-saving measure due to the lower costs for labor, though there is also a concern that robotaxis will lead to unemployment for taxi and paratransit drivers (Hwang et al., 2020; Kassens-Noor et al., 2021).

Perceptions and Expectations of AVs

Many studies have investigated perceptions of AVs (Penmetsa et al., 2019). A significant body of literature exists on attitudes towards AVs among people of various disabilities. Many studies group all people with disabilities in their analysis (Hwang et al., 2020; Janatabadi & Ermagun, 2022; Kassens-Noor et al., 2021; Patel et al., 2021), with varying findings of how they feel about AVs. Kassens-Noor et al. find that people with disabilities generally perceive AVs negatively, while Hwang et al. and Patel et al. find more favorable regard for AVs.

Perceptions of AVs are based on many factors. Bennett et al. finds that the likelihood of someone being willing to ride in an AV is significantly influenced by their "hope for future independence, misgivings about safety, and affordability" (pg. 13, 2019). In another study, Bennett et al. discuss how a person's locus of control (or perception that they are able to control events and outcomes), action orientation, and interest in new technology can influence if they see an AV as dangerous. Brinkley et al. also find that level of education influences optimism around AVs - those with higher education levels are more likely to be skeptical (2020).

Through a synthesis of surveys on perceptions of AVs, Janatabadi & Ermagun reveal that people with disabilities are rarely included in survey samples (2022). Janatabadi & Ermagun also find that survey summaries often have a title/abstract that is more positive of AVs than the results indicate (2022). This leads to "imprecise findings and unrealistic depictions of acceptance of autonomous vehicles by the public," which could point to a general belief that AVs could benefit people with disabilities (pg 330).

Concerns and Barriers for People with Disabilities

Anticipation for AVs is dampened by safety concerns about the technology. The disability community has anxieties over potential technological errors, including the operating system's ability to navigate and make judgment calls during emergencies (Hwang et al., 2020). Kassens-Noor et al. find negative perceptions are partly due to a distrust in technology, whether it be mechanical failures, hacking, or a computer malfunction (2021). Studies have also

shown that people with disabilities do not believe that AVs are equipped to serve their needs, from communicating with the rider or accommodating a wheelchair user (Bennett et al., 2020). People with "multiple accommodation needs" are more likely to be hesitant about the safety and capabilities of AVs than able-bodied people (Kassens-Noor, pg 393, 2021).

Some people with disabilities are concerned about the absence of a human driver. While some in the disability community support not having a driver because of the possibility for harassment or discrimination being eliminated, others are concerned about needing human assistance. In a study based on intercept surveys on public transportation, one survey respondent with a mobility impairment shared that they will need assistance if they fall (Kassens-Noor et al., 2021). In the case of microtransit, which is on-demand transportation using minibuses or vans and called through a mobile app, Patel et al. finds a preference for an onboard safety assistance who would not drive but help people board (2021).

AVs use machine learning provided by humans, but limited data samples could perpetuate society's ableist views (Moura, 2022). Moura expresses concerns of algorithmic bias where AVs do not recognize people with disabilities as pedestrians, especially if they look or act in ways that counter what the algorithm expects. An AV may crash into that person if they are not registered as human; Moura provides several cases where an AV advised to drive straight into people in wheelchairs. If a variety of people with disabilities are not included in data that AVs use to learn what pedestrians look like, this algorithmic bias could severely impact pedestrians with disabilities.

Perceptions By Disability Type

Perception studies that do not generalize all people with disabilities into one category are very valuable. Even within these groups, people have very different needs and preferences. There are existing studies that focus on one type of disability, such as physical disability (Bennett et al., 2019; Cordts et al., 2021), visual disability (Bennett et al., 2020; Brinkley et al., 2020; Fink et al., 2021), and intellectual and developmental disability (Bennett et al., 2019). Some studies break down findings by type of disability. Kassens-Noor et al. find perceptions of AVs vary by type of disability (2021). The study suggests that people with visual impairments are more likely to ride in an AV than those with physical disabilities.

Based on interviews, Bennett et al. find that people with physical disabilities have a greater likelihood of having negative or ambivalent feelings towards AVs (2019). People with physical disabilities may have more anxiety around the safety of AVs, whereas able-bodied people are more likely to have concerns about inadequate road environments for AVs and unsafe human drivers. Conversely, Cordts et al. find that people with physical disabilities have a positive outlook on AVs because of their potential to improve safety on the road, and they may pay equivalent or more money to ride in an AV if they were accessible (2021).

People with vision impairments may be more optimistic than people with other disability types or able-bodied persons (Brinkley et al., 2020). Brinkley et al. finds that people with vision impairments are optimistic for AVs to improve their mobility, and this optimism can supersede concerns that accessible technology is underexplored (2020). Conversely, when interviewing people with visual impairments, Bennett et al. finds that participants were skeptical that AVs would be designed with consideration for their needs (2019).

Bennett et al. also investigated the willingness of people with intellectual disabilities to ride in AVs and identified three themes of conversation around AVs: freedom, fear, and curiosity (2019). Study participants indicated a greater value of the freedom that AVs could provide if their disability interfered with their daily lives. Participants that experienced general anxiety or were female were more likely to indicate fear of AVs. Finally, participants with a high locus of control – or a belief that they had control over events or outcomes – were more likely to be curious of AVs and less likely to be fearful. Individuals who were more knowledgeable of AVs were less likely to be fearful and more likely to be curious and place a high value on freedom. Overall, this study reveals that people with intellectual disabilities have a diversity of opinions that are influenced by their locus of control, gender, prior knowledge of AVs, and intensity of their disability.

Universal Design

Rather than adapting AV technology for distinct populations, some researchers and advocates recommend a universal design approach for initial AV design (Claypool et al., 2017, Bayless et al., 2019). Universal design is a concept that attempts to maximize the number of users without specialized design (U.S. General Services Administration, n.d.). Designing AVs in this manner would work to encompass the needs of any AV rider, regardless of if they are disabled or able-bodied. Bayless et al. predict that accessible vehicles will look and operate in a radically different manner from those of traditional vehicles for more people to have access (2019). However, industry experts have said that a universal design approach to AVs is nearly impossible (Claypool et al., 2017). A likely alternative is to dispatch a special accessible vehicle if the rider has specific needs, similar to how TNCs operate now.

Summary of Literature Review Findings

Public transportation, paratransit, taxis, and rideshare are important transportation modes for people with disabilities. Each is not without challenges: from cost to inconvenience to lack of accessible vehicles, people with disabilities face barriers that limit their mobility and thus their health, employment, and social life. Studies on people with disabilities' perceptions of AVs have produced mixed results. Much of the literature, which looks at AVs in general and not robotaxis specifically, identifies several benefits of AVs, including improved safety and independence. On the other hand, studies have identified concerns of safety of the technology,

the absence of a human driver, and accurate detection of pedestrians with disabilities. Overall, perceptions of AVs are influenced by many factors, including the person's hope for the future, affordability, locus of control, and interest in new technology. Perceptions also vary greatly by type of disability, and there are several studies that investigate how people with physical disabilities, visual disabilities, and intellectual and developmental disabilities feel about AVs. However, many of the perception studies do not investigate diversity of opinion by disability type, race, gender, income, or other identities, or they do not include people with disabilities at all.

Methodology

CPUC Hearing on August 10, 2023

I virtually attended the CPUC hearing which approved Waymo's and Cruise's requests to operate paid robotaxi rides across San Francisco during all hours of the day. The majority of the five hour-long hearing was dedicated to public comments, where residents and advocates argued about the role of state regulation regarding robotaxis. I observed this public comment period and took notes on who spoke and their general argument. I also observed the CPUC's vote and final decision.

Interviews

To better understand expectations for and perceptions of robotaxis, I conducted semi-structured interviews with representatives from disability advocacy organizations. First, I spoke with two subject matter experts who have conducted research on accessible autonomous vehicles or related topics. These experts helped to refine my research scope and interview questions. The literature review also informed the topics I investigated during the interviews.

I interviewed seven representatives of disability organizations in the Bay Area or national organizations that have been involved with AV proceedings in California. I had spoken to several of these representatives in the summer of 2023 prior to the CPUC's hearing and knew they were paying attention to how robotaxis are impacting the disability community. I also interviewed one individual who has worked at an AV company on accessibility-related tasks. I reached out to potential interviewees in January 2024 with a request for an interview. I provided my research brief and an agreement of consent in my request, and once they agreed, I interviewed them over the phone, through a video call, or in person. Each interview lasted about an hour. All responses were kept confidential; many of the organizations have received donations or have been sponsored by AV companies, and I wanted to solicit honest opinions without jeopardizing financial standings. The topics of the interview are shown in Table 3. The conversations were semi-structured which allowed for follow-up questions, and I was able to guide the conversation to where the interviewee was most knowledgeable or passionate. The wording of questions evolved throughout the research process, and the final interview instrument is included in Appendix B.

All interviews were recorded using a digital voice recorder and then transcribed manually. To analyze the responses, I conducted a systematic analysis through qualitative coding. I developed a codebook that encapsulated common themes and concepts of the interviewees' responses. I then tagged responses with relevant codes, and organized them in the Results and Discussion section of this report.

Table 3. Topics investigated during interviews

● The organization's official or unofficial stance of AVs ● Involvement in rulemaking on AVs at the state or federal level ● Perceived impacts on people with disabilities, currently and long-term	● Perceived benefits and concerns with robotaxi technology ● Components of a perfectly accessible AV ● Priorities for accessible robotaxi development ● Relationships with AV companies

Interview Subjects

I identified potential interviewees based on what organizations have been active in policy discussions at the state level. Interviewees were also recommended via snowball sampling. The seven disability advocates and one individual I interviewed are described in Table 4. While each interviewee was encouraged to represent the views of their organization during our conversation, some comments came from personal perspectives and experiences.

Table 4. Overview of interviewees

Five interviewees have a disability	**Five** organizations have held events that were sponsored by an AV company
Three interviewees have ridden in a robotaxi	**Four** organizations serve people with any disability
Three interviewees serve on an AV company's accessibility committee	**Three** organizations serve people with a specific disability
Four organizations are based in the Bay Area	

Interviewee 1

Interviewee 1 is the executive director of a Bay Area-based non-profit organization which supports and advocates for people with all types of disabilities. Interviewee 1 has multiple disabilities. They were excited about the possible benefits of robotaxis, and they saw real world testing and some accessibility requirements for robotaxis as the tools to achieve these benefits. This interviewee's organization has worked with an AV company and has been satisfied with that company's outreach to people with disabilities. Interviewee 1 was passionate about the role of the disability community to be advocates in order for diverse needs to be accommodated.

Interviewee 2

Interviewee 2 is the executive director of a national organization that serves blind people and their families. Interviewee 2 is blind. Their organization supports robotaxis because

of their potential to improve independence and mobility of a group that is frequently isolated in their homes. Interviewee 2 has worked with an AV company and has been satisfied with the company's collaborations with people with disabilities. Interviewee 2 had several concerns of the current state of technology for blind and low-vision people, including how a rider would locate their vehicle and how the operating system would react in the case of a medical emergency.

Interviewee 3

Interviewee 3 is the president and CEO of a national organization for people with cerebral palsy and other intellectual and developmental disabilities. While the organization does not have an official stance, Interviewee 3 explained they support robotaxis because they will improve safety and be a low-cost transportation option. Interviewee 3 was especially concerned that robotaxis are not accessible to many individuals.

Interviewee 4

Interviewee 4 is on the leadership team of a Bay Area-based group that politically mobilizes people with disabilities. Interviewee 4 has a disability. Their organization recognizes some of the benefits of robotaxis but is overall skeptical of their safety, citing concerns over pedestrian detection and wheelchair securement. Interviewee 4 was also concerned about the costs of rides. Interviewee 4 was highly in favor of regulating AV companies and robotaxi operations, and they suggested robotaxi trips could be taxed to support public transportation.

Interviewee 5

Interviewee 5 is on the leadership team of a Bay Area-based non-profit organization that supports adults with intellectual and developmental disabilities. Interviewee 5 saw how robotaxis might improve the lives of people they serve, but indicated that collaboration with the disability community and statewide accessibility standards are essential for these benefits to be actualized. From communications to finding the right vehicle, Interviewee 5 had many specific recommendations that would improve the riding experience for people with intellectual and developmental disabilities.

Interviewee 6

Interviewee 6 is on the board of a non-profit organization in California that serves people living with epilepsy. Interviewee 6 does not have a disability. The organization anticipates that robotaxis will improve mobility for people with epilepsy and will improve overall safety on streets in California. Interviewee 6 was confident in the approach AV companies are taking to test robotaxis and was concerned that regulation may inhibit progress. Interviewee 6 also emphasized that robotaxi rides need to be affordable.

Interviewee 7

Interviewee 7 is the executive director of a national association of independent living centers and people with disabilities. Interviewee 7 is a quadriplegic and uses a wheelchair. Their organization has worked with multiple AV companies. Interviewee 7 trusted that AV companies would see the financial benefits of making robotaxis accessible and was doubtful of paternalistic regulations made by able-bodied lawmakers. Interviewee 7 was hopeful that people with disabilities would be less isolated with the improved mobility from robotaxis.

Interviewee 8

Interviewee 8 is an individual who previously worked for an AV company. As a power wheelchair user, Interviewee 8 advised the AV company on wheelchair securement, tested out new designs, and provided feedback. Interviewee 8 typically drives an adapted van but looks forward to riding in a wheelchair-accessible robotaxi. Interviewee 8 brought up concerns about the lack of standardization of wheelchair tie-downs and the challenge of seatbelts.

Results and Discussion

Target Audience and Universal Design

"The disability community is so diverse, and I can't say that any car will serve 100% of the community." – Interviewee 3

Interviewees agreed that the current design of Waymo or Cruise robotaxis accommodates some but not all disabled riders. Within the blind and low-vision community, someone with limited vision can likely use robotaxis. Interviewee 2 said, "is the technology there for someone who is 'lights out blind'? I don't think it is. For someone with more vision, yeah, I think the current state would suffice." Almost all interviewees mentioned the lack of wheelchair access in robotaxis. According to Interviewee 4, people with "physical and mobility disabilities are totally left behind" because they can not board the vehicle. Overall, interviewees identified wheelchair access as a priority for future robotaxi design. Several interviewees were confident that some (if not all) robotaxis would accommodate wheelchair users, partly because companies like Cruise are working on a wheelchair-accessible vehicle.

The future of robotaxi design is uncertain, and the extent to which diverse and severe disabilities will be accommodated will be dictated by AV companies unless enforced through government regulation. As inspired by universal design, Interviewee 2 spoke of accessibility features that can support more than their intended audiences: "A priority should be designing the carriages to be as low as possible and easy access with a ramp. All of that will help anyone in the disability community." Low carriages would also improve the boarding experience for older adults.

Interviewees disagreed on the future of robotaxi design and who will be able to take advantage of the technology. Interviewee 8 framed the question around serving justice for the most marginalized: "The people that stand the most to benefit are people who have the least level of function and the most severe disability. They have less options, so we should be giving them more independence. But it's a harder engineering challenge and a larger liability." Interviewee 8 supports government regulation to ensure that certain groups will not be left out. To accomplish this, Interviewee 8 proposed identifying a smaller set of users to design for first: "we have to draw a line somewhere and say we can design for these kinds of users, and later we can design for others." Interviewee 8 did not share how this group could be defined.

Several challenges exist to accommodate people with diverse and severe disabilities, including the need to accommodate different body shapes, sizes, and abilities, and the lack of standardization of mobility aids. Because of these challenges, Interviewee 1 argued that there "is no one size fits all." Robotaxis have already shown themselves to be useful to the blind and low vision community, but a vehicle that works for people with visual disabilities is not necessarily going to work for someone with a mobility impairment. People's range of

movement are different, bodies come in different sizes, and wheelchairs are built differently. Recognizing this, Interviewee 1 dismissed the idea of a universally-designed robotaxi, instead proposing a range of vehicles akin to the different Uber options by saying, “we are not talking about one model of car but a few different models of car,” and riders can order the model that caters to their needs. Interviewee 3, which recognized that currently “there’s access only to a certain degree of disability,” also was skeptical of the possibility of a car serving 100% of the disability community. The disability community is diverse, and developing a vehicle that can anticipate every need is likely impossible.

Hope for the Future

“I think it’s going to be a gamechanger. Maybe not in my lifetime. But once implemented in the right way – which means a lot of different things – it will serve people with disabilities very well.” – Interviewee 7

Most interviewees spoke with the assumption that robotaxis would eventually be widely available in the Bay Area and beyond. Several saw that these vehicles have the potential to radically improve quality of life for people with disabilities, but this was not definite. For interviewees who had hope but also skepticism for an accessible and autonomous future, they anticipated that minimum requirements for safety and accessibility would play a role. After sharing their concerns about safety, Interviewee 8 said, “the assumption is that [crashes] will happen very minimally, otherwise [robotaxis] won’t be a thing. It won’t be a viable product if people don’t like it or are terrified by it.” They continued by saying, “That means [robotaxis] have to meet some sort of safety threshold to keep people on board,” both physically and as a consumer. Interviewee 5 echoed this sentiment by saying that they were “very hopeful, but quite a bit of work needs to be done.”

Conversely, others regarded accessible robotaxis as an inevitability. Several interviewees said with certainty that robotaxis would be accessible and did not specifically mention the role of regulation to ensure this. Interviewee 3 anticipated all people with disabilities would be able to use the service: “these cars will have accessibility for various disabilities, and 24/7 service.” Interviewee 1 was confident about the progress being made towards wheelchair-accessible vehicles: “One day there is going to be wheelchair accessible vehicles. I look forward to that day.” Interviewee 2 also anticipated that robotaxi technology was on a linear path to continually be improved. They cited existing driver support features - “our vehicle can drive down I-95 on its own” - as a reason why they had a positive outlook. Regarding timing, the representative from Interviewee 7 shared, “I think it’s going to be a gamechanger. Maybe not in my lifetime. But once implemented in the right way …it will serve people with disabilities very well…It’s something I’m looking forward to for the next generation.” Part of this confidence may be attributed to existing relationships with AV companies or a general positive outlook.

One interviewee said several times that "when it comes to robotaxi technology, the train has left the station. You're either on it, or you miss it." This analogy refers to the idea that robotaxi technology is advancing whether stakeholders like disability advocacy groups and leaders were involved or not. This interviewee spoke about a recent technology that was also ridiculed and feared: the bicycle. The interviewee continued by saying, "like anything else, I think it'll catch on."

Regulation, Responsibility, and Trust in AV Companies

"Ultimately it's up to these [AV] companies to do the right thing, but I live in the real world, and corporate America doesn't do the right thing unless they're pressured to do it … and honestly if there's a dollar value to it." – Interviewee 1

Responsibilities of the State Government

Interviewees did not agree on who is responsible for ensuring robotaxis are accessible to a wide swath of the disability community. Some interviewees were adamant about the role of the state government to require AV companies to accommodate people with disabilities. Interviewees that were strongly in favor of accessibility-related regulation saw current robotaxi design as inaccessible to the majority disabled people. Interviewee 5 said, "a lot of regulations need to be in place for our members to be comfortable and to politically support the technology," highlighting that political approval of AV companies hinges on accessibility features. Interviewee 4 is also strongly in support of accessibility regulations and said that AV companies should "not be allowed to expand [operations] until they figure out how to make [robotaxis] accessible." This comment points to the need for AV companies to switch their priorities from expanding their service areas to improving accessibility. Both Interviewees 4 and 5 highlighted minimum accessibility requirements should include wheelchair access or equivalent service.

While Interviewee 1 felt strongly about AV companies having the right to decide how their vehicles serve people with disabilities, they said, "it's up to these companies to do the right thing, but I live in the real world, and corporate America doesn't do the right thing unless they're pressured to do it." The interviewee supports "some baseline requirements for any companies, in terms of providing alternative forms of transportation for whom their vehicles are not accessible." Interviewee 1 cited how Waymo provides free non-autonomous accessible rides because the company does not have a wheelchair-accessible vehicle yet. Interviewee 1 also was in support of AV companies submitting an accessibility plan to the CPUC before operating on public roadways.

Responsibilities of AV Companies

Conversely, several interviewees felt that AV companies have the choice to address accessibility, and regulations that require Waymo, Cruise, or another entity to meet certain

criteria are unnecessary. Interviewee 1 recognized that "[Cruise] is a company, not a charity." However, these organizations had trust that AV companies would pursue accessible vehicle design and programming. This trust came from several sources. First, these companies will recognize that the disabled population is an untapped consumer base. Interviewee 1 argued that, "there is money to be made in serving the disability community. The corporate sector seems to think that people with disabilities make up a tiny percentage of the public, and that's not true." Invisible disabilities and the isolation of people with disabilities lead to underestimation of how large this consumer base is. Interviewee 7 also spoke to the eventual financial gains of accessible robotaxi design by saying, "it takes a smart and wise business … to know that eventually there will be a return on their investment. A short-term minded person isn't going to see this. They don't understand the challenges that exist for 61 million people [nationally] and haven't connected the dollar signs yet."

Second, some interviewees exhibited trust in AV companies because of the anticipation that companies will respond to demands from and conversations with the disability community. Interviewee 7 is against minimum requirements for AV companies because Cruise, the company they have history with, is already making significant strides towards accessible design and is soliciting feedback from people with disabilities. Importantly, "Cruise started at the beginning including people of all types of abilities… You'd rather build from the ground floor up rather than try to retrofit it afterwards." This comment highlights how AV companies can gain political support: including people with disabilities early in the process.

Interviewee 7 was very wary of regulation due to their views on how ableism has structured and guided this country: "We have able-bodied decision makers who are so concerned about the frailness of people that they are afraid to venture out on stuff…It's based on paternalistic beliefs that we have to take care of our 'frail and vulnerable' populations." Interviewee 7 continued by rejecting this paternalistic view:

> "What policymakers want to do is keep us safe, but there's dignity in risk. They're overly concerned with the 'what-ifs'. When I wanted to live by myself when I was young - my family asked, what if there's a fire? 'What-ifs' can happen to everybody! You can't use that to stop progress."

This emphasis on autonomy is not just for an individual with disability, but for AV companies to test without government restriction. These insights into how disability advocacy organizations are thinking about the role of AV companies and the government to serve disability communities can inform what policies may be supported.

Responsibilities of the Disability Community

Interviewees also discussed the role of the disability community and the importance of centering the lived experiences of people with disabilities. Interviewee 5 emphasized that people with disabilities need to be closely consulted for accessibility to be realized by saying,

"we see the potential for greater accessibility, but we believe the community needs to be more actively involved." Interviewee 1's outlook was that it is the community's responsibility to create political pressure to hold AV companies accountable. They said, "no one is going to make it accessible unless enough noise is made." With this in mind, Interviewee 1 believed that not enough leaders in the disability community were advocating for accessible robotaxis:

> "It's interesting to me that more of my colleagues aren't on board [with robotaxis] or even participating in conversations. Even if you're against this technology, you should be making some noise. It's not going to change because you're sitting in your living room complaining…you can either get involved and push for accessibility or not get involved and find yourself in 5 or 10 years from now wondering why accessibility is taking so long."

Interviewee 1's comment indicates that people with disabilities must play an active role in determining the future of autonomy and accessibility.

Lack of Standardization

"There's going to be problems…these [AV] organizations will set their own accessibility standards and those standards won't be standardized." – Interviewee 5

Interviewee 5 emphasized their organization's support of accessibility-related regulation for the sake of standardization across companies: "If they aren't standardizing regulations at the state level, we believe there's going to be problems…these [AV] organizations will set their own accessibility standards and those standards won't be standardized. A person with a disability will have a very different experience with a Waymo vehicle versus a Cruise vehicle." Other interviewees also expressed concerns about differences between robotaxis from different AV companies, which could be confusing or disorienting to riders.

For example, experts are exploring how wheelchair securement will be accomplished in robotaxis, which is a challenge given the variety of wheelchairs that exist. Interviewee 8 shared, "there is no conformity of wheelchair design. If we had some sort of standard for wheelchairs…some kind of universal tie down would be feasible. It would make it easier for all car companies." In this last sentence, Interviewee 8 alludes to the idea that each AV company will likely design and produce their own mechanism for securing a rider's wheelchair. Interviewee 4 also questioned how AV companies would pursue this challenge and wondered if all of the AV companies use the same restraint mechanism, and if not, how the experience would be for the person in the wheelchair.

Normalizing Disability

"[Robotaxis] could provide liberation and independence in a world where transportation is one of the biggest obstacles. And with better transportation, we can get the broader world more

aware of blind people. We're still so invisible… people don't know how to handle a blind person." – Interviewee 2

While interviewees discussed many benefits of robotaxi, with many parallels to those identified in the literature review, one unique point was the ability of robotaxis to change perceptions of disability. Some interviewees anticipated that the transportation opportunities that robotaxis would provide would revolutionize how able-bodied people thought about disability. As a blind person, Interviewee 2 said, "we're still so invisible…people don't know how to handle a blind person." With loss of vision comes a loss of independence, leading to isolation. Eliminating the transportation barrier will get more people out of their houses and into the public sphere, and the world will be more aware of people with disabilities. This conversation points out that transportation is a huge barrier. If robotaxis allow freedom to travel, then people with vision disabilities will be able to "fully participate in society," including education, employment, and recreation opportunities.

Interviewee 7 echoed this by saying, "it surprises me how many people have never interacted with a person with a disability. They don't see us. They don't develop relationships with us. If you never interact with a person with a disability, how are you going to understand them better?" If the disability community was more visible, and people had more opportunities to speak with and interact with those with disabilities, Interviewee 7 proposed that ableism and discrimination will be less pervasive.

Financial Barriers to Riding a Robotaxi

"AV companies could make [a robotaxi] beautiful and perfect, but if people can't afford to get in it, it doesn't matter." – Interviewee 5

People with disabilities experience poverty at greater rates than able-bodied people and often have higher expenses due to medical needs. When thinking about the cost of a robotaxi ride, interviewees stressed that affordability is as important as accessibility. As described by Interviewee 5, AV companies "could make [a robotaxi] beautiful and perfect, but if people can't afford to get in it, it doesn't matter." While robotaxi service could improve mobility options for people with disabilities, Interviewee 2 shared that "it hard to say if people will travel more [if robotaxis are more common]. It depends on affordability."

The pricing structure of robotaxi service will dictate who can benefit from the technology. Robotaxis will likely be useful for wealthy disabled people who can afford the rides. During our interview, Interviewee 5 used Waymo's app to price a trip from their office to their home. The ride would have cost about $25. In response, Interviewee 5 said, "the majority of [our organizations]'s participants cannot afford this ride. 90% of participants don't have $25 for a one-way ride." Beyond the cost of a ride, the rider must have access to a smartphone, credit

or debit card, and bank account. Interviewee 5 shared that many people with intellectual or developmental disabilities do not have these resources.

For riders, robotaxis may be cost-effective compared to other transportation modes. Several interviewees compared the price of a robotaxi ride to rideshare, anticipating or arguing that the cost should be lower because there is no driver that needs to make a wage. Some families purchase and convert a van to be better used or ridden by a person with a disability which can be very costly, and it can also reduce the integrity of the vehicle. Interviewee 3 anticipates that "Waymo is an option to get from point A to B without investing a ton of money into a conversion of a van."

Regarding pricing, interviewees had several recommendations to improve equity. Interviewee 5 suggested that there be systems to provide subsidies to support the communities robotaxis operated in. Interviewee 4 emphasized that robotaxis should be taxed and funds raised should go towards public transportation. They compared this to the state's TNC Access for All program, which collects 10 cents for every rideshare ride and distributes these funds to rideshare companies that demonstrate provision of wheelchair-accessible rides and to transportation carriers that provide on-demand wheelchair-access transportation.

Comparisons to and Impacts on Public Transportation

"[Robotaxis] will… take riders away from public transit, which is a way that most disabled people get around… A harm for public transit is a harm for disabled people overall."
– Interviewee 4

Public transportation is a valuable and common mode for people with disabilities. Still, people with disabilities face many challenges on public transportation, and traveling via robotaxi may eliminate these challenges. Several interviewees discussed the benefits of robotaxis in comparison to public buses or trains. Interviewees brought up instances when the bus passed by them or refused to secure their wheelchair. Interviewees anticipated that robotaxis will not be able to perpetuate this discrimination. For example, Interviewee 1 said, "as far as I know, a [robotaxi] cannot refuse a ride." Another issue with public transportation is limited service coverage. Interviewee 2 shared, "if you want to run out and go have dinner somewhere, you're contingent on whether or not there's public transportation." Robotaxis could fill gaps in public transportation service. According to Interviewee 8, robotaxi service would be useful "especially when going out at night to bars and shows, when buses and Bart stop service…that's where I would see it being the most useful. To and from the airport would also be nice to have. It sucks to take a bunch of luggage on Bart."

Robotaxis may serve as an alternative to paratransit. Interviewees 1 and 8 shared frustrations with paratransit in San Francisco and found it to be inconvenient. Riders need to schedule a trip at least 24 hours in advance, and "your ride is often late, so you have to

schedule your ride to come early to actually be on time" (Interviewee 1). Interviewee 1 credited some of the challenges of paratransit to a shortage of drivers, which is not relevant to robotaxis. On the other hand, Interviewee 3 pointed out that robotaxis "have not yet been designed to support ingress and egress of wheelchair users, whereas paratransit has these capabilities."

Other conversations focused on how robotaxis would influence travel patterns. Some interviewees regarded robotaxis as an transportation option that would supplement but not replace how their members got around. Interviewee 6 said that people with epilepsy and people who have seizures "need any kind of transportation they can get and driverless cars are one option." Interviewee 4 was concerned about AV's impact on public transportation ridership and funding. "[Robotaxis] will supersede public transit and take riders away from public transit, which is a way that most disabled people get around…A harm for public transit is a harm for disabled people overall." Both Interviewees 4 and 5 indicated that improved public transportation was a higher priority than accessible robotaxis.

Information Sharing and Knowledge Production

"The more I listened, learned, saw, and had conversations with experts, I thought, yeah, I'd give [robotaxis] a try." – Interviewee 7

Much of what interviewees understood about robotaxis was from traditional media or social media. Interviewee 1 reflected on the incident after Outside Lands in 2023 and shared that they saw videos on YouTube before the news outlets reported on it. Interviewee 6, who was the least knowledgeable on robotaxis, stays up to date by reading the paper. They also referenced "a friend who works in tech" from whom they get information on robotaxi technology.

Organizations look towards trusted nonprofits and government agencies for information on robotaxi policy. The representative from Interviewee 4 shared that they do not follow policy development closely, but they look towards national organizations like the Disability Rights Education & Defense Fund that have published policy proposals. For both Interviewees 4 and 5, meetings led by SFMTA, SFCTA, and the Mayor's Office on Disability were enlightening because they were unaware that the CPUC does not have any accessibility requirements. The representative for Interviewee 5 shared, "so much happens around us that if we aren't searching for information, we won't know it. I was not aware…there were no accessibility standards set by the state." Most advocacy organizations do not have the bandwidth to investigate topics like robotaxis, so there is an opportunity for an informed party to be a source of information.

Interviewees 1 and 7 were interested in the role of AV companies to share educational material to increase familiarity with the technology. For those who have not ridden a robotaxi

or live in areas without robotaxis, there can be fear and misinformation on how the vehicles work. According to Interviewee 7, “education is the key. [A robotaxis is] unknown to you unless you read up on it and how it’s happening in other areas. You get a little more comfortable with an idea.” Interviewees emphasized the value of videos. The representative from Interviewee 7, who does not live where robotaxis are currently operating, shared that videos of robotaxis in action can be educational.

A Completely Accessible Robotaxi

Interviewees were invited to describe how “a truly accessible robotaxi” would look and function. I walked through four steps of riding a robotaxi: requesting the ride, boarding the vehicle, communicating with the operation system, and exiting the vehicle. The following is an amalgamation of suggestions that would make a completely accessible AV. Based on observation or personal experience, interviewees suggested accessible elements that would be ideal for themselves or the people they serve.

Requesting a Ride

Prior to their ride, people may be interested in sharing their accommodation needs with the AV company. This way, the company can anticipate if a wheelchair-accessible vehicle is needed or various settings can be adjusted prior to the rider entering the vehicle. Patel et al. also suggests that the AV operating system should be made aware of the rider’s mobility needs, though this may compromise their privacy (2021). A phone number should be easily available if someone wanted to speak to a human about their accommodations or if they had accessibility-related concerns.

Ideally, riders would request a ride through a smartphone app. Smartphones are very accessible, and their owners already have it set to their preferences, so AV companies should lean on this existing technology. The app must meet 508 and 504 ADA mandates. To be friendly to people with intellectual and developmental disabilities, people should be able to save addresses and label them with colorful icons or photos. Interviewees also mentioned that people should be able to call to request a ride if needed.

Several interviewees emphasized that riders need reliable information to assuage anxieties and allow for easy planning. According to Interviewee 5, “there can be some anxiety in calling and waiting for a car. The car should tell you exactly when it is coming in a colorful, bright, and fun way, not in a ‘hurry up and get there’ kind of way,” which is especially important for people with intellectual and developmental disabilities. The app should be transparent about the price of the ride. Extended wait times - without charging extra - should be instated, as it may take people with disabilities longer to leave the house and board the vehicle. To be reliable, Interviewee 8 said that, “the big thing for me is that there are available vehicles that

come in an acceptable amount of time." Around 30 minutes seemed reasonable to Interviewee 8. Interviewees also were interested in the ability to schedule a ride, similar to paratransit.

Finding and Boarding the Vehicle

Riders can see bulky cameras and company branding on the exterior of the vehicle to differentiate a robotaxi from a standard car, but when there are multiple robotaxis in the same area, it may be challenging for some to identify their ride. Interviewees stressed that multiple tools, such as visual, audible, and tactile signals, should be available to help riders find their car. For people with intellectual and developmental disabilities, lights on or in the robotaxi could change a certain color, and the same color would be displayed in the rider's app. This suggestion by Interviewee 5 was inspired by Lyft: "Remember when you could change the color of your Lyft's placard so you knew that that was your car?" For people with no or low vision, the rider could choose from a menu of sounds, and the robotaxi would echo this sound so that the rider could locate it. A variety of sounds will be essential if multiple people are boarding rides in close proximity. Vibrotactile tactile tools could also be integrated into the app, and the rider's phone would vibrate faster as they approached their robotaxi. Finally, Interviewee 2 mentioned that wayfinding within the app was important, and integrating a tool like Google Maps could provide audible door-to-door directions.

Before boarding, the robotaxi must pull up to the side of the road that the rider is on. Otherwise, Interviewee 1 asked, "what if the person catching that ride cannot walk that 100 yards to the car?" The representative of Interviewee 1 had taken multiple robotaxi rides, and often the vehicle did not do door-to-door service. The interviewee told a story of taking their family on a Waymo ride to San Francisco's Chinatown. The car couldn't drop off at the request stop because of policy activity in the area. Instead, the interviewee and their family had to exit about ⅓ of a mile away from their destination, and the interviewee was unable to walk the rest of the way.

For riders with wheelchairs, walkers, or any other mobility aid, several additional measures must be taken. The robotaxi must pull up a curb where the ramp can be deployed. If the rider were to board at the level of the street, they would be forced to locate a curb cut, enter the street at that location, travel to the robotaxi, and then board. Interviewees expressed concern at a robotaxi being able to identify the correct location for boarding, and wanted an option to communicate the exact location where boarding was optimal. As Interviewee 7 asked, "is there a way to say to the vehicle, 'you didn't park near a curb cut, and you need to move up?'" Next, the robotaxi must have an automatic ramp or lift system. Interviewee 5 expressed interest in the rider controlling the speed at which the ramp or lift system deployed. Finally, the rider and their mobility aid must then be secured, or their mobility aid must be stored if they prefer to sit in the vehicle's seat (Claypool et al., 2017). Complications with securement are discussed in the "Lack of Standardization" section of this report.

Several interviewees emphasized autonomy over the robotaxi's operations. The robotaxi should not proceed until the rider indicates they are ready.

Communications

Riders must be given a variety of methods to communicate with the robotaxi's operating system. Interviewee 3 recognized that "this is complex, but there needs to be an array of methods or devices to communicate with severe disabilities." Interviewee 8 shared that "I want to be able to [communicate] on my phone, by voice, or on the vehicle's control panel…and the controls should be within reach" for a person in a wheelchair. All users, especially people with intellectual disabilities, would benefit from a simple interface on the control panel. Interviewee 5 said, "it doesn't have to be space age…ideally [AV companies] make it look like things that people have seen before." Common requests, like changes to the lighting or temperature, should be apparent. Auditory commands are another viable option. While the literature posits that the visually impaired community needs both Braille and auditory methods to communicate (Patel et al., 2021; Claypool et al., 2017), Interviewee 2, which serves people with blind and low-vision, was interested in controlling communication through the app. Using this variety of communication methods, the vehicle should provide information on the vehicle's route, safety precautions, and potential navigational barriers at the drop-off spot (Claypool et al., 2017).

Riders should also have the option to call a customer service representative to communicate their needs. If their robotaxi is stuck, in a crash, or forced to take an alternative route, a customer service representative may need to speak to the rider. During these conversations, riders must be able to communicate in their own language - including American Sign Language - and be able to turn on closed captioning. Robotaxis will be an improvement to human drivers if they have the ability for multi-lingual support (Riggs & Pande, 2021).

For people with intellectual and developmental disabilities, clear communication is essential to their safety. The stress of directives or not understanding the situation may lead the rider to exit the vehicle during the ride. Interviewee 5 said, "I've had people suddenly leave Ubers. Drivers ask questions they don't understand, they get scared, and they leave the car." In a robotaxi, if the ride is disrupted and someone from the AV company's service center contacts the vehicle, "there would be a large proportion of the population that we serve that would not be able to provide the information customer service needs." Interviewee 5 recommended to loop in a secondary contact to communicate with both customer service and the passenger. This secondary contact could be a caretaker or representation from a support organization who was familiar with how the passenger communicates: "I have all of the information, and I would be able to get us through that situation." Interviewee 5 mentioned that they had suggested this to Waymo, but no action has been taken yet. Claypool et al. suggests that an AV may also better communicate with people outside the vehicle - for example, additional information collected through a GPS tracker or in-vehicle surveillance footage may be useful for caretakers

of riders with intellectual and developmental disabilities (2017). Interviewee 5 did not mention this during their interview.

If the rider was experiencing a medical emergency, interviewees were unclear how the rider would ask for help. Interviewee 5 said, "I do not know how they would alert someone if they had a medical emergency, especially if they're nonverbal or have a seizure disorder." Interviewee 6 expressed trust in the AV companies and said, "I don't know how it works, but I'm sure they have a system in place."

Exiting the Vehicle

At the end of the ride, the robotaxi should communicate that it is at the destination and the ride is over. The door should open upon arrival so the rider does not have to deal with locks or handles. The vehicle should drop off the rider at their destination's front door. For a rider who is blind, "the [robotaxi] needs to explain exactly where they are. For example, 'I'm going to drop you off at these two cross streets and you'll be at this corner of the intersection in front of the CVS" (Interviewee 4). If the rider is not familiar with the CVS, the robotaxi needs to provide additional landmarks to help them navigate the space. Interviewee 4 expressed skepticism over this by saying, "There are a lot of things that are helpful that a human driver can help navigate that might not be anticipated…having a conversation is valuable, and you can't really program that." If it is not feasible to drop the rider at their destination, the robotaxi should explain where it is and the reasoning behind this decision.

Additional Accessibility Elements

According to Interviewee 5, additional elements that could improve accessibility within the vehicle include a seat belt for a service dog and identified spaces to hang a medical bag or oxygen tank. If a rider has luggage, bags, a walker, or other belongings, interviewees were unsure if the robotaxi would be able to help at all. When asked if they would be interested in having an attendant in the car, Interviewee 8 said, "if you're taking an autonomous ride to the grocery store, it would be nice to have someone to help put your bags in the car."

While not explored in interviews, the built environment must be accessible. There are concerns that our current built environment is not prepared for AVs (Hwang et al., 2020; Patel et al., 2021). Pickup and dropoff locations need to be accessible, including a continuous and level pathway, shelters with seating, and ramps to the vehicle.

Summary of Interview Findings

Table 5 summarizes the main ideas drawn from my 8 interviews.

Table 5. Summary of Interview Findings

What is the outlook for the future of robotaxis and accessibility?	Robotaxis will be a common transportation mode in the coming decades and could radically improve the disabled population's independence and mobility. Some interviewees spoke about accessible robotaxis as an inevitability in the future; this confidence may be attributed to their existing relationships with AV companies or a general positive outlook. Other interviewees were skeptical or even fearful of the future of robotaxi access without government-set standards for accessibility.
Why should robotaxis serve people with disabilities?	According to principles of mobility justice, everyone deserves the option to ride in a robotaxi no matter their disability. Interviewees recognized that engineering, safety, and liability challenges complicate the development of a robotaxi that accommodates all needs.
Who can use a robotaxi?	Some people with disabilities, such as individuals with certain vision impairments, may feel comfortable riding in robotaxis. However, current robotaxi design is inaccessible for a lot of disabled people, especially those with intellectual, developmental, and/or physical disabilities. The cost of a robotaxi ride is another barrier to people with disabilities, who face disproportionate rates of poverty. Only wealthy people with disabilities will be able to benefit from robotaxis unless the pricing is accessible. Beyond the cost of a ride, the rider must have access to a smartphone, credit or debit card, and bank account.
Why do some interviewees support accessibility regulation for robotaxis?	Interviewees that were in favor of accessibility-related regulation regarded robotaxi design as inaccessible to the majority of people with disabilities. These interviewees were not confident in AV companies to independently pursue accessibility, and they were concerned about the lack of standardization across AV companies. Priorities for regulation are (1) requiring wheelchair-accessible robotaxis (or equivalent service) and (2) including people with disabilities during robotaxi development, testing, and regulation.
Why are some interviewees against accessibility regulation for robotaxis?	Interviewees that were against accessibility-related regulation demonstrated trust in AV companies to pursue accessibility independently. These interviewees have had positive experiences working with AV companies or have observed AV companies soliciting feedback from people with disabilities. Some interviewees anticipate that AV companies will realize that the disabled population is a large customer base, and that it makes sense financially to improve the accessibility of robotaxis.
How can robotaxis normalize disability?	People with disabilities are often isolated in their homes. If robotaxis are accessible, the disabled population will be able to leave the house more

	often to participate in society, and able-bodied people will have more interactions with people with disabilities, thus normalizing having a disability.
How did interviewees compare robotaxis to public transportation?	Interviewees anticipate that robotaxis will not present some of the common issues experienced on public transit by people with disabilities, including discrimination from drivers or other passengers. On the other hand, some interviewees were concerned that robotaxis will take away ridership from transit, which is an extremely valuable resource for the disability community.
How did interviewees compare robotaxis to paratransit?	Interviewees shared that paratransit can be inconvenient. If robotaxis accommodated people who use wheelchairs, it could be a viable alternative to paratransit. Interviewees recognized that robotaxis will not be able to help riders board or exit the vehicle or provide social interaction as paratransit staff do.
How do interviewees learn about robotaxi technology and policy?	In addition to traditional media and social media, organizations look towards trusted non-profits (like the Disability Rights Education & Defense Fund) and government agencies for information on robotaxi regulation. Several interviewees were unaware of the lack of accessibility requirements for robotaxis until informed by San Francisco transportation agencies. Some interviewees wanted AV companies to share educational videos to increase people with disability's familiarity with robotaxis and to demonstrate accessibility-related features.
What are some elements of a completely accessible robotaxi?	**Initiating a ride:** ● The rider uses an accessible smartphone app to request a ride and input accessibility accommodations. ● The robotaxi's operating system adjusts settings (lighting, temperature, etc.) prior to boarding. ● The smartphone app provides reliable information on trip cost, arrival time, and pickup location. **Finding and boarding the vehicle:** ● The robotaxi and smartphone app provides visual, audible, and tactile cues to guide the rider to their vehicle. ● The robotaxi pulls to the curb on the rider's side of the road. ● The robotaxi has a ramp that is deployed automatically if needed. ● The robotaxi safely secures the wheelchair to the vehicle. **Communicating with the robotaxi:** ● The rider can use visual, audible, and tactile methods to communicate with the robotaxi's operating system. ● The rider can communicate in any language, including American Sign Language. ● A human customer service representative is available at all times. A third party can be looped in during conversations if needed. ● A system is established to provide the rider with support during a

medical emergency or if the vehicle gets into an unusual situation.

Exiting the vehicle:

- The robotaxi drops off the rider at their destination's front door.
- The robotaxi announces where the vehicle is as related to nearby buildings or landmarks. The robotaxi also communicates if the requested drop-off location is infeasible and identifies a new safe drop-off location.

Other:

- The robotaxi has a designated space for a medical bag and oxygen tank. The robotaxi has space and a seatbelt for a service dog.

Implications for Policy and Robotaxi Design

While the 8 subjects interviewed do not fully represent disabled people in California, lessons from their interviews provide valuable insight for the future of robotaxis. I identified four principles that should guide conversations, plans, and policies when considering how people with disabilities can access robotaxis:

1. Ableism indoctrinated in robotaxi design and programming actively excludes many people with disabilities.
2. People with disabilities should not be treated as one. When designing or regulating robotaxis, the range of disability type and severity must be considered.
3. The intersectionality of riders must be considered. The cost of a ride or the available language options can be as much of a barrier as the design of a robotaxi.
4. The proliferation of robotaxis will likely impact public transportation and paratransit, which are key transportation modes for disabled people.

With these principles in mind, I present several recommendations for robotaxi design and policy development in California.

Pursue Wheelchair Access (Or Equivalent Service)

For people with disabilities, wheelchair accessible service is a priority. This may look like equivalent service from a non-autonomous vehicle, but interviewees were more supportive of integrating automatic ramps and wheelchair securement systems into robotaxis. Neither is currently required by law in California. While accessibility regulation is otherwise controversial, this common desire points to potential widespread political support for a statewide requirement for wheelchair access. This also highlights a contention point for AV companies, who should be aware that not having wheelchair access prohibits many from using their services and decreases their political support. Wheelchair access is a significant engineering challenge and financial investment, but AV companies may have better public opinions if they are wheelchair accessible, and they may also be able to profit from the large customer base that is California's disabled population.

Identify Initial Target Audience

Some interviewees and industry experts are skeptical that all people with disabilities will be able to use robotaxis. In addition to wheelchair access, people with disabilities need a wide range of accommodations to feel safely served by robotaxis, as investigated in the "A Completely Accessible Robotaxi" section of this document. NHTSA recommends that AVs should be designed with inclusivity in mind, but the agency has little guidance on what inclusive design entails. If industry experts, researchers, policymakers, and people with disabilities

established a target audience to initially design for, it would help AV companies focus accessibility efforts. The target audience should later be expanded to include an even broader range of riders. Moura recommends drawing on work from "the disability rights movement and critical disability studies, which could inform a more inclusive ethical vision for AV design, development, and implementation" (2022). This initial target audience may be used to establish minimum accessibility standards by the CPUC.

Include People with Disabilities in Vehicle and Policy Design

Another priority that emerged from interviews is the need for AV companies to collaborate with people with disabilities throughout the process of developing and testing robotaxis. Waymo and Cruise do work with the disability community, but interviewees desired more involvement. Given that the needs of disabled people vary wildly, AV companies should ensure they are hearing from many different individuals. These individuals should be fairly compensated for their time, provided transportation if needed, and treated with respect. If the CPUC were to require AV companies to include people with disabilities during certain points of robotaxi design and testing, this requirement would likely be politically supported by the disability community.

People with disabilities also want to be included in policy design. The CPUC once had an accessibility-related working group, and this could be revived. The state should consider other measures that invite people with disabilities to actively participate in rulemaking that supports their needs. Integrating accessibility into policy development should be a guiding principle now, and not an afterthought (Riggs & Pande, 2021).

Consider Impact To Public Transportation And Paratransit

The proliferation of robotaxis may impact the ridership and operation of public transportation. Many people with disabilities depend on public transportation, and their mobility is threatened if public transportation is defunded and robotaxis do not serve their needs. Several interviewees prioritized improved public transportation over robotaxis. The CPUC should pursue a program similar to TNC Access for All, which has improved rideshare for people with disabilities and supports public transportation. In addition, robotaxi operations may be generally more supported and useful if their operations are maximized to fill gaps in existing public transit and paratransit. This could include robotaxi trips serving riders during times where public transportation does not operate, or in areas where public transportation is not provided.

Educate and be Transparent with the Public

Robotaxi technology is changing and improving rapidly. Interviewees learn about robotaxi technology and regulation from a variety of sources, but still have questions or

misconceptions. Public information campaigns can help to demystify the highly technological aspects of AVs. Bennett et al. emphasizes that campaigns need to be highly tailored to specific audiences, as groups have different questions and concerns (2019). Videos can be used to explain how autonomous technology works and familiarize riders to the process of calling, boarding, and exiting the vehicle. If or when AV companies release new accessible features in their vehicles, vehicles can be used for education and for publicity purposes.

Government agencies also have the responsibility to be clear about what is expected of robotaxi design and operation. Two interviewees were not aware of the lack of state-level accessibility requirements until informed by city and county agencies in San Francisco. The public deserves information on robotaxi regulation that is easy to understand and to access, and with this knowledge, people with disabilities will be empowered to know when they are being appropriately served or lacking accommodations. As shown in the interviewees, the disability community will continue to advocate for inclusion when it comes to robotaxis, and knowing their rights will support their advocacy work.

Conclusion

This study uses interviews with representatives from disability advocacy organizations to better understand robotaxis from the perspectives of disabled people. Overall, the disability community has a mixture of hope, skepticism, and uncertainty surrounding autonomous technology. What is clear is that changes need to happen for robotaxis to be inclusive: this includes providing wheelchair access, picking up riders at the curb, pricing rides affordably, and allowing interactions in different languages and communication methods.

For people with disabilities, the stakes are high. Robotaxis may continue the trend of systemic exclusion and discrimination, or they may be an extraordinary opportunity to reduce inequality. Decisions made by AV companies, the CPUC, and the DMV will dictate the future of accessibility and autonomy in California, so as AV companies continue to develop robotaxis and as Californian agencies consider how they are regulated, people with disabilities must be centered. As a group that has long been excluded, it is only fair that people with disabilities are part of the autonomous revolution.

Appendix A: Definitions

Disability

The World Health Organization has defined three dimensions of disability: impairment of body structure and function, limitation of activity (such as difficulty seeing or hearing), and restriction of participation in everyday activities (CDC, 2020). The CDC defines a disability as: "any condition of the body or mind that makes it more difficult for the person with the condition to do certain activities and interact with the world around them" (2020). A disability can affect a person's "vision, movement, thinking, communicating, hearing, and mental health" (CDC, 2020). Examples include diabetes, autism, cerebral palsy, intellectual disabilities, deafness or hearing loss, and blindness or low vision. People may have multiple disabilities. Some disabilities are visible, and some are not.

Disability Community

In this paper, the disability community refers to people with disabilities, partners, family members, caretakers, advocates, and others that support people with disabilities. The disability community is very diverse and has many communities within it.

Accessibility

The Offices of Civil Rights for both the Department of Justice and Department of Education define accessibility as a state where,

> "a person with a disability is afforded the opportunity to acquire the same information, engage in the same interactions, and enjoy the same services as a person without a disability in an equally effective and equally integrated manner, with substantially equivalent ease of use. The person with a disability must be able to obtain the information as fully, equally and independently as a person without a disability" (Indiana University, n.d.).

Autonomous Vehicle (AV)

AVs, also called driverless cars or self-driving cars, are equipped with driving automation systems that use RADAR, LiDAR, and cameras to navigate their environment. When these automated driving features are engaged, the person in the driver's seat is not actively driving. Some AVs do not have a driver's seat at all. SAE International defines six levels of driving automation based on the role of the person in the driver's seat and the vehicle's capabilities (see Figure 1). Less advanced AVs (Level 3) may ask the driver to take over when requested and can only operate in limited environments. More advanced vehicles (Levels 4 and 5) will not ask the driver to take control and can drive in all conditions. For people with disabilities, Levels 4

and 5 will be the most useful because human monitoring is no longer necessary (Glennie-Smith, 2018). As of writing, Level 4 automation has been achieved.

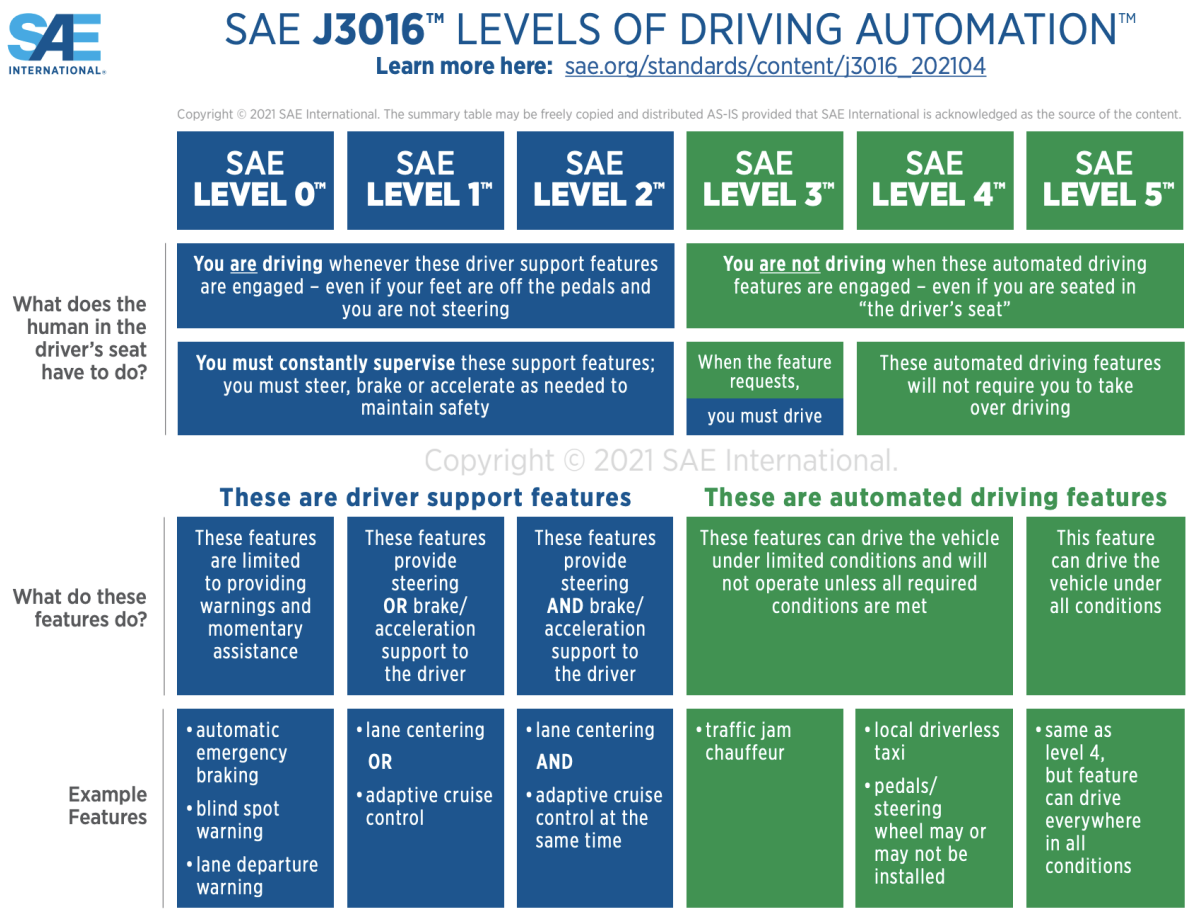

Figure A1. SAE Levels of Driving Automation (Source: SAE)

Paratransit

The 1990 Americans with Disabilities Act requires all public transit agencies to provide transportation services to people who are unable to use the agency's standard transit service due to a disability. Transportation is provided during the same service hours and at an equivalent or reduced price using vans or small buses to provide individual or shared trips. Individuals must qualify for paratransit service, as defined by the transit agency. Rides must be scheduled, often a day in advance. Several transit agencies, including those in San Francisco and Los Angeles, provide subsidized fares for taxis for those eligible for paratransit.

Rideshare

Transportation Network Companies (TNCs) like Uber or Lyft provide ridesharing services that connect riders with drivers through a mobile app. Drivers provide a ride for a fee, typically using a private vehicle.

Robotaxi

Robotaxis are fleets of shared AVs that provide door-to-door rideshare service. These vehicles are SAE Levels 4 or 5. Robotaxis operate on-demand and are typically called through a mobile app. Current robotaxi trips are occupied by one party, but future service may be shared by multiple parties. In California, robotaxis are designed, owned and managed by private companies such as Waymo, Cruise, and Zoox.

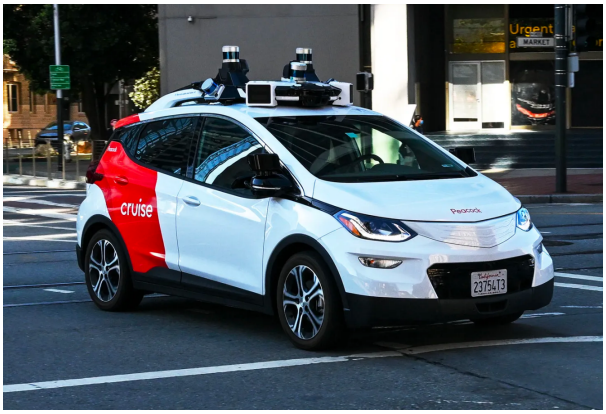

Figure A2. Cruise's robotaxi
(Source: Tayfun Coskun, Getty Images, Wired)

Figure A3. Waymo's robotaxi
(Source: Shiiko Alexander, Alamy, Wire)

Appendix B: Interview Instrument

Pre-Interview Script

As a reminder, my research project is understanding the disability community's expectations for driverless cars. More specifically, I am interested in robotaxis (or autonomous rideshare) that can be called on command for door-to-door service.

This research was inspired by my work at San Francisco's Municipal Transportation Agency, where I worked with the accessibility team. Together, we advocated for accessible autonomous vehicle policy at the state level.

Many people say that driverless cars are the mobility solution for people with disabilities. I'm conducting this research to understand how these cars need to be designed in order to be truly accessible and what policies need to be implemented to make this happen.

This interview will be about 45 minutes long. At any time, you may refuse to answer a question or answer partially. Remember that your responses will remain anonymous. I have my digital voice recorder ready to go - can you confirm your consent that I record our discussion for my personal reference?

Any questions you have for me before we start?

Interview Questions

1. Do you have a disability?
2. Have you ridden in a driverless car before?
3. Let's move on to your organization. What is the mission of [insert organization], and what is your role?
4. How does your [organization] feel about driverless cars? Does [insert organization] have an official stance on AVs?
5. Has [insert organization] worked with or been sponsored by an AV company before?
6. Has your organization gotten involved in decision-making or policy on driverless cars, either at the federal or state level?
7. What are the benefits of driverless cars for people with [insert disability]?
8. What are your concerns with driverless cars for people with [insert disability]?

9. Do you think these cars are currently designed to serve people with [insert disabilities]?
10. Right now, how are driverless cars impacting the lives of the people that your organization serves?
11. In the long-term, how do you imagine driverless cars impacting the lives of people with [insert disability]?
12. Imagine a driverless car that perfectly serves the transportation needs of people with [insert disability]. What does it look like, and how does it function? I want you to think about the accessible features needed for the ride as I walk through the steps of calling, boarding, riding, and exiting.
    a. First, how would riders request a ride?
    b. How would they board?
    c. When in the vehicle, how would they communicate with the car, maybe to turn off the air conditioning or if there's an emergency?
    d. Would you be interested in having an attendant in the car to support the rider?
    e. Anything else you have in mind?
    f. Do you think driverless car companies have the capacity or responsibility to meet these needs?
13. What are your thoughts on accessibility regulation for driverless rideshare? Do you think the government or local agencies have the responsibility to meet your needs?
14. As companies are designing accessible driverless cars, what should their priorities be, either for the development process or the technology itself?
15. What do you know about policy for accessible autonomous vehicles, either at the federal level or in California? What is unclear or confusing to you? What are your recommendations for policy?
16. Where do you get information on driverless car technology and policy?
17. Anything else you want to add? Is there anything I might find surprising?
18. Who would you recommend I talk to about this topic?
19. May I contact you in the future for clarification or an additional interview?

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