Bipartisan Policy Center

Driving Equity:

THE BENEFITS AND IMPACT OF AUTONOMOUS VEHICLES ON UNDERSERVED COMMUNITIES

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Executive Summary

As autonomous vehicles (AVs) begin to shape the future of transportation in U.S. cities, thoughtful policy considerations, industry commitments, and strategic investments are vital to upholding American leadership and maximizing the benefits of this technology while addressing challenges and concerns, particularly for underserved communities.

This report examines how multi-stakeholder led efforts can ensure AVs as a ride-hailing service integrate into urban communities responsibly and equitably, maximizing the benefits for underserved communities. Widespread AV adoption holds significant potential benefits. Proactive collaboration among policymakers, local communities, industry leaders, and researchers is necessary to ensure that the technology leads to a more accessible, safe, clean, and efficient future.

Given the rapid pace of advancement in AV technology, our policy considerations are designed to be flexible and adaptable to future developments. Our analysis and recommendations focus on the use of AVs in ride-hailing services within urban centers, and reflect the current operational scale and available research. Further studies will need to evaluate a more expansive use of AVs as a ride-hailing service.

Key Findings:

- **Inclusive AV Adoption and Access:** AVs have the potential to improve transportation equity by expanding access and opportunities for all riders. AVs promise to provide rides to everyone regardless of age, language, disability, and other factors. However, there are hurdles to overcome, such as affordability, limited technical familiarity, and concerns related to fairness and discrimination. General acceptance of AVs will require government, industry, and community stakeholders to work together to harness the benefits of AVs. Transparency and trust in the technology can create a more inclusive transportation landscape that benefits everyone.
- **Public Transportation and Urban Planning:** Integrating AVs into existing public transit networks and complementing paratransit systems could improve transportation equity, especially for underserved communities and people with disabilities. Several pilot programs and public-private partnerships offer valuable insights into the potential benefits and challenges of incorporating AVs into urban transportation networks. These programs highlight the need for careful planning and collaboration to maximize the equity and efficiency of mobility solutions.
- **Safety:** AVs could make the nation's roads and sidewalks safer by removing the human driver from the equation and using advanced automated safety features. Widespread access to safer transportation might require investments in roadway testing and creating shared safety standards. Policymakers must engage with a wide range of stakeholders to gain diverse perspectives to address their unique needs; such dialogue will also build trust in the technology.
- **Emissions and Electrification:** Most AVs run on electric or hybrid power. Through electrification and smart design elements, AVs show considerable potential to increase energy efficiency and reduce pollution. This is especially crucial for underserved communities disproportionately affected by environmental pollution. However, the complexity of these issues and specific localized energy and environmental effects require nuanced understanding and approaches. Investments in clean energy infrastructure and sustainable and equitable policy frameworks are critical in making AVs part of a cleaner, more inclusive future.

This paper underscores the importance of implementing tailored solutions to unlock the full potential of AVs and to benefit underserved communities, prioritizing their unique needs and creating transportation equity.

Introduction

As an industry that invites novel solutions to the way we move, transportation is fertile ground for innovation. These innovations have cascading effects, creating ripples across many aspects of our lives, including the way we live and work. Through stakeholder collaboration, careful planning, and commitment to sustainable and inclusive solutions, we can harness the transformative potential of innovation to make the nation's transportation systems safer, more accessible, cleaner, and more efficient.[1]

We stand on the cusp of a transportation revolution that is already capturing the public's attention, fueled by the recent developments in and integration of AV technology. Policymakers and regulators have an opportunity to address historic challenges in transportation development and pave the way for a future that is forward-thinking, innovative, and beneficial for all.

Ahead of the potential widespread deployment of AV technology, policymakers and stakeholders should consider proactive measures to expand access and opportunities, and to address such issues as affordability, sustainability, and workforce disruptions. A comprehensive analysis of policies, frameworks, business commitments, and strategic investments can aid in ensuring that the benefits of AV technologies are well distributed.

Preserving U.S. leadership in this sector is essential if the nation is to secure a competitive edge over China. Members of Congress stress the importance of the United States being at the forefront of AV testing and deployment, a priority underscored in the Senate report, *Driving U.S. Innovation in Artificial Intelligence: A Roadmap for Artificial Intelligence Policy in the United States Senate*.[2]

With the right approach guiding their development and deployment, AVs could serve as a catalyst for positive change in transportation and provide significant benefits for Americans, especially those in underserved communities. Achieving this will require a multistakeholder approach involving governments, businesses, academia, and civil society organizations.

The primary purpose of this paper is to contribute to the ongoing dialogue surrounding AVs, self-driving vehicle technology, and their transformative effects, opportunities, and challenges, particularly focusing on their implications for underserved communities. We discuss the role that current AV technology plays in localized ride-hailing services—sometimes referred to as Transportation as a Service (TaaS)[3]—and the nuanced impact that self-driving cars could have on transportation equity. Other applications of AVs, such as freight transportation or private ownership, are significant but fall outside the scope of this paper. Future research endeavors will need to evaluate a more expansive implications of AVs.

We will first provide an overview of AVs, their evolution, and the legislative landscape in which they operate. Next, we will highlight the potential benefits of AVs and the inherent challenges associated with local integration of this technology. Finally, we will synthesize policy considerations derived from existing literature that aim to improve opportunities afforded by AV technology, particularly in reducing inequities for historically underserved or adversely affected populations.

I. OVERVIEW OF AUTONOMOUS VEHICLES

Autonomous transportation is constantly developing, driven by advancements in intelligent technologies and expanding uses. Vehicle testing and deployment span a spectrum of capabilities, from driver assist technology, such as adaptive cruise control or emergency braking systems, to autonomous driving, where the vehicle operates independently with no human intervention.

Although fully autonomous driving vehicles, commonly referred to as self-driving or driverless cars, are operational in certain commercial contexts, such as ride-hailing services, their deployment remains limited. In addition to stakeholders improving the safety and readiness of the technology, policymakers must address several factors before AVs become widespread, including developing appropriate regulations and safeguards.

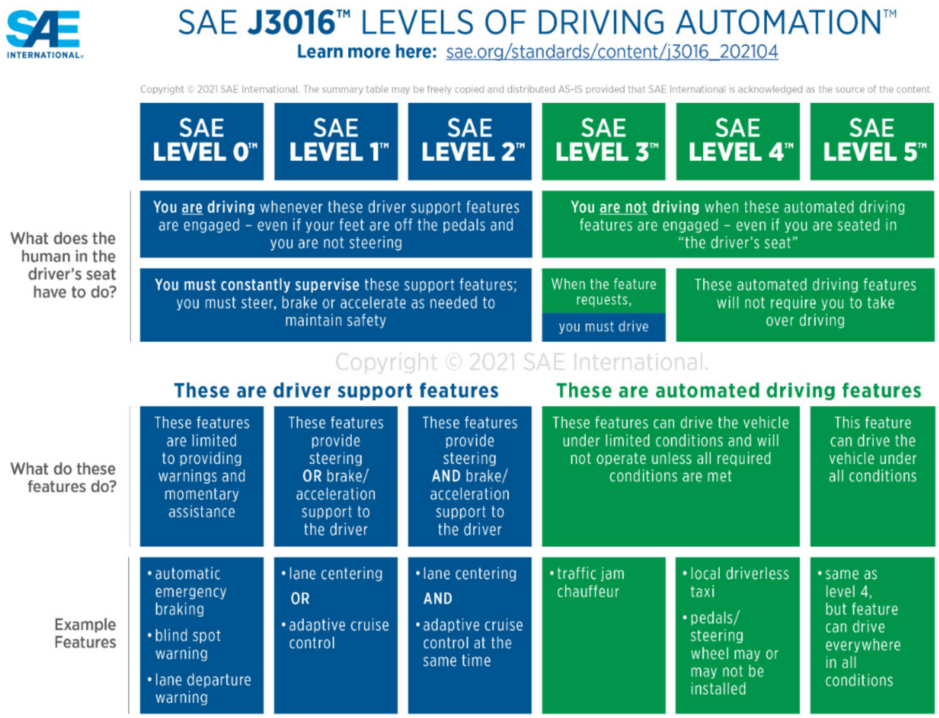

Figure 1: Source: [SAE International]

*Standards developer SAE International, in partnership with the International Organization for Standardization (ISO), developed a set of regularly relied upon standards, SAE J3016, which creates common taxonomy of and definitions for automated driving systems.

SAE identifies six levels of automation, ranging from no automation (level 0) to full automation (level 5). Lower levels of automation (1-3) incorporate driver-assist technology. Notably, driver-assist technology requires a licensed, attentive human driver behind the wheel at all times to monitor and take over operation of the vehicle if needed. Although levels 1 and 2 driver assist features are common in personal cars today, it is important to note that more advanced AVs at level 3 and above are available only in limited markets. Meanwhile, several commercial businesses are actively involved in developing vehicles with higher levels of autonomy, particularly for ride-hailing. AVs that are level 4 and above.

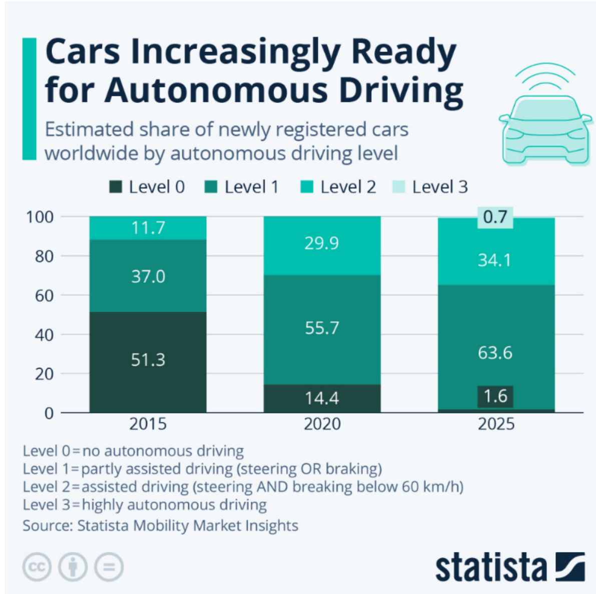

Figure 2: Source: Statista

*According to some experts, the landscape of autonomous features on today's roads is evolving rapidly – from 2015 when a majority of cars globally had no automated features, to 2025 when nearly all new cars will likely have some level of autonomous driving.

Several U.S. cities and states are welcoming fully autonomous ride-hailing services and permitting limited testing of AVs on public roads.[4]

At the local level, several cities actively host AV ride-hailing services, and many others are looking at plans to expand their use or testing capacities.[5] San Francisco, Los Angeles, Phoenix, and Austin, encourage deployment and public use of highly autonomous cars (level 4) as part of AV ride-hailing services. The footprint of these ride-hailing services could expand across several more cities in the coming year.[6]

II. FEDERAL POLICY LANDSCAPE

For over a decade, Congress has grappled with AV policy issues, holding hearings and debating legislation, yet it has not enacted a comprehensive federal AV law.[7] The House of Representatives last passed AV legislation, the SELF DRIVE Act, in the 115th Congress (2017-2018), although the Senate failed to pass it.[8] Similarly, in the Senate, the AV START Act was introduced in the 115th Congress and passed out of the Senate Commerce Committee but did not receive a full Senate vote.[9] Thus far in the 118th Congress, the House is working on re-introducing the SELF DRIVE Act, but a Senate-led bill has made no progress.

As Congress considers AV legislation, the U.S. Department of Transportation (DOT) is using its various authorities to ensure the safe development and deployment of AVs on American roads. AVs are subject to the same motor vehicle safety standards established by the National Highway Traffic

Safety Administration (NHTSA) that are required for other cars and trucks in the United States. NHTSA, the U.S. federal agency responsible for vehicle safety under DOT, has undertaken many regulatory efforts to address AV technology, including starting several rulemakings, creating a mandatory AV crash-reporting database, and issuing voluntary guidance in 2021 for a coordinated governance approach to advancing the technology.[10,11] NHTSA also has extensive investigative and enforcement authority to prevent new technologies, including AVs, from endangering the public, and it has actively conducted investigations and triggered recalls for driving automation technology. Additionally, through the Strengthening Mobility and Revolutionizing Transportation (SMART) program, passed under the Infrastructure Investment and Jobs Act (IIJA), in FY23, DOT awarded $54 million in grant awards for the 34 projects across 22 states, the District of Columbia, and Puerto Rico. Funded developments in connected vehicle technology and sensors could lead to improvements in AV technology.[12]

As Congress and DOT work to update federal regulations to keep pace with advancing technology, nearly all state legislatures have considered or passed legislation related to the testing or operations of AVs.[13] State-level regulations, however, lack a standardized framework, resulting in a patchwork of laws governing a range of issues from exemptions for AV operations to insurance and testing requirements. Notably, no state has explicitly outlawed the use of self-driving cars, leaving the door open to their adoption. The lack of clear, uniform rules and guidelines around the use of AV technology creates regulatory barriers for companies developing or deploying AVs. This patchwork of state and local laws and a renewed possibility for congressional action create uncertainties for companies regarding the trajectory and growth opportunities in the AV industry.[14]

II. Challenges and Opportunities in AV Integration

To enact effective policy, policymakers must first address multifaceted challenges of using AVs, particularly their potential disparate impact on underserved groups. Currently, transportation systems present different challenges relating to access, affordability, and reliability in rural and urban communities. For instance, underserved communities in cities, often comprising low-income individuals and minorities, face poorly maintained roads and lack of affordable transportation options. Conversely, underserved rural populations face a shortage of transportation networks or unreliable options. Over time, AVs could have a substantial impact on these challenges, but the unique needs of different communities must be considered.

To realize AVs' full potential to improve the lives of underserved communities, stakeholders ranging from policymakers to industry leaders and advocacy groups are engaging in ongoing discussions. By embracing diverse perspectives, this dialogue aims to address the challenges and opportunities of AVs, ensuring the benefits are shared equitably across all communities.

To present broad policy considerations across several domains, we draw on insights from experts and examine ongoing collaborative initiatives and policy discussions at both the local and national levels. This section will provide a nuanced understanding of the considerations surrounding AVs and their potential effects on different communities.

A. INCLUSIVE AV ADOPTION AND ACCESS

As AVs with more-advanced capabilities begin integrating into urban landscapes, understanding and addressing public needs and perceptions becomes crucial for successful adoption. AVs have received both positive and negative media attention in recent years, which can be crucial to shaping public sentiment and acceptance in the early stages of any new technology.[15] Public criticisms of AV technology tend to focus narrowly on major incidents, such as two notable wrecks in 2018 involving autonomous features of the vehicles.[16] Additionally, more recent news coverage of a collision involving an AV and pedestrian increased public concerns.[17] One survey found that public apprehensions around AVs have increased in recent years despite improvements in the technology.[18] However, consensus is not universal as other studies have shown that views of AV safety become more positive once people experience a successful AV ride.[19]

Consumers should be presented with research-based information to make informed decisions about utilizing AV ride-hailing services, and AV developers should continue to ensure the technology is used in a responsible and safe manner and to communicate those efforts to the public. Communicating how AVs can benefit local communities will be crucial for gaining public acceptance of this technology.

I. Transparency and local engagement

Support from the federal government and a majority of state governments has spurred the integration of AVs into urban centers, but the technology has also met with criticism in some cities, reflecting concerns regarding vehicle safety, job displacement, traffic congestion, and overall impact on community well-being.[20, 21] Public perception of AVs can be a catalyst or a barrier to expanded AV use and will be shaped by such factors as trust, familiarity, and personal experiences. Initiatives focused on education, demonstration, and community involvement can help bridge the gap between public expectations and the technology's actual benefits.

Addressing the public's concerns requires transparent communication, community engagement, and commitment by the AV industry and local governments to avoid, minimize, and mitigate potential negative consequences. Stakeholders must educate the public about the ways in which AVs differ from conventional vehicles, and the ways this technology could positively integrate into society. These initiatives must be local-based while also encompassing a diverse network of communities so that the risks or concerns of a particular group are well understood and addressed. Additionally, bipartisan support for policy goals aligned with community needs can help instill trust in AVs and improve the public's view of the technology.

II. Responsible and ethical AI development

Real and perceived bias present in artificial intelligence (AI) algorithms and automated systems is an important consideration in gaining public acceptance of AVs.[22] Algorithmic bias is commonly referred to as outcomes produced by automated decision-making systems that disadvantage or adversely affect certain groups. Disproportionate impacts of bias across numerous applications of AI raise legitimate concerns about algorithmic fairness and ethical standards. Considering the potential ramifications of biased decision-making in AV systems, which rely on AI technology, is paramount.

Government entities and industry developers are collaborating to identify and rectify biases, including within the programming of AV systems, and are striving to ensure equitable operations across diverse communities. Research in algorithmic decision-making and effective bias mitigation has helped to address concerns about bias and to advance technology that caters to the needs of all individuals. Policymakers play a pivotal role in safeguarding the ethical development and deployment of AI by fostering collaborative efforts and crafting informed policy frameworks.

III. Increased transportation equity, access, and inclusion

If properly planned, the adoption of AVs can reduce inequities across transportation systems, offering dependable alternatives to transit options. This new technology is particularly significant for underserved communities who need better access to essential services and resources – such as health care, education, and employment.

Some evidence shows that existing human-driven ride-hailing services, by providing reliable and affordable transportation for medical needs, have narrowed the gap in access to resources that improve health outcomes.[23] This finding suggests that integrating AV technology into transportation networks could further improve access to essential services and resources by providing complementary options for those in rural areas, the economically disadvantaged, adults with disabilities, and others. Public health agencies, community organizations, and AV developers can work together to harness the potential of AVs to positively impact socioeconomic and broader societal factors.

AVs stand to address several issues around discrimination by removing the real or perceived biases of the human driver from the equation. By removing these human biases, which could lead to racial profiling or discrimination based on gender or socioeconomic status, AVs could provide a more neutral and fair service to all users, provided the technology is developed and deployed in an unbiased manner.

However, barriers to entry—including cost and payment, tech literacy, and language (especially for non-English speakers)—can limit access to automated systems for underserved populations. These barriers are significant and may prevent equitable access to this technology. Therefore, it is crucial to balance the benefits of AVs with efforts to prioritize access and inclusion, ensuring that all populations can benefit from this technological advancement.

Policy considerations

Transparency surrounding the use of AVs is critical to instilling public trust and informed use, while also ensuring AV developers are responsibly applying standards and laws. In communities where societal inequalities coincide with transportation challenges, a transparent policy framework for AV technology will be even more crucial. We identified two policy considerations that can contribute to the overall transparency and trustworthiness of AV technology.

1. Privacy

Regulations aimed at governing the collection, use, storage, or sale of data hold relevance for AV technology, particularly for training AI systems, vehicle operation, or in ride-hailing services applications. Although there is no federal consumer data privacy law, many states have either introduced legislation or passed their own privacy laws, which are crucial to protecting users' personal information and encouraging responsible data practices within the AV industry. Policymakers must strike a balance to ensure these protections do not impose unnecessary restrictions on innovation or impede the processing of data essential for advancing

AI technologies, especially in ways that mitigate bias. AVs are part of an increasingly connected world where data may be routinely collected, used, and shared. Privacy laws could have major implications for how the data collected by AVs is handled and what rights people have to limit the collection and use of that data.[24]

2. Trustworthy and responsible technology R&D
Inclusive research and development efforts are crucial for building trust in AV technology and fostering equitable outcomes. Research and development efforts should involve a diverse range of stakeholders, including developers, civil society groups, and experts, to inform shared foundations, terminology, and standards for AV technology that prioritize safety and address needs across diverse communities. DOT, for example, is awarding grants for university-led research at historically Black and minority-serving institutions through the University Transportation Centers (UTC) Program authorized under the IIJA.[25] This program is designed to support diversity among researchers shaping the future of this technology, a goal BPC supported in its 2020 report, *AI and Ethics*.[26] These efforts have the potential to spur job growth in STEM fields. Research by the Chamber of Progress notes, "Cities, states, and higher education partners can play an important role in upskilling, reskilling, and developing the skill sets of potential AV workers through collaboration with AV companies and research facilities."[27] This collaborative approach not only fosters economic empowerment but also creates employment opportunities. Moreover, nurturing partnerships with communities that are underserved or concerned about potential job displacement in the automotive industry, as well as investments in upskilling the workforce for tomorrow, can address concerns and mitigate apprehensions.

B. PUBLIC TRANSPORTATION AND URBAN PLANNING

As fleet-based TaaS AVs become more prevalent in American cities, they will likely have an impact on public transit systems and planning practices. However, because AV ride-hailing fleets are still limited, their long-term effects on cities are difficult to predict.

Some research suggests that AV fleets could produce significant benefits by providing inexpensive transportation options for populations that are not well served by existing public transit options and by reducing carbon and air pollution through electrification.[28] Caution is warranted, however, because fleet-based AV adoption could incentivize greater car use over mass transit due to reductions in cost and improved convenience; such a development would potentially exacerbate road congestion and increase vehicle miles traveled by individuals.[29] Moreover, the arrival of fully autonomous vehicles might reduce the opportunity cost of lengthy commutes, potentially worsening urban sprawl.[30]

I. AV Services and Public Transit Networks

AV ride-sharing services operate within a complex landscape, potentially interacting with multiple overlapping systems—including public transit networks, urban streets and other infrastructure, zoning and land use regulations, and other local policies.

Prior research has focused on understanding how AVs would interact with public transit networks and potentially serve as a solution to the problem of first- and last-mile (FLM) connectivity. FLM refers to the distance commuters need to travel from a public transit stop to their destination, or vice versa, whether that would be their home or place of work. Mass transit nodes tend to be concentrated in high-traffic locations, which may not lie at a convenient distance for efficient commutes, and 45% of Americans have no access to bus or rail service altogether.[31] The FLM problem is one of the reasons only about 5% of U.S. workers regularly use public transit in their daily commutes.[32]

Ride-sharing and micro-mobility (e.g., electric bikes and scooters) serve as positive-use cases in which cities have accepted innovative transportation options in addressing FLM connectivity. For example, Seattle has offered on-demand ride-sharing services for commuters to get from transit stations to their final destinations. Alexandria, VA, provides subsidies for bike-sharing or other shared mobility systems.[33] The mass adoption of fleet-based AVs can build on these policies, providing commuters with cost-effective and more easily accessible means to complete the first or last leg of their trip.

Various proposed modes of AV deployment can complement public transit systems and mitigate traffic congestion concerns. Networks of fleet-based AVs can fill gaps in public transit coverage, providing transit modes for customers with varying transportation needs. For example, by operating 24/7 or offering extended hours, ride-hailing AV services can also be complementary, or auxiliary, to public transit in off-peak or nonoperating hours.[34] Additionally, AVs can supplement the current paratransit model of service provision for people with disabilities or the elderly; paratransit can often be expensive or limited in availability. Pilot projects, such as the FTA Valley Metro-Waymo Automated Vehicle RideChoice project, show the potential benefits of AV-based services for mobility-disadvantaged users and their receptiveness to this option.[35,36] AV deployment could represent a more efficient solution for meeting the mobility needs of elderly or disabled customers who currently rely on paratransit arrangements that are often inefficient and costly to operate for transit authorities.

AVs might also provide linkages between public transit systems and underserved urban areas more efficiently than extended public transit, given the challenges and costs involved in scaling public transit infrastructure.[37] However, existing research shows that it is still too early to draw definitive conclusions about the impact of fleet-based AVs on public transit systems: Recent research conducted in Washington, DC, suggested that automated ride-hailing might outcompete bus and rail for trips with poor transit options, while public transit could remain competitive for trips where good transit options were available.[38] Attempts to model the potential impact of AV take-up in Singapore led scholars to conclude that under the right regulatory conditions, AVs and public transit can be complementary—making urban transit systems more efficient while also increasing profits for both transit authorities and AV operators.[39] A different modeling exercise focused on Los Angeles and Atlanta—American cities with relatively limited public transit networks—suggested that public transit and private car ownership remain more affordable and efficient means of increasing job accessibility unless AV fares are drastically reduced.[40] Attempts to link AVs and public transit systems effectively must also contend with the perceived difficulty riders fear of transferring between multiple types of transportation—sometimes referred to as the "transfer penalty."[41]

Ultimately, the impact of the relationship between AVs and public transit is dynamic and hard to predict, making public policy decisions more complex. While transit authorities in Hamburg, Germany, and Oslo, Norway, are pursuing the deployment of thousands of AVs to scale up shared mobility, similar initiatives have not emerged in U.S. cities.[42, 43] More research and on-the-ground implementation may be needed to fully understand the potential effects of AV availability on transportation costs, access to employment opportunities, and other outcomes.

Policy considerations

The impact of fleet-based AV adoption on transit networks will depend on the interplay between new technology, existing infrastructure, public policy, and the availability of public grants and subsidies. Based on the experience of cities that have partnered with fleet-based AV systems, our research identified the following policy considerations for policymakers and stakeholders seeking to maximize the benefits of AV use for underserved communities:

1. Integrating public transit and shared AV mobility
AV-based shared mobility systems can create opportunities to connect underserved communities with transit nodes, as well as to integrate them directly with public transit systems, as demonstrated in recent pilot programs. Since 2017, the city of Arlington, TX, has partnered with Via to develop an on-demand ride-hailing system, becoming the first city in the country to deploy on-demand

technology as its primary means of public transit. In 2021, Arlington began integrating AVs into its on-demand service. It later secured a Federal Transit Administration (FTA) grant to explore integrating AVs into its public micro-transit system. Such pilot programs provide an opportunity for cities to study how incorporating AVs can further their goals to expand accessible and affordable mobility options.[44]

2. Complementing paratransit options

If deployed correctly, AVs could significantly expand access to affordable and efficient transit for people with disabilities. Another pilot program collaboration between Waymo and Valley Metro's RideChoice program—a subsidized curb-to-curb mobility service for individuals with disabilities and older adults in the Phoenix area who are eligible for paratransit—provides an example of how AVs could help expand existing paratransit systems. Participants in the demonstration found the service more convenient than typical RideChoice options, and they expressed strong satisfaction with the wait times. Participants also indicated they would take longer trips if the service area were expanded.[45] As other jurisdictions consider similar programs, policymakers should consider the benefits of establishing and upholding accessible design standards, and of working to eliminate unnecessary requirements for AV use that could create barriers for seniors or people with disabilities.

C. SAFETY

The evolution of vehicle safety has been marked by major milestones—progressing from features such as seatbelts in the 1960s and antilock brakes gaining popularity and 1990s to the latest advancements in advanced driver assistance systems (ADAS), such as lane keeping and traffic jam assistance technology. [46]

Despite significant advancements in highway and car design, driving remains a leading cause of death in the United States.[47] Higher levels of automated driving systems "remove the human driver from the chain of events that can lead to a crash," which could save more lives and prevent life-threatening injuries.[48]

New standards for autonomous driving that encourage advanced technological abilities and address concern for individuals' safety could offer potential solutions to many of the contributing factors leading to unnecessary vehicle fatalities. However, many of these AV features are still being tested and monitored for effective real-world applications.

I. Enhancing Road and Pedestrian Safety

One critical aspect of road safety is pedestrian safety—which has a particularly disparate impact on communities of color. A study reviewing national trends from 2015-2019 found that people identifying as non-Hispanic and Black represented 21% of pedestrian fatalities even though they made up only 12% of the population; the Hispanic population, making up 19% of the U.S. population, accounted for 21% of pedestrian-related deaths; and, Native Americans, representing just 0.7% of the population, were 2.4% of pedestrian fatalities, "more than triple what would be expected if pedestrian deaths were distributed equally among race and ethnicity categories."[49]

Addressing the underlying factors that contribute to pedestrian fatalities is essential for addressing these systemic effects on minority communities. AVs possess the unique potential to mitigate pedestrian traffic-related fatalities caused by major factors like speeding and distracted or impaired driving.[50] Ideally, by leveraging precise sensor systems, rapid decision-making capabilities, and collision-avoidance mechanisms, AVs could safely navigate roadways while remaining undistracted, thereby improving both pedestrian and road safety. We are already seeing safety improvements from today's partially automated features and are likely to see greater improvements as the effectiveness of these technologies improves and reaches higher levels of automation.[51]

AVs, through ride-hailing services, offer a safer alternative for travelers from their doorstep to their destination. This is especially important for individuals who may feel vulnerable or encounter difficulties when traveling from public transit to their homes.

II. Factors Affecting AV Safety

Despite widespread optimism among industry experts and researchers regarding the safety benefits of AVs, they agree that more research and testing must be done to ensure that as the technology progresses, it keeps riders and others on the roads safe.[52, 53] AV safety is dependent on many factors that will warrant further exploration and real-world testing. For instance, researchers anticipate AVs will eliminate much of the human error often associated with crashes.[54] However, one paper highlights the current contradictory state of research on AV safety, pointing out inconsistencies in the benchmarks used for evaluation.[55] Establishing standards and common terminology for crash assessments and safety tests could improve the consistency and reliability of this important research.

A particularly important aspect of AVs is the sensors and visualization systems they employ to navigate their environments. As this technology continues to evolve,[56] it will become increasingly imperative to fully understand the capabilities and limitations of different systems. Different approaches, such as safety case frameworks or advanced notice of proposed rulemaking, should consider how these advancements can benefit all members of society equitably and consider the specific challenges faced by underserved communities.

Testing is especially imperative for AVs operating in different driving conditions, including variations in weather and road conditions. Road conditions tend to be worse in neighborhoods home to low-income residents.[57] Vehicle collisions in poor-weather conditions might disproportionately involve drivers navigating suboptimal roads, especially in more rural communities where road maintenance might be neglected. These factors underscore the importance of enhancing the technical capabilities of AV algorithms to effectively navigate a diverse range of driving scenarios and to ensure safety for all.

Developers and deployers of AV algorithms must carefully consider the ethical consequences of the safety decisions made for real-world situations, for example balancing collision avoidance with strict adherence to traffic laws. This is crucial for the safe deployment of AVs and for establishing public trust in the technology. The success of AVs depends on the comfort and trust in technology. Passengers must be willing to trust autonomous safety operations of the vehicle and, in cases of lower levels of driving automation, remain attentive in a situation requiring human intervention.

Policy considerations

Solutions to address safety concerns related to technological advancements must prioritize the well-being of community members, and include a keen understanding of the disproportionate risks facing certain communities.

Driver assistance and partially automated safety features require lower levels of automation than fully autonomous systems. As the complexity of the technology increases, so does the likelihood of technical errors that could compromise vehicle safety.[58] Given the potentially severe consequences of algorithmic errors in complex systems, policymakers and stakeholders should consider a more cautious approach to testing and governance; to mitigate risks, this would involve assessing AVs' performance and safety across a wide range of scenarios.

1. Increased capacity for roadway testing

A critical step in ensuring the safe deployment of AVs is expanding testing capacity on public roads, as authorized by some states. More road tests would give manufacturers valuable real-world experience, contributing to the refinement of AV technology.

2. Improved safety testing and reporting

NHTSA launched the AV TEST Initiative in 2020 to guide and enhance public information about AV safety, testing, and precautions.[59] Today it maintains a voluntary database for test results, while crash reporting remains mandatory. Although federal regulators do not mandate testing, industry participation is considerable. As of November 2023, 19 states and 29 companies participated in the voluntary reporting of safety self-assessments.[60] NHTSA also has a Standing General Order on Incident Reporting for advanced driving systems that requires manufacturers and operators to report crashes and identify gaps in safety. Policymakers at the state and local levels should consider increasing engagement in AV testing and reporting initiatives such as these to inform their AV policy decisions.

3. AI risk assessments

The accuracy and performance of algorithms that power autonomous driving systems and the sophistication of the technology required to operate them should be monitored continuously and improved upon, as suggested by the National Institute of Standards and Technology AI Risk Management Framework.[61] This approach allows for AV technology to adapt to evolving safety standards, mitigating risks of AI used in autonomous driving systems.

D. EMISSIONS AND ELECTRIFICATION

AVs offer a sustainable transportation solution that can reduce emissions of air pollutants and greenhouse gases. However, to fully realize their potential, it is important to carefully consider the net effects of AV deployment.

A holistic understanding of the broader environmental implications, including consideration of emissions throughout the life cycle of these technologies, as well as location-specific challenges faced by underserved groups, is crucial for making informed AV policy decisions. This approach can mitigate the inadvertent widening of existing disparities and foster more equitable outcomes.

Acknowledging the gaps in AV literature, especially concerning emissions from electricity generation, manufacturing processes, and raw-material extraction, is vital. Nevertheless, valuable insights can be gleaned from the existing literature, including case studies, on the environmental implications of AVs, shared mobility, and the transition to electric vehicles. Leveraging this knowledge can help guide informed policy decisions that prioritize sustainability and equity.

I. Potential for Emissions Benefits from Electric and Smart Vehicle Design

The primary public health impact from transportation stems from exposure to tailpipe air pollution. Shared fleets of electric AVs offer a promising solution to this issue, as they can significantly increase access to zero-emissions transportation. A majority of zero-emissions cars today are powered by batteries, and a few are powered by hydrogen fuel cells, both of which produce no tailpipe emissions of air pollutants or greenhouse gases. This means that electric AVs result in far less roadside air pollution compared with conventional gasoline or diesel-powered vehicles.[62] This is significant, because transportation-related air pollution exposure can lead to negative health outcomes and premature mortality, particularly in underserved communities.[63, 64] In recognition of these benefits, some states and cities have passed requirements for ride-hailing vehicles to transition to zero-emissions vehicles—for example, 90% and 100% by 2030 in California and New York City, respectively.[65,66]

Emissions benefits can also be achieved by integrating smart design elements into AV operations. AVs can be designed and programmed to reduce or eliminate vehicle collisions, optimize smart traffic flow, serve passengers 24 hours a day without rest breaks, utilize more efficient driving routes, and leverage eco-friendly traffic signals. Together, these smart design elements can alleviate traffic congestion, reduce emissions, and reduce the number of vehicles needed to serve passengers.[67, 68, 69]

II. Multi-Occupancy Benefits

Shared AVs are likely to yield better environmental outcomes than non-shared AVs. Research indicates that each shared AV can replace 9-13 conventional vehicles, reducing the need for car ownership but likely increasing vehicle miles traveled (somewhere between 10-14%) due to additional empty travel during passenger pick-up.[70, 71] By 2030, with a cleaner grid and additional smart vehicle designs, electrified shared AVs could reduce emissions by more than 60% compared with current or future vehicles.[72] However, ensuring accessible and clean AVs that complement public transit and do not exacerbate congestion requires robust public policy frameworks. Such policies must prioritize equity, accessibility, and sustainability to ensure that AV deployment aligns with broader societal and environmental goals.

Policy considerations

The environmental advantages of AVs are closely tied to the availability of clean energy and its associated infrastructure. Ride-hailing AVs that are electric and multi-occupancy have the potential to address several transportation-related air quality and climate effects, and could yield positive environmental benefits for underserved communities when they are deployed with careful consideration for the specific needs of the target community. Here, we explore several policy considerations aimed at ensuring greater equity in urban transportation and the sharing of environmental benefits among all Americans:

1. Clean energy infrastructure investments with equitable outcomes

BPC has previously identified three categories of clean energy infrastructure investment that can support more equitable outcomes for communities.[73] They are:

- **Foundational Investments:** Targeting areas of historic underinvestment to modernize energy infrastructure and support communities' economic participation and well-being.
- **Remedial Investments:** Aiming to correct or eliminate existing infrastructure deficiencies resulting from neglect, harm, or obsolescence.
- **Resilience Investments:** Improving energy infrastructure so that communities can better withstand the impacts of extreme weather and climate-induced hazards.

Ensuring investments in AV infrastructure, such as charging infrastructure for electric AVs, toward these categories may help address infrastructure disparities and improve the accessibility of ride-hailing AVs in underserved and rural communities.

2. Comprehensive research on the environmental effects of AVs

Electric AVs offer substantial energy-saving benefits compared with traditional internal combustion engine vehicles. It is crucial to consider the broader environmental challenges associated with their production and usage as well as innovative opportunities and proactive measures that might mitigate disparate, adverse effects.

Coordinated environmental research efforts are needed to shed light on the role of ride-sharing AVs in sustainable transportation solutions for everyone. For instance, greater research is necessary to understand the life cycle greenhouse gas emissions associated with AVs' computing hardware. This could lead to improved algorithmic and hardware efficiencies and lower emissions.[74, 75] Additionally, as AV companies bring more hybrid, plug-in hybrid, and fully electric vehicles into their fleets,[76] further research is needed to quantify their net effects on air and climate pollution. This knowledge will help shape potential policy solutions. Effective solutions to address disparate impacts of sourcing and recycling critical minerals and rare-earth elements that are used in EV batteries, semiconductors, and advanced electronics can help mitigate environmental hazards and ensure resource sustainability.

III. Conclusion

AVs have the potential to revolutionize mobility, particularly benefiting underserved communities. The technology's ultimate impact remains unclear, however, and is subject to many variables.

Policymakers, industry leaders, and advocacy groups should work together to address the challenges and opportunities presented by AV technology and ensure U.S. leadership in this field. This collaborative effort can promote responsible and equitable integration of AVs into transportation systems and improve the lives of underserved communities.

Because AV technology affects transportation and mobility ecosystems across the country, more research will be necessary to inform evidence-based policies. Governments at all levels must engage with diverse stakeholders to ensure that their work is addressing the needs and concerns of different populations. Moving forward, policymakers, industry leaders, and advocacy groups must prioritize research, collaboration, and investment in infrastructure and policy frameworks that will strengthen equity, safety, and sustainability.

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