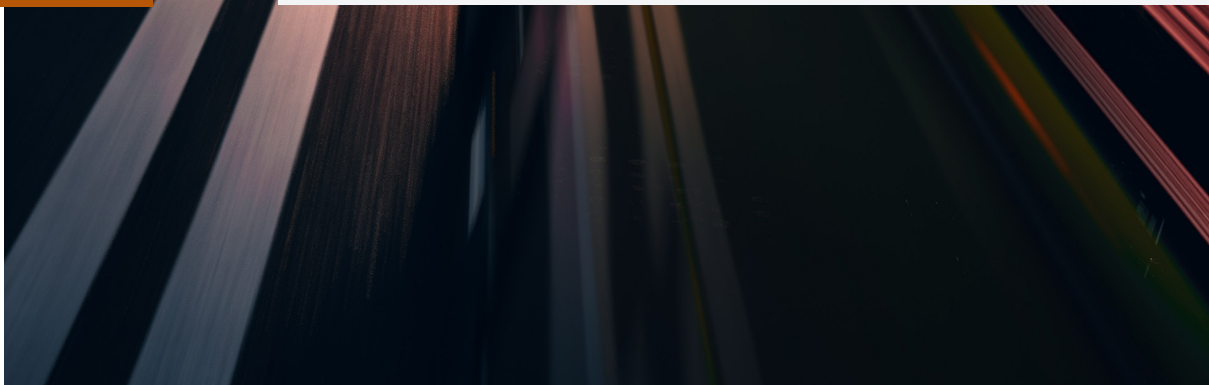




Fostering Economic Opportunity through Autonomous Vehicle Technology

JULY 2020



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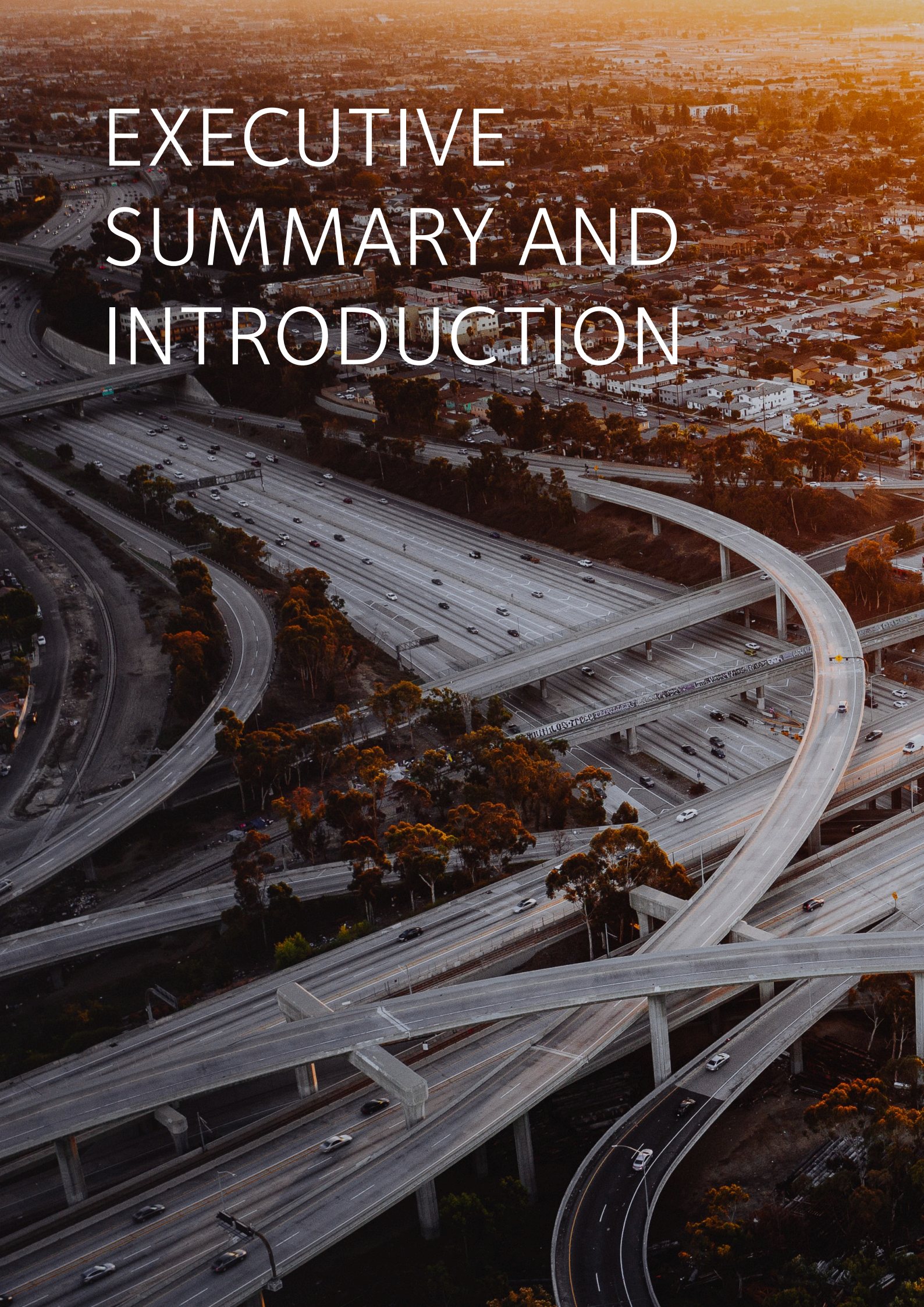
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Contents

EXECUTIVE SUMMARY AND INTRODUCTION	6
Executive Summary	8
Summary of Policy Recommendations	10
Introduction	12
CHAPTER 1: TRANSPORTATION'S ROLE IN AMERICA	14
Transportation's Role in America	17
1.1 – Mobility and the Economy	17
1.2 – Car Dependence and its Implications	18
1.3 – Affected Communities	18
Case Study – New York and Los Angeles	19
1.4 – Private Vehicles – Cost and Impact	21
1.5 – Vehicles and Public Health	21
1.6 – Automobiles and Medical Transportation	22
CHAPTER 2: TRANSPORTATION AND HOUSING AFFORDABILITY	24
Transportation and Housing Affordability	27
2.1 – Transportation's Impact on Housing Affordability	27
2.2 – Transit as a Solution	29
2.3 – Challenge to the Traditional Tools	31
2.4 – Growing Job Opportunities Remain Inaccessible	31
CHAPTER 3: MOBILITY TECHNOLOGY IN SERVICE TO SOCIETY	34
Mobility Technology in Service to Society	37
3.1 – Emerging Technologies	37
3.2 – Autonomous Vehicles (AVs)	37
3.3 – Electric Vehicles	39
3.4 – Transportation Network Companies	39
3.5 – Maximizing Technological Benefit Through Mutual Cooperation	40
3.6 – Emissions Benefits of Shifting to Shared, Electric Transportation	40
3.7 – Potential Solution During Times of Crisis	41
CHAPTER 4: POLICY RECOMMENDATIONS	44
Policy Recommendations	46
4.1 – Technology Development and Operation	46
4.2 – Operational Regulation	47
4.3 – Integrating Emerging Mobility with Other Transportation Modes	47
4.4 – Transportation Policy Governance	48
Methodology	49

EXECUTIVE SUMMARY AND INTRODUCTION





Executive Summary

Reliable, affordable, and efficient transportation is a crucial factor in determining the upward social mobility of low-income households. Every city in the United States has been built around the automobile, and ownership of – or access to – a car is vital for Americans wishing to reach the middle class. Yet for many low-income households, which spend a greater percentage of their income than higher-income households on transportation, owning a car remains an unaffordable option.

New technologies and business models, however, hold the potential to upend the current paradigm. By providing the convenience of door-to-door, on-demand mobility at costs significantly below that of personal vehicle ownership, autonomous vehicles (AVs) stand to impact society in ways unseen since the invention of the automobile itself. If this autonomous future is realized, low-income communities will not only have greater access to jobs but could also see large-scale improvements to standard of living by dramatically reducing per-household transportation expenses. Efforts are underway to address urban land use issues that have contributed to many of the difficulties low-income communities face, but they will take decades to resolve. Low-income residents cannot wait that long and it is incumbent on government to find additional means forward. Supporting AV development is a promising avenue.

To provide a greater understanding of the challenges faced by low-income communities with respect to transportation and economic well-being, SAFE conducted analyses to examine transportation costs, improvements in living standards, and job opportunities. In discussing housing, SAFE used a modified version of the Center for Neighborhood Technology's Housing + Transportation (H+T) Affordability Index¹ that deemed housing affordable if combined housing and transportation costs are under 45 percent of a typical household's pre-tax income.² SAFE's key findings were:

- The most conservative cost-per-mile estimate for an autonomous, shared and electric car in 2030 is 50 cents. In contrast, the cost per mile for buses today is \$1.31.
- More than 75 million households – representing approximately two-thirds of Americans – live in neighborhoods that are beyond their means because of largely unseen transportation costs.

Affordability of U.S. Housing and Transportation

Group	Households	Fraction of U.S. Households
Entire United States	115.8 million	100 percent
in neighborhoods with affordable housing	71.6 million	61.9 percent
affordable housing and affordable transportation	30.7 million	28.2 percent

(Source: Center for Neighborhood Technology | Created with Datawrapper)

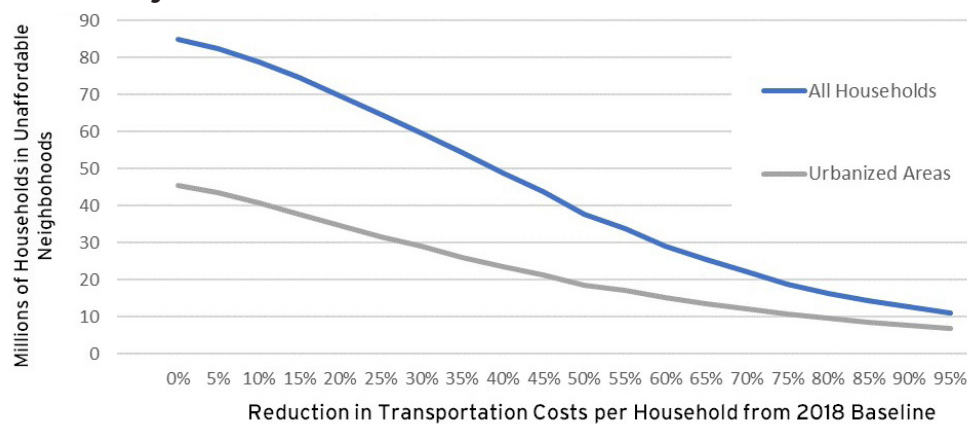
¹ The Center for Neighborhood Technology, "The Housing and Transportation (H+T®) Affordability Index."

² The Center for Neighborhood Technology found 15 percent of income to be an attainable goal for transportation affordability. By combining this 15 percent level with the 30 percent housing affordability standard, the H+T Index recommends a new view of affordability defined as combined housing and transportation costs consuming no more than 45 percent of household income, per "H+T Index Methods," August 2017.

- For every 1 percent reduction in the cost of transportation with a fixed housing cost, approximately 750,000 households enter affordability - in which combined housing and transportation costs account for less than 45 percent of a typical household's income.
- AV transportation could reduce household costs by as much as \$5,600 per household,³ or \$3,800 per American.⁴ SAFE found that reducing average transportation costs by \$5,000 per year in urbanized neighborhoods would result in more than 25 million households becoming affordable.
- Employment growth areas in our modern economy - such as job opportunities in e-commerce - remain accessible only by car. SAFE found, for example, that Amazon's 60 largest U.S. fulfillment centers and facilities are inaccessible to those who work there, unless commuting by personal vehicle.

Transportation is a typical household's second-largest expense, behind housing, and low- and middle-income populations find the lower housing costs when they move to suburbs and exurbs are often offset by the higher amount they spend on transportation.⁵ As their housing costs decrease, their transportation costs can increase by as much as five times, as measured by a share of income.⁶

Reductions in Transportation Cost Significantly Increases Neighborhood Affordability



(Source: Center for Neighborhood Technology's H+T Index Data portal)

Reductions in household transportation costs also hold the potential to dramatically improve job availability for communities across the country. SAFE's findings included:

- A 50 percent reduction in transportation costs would provide Americans living in neighborhoods with poor access to jobs the ability to reach as many jobs as enjoyed by residents of the top 10 percent of neighborhoods with the best access in the United States.
- Access to convenient and reliable transportation helps low-income and underserved communities and can play a crucial role in reducing economic inequality: individuals with access to vehicles are four times more likely to have a job.⁷

³ James Arbib & Tony Seba, "Rethinking Transportation 2020-2030: The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries," RethinkX, May 2017.

⁴ Lewis M. Clements and Kara M. Kockelman, "Economic Effects of Automated Vehicles," Transportation Research Record, January 1, 2017.

⁵ Ibid.

⁶ Ibid.

⁷ Blumenberg et al., "Transportation Access, Residential Location, and Economic Opportunity: Evidence From Two Housing Voucher Experiments," Cityscape, 2015.

Lastly, the COVID-19 pandemic appears to exacerbate existing transportation challenges for vulnerable communities. But there is reason to believe that AV transportation might offer a mitigating solution for future health crises. As the pandemic is shifting behaviors, from shopping habits to greater health precautions, it will likely also shift consumer and employee preference for travel.

Summary of Recommendations

The question of how to better facilitate economic opportunities and transportation equity is complex. Transportation alone will not solve all the challenges that underserved and low-income communities face, but SAFE believes new transportation technologies and related policy measures can be a powerful solution for many in the United States. SAFE's recommendations to achieve this are as follows:

- **Technology Development and Operation**

- **Promote the development and accelerated deployment of new transportation technologies.**

SAFE believes that instead of over-regulating new technologies to the point where their societal value is unduly constrained, pathways should be provided for widespread market acceptance - which will be of importance to AVs in the near future.

- **Create pilot programs with a focus on equity and new-use cases.** When pilot programs are being developed for new transportation technologies, policymakers must ensure that underserved, low-income households are included in order to accurately assess their impact. Pilot programs should track impacts on equity, and the results of such pilots should be used to identify and understand the viability of economic pathways for developing social use cases for other emerging technologies.

- **Operational Regulation**

- **Tailor user fees and regulatory frameworks to prioritize shared, electric transportation.**

Any user fees, utilization policies, or licensing restrictions on emerging transportation technologies must explicitly promote connected, autonomous, shared, and electric vehicles. Regulations that restrict or impose fees on emerging transportation modes should offer reduced burdens on such vehicles, services, and programs.

- **Integrating Emerging Mobility with Other Transportation Modes**

- **Road pricing should be calibrated across modes.** Pricing strategies put in place to manage congestion or other outcomes must use mechanisms that are not mode-specific - such as fees specifically on transportation network companies (TNCs) that are not calibrated with personal vehicle road-use fees. In addition, governments should promote research and development into analytical frameworks, like Mobility Energy Productivity (MEP), that create a common language to compare tradeoffs between different modes.

- **Improve integration between emerging technology and public transportation.** Integrating emerging technology with existing public transportation holds great potential to benefit a diverse array of communities across the country, but further work and experimentation is required if such solutions are to be deployed effectively and at scale. For instance, AVs could increase commuter rail use by providing cost-effective ways of bringing people to stations without having to park their vehicle.

- **Update housing policy to better leverage advantages of emerging transportation technology.** More attention must be paid to including lower-income communities in suburban and other less-dense areas, for whom traditional economic development and public transportation solutions have not worked well in the past. As federal mortgage policy implicitly favors pushing households out into neighborhoods with higher transportation costs, the Federal Housing Administration (FHA) - and private lenders and insurers - should also account for transit costs in mortgage issuance and insurance.

- **Transportation Policy Governance**

- **Implement a reorganization of the U.S. Department of Transportation (USDOT) and a cross-cutting governance model that encompasses all modes.** As transportation is becoming increasingly multimodal, USDOT should create a cross-cutting governance structure to integrate transit with other modes. This may take the form of expanding the Non-Traditional and Emerging Transportation Technology (NETT) Council, which was formed in 2019 to address technologies that do not squarely fit into a specific mode.

Introduction

LaToyia Newman-Gross, a single mom, has a bus stop right outside her apartment, but that does not make transportation easy for her. If she misses the bus that runs only once an hour, she is stuck. And waiting out in the rain or the heat with her four children generally is not a good option. "There've been times when I've been standing on the bus stop with my kids, watching other people drive by with their cars, and you just feel less-than, when you can't do something so simple, that most people take for granted," Newman-Gross says. With young children, Newman-Gross has doctor appointments, meetings with teachers, and travel to grocery and clothing stores. She often would spend large amounts of money on taxis, sometimes as much as \$60 to get to just one doctor.⁸

Darryl Haden, who works at a restaurant in Washington, DC and lives in Oxon Hill, Maryland, frequently finds his 4:00pm - 4:00am work schedule creates complicated transportation challenges. "Sometimes it's cool during the week. We get off at about 4am and the train starts at 5am," he says, "But on the weekend, it gets you thinking about decisions you made. If I leave at 5:30am, I don't get home until about 8:30am, or 9:00am because the trains don't run in Maryland." Haden adds that the onerous commute has had a deleterious effect on every aspect of his life, including upward economic mobility and family time. "I got a day job, but I had to cut back because I couldn't get there on time. It's rough. I got two boys," he says, noting that ride hailing options are prohibitively expensive. "It costs me \$36 to get home on the weekends."⁹

Across the United States, millions of Americans are forced to contend with unreliable or inaccessible transportation options that limit their prospects for a better life. Workers who finish their shifts in the early hours of the morning, after the last bus or subway of the evening, are forced to forfeit large portions of their hard-earned wages every night on taxis or rideshares to get them home. Young parents, working two jobs to make ends meet, find their employment options limited by access to daycare. Senior citizens, isolated in their homes and unable to drive, miss vital medical appointments. Black communities often find themselves cut off from other parts of urban centers without adequate transportation options, and Americans living with disabilities, six million of whom struggle to access the transportation they need, miss out on education and job opportunities.¹⁰

In a country built around the automobile, owning a car has long been the answer to this problem: having a car increases the likelihood of finding a job by a factor of two and of having a job by a factor of four.¹¹ Yet for low-income households, car ownership brings problems of its own. For millions of Americans, having and keeping their car is a priority, and many are forced into making extremely difficult financial choices or tradeoffs. Seven million Americans are at least three months behind on car payments, and many that do make car payments are doing so instead of paying rent or mortgages.¹²

One of the largest factors determining upward economic mobility is actual mobility itself - the ability to travel quickly and conveniently from point A to point B. Yet as suburban poverty increases, and urban poverty persists, the prospects of living in a community where such accessibility is available to all are very low and continually decreasing.

8 Sophie Quinton and National Journal, "How Car Ownership Helps the Working Poor Get Ahead," *The Atlantic*, July 24, 2014.

9 George Jordan, "Commuting without Metro is a struggle for late-night workers," *Greater Greater Washington*, July 24, 2019

10 Securing America's Future Energy, "Self-Driving Cars: The Impact on People with Disabilities," January 2017

11 Blumenberg et al., "Transportation Access, Residential Location, and Economic Opportunity: Evidence From Two Housing Voucher Experiments" *Cityscape*, 2015.

12 Heather Long, "A record 7 million Americans are 3 months behind on their car payments, a red flag for the economy" *Washington Post*, February 12, 2019.

However, a suite of technologies is being developed that hold the potential to upend this paradigm and create affordable, reliable, door-to-door transit for all households. Autonomous vehicle (AV) technology promises efficient, on-demand transportation at costs that would be cheaper than personally owned vehicles,¹³ and could serve all areas including where public transit is lacking or underserved, or at times when it does not run. Additionally, the ride hailing business model of transportation network companies (TNCs) provides a new framework with which to build a convenient and affordable transportation network for low-income households, when combined correctly with AVs.

Through this combination of affordability and utility, these technologies can fill the gap where traditional transit options fall short. Analysis can be conducted to demonstrate that certain transit routes, such as low ridership routes, would be better served or could be augmented via a shared AV solution. Low-income communities could reach new opportunities without having to compromise on cost, allowing transit agencies to preserve resources and spend taxpayer dollars where they are most impactful, without sacrificing the public's ability to travel.

Moreover, millions of Americans would be enabled to realize their full economic potential, and finally experience upward economic mobility. Our study found that better and less expensive access to more convenient and efficient forms of mobility can make significant inroads into integrating underserved and low-income communities into wider urban centers, while allowing new investments into their communities, creating more economic opportunities and facilitating broader cultural connections as a result.

13 Todd Litman, "Autonomous Vehicle Implementation Predictions," Victoria Transport Policy Institute, June 5, 2020.





C H A P T E R O N E

TRANSPORTATION'S ROLE IN AMERICA



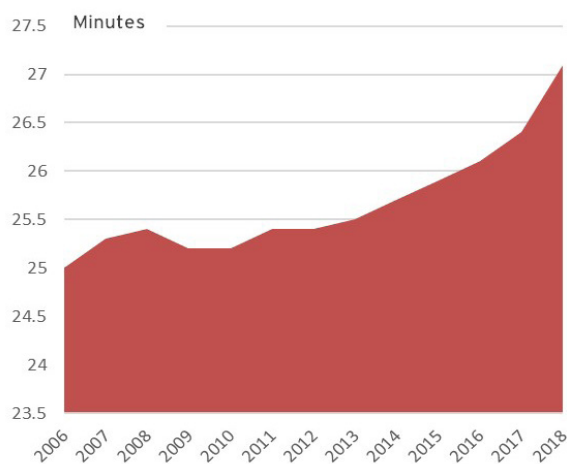
1 – Transportation's Role in America

Cars are central to the U.S. economy and the American way of life. Automobiles and roadway infrastructure have connected disparate areas, expanded communities, and unlocked new opportunities. As a result, travel per capita has increased fifty-fold since the invention of the car,¹⁴ with 164,000 miles of highway and 4 million miles of public roads connecting population centers across the country.¹⁵

1.1 – Mobility and the Economy

"Within a transportation context, one structural challenge [to equity] that has to be looked at is the built environment. In many cases, for a long time the private vehicle has been heavily subsidized through the infrastructure investment," says Adam Cohen, a Survey Researcher at the Transportation Sustainability Research Center (TSRC) at the Institute of Transportation Studies at the University of California, Berkeley.¹⁶ The emergence of a nationwide highway system and widespread automobile availability in the United States led directly to the growth of suburban sprawl.¹⁷ Following the end of World War II, wealthier Americans moved out of urban centers and into the suburbs. Stores, businesses, and other services followed them, leaving behind low-income and minority populations.¹⁸ There is a positive correlation between urban sprawl and income inequality,¹⁹ and sprawl's effect on upward

Average One-way Commute Time



(Source: U.S. Census Bureau)

mobility is most clearly seen through the inaccessibility of jobs for those left behind in the cities' cores.²⁰ Increasing distance from work centers leads to rising unemployment rates among inner city residents and, in turn, "increased poverty outcomes for the region as a whole."²¹

14 Andreas W. Schafer, "Long-Term Trends in Domestic US Passenger Travel: The Past 110 Years and the Next 90," *Transportation*, July 10, 2015.

15 U.S. Federal Highway Administration, "Our Nation's Highways 2011," 2011.

16 SAFE Interview with Adam Cohen, Survey Researcher at the Transportation Sustainability Research Center (TSRC), Institute of Transportation Studies at the University of California, Berkeley, October 28, 2019.

17 Ralph Buehler, "9 Reasons the U.S. Ended Up So Much More Car-Dependent Than Europe," *CityLab*, February 4, 2014.

18 Ewing et al., "Does urban sprawl hold down upward mobility," *Landscape and Urban Planning*, January 6, 2016.

19 Yehua Dennis Wei and Reid Ewing, "Urban expansion, sprawl and inequality," *Landscape and Urban Planning*, May 2018.

20 Ewing et al., "Does urban sprawl hold down upward mobility," *Landscape and Urban Planning*, January 6, 2016.

21 *Ibid.*

This is primarily due to lack of transportation accessibility. Studies have shown that "access to automobiles is associated with improved economic outcomes" and "better facilitates job acquisition, job retention, and earnings than public transit."²² This effect carries beyond just urban centers and affects even low-income families that live in suburbs, subject to dispersed economic opportunities and limited transit options. The effect is most pronounced, however, for low-income, inner-city residents, who are most likely to have a modal mismatch, highlighting an extreme deviation in the comparative advantage between those that have personal vehicles and those that do not.²³ With most American cities designed to require cars (as the "Case Study: New York City & Los Angeles" explores further), low-income Americans are at a distinct disadvantage. Though it will likely take many years to correct this discrepancy, AVs could help significantly.

1.2 – Car Dependence and its Implications

Access to a private vehicle is not only positively correlated with employment, but car ownership also predicts higher earnings to a far greater degree than access to public transit.²⁴ Cars have been consistently proven to help low-income and underserved communities and can play a crucial role in reducing economic inequality. Affordable and stable automobile availability can reduce the negative impacts of geographic isolation for families that live in low-income neighborhoods, as cars offer them increased access to jobs and education.²⁵

However, as the country historically became more dependent on cars, the consequences of lacking a car have become more pronounced. Between 2001 and 2015, households without vehicles saw an average decline of approximately 3 percent in their real

incomes.²⁶ Meanwhile, income continued to grow for households that owned cars.²⁷

Census data shows that although the U.S. poverty rate fell from 24 to 14 percent between 1960 and 2014, the poverty rate for households without vehicles increased from 42 to 44 percent.²⁸ Notably, even as personal vehicles have become more necessary to fully participate in society, they have not become more affordable. Yet, it remains clear that having a car is economically valuable: though more households living in poverty are obtaining cars, they are doing so by taking on additional financial stress. Even small increases in available spending for low income households are often converted into vehicle purchases.²⁹

Households with less access to jobs spend a greater percentage of their income on transportation than households with greater access to jobs. Lower-income households travel further for much of their day-to-day lives, including traveling to and from work or school, as well as for shopping, medical appointments, and other errands. Exacerbating this problem is the inflexible nature of lower-income jobs, which often require a physical presence for specific time periods. Approximately 70 percent of regional jobs, retail, and other opportunities are now outside of downtown centers,³⁰ yet public transit still retains a focus on carrying riders from the suburbs to city centers.³¹

1.3 – Affected Communities

Vehicle ownership – or lack thereof – affects quality of life; communities with lower levels of automobility face greater economic vulnerabilities. Vehicle ownership represents a significant financial burden that weighs especially heavily on low-income families, as outlined further in Section 1.4. This is particularly significant when considering that almost 45

22 Blumenberg et al., "Transportation Access, Residential Location, and Economic Opportunity: Evidence From Two Housing Voucher Experiments," *Cityscape*, 2015.

23 Ibid.

24 King et al., "The Poverty of the Carless: Toward Universal Auto Access," *Journal of Planning Education and Research*, February 2019.

25 Pendall et al., "What if Cities Combined Car-Based Solutions with Transit to Improve Access to Opportunity?" *Urban Institute*, June 2016.

26 King et al., "The Poverty of the Carless: Toward Universal Auto Access," *Journal of Planning Education and Research*, February 2019.

27 Ibid.

28 Ibid.

29 Ibid.

30 Stuart Cohen and Sahar Shirazi, "Can We Advance Social Equity with Shared, Autonomous and Electric Vehicles?" *UC Davis Institute of Transportation Studies*, February 2017.

31 Monica G. Tibbits-Nutt, "Technology for All: How Equity, Access and Affordability Must Feature in Next-Generation Vehicle Policy," May 2019, *TR News*.

Case Study

New York City & Los Angeles

How does the built environment affect households without a vehicle? Conventional logic suggests that where public transit is prevalent and easily accessible, families without vehicles should fare better than they otherwise would in a place optimized for automobiles. To test this, researchers compared the economic fortunes of carless households in New York City and Los Angeles.

New York City typifies the public transit environment. While the United States' population-weighted density decreased, on average, by more than 50 percent between 1950 and 2013, New York's population density increased between 1950 and 2014, and, in 2015, remained more than ten times the national average. This density, combined with the city's compact grid of narrow streets, limited parking, and lack of vehicle fueling options – Manhattan has only 50 gasoline stations despite having a daytime population larger than 27 states – make New York a difficult place to own an automobile.

Los Angeles, on the other hand, is in many ways New York's antithesis. Despite increasing population density, cars have remained the dominant mode of transport, partly due to Los Angeles's zoning laws. Both Los Angeles and New York are large urban centers – but while Los Angeles's layout encourages vehicle ownership, New York's discourages it.

The evidence seems to prove this notion: New York's car-less households have seen their median incomes rise since 1960, to \$36,600 in 2014, double that of Los Angeles. The opposite has held true for Los Angeles's zero-vehicle families, whose median household income has fallen by 14 percent in constant terms over the same period. Moreover, the gap between car-less and car-owning households is significantly higher in Los Angeles: zero-vehicle households earn an average income that is 67 percent below the citywide average. Conversely, in New York, the mean income for carless households is only 20 percent below the citywide average.

To control for the multitude of differences between New York and Los Angeles, researchers also compared median incomes in Staten Island and Manhattan. Although it is one of the five boroughs that constitute New York, Staten Island is much closer to Los Angeles in layout and auto-orientation. It lacks connection to the New York subway system, contains more off-street parking, has a high percentage of single-family homes, and has the lowest population density of the five boroughs.

The results told the same story: in absolute terms, as well as in relation to car-owning families, zero-vehicle households in Staten Island experienced a decline in median household income. Between 1960 and 2014 the probability that a car-less household would experience poverty fell by 20 percent in Manhattan. In Staten Island, that probability more than tripled. Moreover, while incomes for zero-vehicle families more than doubled in Manhattan, they fell by 41 percent in Staten Island. Clearly, built environment matters for zero-vehicle households.

Source: King et al., "The Poverty of the Carless: Toward Universal Auto Access," *Journal of Planning Education and Research*, February 2019.

percent of all American workers qualify as low-wage, with median annual earnings of about \$18,000.³² More than one-half of these workers are in their prime working years and also are most likely to be raising children, with almost one-third of them living below the federal poverty line.³³ Additionally, racial discrepancies are quite significant when it comes to vehicle access. For instance, roughly 19 percent of African American and 11 percent of Hispanic households do not have a car, in stark contrast to roughly 6 percent of white, non-Hispanic households.³⁴

For elderly Americans, aged 65 and older, having vehicle access is of paramount importance to maintaining an independent lifestyle and participating in society.³⁵ Having transport options is also key to caring for their health and allowing them to age in place in their community.³⁶ At the same time, only 15 percent of older Americans use public transit options and even fewer take advantage of special transportation services or choose to ride with volunteers.³⁷

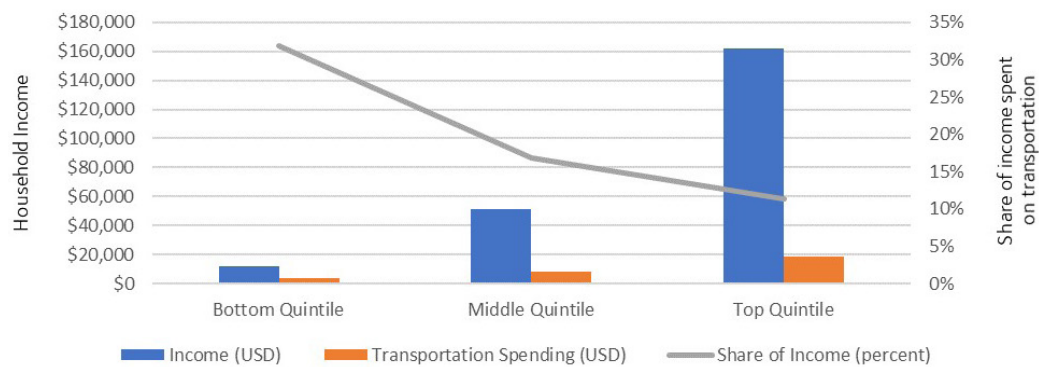
It is increasingly likely that the United States' aging population will find owning a car to be a financial burden they can no longer afford.³⁸ Studies have shown

that when those aged 65 or older stop driving, a variety of negative consequences have been observed, including an increase in loneliness, strained relationships with family, symptoms of depression, and reduced participation in activities outside of the home.³⁹ This is exacerbated by the fact that older licensed drivers are less inclined to use public transportation and are unlikely to be picked up or dropped off.⁴⁰ Increased accessibility and safer mobility options could greatly enhance the lives of older Americans.

The same rings true for Americans who are living with a disability. In January 2017, SAFE released the report "Self-Driving Cars: The Impact on People with Disabilities."⁴¹ It detailed the transportation issues that those with disabilities bear:

The most recent government transport survey conducted in 2003 indicated that 15 million Americans have difficulty getting the transportation they need, including more than six million individuals with disabilities. Problems with obtaining access to transportation disproportionately affect individuals with disabilities, indicating that systemic barriers

Transportation Spending by Quintiles of Income



(Source: Consumer Expenditures Survey 2018)

32 Martha Ross and Nicole Bateman, "Low-wage work is more pervasive than you think, and there aren't enough "good jobs" to go around," The Brookings Institution, November 21, 2019.

33 Martha Ross and Nicole Bateman, "Meet the low-wage workforce," The Brookings Institution, November 7, 2019.

34 U.S. Department of Transportation, "Beyond Traffic 2045," January 9, 2017.

35 Rahman et al., "Evaluation of transportation alternatives for aging population in the era of self-driving vehicles," IATSS Research, June 4, 2019.

36 National Association of Area Agencies on Aging, "Transportation."

37 National Aging and Disability Transportation Center, "Transportation Needs and Assessments - Survey of Older Adults, People with Disabilities, and Caregivers," December 6, 2018.

38 SAFE Interview with Andrew Salzberg, Loeb Fellow at Harvard University Graduate School of Design. November 13, 2019.

39 Rahman et al., "Evaluation of transportation alternatives for aging population in the era of self-driving vehicles," IATSS Research, June 4, 2019.

40 Ibid.

41 Securing America's Future Energy, "Self-Driving Cars: The Impact on People with Disabilities," January 2017.

exist, which may, in turn, contribute to lower rates of employment, education, and income.⁴² In particular, for a large subset of the disability community, many modes of transportation remain either inaccessible, unreliable, or ill-suited toward some or all of their transportation needs.

1.4 – Private vehicles – Cost and Impact

As the figure below shows, in 2018, households in the lowest quintile of income spent three times a larger share of their post-tax income on transportation compared to the highest quintile. More telling is that 93 percent of the amount spent by the bottom quintile was on vehicle-related expenses, including fuel, maintenance, and insurance.⁴³ In terms of car financing, residents of lower-income neighborhoods pay \$50 to \$500 more for the same car than residents of higher-income neighborhoods. Auto loans on average cost 2 percentage points higher for low-income drivers.⁴⁴ Moreover, low-income residents pay 40 percent more on average for insurance than more educated, higher-income households.⁴⁵

The added economic stress that low-income households shoulder when they choose to own a vehicle – despite sometimes lacking the means to do so comfortably – can result in material deprivation and the forfeiture of other basic needs, such as heating their homes, in order to pay for their car.⁴⁶ As a result, the costs of car ownership can be damaging for low-income individuals and families, which constitute almost one-third of Americans.⁴⁷

1.5 – Vehicles and Public Health

Reduced access to private vehicles not only limits economic prosperity, but it also has a negative impact on individuals' physical health: while access to private transportation is limited, low-income communities are more likely to be located in areas and near facilities with higher emissions, such as highways, power plants and manufacturing.⁴⁸ Increased exposure to air pollution is associated with increased depression in both adults and children, with the latter also at higher risk of anxiety.⁴⁹ Exposure to fine particulate matter (PM2.5) emitted by car engines is positively associated with higher levels of psychological distress.⁵⁰ Low-income communities suffer even more sharply from unclean air: exposure to higher levels of total suspended particulates (TSP) in children from low-income families is linked to lower upward economic mobility, whereas there is no association for children from high-income families.⁵¹

Children from low-income families suffer disproportionately from unclean air because they are more exposed to it than the rest of the population. Low-income communities are, on average, more vulnerable to air pollution from traffic, and consequently are at higher risk of resulting health issues.⁵² This, too, is linked to car access: while owning multiple cars and driving alone are associated with lower household exposures to air pollutants and health risks, not owning a car and walking or using public transportation are associated with higher exposures and health risks.⁵³ In addition, low-income communities also suffer from a traffic collision fatality rate that is twice as high as high-income areas.⁵⁴

42 Bureau of Transportation Statistics, "Transportation Difficulties Keep Over Half a Million Disabled at Home," April 2003.

43 SAFE calculations based on 2017 Consumer Expenditures Survey.

44 Elizabeth Kneebone and Alan Berube, "Confronting Suburban Poverty in America," Brookings Institution Press, January 13, 2014.

45 Ibid.

46 Giulio Mattioli, "'Forced Car Ownership' in the UK and Germany: Socio-Spatial Patterns and Potential Economic Stress Impacts," Social Inclusion, 2017.

47 Fontenot et al., "Income and Poverty in the United States: 2017," U.S. Census Bureau, September 12, 2018; low-income defined as an income below 200 percent of an individual's poverty threshold, as defined by the National Center for Children in Poverty, "Measuring Poverty."

48 Cheryl Katz, "People in Poor Neighborhoods Breathe More Hazardous Particles," Scientific American, November 1, 2012.

49 Vert et al., "Effect of long-term exposure to air pollution on anxiety and depression in adults: A cross-sectional study," International Journal of Hygiene and Environmental Health, August 2017; Yolton et al., "Lifetime exposure to traffic-related air pollution and symptoms of depression and anxiety at age 12 years," Environmental Research, June 2019.

50 Sass et al., "The effects of air pollution on individual psychological distress," Health & Place, October 2017.

51 O'Brien et al., "Prenatal Exposure to Air Pollution and Intergenerational Economic Mobility: Evidence from U.S. County Birth Cohorts," Social Science & Medicine, September 27, 2018.

52 Pratt et al., "Traffic, air pollution, minority and socio-economic status: addressing inequities in exposure and risk," International Journal of Environmental Research and Public Health, May 2015.

53 Ibid.

54 U.S. Department of Transportation, "Beyond Traffic 2045," January 9, 2017.

This can be traced, at least in part, to an underinvestment in adequate infrastructure for lower-income neighborhoods. Nearly 90 percent of high-income neighborhoods have sidewalks, compared to only 50 percent of low-income ones.⁵⁵

1.6 – Automobiles and Medical Transportation

Approximately 3.6 million people a year do not receive medical care due to transportation barriers, and these people are disproportionately poorer, less educated, more likely to be part of a minority group, female, and older.⁵⁶ Almost one quarter of low-income adults living in suburbs have missed or rescheduled a medical appointment in the past due to transportation issues, and nearly one third have chronic problems with transportation.⁵⁷ Patients from low-income backgrounds consistently face more transportation barriers than their higher-income counterparts, which inhibits their access to ongoing healthcare, pharmacies, and medication.⁵⁸

Underserved populations face severe health consequences as a result of their increased transportation barriers to medical care. An analysis of more than 44 million trips for hemodialysis treatment for 180,000 Medicare Primary patients with end-stage renal disease – kidney failure – showed that patients who missed their trips were more than four times more likely to be hospitalized; more than three times more likely to visit the emergency room; and four times as likely to be admitted to the intensive care unit or coronary care unit.⁵⁹ Patients who used public transit to get to their treatment were more likely to miss their appointments, while patients with access to a vehicle had better attendance and treatment outcomes.⁶⁰ For all individuals, reliable and consistent access to medical services is essential to maintaining good health – yet a lack of point-to-point transportation often limits this access for disadvantaged and low-income communities, with adverse health outcomes not only for themselves, but for the broader health care system.

55 U.S. Department of Transportation, "Beyond Traffic 2045," January 9, 2017.

56 Wallace et al., "Access to Health Care and Nonemergency Medical Transportation: Two Missing Links," *Transportation Research Record Journal*, January 2005.

57 Silver et al., "Transportation to Clinic: Findings from a Pilot Clinic-Based Survey of Low-Income Suburbanites," *Journal of Immigrant and Minority Health*, April 2012.

58 Syed et al., "Traveling Towards Disease: Transportation Barriers to Health Care Access," *Journal of Community Health*, March 2013.

59 Chan et al., "Adherence Barriers to Chronic Dialysis in the United States," *Journal of the American Society of Nephrology*, November 2014.

60 Ibid.





C H A P T E R T W O

TRANSPORTATION AND HOUSING AFFORDABILITY





PETER MACCHIARINI ST EPS

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2 – Transportation and Housing Affordability

Effectively addressing the issues outlined in the previous chapter requires an appraisal of the cost and availability of various transportation options. Reducing transportation costs can be an incredibly powerful lever for improving neighborhood affordability by giving households greater choice over where to live. Perhaps surprisingly, the problems expressed above are just as prevalent in suburban areas as they are in urbanized communities. In 2017, more than half of Americans described themselves as living in a suburb.⁶¹ In recent years, more Americans have lived in poverty in the suburbs rather than in urban cores,⁶² with the number of suburban poor growing 57 percent from 2000 to 2015.⁶³ Similarly, urban poverty has increased approximately 20 percent over the same period.⁶⁴ Though public transportation can work well in dense cities, it serves sparsely populated ones poorly; meanwhile, as discussed, car ownership has become an increasingly expensive prospect for low-income households across the United States. This suggests that AVs could be particularly helpful in less dense urban environments, because transit has a limited potential there for the foreseeable future. In either case, access to reliable, affordable transportation is difficult when public transportation does not serve riders' needs and car ownership is not affordable.

2.1 – Transportation's Impact on Housing Affordability

After housing, a typical household's biggest expense is transportation. The standard benchmark for housing affordability is 30 percent of income, meaning that households that fit this spending pattern will still have enough income left over to cover nondiscretionary spending.⁶⁵ Levels of available affordable housing have progressively fallen over the past five decades, resulting in a situation that some have described as an "affordable housing crisis."⁶⁶ Notably, the lower housing costs that low- and middle-income populations find when they move to suburbs and exurbs are often offset by the higher amount they spend on transportation.⁶⁷ As their housing costs decrease, their transportation costs rise by up to five times, as measured by a share of income.⁶⁸

This affordability benchmark can be applied to neighborhoods as well. Under the Center for Neighborhood Technology's Housing + Transportation (H+T) Affordability Index,⁶⁹ a specific neighborhood is affordable if housing

61 Shawn Bucholtz and Jed Kolko, "America Really Is a Nation of Suburbs," CityLab, November 14, 2018.

62 SAFE interview with Ellen Dunham-Jones, Director, Urban Design Program at the Georgia Tech School of Architecture, November 18, 2019.

63 Elizabeth Kneebone, "The changing geography of US poverty," The Brookings Institution, February 15, 2017.

64 Ibid.

65 Mary Schwartz and Ellen Wilson, "Who Can Afford To Live in a Home? A look at data from the 2006 American Community Survey," U.S. Census Bureau, 2008.

66 Sisson et al., "The affordable housing crisis, explained," Curbed, May 15, 2019.

67 Ibid.

68 Ibid.

69 The Center for Neighborhood Technology, "The Housing and Transportation (H+T®) Affordability Index."

costs in that neighborhood are below 30 percent of the median income for a regional household. Providing the opportunity to evaluate the financial impact of location decisions, the H+T Index found that transportation costs are highly correlated with neighborhood characteristics. Areas it considers affordable – or "location efficient" – are close to jobs and services, with a variety of transportation choices, which allow people to spend less time, energy, and money on transportation.

Affordability of U.S. Housing and Transportation

Group	Households	Fraction of U.S. Households
Entire United States	115.8 million	100 percent
in neighborhoods with affordable housing	71.6 million	61.9 percent
affordable housing and affordable transportation	30.7 million	28.2 percent

(Source: Center for Neighborhood Technology's | Created with Datawrapper)

However, this alone offers an incomplete view of neighborhood affordability. To analyze and include the role of transportation, SAFE used a modified version of the H+T Index.⁷⁰ Instead of deeming a neighborhood affordable if the typical household in the region can afford local housing on 30 percent of its income, this

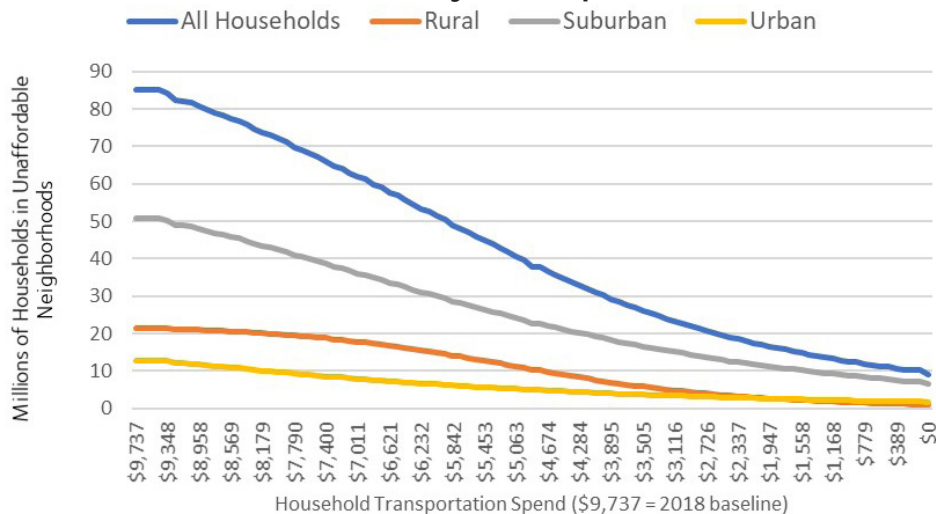
new analysis includes both housing and transportation costs – requiring combined housing and transportation costs to be under 45 percent of a typical household's income.⁷¹

As the table to the left shows, nearly 40 percent of American households live in neighborhoods where housing costs are not affordable. This picture worsens dramatically when transportation costs are considered – more than 70 percent of households are considered not affordable under this criterion.

Even small changes in transportation costs result in significant improvements in affordability. As illustrated in the figure below, even a 1 percent reduction in transportation costs moves more than 750,000 households into affordability, including nearly 400,000 in urbanized neighborhoods. Accomplishing a 20 percent reduction in transportation costs would open affordable neighborhoods for more than 15 million households, including 8 million urbanized households

Households across the country, on aggregate, spend a similar proportion of their income on housing – about 30 percent.⁷² However, even across urbanized areas, transportation costs tend to be higher for neighborhoods with worse job access and lower for neighborhoods with better job access.⁷³

More Households Enter Affordability as Transportation Costs Fall



(Source: Center for Neighborhood Technology's H+T Index Data Portal)

70 The Center for Neighborhood Technology, "The Housing and Transportation (H+T®) Affordability Index."

71 The Center for Neighborhood Technology found 15 percent of income to be an attainable goal for transportation affordability. By combining this 15 percent level with the 30 percent housing affordability standard, the H+T Index recommends a new view of affordability defined as combined housing and transportation costs consuming no more than 45 percent of household income, per "H+T Index Methods," August 2017.

72 SAFE analysis of Center for Neighborhood Technology's H+T Index Data.

73 SAFE analysis of Center for Neighborhood Technology's H+T Index Data.

This suggests that many households would be better off spending a greater proportion of their income on housing and less on transportation, but housing policy and subsequent market realities make this an extremely difficult prospect. Housing in areas that have excellent transportation links and great walkability are usually parts of town that are far too expensive for low-income individuals. Households are thus forced to make a tradeoff between job access and housing affordability, but at the cost of higher proportional expenditures on transportation. This implies that technology and business models that reduce the cost of transportation may significantly improve access to jobs for communities.

Estimates range, but recent research suggests that households that rely on a shared fleet of AVs could reduce their annual transportation budget by \$3,800⁷⁴ to \$5,600.⁷⁵ Applying a 50 percent reduction in transportation costs to our analysis, we find that nearly all U.S. households will have transportation costs comparable to what today is considered the top 5 percent of neighborhoods in terms of job access. A significant reduction of transportation costs will put a far greater number of jobs within reach for communities that do not have sufficient job access today.

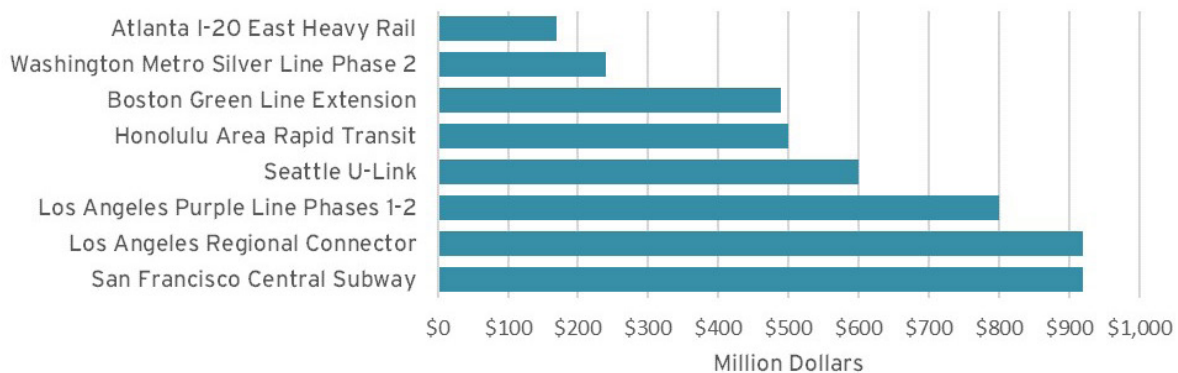
2.2 - Transit as a Solution

After half a century of falling ridership, passenger numbers on public transit began to grow again in the 1990s, increasing by more than 20 percent over the past two decades.⁷⁶ Public transit agencies have expanded their services since 1995, with public transit vehicle revenue service hours increasing by 46 percent, commuter rail service increasing by almost 50 percent, and light rail service rising by more than 100 percent.⁷⁷

Yet as the figure below shows, traditional light rail, subway and commuter rail options are not always cost-effective, as significant investments are often required for new projects. Moreover, underinvestment in maintaining and improving public transport options exacerbates this issue. Public transit systems face more than \$100 billion in a repair backlog, which is expected to grow to \$141 billion by 2030 should levels of spending stay the same.⁷⁸

On average, in 2018, passenger fares covered only 36 percent of public transit operating expenses in the United States.⁷⁹ The remaining 63.8 percent is covered by a combination of government funding from local and state sources and from the federal government.⁸⁰ Bus fares cover only 22.4 percent of operating costs, lower even than the overall transit average.⁸¹

Cost Per Mile for New Light Rail Projects



(Source: CityLab)

74 Lewis M. Clements and Kara M. Kockelman, "Economic Effects of Automated Vehicles," *Transportation Research Record*, January 1, 2017.
 75 James Arbib & Tony Seba, "Rethinking Transportation 2020-2030: The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries," *RethinkX*, May 2017.
 76 U.S. Department of Transportation, "Beyond Traffic 2045," January 9, 2017.
 77 *Ibid.*
 78 *Ibid.*
 79 U.S. Federal Transit Administration, "National Transit Database: 2018 National Transit Summaries and Trends," Office of Budget and Policy, December 2019.
 80 *Ibid.*
 81 *Ibid.*

Nevertheless, bus transport has been shown to be a highly utilized and cost-effective means of public transit, especially in certain areas when compared to rail.⁸²

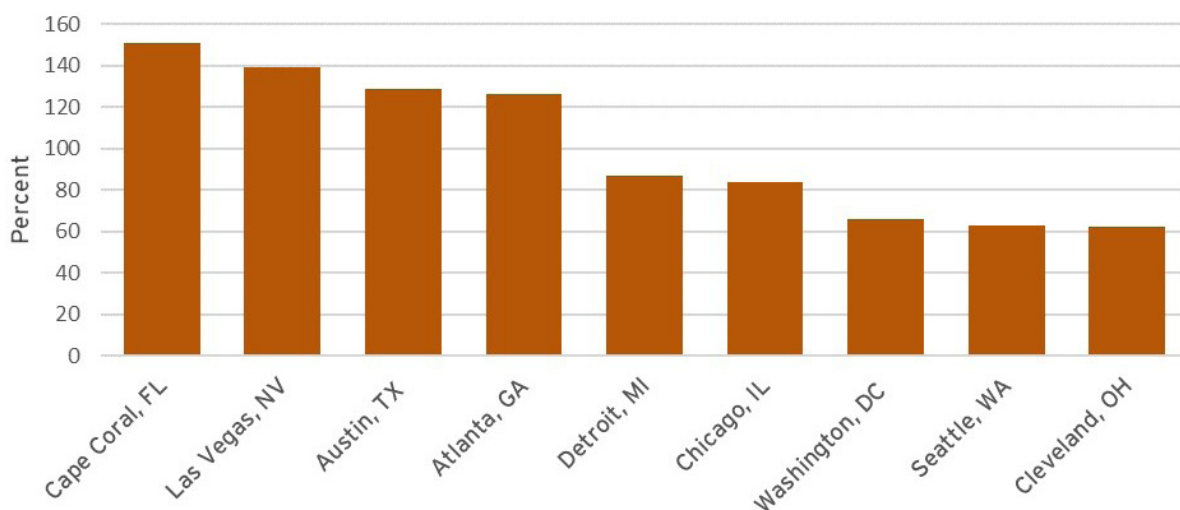
Public transportation provides an undeniable benefit to low-income individuals; households that utilize public transportation and live with one less car can save nearly \$10,000 per year.⁸³ Incomes vary widely among transit users across different sized cities, but the data demonstrates that in smaller and mid-sized cities low-income households are utilizing transit at higher rates than other groups. In the smallest American cities, almost 50 percent of riders have incomes less than \$15,000, with that same group comprising 45 percent of riders in mid-size cities. This is in stark contrast to the largest cities, where riders with incomes less than \$15,000 are only 20 percent of transit ridership.⁸⁴

Despite continued investments, public transit service is still not suitable for all. In suburbs, where the majority of Americans reside, transit is less likely to offer sufficient access to employment opportunities.⁸⁵ Though 77 percent of low-income suburban residents

who are of working age have at least one transit stop serving their neighborhood, prevalence of service does not immediately guarantee reliable connections to job opportunities.⁸⁶ In fact, the average low-income suburban resident with transit service can access only 25 percent of metropolitan jobs within a ninety-minute commute window, with only about 4 percent of metropolitan jobs within a 45-minute commute.⁸⁷ This difficulty is particularly acute for low-income individuals, as low wage jobs often require their employees to work late hours or weekends when public transit runs far less frequently or even not at all.⁸⁸

Additionally, though ridership has increased significantly during the 21st century, it is still not fulfilling the majority of daily rides or commuting needs. Today, public transportation accounts for only 3 percent of all daily trips and 7 percent of commute trips. Almost 75 percent of all public transportation trips are made in just 10 urban areas, with roughly four out of every 10 trips being made in the New York City area alone.⁸⁹ Transit analysts estimate 45 percent of Americans have no access to public transportation.⁹⁰

Increase in Urban Poverty Levels, 2000-2015



(Source: The Brookings Institution)

82 Thomas A. Rubin and James E. Moore, II, "Metro's 28 by 2028 Plan: A Critical Review | XV. Metro Bus Is Very Productive and Cost Effective," Reason Foundation, May 2019.

83 American Public Transportation Association, "Public Transportation Facts."

84 Hugh M. Clark, "Who Rides Public Transportation," American Public Transportation Association, January 2017.

85 U.S. Department of Transportation, "Beyond Traffic 2045," January 9, 2017.

86 Elizabeth Kneebone and Alan Berube, "Confronting Suburban Poverty in America," Brookings Institution Press, January 13, 2014.

87 U.S. Department of Transportation, "Beyond Traffic 2045," January 9, 2017.

88 Ibid.

89 Congressional Research Service, "Federal Public Transportation Program: In Brief," Updated February 4, 2020.

90 American Public Transportation Association, "Public Transportation Facts."

Public transit performs an invaluable function to society. However, given the realities of population distribution in the United States, job locations, and the acute need to efficiently connect one to the other, transportation solutions beyond both transit and personal vehicle ownership should be considered and encouraged.

2.3 – Challenge to the Traditional Tools

Changing demographics have challenged the traditional tools that are often deployed to address economic distress and job access. As the figure below shows, the rise in poverty has not been limited to a specific region nor to a certain type of economy.

This rise in poverty has developed concurrently with a decline in available jobs within a typical commuting distance for suburban communities. Between 2000 and 2012, the number of available jobs within the reasonable commuting distance dropped by 7 percent for suburban residents, more than double the drop experienced by the average urban resident. Typically, low-income individuals saw a decline of 17 percent in available jobs within a normal commuting distance.⁹¹

Therefore, even as total available suburban jobs grew, they did so while also becoming more spread out due to a decline in neighborhood density.⁹² This is of concern for low-income and minority residents, especially for those in suburban neighborhoods. Proximity to places of employment might be a more sensitive consideration because of the existing difficulties they face with transportation, particularly in the suburbs, thereby making the circle of job opportunities smaller than for others.⁹³ Automobiles are the most common form of transport for low-income suburban residents, with 74 percent driving by themselves and 12 percent utilizing carpool for work travel, but, as outlined earlier in this paper, they place greater financial strain on low-income households.

2.4 – Growing Job Opportunities Remain Inaccessible

To consider how current transportation options may affect access to growth industries and jobs of the future, Amazon presents a compelling case study. The company is a leader in the growing e-commerce sector, is present in every corner of the country, and has job opportunities at every level of education and experience. Amazon fulfillment centers in the United States have more than 125,000 full-time employees,⁹⁴ have contributed to 360,000 non-Amazon jobs,⁹⁵ and Amazon is planning on hiring 175,000 additional workers for its facilities due to COVID-19 related ordering surges.⁹⁶ The facilities are spread across the United States, offering a national perspective in transport accessibility to regional job centers. Amazon pays employees \$15/hour,⁹⁷ far higher than the national minimum wage, but still offering only an annual salary just under \$30,000. In California, for instance, fulfillment center workers are predominately people of color, the majority of whom identify as Latinx. Of those working in 2017, 54 percent were Latinx, 9.5 percent were Asian and 9 percent were African American.⁹⁸ Though some Amazon Associates have been able to purchase a home on their salary, access education, and receive health insurance, there are many instances where fulfillment center staff have to take on a second job to survive or live at their parents' home.⁹⁹ In this, many of the Amazon fulfillment jobs are similar to other low-income job opportunities: a stream of income that incurs constant trade-offs involving time, money, transportation and other factors, all of which ultimately impact upward mobility.

As detailed in this paper, transportation costs can present a significant strain on communities of color and low-income individuals. Growing job opportunities, as exemplified by Amazon fulfillment centers, are not being served by the traditional transit model. SAFE conducted an analysis of more than 60 of Amazon's largest fulfillment centers and similar facilities

91 Elizabeth Kneebone and Natalie Holmes, "The growing distance between people and jobs in metropolitan America," The Brookings Institution, March 24, 2015.

92 Ibid.

93 Ibid.

94 Colin Lecher, "How Amazon automatically tracks and fires warehouse workers for 'productivity,'" The Verge, April 25, 2019.

95 Day One Staff, "The Amazon effect: What a fulfillment center means to its community," The Amazon Blog: Day One, December 18, 2018.

96 Annie Palmer, "Amazon to hire 75,000 more workers as demand rises due to coronavirus," CNBC, April 13, 2020.

97 About Amazon Staff, "Compensation and Benefits," AboutAmazon.com.

98 Irene Tung and Deborah Berkowitz, "Amazon's Disposable Workers: High Injury and Turnover Rates at Fulfillment Centers in California," The National Employment Law Project, March 2020.

99 Alana Semuels, "What Amazon Does to Poor Cities," The Atlantic, February 1, 2018.

(1,000,000 square feet or more) using TransitScreen's MobilityScore. The tool works by factoring in all transportation options at a specific address, such as public transit, rideshare, bikeshare, and ride hailing services. With each option, the software calculates how long it may take until one can start moving on it - for instance, the length of time to walk to a bus stop and the frequency at which the bus runs - and indicates how easy it is to get around, that is the level of your transportation access.¹⁰⁰

Based on SAFE's analysis, 67 percent of the largest 60 fulfillment centers are inaccessible by traditional forms of public transit. Of those that were accessible by public transit, 85 percent had severely limited service and/or were located a less than ideal distance away from the transit stop. This indicates that the primary method of access for these job centers is by car, an option that remains unaffordable for many who work there. This example makes clear the trade-off and resultant economic pressure facing many. Whether by utilizing existing ride hailing services or purchasing a personal vehicle, fulfillment center employees are often forced to either forego a job opportunity, or to take on the financial responsibility of an unaffordable transportation option in order to access their employment.

Additionally, even those facilities that do have better access of transit will often still see employees use personal vehicles, as transit often not operate at night. Moreover, there are Amazon workers with shifts that have odd hours, placing them outside the normal operating hours of public transit. E-commerce has been a growing sector over the last several years as consumers continue to prize convenience and price. The onset of COVID-19 has accelerated this growth and as the pandemic continues, the country is likely to remain ever more reliant on online deliveries. These fulfillment centers therefore represent one of the few rapidly-growing sources of blue-collar employment in our modern economy, but personal vehicles are still overwhelmingly necessary to access the jobs they provide.

100 Team TransitScreen, "Introducing MobilityScore," TransitBlog, September 22, 2017.



72

Planned Work

Nights

11:45 PM to 5 AM, Mon to Fri
Nov 13 - 17



No downtown late night service at this station

Trains run express to 59 St

Travel alternatives:

- For downtown service, take an uptown **A** to 125 St and transfer to a downtown **A**.
- Or, take the **M10** bus on 8 Av/Central Park West for local service.


Reminder: **C** trains do not run overnight.

Track
Maintenance

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C H A P T E R T H R E E

MOBILITY TECHNOLOGY IN SERVICE TO SOCIETY



3 – Mobility Technology in Service to Society

For 75 million households, transportation costs are the difference between living in affordable neighborhoods with good access to jobs or remaining tethered to communities with limited options for upward economic mobility. Rather than being forced into neighborhoods with poor transportation options and access to jobs, a better suite of policy and technology options can make existing neighborhoods more affordable while also opening access to neighborhoods previously considered unaffordable for lower- and middle- income households. The transportation sector is on the verge of a generational shift toward digitized and electrified transit, with a focus on connected, autonomous, shared and electric vehicles.

Such solutions, which hold the potential for efficient on-demand, door-to-door transportation at low cost to consumers, could prove transformative for policymakers. For example, autonomous vehicles by themselves may be an important safety technology, but when combined with decreasing electric vehicle costs, and the ability to dispatch rides as needed, they could contribute to a lower-cost, automated transportation system that can operate 24 hours a day. Connected, autonomous and shared transportation also offers low-income communities the promise of breaking away from the need to own a private car to access a wider array of jobs and opportunities. Addressing longstanding barriers to mobility will require coordinating disparate technologies, creating a role for connectivity that spread information, and coordinating travel. As local, regional, and state authorities must balance limited resources and competing priorities – a situation that has become particularly acute during the COVID-19 pandemic – they are frequently forced into investing in sub-optimal solutions. Yet with better technologies, especially if supported by well-constructed policy, we can increase the potential set of solutions and get improved outcomes with the same set of resources.

3.1 – Emerging Technologies

Transportation is the difference between prosperity and financial hardship for many households. This is a key reason why transportation technology can be a central component of making life more affordable and sustainable for lower- and middle-class households. Over the last decade, a broad wave of innovation has made major inroads into the mobility system. The following technologies have emerged as some of the most promising options for providing affordable, reliable, point-to-point transportation.

3.2 – Autonomous Vehicles (AVs)

Holding the promise of low-cost, on-demand transit in electric vehicles, AVs can offer affordable and efficient transportation. Although still in its early stages, the industry is rapidly maturing in its deployment of pilot programs: companies are providing members of the public with driverless ride-hailing services in select areas, and driverless shuttles are running in

private residential developments and in limited city center routes. AV developers are increasingly turning toward self-driving fleet vehicles such as the recently-unveiled Cruise Origin, a vehicle without traditional operating controls such as a steering wheel or pedals, or people movers such as Local Motors or Optimus Ride, as the likely first wave for wider AV deployment. Unlike conventional mass transit options, which are bound by defined and existing routes, these connected, autonomous, shared and electric vehicles will be able to transport multiple riders point-to-point efficiently and safely. These technologies could also provide additional flexibility in providing private point-to-point transport, or being used in the delivery of goods, which can unlock additional benefits for small businesses in lower income areas by affordably expanding their reach in an era of growing e-commerce.

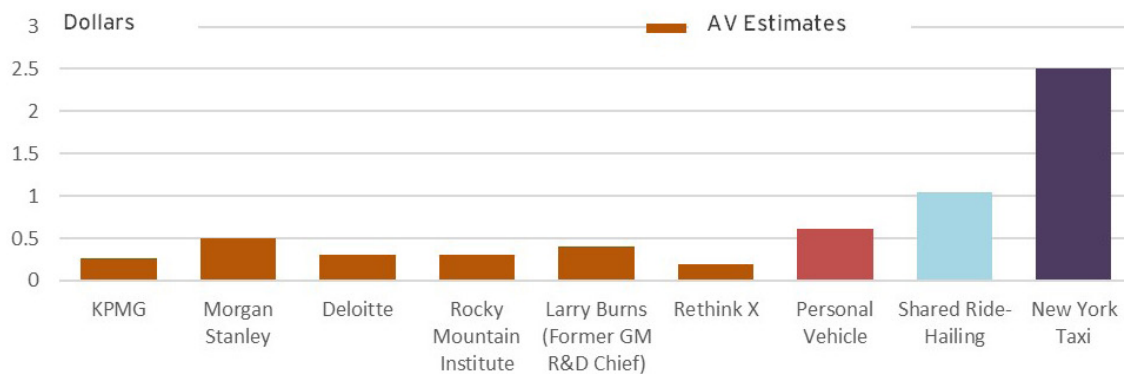
As the figure below shows, AVs may be able to provide point-to-point transportation at significantly lower costs than current options. Additional research pairs the use of ride sharing to electric drivetrains to ensure that the benefits are fully realized.¹⁰¹ For instance, Morgan Stanley, with one of the more conservative estimates, predicts significant consumer savings with deployment of a shared, electric, autonomous fleet. They estimate that the 2016 cost

per mile of a shared ride is \$1.50; in 2030, with an autonomous, shared and electric car, that cost per mile decreases to just 50 cents.¹⁰² This is in stark contrast to the \$1.31 cost per mile for buses.¹⁰³ These savings are realized from the combination of several key cost factors: reduced overhead without human drivers; increased vehicle-utilization rates; lower operating and service costs realized by switching from internal combustion engines to electric vehicles; and reduced finance, energy, and insurance costs.^{104 105}

Point-to-point travel provided by AV technology promises to bring greater convenience and cheaper travel options to communities currently underserved by transit options. This holds relevance and potential for low-income communities without the means to access or own a personal vehicle, and whose opportunities are subsequently constrained by urban sprawl, by opening up additional job opportunities.

Moreover, connected, shared and autonomous vehicles could potentially make longer commutes more viable: time that would otherwise be spent driving can be freed up for other pursuits, and journey times can be shortened through improvements in traffic congestion provided by the technology.¹⁰⁶ As a result, AVs could broaden access to job opportunities for workers, while simultaneously growing the labor pool for employees.

Estimated Cost Per Mile of Vehicle Modes for Consumers



(Source: Business Insider, Deloitte, KPMG, Morgan Stanley, RethinkX, RMI, Larry Burns)

101 Mares et al., "How Autonomous Vehicles Will Drive Our Budgets," Conservation Law Foundation, June 2018.

102 Morgan Stanley, "Shared Mobility on the Road of the Future," June 15, 2016.

103 U.S. Federal Transit Administration, "National Transit Database: 2018 National Transit Summaries and Trends," Office of Budget and Policy, December 2019.

104 James Arbib & Tony Seba, "Rethinking Transportation 2020-2030: The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries," RethinkX, May 2017.

105 Charlie Johnson and Jonathan Walker, "Peak Car Ownership: The Market Opportunity of Electric Automated Mobility Services," Rocky Mountain Institute, March 2017.

106 Securing America's Future Energy, "America's Workforce and the Self-Driving Future," June 2018.

An illustrative example can be seen in the figure below, which shows a significantly larger potential commute for workers living in Wilmington, DE.

Broader AV Commute For Wilmington, DE Costs Fall



(Source: SAFE)

3.3 - Electric vehicles

Wider adoption of EVs offers considerable equity impacts by reducing the emissions in lower-income neighborhoods and communities of color. Fine particulate matter air pollution is disproportionately produced by the consumption of goods and services by the non-Hispanic white majority in the U.S., but disproportionately inhaled by Black and Hispanic communities.¹⁰⁷ Neighborhoods near major highways and shipping routes will benefit from the electrification of medium- and heavy-duty vehicles, which contribute significantly to air pollution – an issue that would be substantially mitigated with a shift to electric drivetrains, as has been noticed with the reduced traffic during the COVID-19 pandemic.

In addition, maintenance and refueling of EVs promises to be much cheaper than today's internal combustion engine vehicles. Tied to fluctuations in the price of oil, gasoline prices have the capacity to change wildly on events beyond U.S. control, regardless of how much oil is produced domestically. In contrast, electricity is a domestic and diverse fuel source that is both low and stable in price. This allows a shared fleet of autonomous cars to keep fuel costs low.

107 Tessim et al., "Inequity in consumption of goods and services adds to racial-ethnic disparities in air pollution exposure," PNAS, March 26, 2019.

108 Securing America's Future Energy, "Transportation Network Companies: Broadening Access and Improving the Efficiency of Travel," August 2018.

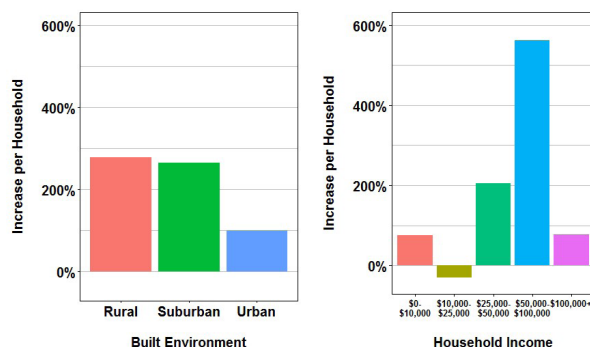
109 SAFE interview with Malcom Glenn, Head of Global Policy, Accessibility and Underserved Communities at Uber, October 31, 2019.

110 Ibid.

3.4- Transportation Network Companies

In just a decade, transportation network companies (TNCs) Uber and Lyft have become household names, publicly traded companies, and ubiquitous in many U.S. cities. Although TNC riders tend to be wealthier, the figure below shows TNCs have considerably expanded the availability and use of on-demand transportation to middle-class households.¹⁰⁸ The figure below shows the increase in taxi/TNC usage from 2009 to 2017 for different geographic communities as well as different income levels. The biggest increases are from rural and suburban households, although these households started with a very low base of taxi rides in 2009 (since TNCs did not exist and taxis rarely served outside the urban core). However, by far and away the biggest increases in taxi/TNC usage came from middle-income households. Before TNCs, taxis were mostly used by the very wealthy (who could afford them) and the very poor who could not afford a car and therefore were forced to use taxis. TNCs have also broadened access in major urban centers like New York City, to the point where half of Uber's rides in New York now take place in the outer boroughs.¹⁰⁹ They have also provided the benefit of upfront pricing and continue to make progress in making wheelchair-accessible vehicles available on-demand.¹¹⁰

Increase in For-Hire Vehicle Rides (2009-2017)



(Source: National Household Travel Survey)

The ride hailing aspect of the TNC business model foreshadows the impacts of the AV "robotaxi" model, which promises to provide the same on-demand, door-to-door transit at lower costs, as the requirement of a human driver has been removed. Cities have already started turning to rideshare companies to complement their existing transportation infrastructure: Dallas Area Rapid Transit (DART) subsidizes shared Uber rides within a certain radius of its rail stations, in an attempt to boost DART's ridership.¹¹¹ Similarly, the city of Altamonte Springs, Florida recognized that TNCs are now a key part of citizens' transportation needs, and started subsidizing 20 percent of the cost of every Uber ride starting and finishing with its city limits.¹¹² Additionally, Pinellas County, Florida started a program for those participating in the state's "Transit Disadvantaged" program to give low-income riders 23 free rides per month from Uber or United Taxi between 9:00pm-6:00am, recognizing that the county's bus service does not always serve users' needs.¹¹³ These are the types of programs that could be expanded if AVs reduce the cost of ride hail-like services.

3.5 – Maximizing Technological Benefit Through Mutual Cooperation

Each of the technologies mentioned in the section above have either begun to impact the overall transportation system or have potential to impact it in the future. However, truly transformational impacts would most likely occur from the combination of multiple technologies, especially when supported by well-designed policy. For example, AVs by themselves may be an important safety technology, but when combined with decreasing EV costs, and the ability to dispatch rides as needed, they could contribute to a lower-cost transportation system. Though many of the most affected groups may still be able to find transportation solutions today, existing options are generally more expensive than the combination of these new technologies. Buses and other transit systems only achieve affordability through the billions

of dollars in subsidies they receive; taxis are expensive in general, particularly for already cash-strapped households; TNCs' prices are subsidized in price wars through venture capital firms and the public markets; and this paper has already outlined the difficulty many households have in affording ownership of a private vehicle. In most parts of the country, from a societal and individual level, none of the current transportation options are as cheap as shared, electric, autonomous vehicles portend.

Addressing longstanding barriers to mobility will require coordinating disparate technologies. There are already examples where connective technologies have been applied to improve outcomes for lower-income households. In New York City, Via – a TNC that specializes in multi-occupant shared rides – licensed its routing technology to the New York City Department of Education to help create and optimize school bus routes.¹¹⁴ The partnership is meant to allow continued and efficient service when students move, which happens very frequently for low-income families (one in 10 NYC public school children live in temporary housing).¹¹⁵ Via notes that it has seen a greater proportion of pooled rides than single-occupancy rides in low-income neighborhoods, likely because they are more affordable than other transportation options.¹¹⁶ Another such example is Via's partnership with the Los Angeles County Metropolitan Transportation Authority (Metro). Designed to expand access to public transit by using shared vehicles to bring people to and from Metro stations, the partnership has demonstrated the potential for cities to expand and augment the transport services they provide. Moreover, the pilot incorporated a call-in center, allowing residents without a smartphone to still utilize the service.¹¹⁷

3.6 – Emissions Benefits of Shifting to Shared, Electric Transportation

By running on electricity rather than petroleum fuels, new electrified and autonomous transportation technology represents a commercially-viable new

111 Alexander Sammon, "When Cities Turn to Uber, Instead of Buses and Trains," *The American Prospect*, August 13, 2019.

112 Uber Promotions, "Uber and Altamonte Springs launch pilot program to improve transportation access," *Uber Blog*, March 21, 2016.

113 Laura Bliss, "A Florida Transit Agency Takes On the Digital Divide in a Partnership With Uber," *CityLab*, June 20, 2016.

114 Eillie Anzilotti, "New York City's school buses will now be automatically routed and tracked using Via's algorithm," *FastCompany*, August 21, 2019.

115 Eliza Shapiro, "Homelessness in New York Public Schools Is at a Record High: 114,659 Students," *The New York Times*, October 15, 2018.

116 SAFE interview with Andrei Greenawalt, Head of Public Policy at Via, September 13, 2019.

117 Via, "Via and LA Metro announce extension and expansion of shared ride service," January 24, 2020.

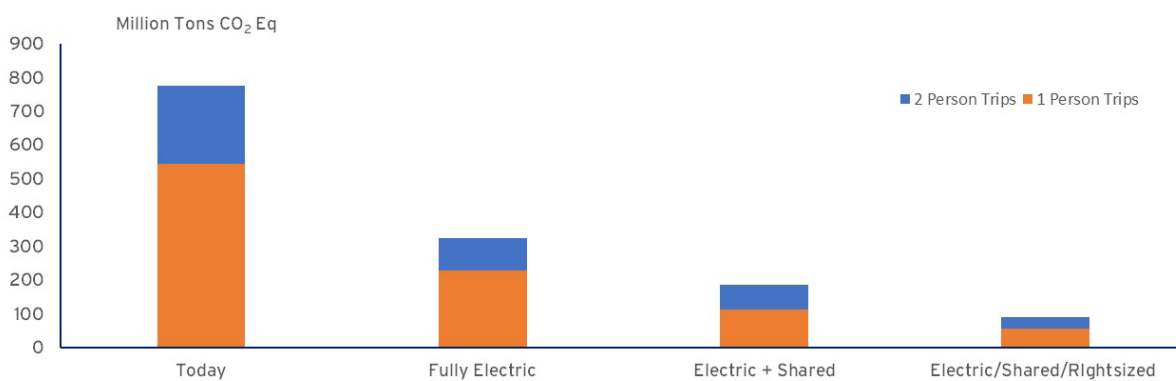
avenue for cities, municipalities, and states seeking to meet their greenhouse gas emission and air quality goals, while also potentially providing a public transit option that is both convenient and efficient. As the figure below shows, fully electrifying 84 percent of trips taken in vehicles every year with one or two occupants and placing them into electric, shared and appropriately-sized options result in a nearly 90 percent reduction in transportation emissions. Even if those journeys are simply taken in electrified transit alone, emissions are more than halved.

3.7 – Potential Solution During Times of Crisis

As the COVID-19 crisis has raged across the world, disrupting and hurting the lives of many, hundreds of thousands, if not millions, of workers in the United States have bravely continued to show up to work in industries deemed essential, such as food production, public transit, and grocery stores. For many of these industries, employees do not have the luxury of being able to work from home, live in isolation, or even drive themselves to work. An overwhelming majority of workers deemed newly essential in this time are earning low and working-class wages.¹¹⁸ For instance, the average annual wage for grocery workers is roughly \$23,000.¹¹⁹

Low-income workers are uniquely susceptible to the risks posed by not participating in social distancing; smartphone data analysis suggests that these workers continue to move about while those who have higher incomes are able to stay at home.¹²⁰ Moreover, it is disproportionately people of color who have been left with no choice but to continue to use transit services.¹²¹ For many of these workers, public transit remains their only option. Adarra Benjamin, a home nurse in Chicago, gets on the bus every morning for a 20-mile journey to her clients. Though aware of the dangers and worried about getting sick, she needs the job, which pays around \$13 an hour.¹²² Workers in Detroit – a city where almost 80 percent of residents are Black – has seen similar concerns from its essential workers. Valerie Brown, a 21-year-old fast food worker, has to take the bus to reach her job. Oftentimes the bus is fully packed and even with a mask on, she will sometimes wait for the next bus to come as "she does not like chances."¹²³ The risks posed by full buses and traveling to work does not only impact those utilizing the transit services, but also the drivers themselves. In Detroit, it took the city's 550 drivers walking off their job to push officials to implement additional safety features, such as backdoor entry and more frequent cleaning. Yet bus drivers remain nervous, as riders are not required to wear masks or gloves and buses remain full.¹²⁴

Fuel Saving Estimates



(Source: SAFE analysis; DOT data; FASTSIM)

118 Jessica Calefati, "Still going in to work in Pennsylvania amid the coronavirus? Chances are, you're a low-wage worker, data show," The Philadelphia Inquirer, April 21, 2020.

119 Ibid.

120 Valentino-DeVries et al., "Location Data Says It All: Staying at Home During Coronavirus Is a Luxury," The New York Times, April 3, 2020.

121 Trevor Hughes, "Poor, essential and on the bus: Coronavirus is putting public transportation riders at risk," USA Today, April 14, 2020.

122 Valentino-DeVries et al., "Location Data Says It All: Staying at Home During Coronavirus Is a Luxury," The New York Times, April 3, 2020

123 John Eligon, "Rolling Through the Pandemic," The New York Times, April 15, 2020.

124 Ibid.

In New York City, more than 40 transit workers have died from COVID-19 infection, more than firefighters or police officers.¹²⁵

Though the existing pandemic seems to exacerbate the existing transportation challenges for vulnerable communities, there is reason to believe that an autonomous service might be able to offer a solution for similar problems in the future. Without a human driver, the highest risk for transit employees is eliminated. And though the most cost-effective method may be a shared service, in extreme times such as we are experiencing, both private fleets and transit operated services could offer individual, point-to-point transport for essential employees. As the pandemic is shifting behavior, from shopping habits to health precautions, it will likely also shift consumer and employee preference for travel. Oliver Cameron, the CEO of autonomous startup Voyage, says "in a world where people may still be hesitant to get into a car with strangers, a driverless car would mitigate those fears."¹²⁶

125 Trevor Hughes, "Poor, essential and on the bus: Coronavirus is putting public transportation riders at risk," USA Today, April 14, 2020.

126 Megan Rose Dickey, "In a world where people may still be hesitant to get into a car with strangers, a driverless car would mitigate those fears," TechCrunch, April 13, 2020.



62





C H A P T E R F O U R

POLICY RECOMMENDATIONS

4 – Policy Recommendations

For millions of households across the United States, access to affordable, reliable, and convenient transportation is the difference between upward economic mobility and financial hardship. Accordingly, SAFE believes the following recommendations should be adopted and implemented to ensure that the next generation of transportation technologies are able to positively impact low-income communities' ability to improve their economic and societal opportunities, as well as allowing them to lead healthier lives.

4.1 – Technology Development and Operation

Promote the development and accelerated deployment of new transportation technologies.

Policymakers across all levels of government have struggled to regulate emerging transportation technologies, such as TNCs and micromobility. SAFE believes that instead of over-regulating new technologies to the point where their societal value is unduly constrained, pathways should be provided for widespread market acceptance – which will be of importance to AVs in the near future.

Additionally, USDOT should seek to clarify the specific cost savings to cities possible through autonomous public transportation. There is no good data presently available about how much cheaper an autonomous bus or train would be to operate. Our cost per mile comparison mentioned in Section 3.1 demonstrated that the mathematics indicate AV service as the likely more affordable option for public transportation. A limited analysis of the bus fleet in Austin, TX demonstrated similar findings when exploring the impact of emerging technologies on fleet operations.¹²⁷ Further analysis could make it more likely that transit agencies will consider adopting AV solutions for budgetary reasons.

Create pilot programs with a focus on equity and new-use cases.

When pilot programs are developed for new transportation technologies, policymakers should ensure that there is an opportunity to demonstrate impact on underserved, low-income households. In order to do so, it is critical that even temporary pathways to market are not unduly constrained through limiting mechanisms, such as vehicle caps that have been discussed within the TNC debate. Tools like this all but ensure that pilot deployments will only occur in the most high-traffic, profitable, and affluent areas. As new technology development is highly capital intensive, scale is key to cost reduction, which brings with it the ability to deploy new technologies in what may otherwise be unprofitable geographies, such as low-income neighborhoods. Within that context, private sector developers should be encouraged to track their impact on equity. The results of such pilots could then be used to better understand the utility of new technologies in creating economic pathways for low-income communities.

Additionally, the Federal Transit Administration (FTA) could fund pilots

¹²⁷ Quarles et al., "Costs and Benefits of Electrifying and Automating Bus Transit Fleets," Sustainability, 2020.

to test whether AVs can expand commuter rail station capacity and utilization, e.g. "first-mile, last-mile," both by bringing people to the station and by parking automobiles more tightly together (if AVs do need to be parked, they will require less space between vehicles – which increases parking lot capacity¹²⁸). This could serve as a way to encourage transit agencies to consider AVs as a way of boosting rail ridership, using the technology to help solve a persistent problem for transit agencies across the country. The FTA could fund AV point-to-point pilots that mimic traditional public transportation routes late at night, potentially saving the agency money compared with traditional transit services. The FTA should also fund a pilot focused on daytime use that is more expansive than the night-time deployment.

4.2 – Operational Regulation

Tailor user fees and regulatory frameworks to prioritize shared, electric transportation.

Any user fees, utilization policies, or licensing restrictions on specific transportation modes or technologies must explicitly promote connected, autonomous, shared, and electric vehicles. Regulations that restrict or impose fees on emerging transportation modes should offer reduced burdens on such vehicles. Despite the fact that cities across the country identify vehicle emissions reductions as a core objective, of the 19 city- and state-level TNC taxes in place in 2018, none modified its fee for an electric vehicle trip.¹²⁹ More recently, San Francisco's TNC tax passed in November 2019 reduces its fee for rides in electric vehicles as well as for shared vehicles.¹³⁰

4.3 – Integrating Emerging Mobility with Other Transportation Modes

Road pricing should be calibrated across modes.

Pricing strategies put in place to manage congestion or other outcomes should use pricing mechanisms that are not mode-specific – for example, fees specifically on TNCs that are not calibrated with

personal vehicle road-use fees. The goal should be to ensure that policies are not discriminatory for one mode. For example, San Francisco has offered congestion mitigation as a key rationale for TNC fees.¹³¹ However, if TNC fees are not accompanied by an equivalent fee structure for private vehicles, the policy ends up distorting the market by internalizing the congestion costs of one mode (e.g. TNCs) and not internalizing the costs of another (private vehicles). Such policies should be technology agnostic, but externality specific.¹³² One such policy could be having shared rides pay a lower road usage fee.

In addition, governments should promote research and development into analytical frameworks, like Mobility Energy Productivity (MEP), that create a common language to compare tradeoffs between different modes. Modes are siloed by their governance and it is currently difficult to synchronize across industries, modes, and different governing bodies. At the same time, governments should create the technological infrastructure to track various modes of transportation and promote policies – including subsidies and fees – that are implemented to advance specific aims, such as congestion mitigation.

Improve integration between emerging technology and public transportation.

Integrating emerging technology with existing public transportation holds great potential to benefit a diverse array of communities across the country, but further work and experimentation is required if such solutions are to be deployed effectively and at scale. For instance, AVs could expand commuter rail capacity by providing cost-effective ways of bringing people to stations without having to park their vehicle. Further, these vehicles could offer a new type of point-to-point system to supplement what transit options currently exist, providing first mile/last mile connectivity as well as service when public transit is not running. Such a system could even fully replace existing train and bus routes in certain areas of the country, privately owned, but publicly funded.

128 Charles Q. Choi, "How Self-Driving Cars Might Transform City Parking," IEEE Spectrum, February 20, 2019.

129 So Jung Kim and Robert Puentes, "Taxing New Mobility Services: What's Right? What's Next?," Eno Center for Transportation, July 23, 2018.

130 San Francisco Bay Area Planning and Urban Research Association, "SF Prop D: Ride-Hailing Tax."

131 Trisha Thadani, "Uber and Lyft could face tax for snarling S.F. traffic: 'Everyone needs to pay their fair share,'" San Francisco Chronicle, May 21, 2019.

132 SAFE Interview with Andrew Salzberg, Loeb Fellow at Harvard University Graduate School of Design. November 13, 2019.

For effective assessments of such integration, more data is required and metrics need to be refined to appropriately measure the efficacy of new transportation modes within existing public transit systems.

Governments should encourage continued experimentation around the intersection of new mobility modes with current public transportation options. Pilot programs – particularly around TNCs, AVs and micromobility – have already begun at the local level. Yet if we are to truly integrate new mobility models with existing public transit at a level that provides impactful and meaningful results for low-income communities across the United States, the amount, scope, and scale of these projects must increase.

Update housing policy to better leverage advantages of emerging transportation technology.

Cities should reduce parking minimums for building construction – local laws that require private businesses and residences to provide at least a certain number of off-street parking space – as new technologies increasingly negate the need for private vehicle ownership. When updating such policies with these new technologies in mind, regional planners should also prioritize low- and middle-income affordable housing integration with transit-rich options. In particular, more attention must be paid to lower-income communities in suburban and other less-dense areas, for whom traditional economic development and public transportation solutions have not worked well in the past.

Moreover, as federal mortgage policy implicitly favors pushing households out into neighborhoods with higher transportation costs, the FHA – and private lenders and insurers – should also consider transit costs in mortgage issuance and insurance. The FHA has set a precedent for this, allowing a higher debt-to-income (DTI) limit than the standard 31 percent for homebuyers making energy efficiency improvements: although these improvements raise the initial cost, energy savings subsequently improve affordability.¹³³

The same approach can be taken with transportation, by increasing the DTI beyond 31 percent if projected transportation costs for the areas would result in savings over the national average.

4.4 – Transportation Policy Governance

Implement a reorganization of transportation agencies and a cross-cutting governance model that encompasses all modes.

The main functions of USDOT are separated by modes, including the FTA, the National Highway Traffic Safety Administration (NHTSA), the Federal Highway Administration (FHWA), and the Federal Aviation Administration (FAA), among many others. As transportation is becoming increasingly multimodal, the USDOT should create a cross-cutting governance structure to integrate transit with other modes. This may take the form of expanding the Non-Traditional and Emerging Transportation Technology (NETT) Council, which was formed in 2019 to address technologies that do not squarely fit into a specific mode.¹³⁴

The agency should also incorporate destination accessibility impacts into its investment ranking criteria, weighing tradeoffs between modes and pursuing greater access to economic opportunities. In other words, to what extent does a new investment – such as an AV investment – enable people to reach places that were previously harder to access? This is an urgent need for low-income commuters.

On a more general level, transit agencies should consider reorienting themselves around challenges, such as expanding access for low-income communities, rather than around mode of travel since the objectives they are trying to solve are multimodal by nature. Such an approach can help ensure that the full breadth of potential solutions, both public and private, are considered through the lens of impact, rather than siloed by method, as is currently the case.

133 U.S. Department of Housing and Urban Development, Mortgagee Letter 2015-22: New Standards for Energy Efficient Homes (EEH) Stretch Ratio Policy: Incorporating the Department of Energy's (DOE) Home Energy Score, September 30, 2015.

134 U.S. Department of Transportation, At South by Southwest, U.S. Secretary of Transportation Announces Launch of Council to Support Emerging Transportation Technology, March 12, 2019.

Methodology

To add substantive analysis to the wider discussion of transportation, technology and low-income communities, SAFE used a modified version of a housing affordability index from the Center for Neighborhood Technology called the Housing + Transportation (H+T) Affordability Index to analyze the effect of cost reductions in transportation on the ability of households to afford their homes. Instead of deeming a neighborhood affordable if the typical household in the region can afford local housing on 30 percent of its income, the H+T Index includes both housing and transportation costs. To be an affordable neighborhood, its combined housing and transportation costs must be under 45 percent of a typical household's income.

When transportation costs are considered, SAFE found that less than one-third of American households live in affordable neighborhoods. This analysis considers a census block group to be a neighborhood. SAFE analyzed data provided by the Center for Neighborhood Technology on 212,621 block groups, which included data on local housing and transportation costs. Data was obtained from CNT's H+T Index Data portal.¹³⁵ SAFE also performed an analysis that quantified the impacts of incremental reductions in transportation expenses. This analysis found that a 1 percent reduction in transportation costs would move over 750,000 households from "unaffordable" to "affordable" neighborhoods, including nearly 400,000 in urbanized neighborhoods. For the purposes of this analysis, an urbanized neighborhood is an area in which there are more than 500 household units per square mile.

135 The Center for Neighborhood Technology, "The Housing and Transportation (H+T[®]) Affordability Index."

