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Autonomous Shuttle Transit: An Exploratory Case Study and the Future Impact on TSU Campus

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AUTONOMOUS SHUTTLE TRANSIT: AN EXPLORATORY CASE STUDY AND THE FUTURE IMPACT ON TSU CAMPUS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

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Abstract

By 2040 the third-largest city in the United States, Houston, Texas, a top global city for traffic congestion, will become a significant metropolis with future growth possibilities of 11 million people (about twice the population of Arizona) passing Chicago (HGAC, 2018). For this purpose, Houston and surrounding growing populations will contribute to gridlock traffic, with highway expansions increasing ozone and inefficient transit systems with longer commutes in underserved, sidelined communities. Historically, persons of color, notably Black Indigenous Persons of Color (BIPOC) in Black and Brown marginalized communities, are deprived of transportation accessibility. Undoubtedly, Driverless Shuttle (DS) rideshare platforms reflect that higher-income whites are admittedly more likely to hold discriminatory attitudes toward fellow passengers of different classes and races (Middleton & Zhao, 2019).

At the same time, Environmental Justice (EJ) studies have shown that Black and Brown low-income disenfranchised communities are more exposed to inefficient transit systems. They are characterized by unequal treatment and accessibility to the bus than affluent White commuters

(Bullard, Johnson, and Torres, 2004). As a result, systemic racism, an unfair burden of environmental injustice, has plagued the Greater Third Ward transit-dependent population. For this purpose, Houston's Metropolitan Transit Authority (METRO) riddle inequities have shaped public transportation for every minoritized BIPOC within the community (Spieler, 2020). Most importantly, Blacks are twice as likely to experience inferior transportation access as their more affluent counterparts (Sisson, 2019; Bullard, Johnson, and Torres, 2004, p.2). According to Harvard Law (2021), Bullard states, "In 1990, Dumping in Dixie: Race, Class and Environmental Quality assuredly documented that environmental vulnerability mapped closely with Jim Crow segregation. This why racial redlining discriminatory zoning, and inefficient land use practices," (Bullard, 2021, p. 245; Bullard, 1990) target Houston's Black and Brown neighborhoods, hindering economic and social advancement in employment, education, and health care (Bullard, 2021, p. 245; Bullard, 1990; Freemark, 2020; Talbott, 2020).

The problem of injustice was examined by longitudinal data where an Autonomous Vehicle bus pilot associated with the built environment in this study highlighted

1. Transportation inequality along the TSU Campus Tiger Walk is related to bus stops.
2. Distance between three designated bus stop locations.
3. Safety and critical driving functions fully driverless for an entire trip.
4. First/last mile driverless shuttle connectivity interacting with Metro buses and Light Rail in Houston's Greater Third Ward neighborhood.

The methods of research incorporated qualitative and quantitative analysis. The study used a driverless shuttle to compare racial and social economics between bus stops at Texas Southern University, a historically black university, during an Autonomous Vehicle (AV) Shuttle pilot study. For this purpose, Autonomous Shuttle Transit, an additional mode of mobility, will connect

Houston's Greater Third Ward transit-dependent population to Metro's bus and light rail networks. In addition to bus stops along the TSU Campus Tiger Walk. This study made a similar theoretical comparison of the Tiger Tram to AV two years before the TSU Shuttle pilot. The results indicated a link between income and transit-dependent populations using a driverless shuttle under specific conditions.

A Google Map determined the half-mile distance along the TSU Campus Tiger Walk. The driverless shuttle and socioeconomics of Political Science, Administrative Justice, and Psychology undergraduate classes were used to measure transportation equity horizontally. A regression analysis was carried out to determine if the socioeconomic factors had statistical significance. Also, linear regression modeling was used to determine which sociodemographic variables strongly predict the transport mode used.

The findings revealed that Blacks, people with disabilities, and the TSU AV shuttle working with metro buses were statistically significant at a 95% confidence level. Also, a predictor of respondents walking, and biking will use the Autonomous Shuttle as an additional mode of transportation. Also, the data analysis results indicate a significant negative correlation between the driverless shuttle time intervals along the TSU Tiger Walk and the Metro bus service. This correlation implies that higher percentages of respondents will walk further from the TSU campus Tiger Walk central location to the bus stop connecting Third Ward's transit-dependent residents to the Metro Light rail.

Likewise, in the Third Ward community, low-income transit-dependent populations in the Cuney Homes are disproportionately exposed to inadequate transit access than any other area in the neighborhood. The results also support the Environmental Justice (EJ) claim that minorities and low-income transit-dependent populations are closer to bus stops and farther away from the light rail.

Although the results showed that race, income, and disability variations are likely to predict that TSU's transit-dependent population will use the TSU Autonomous Shuttle connecting the Third Ward community. Comparing the social demographic indicators along the TSU Tiger Walk and the Third Ward area shows that deed restrictions do not address EJ concerns associated with bus stops and transportation modes. The conclusion indicates that despite several decades of EJ policies and transit regulations, institutional racism in the Third Ward neighborhood is embedded. Over the decades, African Americans and other people of color have been disproportionately exposed to transit injustice because they are concentrated in neighborhoods with less transit accessibility. However, the TSU Campus Tiger Walk still has fewer efficient transit options than other Third Ward census tracts that map closer to bus stops with higher income.

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List of Acronyms

ADA……...Americans with Disabilities Act

APTA……. American Public Transportation Association

AST……...Autonomous Shuttle Transit

AV…… Autonomous Vehicle

BEB……..... Battery Electric Buses

BIPOC……. Black, Indigenous, and People of Color

BRT……...Bus Rapid Transit

CBD……...Central Business District

CBO……. Community-Based Organizations

CTA……. Chicago Transit Authority

COVID-19……...Coronavirus Disease 2019

DEC……. Department of Environmental Conservation

DVRPC……...Delaware Valley Regional Planning Commission

DOT……..... Department of Transportation

DS……...Driver Shuttle

EIA……..... Energy Information Administration

EJ……..... Environmental Justice

EPA……. Environmental Protection Agency

ETA……. Equity Through Access

FAVES……. Fleet of Autonomous Vehicles Electric and shared

GHG……..... Greenhouse Gas

GIS……. Geographic Information System

HBCU……. Historically Black College and University

HCT……...High-Capacity Transit

HGAC……. Houston Galveston Area Council

HOV……. High Occupancy Vehicle

ISTEA……..... The Intermodal Surface Transportation Efficiency

LDV……. Light Duty Vehicle

Mcity……The University of Michigan North campus

METRO……...Metropolitan Transit Authority of Harris County

MPO……...Metropolitan Planning Organizations

MSA……..... Metropolitan Statistical Area

MTA……. Metropolitan Transportation Authority

NAACP LDF……. National Association Advancement Colored People Legal Defense Fund

NEPA……. The National Environmental Policy Act

NHTSA……..... National Highway Traffic Safety Administration

NHHIP……North Houston Highway Improvement Project

NYSERDA……. New York State Energy Research and Development Authority

PEJA……. Potential Environmental Justice Areas

PROWA……. Personal Responsibility and Work Opportunity Act of 1996

PWI…….....Predominantly White Institution

ROW……..... Right-of-Way

RTP……. Regional Transportation Plan

SAE……. Society of Automotive Engineers

SAFETEA-LU……...Safe, Accountable, Flexible, Efficient Transportation Equity Act 2005

SAV……. Shared Autonomous Vehicles

SPSS……. Statistical Package for Social Science

STFID…….15-digit census tract numeric identifier

TEA-21……. The Transportation Equity Act of the 21st Century

TMC……... Texas Medical Center

TNCs……...Transportation Network Company

TSM&O……. Transportation System Management and Operations

TSU……. Texas Southern University

U of H……. University of Houston

VTT……Vehicle Travel Time

Vita

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Chapter 1

1.0. Introduction

Houston's downtown intergenerational protests (Bullard, 2021) have fueled the Metropolitan Transit Authority of Harris County (METRO), where a systemic unjust transportation system has led to inefficient mobility options too costly for low-income riders, exacerbating unequal transit access for the Greater Third Ward neighborhood. In addition, Frontline disruption and reversed hand picketing signs have also raised the Environmental Justice Movement, which is more robust today than in the 1960s. Finally, newly invigorated rallying has fueled the rise of Black Lives Matter after the police killings of George Floyd, Breonna Taylor, and countless other Black people during the Summer of 2020 (Bullard, 2021). A Harvard study recently found that a person's commute time remains an insurmountable barrier disrupting the Black community, where more than two-thirds of transit users in the United States walk to their bus stop or station (Cregar, 2019; Talbott, 2020; Karas, 2015).

Historically, transportation-related barriers, as mentioned, have led Texas Southern University (TSU), a public historically black university (HBCU), to unleash a cutting-edge twenty-first-century Autonomous Shuttle from its Tiger Walk into the heart of Houston's Greater Third Ward, an urban core Black "Ghetto" neighborhood, also known as the "TRE." This new mode of transportation will make Driverless Shuttle (DS) bus commuting convenient and reliable for transit-dependent populations exposed to unequal treatment than more affluent White commuters (Bullard, Johnson, and Torres, 2004). For centuries separatism, a riddled inequity for persons of color, notably African American and other people of color, has always been deployed to maximize the ingrained systemic oppression of Black America in our nation's transportation system, accelerating the accumulation of political and economic power in white communities. Many hope that driverless

shuttles will transform our economy in ways that drive growth. However, like other American systems, embedded racism has systematically shaped public transit in the Black community, like steam engines in the late 19th century and electricity in the early 20th century (Seamans, 2021). As Houston and surrounding areas sprawl, we could see punishing longer commutes with eleven million people and future growth possibilities passing Chicago (Seamans, 2021).

Henceforth, it is hard to imagine that maps on smartphones, chatbots, and other existing innovative mobility services will drive the economic growth we saw from steam and electricity (Seamans, 2021). Autonomous Shuttles will improve the Third Ward neighborhood's bus and light rail connectivity. If not, radically change social equity where racist political barons have systematically created increased highway construction barriers along the byways into the nation's transportation system, excluding the American dream to employment, education, and health care (Freemark, 2020; Talbott, 2020). Depending on how Autonomous Shuttle Transit (AST) deploys, the Third Ward transit-dependent population will need a dramatic new Elon Musk Artificial Intelligence (AI) killer app to transform Houston and surrounding areas.

Historically, research has shown that inefficient transit systems have characterized disenfranchised communities, and "transit subsidies disproportionately favor suburban transit and expensive new commuter rail lines that serve wealthier discretionary riders" (Bullard, 2005, p. 9). It has long been taken that Blacks and other people of color in the Black community have been taken captive by transit agencies and are twice as likely to experience inferior access to transportation than their more affluent counterparts (Bullard, Johnson, and Torres, 2004, p. 2). Bullard (2003) examined transportation issues as a continuation of the civil rights movement wrestling with differential

treatment that goes back to Plessy v. Ferguson and later Brown v. Board of Education and Rosa Parks. It has long been taken that Blacks and other people of color, as shown in Figure 1, Black urban neighborhoods are twice as likely to experience inferior access to transportation than their more affluent counterparts (Bullard, Johnson, and Torres, 2004, p. 2).

Figure 1

Transportation and Civil Rights

Source: https://www.newyorktimes.com/interactive/2019/08/14/

However, "In 1990, Dumping in Dixie: Race, Class and Environmental Quality documented that environmental vulnerability mapped closely with Jim Crow segregation, racial redlining and discriminatory zoning, and land use practices" (Bullard, 2021, p. 245; Bullard,1990). These efforts began in 1917 when Chicago's Real Estate Board lobbied to zone the city because of its influx of sidelined southerners (Hunter, 1980; Ellison, 2017), keeping Blacks in specific divided minority neighborhoods separate from white communities (King, 2021; McKelvey, 2021). "This is why racial redlining discriminatory zoning, and inefficient land use practices," (Bullard, 2021, p. 245; Bullard, 1990) target Houston's Black and Brown neighborhoods, as shown in Figure 2, where pollution

from the rail yard contaminated the underground water hindering economic and social advancement in employment, education, and health care (Freemark, 2020; Talbott, 2020).

Figure 2

Segregation and Land Use practices

Source: www.houstonchronicle.com/news/houston/article/Systemic racism

Unfortunately, zoning rules are typically written by affluent white men who own homes benefiting their wealthy white neighborhoods (Capps, 2019). As a result, they zoned municipalities to ensure racial segregation where residential patterns have reversed. For example, younger and higher-income people have increasingly chosen to move back into today's Black urban core ghetto neighborhoods due to gentrification (Fedorowicz, 2020; Baum & Hartley Snow, 2017; Couture & Handbury, 2017; Edlund, Machado, and Sviatschi, 2015). In the last century, the effects of zoned redlining are still apparent today (O'Donnell, 2019), and Black households, regardless of wealth, are 1.5 times more likely than U.S. households, in general, to be exposed to environmental risks such as poor air quality and contaminated water (Brennan et al., 2019).

Subsequently, many communities with a high proportion of low-income and minority people lack transportation amenities that promote good health, such as grocery stores with healthy food options (Brennan et al., 2019). Although some progress has been made as laws have changed around

practices like housing segregation, however, according to Bullard, minorities are often not considered in planning decisions. He refers to the current situation as "highway robbery," in which minorities pay taxes at the same rates that white people do, but those funds are then used for other purposes to subsidize racist development patterns (Valentine, 2020; Bullard, 2004). In addition, housing advocates point to restrictive zoning as one of the factors limiting social mobility and contributing to the racial wealth gap (O'Donnell, 2019), particularly generations of misguided "negro removal" (Patterson, 2020; Hale, 2018) known as urban renewal. These racialized policies—from redlining restrictive housing covenants to so-called "security maps" (Hale, 2018, p. 2, para. 4.) indeed adopted by the Federal Housing Administration maliciously color-coded invariably poor Black neighborhoods. For this reason, red represents areas as "hazardous" for lenders (Hale, 2018; Urban Institute, 2020). Furthermore, these practices meant that African Americans were primarily excluded from homeownership following the destroying black-owned businesses, and the chance to accumulate wealth through any investment in their neighborhoods was discouraged (Hale, 2018).

According to Campanella (2017), racist planning policies have been embedded into the public works beneath a series of overpass bridges Robert Moses, an urban planner. His Racist Parkway (Campanella, 2017, para. 3) the mass construction of federally funded interstate highways began in the 1950s (Urban Institute, 2020). Outside of preventing poor people from using the highway as the Law of White Supremacy rule Ricardo Favela, a notorious Ku Klux Klansman, states, "The border wall sounds good to people who don't live here" (Wong, 2018, para. 10) unquestionably different from a working-class community of immigrants and African Americans surrounded by a ring of poured concrete around the neighborhood (Miller, 2018). For this purpose, even today, highway concrete barriers have shaped the contemporary U.S. transportation landscape, starting with the rise of automobile ownership, as shown in Figure 3.

Figure 3

The Rise of Automobile ownership

Victor Stewart's 1947 Chevrolet

Source: Rayford Richardson

U.S. highway construction and ongoing urban renewal efforts from the 1930s to 1970s destroyed and displaced many Black neighborhoods. This displacement increased segregation, isolation, crowding, and clustering of communities of color (Urban Institute, 2020). For example, according to McKelvey (2021), when the U.S. highway system was being built in the 1950s to 1970s, urban planners often designed them to deliberately cut through neighborhoods where the property value was the lowest occupied by Black families and other people of color, walling these communities off from jobs and opportunity (Agyeman, 2020). Alfred Johnson, a leading lobbyist involved in the writing of the 1956 Federal Highway Act, recalled that some local government officials ``expressed the view in the mid-1950s that urban interstates would give them a good opportunity to get rid of the local 'Niggertown" residents (Rothestein, 2017; Hale, 2018; Dillon & Poston, 2021).

According to Agyeman and Fitzgerald (2021), "President Joe Biden proposed $20 billion (about $62 per person in the US) for reconnecting neighborhoods isolated by historical federal

highway construction, the bill currently provides only $1 billion (about $3 per person in the US) for these efforts – enough to help just a few places" (Agyeman & Fitzgerald, 2021, para. 3). Subsequently, benefits, and burdens of our transportation system—highways, roads, bridges, sidewalks, and public transit—have been planned, developed, and sustained to benefit white communities. Simultaneously, resources pulled from Black communities are deployed and invested in helping large numbers of white households that have moved from the city to the suburbs. Car ownership allows these families to continue to commute into the city for jobs (Archer, 2021; Turner & Skidmore, 1999; Woods, 2012). Civil rights activists have called miles of interstate "racist highways," dividing minority neighborhoods and polluting these communities (Mckelcey, 2021, para. 4). Meanwhile, President Biden has this within his insight (McKelvey, 2021).

Unfortunately, the U.S. landmark court ruling decided that Plessy V. Ferguson separate but equal land codification laws and many other subverted civil rights milestones (Bullard, 2004) have not eradicated Jim Crow's historical disparities where transportation's exclusion of minorities is intertwined with systemic racism (Bullard & Johnson, 1997). Meanwhile, Houston's no zoning practices and inefficient transportation policies have continued directly or indirectly to perpetuate these inequities. However, generations of disinvestment and inadequate transit bus connectivity and accessibility are clear. Most importantly, urban core exclusion and disinvestment have led to racial disparities built at the expense of Black communities, reinforced daily by bridges, highways, roads to sidewalks, and public types of planned transit buses have raised some questions (King, 2021; Archer, 2020).

Inefficient planning has led to disinvestment in the urban core. Wealthier whites' concentration resides in suburban and non-rural communities where lower access is often subpar and unfairly distributed into our transportation systems. In response, the 1960s Civil Rights

Movement highlighted the link between public transportation access and economic mobility (Patterson, 2020). Moreover, confronting public transportation inequity demands that we confront public transportation systemic rigidities and biases to fight systemic racism (Barot, 2020). Presently, Executive Order (E.O.) 12898: Federal Actions address minority and low-income populations inequalities, extending federal Environmental Justice and nondiscriminatory protection (Cutter, 1995).

Although federal policies have been implemented to minimize underinvestment in public transportation, according to Bullard (2020), movements for Environmental Justice have long been changing the routes of freeways and transit systems (Valentine, 2020; Bullard, Johnson, and Torres, 2004). Unfortunately, additional transit modes have led to fare hikes, service cuts, and poor connectivity (Mallet, 2018; Patterson, 2020). For this reason, notably for Black people of color, as shown in Figure 4, the segregated South Whites were victims of Jim Crow segregation laws" (Blakemore, 2020, para. 1).

Figure 4

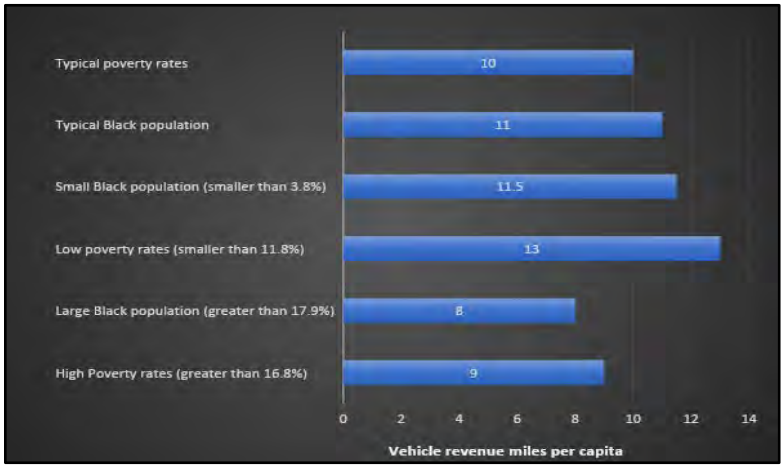
Jim Crow Oppression of Black People

Source: https://www.nationalgeographic.com/history/article/jim-crow-laws-created-slavery-another-name

In addition, those who depend on public transit have the most extended commutes during nights and weekends (Enchautegui, 2013) (Mallet, 2018; Patterson, 2020; Nation Equity Atlas, 2015). Although, according to Freemark (2020), transit service typically for people of color is 37 percent less compared to their wealthiest counterparts, based on population, the urban areas with the highest poverty rates fall into the lowest quartile. Meanwhile, underfunded public transportation in impoverished U.S. areas, shown in Figure 5, transit access is 24 percent worse and is less accessible in urban areas with Black residents than the fewest (Freemark, 2020).

Figure 5

Transit is less accessible in Urban Areas with Higher Poverty Rates and More Black Residents



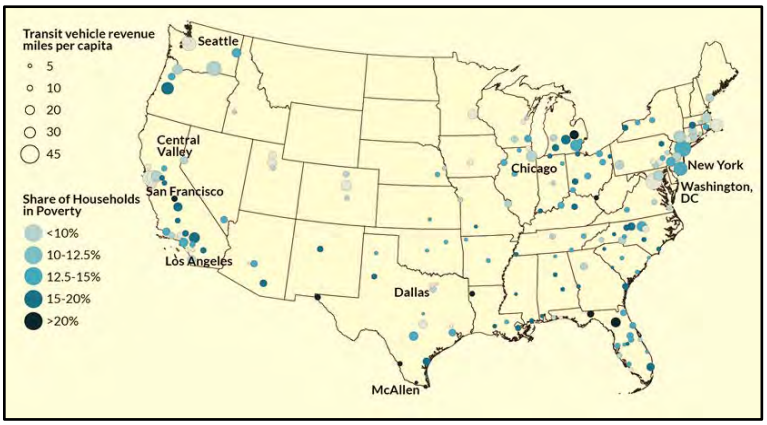
Source: Author tabulations of the National Transit. URBAN INSTITUTE
Database and 2014-18 American Community Survey
Note: Tabulations do not account for margin of error

While the country prioritizes heavy investments in highways and suburban commuter rail systems, communities of color are chronically underserved by underfunded public transportation systems. As a result, many U.S. impoverished urban areas are disadvantaged and have fewer transit options, as shown in Figure 6. There is also a spatial dimension to equity and diversity in many places, and poverty is often disproportionately concentrated geographically in communities with

high minority populations (Epanty, 2018). Therefore, the proximity of bus stops can make the difference between an affordable community and not (Miller, 2018).

Figure 6

Map I US Impoverished Urban Areas with Fewer Transit Options.



Source: National Transit Database and 2014-18 American Community Survey
Note: Shows urban areas with at least 200,000 residents

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1.1 Study Rationale

Economic segregation often impedes the central city, improved transportation links between ghetto neighborhoods, and new suburban job locations (NACCD 1968). Wyczalkowski and Huang (2017) analyzed the geographical link between public bus routes and poverty in the Atlanta metropolitan area (Miller, 2018). The authors found that a public bus route in Atlanta's suburban census tracts is associated with an average increase in the poverty rate compared to census tracts without bus routes (Miller, 2018). Public bus routes attract low-income residents because they offer affordable transportation. However, the system needs more consideration for connecting poor people with their jobs (Miller, 2018). There is only one explanation for this situation that is the racist blindness of city planners (Sanchez, 1998, p.4; Washington, 2003), where declining property values

and construction barriers to revitalization often bear the burden of funding transit and lack the tax base to support equitable, high-quality transportation systems.

This research examined the relationship between racial and socio-demographic characteristics and the Autonomous Shuttle along the Texas Southern University Campus Tiger Walk. TSU and Metro introduced an Easy Mile Shared Autonomous Vehicle (SAV) on June 19, 2019, the first in the region to Houston's Third Ward neighborhood (Metro Magazine, 2019). The shuttle traveled along a one-mile campus corridor, connecting multiple buildings and points for TSU students, faculty, and staff (Metro Magazine, 2019). With reported driverless shuttle pilots at Predominantly White Institutions (PWI), the research study was an opportunity to explore transportation equity at Texas Southern University, a public historically black university (HBCU) in Houston, Texas, during the first phase of the University district circulator pilot study.

1.2 Research Statement

Today's researchers inadvertently ignore how Autonomous vehicles will affect vulnerable groups, notably Black and low-income persons of color, heavily focusing on theoretical problems alleviating the harms that current transportation infrastructure can inflict. The Metropolitan Transit Authority of Harris County (METRO) and other stakeholders to do everything possible to remove all barriers in the HMA network. For example, connect driverless shuttle bus routes to the light rail near interstates where transportation professionals' and practitioners' shadowy planning decisions have destroyed isolated Black and Brown neighborhoods. In addition, businesses and grassroots advocates in community-based organizations are misinformed about the planning process for displacing residents, which affects the Black and Brown neighborhood characteristics (Hale, 2018).

Factors include planning for an additional mode of transit along Cleburne Street, which has reduced lanes since there is no dedicated transit lane, for driverless shuttle mobility and landscaping

aesthetics, which now serve as a potential barrier to slow traffic for Third Ward's transit-dependent population. Therefore, during peak hours, increased traffic congestion coming from State Highway 288, particularly for Texas Southern University students, faculty, and staff, may increase travel times due to inefficient short-range planning for:

- Permanent White Supremacy Spatial Toolkit.
- Policies and practices are the legacies of racist planning.
- Housing and Infrastructure barriers that maintain White Supremacy boundaries could withstand the evolution of civil rights laws (Agyeman, 2020).

"Rather than be forced to comply with the law, the highways were the law" (Archer, 2020, pp.1259, para. 3).

This research looked at the equity of an autonomous shuttle for the transit-dependent population along the Texas Southern University Campus Tiger Walk. Further analysis examined the built environment demographic characteristics to discover any relationship between these factors. Finally, the research aimed to consider if an autonomous shuttle would provide an additional mode of transportation for the TSU campus Tiger Walk and the Third Ward neighborhood.

1.2.1 Justification

Epting (2018) analyzed how transportation-related barriers remain in place, as usual, hinder economic and social advancement. Thereby perpetuating depressed black oppression is why transportation professionals and practitioners exacerbate inefficient planning practices and assuredly wield exceptional power against Black people at every level down to the neighborhood (Epting, 2018; Wellman, 2015). Indeed, the United States Environmental Justice movement has come a long way since the Labor Community Strategy Center vs. Los Angeles Metropolitan Transit Authority in 1996. This case was settled out of court and showed environmental racism in the United States.

Whereas an all-time historical issue carried out by residents and lawyers, the NAACP Legal Defense and Education Fund (NAACP LDF) revealed inequitable funding and transportation operations primarily used by low-income transit-dependent commuters (Bullard & Johnson, 2000).

For this purpose, a study by UCLA showed just how significant the demographic divide coupled with public transportation was after a review of Census Bureau survey estimates (2012). Commuters are disproportionately lower in every city, with many riders outside a few sizable mid-Atlantic transit systems (Maciag, 2014). Moreover, social movements across the United States show that much has stayed the same. From this standpoint, poor or mediocre public transit services in areas of high proportions of poverty-stricken minorities, primarily people of color, suffer from transit bus idling, spewed diesel emissions, and higher COVID-19 rates. Vulnerable, voiceless transit-dependent populations are impacted by transportation policies that only decrease choices for those with limited transportation options (Garrett & Taylor, 2012).

Nevertheless, at the same time, they are left standing or living in fence-line communities near public transportation hubs. As a result, particle pollutants hover in the air, are absorbed into buildings and houses, and find their way into residents' lungs. As a rule, a rapid-transit system has been laid out to convenience the white upper-middle-class suburbanites who commute to jobs in downtown Central Business Districts (Washington, 2003). However, EPA's standards on particle pollutants should only be "exceeded once per year on average over three years (Ramey, 2015). For this purpose, AV technology's potential effects on planning may be significant, considering new, more stringent ozone standards near the bus stop.

Municipal transit agencies should provide equitable access opportunities to address poverty, unemployment, and equal opportunity goals. In addition, ensuring grassroots advocates are highly engaged in the planning process encourages equity for future Autonomous Shuttle vehicles to access

jobs, medical, and education. This study will build on past research on transportation inequalities and re-examine Environmental Justice in Houston's Greater Third Ward metropolitan area. This study will use a Google map spatial and statistical investigation of the sociodemographic surrounding Texas Southern University Campus Tiger Walk. The problem of environmental injustice will be investigated longitudinally by analyzing Third Ward's EJ census tract data to determine the changes and trends in the race, ethnicity, and socioeconomic demographics of the population in proximity to bus stops in Houston Greater Third Ward near Texas Southern University.

This study will also critically investigate the literature on transportation equity for an Autonomous Shuttle by examining transportation barriers near public transportation hubs and the population near them. Addressing environmental justice aims to add to the body of knowledge and strengthen transportation equity at the transit agency, primarily at local and community levels. Studies like this are helpful to Community-Based Organizations (CBOs) seeking to advocate for their communities. It can also provide information to federal agencies such as the United States Department of Transportation and the Federal Highway Authority while giving Metropolitan Planning Organizations and transportation agencies policy guidelines to operate Autonomous Shuttles in Black urban ghetto neighborhoods. Finally, transit agencies can benefit from this research because it can facilitate further environmental justice studies for voiceless communities of color near public transportation hubs.

1.3 Research Objectives

1. To assess the present condition of existing shuttle and recommend the need for an Autonomous Shuttle for transit dependent population along TSU Tiger Walk.
2. To compare the demographic and socioeconomic factors of proximate areas (census tracts) that do not have adequate transit.

3. To determine if there is a significant relationship between race, socioeconomic factors, time intervals, the distance between stops, and transportation modes.
4. To determine the perception and everyday experiences of commuting in a Historically Black University (HBCU) setting along Texas Southern University Campus Tiger Walk, where a driverless shuttle is an additional mode for transit- dependent populations biking and walking.
5. To investigate equity associated with the residents living in Houston's Greater Third Ward community near public transportation hubs.

1.4 Research Questions

Research Question #1	Do driverless shuttles provide another mode of transportation for a transit-dependent population?
Research Question #2:	Is there a relationship between racial and socio-demographic characteristics of areas that do not have adequate transit.
Research Question #3	Is there any relationship between the racial and socioeconomic characteristics and distance to the destination?

Research Hypothesis

This research study will attempt to test the following hypothesis.

From research question #2:

Null Hypothesis **H02:** There is no comparison between the demographic and socioeconomic characteristics of proximate areas (census tracts) that do not have adequate transit.

From research question #3:

> ***Null Hypothesis*** **H03:** There is no significant relationship between racial, and socioeconomic characteristics (independent variables) and the Autonomous Shuttle (dependent variable) to destination.

1.4.1 Background

Houston's alienated urban core, the Greater Third Ward, a black ghetto neighborhood, has been fading away with the spread and advancement of cellular and 5G wireless communication. Howell (2020) states, "Between 2000 and 2012, there were 14% fewer jobs near Black residents due to gentrification and housing cost and 25% of Black households do not have smartphones and cannot use ride-hailing options" (p. 1). In a 2010 study of Transit-Oriented Developments, Murphy found that 50% of residents live "within a half-mile of existing rail stations… make less than $25,000 a year and within a quarter mile of existing rail stations, renters make up 65% of the population" (Welch, 2013, p. 283). Moreover, over half of the families living in poverty do not have access to a vehicle at least some of the time (Klein & Smart, 2017), which limits access to a range of essential services like jobs, health care, and food (Blumenberg & Pierce, 2017; Bullard et al., 2004; Dawkins et al., 2015).

According to the U.S. Census Bureau, only 55.4 percent of households making less than $25,000 owned a smartphone in 2016 due to physical or economic constraints (Brown, 2017), including over 25% of households earning less than $25,000 per year (U.S. Census Bureau, 2020). A recent study found that 20% of Black households do not have a vehicle, and unbanked rates were higher among low-income families without a smartphone. With a bank account, only some transit riders, especially those from low-income families, where 25.7 percent of households make less than $15,000, can pay for transit (Ezike, 2020). In addition, arranging services for shared transportation typically relies on access to a mobile app linked to credit cards, creating barriers for users who need

smartphones or bank accounts (DOT, 2016). Also, applications requiring new mobility services can create access barriers for some (DOT, 2016) households with the lowest smartphone ownership rates (Ezike, 2020).

Housing affordability for renters has long been a problem for poor middle-income, particularly in urban areas with solid job markets (Schuetz, 2020). For example, in 2017, half of the renter households spent more than 30 percent of their income on rent, whereas 12.3 percent of homes in the $15,000–$30,000 income range met the Department of Housing and Urban Development's (HUD) "cost-burdened" (Schuetz, 2020; Ezike, 2020) and renters make up 65% of the population. According to the Federal Highway Administration, households making more than $100,000 take three times as many trips as those below the poverty level (Ezike, 2020). Furthermore, housing near jobs and transit centers is expensive, and increased density in the urban core has pushed moderate and lower-income residents into the less dense suburbs creating transportation challenges for residents (Kneebone & Berube, 2013; Rayle, 2015; Revington, 2015), requiring them to spend more time and money commuting (Schuetz, 2020).

"Transit-dependent communities are segments of the population without personal vehicles that use public transportation as their primary source of mobility. Based on recent Census data and socio-demographic analysis, many of these communities are increasingly being found outside the Metro service area" (HGAC, 2016, p13. para. 5). Therefore, poverty-stricken transit-dependent populations bear the burden of attaining reliable transit service, notably marked by underinvestment, environmental hazards, and high crime rates (Ellison, 2017). Simultaneously, over the next 26 years, two-thirds of the world's population, particularly lower-income households living in urban areas (United Nations, 2018), will rely more heavily on public transportation than higher-income families.

Under the upright policy, vehicular automation could support Metro's 2045 dominant vision of meshing a 20-mile light-rail extension connecting 75 miles of new Bus Rapid Transit (BRT) extensions with level boarding and comparable stations near Texas Southern University (MetroNext, 2022, p. 4). Metro's extensions would be along five lines, including Hobby Airport to the medical center (MetroNext, 2022). The amenities will include the University of Houston, one of the system's busiest north-south routes. In addition, they are extending Westheimer's Uptown east-west bus route to Third Ward's Emancipation Park between the Texas Medical Center and downtown. Different from Houston's west side, the Uptown district targets service enhancements. For example, the region's first dedicated bus lanes include the state's most congested roadway, West IH 610 Loop (METRO Next, 2022).

1.4.2 Houston's Regional Transportation Plan

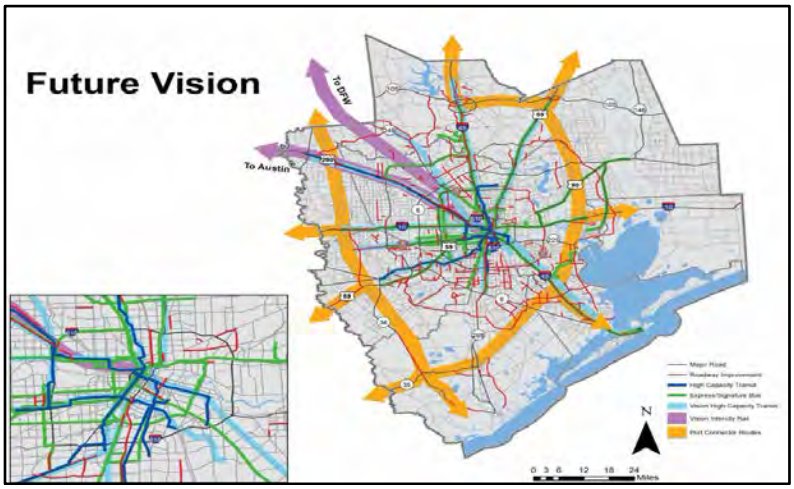
Autonomous Shuttle Transit and its first-last mile connectivity are beginning to close gaps for people of color, improving mobility practices at Texas Southern University (TSU). Still, there are critical steps the Greater Third Ward community must take. For example, activity centers near the University of Houston, TSU, Greenway Plaza, and the Galleria area will all be tied together and serve as one transit corridor route with much smaller single-digit percentages (Meyer, 2019). With so much travel shifting further away from the historic core of Houston's downtown, Houston's low cost of living and attractive business climate is more likely to generate a vast increase in population and employment growth.

Meanwhile, Houston's 2040 Regional Transportation Plan (RTP) expenditures do not fit into new urban districts, one of many corridors significant to activity that are beginning to thrive around the Beltway and beyond (HGAC, 2016, p. 21 para, 3). Examples of 2040 RTP projects include an

extensive transit network, as shown in Figure 7, which supports the vision of 700 miles of high-capacity transit, light rail, commuter rail, bus rapid transit, and high-speed intercity passenger rail to move persons within the region and between neighboring areas (HGAC, 2016, p. 23, para 2).

Figure 7

Map II Future Vision



*Source:*https://www.h-gac.com/getmedia/b6dc64b9-f5ea-4e7e-b708-38f64d15eccd/2040-RTP-revised-April-2016.pdf

Consequently, Transportation System Management and Operations (TSM&O) should aim to develop a sustainable, Autonomous Shuttle vehicle initiative with the following goals:

- Leverage of emerging technologies (ET)
- Industry Testing and Implementation Opportunities
- CAVI-friendly and deployment-centric infrastructure
- Cross-Disciplinary Institutional Framework

Leverage in emerging technologies, industry testing, and implementation opportunities will rapidly increase Houston's traffic congestion. For this purpose, it is crucial to match the need for transit access to jobs from the Third Ward community to areas between Beltway 8 inside Grand Parkway

(SH 99) and beyond (HGAC, 2016, p.22, para. 2). High growth forecasted in suburban areas would experience a population significant to employment. Furthermore, percentages with 1.5 million jobs are bounded by elevated portions of IH-45, IH-10, and IH-69 (HGAC, 2016).

Assuredly, it would need advanced wireless infrastructure improvements to promise significant impacts, whereas collaborating with other expanded regional areas ordinarily doubles bus ridership and expands access with connections outside the service area of Missouri City and Sugar Land. Houston Metro must develop a cross-institutional driverless shuttle framework with economic investment in opportunity zones for services, and amenities, for work-related trips especially moving through Houston's "hub-spoke" travel corridors, particularly connecting people in low-income neighborhoods to neighborhoods of higher opportunity activity centers and employment districts (Stacy & Meixell, 2019).

1.4.3 Houston's Economic Center Transportation Infrastructure

Metro serves three major employment centers within the Houston TMA, (1) Central Business District (CBD), (2) Texas Medical Center (TMC), and (3) Galleria Uptown. The Uptown Post Oak corridor from interstate 610 to Richmond Avenue constitutes a primary transportation facility serving one of the most significant employment and retail centers with 59089 residents. However, the fact remains that the Uptown corridor is rapidly becoming one of the region's highest-density residential centers (Ramesh & Mohan, 2017). For this purpose, this area is highly populated with occupied rental housing and few public transportation commuters.

To support the fact that public transit is low in an area with sizable rental occupancy is problematic. Chiefly, Uptown's concentration of employment centers must be served through a High-Capacity Transit (HCT) system and infrastructure granted within the area encircled by IH-610. In addition, residents' ongoing movement to provide services (like ambulance, garbage collection,

or fire rescue) covers greater distances and uses more fossil fuels per person (Banties, 2011). These services will remain the most challenging, even as AV technology transforms our vehicles, the new ride-hailing car services, and the public transit systems.

1.4.4 Alleviating Congestion for Travel Time Savings

Houston's region is home to 40% of the state's most congested roadways, not all of which can be widened. For example, commuter rail could help alleviate the roadway travel share because rail has a significantly higher carrying capacity than highway lanes miles serving single-occupant vehicles. Currently, the Gulf Coast Rail District is studying possibilities along three regional corridors; this provides a framework in which the transportation community could advance the development of options necessary for the future. However, since some transit expenditures fall within this category, including:

- Regional vanpool program ADA accessibility and paratransit service.
- Preventative maintenance enhancements and replacements to the bus and rail systems.
- IT system improvements and work regarding passenger shelters, facility maintenance, transit centers, and parks & rides.

Federal transportation expenditures are dispersed disproportionately between public transportation and road and highway infrastructure maintenance (Epanty, 2018). Transportation funds are represented in ITS, safety, thoroughfare development, suburban connectors, freight, pedestrian/ bicycle improvements, transit, and land use coordination ((HGAC, 2016, p. 21 para, 3). It is creating structural and institutional disparities in the abilities of different populations to access safe and reliable transportation (Epanty, 2018). Significant investment in travel corridors serving both travelers and freight, such as the completion of the Grand Parkway, intermodal connector improvements, and the construction of freight relief routes, will accommodate ports-area mobility

and a completed network of more than 2,600 miles (about the width of the United States) of local thoroughfares. In addition, a robust, interconnected pedestrian/bicycle network of more than 986 miles (HGAC, 2016, p.23. para. 2). Such disparities indicate significant changes to the available travel options, and congestion mitigation methods will be necessary.

1.5 Research Design

This research used quantitative and qualitative analysis to examine the possible relationship between the built environment, the social-economic factors, and travel distance occurring there. The Tiger Tram is the primary transit choice along the Texas Southern University TSU Campus Tiger Walk, but the EasyMile electric Autonomous Shuttle bus was used for this study. The statistical model used for the research is as follows:

$$Y = f(X)$$

$$Y = f(ENV, DC, Distance)$$

ENV= Time intervals, Travel mode, Transport on campus

DC= Demographic Characteristics

1.5.1 Data Characteristics

The study used primary data from an online survey of the TSU Autonomous Shuttle, the built environment surrounding bus stops along the TSU Campus Tiger Walk, and data from the 2018 US Census Bureau, the American Community Survey, American Public Transit Association. There are four bus stops along the TSU Campus Tiger Walk–two with east and westbound stops. Two of the four stops are at a central location with longer travel times for each east and westbound commute. This data provided statistical analysis for the four stops used in this research.

1.5.2 Method of Analysis

The research used mixed methods analysis to study an Autonomous Shuttle (dependent variable) along the TSU campus Tiger Walk. Independent Variables were: (1) Travel distance between stops (buildings residential housing and the Library and Learning Center dominate the eastern portion of the campus. The Health and Physical Education arena (HPE), Spearman Technology Building, and New Science Building anchor the west. In addition, there are administrative offices, classrooms, the Sterling Student Life Center, the Recreation Center, and the Post Office. (2) Social-economic factors for students, faculty, and staff. (3) Time intervals for driverless shuttle-Morning (8 a.m.), Mid-day (noon), Evening (5 p.m.).

1.5.3 Problem Statement

Houston Metro bus and light rail travel through the Third Ward neighborhood, Medical Center, and downtown. With new infrastructure technology, the Driverless Shuttle will connect students to METRO buses and light rail to urban, suburban, and rural environments. Transit access between Third Ward's Eastwood Transit center and the university corridor creates essential east-west transportation links, notably for transit-dependent population connections. The distance from the METRO LRT bus stop on Cleburne at Scott to the TSU AV stop is (0.2 miles), a five-minute walk. The researcher noticed only one Metro bus option connecting TSU students, faculty, staff, and Third Ward residents from the Cuney Homes to the Metro light rail nearby and the Main Street corridor for at least one bus stop.

CHAPTER 2

2.0 Literature Review

2.1 Introduction

By 2035, the United States will have more than 30 million Autonomous Vehicles (AVs) streaming through most metropolitan areas (Grunwald, 2016). However, there are other concerns when imagining a future where Jarvis (Artificial Intelligence) takes the wheel. Proponents of AVs hold that these technologies will reduce travel times and carbon emissions by delivering electric vehicle buses to support clean air (The Bipartisan Infrastructure Law, 2021). Thereby potentially eliminating road dangers posed by fallible human motorists and saving lives where "artificial intelligence is prone to road rage, distracting drivers, or the ability to fall asleep (Miley, 2021; Grunwald, 2016).

Recently the Congressional Black Caucus (2020) found that 20% of Black households in disadvantaged communities do not have a vehicle to access education and employment. Public transit remains essential for many Blacks, Indigenous, and People of Color (BIPOC) escaping poverty's generational racist structures (Howell, 2020). Access to quality public transportation is critical for many of these populations. Green (2015) states, "Blacks are six times more likely and Latinx three times more likely than Whites to rely on public transit" (p. 1). Compared to other workers, 24% of public transit riders are African American, and travel by transit has a higher time cost than personal auto travel (Downs, 1992). However, they only comprise 12% of the US population (Howell, 2020). "For this reason, travel time alone is an unreliable measure of relative employment accessibility" (Sanchez, 1998, p. 2).

2.2 Transportation Equity: The murder of George Floyd, a Houston native, compelled the entire country to reconsider race and prejudice (Zurcher, 2021), for example, during the Black Lives Matter demonstration, as shown in Figure 8. Metro was an ally for Houston's Police Department and its clandestine (riot gear) police officers as buses transported them into downtown Houston (Begley, 2020). Although, according to Begley (2020), 50 persons held by Houston police during the protest were unlawfully transferred by a Metro bus, violating the transit agency's rules, a mistake officers and bus leadership stated was promptly addressed.

Figure 8

Detained Protesters Downtown Houston

Source: https://www.houstonchronical.com

"If you are part of a transportation agency, you should be thinking about systemic racism and making sure you are part of the solution, not part of the issue," says Spieler (2020).

Transportation policies in the United States continue to be a central focus for ongoing struggles as inequality has primarily caused systemic racial tensions (Malapit, 2020). King's words remain true today — with renewed national debates over systemic racism. Meanwhile, the current

50-year wave of protest and their equitable benefits for the Black community exacerbate transportation inequities (Patterson, 2020; Grisby, 2020).

For example, the TSU Riots in 1967, after a young boy drowned at the Holmes Road landfill, led to an Environmental Justice outcry in Houston's Third Ward on the TSU campus. Following this, illegal law enforcement (Rampell, 2020; Begley, 2020) on the TSU campus, as shown in Figure 9, differs, affecting vulnerable communities of color out of grievances related to this history of racialized colonization and oppression. Indeed, this has contributed to the rise of the EJ movement and a reaction to EJ injustices.

Figure 9

The 1967 TSU Riot

Source: www. http//houstonchronicle.com/

Likewise, in 2019, 54% of those who died because of police harm, particularly those whose race was identified, were people of color – including Asian, Black, Hispanic, Native American, and Pacific Islander – compared to 50% in 2014 (Mcphillips, 2020).

According to Grisby (2020), "the US has failed to address the implications of racist transportation investment through racist policies. For this purpose, "the nation's infrastructure has

promoted racial tensions that systemically impact the generation of African Americans'" (p.1). However, President Dwight Eisenhower rarely addressed civil rights issues and indirectly supported slavery by reinforcing segregation with the Federal Highway system. In 1955 he refused to comment on the Emmett till case and the bombing of Martin Luther King's home (Fitch, 2014, p. 9, para. 2). The administration ignored pressure from the African American community to pass legislation protecting voting rights (Fitch, 2014, p. 9, para. 2).

To keep African Americans "in their place" socially and politically manifested itself in keeping them quite literally in one place or another. For this purpose, before the Civil War, White plantation masters kept enslaved African Americans nearby to coerce their egregious labor and guard against revolts (Kruse, 2019). With the abolition of slavery, the spatial relationship reversed. However, Whites admittedly wanted them out of sight once they did not constantly need to watch African Americans. So instead, civic planners pushed them into the segregated ghetto neighborhoods we know today (Kruse, 2019).

> “Policy makers and planners saw highway construction as a convenient way to raze neighborhoods considered undesirable or blighted. And they deployed the massive infrastructure elements—multi-lane roadbeds, concrete walls, ramps, and overpasses—as tools of segregation, physical buffers to isolate communities of color. Our categorical imperative is action to clear the slums,” Moses said in a 1959 speech. We can’t let minorities dictate that this century-old chore will be put off another generation or finally abandoned (Evans, 2021, para. 6).

Transportation policies have inequitable effects on economically challenged vulnerable populations of color, often restricting their access to social and economic opportunities, including jobs, education, health care services, and other social places. In the United States, federal agencies must provide equal access to resources for minority and low-income populations to improve the accessibility and delivery of transportation services. Federal agencies must provide equal access to resources for minority and low-income populations where 4.5 million Americans cannot access

affordable, reliable transportation (Brito, 2020). In addition, the Personal Responsibility and Work Opportunity Act of 1996 (PROWA), "welfare-to-work," and job access programs have been initiated to address low-income mobility problems (Willis, 1997; US DOT 1998).

2.3 Electric Vehicle Infrastructures: Given that Autonomous Shuttle deployment remains incipient, Houston's Greater Third Ward is experimenting with targeted infrastructure rollout to support uptake in parallel with driverless vehicle incentives (e.g., public charging stations and transit routes, electric shuttle buses, strategic electric distribution grid system upgrades). The federal government has another $2.5 billion (about $8 per person in the US) in grants for installing chargers in disadvantaged and rural communities (Marshall & Simon, 2022), which currently need to be found on many highways. The funds are part of the Biden Administration's larger plan to improve charging access and eliminate gas and diesel-powered vehicles as significant contributors to climate change. However, transitioning away from them will require far more charging stations and infrastructure changes. In addition, many cities and states have incentive programs to encourage installing more public chargers (Marshall & Simon, 2022). Utilities have pledged billions of dollars to support stations, and EV advocates hope that other companies will follow suit though the economics of charging can be tricky (Marshall & Simon, 2022).

The time has come for solar energy to prove its merits without billions in support from the federal government both here and abroad to transition transit systems to unrestricted access for clean, affordable, and efficient public transportation in minority communities, particularly in projects that mitigate US carbon emissions and increase access to opportunity for people of color. Unfortunately, for all those reasons, President Biden's agenda of improving racial equity requires dismantling racist polluting freeway projects or reimagining parts of America's transportation system, which has long

tacked the odds against people who rely on it to climb the economic ladder (Mintz, 2021; Wilson, 2021).

Historically, the federal government has not invested much in funding transit operations; state and local governments typically cover these costs. Federal expenditures include capital investments, like new lines, buses, and maintenance. This nascent stage of targeted investment is a tremendous opportunity for Houston Galveston and the surrounding area (HGAC) to prioritize Environmental Justice (EJ) in transportation policy regulation for planning. Therefore, this chapter will be presented in two sections. The first section presents the history and evolution of the Environmental Justice movement and Environmental Justice in Transportation Planning. The second section provides the literature on the history and development of Autonomous Vehicles and the Environmental Justice of Autonomous Shuttle Transit in the built environment. Finally, this chapter will cover the gap in the literature.

2.3.1 History of Environmental Justice

More than forty years ago, in 1979, Texas Southern University professor Robert Bullard first researched the first Environmental Justice case. "Environmental justice did not originate with the Environmental Protection Agency ("EPA") or government but grew out of local grassroots community struggles" (Bullard, 2021, p. 244, para 2). Where Bean v. Southwestern Waste Management, the Black residents of North wood Manor, a Suburban, middle-income neighborhood in Northeast Houston, and their attorney, Linda McKeever Bullard, lost the Lawsuit, which laid the case for environmental racism (Bullard, 2021, p. 244, para 2; Ahmed, 2021).

This Environmental Justice Movement catapulted the national limelight three years in rural and primarily Black Warren County, North Carolina—again over waste dumping in 1982 when an African American community challenged inequities in distributing polychlorinated biphenyls

environmental hazards (Friedman, 2022; Bullard, 2021; Bullard, 1993; Lee, 1992). “The toxic landfill ignited protests led by Reverend Benjamin F. Chavis and others, resulting in over 500 arrests. “The protests also provided the impetus for the 1983 U.S. General Accounting Office (“GAO”)—now the Government Accountability Office and the auditing arm for the government (Friedman, 2022)—a study of hazardous waste dumping in EPA Region 4, which covers eight states in the South” (Bullard, 2021, p. 244, para 4; Bullard & Wright, 1994).

As an act of environmental racism (Bowden, 2002) and case study evidence of racial and ecological discrimination, Bullard (1983) found that hazardous waste site pollution-producing facilities were often disproportionately located in African American poor communities (Friedman, 2022; Skelton & Miller, 2016). Subsequent research documented racial disparities in other hazardous exposures, such as industrial plants and bus depots (Bryant & Mohai, 1992; Bullard, 1990). According to Friedman (2022), “the practicalities of righting historical wrongs — racist zoning and housing policies that located polluting industries and highways in communities of color — have not been easy” (Friedman, 2022, para. 33). “No one wants a factory, a landfill or a diesel bus garage for a neighbor” (Cunningham, 2017, p.13). It was noted that “corporate decision makers, regulatory agencies and local planning and zoning boards had learned that it was easier to site such facilities in low-income African American or Latino communities than in primarily white, middle-to-upper-income communities” (Skelton & Miller, 2016, para. 8).

After racial controversy movements to enforce environmental laws (Lavelle & Coyle, 1992) in support of the 1964 federal civil rights law, the environmental justice movement gained force in the 1980s and 1990s. For example, the Case of Labor Community Strategy Center v. Los Angeles Metropolitan Transit Authority in 1996 showed inequalities in the distribution of funding and transportation operations primarily used by low-income transit-dependent commuters (Bullard &

Johnson, 2000). It showed the inequitable funding and bus transportation operation. The Los Angeles bus riders Union epitomizes grassroots challenges to racism in communities of color, which have assisted in campaigns for crowded seating and second-class treatment by the MTA. This Association has since been involved in the policymaking debate of stopping transportation racism (Bullard et al., 2000).

By the mid-1990s, the movement had transcended its original focus to include communities of color, particularly women, children, and the poor (Cutter, 1995). In 1991, the First National People of Color Environmental Leadership Summit in Washington, D.C., adopted 17 "principles of environmental justice," as shown in Appendix B, extending the movement's focus on race to include other concerns, such as class and nonhuman species (Goldman, 1996). In 1994 the Presidential Executive Order (E.O.) on environmental justice (E.J.), EO 12898, was signed by President Clinton. In addition, Reverend Benjamin Chavis and Dr. Robert Bullard to his Natural Resources transition team helped make environmental justice essential in Clinton's stated environmental policy (Skelton & Miller, 2016).

As a result, transportation agencies have developed a range of policies and programs for health concerns. Black people are also more likely to live near high-traffic roads than White people (Howell, 2020), where quality public transportation access is critical for mobility for Blacks and other people of color. However, freeways and bus routes are what urban planners refer to as locally unwanted land uses, just one part of a bigger picture: These projects include highways, landfills, incinerators, bus depots, and other kinds of projects that disproportionately fall in minority communities and often cause pollution and harm the health of residents (Valentine, 2021).

E.O.12898 effectively brought together two previous regulations: Title VI of the 1964 Civil Rights Act to monitor, mitigate, and prevent disproportionate adverse impacts of transportation on

minority and low-income communities, which focuses on non-discrimination, and the 1969 National Environmental Policy Act (NEPA), which focuses on protecting the natural environment. Thus, the executive order directed the federal government to make Environmental Justice a part of the federal decision-making process. Besides, it focuses on the health and environmental conditions in minority, tribal, and low-income communities, intending to achieve Environmental Justice and foster non-discrimination in programs that affect human health or the environment (U.S. Department of Energy, 2020).

2.4 Environmental Justice in Transportation Planning

Historically, the Black community has been left out of transportation planning decisions and infrastructure development. For example, in 1966, then-president Lyndon B. Johnson noted that we must continue to plan our highway system to contribute to the rational use of urban space (Freemark, 2021). His successor, Richard Nixon, argued in 1973 that good public transportation is essential to ensure adequate transportation for all citizens and advance the common goal of less congested, cleaner, and safer communities (Freemark, 2021). Today, cities are integrating technological innovation in decision-making and service provision to address various challenges caused by urbanization—e.g., traffic congestion, greenhouse gas emissions, and energy efficiency—under the intelligent city notion (Townsend, 2013; Yigitcanlar, 2016; Kellerman, 2018).

2.4.1 President Biden's Infrastructure Projects: Federal funding is crucial to completing major infrastructure projects nationwide, taking many years and ongoing commitments (FBS, 2020). According to Wright (2022), "to raise the alarm about climate change and the harmful fossil fuels that destroy communities, lives and the promise of future generations" (para. 2). Subsequently, the environmental justice movement seeks to protect all people from ecological degradation and toxins and provide equal access to all demographic groups (Velasco, 2020). First, however, the transition

to electric vehicles requires federal tax dollars to subsidize controlled access construction projects to reduce greenhouse gas emissions along automobile-oriented freeways (Freemark, 2020; Bullard & Johnson, 1997). Second, energy-efficient transportation is needed for inner-city residents to access jobs, healthcare, shopping, and childcare services (Bullard & Johnson, 1997).

In comparison, during the Trump administration, unfortunately, many of the infrastructure projects cut through isolated communities of color (Bullard & Johnson, 1997), namely, the North Houston Highway Improvement Project (NHHIP), as shown in Figure 10, a $7 billion (about $22 per person in the US) plan by the Texas Department of Transportation to widen I-45 and parts of I-10 and I-610 on the downtown edge of the state's most significant city highway (Bustamante, 2022).

Figure 10

I-45 Expansion Project

Source:*https://abc13.com/i-45-expansion-project-remains-stalled-the-harris-county-attorne s-office-Tx dot/11701692/*

Similarly, President Dwight Eisenhower's highway expansion between the late 1950s and early 1970s aimed to eliminate unsafe roads, inefficient routes, and traffic jams that impede fast and safe

cross-country travel. However, it was a massive cost to America's urban communities of color (Evans, 2021).

> According to U.S. Department of Transportation estimates, more than 475,000 households, and more than a million people were displaced nationwide because of the federal roadway construction. Hulking highways cut through neighborhoods, darkened, disrupted the pedestrian landscape, worsened air quality, and torpedoed property values. Community's lost churches, green space, and whole swaths of homes. They also lost small businesses that provided jobs. They kept money circulating locally in crucial middle-class footholds in areas already struggling from racist zoning policies, disinvestment, and white flight (Evans, 2021, para. 3).

Even though President Biden's proposed policies aim to restore divided sideline communities of color haunted by fence line federal highways and other infrastructure, exposing them to the lion's share of pollution from emissions (Adam, 2020). According to the White House (2021), it looks to target 40 percent of the benefits of climate and clean infrastructure investments to disadvantaged Black and brown communities under the Bipartisan Infrastructure Law (King, 2021; The White House, 2021). Admittedly, Biden's Plan promises to address the historical racism ingrained by urban transportation planning that would "reconnect neighborhoods cut off with bridges too low for city buses to pass, providing connecting accessibility (King, 2021), eliminating increasing needs for practical urban transport (Ainsalu et al., 2018).

President Joe Biden's campaign platform emphasized that he would work to ensure that new, fast-growing areas are designed and built with clean and resilient public transit in mind (Velasco, 2020). Undoubtedly, according to TxDOT's (2021) environmental review, the NHHIP would remove more than 1,300 homes, businesses, schools, and places of worship (Bliss, 2021). In other words, much of the impact would land in low-income Black and Brown Latinx neighborhoods. In addition, NHHIP would add multiple lanes and shift approximately 26 existing school and daycare campuses within 500 feet of the highway, violating Title VI of the civil rights act and National Environmental Policy Act and subjecting nearby communities of color to increased levels of air

pollution, residential displacement, and flooding, and escalating traffic volume and pushing more air pollutants into nearby areas. Some of the same ones the highway's original construction tore through in the 1950s and '60s (Bliss, 2021; Adams, 2020; Wilson, 2021).

2.4.2 President Trump and The CARES Act: History has shown that government regulatory action alone cannot make a realistic and just transportation transition (Freemark, 2020) regarding policies and plans for vehicle electrification. President Trump's Coronavirus Aid, Relief, and Economic Security Act, also known as the CARES Act, approved in March 2020, provided the transportation sector with $25 billion (about $77 per person in the US) in emergency funding assistance. It included a stipulation requiring funds to be allocated within seven days (Libman, 2020). The funds were allocated in six days by the U.S. Department of Transportation and the Federal Transit Administration (Libman, 2020), including operating needs, potentially setting a precedent for a new initiative in the Biden administration (Libman, 2020).

This funding is part of more than $30 billion (about $92 per person in the US) for public transportation in the American Rescue Plan Act, signed into law by President Biden on March 11, 2021 (FTA, 2021), "includes $30.5 billion (about $94 per person in the US) in federal funding to support the nation's public transportation systems as they continue to respond to the COVID-19 pandemic and support the President's call to vaccinate the U.S. population" (FTA, 2021, para. 1). DOT notes the funding comes from the $26.6 billion (about $82 per person in the US) allocated by statutory formulas to urban and rural areas, tribal governments, and the enhanced mobility of seniors and individuals with disabilities. The act also included $2.2 billion (about $7 per person in the US) for additional transit pandemic-associated needs, which will be awarded later this year, DOT said in its news release. Moreover, it has opened the door to an additional stimulus that speeds the shift to low-emissions transport nationwide (Freemark, 2020).

The current rules introduced by the Trump administration require carmakers to improve their vehicles' fuel efficiency by 1.5% between 2021 and 2026. Subsequently, it is also a first step and down payment on more action to revive the economy and contain the pandemic (Libman, 2020). In comparison, the previous Obama administration had demanded a 5% fuel efficiency improvement (Skibell & Aton, 2021). Beyond that, Biden's administration will reverse President Donald Trump's moves to loosen Obama-era auto emissions regulations (Skibell & Aton, 2021). The first prong of the administration's plan aims to restore former President Obama's greenhouse gas and fuel economy standards for light-duty vehicles, which is jointly set by the EPA and a division within the Transportation Department, would incrementally ratchet up fuel efficiency requirements through the model year 2026 (Skibell & Aton, 2021).

2.4.3 President Biden's Administration Electric Vehicle Regulations: The Biden administration is now working to convince the world that the US is serious about tackling climate change, setting a target by which half of all car sales would be electric models, including battery-electric, fuel cell, and plug-in hybrid vehicles by 2030 (Skibell et al., 2021). President Biden's move does not go as far as the US state of California, which requires that by 2035 all new cars sold be zero-emission vehicles. Similarly, China aims for 20% of cars sold in 2025 to be zero emissions, rising to half by 2035 (BBC News, 2021). The EU, meanwhile, has proposed limits that would effectively end new petrol and diesel vehicle sales by 2035 (BBC News, 2021). However, Green Mile Standard—passed through the California State Legislature in 2018–impacts air pollution. The statute required the California Public Utilities Commission (CPUC) to work with the Air Resources Board to reduce greenhouse gasses (GHG) and air pollution from TNCs (Patniak & Shiroma, 2020). The White House said Mr. Biden also planned to toughen fuel consumption and emissions

regulations but did not give details. CPUC will closely monitor the innovative programs' safety, accessibility, and environmental impacts (Patnaik & Shiroma, 2020).

2.4.4 COVID-19 and the American Rescue Plan: Buttigieg, the secretary of Transportation DOT, has a role at a crucial time for Transportation. The COVID-19 pandemic has decimated most modes of transportation with airlines, transit, and Amtrak. However, the Los Angeles County Metropolitan Transportation Authority (METRO) has been awarded $1.24 billion (about $4 per person in the US) in American Rescue Plan funds to assist people commuting to work, hospitals, and grocery stores. Supply chain disruptions caused by container vessel backlogs throughout this pandemic (Nickloskross, 2022). As a result of the rising COVID-19 strain, the American Rescue Plan Funds ensure that people can get where they need to go (Nickloskross, 2022). Furthermore, assist Los Angeles County METRO maintain service and keep transit workers and employees on the payroll.

However, under the Trump Administration, $14 billion (about $43 per person in the US) was allocated under H.R. 133, Consolidated Appropriations Act, 2021, which includes $13.27 billion (about $41 per person in the US) for urbanized area formula funds and $50 million for enhanced mobility, $678.65 million for rural area formula funds (Libman, 2020). In addition, President Trump also implemented Amtrak's $1 billion (about $3 per person in the US) in emergency funds, and private transportation providers such as motorcoach carriers and school bus operators will have access to $2 billion (about $6 per person in the US) in emergency relief funds (Libman, 2020). In comparison, the Biden administration seeks federal financial aid to help it survive a steep decline in Amtrak's ridership.

Most notably, the $1 trillion (about $3,100 per person in the US) investment in power and water infrastructure, broadening broadband and mass transit, and changing how communities are

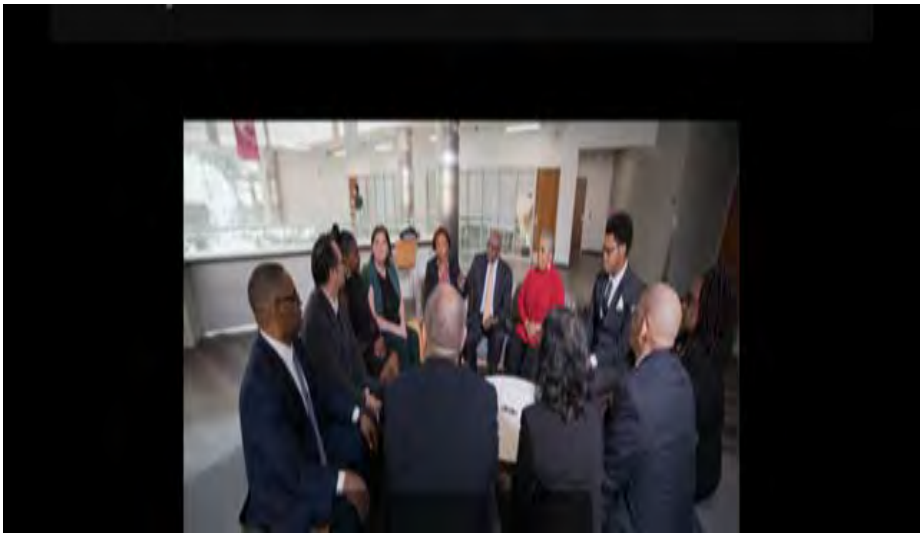
developed will provide us with an excellent opportunity to go into the laboratory to see what the country's future might look like and then double down on that going forward (Tomer & Pita, 2021). Thus, our infrastructure will become more robust, and we must ensure that our roads and bridges are constructed to withstand increasing sea levels and more heatwaves, which will continue to occur, Buttigieg added. Nonetheless, we must second prevent it from worsening (The Congressional Insider, 2021). It is why we must make sure we have alternatives like transit and make sure it is easier for people to get around without having to bring a vehicle sometimes, depending on where you're going, he added (The Congressional Insider, 2021).

Similarly, the U.S. House of Representatives-passed Moving Forward Act promotes a similar ambition to significantly improve transit service across the country (Freemark, 2021). After the imminent advent of modern technology such as autonomous vehicles, the giant question mark is that the COVID-19 pandemic has created around the future of commuting, it ranges making it easier to obtain and operate an electric vehicle, making it easier not to need a car, also making it easier to avoid the need for an automobile. Next, a plan to repair the country's deteriorating infrastructure, investing hundreds of billions of dollars in improving roads and bridges. Finally, updating transit systems, expanding interstate railways, and dredged harbors, ports, and channels (Associated Press, 2020).

Environmental Justice is about equity and making sure that we do not repeat the mistakes of the Eisenhower years and, on the contrary, use this as a force to fight environmental injustices, as shown in Figure 11, that purposefully or unintentionally imposed on specific Houston communities that may lose homes to freeway projects and prevent such injustices from occurring in the future (CBS News, 2022).

Figure: 11

Communities In the Crossroad



Source: CBS Morning News

For example, Biden's $1 trillion (about $3,100 per person in the US) infrastructure plan, which includes $20 billion (about $62 per person in the US) to redress historical inequities and build the future of transportation infrastructure, further encourages highway foes that are a new chapter in the story of U.S. Road building (Bliss, 2021).

> According to Patel & Hawkins (2022) "President Joe Biden's $1 trillion infrastructure plan, billions of new funding for the creation of a national network of electric vehicle charging stations. Buttigieg will have some say in how those billions of dollars get spent. He also has regulatory oversight of a rapidly changing auto industry, where electrification and automation are upending decades of transportation habits in the US. And he must make sure those new technologies are rolled out safely and effectively, against the backdrop of rising carbon emissions and a spike in reckless driving and traffic fatalities" (para. 3).

In addition, as vehicles become more efficient and pursue renewable energy, there will be questions about whether the gas tax can be effective (Buttigieg, 2021). Humphrey explains that this call for doubling the right-of-way in some areas where there is a hundred percent increase in potential vehicle miles traveled is what we need for reducing greenhouse gas emissions to prevent catastrophic

climate crises. The exact opposite and converting from the current Highway Trust Fund, paid for with the gas tax, to a "vehicle miles traveled" option that would tax drivers based on their commuting distance (Adams, 2020).

As mentioned, Los Angeles County METRO maintains service and keep transit workers and employees on the payroll. According to research, environmentally harmful facilities and infrastructure, such as motorways, have been intentionally and disproportionately located in low-income and minority communities where residents are exposed to elevated air, water, and noise pollution (Velasco, 2020). However, with a new U.S. administration, Congressional majorities (slim as they are) intended to get Covid-19 vaccinations to patients (Silo, 2021). In addition, the new administration is also concerned about climate change and its potential impacts on transportation, with President Biden proposing to replace the federal government's fleet of cars and trucks with American-made electric vehicles (Silo, 2021).

2.4.5 Clinton Administration Gas Tax Vehicle Miles Traveled: The gas tax increase in 1993 under President Bill Clinton and most of its history was straightforward: Vehicle users paid federal gas taxes. Subsequently, the federal gas and diesel tax of 24.4 cents per gallon has been a significant revenue mechanism for the nation's highways since the development of the Interstate Highway System began in the 1950s (Lacy, 2018). Those taxes went into a fund that taxpayers paid to build and maintain highways. Therefore, we need transportation options that induce effective land-use planning and land-use plans that enable transportation options.

Nevertheless, administratively, these two issues are divided at the federal level. The Department of Transportation (DOT) oversees transportation policy and grants, while the Department of Housing and Urban Development (HUD) oversees housing and land-use policy (Freemark, 2021). History and evidence from abroad suggest that improved federal government

planning and coordination enhance communities' development and ensure populations have access to more comparable results (Lonescu, 2021). Subsequently, inefficient planning collaboration with the federal government results in racial health disparities and economic disinvestment in low-income communities and communities of color. It also means that surrounding areas benefit less from transportation improvements and have less access to specific destinations and amenities (Velasco, 2020).

However, studies show that state and municipal transportation planners must provide adequate access to transportation services and equitable protection from the environmental risks of infrastructure development and toxic facilities (Velasco, 2020). Although the use of environmental justice language in transportation planning is mandated under Title VI and Executive Order 12898, substantial efforts toward eliminating structural barriers of racially biased systems for organizations that exploit the ideology of justice movements. Even with neglecting to take the required activities to make justice a reality, they have the potential to hinder progressive community organizers and planners (Velasco, 2020).

When organizations misuse the ideology of justice movements without taking the necessary actions to make justice a reality, they frequently stifle progressive activity by transformative community organizers and planners. For example, new mobility technologies can reduce existing transportation inequities. As a result, transit agencies' inequitable systems have placed a heavy burden on vulnerable transit-dependent commuters (Hipkins & Bush, 2017). Nevertheless, they could reinforce existing inequities without proper planning and fail to deliver inclusive and equitable transportation outcomes.

The Federal-Aid Highway Act of 1944 and 1956 were passed to provide funding for extending and linking the interstate system (U.S. Department of Transportation, 2011). However,

recent research suggests that our current system's MPO environmental justice analyses can only achieve transformational change by shifting power to communities (Kramer et al., 2020). Therefore, MPO must:

- **Connect residents with policymakers**. MPOs are improving opportunities for residents to communicate with public officials, building on the Intermodal Surface Transportation Efficiency Act and the Transportation Equity Act for the Twenty-First Century (Velasco, 2020). MPOs must meet with individuals in their communities, pay people to participate in engagement, and cover expenditures such as transportation to meetings and childcare during meetings in current planning procedures (Velasco, 2020).
- **Use local data.** Federal rules and guidelines for defining environmental justice neighborhoods rely on national data sources like the American Community Survey, which must be adopted across the board (Velasco, 2020). MPOs, on the other hand, may consider using local or community-collected data to provide further detailed information on transportation access and barriers in environmental justice areas. Furthermore, community-led data studies can uncover impressive findings that would have gone undiscovered by outside government officials (Velasco, 2020).
- **Engage community-based organizers.** Most agencies focus on selecting census tracts with large percentages of low-income persons, people of color, zero-car households, individuals with disabilities, and people with poor English proficiency when determining where environmental justice communities are located (Velasco, 2020). However, concentrating only on this method may hide those who live outside of specified census tracts but still suffer accessibility problems or are vulnerable to disproportionate impacts of specific programs or policies (Velasco, 2020). In addition, engaging community-based organizers who are familiar with residents can assist transportation agencies in better prioritizing residents' needs and better understanding the local mobility inequalities they experience (Velasco, 2020).

2.4.6 Implementing New Mobility Policies: Providers must focus on the inner-city minority and low-income communities, where the bus is the primary type of transportation. New infrastructure should focus on strong environmental protection laws, but it should also develop innovatively and emphasize things that provide economic rewards now and in a low-carbon future (Quigley, 2021). In conjunction, the Federal Housing Administration (FHA) has low-interest and low-down-payment loans (U.S. Department of Housing and Urban Development, 2013). Loans

should include waterway locks and dams that are functional and reliable, permeable pavement and other green infrastructure to reduce flood damage, electric vehicle charging infrastructure, and an efficient freight train system (Quigley, 2021). In addition to equity, the federal government approved legislation to expand the transportation network to ensure new mobility services successfully increase equitable access to transportation.

Moreover, local policymakers must intentionally incorporate equity considerations into planning and implementation by assessing and responding to barriers to transportation access, such as cost of use, service availability, the geographic distribution of routes, physiological challenges, and social barriers (Fedorowicz, et al., 2020). Furthermore, transportation equity is critical to equitable transformation: highways must be redeveloped with sustainable modes of transportation (ITDP, 2021). Finally, cities can test and incorporate equality demands in new mobility operations utilizing flexible agreements such as proposals, permits, and pilots.

- Intermediary data organizations can support medium-sized cities in increasing data capacity, navigating data privacy rules, and managing partnerships with new mobility providers.
- Collaboration across authorities and sectors is essential for constructing the transportation infrastructure required for new modes of mobility.

Cities may include equity concerns in their operations by recalibrating internal structures and integrating equity guidelines into strategic plans (Fedorowicz et al., 2020). According to the World Economic Forum (2020), delivering many infrastructure projects, such as public transportation, is economically viable when a certain critical mass of the population is reached. However, when urbanization is rapid and poorly planned, widespread poverty occurs in the context of higher population density, which creates negative externalities for people of color. Litman (2015) argues

that transportation policies are equitable if they favor economically and socially disadvantaged groups.

Bullard and Johnson (1997) and Sanchez (2003) further argue that transportation investments focus on regions in the more affluent, sprawled suburban communities, neglecting minority and low-income communities with disparities in transportation investments. Most importantly, highway projects' funding focused on connecting the central city with sprawling suburban cities more susceptible to pollution, no automobile accessibility, and reliance on public transportation services. Researchers proclaim that urban sprawl has environmental, social, spatial, and economic impacts (Johnson, 2001; Nguyen, 2010; Burchell et al., 1998; Sanchez, Stolz, & Jacinta, 2003).

2.5 Vertical and Horizontal Equity

Transportation equity is considering racial, economic, and social equity in transportation. (Recommendations of the Safe System Consortium, n.d. pp.3). A range of groups is emphasized in equity analyses, including but not limited to genders, income classes, and spatially, mentally, or physically disabled groups. A commitment to transportation equity involves creating affordable and accessible transportation options for all people; ensuring fair access to quality jobs, workforce development, and contracting opportunities in the transportation industry; promoting healthy, safe, and inclusive communities; and making equitable investments in transportation infrastructure and planning, especially in low-income areas and communities of color (Recommendations of the Safe System Consortium, n.d. pp.3).

Litman (2002) classifies equity into two types - horizontal and vertical. Firstly, horizontal equity focuses on the fairness of cost benefits allocation compared to wealth and ability (Bullard,

Johnson, and Torres 2004). For example, better job accessibility in more compact commuting zones is stronger than the indirect effects of income (Bullard, Johnson, and Torres 2004). Horizontal equity refers to fairness between individuals of the same ability, income, and social class. Secondly, vertical equity is concerned with the cost allocation regarding income and social class as measured regarding how one needs to be met compared with others in the community (Bullard, Johnson, and Torres 2004). This measurement includes fairness between individuals across different abilities, incomes, and social classes (Foth et al., 2013; Kaplan et al., 2014; Pritchard et al., 2019).

2.5.1 Vertical equity concerning income – affordability: Autonomous vehicles are likely to support some equity goals but contradict others across the country, paratransit riders—and people with disabilities in general (Fiol & Weng, 2022). This perspective assumes that public policies should favor poorer people over wealthier people and increase affordable transportation options, particularly to access essential services and activities (healthcare, basic services, education, jobs, Etc.). Lower-income households will be unable to purchase personal autonomous vehicles, and policies that encourage their use, such as dedicated lanes, would be regressive (Litman, 2022). Autonomous vehicles can provide independent mobility for some disadvantaged groups—who frequently face challenges accessing services, such as absentee drivers, late pickups, and incorrect ride charges. For example, people with visual impairments can reduce taxi and public transit operating costs, which increases affordability for people who drive less than 5,000 annual miles (Fiol & Weng, 2022; Litman, 2022). However, private autonomous vehicles will be costly for more than a quarter of US adults who have a disability (Fiol & Weng, 2022).

Moreover, about half of disabled Americans have a travel-limiting disability, so subsidies for AV use tend to be unfair, regressive, and defined as medical devices, including canes, wheelchairs, and seeing-eye dogs (US DOT, 2022; Fiol & Weng, 2022). According to the CDC

(2022), 61 million American adults have a disability if they induce additional vehicle travel and sprawl, which increases external costs (congestion, infrastructure costs, crash risk, and pollution emissions imposed on other people)(CDC, 2022). Low- and moderate-income households can only benefit from autonomous vehicles as part of a multimodal lifestyle; they will need more than autonomous vehicles to afford the high-annual miles required for living in sprawled locations. Disabled Americans must schedule their days around the few available transportation options or if they increase automobile dependency and sprawl. Often scheduling days in advance, which limits their mobility and independence (Fiol & Weng, 2022), reduces affordable transport options.

AVs can reduce affordability and fairness and harm non-drivers where segregation impacts, lack of car ownership, and inadequate public transit service in central cities and metropolitan regions exacerbate social and economic conditions for people of color (Litman, 2022; Bullard, 2004). For example, "if Autonomous vehicles are programmed to maximize passenger safety unless implemented with effective demand management incentives. They are likely to increase total vehicle travel where racial isolation and residential segregation primarily exist among people of color living close to the CBD traffic problems and sprawl, increasing total congestion, crashes, pollution, and other costs (Litman, 2021, p.2; Nadafianshahamabadi, Tayarani & Rowangould 2021; Bullard, 2004).

According to Bullard et al. (2000), there are institutional embedded constraints of urban sprawl, subsidizing separate but unequal suppressed economic development government housing in segregated neighborhoods. Isolated segregation, a new form of "residential apartheid, is an emerging crisis in sprawling metropolitan areas like Atlanta (Bullard, 2004), and underserved people of color are further pushed apart geographically, politically, economically, and socially. Under the circumstances, this exacerbates a pattern of race and class (Bullard, 2004) and a spatial mismatch

between jobs, services, and housing (Bullard, 2000). Reduce the economic isolation for people of color is complicated because of inadequate public transit (limited, unaffordable, or unavailable service and routes, and security and safety concerns), lack of personal transportation (no privately owned car available to travel to work), and spatial mismatch (location of suitable jobs in areas that are inaccessible by public transportation inadequate transit funding, affordable travel mode choices, and accessibility to jobs (Bullard & Johnson, 1997).

2.5.2 Rawls's Theory of Justice: Methods to studying social equality in transportation have included referencing Walzer's Spheres of Justice (Walzer, 1983) and Rawls' A Theory of Justice (Rawls, 1971). This investigation advocates for increasing the average accessibility in a region while at the same time decreasing the disparity between the wealthiest and lowest levels of accessibility (Martens, Golub, & Robinson, 2012; Martens, 2016; Pereira et al., 2017). Through the equitable distribution of public resources, including transit provision at a basic level, social equity refers to the fairness that impacts (i.e., benefits and costs) communities of color. However, the extent to which that obligation holds, especially in the context of transportation policy, is still being determined.

A Capabilities Approach (C.A.) to justice builds on these Rawlsian arguments. Unlike Rawls' theory which focuses on primary goods, the C.A. argues for the equalization of capabilities, the ability of an individual to pursue and develop a combination of functioning (actions and states of beings). Martha Nussbaum lists ten essential capabilities necessary for justice, with examples ranging from bodily health and integrity to things like play and affiliation (Pereira et al., 2017). However, her list needs to address the importance of transportation. Schwanen and Bannister argue that accessibility should be considered a necessary capability because a minimum level of access to grocery stores, schools, hospitals, and jobs are needed to meet basic needs (Pereira et al., 2017).

They add that accessibility as a capability can be broken into two components. First is the capability to access transportation via car, bus, or other technologies using a smartphone to call an Uber (Pereira et al., 2017). Secondly, how transport systems and land use patterns affect people's capabilities, this conception of access capabilities is applicable to TOD (Pereira et al., 2017). For example, cases where transportation investment and housing policies interact in a way that forces the poor to move far away from nearby transit violate essential capabilities by reducing the ability to meet basic functions. If we consider accessibility a necessary capability, then justice requires that changes be made so that poor households can gain more or, at minimum, maintain the same level of accessibility, especially in cities more generally dealing with new mobility technology strategies to support equitable outcomes (Fedorowicz, 2020).

Rawls argues for the guarantee of fair equality of opportunity and freedom of choice and allows for inequalities to exist only when worst-off individuals are as well off as possible compared to other alternatives, often known as the "difference principle" (Sen, 2005). A typical application of this theory is justifying educational policies targeting close attainment gaps between rich and poor individuals with similar talent and work ethic (Stewart, 2005). Pereira, Schwanen, & Bannister (2017) interpret Rawls' theory and apply it to transportation equity in the context of how institutions and policies try to reduce inequalities of opportunities. However, first, they claim that Rawls' theory misinterpretations may seem compatible with transport policies that aim to advance by improving average levels of accessibility (Tonon, 2018). A description that aptly describes the Federal Highways Act of 1956. They then assert that a proper application of Rawls' difference principle "entails those interventions such as infrastructure investments, subsidies, and service provision can only be considered fair if they improve the accessibility of the least advantaged groups" (UNDESA, 2015).

Some might argue that TOD initiatives, unlike highway construction, are consistent with these guiding morals. In theory, TOD should increase accessibility for poor households by increasing transit options and transit-accessible destinations. However, given that poorly implemented TOD has sometimes reduced the accessibility of the least advantaged groups by pushing them away from transit, Pereira, Schwanen, and Bannister's interpretation of Rawls' theory support the argument for reconsidering approaches to TOD (Pereira et al., 2017).

This interpretation may seem compatible with transport policies that aim to advance the common good by improving overall or average accessibility levels. However, some authors recognize that not all inequality is unfair. Fairness sometimes comes at the price of treating people differently according to their differences and even limiting some individual liberties (Dworkin, 1981; Rawls, 1999; Sen, 2009). Therefore, the normative argument for reducing inequalities is often framed through a moral lens of social equity from a justice perspective. First, infrequent service and difficulty in connections are significant problems faced by transit-dependent people of color. Thus, the city's plan makes it exceedingly difficult for buses to get around, further compounding the problem. In addition, services for the ADA in the city are also very inadequate, and overcrowding on some bus lines is an issue for transit-dependent citizens. Therefore, more buses and interconnectivity of modes are needed for better service. Second, there is discrimination in the provision of transportation services and transportation infrastructure.

Environmental justice triggers the burdens related to transportation plans, programs, and policies that fall disproportionately on low-income or minority communities or where these traditionally underserved and overburdened populations are not given a meaningful and fair opportunity to participate in the planning decision-making process. For planners, this is where the rubber hits the road (literally), particularly in E.J. communities. Long commutes and travel times

should motivate people to buy cars and not endure the burden of inefficient public transit. This situation is a" transportation catch-22," meaning that poor people who cannot afford a vehicle must buy one to overcome the problem of not owning a car (Epting, 2016b). While this feat is attainable, residents must endure until they can overcome this hardship or until planners can ameliorate such matters.

Several decades ago, research showed how constructing the federal-aid interstate highway system through the nations' inner cities ripped apart well-established African American communities, "producing lopsided and skewed patterns of infrastructure development" (King, 2021 para. 6). With the Highway Trust Fund in place, agencies are obligated to comply with the moral values of providing an equitable distribution of transportation services such as Autonomous Shuttle Transit to identified minority and low-income communities (Wang, Lu, & Reddy, 2013). In addition, automated vehicles could address the needs of Environmental Justice populations or further transportation inequities. For example, AV technology for low-income populations, compared to other populations, may need more access to personal vehicles, live further from their workplaces, or have jobs with non-conventional schedules and limited work location flexibility (FHA, 2016).

Thus, despite transportation's transformative importance to economic growth and community development, transportation policies may also produce harmful consequences for vulnerable populations where transportation developments can divide, isolate, disrupt, and impose economic, environmental, and health burdens on communities, particularly among the underserved.

2.6 Transportation Policies that Contribute to Environmental Justice

Environmental Justice in transportation planning emerged from Title VI of the Civil Rights Act of 1964, ensuring no human health or environmental effect on traditionally underserved populations is affected. Environmental Justice in transportation planning is a public policy (Forkenbrock & Schweitzer, 1999) where underserved populations should be given a meaningful and fair opportunity to participate in the planning decision-making. As a result, the National Environmental Policy Act (NEPA) of 1969 and the Federal-Aid Highway Act of 1970 address how we approach inequities concerning sideline communities of color left out in the transportation planning process.

In 1970, the Federal-Aid Highway Act passed, requiring states and metropolitan planning organizations (MPOs), the policymaking body for regional transportation investments, to develop long-range plans that consider the "overall social, economic, energy, and environmental effects of transportation decisions" (Cairns, Greig, & Wachs, 2003). MPOs and state departments of transportation conduct evaluations if planned infrastructure would harm low-income areas, communities of color, and other groups classified as "minorities" by the government (Velasco, 2020). These groups are called "environmental justice communities" (Velasco, 2020).

The MPO provides oversight regarding how these investments impact the protected populations. Steinberg (2000) argues that, unlike Title VI, NEPA is a procedural statute requiring evaluating and considering alternatives to ensure decision-makers use appropriate discretion when the results may impact the environment (Sanchez, Stolz, & Jacinta, 2003). Most importantly, transportation industry projects cannot disproportionately affect minority populations. According to Harrington & Schenck (2017), careful consideration and diligent planning contemplate lessons learned from the past can make this next AV transportation revolution an opportunity for all

communities while minimizing the impact on the built and natural environment (Harrington & Schenck, 2017). We must put marginalized people first by putting knowledge in the hands of those affected to promote environmental justice by enabling better-informed decisions.

The Transportation Equity Act of the 21st Century (TEA-21) was built on ISTEA. TEA-21, and its supporting regulations, reinforced Title VI and continued to strengthen initiatives that protect and enhance disenfranchised communities and the natural environment (Passwell, 2001). Additionally, TEA-21 established a new program for Job Access and Reverse Commute Grants to create transportation services for welfare recipients and low-income people to get to and from jobs as well as implement strategies for effective community engagement, including members of marginalized populations as a part of the planning process from start to finish (Kennedy, 2004).

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005 builds on the two previous surface transportation authorization laws and maintains the emphasis on equity participation in addition to safety. For example, participation is an integral part of Long-Range Transportation Plans in the act. Metropolitan Planning Organizations (MPOs) will need a participation plan that provides reasonable opportunities for commenting by all parties (APTA, 2007).

- The Intermodal Surface Transportation Efficiency (ISTEA), Public Law 102-240, concerns how driverless vehicle mobility may impact urban life, including social inequities and pollution on health (Rowangould et al., 2016).
- The Self-Drive Act Nationally, the US Department of Transportation and the National Highway Traffic Safety Administration (NHTSA) released the Federal Automated Vehicles Policy in 2016, which included guidelines for designing, testing, and introducing AVs, along with policy recommendations and ethical guidelines for states (US Department of Transportation 2016).
- ISTEA aimed to increase public involvement in the transportation planning process by requiring public review and comments on crucial transportation decisions; mandating that the public involvement process be inclusive, involving those traditionally underserved by transportation systems; and requiring the demonstration of explicit consideration and response to public input.

First, we must address past and current injustices by redistributing societal benefits, burdens, and resources in a way that lifts communities of color who are left behind. The biggest challenge is to include social justice elements such as participation in the purview of best practices for urban mobility because such ideas challenge established practices. For example, Mitcham (1997, p. 272) argues that engineers must expand their mindset to include additional aspects to account for the existing conditions. This notion applies to those professionals who bring AVs into mobility systems with different social, political, and environmental characteristics (Epting, 2019). Secondly, excluded communities should have community power to influence decisions in a way that addresses their needs and concerns.

2.7 MPO and Environmental Justice Transportation Planning Process

MPOs in Environmental Justice communities play a significant role in regional transportation planning. However, many communities in America today are still being built under undergrowth and development policies adopted in the 1950s. Research has shown that regional planning bodies heavily fund MPOs coordinating federal transportation programs (Sanchez, 2005) concentrated with less well-maintained infrastructure, greater exposure to high-volume roadways, or higher pedestrian activity levels. More so, inequity concerns in EJ communities take at least two forms.

First, some transportation infrastructure aspects, such as highways and bus depots, are "locally undesirable land uses." Poor, marginalized people of color live near these locations and suffer associated health consequences—the effects of diesel air pollution, noise, injury risks, and ugliness. Second, transportation systems do not provide the poor marginalized with convenient, practical access to employment, medical care, and other necessities, which undermines their health in numerous ways (Bullard et al., 2004; Schweitzer & Valenzuela, 2004). New vehicle technologies may improve safety in those conditions, and there is also the potential for negative impact if, for

example, lack of infrastructure maintenance impairs AVs' ability to navigate the infrastructure and operate safely.

Environmental Justice ensures that no population, as shown in Figure 12, is forced to shoulder a disproportionate burden of pollution or other environmental hazards' adverse human health and environmental impacts.

Figure: 12

*Environmental Health Hazard*s Marginalized Groups

Source: Rayford Richardson

This significant urban influx raises challenges for decision-makers to improve urban livability, including access to safe, clean, and affordable mobility by creating a just and fair transportation system (Creger, 2019). Therefore, the development, deployment, and regulations around all forms of Autonomous Vehicles must be anchored in the three goals of mobility equity:

- Transportation equity: Increase access to high-quality mobility options for marginalized groups, such as low-income communities of color, the elderly, and people with disabilities.
- Environmental equity: Reduce air pollution and improve health outcomes for marginalized people.

- Economic equity: Enhance economic opportunities for marginalized people.

To ensure these three mobility equity goals guide Autonomous Vehicle development and deployment, policymakers, transportation planners, and decision-makers must leverage our Mobility Equity Framework indicators to develop principles, regulations, and policies. Equity must be a central focus in the research, development, and deployment of a Fleet of AVs that are Electric and Shared (FAVES) and other forms of AV to ensure that these emerging mobility services meet all vulnerable, marginalized group needs (Creger, Espino & Sanchez, 2019). All sectors pushing AVs forward must embrace diversity, equity, and inclusion to produce meaningful, equitable outcomes. Therefore, marginalized community members must have a seat and a voice at the decision-making tables across all private or public sectors. For example, we need fair and accurate representation for low-income communities of color, particularly ADA, on transportation decision-making bodies such as city, county, and regional transportation boards and commissions. The people closest to the pain must be closest to the solutions.

2.8 Autonomous Vehicles

The US transportation system is transformed by three rapidly evolving and emerging mobility options: shared mobility, electric vehicles, and autonomous vehicles. Shared mobility services and electric vehicles are changing the transportation landscape (CBFC, 2020). Therefore, Autonomous Vehicles are set to disrupt the existing transportation sector. This disruption will initiate a mobility revolution that will shape the urban environment and modify urban populations in the coming years.

"Autonomous technology" means a vehicle technology that can drive without a human operator's active physical control or monitoring (Rojas-Rueda et al., 2020). Although many people need access to personal vehicles or conventional mass transit (The Conversation, 2018), AV has a

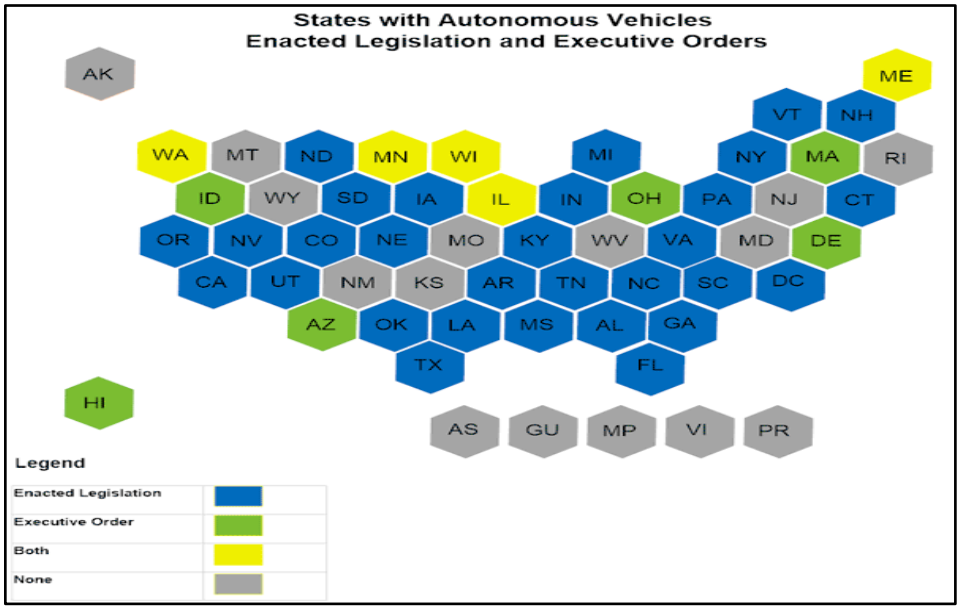
full-time automated driving system that undertakes all aspects of driving that a human would otherwise undertake under all roadway and environmental conditions. However, as the world's population and the economy grow, mobility demand will grow too. Additionally, emerging AVs can decrease transportation costs and have far-reaching applications for low-income households and persons with mobility implications (Bagloee et al., 2016). Thus, AV can decrease transportation costs and increase accessibility and implications beyond expectations (Bagloee et al., 2016).

People worldwide spend 600 billion hours (about 68,000,000 years) per year in cars to improve travel times, make services more efficient and effective by dedicating costly resources (Jonas, 2018), and value getting back those hours by driving rather than driving. Given the former's simple construction, AVs should be cheaper than conventional vehicles (Alves, 2017). Cortright (2016) reported the cost reduction estimates of several manufacturers, which suggested that by 2040 the current passenger vehicle cost of between US $1.0 and $0.83 per mile will fall to between $0.33 and $0.15 per mile. Affordable and ready access to easy-to-use transportation has been described as a "missing link" to a better life for most intellectually impaired individuals (MHAG, 2011 p.3), especially vis-à-vis the avoidance of social exclusion (DOH, 2011).

Several US government agencies are adopting preemptive policies supporting AV development and implementation. For instance, Nevada was the first state in the USA to draft policies to encourage safety measures. Since then, 12 other states, as shown in Figure 13, have followed suit (National Conference of State Legislatures, 2017). Along with a Zero Emission vehicle mandate requiring automakers to sell a certain number of which has been enacted in fifteen states (Hebbale & Urpelainen, 2022).

Figure 13

States with AV Legislation and Executive Orders



Source: https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx

Nationally, the US Department of Transportation's National Highway Traffic Safety Administration released the Federal Automated Vehicles Policy in 2016, which included guidelines for designing, testing, and introducing AVs, along with policy recommendations and ethical guidelines for states (US Department of Transportation 2016). While these considerations cover much ground, ethicists have advanced several other concerns, exhibiting such issues' depth. Initial worries focused on AV's algorithms that will make decisions if a crash is imminent.

2.8.1 Autonomous Shuttles

Automated shuttles are small, low-speed (less than 25 mph) vehicles that do not require a human operator. However, early demonstrations all have included an onboard human attendant to observe passengers, record data, answer questions, and serve as a safety operator if needed (Valdes et al., 2018). These shuttles typically meet the Society of Automotive Engineers (SAE)’s definition

of Level 4 automation, a high automation mode in which the system uses an automated driving system that involves the driver's assistance in some situations. In addition, shuttles are typically limited to operating in specific environments, such as parking lots, busways, campuses, downtown districts, and retirement communities (Valdes et al., 2018).

Over the past decade, Autonomous Shuttles, an 8-20 passenger self-driving vehicle, has become one of the leading low-speed self-driving platforms for low-traffic private environments leading to neighborhoods. The autonomous shuttle is designed to help solve the problem of getting to jobs and services beyond the first last mile of a fixed bus route transit system (Ghose, 2020). According to Gindrat (2019), the Easy Mile AV innovative system provides regular routes to improve travel times through a residential neighborhood where people need access to services. Driverless Shuttle vehicles by Easy Mile, shown in Figure 14, along Texas Southern University Campus Tiger Walk, exist in various cities worldwide (Fraszczyk & Mulley, 2017).

Figure 14

The Easy Mile Driverless Shuttle Vehicle along TSU campus Tiger Walk

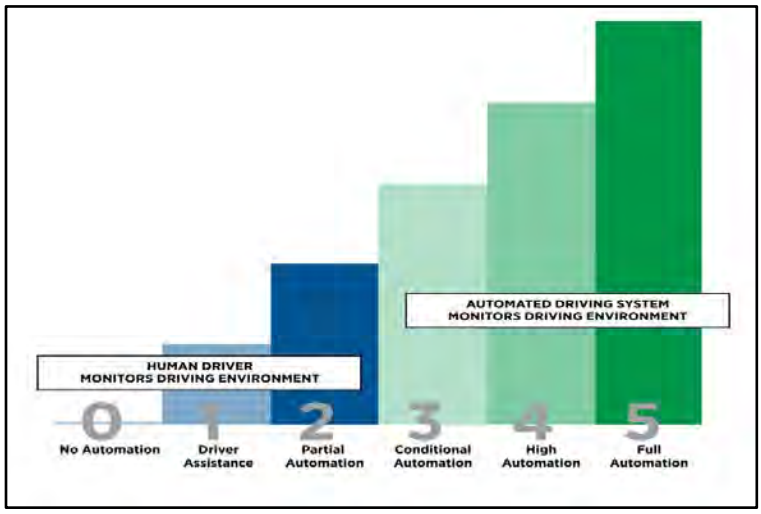
Source: Juan Figueroa, Houston Chronicle/ Staff photographer (Begley, June 2019)

Some 120 shuttles in 28 countries, including about ten spots in the US – mostly circling downtowns, college campuses, and tourist spots. Autonomous Shuttle trials explore many applications, from empowering the poor and disabled to viably filling in gaps in the transportation network and replacing very underutilized vehicles such as school buses and private cars, reducing congestion and cost (Edwards, 2020).

There are five levels of vehicle autonomy, as shown in Figure 15 and 16 as defined by the Society of Automotive Engineers (SAE): Levels 0–2 is those were the human driver needs to monitor the driving environment, and levels 3–5 are those where an automated driving system monitors the driving environment (also referred to in the US federal policy guidance as highly automated vehicles) (SAE Int, 2018; Zmud, 2017).

Figure 15

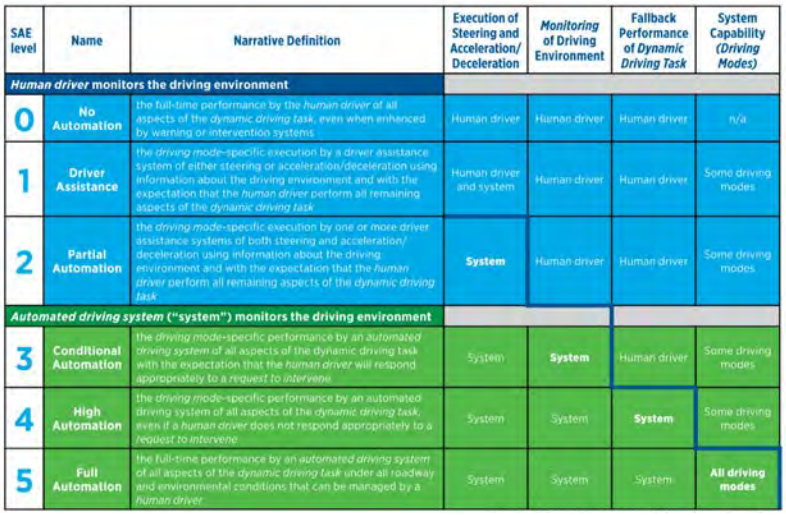
Levels of Autonomy



Source: https://medium.com/@vieira.jluiz/self-driving-cars-levels-of-automation-of-a-vehicle-8ebb7f9a3e13

Figure 16

AV levels (adapted from SAE International J3016)



SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Source: Self-Driving Cars: Levels of automation of a vehicle | by João Luiz Vieira

It is important to note that the level of automation can vary from zero to full automation. NHTSA classifies vehicle automation into five levels (NHTSA, 2013):

Level Zero**: No Automation** – The driver is responsible for doing all the driving without any help from the vehicle.

Level One**: Driver Assistance** – The vehicle helps steer or speed up/slow down, but the motorist performs all other duties.

Level Two**: Partial Automation** – The vehicle helps with one or more systems while the motorist does the rest.

Level Three**: Conditional Automation** – The vehicle completes all duties, but the motorist intervenes when necessary.

Level Four**: High Automation** – The vehicle completes all driving duties even if the driver does not intervene.

Level Five**: Full Automation** – The vehicle completes all duties without a driver on all roads in all conditions.

2.8.2 Benefits of Autonomous Shuttle Transit

AST can help bridge the mobility gap until fair and sustainable land uses take hold. Transit mobility applications will provide intelligent choices that reduce travel delays. The power of such technological advancements is tremendous and could significantly reduce crashes; lessen congestion; and provide travelers with improved mobility, accessibility, and overall livability (Leonard, 2016). AST will provide Mobility-as-a-Service with no need for drivers to offer door-to-door rides via an app (O'Kane, 2018). For example, in Arlington, Texas, residents may now order and board an autonomous shuttle for excursions throughout the city and the University of Texas at the Arlington campus (Descant, 2021). Due to COVID-19 limitations, the trips will accommodate up to two passengers.

RAPID (Rideshare, Automation, and Payment Integration Demonstration) has partnered with the city and UT Arlington, a transit provider. In addition, Via, a maker of autonomous technology, is an industry leader in on-demand transit and fleet services that provides service in areas where the operational efficiencies of on-demand micro-transit have discouraged the use of scheduled buses and expanded the idea of autonomous shuttles to other markets (Descant, 2021). One of the critical goals for the public transportation system is to increase connectivity, including intra-cities and first/last mile commutes. It is essential in large, dense cities where most residents depend on public transport. Moreover, AVs are a way of promoting a better quality of life in cities (Yigitcanlar, Wilson, & Kamruzzaman, 2019, p. 126), while the pessimistic view suggests that "the built environment will reshape to accommodate the needs of AVs and their users in preference to the needs of other social groups. As a result, AVs increase suburbanization or sprawl due to the comfort of trips" (p. 126).

2.8.3 Blend of Modalities for EJ populations: AVs can improve safety and quality of service, save travel time, and lower the cost of providing traditional transit services or alternatives such as "shared mobility" (automated taxis or paratransit vehicles). However, a blend of modalities should take advantage of transportation systems currently at our disposal, augmented through a higher interconnectivity level of these internalized benefits, which accrue to the providers in the form of higher profits (or, in the case of public transportation, lower losses) reduced prices and better service for the consumer (Montgomery, 2018). These benefits may be significant for EJ populations. Nevertheless, these technologies may have some risks, especially concerning the equitable distribution of benefits and burdens. For example, barriers to driving include the cost of full-time car ownership, learning to drive, difficulties with licensing, or factors related to health, disability, or age (Rueda et al., 2020).

Low-income populations may experience the benefits of AV technology differently than more affluent populations because they have less access to personal vehicles, live further from their workplaces, or have jobs with non-conventional work schedules and limited flexibility. In addition, AVs offered through car-sharing services or automated taxis in EJ communities may be concentrated in neighborhoods with less well-maintained infrastructure, greater exposure to high-volume roadways, or higher pedestrian activity levels (Bagloee, Tavana & Asadi; M. et al., 2016). While new vehicle technologies may improve safety in those conditions, there is also the potential for negative impact if, for example, lack of infrastructure maintenance impairs AVs' ability to navigate the infrastructure and operate safely (Bagloee, Tavana & Asadi; M. et al., 2016).

Most importantly, limited access to smartphones or electronic payment methods among EJ populations may restrict Automated Shuttles' use in marginalized communities. However, most entry-level jobs that welfare recipients and the poor would fill are in the suburbs with limited or no

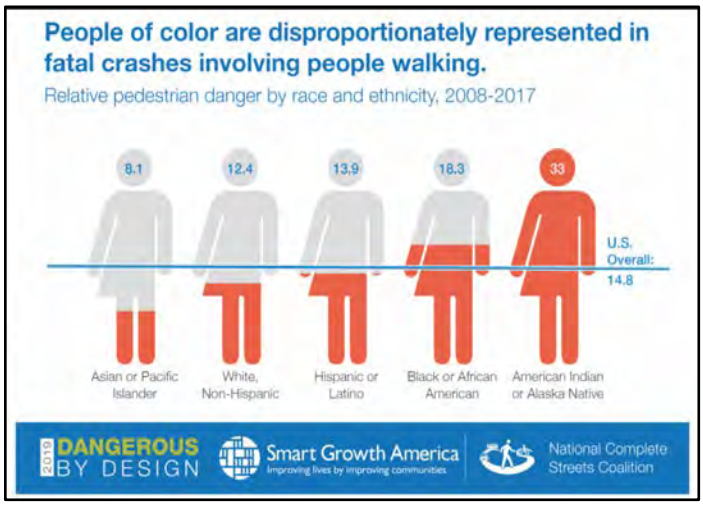
accessibility through existing public transportation systems. Notably, many entry-level jobs require shift work in the evenings or on weekends when public transit services are unavailable or limited (US GAO, 1998). Thus, AST may be a necessary and viable option to connect them with longer distances, and commutes to jobs could be better.

2.8.4 Impact of Autonomous Vehicles on Public Health

The National Highway Traffic Safety Administration (NHTSA) studies have proven that over 90 percent of traffic deaths are caused by human error. However, the World Health Organization has indicated that 1.2 million people (about half the population of Arkansas) die in accidents yearly (WHO, 2015). AV will reduce morbidity and mortality due to human error from motor vehicle crashes by 40,000 deaths annually (Kyriakidis et al., 2015). Blacks are also more likely to live near high-traffic roads than white people (Howell, 2020). A recent report found that Black pedestrians are also more likely to be hit than white pedestrians due to unsafe sidewalks, signage, and lighting in their communities (Howell, 2020). People of color, as shown in Figure 17, are often disproportionately misrepresented in fatal crashes involving people.

Figure 17

People of Color represented in fatal crashes involve people walking.



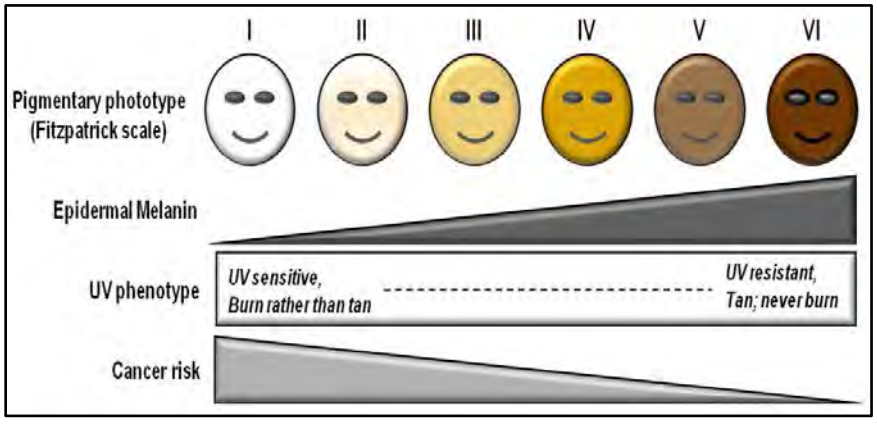
Source: (Smart Growth America, 2019)

According to a recent study by the Insurance Institute for Highway Safety, crashes would still occur in at least 66 percent of cases, even if all vehicles on the road became autonomous tomorrow. That is in large part because AVs are not up to the complex task of piloting a dangerous machine through a dangerous built environment where Algorithms are not perfect and require all-too-dangerous fallible human beings as their creator with implicit racial biases to help them out (Miley, 2021; Wilson, 2020) where AI presents many risks. Concerns include biased algorithms, privacy violations, and the potential for injuries attributable to defective autonomous vehicle software.

According to a Georgia Institute of Technology (2019) study, Blacks with dark skin may be more likely to get hit by a self-driving car than Whites because automated vehicles may better detect pedestrians with lighter skin tones (Samuels, 2019). However, in 2015 Google lens, an image-recognition algorithm, auto-tagged pictures of Black people as "gorillas" (Hern, 2018, para 1). Furthermore, nationally many Black indigenous and other people of color, as shown in (Figure 17), fall into the higher end of the Fitzpatrick scale and are significantly more likely to be killed in pedestrian crashes with motor vehicles (Wilson, 2020).

Figure 18

The Fitzpatrick scale and risk of skin cancer



Source: (D'orazio et. al, 2013)

According to the six categories, the following list shows six categories of the Fitzpatrick scale with the 36 categories of the older von Luschan scale (in parenthesis):

- Type I (scores 0–6) always burns, never tans (palest; freckles)
- Type II (scores 7–13) usually burns, tans minimally
- Type III (scores 14–20) sometimes mild burn, tans uniformly
- Type IV (scores 21–27) burns minimally, always tans well (moderate brown)
- Type V (scores 28–34) very rarely burns, tans very easily (deep brown)
- Type VI (scores 35–36) never burns (deeply pigmented deep brown to darkest brown, black type)

According to NHTSA (2018), most of the incidents involving Tesla's autonomous vehicles took place after dark, and those kinds of incidents will not fly in the world of autonomous driving despite control measures such as emergency lights, rod cones, and illuminated onboard signaling alerting the driver to change lanes (Alamalhodaei, 2021). The Law Commission, however, stated that autonomous cars "may fail to distinguish dark-skinned people in the dark" while developing a legal framework for their deployment on UK roads in 2021. Furthermore, the research shows impaired people are also in danger (Miley, 2021). For example, systems may not have been trained to handle various wheelchairs and mobility scooters (Shivdas & Kelly, 2021).

Toyota Motors, for example, halted all self-driving e-Palette mobility pods at the Tokyo Paralympic Games village a day after one of the cars crashed with and wounded a visually impaired person (Shivdas & Kelly, 2021). Subsequently, according to Toyota (2021), the accident showed the self-driving vehicle's difficulty operating in unusual circumstances with visually impaired people or others who have disabilities (Shivdas & Kelly, 2021). Our government has various duties for traffic operations interventions, such as coordinated traffic signals and connected and automated vehicles to safeguard communities. Public health leaders will play an ethical role by ensuring that communities have the information they need for informed decisions about how autonomous vehicles in traffic incidents are a relevant factor to consider (Maxmen, 2018). Having a vehicle make these

ethical decisions can be an uncomfortable thought, but as automation on the roadway grows, it is a subject that must be dealt with (Musson, 2021).

2.8.5 Ethics of Autonomous Vehicles: The problem with ethics is that there is often no black-or-white answer. For example, an imminent crash may pose instantaneous decisions about who will die: a passenger or pedestrian, an older person, or a child. The moral elements of such decisions must be programmed into the algorithms used by AVs. Even though some geographical differences, like people in Asia, have chosen saving young over old less than in other parts of the globe, the world's choices showed consistent moral choices. Indeed, if programmed correctly, autonomous vehicles will eventually have to make hard choices in which all options include a fatality. The decision must be programmed into the vehicle's operating system (Musson, 2021), whose life should be saved. The older man in the crosswalk or the pregnant woman on the sidewalk? Young over old, humans over animals, and few over many. Having a vehicle make these ethical decisions can be an uncomfortable thought, but as automation on the roadway grows, it is a subject that must be dealt with (Musson, 2021).

2.9 Cost-Benefit Analysis Electric Buses over Gasoline

Though most of the focus has been on personal use of autonomous technology, public transit, particularly bus systems, stands to be significantly impacted than rail modes, resulting in higher per-passenger driver costs (Quarles et al., 2020). Nevertheless, since Climate change is cited as the main reason to switch to clean, renewable energy, many additional factors may play critical roles in individuals, firms, and government decisions. Some of these factors include improving air quality and reducing costs—cost-benefit analysis (CBA). For this purpose, various automation levels exist but focus on self-driving buses that can operate without the assistance of a human driver. However,

experts disagree on how the deployment of completely autonomous vehicles will impact public transportation (Quarles et al., 2020).

Given current federal transportation outlays, a widespread high-quality public transportation service is financially possible, and a national investment could speed the shift to low-emissions transport nationwide (Freemark, 2020). In addition, electric vehicles will reduce local air pollution, a significant problem in many low-income neighborhoods and communities of color (Freemark, 2020). Meanwhile, tremendous advances are being made in autonomous vehicle (AV) technology. US data show 62,000 buses run on fossil fuels (Freemark, 2020). Nevertheless, if the federal government replaced 6,000 of those buses annually with electric vehicles, it would need to allocate a modest $3 billion (about $9 per person in the US) for the purpose, assuming bus purchase costs of about $500,000 (Freemark, 2020).

New York's State Department of Environmental Conservation (DEC) and the New York State Energy Research and Development Authority (NYSERDA) announced that more than $24 million is now available to replace diesel-powered new all-electric transit buses (DEC, 2020). Transit bus replacements are targeted at New York State government entity-owned bus fleets with bus depots located within Potential Environmental Justice Areas (PEJAs) or operate routes that serve PEJA areas (DEC, 2020). DEC considers PEJAs communities of color or low-income communities that experience a disproportionate share of environmental harms such as vehicle emissions and pollution (DEC, 2020). The investment will fund over 2,400 new buses, depot improvements, and customer experience upgrades. In addition, it will add to the transition to a fleet composed entirely of zero-emissions electric buses by 2029 (Intelligent Transport, 2019).

It is predicted that by 2050 most vehicles will be battery-electric or hybrid, resulting in an increase in electricity consumption by the transportation sector (Hillberg, Santhanam, & Kaimal,

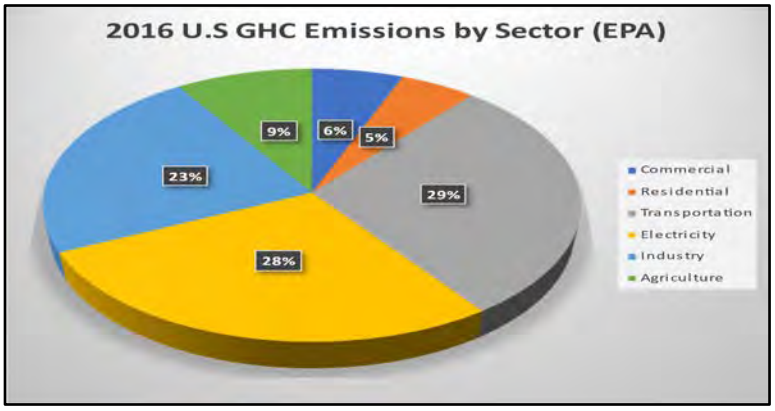
2019). According to Hebbale and Urpelainen (2020), "President Biden has issued a flurry of executive actions to electrify the federal fleet by 2035" (Hebbale & Urpelainen, 2020, para. 6). For this purpose, "executive actions invoking the Defense Production Act to shore up a domestic supply chain of critical minerals like lithium, nickel, and cobalt for EV batteries. Different from tasking, the Department of Transportation (DOT) and Environmental Protection Agency (EPA) devise new vehicle emission standards" (Hebbale & Urpelainen, 2020, para. 6).

Fully autonomous driving is expected to improve safety, roadway capacity, fuel consumption, and emissions (Fagnant & Kockelman, 2014, 2015; Gurumurthy, 2019). Predictions range from a belief that shared AV fleets of personal-sized vehicles will effectively replace public transit (Shaheen & Cohen, 2018), to a possibility of fleets of smaller autonomous buses, to an expectation that public transit will be strengthened by autonomous technology. Meanwhile, the vehicle electrification wave dramatically changes the transportation industry (Rangel, 2019).

In 2016, the transportation sector, as shown in Figure 19, was the most significant contributor to greenhouse gases (Wendel, 2021). While reducing transportation's overall carbon footprint and mitigating risks by lowering their environmental impact, vehicle electrification markets worldwide are predicted to grow exponentially. According to Hsu and Lutsey (2021), "equitable electrification can serve as a key component that helps pave the way to a just transition" (p. 17). Therefore, the shift to electric vehicles and Battery Electric Buses (BEBs) (Wendel, 2021) will help reduce greenhouse gas emissions in the United States. So far, Congress, from the Bipartisan infrastructure bill, has authorized 7.5 million to build a nationwide network of half a million charging stations (Hebbale & Urpelainen, 2022).

Figure 19

Largest contributor to U.S GHG Emissions



Source: https://wendelcompanies.com/battery-electric-buses (2021, Wendel)

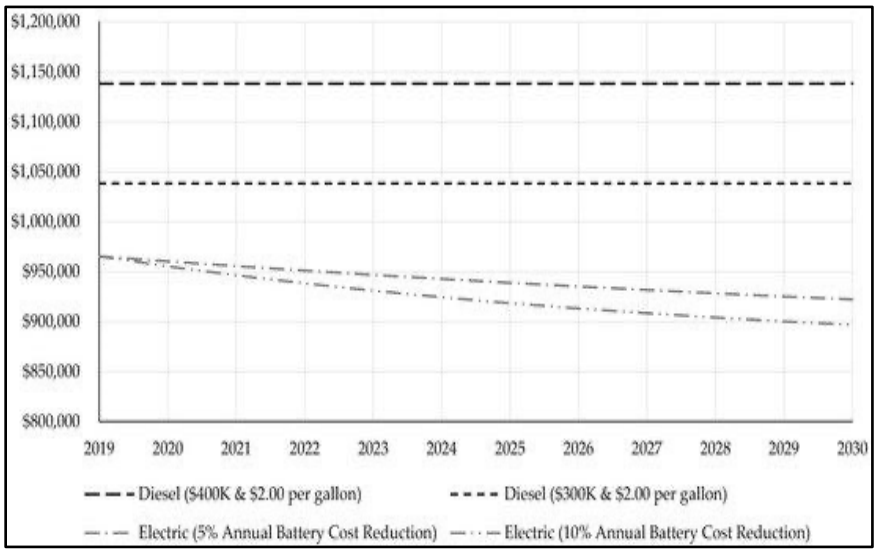
According to recent research, the global vehicle electrification industry would increase at a compounded rate of 7.8 percent, amounting to $45.5 billion (about $140 per person in the US) for electric car makers (Rangel, 2019). In addition, electric buses and battery-electric vehicles, in general, are becoming more affordable.

For example, according to Gurciullo (2016) of the US Energy Information Administration (EIA), the Chicago Transit Authority (CTA) spent $1 million per electric bus in 2014 (Gurciullo, 2016). Thus their 2016 purchase at $800,000 indicates a 20% overall price decrease in two years or a 10.56 percent yearly reduction (Gurciullo, 2016). As illustrated in Figure 19, the cost of purchasing an electric bus will decrease if the cost of battery packs continues to decline by 10% annually. Nykvist and colleagues (2015) indicate that the cost of an electric vehicle's battery pack is dropping by 14% yearly. Future cost analysis predicted yearly discount rates of 5% and 10% for BEB batteries and a $500/kWh average cost for battery-based energy storage (Quarles et al., 2020), assuming a battery capacity of 200 kWh (representing a combination of the depot and in-route BEBs), a BEB battery costs $100,000.

Even if diesel buses cost $400,000 to acquire, they need to be more competitive with diesel power from a premium cost viewpoint (Quarles et al., 2020). With diesel fuel priced at $2.00 per gallon and electricity priced at $0.07 per kWh, however, BEBs will outperform diesel buses in terms of lifetime competitiveness at diesel bus purchase prices of $400,000 and $300,000 (Quarles et al., 2020), as shown in Figure 20. For both a 5% and 10% annual reduction in battery costs, a BEB's life cycle cost will be at the $400,000 and 300 K diesel buses at present (the year 2020), as shown in Figure 21(Quarles et al., 2020). Therefore, with a conservative 5% annual reduction in battery costs, BEB will contribute 12-year lifecycle savings, as shown in Figure 20, of $116,000 and $216,000 for $400,000, and $300,000 diesel buses, respectively (Quarles et al., 2020).

Figure 20

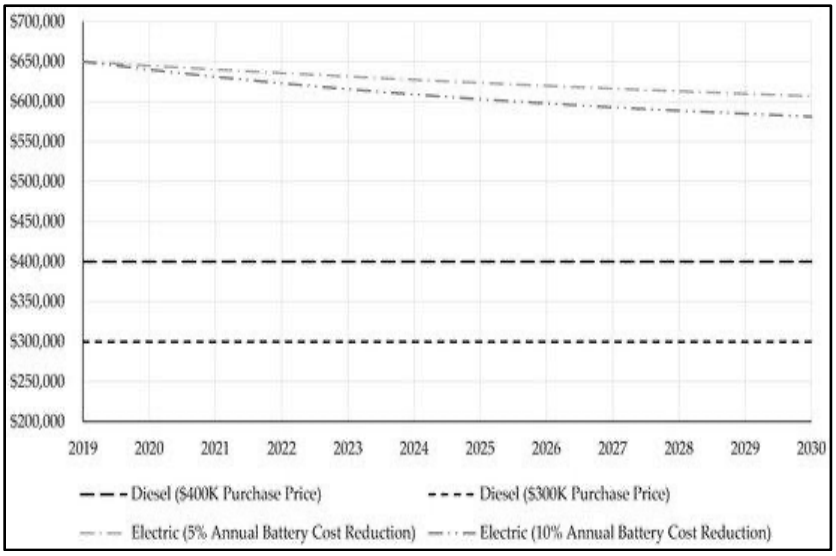
Purchase Cost of BEBs at 5% and 10% Annual Reduction of Battery Cost.



Source: (Quarles et. al, 2020)

Figure 21

Total lifecycle cost (12 Years) for diesel and electric powertrains (assuming 5% and 10% annual battery cost reduction, $500/kWh, and 200 kWh- BEB).



Source: (Quarles et. al, 2017)

In a comparison between electric and diesel buses, the transit agency discovered that the electric fleet's fuel efficiency was 16.5 miles per gallon equivalent compared to 3.8 miles per gallon for the diesel fleet, and the fuel per mile cost $0.28 for the electric buses compared to $0.59 for diesel buses (Maloney, 2019). In addition, local emissions produced by diesel buses have wide-ranging effects beyond respiratory health (Quarles, 2020). For example, these emissions are often expelled within a few feet of passengers alighting or waiting at bus stops, making the air unpleasant for these passengers and others in the area (Quarles, 2020). Additionally, the diesel engine produces considerable noise and heat that can be unpleasant for people in and near predominantly Black and Brown neighborhoods (Mukhi, 2021). The injustice of these factors is particularly salient and may dissuade potential riders, negatively influencing public opinion of bus services, especially since these communities host most environmental hazards (Mukhi, 2021; Quarles, 2020).

2.9.1 Autonomous Vehicle Impact on the Built Environment

Autonomous shuttle mobility options for on-demand shared rides will evolve fast with the application of emerging IT technologies and business practices. Thus, it is difficult to discern the impact these technologies will have in reducing the two negative travel externalities, road congestion and low-density expansion of cities. Only a few studies or papers have explored the effects of land use (Anderson et al., 2016; Chapin et al., 2016; Heinrichs, 2016; Heinrichs & Cyganski, 2015; Litman, 2015), primarily in a U.S. context. They identify impacts on road and movement space, such as adjustments in lane widths and layouts, removal of signage, or the need for drop-off and pick-up areas. The studies highlight redevelopment opportunities in urban areas dominated by surface parking and wide roadways(Anderson et al., 2016; Chapin et al., 2016; Heinrichs, 2016; Heinrichs & Cyganski, 2015; Litman, 2015). Furthermore, they sketch that autonomous driving may alter households' trade-offs between choosing a location and daily mobility and thus may affect long-term land-use patterns.

Among the key themes change in the required road space (rights-of-way and travel lanes) and infrastructures (signage), effects on the location, form, and amount of parking, interactions with cyclists and pedestrians' mobility, and changes in land use and residential relocation. The studies highlight redevelopment opportunities in urban areas dominated by surface parking and wide roadways (Anderson et al., 2016; Chapin et al., 2016; Heinrichs, 2016; Heinrichs & Cyganski, 2015; Litman, 2015). Automated vehicles could also reduce the number of lane kilometers required by increasing lane capacity. Automation could reduce the life cycle energy use of the road system by about 2–4%, equivalent to cutting operational energy use by up to 5% by enabling narrower lanes (Greenwald & Kornhauser, 2019)—energy and travel demand benefits by permitting these services to operate within their districts. Current on-demand mobility providers have an opportunity to learn

and prepare for future automated taxi services, cost reduction distribution, and the value of time, particularly among adopters of automated vehicles.

Policymakers can use new federal funding made available by the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act to support pollution barriers or less-polluting road designs by leveraging transportation spending. To promote less construction in polluted areas, local land-use restrictions, notably those allowing construction close to highways, should be changed (Samuels & Freemark, 2022). In addition, local governments can think imaginatively about developing future neighborhoods—and redeveloping current communities—into places where residents do not depend on cars and therefore are less likely to be exposed to their pollution (Samuels & Freemark, 2022). Elsewhere have been insidious tools of racism that contribute to severe public health problems like asthma, childhood cognitive delays, and premature death are exacerbated and caused by air pollution (ITDP, 2021; Stomberg, 2016; American Lung Association, 2021).

2.9.2 Autonomous Vehicle and Land use: Land use transportation planning and other policies have a long history of marginalizing and oppressing vulnerable groups worldwide. Segregation through urban design has been realized in land use planning and transportation (ITDP, 2021). People of different races and ethnicities are equally likely to live and work near Texas highways—a sign that exposure to roadway pollution is not racially differentiated. Exposure, however, is differentiated based on class: People with incomes below the federal poverty level and households receiving food stamps are exposed to roadway pollutants at higher rates than the population overall (Samuels & Freemark, 2022). Households with no car access are also much more likely to live near highways than those with cars, meaning they are disproportionately exposed to the pollution produced by others (Samuels & Freemark, 2022).

SAV fleets could have positive impacts on urban land use. Urban parking space may be reduced by 90% if AVs are implemented in ridesharing mode (Soteropoulos et al., 2019). AV could encourage infill development in eminent domain cities, reducing outward expansion and making per-capita environmental footprints smaller. The benefits are not restricted to cities; employing AVs to coordinate with public transit to encourage transit-oriented development is a more attractive place to live (Vert, 2019). Moreover, AVs could also permit public space from automobile infrastructure to other activities, such as green and blue spaces that support physical activity and social interaction (Vert, 2019). Most importantly, with transit-AV coordination, shared AVs can help fill in these accessibility gaps.

Coordination might come in the form of congestion pricing or other access controls such as high-occupancy-vehicle lanes in heavily traveled transit-rich corridors, regulations or incentives spurring AVs to fill in the gaps, and extension of transit subsidies to shared AVs under certain circumstances. AVs will also increase accessibility to multiple destinations, which is more relevant for populations living in suburbs and rural regions. Increasing access to destinations by reducing the opportunity cost of travel time, increasing road capacity, and reducing travel time could increase urban sprawl (Creger et al., 2019; Levin, 2018; Soteropoulos et al., 2019).

2.9.3 Autonomous Shuttles for Houston Job and Activity Centers: Research has shown autonomous vehicles could help bridge the gap for first last-mile commutes in Houston's downtown CBD. With an estimated 157,906 employees, 100,000 commute daily by Metro bus and rail line to the Texas Medical Center. According to Myer (2019), as shown in Table 1, downtown employers draw workers from across the Houston region.

Table 1

Houston's Employers Across the Region

Houston's Employers Across the region		
Employer	**Mode of Transit**	**Job/ Students**
The University of Houston / TSU area	Transit Bus and Light Rail, Car	With over 40,000 students and faculty, TSU's student body has some 8,000 students.
Downtown Houston	Transit Bus and Light Rail, Car	The Downtown Employment center has some 150,000 jobs.
The Port of Houston	Car	The Port is solely responsible for over 100,000 jobs.
The Texas Medical Center	Transit Bus and Light Rail, Car	Another major employment center with 100,000 or more jobs.
The Clear Lake / NASA area	Car	Perhaps a few tens of thousands of jobs.
Greenway Plaza	Transit Bus and Car	An employment center with a similar number of jobs to NASA / Clear Lake.
The Uptown / Galleria area	Transit Bus and Car	The area around Houston's most famous shopping mall with some 80,000 jobs.
The I-10 / Beltway 8 Energy Corridor:	Transit Bus and Car	Again, another employment area with a few tens of thousands of employees.
The Beltway 8 / Greens point Mall area	Transit Bus and Car	Like other minor employment areas, with a few tens of thousands of employees.

Source: https://www.bloghouston.com/ (Myer, 2019).

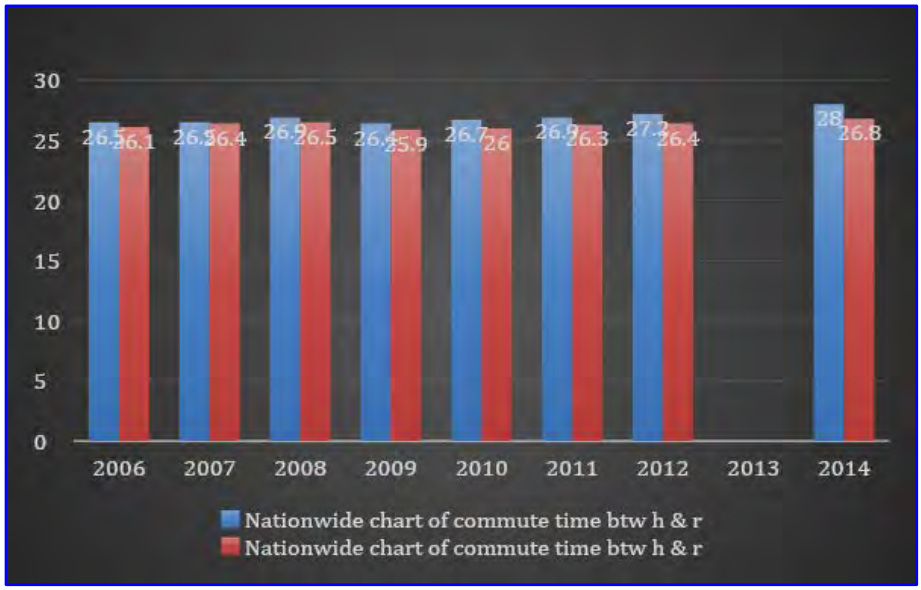
The Medical Center is the nucleus of a dynamic regional economy. It is the most critical activity center for Houston's eight-county surrounding region. Houston has two main airports: Hobby and Bush Intercontinental. However, Hobby serves some 35,000 – 40,000 passengers (about twice the seating capacity of Madison Square Garden) daily, while Intercontinental serves 110,000 – 120,000 passengers daily (Myer, 2019). Demographic shifts in public transit use have supported local and downtown commuter services, including rail transit networks, to attract more discretionary commuters from their automobiles (Garrett & Taylor, 2012). Houston's demographic shifts in public transit, as shown in (Figure 10); 68% of commuters living in poverty take public transit. Therefore,

Third Ward's transit-dependent population without a car has less access to jobs downtown other than traveling by rail or one of the six bus lines passing through.

American Community Survey found that in 43 out of 50 of the country's largest metro areas, the commute for renters, as shown in Figure 22, is about 1.5 minutes shorter than for homeowners, adding up to an entire workday's worth of saved time over a year (Florida, 2016). For example, the typical American commute time is shown in (Figure 22) the average one-way commute in Houston takes 27.0 minutes. That is longer than the US average of 26.4 minutes (Florida, 2016).

Figure 22

Nationwide Chart of Commute Time between Homeowners and Renters



Source:https://www.citylab.com/transportation/2016/03/trulia-renting-shorter-commutehomeowners/472755/

It was discovered from the study that renters are also more likely to use public transportation and live closer to where they work (Florida, 2016). The report finds that shorter commute times or proximity to public transportation were the second most important criteria (behind crime rates) for Americans looking for a place to live (Florida, 2016). Among millennial renters, commute times even topped crime rates. Since renters tend to use public transit more than homeowners, it is a

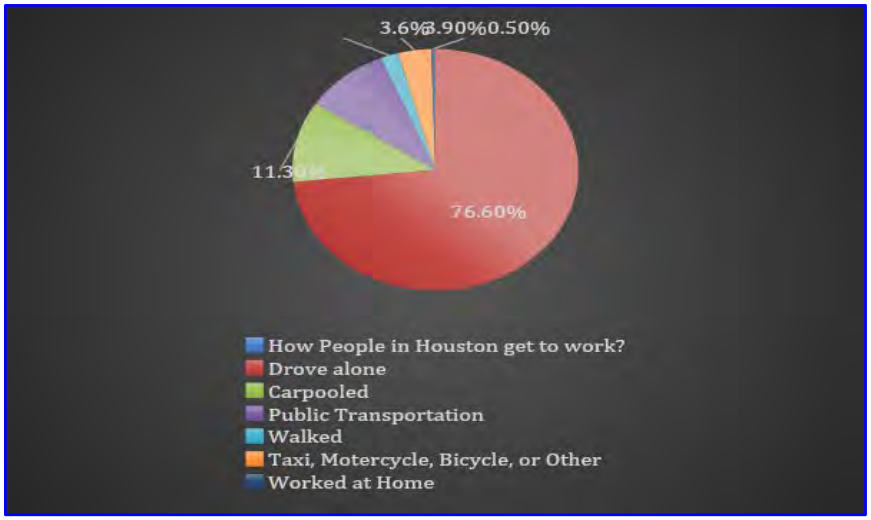
problem that public transit commute in this study area could be higher in an environment filled with rental occupancy (Florida, 2016).

There are various reasons for public transportation's low ridership commute. However, since this study focuses more on Autonomous Shuttle Transit along the TSU campus Tiger Walk, it could be said that the lack of efficient transportation is the primary reason low-income Blacks and other people of color would prefer to commute by bus. This transportation barrier is because most people are willing to take public transit during peak congestion. As a result, the bus starts to make stops during congestion, thereby adding to their travel or commute time (Florida, 2016).

2.9.4 Harris County and Surrounding area Internal Commutes: Houstonians congregated together, traveling in teeming hordes from one activity center to another. Among suburban districts, Fort Bend County sent the most critical part of residents into a nearby urban region, with 59.7 percent of its workforce — or 169,194 occupants — heading into Harris County, home to Houston (McCullough & Ura, 2015).

Figure 23

How Houstonians get to work



Source: Houston, Texas Commuting (bestplaces.net)

How people in Houston get to work, as shown in Figure 23

76.6% drive their car alone

11.3% carpool with others

3.6% work from home

3.9% take mass transit

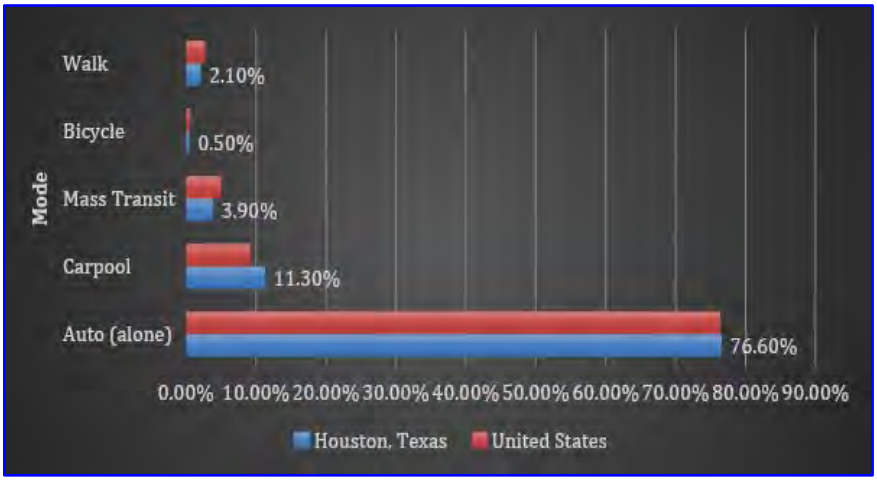
2.9.5 Benefits of Autonomous Shuttle Transit in Third Ward

AST is not just about a driverless future; potential benefits include energy, the environment, and human rights. However, for some population groups, there are more feasible options than driving. For example, the lack of transit harms those who rely on public transit people are too young, old, poor, or have disabilities that do not allow them to drive (Jiao, 2018). According to Rueda et al. (2020), barriers to driving include the cost of full-time car ownership, learning to drive, difficulties with licensing, or factors related to health, disability, and age.

AST will provide Mobility-as-a-Service without requiring drivers to offer door-to-rides by an app (O'Kane, 2020). Instead, an efficient solution is a mixture of autonomy, light rail, and shared mobility services not limited to Autonomous vehicles (O'Kane, 2020). These internalized benefits accrue to the providers in the form of higher profits (or, in the case of public transportation, lower losses) or to the consumer in the form of lower fares and better service (Montgomery, 2018). Additionally, as shown in Figure 24, a blend of modalities should take advantage of the current transportation systems at our disposal, augmented through a higher interconnectivity level.

Figure 24

Transportation Houston vs United States



Source: Houston, Texas Commuting (bestplaces.net)

Given the former's simple construction, AVs should be cheaper than conventional vehicles (Alves, 2017). These mixed internalized benefits accrue to the providers as high profits for public transportation agencies (Alves, 2017). Also, AVs will provide benefits in lower transportation costs and greater access to those who do not purchase their vehicles but instead use taxis, ridesharing services, or public transportation (Fiol & Weng, 2022). Cortright (2016) reported the cost reduction estimates of several manufacturers, which suggested that by 2040 the current passenger vehicle cost of between US $1.0 and $0.83 per mile will fall to between $0.33 and $0.15 per mile.

Affordable and ready access to easy-to-use transportation has been described as a "missing link" to a better life for most intellectually impaired individuals (MHAG, 2011, p.3), especially in the avoidance of social exclusion (DOH, 2011). These cost-savings can eliminate human drivers' costs, better capacity utilization, and shorter wait times for on-demand 24-hour service. Besides, analysts observe all the efforts made. However, many local authorities must recognize and respond appropriately to equity priorities related to transportation costs, access to destinations, services (such as health services), and employment (Cohen et al., 2017).

Some advocates argue that self-driving cars or autonomous vehicles (AVs) may help close that gap since they could operate more affordably than taxis, go farther than public transportation, and provide comfortable seating options accessible to individuals with impairments (Fiol & Weng, 2022). Although available resources are insufficient to address the real problems, a recent study modeled AVs' equity impact on job accessibility in Washington, DC (Cohn et al., 2019). The study found that in all the scenarios modeled, AVs increased job accessibility, especially in more disadvantaged populations and in scenarios using ridesharing SAVs (Cohn et al., 2019). Therefore, two main recommendations to support social equity for AVs are (a) to engage and include disadvantaged communities in transportation planning, especially regarding SAVs, and (b) to reduce barriers to using SAVs, including financial, technological, language, and cultural barriers. In addition to these recommendations, a 2018 report related to the impact of AV on US workers found that the introduction of autonomous cars and trucks could directly eliminate 1.3–2.3 million workers' jobs over the next 30 years; this issue also needs to be considered in terms of workers' health (Groshen et al., 2018).

Moreover, problems associated with AV energy consumption and environmental health-related impacts are far from all benefits. Vehicle automation could increase mobility, improve safety, lower cost, lower stress, improve public infrastructure utilization, reduce traffic congestion, and make fleet management companies productive while lowering emissions and reducing energy use (Greenwald & Kornhauser, 2019). When implemented aside from the expected benefits associated with traffic safety, AVs as fully electric (depending on renewable sources) could offer significant public health opportunities in a ridesharing format, manufacturing, and integrated with public and active transportation modes (Greenwald & Kornhauser, 2019).

2.9.6 Autonomous Vehicle Energy Consumption

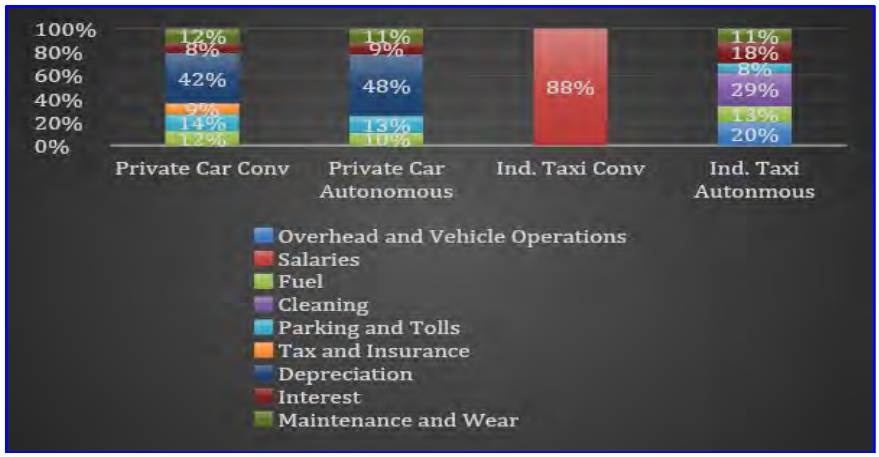
According to a new analysis, Black households pay more than White households but suffer the most when it comes to clean, efficient energy (Franzin, 2020). Given the historically discriminatory housing policy, there is evidence linking expense disparity in the total number of houses and apartments and energy-efficient investments (Franzin, 2020). However, in 2017, black renters spent $200 more annually on energy than white renters. In addition, black homeowners paid $310 more per year than white homeowners (Franzin, 2020).

It is predicted by the year 2050 that the cumulative energy impacts, as well as potential changes in electric fuel consumption, primarily battery-electric or hybrid vehicles increasing, could range from a 90% decrease to a 200% increase in fuel consumption by the transportation sector (Hillberg, Santhanam, and Kaimal, 2019). Initial savings come from vehicle connectedness and energy-reduction benefits through partial automation, particularly among adopters of automated vehicles. At the same time, the significant energy/emission downside risks are more likely to appear at full automation. In addition, recent findings show that Black Americans bear a double disproportionate burden of the current energy system through pollution, exposure, and excessive expenses because of ongoing wealth and housing disparities (Franzin, 2020).

According to Metro (2021), electric buses and vehicles are designed for routes in communities affected by carbon emissions (Romero, 2021). In addition, automated vehicles could also reduce the total number of lane kilometers required by increasing lane capacity and lifecycle energy use of the road system by permitting these services to operate within their jurisdictions so that current on-demand mobility providers have an opportunity to learn and prepare for the future automated taxi services as shown in Figure 25, as well as the distribution of cost reduction, the value of time, particularly among adopters of automated vehicles.

Figure 25

Cost structure comparison (Autonomous) and without (Conv) vehicle automation for private vehicles (Private Car) and taxi fleet vehicles without pooling



Source: (Bosch et al., 2018)

Automation may affect travel and energy demand from GHG emissions, bringing them together using a coherent energy decomposition framework (Wadud, MacKenzie, & Leiby, 2016). Subsequently, energy and the environment are imperative for the AV reducing greenhouse gas (GHG) emissions and save energy. For example, in major metropolitan areas, New York and Denver TNCs replaced 39% of driving, 15% of public transportation, and 23% of biking or walking; 22% would not have made the trip (Greenwald & Kornhauser, 2019). Ninety-five percent of passengers in the Denver area said they were using a TNC for their entire trip; 5.5% connected with another transportation mode. In denser urban areas like New York, vehicle automation would see a higher-than-average VMT reduction, mainly if private TNCs reduce mass transit ridership (Greenwald & Kornhauser, 2019).

2.9.7 Transportation Planning in Houston's Metropolitan Area

Over the last ten years, Uptown Houston has become a leading economic driver outside downtown (COH, 2020). I-45 runs north to south and traverses downtown (Adams, 2020). Meanwhile, Metro's BRT and I-H 610 dedicated HOV lanes transport more affluent commuters

from West U to the Galleria area in the heart of suburban communities where most Uptown employees live. Uptown Houston faces its greatest challenge with more HOV infrastructure and Bus Rapid Transit: some 80,000 employees (about the seating capacity of the Los Angeles Memorial Coliseum) lack commuter transit options. In theory, BRT on Post Oak will help ease traffic congestion, which is detrimental to growth (COH, 2020). The question is whether Uptown will utilize a driverless shuttle in the Galleria area before the Third Ward neighborhood.

The voluminous number of vehicles on the road has increased environmental and safety concerns and commenced a National Environmental Policy Act process for the Interstate 45 expansion in the north Houston area (Adams, 2020). With potential violations of Title VI of the Civil Rights Act, the North Houston Highway Improvement Project has been given the green light to move forward with a three-segment Texas Department of Transportation plan to alleviate traffic problems in the city that has been in development for some time (Fisher, 2021; Adams, 2020). Since the 80s, Third Ward's poverty-stricken residents have struggled with political and economic forces caused by transportation disinvestment and suburbanization (Olin, 2020). However, pending approval, the ambitious North Houston Highway Improvement Project seeks to untangle the traffic congestion as the population expands in America's fourth-largest city (Adams, 2020).

Meanwhile, the Third Ward needs BRT investments, directly functioning as toll lanes and Park and Ride to Uptown and other activity centers. Unfortunately, investments in the last twenty years have exacerbated racial isolation in Houston's Third Ward community. In comparison, funding for the project on Interstate 45 (Fisher, 2021) is $9 billion (about $28 per person in the US). North Houston Highway Improvement Project makes up about 12% of the $74 billion (about $230 per person in the US) allocated in the Unified Transportation Program (Fisher, 2021). Montgomery County Judge Mark Keough warned the commission of the claims being made by the opposition,

which have halted the North Houston Highway Improvement Project (Fisher, 2021). Although on the other side of the fence, opponents claim that the project will neither improve safety nor reduce congestion (Fisher, 2021). They also claim that the project adversely affects low-income residents and communities of color (Fisher, 2021).

"Fifty years ago, Cooper's Black neighborhood in Houston's Fifth Ward was devastated to build the freeway. Now, another cycle of dislocation looms" (Dillon & Poston, 2021, p. 1). According to Hale (2018), the displacement of Black people from the Third Ward has been in motion for over half a century, approaching a century (Hale, 2018). Bus routes that travel downtown have missed several job activity centers (Olin, 2020), where Metro still needs to keep up with middle-class neighborhood demographics. Including hub-spoke bus systems that provide suburbanization networks to low-income areas (Olin, 2020), connecting State Hwy 288 expansions from Brazoria County past the Texas Medical Center entails toll lanes that stretch 10.3-miles from US 59 and IH 45 to the Harris County line Clear Creek.

2.9.8 Houston's Transportation Inequity

Too often, poor working-class people need to be more noticed when it comes to flashier forms of transit, particularly in wealthy concentrated areas. Scott (2020) states, "A lack of equitable investments continues to perpetuate long-standing and racial disadvantages" (para. 6). Spieler (2020) argues that local streets are delayed by traffic lights and cars turning into driveways. Therefore, some bus stops are no more than a sign on a narrow sidewalk, where waiting passengers will find neither shade nor a place to sit (Spieler, 2020).

Metro is a lifeline for low-income transit-dependent commuters (Scott, 2020). In many Black and other communities of color across Houston, transit justice is a form of freedom. It is a mandate and a civil right for transit-dependent commuters with no car to access reliable public transit (Scott,

2020, para. 6). Sidewalks and curb cuts are fundamental provisions. They must be up to code, especially for people with mobility challenges, because the built environment provides transit access to many upward opportunities, including jobs, medical appointments, and education (Scott, 2020).

Transportation investments in Houston's Third Ward Metro's mobility practices rapidly shift into high gear with the region's first Autonomous Shuttle vehicle. "With the Build Back Better Framework, the Bipartisan Infrastructure Bill will increase our country's resilience. The United States will be able to achieve President Biden's goal to cut our emissions by 50–22% from 2005 levels by 2030 thanks to these historic investments, which will contribute to a reduction of our emissions of well over one gigaton this decade (The Bipartisan Infrastructure Law, 2021, "Advances in Environmental Justices," para. 4). These delayed investments will help areas that have been burdened, neglected, and left behind by taking urgent action to enhance public health, decrease pollution, and bring about economic regeneration (The Bipartisan Infrastructure Law, 2021, "Advances in Environmental Justices," para. 4).

Autonomous Shuttle Vehicles, an added mode of transit, will change the historical infrastructure, which has long been used to divide Third Ward's residents disproportionately impacted by transit accessibility. For example, infrastructure investments have begun near TSU and U of H, where highways and railroads cut communities off from other parts of the city. More connected pavement networks will carry commuters quickly by connecting the TSU Tiger Walk into the Third Ward Community. This connectivity will allow pedestrians, drivers, cyclists, and low-income people to use more mass transit (Mcananey, 2017).

Meanwhile, Metro now operates a two-standard type bus rail system that systemically puts transit-dependent commuters at a disadvantage. For the "dependent riders," the Houston Metro Transit agency preserved and expanded urban bus (and rail) systems (Spieler, 2020). Nevertheless,

being "dependent" meant they would not have preferences; here, the focus was more on delivering service than on giving the "choice riders" a pleasant experience (Spieler, 2020). To lure people out of their automobiles, agencies instead provide exceptional service in the form of brand-new train lines and limited-stop express commuter buses (Spieler, 2020).

It is easy to talk about this as a bus/rail divide, with only 5 percent of Blacks taking public transit and less than 2 percent of White (Fitzgerald, 2018), but it is not that simple. Spieler (2020) claims that to fulfill this dual goal, numerous agencies built and ran two separate systems with various requirements for amenities, services, and subsidy levels. In addition, there are bus routes designed for "choice" passengers and rail lines geared for "transit-dependent" passengers; they are differentiated by aim rather than technology (Spieler, 2020).

However, the most promising economic recovery strategy has become a booming field for young "tech" professionals moving to Houston's Third Ward community to access all its opportunities. According to Pinckney (2021), young professionals want to live, shop, eat, and work with easy access to public transit. This demand boom driving investment in housing and transit is evident in Third Ward (Pinckney, 2021). One standalone activity center, the Ion, a planned "nucleus for innovation," has sprung up around Midtown, attracting visitors to the neighborhood for the restaurants, shops, and pedestrian areas and promoting the use of the Houston Metro transit system (Pinckney, 2021).

Entrepreneurs and corporations will "come together to solve some of the world's most significant problems (Bach, 2020). These innovations are thriving because of Houston's increasing urbanization population and proving that Third Ward's community access to transit has become more important than major roadways. Exit ramps remain the most significant transport source for mobility to address the problems inherent in long-range travel benefits. Meanwhile, better use of the Right-

of-Way (ROW) could convert the current lane thoroughfares to one that includes Bus Rapid Transit (BRT) compared to Uptown Galleria, generous sidewalks, and AV and bicycle lanes—while retaining lanes of through traffic (Steuteville, 2020). Furthermore, it should include a regional AV mobility plan for transit-dependent populations at a low cost to service high-demand corridors and improved modal connectivity. In addition, service hours must exceed its system-wide connectivity where ridership fails (Olin, 2020).

However, a non-exclusive spatial review of the proposed local thoroughfare and significant transportation improvements reveals disparate investments in Third Ward compared to non-target areas.

- 78% of the mapped local projects from the H-GAC ten-year plan (2017 – 2026), amounting to about 88% of the allocated funding, were programmed in non-environmental justice target areas. In comparison, 66% of the projects fell within or ran adjacent to an environmental justice-sensitive area. The cost of the projects serving the environmental justice neighborhoods amounted to about 50% of the allocated funding (HGAC, 2017).
- The spatial distribution of the significant transportation investments, including tolled facilities, is like that of the local projects and will disparately benefit the non-target areas (HGAC, 2017).
- Despite locational disparities, quantitative analysis suggests that the environmental justice population would enjoy greater accessibility to jobs than the non-target population by constructing regionally significant projects (HGAC, 2017).
- Although the environmental justice population will experience improvements in travel time and travel speed, improvements in these areas will be proportionately less than the non-target population's improvements (HGAC, 2017).

The federal government needs to invest more in funding transit operations. For example, joint ventures nearby could improve Texas Southern University and the University of Houston

(Rivas, 2018). State and local governments typically cover these costs, a significant investment in pricey transit where federal expenditures mostly go to capital investments, like a modern design, to achieve high-quality service costs (Freemark, 2020). This venture improvement will satisfy transit-dependent commuters' needs and bring economic change by including a cutting-edge driverless shuttle in the Third Ward community.

New York City's buses and subways will receive more than $40 billion (about $120 per person in the US) in investments from the Metropolitan Transportation Authority (MTA). Investments will fund over 2,400 new buses, depot improvements, and customer experience upgrades. In addition, it will add to the transition to a fleet composed entirely of zero-emissions electric buses by 2029 (Intelligent Transport, 2019). In comparison, as part of a commitment to invest in future transportation, Houston Metro is adding 20 full-size electric buses and ten paratransit vans to its fleet (Romero, 2021). Introducing electric buses and cars, including a zero-emissions vehicle program, is part of the transportation agency's more comprehensive climate action plan as a succession of environmentally sustainable measures (Romero, 2021).

New York City region, where transit is frequent and convenient, and the average urban resident takes 224 transit trips annually. However, in the Cincinnati region, buses are infrequent. They serve only a few neighborhoods. Indeed, the average resident takes fewer than 11 transit trips yearly (Freemark, 2021)—using five urban areas' current transit services as potential goalposts (Chicago, Dallas, Los Angeles, New York City, and Washington, DC), as shown in Table 2, and estimating the cost of increasing transit service quantity in all urban areas with 100,000 or more residents.

Table 2

Top Ten Transit Agency 2019 Annual Ridership

Agency	Primary City 2019	Annual Ridership	Average Weekly Ridership	Driverless Shuttle Pilot Investments
1 MTA	New York City	732,636,800	2,259,100	No
2 LACMTA	Los Angeles	278,109,900	865,600	No
3 CTA	Chicago	237,276,500	760,200	No
4 Muni	San Francisco	159,331,200	502,000	No
5 New Jersey Transit	Newark	150,997,300	Not Available	No
6 SEPTA	Philadelphia	142,043,800	508,400	No
7 King County Metro	Seattle	121,300,300	399,600	No
8 MTBA	Boston	116,372,700	391,000	No
9 WMATA	Washington, D.C.	105,469,800	340,100	No
10 RTD	Denver	69,870,300	265,200	No
* METRO	Houston	67,353,100	224,000	Yes *

Source: (APTA, 2020)

The Department of Transportation Federal Transit Administration announced that it is awarding $298.6 million in American Rescue Plan funds to the Metropolitan Transit Authority of Harris County (Cochran, 2021). "This funding from President Biden's American Rescue Plan will help protect transit employees from layoffs, keep transit service running, and ensure people can get where they need to go (Cochran, 2021, para. 3). "Public transportation has been a lifeline for communities and the American people throughout this pandemic," said the U.S. Transportation Secretary Pete Buttigieg (DOT, 2022, para. 3). For example, Houston's Third Ward is now changing the number of bus routes drastically, increasing service to midnight every day and running buses every 15 minutes on all routes—which could make transit-accessible and convenient to the region's inhabitants.

As a state, Texas has suffered losses from hurricanes Harvey, Ike, and Allison. For this purpose, Texas has 46 of the 2,800 zero-emission buses in the nation. In addition, Metro is transitioning away from diesel buses, with plans to convert the entire fleet to electric by 2045 (George, 2021). The transition occurs in a rapidly changing political and technological climate (George, 2021). The move is a departure for a transit agency with only one electric bus in its fleet. However, it coincides with the Biden administration's focus on enhancing and modernizing public transportation nationwide. A bipartisan infrastructure deal includes $7.5 billion (about $23 per person in the US) for electric buses. Assuredly, Washington's enthusiasm encourages transit officials to advance with service enhancements (George, 2021). However, officials warn that there are many uncertainties.

A shift away from fossil fuels will come with some considerations if BRT takes hold in the region with 75 miles planned (Begely, 2021). Metro follows a plan for automated transit stations, facilitating faster regional trips. Indeed, only a few hundred of the city's 1,200 buses run on compressed natural gas, while the remainder uses diesel fuel - 385 of which are diesel-electric hybrids (Begely, 2021). Whereas petrochemical fuels can be stored, electric buses require a functioning grid - something Houston lacks (Begley, 2021).

Simultaneously, Metro received a $1.5 million grant after its board approved a $250,000 investment in 2018 to the automated pilot program (Land, 2018), the initial phase of developing an autonomous electric shuttle bus that will go to Texas Southern University, the University of Houston, and the Third Ward area of Houston. A first-last mile AV shuttle service linking users to the TSU campus, a neighboring rail station, and the University of Houston campus will be a part of phase two. The shuttle will also connect to Metro buses and light rail, and its potential for deployment in urban, suburban, and rural settings will be researched (FTA, 2020).

2.9.9 Literature Gap

Several pilot studies have concerned Autonomous Shuttles at Predominantly White Institutions (PWI). Similarly, there is a lack of Autonomous Shuttle vehicle pilot studies conducted in the Black community. For this purpose, this situation is on a Historically Black College and University (HBCU) campus. Therefore, they can equitably serve low-income transit-dependent populations, particularly people of color. However, several pilot studies have focused primarily on the adoption and consumer acceptance of technology and data collection for Autonomous shuttles on PWI campuses. Besides, commuters with higher incomes are non-transit users. Therefore, this will put TSU students, faculty, staff, and poverty-stricken residents of the Third Ward neighborhood at a disadvantage. For this reason, for students from Michigan University, most household income is $154,000, and 66% comes from the top 20 percent. At the same time, about 1.5% of students in Michigan come from poverty.

For example, Keenan (2020) stated, "Most Riders trust Mcity Driverless Shuttle at the University of Michigan after the Pilot Project." He concluded that consumers' skepticism and hesitancy diminished through positive experiences after riding the shuttle (Keenan, 2020), and participants were satisfied with their experience. "Despite declining satisfaction with AVs nationally, robust preparation and oversight are important to ensure safe deployment (Keenan, 2020). That will build consumer trust, says Huei Peng, director of Mcity. " Without that, a driverless vehicle will never achieve its full potential to improve traffic safety, cut fuel consumption, and increase mobility for those with limited transportation options" (Keenan, 2020).

Also, Sheriff (2020) examines the link between transportation and public health during the successful completion of autonomous shuttle trials at Sharjah University City. However, during the

COVID-19 pandemic, 19 electric vehicles and drivers were deployed pro bono to transport Sharjah Medical District to facilitate home visits for testing by doctors. The pilot research channeled electric vehicles' impact on health through medical coordination services used by University Hospital for fast and efficient delivery. Therefore, intelligent electric shuttles can offer regular and dependable services within the city while reducing vehicular traffic and improving air quality.

One modeling study of private AVs in Melbourne, Australia, with a scenario for the year 2046, projected a 4% reduction in the population living in the inner parts of the city and a 3% increase in the population living in the far outer suburbs (Thakur et al., 2016). In the same study, a scenario considering ridesharing SAVs in Melbourne reported a 4% increase in population in inner parts of the city, while far outer suburbs experienced a 3% reduction (Thakur et al., 2016). Another modeling study in Atlanta concluded that SAV use would not induce residential sprawl into exurban areas but accelerate urban deindustrialization (Zhang, 2017).

O' Kane (2020) explains the emergence of pilot study risk after a self-driving shuttle performed an emergency stop unexpectedly in Linden, a residential neighborhood north of Columbus downtown, as it pulled away from an intersection. The author focuses on the NHTSA safety protocol for newly added mandatory seat belts. It also features extra signage and audio announcements that warn passengers about the possibility of sudden pauses and training for the safety operators on the shuttles. For example, "remind passengers to hold on with feet firmly on the floor" while in motion.

However, most of the above studies emphasize the interactions autonomous shuttle has on the built environment resulting from adequate accessibility. Some studies have examined shuttles' driverless impact on the PWI campus population, public health efficiency, and the inner city. Some

have been able to quantify urban sprawl, address pollution, and NHTSA safety protocols. More so, there is limited research data on public health, safety, and accessibility. However, such information regarding communities of color is minimal. Because there is a lack of documented statistical data on Autonomous Shuttle acceptance, travel time for students, faculty, staff, and residents living in marginalized communities, especially near HBCU campuses, therefore, it is vital to examine transit accessibility for the driverless shuttle along TSU Tiger Walk, going to Cleburne Street in the Third Ward community. This gap found is what this research will attempt to cover.

Chapter 3

Research Design and Methodology

3.0 Rationale Approach

Building on the theoretical analysis presented within the EJ framework, this research is an exploratory case study of Autonomous Shuttle Transit and its impact on students, faculty, and staff bicycling and walking along the TSU Campus Tiger Walk. This chapter provides the methodology for the current research. It seeks to investigate the possibility of a relationship between the Autonomous Shuttle and the built environment surrounding each bus stop along with the TSU campus Tiger Walk. The research used the built environment to determine transport mode. In addition, the investigation included social and economic data for analysis as insight into the Autonomous Shuttle.

The researcher also used the results of a qualitative survey to determine if a driverless shuttle would provide an additional mode of transportation for students, faculty, and staff biking and walking along the TSU Campus Tiger Walk connecting to Houston's Greater Third Ward, a Black neighborhood. Therefore, this chapter will describe the approaches to meet the study's objectives. To provide an in-depth understanding of the research problem, a mixed-method research approach, which involves both quantitative and qualitative methods, will be employed in this study.

Quantitative research is the dominant method that includes descriptive statistics, Google Maps for spatial analysis, and statistical analysis. The qualitative research method will include an online questionnaire directly observing the study area. Firstly, this chapter briefly describes the study area, the bus stop location, and the criteria for selecting the campus-designated stops for the study. The chapter further explains the rationale for the choice of research method and the detailed explanation of using spatial and statistical analysis for this research and qualitative research methods.

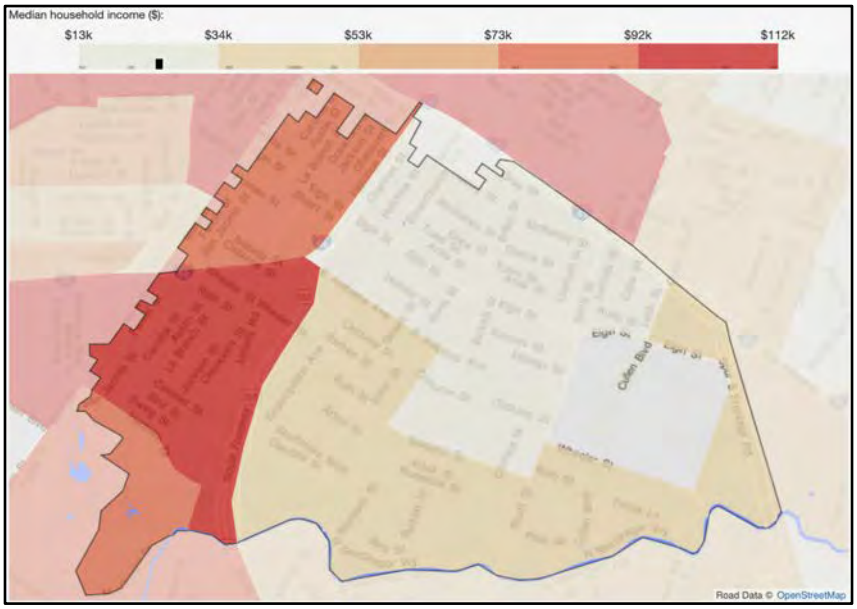
The chapter also presents the data collection methods and source, the variable of interest, and finally, it will explain how to maintain the validity and reliability of the study.

3.1 Study Area

Third Ward, an African American community established in 1837, is one of Houston's six wards on latitude coordinates 29.72477° N and longitude -95.35434° E (COH, 2017) has a total geographical area of 2.57 square miles (1,700 km2).Third Ward, as shown in Figure 26, is centrally located outside downtown, East of the medical center inside IH 610 near State Highway 288. Being that it is East of the medical center inside IH 610 near State Highway 288, its extensive economic base for black businesses and urban culture has suffered within the last twenty years due to disinvestment, redlining, stymied new growth, poverty, gentrification, and the War on Drugs has contributed to aggressive policing and mass incarceration.

Figure 26

Map III Houston's Greater Third Ward



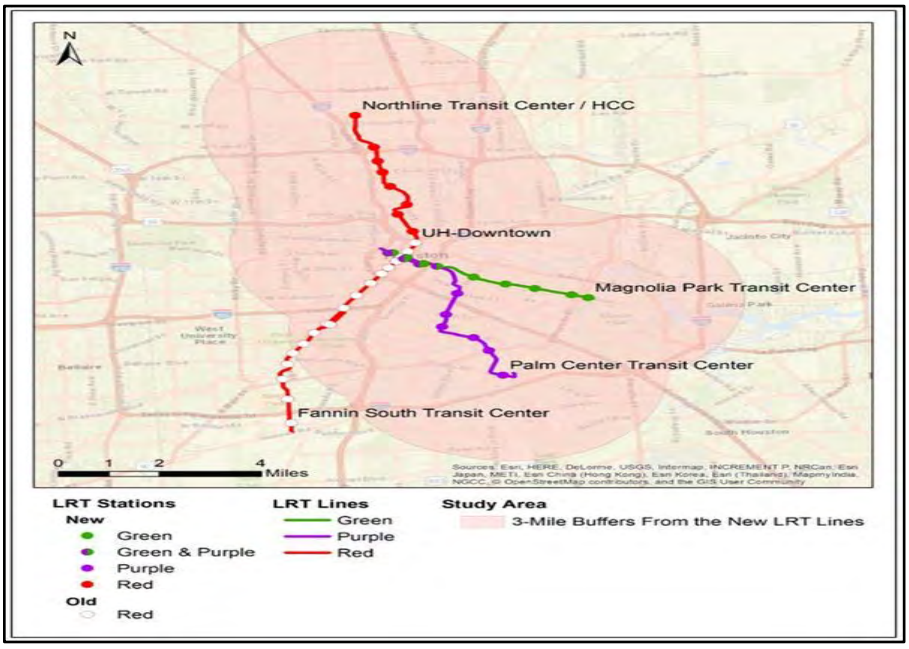
Source: https://statisticalatlas.com/zip/77004/Household-Income

Unity Bank is within view of Texas Southern University and has been serving some of the city's most poorly served since 1963 (Snyder, 2020). Social economics has heavily contributed to Third Ward's diverse population growth. However, most residents are without smartphones and have less transit to and from work, doctor's offices, and essential places. Although Unity Bank has supported the banking needs of low- and moderate-income communities for decades, the same communities have suffered the worst effects of COVID-19.

Metro bus and light rail, as shown in Figure 27, connect to Texas Medical Center and Downtown Houston, two of the region's largest employment centers. In addition, a sprawling innovation district nearby is expected to accelerate the trend (Bach, 2020) by connecting a driverless shuttle from Wheeler Transit Station, including Texas Southern University Tiger Campus Tiger Walk, to the Metro rail Purple Line on Scott.

Figure 27

METRO Rail



Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7531275/

Planning for an additional mode of transit along Cleburne Street has reduced lanes. As a result, there is no dedicated transit lane for driverless shuttle mobility. In addition, landscaping aesthetics now serve as a potential barrier to slowing traffic for Third Ward's transit-dependent population. Therefore, during peak hours, increased traffic congestion coming from State Highway 288, particularly for Texas Southern University students, faculty, and staff, may increase travel times due to inefficient short-range planning.

3.2 The Greater Third Ward Population

Houston Greater Third Ward has a population of 13,295 African American (66.9%)(Census, 2018). With an average per capita income of $27,860 and a median household income (of $30,713) (Census, 2018), 38.9% of the population lives below the poverty level— compared to Houston's city with a 22% African American population, per capita income of $69,193, and median household income, respectively (Census, 2018). The economic prospects for Third Ward are bleaker than the rest of the city of Houston in general, where more than 30 % of household income is going toward housing costs and 29% are without access to a vehicle where 12% of the population commutes by public transportation, walking or biking (Census, 2018). Nevertheless, the TSU campus Tiger Walk Third Ward makes an excellent exploratory case study for AST because of the elevated levels of concentrated poverty. Houston's growth is expected to add over 3 million more people, totaling about 9.7 million residents (about half the population of New York) by 2040 (HGAC, 2018).

With Houston's projected growth in population and the continuous increase in jobs, many new developments have already begun. For example, projects include developing an Automated Electric shuttle bus to serve Texas Southern University and Houston's Third Ward community (Cary, 2020). Table 3 shows an overview of the socio-demographic characteristics of the nine

neighborhoods, including Third Ward. Therefore, it is essential that all groups, especially those who are most vulnerable to first- and last-mile transit commutes close to Texas Southern University, utilize modern technologies and services, such as micro-transit, vehicle automation, connectivity of ride-hailing services with transit, and contactless fare payments (Cary, 2020).

Table 3

Socio-demographic characteristics of Houston's Greater Third Ward and surrounding neighborhoods

Characteristic	Third Ward	Fifth Ward	Sunny Side	South Acres /Crestmont Park	Ost/South Union	South Park	Midtown	West University	Uptown	Bellaire
Total Population/ Density	13,295/ 6,732/mi²	19,823/ 6376/mi²	20,282/ 6,800/mi²	18,941/ 5,676/mi²	20,152/ 6264/mi²	22,051/ 8004/mi²	8526/ 9594/mi²	15,318 8665/mi²	49,277 17,295/mi²	18,140/ 6752/mi²
Race/ Ethnic										
% Of White	15.1%	3.8%	1.9%	2.3%	4.3%	1.4%	58.9%	73.5%	62.9%	62.9%
% Of African American	64.5%	47.1%	79.9%	85%	79.2%	70%	12.4%	1.6%	4.64%	4.6%
% Of Hispanic	11.8%	48.1%	15.7%	10.3%	14.9%	26.5%	17.1%	10.1%	9.81%	9.81%
% Asian and Others	7%	0.7%	0.6%	2.4%	0.7%	0.3%	9.5%	12.1%	8.1%	20.4%
Gender										
Female	48.9%	48.8%	51.9%	52.4%	55%	53.3%	61.5%	52.4%	50.4%	52.2%
Male	51.05%	50.12%	48.07%	47.5%	44.9%	47.6%	38.4%	47.6%	49.5%	47.7%
Median Household income	$27,860	$27,046	$25,240	$45,931	$32,166	$36,436	$90,617	$186,657	$85,322	$150,546
Person below poverty line	38.9%	28.6%	36.6%	17.1%	32.8%	28.2%	10.1%	2.6%	7.2%	2.2%
Education										
High school grad or higher	28%	33.5%	35.1%	35.2%	34.7%	35.8%	6.2%	3.3%	8.2%	6.3%
Bachelor's degree or higher	25.3%	12.8%	10.2%	18.1%	16.5%	7.8%	68.5%	83.8%	70%	79.4%

Age										
Children Under 5 years	4.9%	7.3%	5.8%	7.5%	6.2%	9.7%	2.7%	5.6%	8.3%	5.8%
65 years and over	6.7%	10.7%	16.8%	15.7%	14.8%	19.1%	9.8%	17.4%	13.3%	13.2%
Number of jobs	3876	4105	2204	1010	3953	3480	20994	11430	114635	11430
Mobility % HH without a Car	29.75%	20.5%	22.2%	9.6%	18.9%	12.3%	7.6%	1.79%	4.7%	2.2%
% Renters Paying more than 30% of Income on Housing Cost	48.6%	56.81%	54.3%	37.6%	53.4%	51.4%	37.1%	35.42%	31.7%	31.7%
Median Housing Value	**$144,595**	**$81,332**	**$149,950**	**$92,754**	**$87,669**	**$81,024**	**$345,134**	**$956,390**	**$333,532**	**$716,477**

Source: U.S. Census Bureau, (2018). American Community Survey 2018 -1year estimates.

3.3 Vulnerable Populations

Vulnerable populations are low-income, seniors, physically disabled, mentally disabled, and more likely to be transit-dependent than the general population (DVRPC, 2020). Barriers and gaps in infrastructure, service coordination, and policies more critically impact the disadvantaged segment of the community. According to the DOT (2013), low-income and minority communities are likelier to be near highways and other transportation facilities that produce reduced local air quality and suffer from adverse health effects such as asthma. In addition, many indigenous populations are exposed to hazards and lack the capacity for cultural, economic, environmental, social, and development of technological processes for transit accessibility (Orhan, 2012). These individuals' or populations' vulnerability is enhanced by race, ethnicity, age, sex, and social factors such as income, poverty, inadequate education, and the absence of a usual care source (Shivayogi, 2013).

The World Health Organization (2021) considers the price of health services and indirect and opportunity costs (e.g., transportation to and from facilities and taking time away from work).

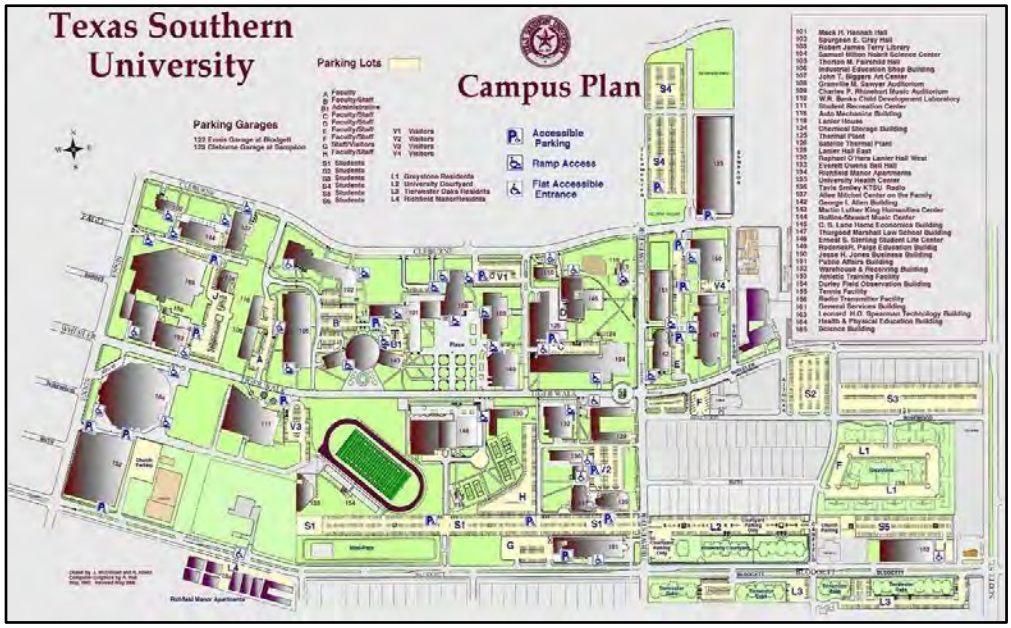
Affordability is influenced by the more comprehensive health financing system and household income. In the context of environmental inequality, the vulnerable population will be an individual or group of people who cannot cope, adapt, resist, or recover from the impact of the disproportionate exposure to environmental hazards through their proximity to public transportation hubs. According to the American Journal of managed care, vulnerable populations including but not limited to children, pregnant women, nursing mothers, late adulthood, the poor, racial and ethnic minorities, the uninsured, people experiencing homelessness, those with terminal or chronic health conditions, visual or hearing impaired, and educationally disabled (Hirsch, 1994) in the environmental justice framework are the minority and low-income communities. Therefore, this study will adopt the EJ framework and classify the vulnerable population as the racial minority and low-income populations below the poverty line.

3.4 Study Area Boundary

Texas Southern University, a Historically Black College and University (HBCU), is three miles southeast of downtown Houston and six miles east of Uptown. TSU comprises more than 45 buildings on a 150-acre urban gated campus with over 10,000 students (about the seating capacity of Cameron basketball stadium at Duke University). The TSU “Tiger Walk” campus study area, as shown in Figure 28, consists of a two-mile corridor between Tierwester and Ennis Street (East to West).

Figure 28

The TSU Tiger Walk Campus Study Area



Source: tsu-campus-map.pdf

3.5 Choice of Designated Bus Stop Location

Among the TSU AV shuttle vehicle bus stops along the TSU Campus Tiger Walk, three AV Stations have purposefully been selected for the study due to their distance between buildings, land use, size, the volume of pedestrians commuting by the bus stop, and campus activities.

3.6 Data Collection and Approach

A mixed quantitative and qualitative research approach was utilized to achieve this study's associated aims and objectives. However, at its core, the study was driven by a quantitative approach, and less of a qualitative approach was used to complement the quantitative approach. In this study, data gathering was carried out through both primary and secondary sources. The quantitative spatial analysis of this study's population is a Google map based on the population living near Texas

Southern University Campus Tiger Walk. Therefore, the evidence for the study will be collected primarily from secondary data sources.

3.7 Primary Data Sources

To obtain the primary data, a structured online questionnaire guides survey instruments to solicit information from the following respondents: those living near the TSU Tiger Walk AV Shuttle stations (nearby students), informal university participants (faculty), and Texas Southern University Staff. Other primary data sources for socio-economic and demographic information include the website of the US Census Bureau.

3.8 Questionnaire Survey

For the current research study, a structured online questionnaire survey instrument was utilized to obtain the primary data to solicit information from undergraduate students, faculty, and staff of Administrative Justice, Political Science, and Psychology undergraduate classes to establish who took the driverless shuttle when enrolled in classes for 2019 summer, fall and spring 2020 sessions, for this purpose to understand the experiences and perceptions of the student, faculty, and staff commuting within a 1⁄4 and 1⁄2 mile by a driverless shuttle bus along Texas Southern University Campus Tiger Walk during a pilot study. In addition, the researcher obtained permission for instruction by email to administer questionnaires to undergraduate students of more significant Political Science, Administrative Justice, and Psychology classes with information that addressed the following areas.

- **Socioeconomic characteristics of the respondents**: information on variables like age, race, gender, education, transport mode on campus, and vehicle use were captured to understand the direct link of listed issues.
- **Attitudinal:** Questions regarding driverless shuttles were adapted from questions that have previously been validated in other studies, like Kolodge et al. (2020) Mcity driverless shuttle: What we learned about consumer acceptance of Automated Vehicles; Schoettle and Sivak (2015) a survey of public opinion about autonomous and self-driving vehicles in the U.S., the U.K., and Australia; Kaur et al. (2018) trust in driverless cars: investigating key factors influencing the adoption of driverless cars and other literature. These concerns would comprise the following mode of transit outcomes; commuting by self-driving vehicles, not driving, and human riding in a self-driving vehicle with no driver controls available. In addition, safety, comfort, cost, stress, and time savings are commuting behavior concerns.
- **Built Environment:** Environmental factors from land use (number of stops, congestion, and shuttle route).

3.8.1 Secondary Data Sources

This research's secondary sources will be obtained from Driverless Shuttle observations along the Tiger Walk. In addition, data from the Texas Southern University Tiger Walk showed the locational features and analysis of the driverless shuttle, which included three designated bus stop data. Finally, peer-reviewed journal articles, conference papers, reports from government agencies, newsletters, internet sources, government agencies websites, and newspaper articles provided a reliable source of background information about the study. Also, they brought forth issues that should have been noted by other means to demonstrate demographic acceptance, safety confidence, software security concerns, technology familiarity and interest, and preference for human control.

3.8.2 Statistical Methods of Data Analysis

The research will adopt a series of statistical models to test and analyze the data collected. Specifically, descriptive statistics describe the demographic profiles of students, faculty, and staff, and findings will be statistically interpreted using SPSS version 22. In addition, the research will adopt a mix of statistical analyses such as T-Test, Z-Test, Chi-square, and Regression Analysis to test the hypotheses and analyze the results. Based on the data collected, which attempt to measure driverless shuttle experiences and perceptions amongst students, faculty, and staff along with the TSU Campus Tiger Walk to determine the driverless shuttle's impacts on the overall transit-dependent population in the Third Ward community.

3.8.3 Data Analysis

This study intends to identify the different environmental transportation problems along the TSU Campus Tiger Walk. Student, faculty, and staff information captured via primary sources were gathered, categorized, and analyzed for this study. First, the data collected were organized in the Statistical Package for Social Science (SPSS). Then, a statistical analysis of data involving basic descriptive statistics (frequency counts, percentages, means, and standard deviation) was completed to provide insight into the frequency distribution of the variables (socioeconomic factors).

3.8.4 Variable of Interest

Several variables have been identified in the EJ literature and regulatory agencies as indicators of community well-being or potential vulnerability to environmental injustice. However, the most common demographic variables are race/ethnicity and income. They may be measured in diverse ways to investigate the sociodemographics of each census tract around the TSU Tiger Walk. This study will examine six racial and socioeconomic independent variables in Table 4 below. The variables were chosen because they have been identified in the EJ literature and through agency

research as critical measures of the minority and the community's well-being. The independent variables are defined as follows:

Table 4

Independent Variables Utilized in Study

Variables	Description of variables
(1) Race/ethnicity	
Black or African American	Proportion (%) of Black population
White	Proportion (%) of White population
Asian	Proportion (%) of Asian population
Hispanic or Latinx	Proportion (%) Hispanic or Latinx population
Native American/ American Indian	Proportion (%) of Native American/ American Indian population
Other	Proportion (%) of other population
Socio-economic Characteristics	
(2) Dorm to class	Those who rode shuttle along Tiger Walk
(3) Disabilities	Those with disabilities
(4) Transport Mode used TSU Campus	Pass car, Motorcycle, SUV, UV, Other, I do not drive
(5) Distance Between Stops	¼-mile, ½-mile, and 1-mile
(6) Variable Time Intervals	Morning (8a.m.) Mid-day (12p.m.) Evening (5p.m)

Source: Rayford Richardson

3.8.5 Statistical Procedures and Model Selection

This part of the research study discussed the development of the regression analysis. A statistical model, and the responses of attitudes that significantly impact the student, faculty, and staff travel time, identify the dependent variable and validate independent variables and how they will impact the dependent variables. In addition, linear tests were utilized to understand driverless

shuttle experiences and perceptions amongst students, faculty, and staff, along with the TSU Campus Tiger Walk, to respond to the research questions.

3.8.6 Statistical Analysis

Statistical analysis involves collecting and examining data to conclude the information they contain using systems or software. For example, the environmental justice hypothesis has always been that minority and low-income communities are disadvantaged by transit accessibility. Therefore, the statistical analysis aims to objectively determine the direction of the relationship between the variable sets (either positive or negative) and the degree of the relationship and to know if these relationships are statistically significant. Thus, statistical analysis is essential in this study to support the spatial conclusions observed with Google Maps.

Several studies have used various statistical methods to describe the relationship between accessibility and sociodemographics as evidence of extreme environmental conditions (Mavoa et al., 2012). For example, some EJ research used generalized linear or multivariate regression (linear statistical methods) to test for correlation between environmental factors and transit-dependent population characteristics. In contrast, some studies have used logistic regression and inferential statistics to test for significant differences between vulnerable and non-vulnerable populations. The variables used throughout the study measure racial/ ethnic and social characteristics.

This study's statistical model will be framed around the research question and objectives. The first research question compares the demographic and socioeconomic characteristics of proximate areas that do not have adequate transit. Therefore, to decide if the observed differences

are significant. The first statistical analysis compared the means of two populations, primarily for the population's standard deviation, to test the mean of one population against a standard deviation. The second analysis was where separate tests were used for the percentage of the descriptive statistics.

First, the differences in sociodemographics along the TSU Tiger Walk within the census tract of the Third Ward will be examined. This comparison will help better understand the spatial configuration of the socioeconomic disparities associated with driverless shuttle transit. The third analysis, multiple regression, explains the significant relationship between a continuous dependent variable and two or more independent variables contributing to the outcome (Babbie, 2013). Several types of research using the environmental justice framework have used multiple regressions to investigate and analyze the relationships between a population's sociodemographic and transportation modes between TSU AV stations. The Statistical Package for Social Science (SPSS) will analyze the data.

3.8.7 Model Structure Explanation

This part of the research study discussed the development of the regression analysis—a statistical model, including the explanation of each environmental factor affecting transit-dependent populations. In response to the research questions, linear tests were utilized to understand the driverless shuttle, the TSU Tiger Walk, and its future impact on transit-dependent populations. In addition, multiple linear regressions were utilized to investigate the environmental factors affecting the transit-dependent population. This investigation is an extension of linear regression in which more than one independent variable (X) is used to predict a single dependent variable (Y). In multiple

regressions, the interrelationships among all the variables must be considered in the weights assigned to the variables. For example, with three independent variables, the prediction of Y is expressed by the following equation:

$$Y = f(X)$$

$$Y = f(ENV, DC, Distance)$$

ENV= Time Intervals, Transport mode, Vehicle on campus

DC= demographic characteristics

D=distanced measured

The most common demographic variables are race/ethnicity and income. However, they may be measured differently to investigate each socio-economic and demographic characteristic along the Texas Southern University Campus Tiger Walk. The dependent variable to be examined in this study is whether each AV station is within a 1/4-mile, 1/2-mile distance, and 1 mile to a transit station. The dependent variable is the Autonomous shuttle measured with three options: travel distance between stops, time intervals, students, demographic characteristics, faculty, and staff near the TSU campus.

- The independent variables are race, travel mode, transport mode used on campus, the distance between stops, time of travel (intervals) morning, mid-day, evening, and faculty and staff income near TSU Campus.
- A ½ distance was chosen because longer commute times to employment may affect students, faculty, and staff.

The statistical analysis of data, which involves basic descriptive statistics (frequency counts, percentages, means, and standard deviation), was completed to provide insight into the frequency distribution of the variables (socio-economic factors). Also, a linear regression was used to test for

the relative strength of the association between the built environment, demographics, characteristics, and variable time intervals of a driverless shuttle. Finally, a quantitative multi-regression analysis was used to determine the percentile of respondents and the significance of various transportation experiences they may have encountered due to the impact of a driverless shuttle and to identify critical variables that predict the knowledge indicators. The statistical significance defined for this analysis was $p < 0.05$.

Finally, the correlation coefficient was used to test for the relative strength of association between the social-economic variables of self-reported characteristics and the distance between bus stop locations. Some EJ research used logistic regression to test the relationship between environmental factors and proximate population characteristics. In contrast, some studies have used linear regression and inferential statistics to test for significant differences between vulnerable and non-vulnerable populations. The variables used throughout the study measure racial/ ethnic and social characteristics.

3.9 Expected Outcomes

The study will show transportation inequity on the Texas Southern University campus for transit-dependent populations and the possible effects of connecting driverless shuttle buses to METRO bus stops and light rail platforms in the Third Ward neighborhood. The new research will add to the growing literature surrounding Environmental Justice and its impact on Autonomous Shuttle Transit for HBCU campuses. Finally, this literature will aid policymakers with an EJ framework for Autonomous Shuttle vehicles. This framework will bring comprehensive legislation for communities of color that requires MPO regional planners and transportation professionals to seek an all-inclusive transportation network system.

CHAPTER 4

4.0 Results and Discussion

The preceding chapters in this study examine the relationship between the built environment and the future impact of a driverless shuttle as an additional sustainable mode of transportation for transit-dependent populations bicycling and walking along the Texas Southern University Campus Tiger Walk. The present chapter explores the social and economic factors of students, faculty, and staff in the Houston Third Ward neighborhood. This dissertation is also concerned with whether Environmental Justice has played a role in safeguarding students, faculty, and staff compared to Third Ward's transit-dependent population, which only has subdivision regulations for protecting residents from transportation exclusion. Finally, the dissertation is based on TSU students, faculty, and staff, with the future intention to use Autonomous Shuttle Transit, a driverless vehicle, as an additional mode that would later be introduced to the Third Ward community.

The TSU AV shuttle pilot was used to investigate the experiences and perceptions of students, faculty, and staff commuting within a ¼ and ½-mile closed loop along the Texas Southern University Campus Tiger Walk.

Research question #1 Do driverless shuttles provide another mode of transportation for a transit-dependent population?

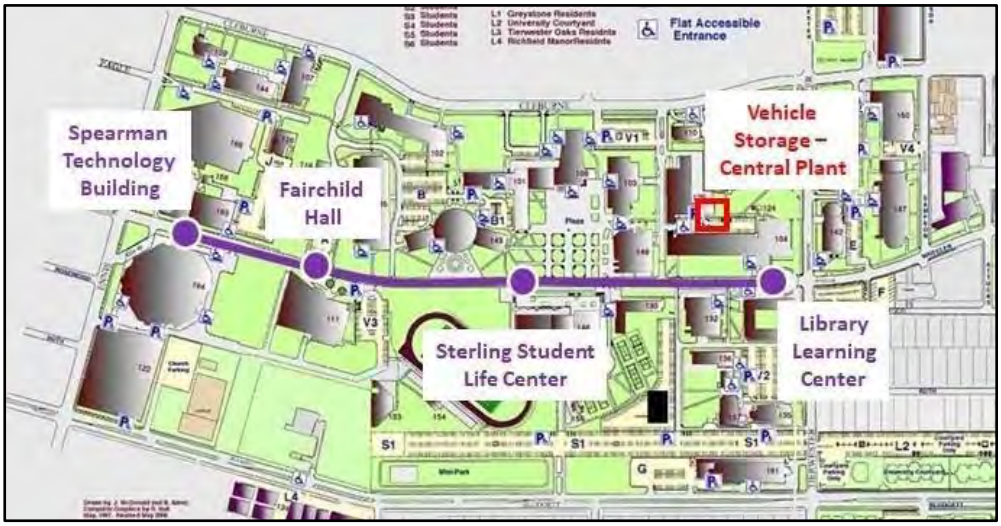
For research question # 1, the main objective is to review and describe the conditions of using a driverless shuttle as an additional mode of transportation for students, faculty, and staff walking and bicycling along with the TSU Campus Tiger Walk.

4.1 Texas Southern University Campus Tiger Walk

To achieve "Equity" in the utilization of a Driverless Shuttle in Third Ward, which is a community that is (66.9) percent "Black-African American." The Easy Mile Autonomous Shuttle bus was introduced to Texas Southern University Tiger Walk by METRO as a pilot in the residential area of Third Ward. They planned to drive there for six months in total. This study aims to understand whether frequent Autonomous Shuttle buses facilitate public transport instead of walking and bicycling. The TSU AV route on Wheeler Avenue covers a ½-a mile along the TSU Tiger Walk, as shown in Figure 29.

Figure 29

The TSU Tiger Walk AV Stations



Source:*https://www.h-gac.com/getmedia/5467d78f-8b9c-4ccf-966f-50228fb35463/TSU-AV-Pilot-Final-Report-October-2020*

The West Parking Garage and the 4 Beechnut METRO bus stop on Ennis Street at Wheeler Avenue are within walking distance of TSU Tiger Walk, as is the Spearman Technology Building AV stop (TSU AV, 2020). For example, walking 797 feet from the West Parking Garage, as shown in Figure 30, to the Technology Building AV stop takes three minutes (0.15 kilometers) (TSU AV, 2020).

Figure 30

West Parking Garage

Source: Rayford Richardson

The walk from the METRO bus stop to the Technology Building AV stop is around 427 feet (0.08 kilometers) long and takes approximately two minutes (TSU AV, 2020). Once on the Texas Southern University campus, the Tiger Walk AV path, shown in Figure 31, is over 2,000 feet long (about twice the height of the Empire State Building) (TSU AV, 2020).

Figure 31

TSU Tiger Walk AV Path

Source: Rayford Richardson

The first AV Station on Wheeler Avenue and Ennis is 81 feet from the Spearman Technology building, as shown in Figure 32. In addition, the USPS AV stop is 453 feet apart (0.08 miles), as shown in Figure 33 (TSU AV, 2020). Ordinarily, a two-minute walk between the USPS AV stop and the Sterling Student Life Center AV stop is 528 feet, also an option (0.1 miles) (TSU AV, 2020).

Figure 32

Spearman Technology building AV Station

Source: Rayford Richardson

Figure 33

TSU US Post Office AV Station

Source Rayford Richardson

Alternatively, it is a three-minute walk from the Sterling Student Life Center AV station to the Library Learning Center AV stop, which is 1,056 feet (0.2 miles) (TSU AV, 2020). The

Spearman building and the library also have one AV stop. The Sterling Student Life Center and Hanna Hall administration buildings across from each other share the same east and westbound stops with two stations, and those with separate east-west bound AV stops, as shown in Figure 35. Therefore, two of the four stops have separated each east and westbound stop, as shown in Figure 34.

Figure 34

Sterling Student Life Center and Hanna Hall East - West bound AV Stops

Source: Rayford Richardson

Figure 35

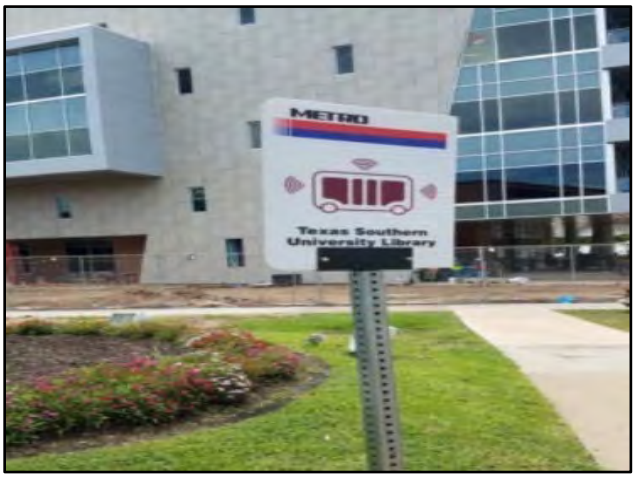
East and West Bound AV Stops

Source: Rayford Richardson

The TSU Library Learning Center AV stop, as Figure 36 shown, is the closest to the East Parking Garage. Figure 37 shows the METRO bus stop on Cleburne Street at Tierwester Street. Comparatively, the East Parking Garage is 1069 feet (0.2 kilometers) from the TSU Library Learning Center AV stop, a five-minute walk (TSU AV, 2020).

Figure 36

The Library Learning Center AV stop



Source: Rayford Richardson

The Library Learning Center AV stop is 922 feet (0.17 kilometers) from the METRO bus stop on Cleburne at Tierwester, a four-minute walk (TSU AV, 2020).

Figure 37

East Parking Garage on Cleburne

Source: Rayford Richardson

4.2. Case area

Third Ward is a low-density, single-use area of suburban character. For this reason, the distance to Houston's downtown Central Business District (CBD) is around 1 mile. Ordinarily, the travel time by regular bus is 15 min. Similarly, the TSU AV shuttle, an additional mode, was introduced by METRO as a pilot for the first last-mile transportation option, coupled with providing connections to multiple points and buildings on the TSU campus for students and faculty (Metro Magazine, 2019).

4.3. Overall Discussion

Based on the preceding analysis's characteristics and features, the Tiger Walk tends to be the driverless shuttle's current conditions and operations study area. In addition, one could clarify that the TSU Campus intends to sustain a campus atmosphere. Based on the TSU Tiger Walk reviews, HGAC planning laws allow the introduction of autonomous vehicles – in this case, autonomous buses – for testing their impact on road safety, traffic efficiency, and mobility. As part of a more extensive mobility program, the idea is to become the University District Automated Vehicle project in the Houston region.

4.4 Criteria and Restrictions for Autonomous Shuttle Transit Land Use

The Department of Transportation's National Highway Traffic Safety Administration allows for six levels of self-driving vehicles: Automation Levels 3 and 4, as shown in Table 5, are the two-level types accepted for commuting based on pilot study authorization. Level 3 automation under specific traffic or environmental conditions, the onboard staff cedes complete control of all safety-critical functions. It relies heavily on the vehicle to watch for any changes in situations requiring a transition to the driver (NHTSA, 2013). While level 4 monitors roadway conditions and acts solo, performing all safety and critical driving functions fully driverless for the trip (NHTSA, 2013).

NHTSA permits the authority to operate driverless shuttles on roads, highways, and closed-loop settings. Therefore, pilot trips accepted by a particular driving environment are subject to the pilot study provision and limitations.

Table 5

Levels of automation accepted for pilot studies in Texas.

Automation Pilots	Level 3 Automation	Level 4 Automation
Under certain traffic conditions or environmental conditions, the onboard staff person cedes full control of all safety-critical functions and relies heavily on the vehicle to watch for any changes in situations requiring a transition to the driver.	✓	✓ (Limited)
Monitor roadway conditions and act solo, performing all safety and critical driving functions for an entire trip fully driverless.	✓	✓
NHTSA permits the authority to operate driverless shuttles in closed loop settings and on roads and highways.	✓	✓
Senate Bill 2205 requires driverless highway vehicles to comply with all traffic laws. Equipped with video recording devices and be insured just like other cars (Formby, 2017).	✓	✓
The Self-Drive Act permits driverless vehicles testing on road and highways without a driver behind the wheel (Formby, 2017).	✓	✓
Manufacturers are responsible for any broken traffic laws or car wrecks if the automated driving system has not been modified by anyone else.	✓	✓

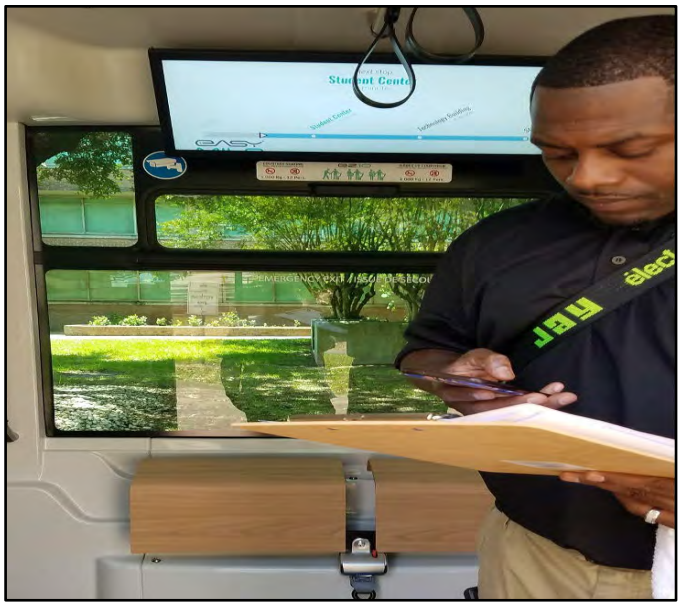
Source: The U.S. Department of Transportation's National Highway Traffic Safety administration https://www.tceq.texas.gov/assets/public/permitting/waste/msw/msw_disposal_matrix.pdf

Under all conditions, table 3 shows that level 3 automation requires driverless vehicles on highways (equipped with video recording to be insured just like other cars). For this purpose, manufacturers are responsible for broken traffic laws or car wrecks if anyone else has not modified the automated driving system. On the other hand, level 4 limited safety-critical functions rely heavily

on the vehicle to monitor any situation changes. As a rule, traffic conditions in a level 4 automation exhibit minimal or reduced human error in situations requiring a driver's transition, as shown in Figure 38. Outside level 4, automation receives less human control than level 3.

Figure 38

TSU Shuttle requires a driver along Tiger Walk.



Source: Rayford Richardson

Nationally there have been ten (10) level 4 automation pilot studies. As a rule, based on the study's peculiarity in examining Environmental Justice and the impact of driverless shuttles for transit-dependent populations along the Texas Southern University Campus Tiger Walk. For this purpose, level 4 automation will be focused on in this dissertation research. First, however, a descriptive statistical analysis will be carried out in the Greater Third Ward Metropolitan area on hosting level 4 automation compared with other automated shuttle projects hosting Type 4 automation. Table 6 lists all level 4 pilot studies nationally, showing the year they launched in 2016.

Table 6

Selected level 4 Automated Shuttle Pilot Launch in the United States

#	City, State	Deploying Organization	Launch Date	Shuttle Manufacturer
1	National Harbor, Maryland	Local Motors, IBM	16th June 2016	Local Motors
2	San Ramon, California	Contra Costa Transportation Authority (CCTA), Bishop Ranch Office Park	2013	EasyMile
3	Jacksonville, Florida	Jacksonville Transportation Authority (JTA)	1998	EasyMile
4	Greenville, South Carolina	University Campus	1973	Cushman
5	Arlington, Texas	Blue Ridge Landfill	1992	EasyMile
6	Las Vegas, Nevada	Fort Bend Regional Landfill	2004	Navya
7	Weymouth, Massachusetts	Galveston County Landfill	1978	Optimus Ride
8	Minneapolis, Minnesota	Coastal Plains Landfill	1985	Easy Mile
9	Gainesville, Florida	University Campus	1971	EasyMile
10	Ann Arbor, Michigan	University Campus	1978	Navya
11	Houston, Texas	University Campus	2019	EasyMile

Source: (Mohsena & Candace 2020).

Texas Southern University possesses a unique travel characteristic. In addition, METRO, the City of Houston, and HGAC Highway planners have long acknowledged trip generation formulas that rely on socio-economic data that do not produce valid results in Environmental Justice neighborhoods near university settings. For example, level of income, the number of students with vehicles, and employment status cease to be valid indicators of travel behavior. Campus communities with an approximate population of 10,000 (about the seating capacity of Cameron basketball stadium at Duke University), such as Texas Southern University, as shown in Figure 39, strongly possess the housing density that should consider any fixed-route Autonomous Vehicle shuttle.

University policies intended to sustain a pedestrian campus atmosphere combined with the general propensity of students to live in group settings have resulted in population densities in these small university communities that are reflective of densities seen in larger urban areas. In turn, these higher housing densities strain the transportation system disproportionate to the community's size.

Figure 39

Texas Southern University Autonomous Vehicle fixed route location

Source: Rayford Richardson

The driverless buses on TSU's campus ran during the trial program from June 2019 through February 2020. The TSU AV were self-driving electric shuttle buses that could transport up to eight people and a host, as shown in Figure 40. The buses travel at a maximum speed of 18 km (about 11.18 mi/h) and are not entirely automated, as they pursue a fixed route (Ruter, 2020). Although technology does not allow the bus to deviate from its predetermined route, the host on board may be able to steer past bus barriers, manually operate the vehicle and provide necessary support information.

AV technology does not allow the bus to deviate from its predetermined route. The host on board may be able to steer past bus barriers and adjust its speed based on the distance to the

surroundings and other road users. It stops if another road user comes close. The bus cannot distinguish between different objects, so its reaction is identical to any object scanned by its sensors. For this reason, the driverless shuttle bus cannot operate in case of heavy precipitation (Lopatka, 2019).

Figure 40

Self-driving Electric Shuttle Bus

Source:https://www.h-gac.com/getmedia/5467d78f-8b9c-4ccf-966f-50228fb35463/

Instead, the driverless shuttle bus drives using sensors continuously gather data on the surrounding objects, vehicles, and pedestrians. It uses light detection and ranging (LIDAR) sensors (8 sensors, four front and four rear), a global navigation satellite system (GNSS) for positioning, an odometer for scroll wheel information, and an inertial measurement unit (IMU) that measures the bus movement pattern to recognize speed bumps and distortions along the route (Ruter, 2020). Three AV bus stops have been chosen to cover the current study due to the driverless shuttle's predetermined route.

Research Question #2:

Is there any relationship between racial and socio-demographic characteristics of areas that do not have adequate transit?

For research question # 2, the research started with 300 currently enrolled undergraduate participants who rode the driverless shuttle along with TSU Campus "Tiger Walk." The essential qualifications of respondents for the study were any adult at least 18 years old, as the Urban Planning and Environmental Policy department adheres to research with undergraduate students. The TSU AV Shuttle pilot study survey was anonymous from January 27 to March 21, 2022. The data was collected online through Survey Monkey questionnaires, observations, and discussions from various subjects of Political Science, Administrative Justice, and Psychology undergraduate classes. In addition, survey discussions were held with the faculty to gain permission and their perspectives and viewpoints to administer the questionnaires.

Before meeting with various subjects of Political Science, Administrative Justice, and Psychology undergraduate classes, a QR code was created for the survey instrument and piloted with six subjects from a Political Science class, one faculty, two graduate, and three undergraduate students. The QR code worked for 4 of the six subjects but did not work for two other subjects studied: one had already looked at the survey, and the final respondent's camera would not pick up the QR code. After completing the survey, the data was imported from Survey Monkey, coded in Excel, and entered by computer for statistical analysis using SPSS version 22. Frequency tables were adopted as a statistical model for analyzing the demographic profiles of respondents and reports of the questionnaire variables.

A mix of regression analysis, cross-tabulations of data, t-tests, and chi-square tests were used to measure the set of hypotheses. For a straightforward presentation of measurable data, variables on the survey questionnaires were regrouped into categories and ranges appropriately imputed into the SPSS for measurement. The results are presented in the following tables and bar charts divided into three sections: the informal and formal sector results. The last section of the chapter deals with analyzing the hypotheses, results, and finding.

Of the initial 261 respondents surveyed, 36 questionnaires were disqualified from the study sample for the following reasons. The first reason resulted from incomplete answers to relevant questions in the questionnaires. Others still need to sign the consent form. Table 7 shows the social-demographic characteristics of student, faculty, and staff respondents.

Table 7

Demographic and Socio-economic characteristics of Student, Faculty and Staff Respondents

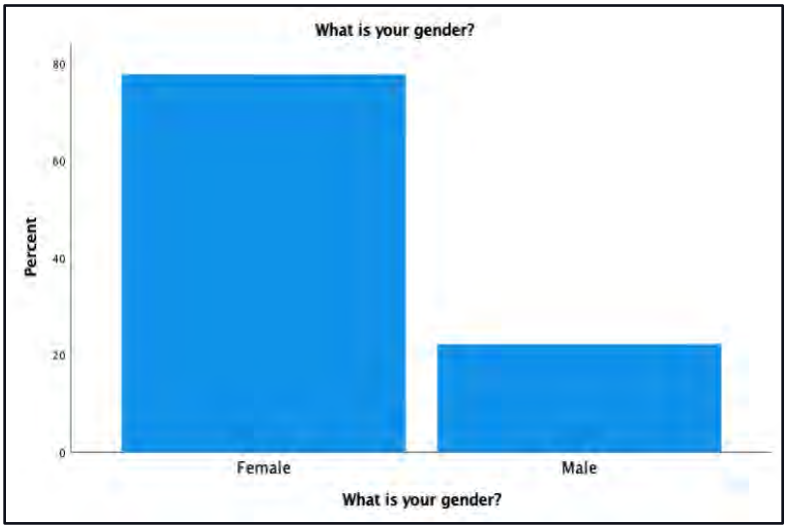
Characteristics Tiger Walk Students, Faculty, and Staff	**Frequency**	
	N	**%**
Age (Years)		
18-24	197	87.56
25-34	13	5.78
35-44	9	4.0
45-64	6	2.67
65+	0	0
Total	**225**	**100**
Gender		
Male	53	23.56
Female	172	76.44
Total	**225**	**100**
Ethnicity or Race		

White	4	1.78
Black or African American	203	90.22
Hispanic or Latino	13	5.78
Asian	1	0.44
Native American/ American Indian	0	0
Other	4	1.78
Total	**225**	**100**
Level of Education /Income		
Undergraduate ($13,908)	214	95.96
Graduate ($50,029)	7	3.14
Other	2	2
Total	**223**	**100**
Vehicle Used Most		
Pass	95	42.22
SUV	27	12
I do not drive	82	36.44
UV (Utility Vehicle)	4	1.78
Other	17	7.56
Total	**225**	**100**
Transport Mode		
Walk	201	89.33
Bike	2	0.89
Autonomous Shuttle	6	2.67
Other	16	7.11
Total	**225**	**100**

Of the initial 300 respondents, 225 were from sampling Political Science, Administrative Justice, and Psychology undergraduate classes. In addition, the data show that 77.8% of the total respondents were female, and 22.2% were male, as shown in Figure 41.

Figure 41

Gender of Respondents

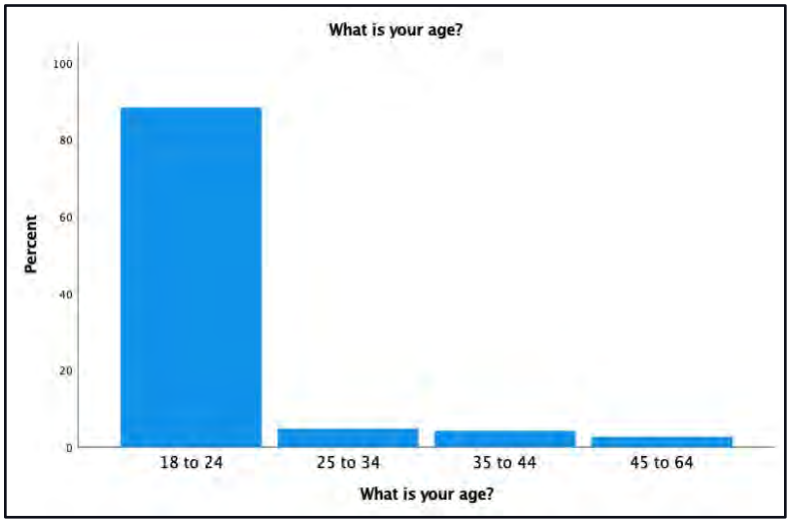


Source : Rayford Richardson

None of the participants was under 18 years old in age distribution. The data reveals that 87.56% of the participants were within the age bracket of 18-24. While the following represents the other age groups in the survey: 25-34 years represents 5.78%, the 35–44-year age group represents 4.0%, and only 2.67% of the respondents were in the age bracket of 45-64. This result shows that the leading age groups (18-24 years and 25-34 years) fall within the undergraduate group, as shown in Figure 42. According to similar research studies by (Guisai et al., 2014; Medina, 2000), this proves that being part of the transit-dependent population or riding the driverless shuttle is a viable additional mode of transportation with some benefits. Furthermore, the presence of respondents within the age group of 18-34 years shows pointers to the poverty level in society (Guisai et al., 2014).

Figure 42

Age of Respondents

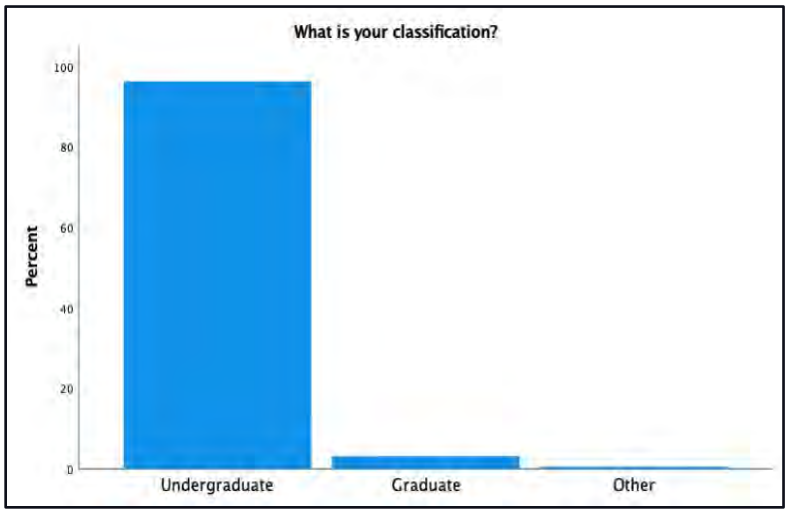


Source : Rayford Richardson

Figure 43 shows that 95.96% of the respondents were undergraduate students in educational attainment. 3.14% of the respondents were graduate students, while 0.9% attained other education.

Figure 43

Education Attainment



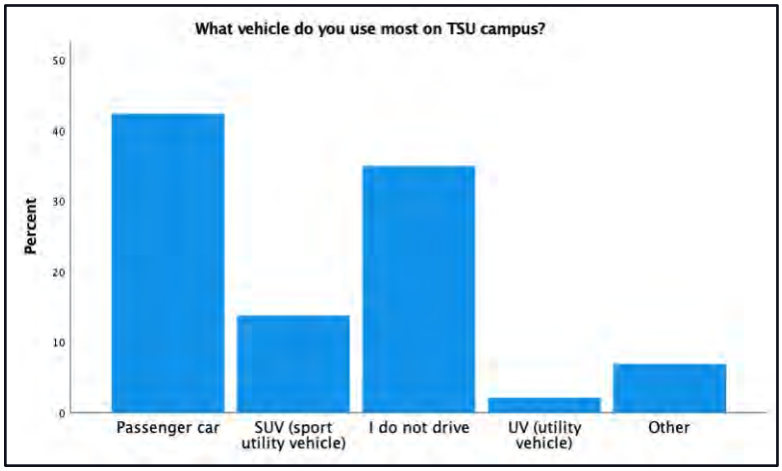
Source : Rayford Richardson

4.5 Vehicles used on TSU campus

Figure 44 indicates the vehicles students, faculty, and staff use along the TSU Tiger Walk. The results showed that out of the total respondents, 42.22% used passenger cars, 36.44% did not drive, only 12% used SUVs, 7.56% used other modes, and 1.78% of respondents used utility vehicles.

Figure 44

Vehicles used most on TSU Campus



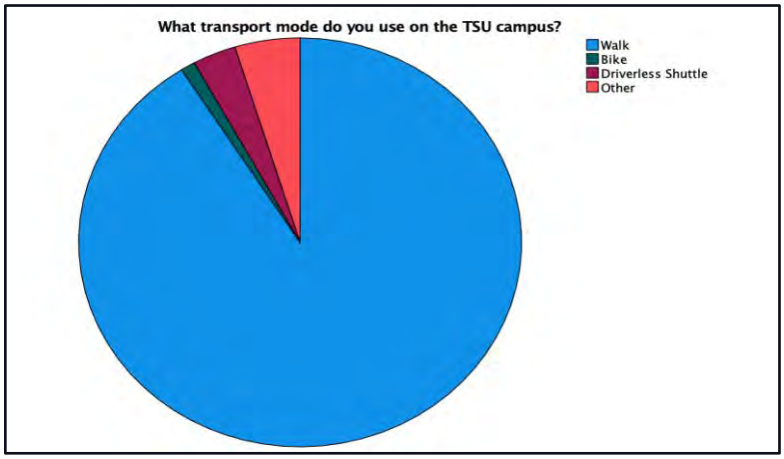
Source : Rayford Richardson

4.6 Transport mode used on TSU Campus

Figure 45 shows the transport mode used on TSU Campus among students, faculty, and staff, where 89.33% walk, 0.89% bike, 2.67% use the driverless shuttle, and 7.11% use other transport modes.

Figure 45

Transport mode used most on TSU Campus

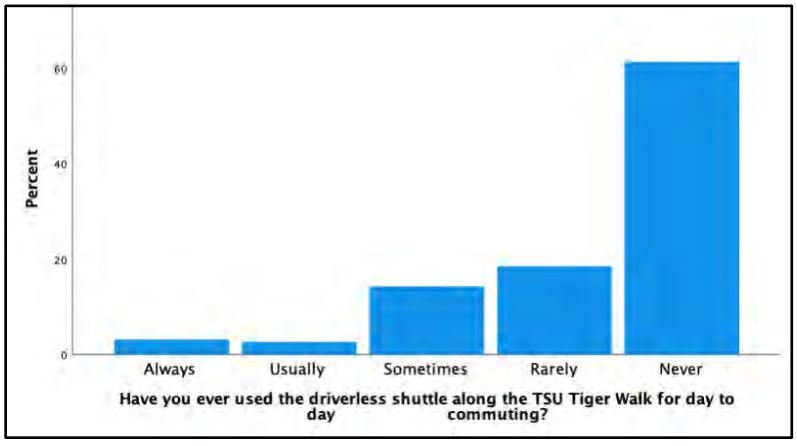


Source : Rayford Richardson

The survey included a question: Have you ever used the driverless shuttle along the Tiger Walk for daily commuting? Figure 46 represents the results for this question. Of most respondents, 61.61% noted they never used the shuttle, while 18.3% indicated that they rarely use the shuttle bus.

Figure 46

Respondents that used Driverless Shuttle day-to-day for commuting



Source : Rayford Richardson

The survey data were examined with linear regression to see whether a driverless shuttle would provide another mode of transportation. In addition, respondents were asked to respond to several statements about their travel attitudes and experiences using a five-point Likert scale during the survey. The 35 statements in (Appendix I1) focused on demographics and driverless shuttle characteristics, attitude, and the built environment surrounding the TSU AV stations. The survey also asked respondents: What transport modes you used most on the TSU Campus Tiger Walk?

4.7 Interpretation of Autonomous Shuttle Results

The descriptive statistics of the 225 survey evaluations, as shown in Table 8, indicate the mean score for the independent variables. It also depicts the standard deviation of block groups. Table 20 shows the highest mean score of 3.74 on a scale of 5, while other independent variables evaluated for the Autonomous Shuttle recorded high mean scores ranging from 1.20 to 3.74. Table 20 indicates that the Time Interval evaluated scored higher (Median: M = 3.74, Standard Deviation: SD = 1.75) than the other five variables evaluated. Other significant impact variables include Race (M = 2.08, SD = 0.39) and Dorm to Class (M = 1.54, SD =0.05). It also includes transportation modes on campus (M= 1.19, SD = 0.56), Metro service (M= 2.87, 1.37), and Disability (M =1.33, 0.47).

Table 8

Descriptive Statistics of the neighborhood environment for census tract block groups (N=225); average household income was calculated for median not mean.

Independent Variables	N	Min	Max	Mean	Std. Dev	Var.
Race	225	1.00	4.00	2.08	0.398	0.352
Transportation Mode	225	1.00	3.00	1.19	0.056	0.224
Time Interval	225	1.00	5.00	3.74	1.759	3.095
Metro service (Multimodal)	225	1.00	5.00	2.87	1.376	1.894
Disability	225	1.00	2.00	1.33	0.473	0.224
Dorm to Class	225	1.00	2.00	1.54	0.500	0.250

Dependent Variable: Autonomous Shuttle ride time
N= Number of Respondents

4.8 Analysis of Independent Variables Using Liner Regression

Linear regression analysis enables the prediction of the dependent variable using the independent variables. In this dissertation, a linear regression model developed allowed an analysis of the six independent variables to explain the mode of transport used. The independent variables measured in the study included the linear regression model set up for the study, as shown below:

$$Y = f(X)$$

$$Y = f(ENV, DC, Distance)$$

ENV= Time Intervals, Transport mode, Vehicle on campus

DC= demographic characteristics

D=distanced measured

(y) is related to the ENV (environmental factors affecting transport mode of students, faculty, and staff) = X_1, X_2, X_3, DC *(demographic characteristics)* = X_4, X_5, *(distance as measured)* = X_6 *by the following linear regression model.*

$$(y) = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4e + b_5x_5 + b_6x_6$$

Therefore, $(y) = b_0 + b_{1\ Time\ intervals} + b_{2\ Metro\ service}\ b_{3\ Transportation\ modes}\ b_{4\ Race} + b_{5\ Disability} + b_{6\ Dorm\ to\ class}$

$$(y) = f\ (x_1, x_2, x_3, x_4, x_5, x_6)$$

Where: P is the probability of the dependent variable (Autonomous Shuttle)

X_1 to X_n represents the independent variables.

n is the number of independent variables (n=6).

β_0 is the regression coefficient for the Y-axis intercept.

β_1 to β_n represents the regression coefficient for each independent variable (Mertler & Reinhart, 2016; Moore, McCabe, & Craig, 2009).

The independent variables measured in the previous Autonomous Shuttle study analysis include socio-demographic attributes like income and education level, attitudes towards travel, and travel preferences (Mouratidis & Serrano, 2021). This study incorporates environmental factors, race, socioeconomic characteristics, and distance traveled, known as equity and social justice. The equity and social justice principle allows the conceptualization and measurement of the disproportionate race, ethnicity, age, sex, and social and economic factors such as income, poverty, inadequate education (Shivayogi, 2013), and transportation mode's impact on vulnerable

populations. Characterizing vulnerable people relies on the established perspectives of equity and environmental justice (EJ) principles.

The description includes a balanced mix of gender and Age groups, Income, Race, Vehicles used on campus, and Time Intervals. Tables 21 of the statistical analysis outline the linear regression results using Statistical Package for Social Science (SPSS) software. The result of the linear regression, as shown in Table 21 below, indicates that race, people with disabilities, shuttle working with metro buses and transportation modes were statistically significant at a 95% confidence level, with a p-value less than 0.05 and a predictor of using the Autonomous Shuttle as an additional mode of transportation. This finding confirms the hypothesis of those who do not have adequate transit. However, most of the socioeconomic indicators were not statistically significant.

For example, race, people with disabilities, shuttle working with Metro buses, and transportation modes were significant. Time intervals when people used shuttle buses that worked with Metro bus service showed a negative correlation meaning the higher percentages of low-income undergraduates will walk, and those with disabilities will travel further. The results support the Environmental Justice claim that race is a significant predictor of areas without adequate transportation.

Table 9

Linear Regression
Dependent Variable: Autonomous Shuttle (ride time)

Variable	*B*eta	Std. Error	t	Sig.
Z_code Time Interval	-0.00	31.92	-0.023	0.22
J_code Race	0.21	67.45	2.567	0.01**
R_code Transportation Mode	0.25	55.72	3.005	0.03**
AB_code Dorm_class	0.46	3.211	0.350	0.72
BH_ Code Metro_service (Multimodal)	- 0.94	5.902	-2.798	0.01**
BN_ Code Disability	0.97	3.466	4.599	< 0.01***

Notes: *** p< 0.01; ** p< 0.05; * p< 0.1

Research Question #3:

Is there any relationship between race, socio-economic characteristics, and distance to the destination?

The objective is to compare the racial and socioeconomic characteristics of the distances between bus stops in Houston's Greater Third Ward. In answering this question, two different comparison approaches were made. The first was determining the walking distance within ¼ mile, 1/2 mile, and 1 mile using Google Maps (discussed in Chapter 3). Next, the demographics of the

Block groups 312700 and 312800, as shown in Figures 47 and 48, were compared to determine if there are any disparities.

Secondly, the sociodemographic characteristics of the TSU Tiger Walk within a ¼, and 1/2-mile distance of the bus stop (Tiger Walk) were compared to the area beyond the 1-mile distance into the Third Ward community. Finally, these comparisons were made longitudinally by examining the socioeconomic characteristics from the 2020 Census. Third Ward's transit-dependent population was examined in this comparison as specific racial and ethnic groups, such as percentages of White, African Americans, Hispanics, and Asians.

Figure 47

Block Group 3127000

Figure 48

Block Group 3128000

Source: https://statisticalatlas.com/block-group/

4.8.1 Results of Racial, Socioeconomic Characteristics and Distances between stops for Houston's Greater Third Ward using 2020 Census

The first approach in comparing the TSU Tiger Walk is to examine the characteristics of the racial and socioeconomic indicators using ¼-mile, ½- mile, and 1-mile distances between stops. This section used Google Maps to construct the three different scenarios.

4.8.2 Results of Distances between stops (¼, ½, and 1 mile) for B.G. 3127000-1 and 3128000-1 using the 2020 Census

Table 10 displays the results and the demographics of the TSU Tiger Walk and the distances between stops. The results show Blacks are less within a ¼-mile distance to bus stops (79.8%), increasing within a ¼-mile distance to bus stops (79.8%), increasing within a ½-mile (84.7%) to the bus stops and further increases (87.7%) within 1 mile of the other distances.

Table 10:

Results of the sociodemographic characteristics and distances between stops of B.G. 3127000-1, 3128000-1, and 3128000-2 for 2020

		2020		
		¼-mile	1/2 - Mile	1 -Mile
Total Population	4534			
Racial/ Ethnicity				
% White		14.6%	4.9%	7.0%
% Black		79.8 %	84.7%	87.7%
% Asian		0.0%	6.33%	2.90%
% Hispanic		5.6%	2.60%	2.0%
Other		0.0%	0.603%	0.0%

Socioeconomics			
Median household Income	$50,029	$13,908	$13,908

Source: https://data.census.gov/cedsci/profile/Block_Group_2,_Census_Tract_3128,_Harris_Count

The individual minority racial group all followed the same trend. The distance from the Spearman Technology building AV stop to the USPS AV stop is 453 feet (0.08 miles), as shown in Figure 49, or a two-minute walk. The distance from the USPS AV stop to the Sterling Student Life Center AV stop is 528 feet (0.1 miles), or a three-minute walk. The proportions of Blacks, Asians, and Hispanics were closer to the bus stop distance, and Hispanics decreased within 1/2 miles of the bus stop.

Figure 49

Distances Between Stops

Distance Between Stops			
	Feet	Miles	Minute
Technology Building AV stop to Post Office	453	0.08	2
Post Office AV Stop to Student Center	528	0.1	3
Student Center AV Stop to Library Learning Center	1056	0.2	3

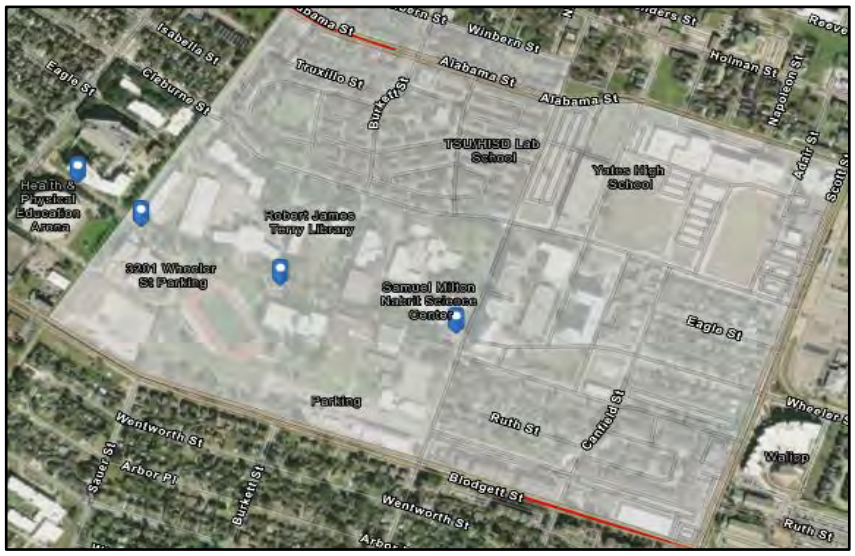
Source: Adopted from Texas Southern University Automated Vehicle. (2020, July 20). https://www.h-gac.com/getmedia/

Moreover, the distance from the Sterling Student Life Center AV stop to the Library Learning Center AV stop is 1,056 feet (0.2 miles), as shown in Figure 50, or a three-minute walk

(TSU AV, 2020). Although Blacks continued increasing within the 1-mile distance, Hispanics and Asians decreased. Whereas the percentages of White are more significant (14.6.%) closer to the bus stop (¼- mile), they decreased within a 1/2-mile distance (4.9%) and increased by 1 mile to the bus stop (7.0%).

Figure 50

Distances Along the TSU Camp Tiger Walk



Source: https://ricegis.maps.arcgis.com/apps/MapSeries/index.html

4.8.3 TSU Shuttle Ridership Boarding and Alighting

The three trips of each shuttle ride showed boarding and alighting from each stop. The highest frequency of passengers boarding not here was seen at stop number one, which included four passengers, as shown in Table 11. Concurrently, the highest alighting was also observed at stop two near the student center.

Table 11

Shuttle Eastbound and Westbound Volumes
Monday (M), Tuesday (T), Thursday (TH) (8 a.m. to 3 p.m.)

	E A S T B O U N D		W E S T B O U N D				
Station Location	Boarding (M)	Alighting (M)	Boarding	Alighting	Boardings	Alighting	Totals
Spearman	8:00	1	-	9:00	-	-	1
MLK Building	8:02	2	1	8:40	-	2	5
Student Center	8:04	-	1	8:20	2	-	3
Education	8:06	-	1	8:10	-	-	3
	(T)		(T)				
Spearman	9:00	2	-	10:00	-	-	2
MLK Building	9:02	1	-	9:40	-	4	5
Student Center	9:04	-	2	9:20	4	-	6
Education	9:06	-	1	9:10	-	-	1
	(TH)		(TH)				
Spearman	1:00	4	-	2:00	-	-	4
MLK Building	1:02	1	1	1:40	-	3	5
Student Center	1:04	2	4	1:20	3	-	9
Education	1:06	-	2	1:10	-	-	2
Totals		14	14		9	9	45

Source: Adopted from Internship Report Autonomous Shuttle Transit March 2018 by Rayford Richardson

4.9 Total Eastbound and Westbound Volumes

Most shuttle trips peaked at midday, with passengers traveling eastbound and westbound, as shown in Table 23. The study's large share of trips was made exclusively by the TSU Driverless Shuttle. In addition, a volume of students, faculty, and staff commuting within the university campus due to an influx of people congregating in a central region after class ends.

Table 12

Summary of East and West Bound Totals by Stops

Stop Location	Education Building	Student Center	MLK Building	Spearman	Total
Passengers Boarding (EB)	1	2	3	7	13
Passenger Alighting (WB)	-	-	4	3	7

Source: Adopted from Internship Report Autonomous Shuttle Transit March 2018 by Rayford Richardson

The socioeconomic indicators show that median household income was higher closer to the bus stop ($50,029) and reduced farther away from the bus stop by 1 mile ($13,908). Likewise, the percentages of people below the poverty show a decrease (13.4%) closer to the bus stops and an increase farther away (54.6%). Looking at educational attainment, the percentages of people with less than high school graduates and some college experiences are closer to the bus stops than people within 1 mile. Percentages of people with high school graduation were higher closer to the bus stop (57.7 %) than when farther away within a 1-mile distance (44.7 %). However, percentages of people with bachelor's degrees are lower closer to bus stops (24.4 %) and increase further away from bus stops (44.7 %).

Chapter 5

5.0 Summary, Conclusion and Recommendations

5.1 Summary of Findings

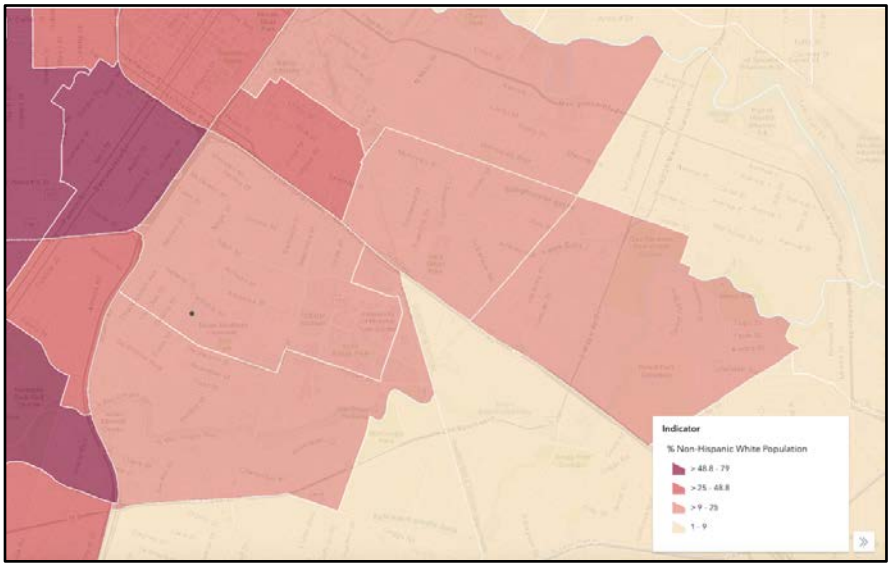
The study's main research findings are summarized in this section. The primary research question is: Do driverless shuttles provide another mode of transportation for a transit-dependent population? The current study sought to answer this fundamental question by reviewing the Texas Southern University Autonomous Shuttle Vehicle conditions and three designated AV stations for students, faculty, and staff in Houston's Greater Third Ward neighborhood. Therefore, to fill the research gap, this study examined the future impact of Autonomous Shuttle Transit along the TSU Campus Tiger Walk in Houston's Third Ward neighborhood.

Based on the study's first objective, having surveyed participants who used the Autonomous Shuttle along the TSU Campus Tiger Walk, higher percentages of low-income undergraduates between the ages of 18 and 24 were likely to travel farther than ½ mile along the Tiger Walk. To achieve the second objective, a comparison between demographics, socioeconomics, and of commuters living closer to bus stops than those who live further was necessary. Due to this, the data analyzed proved that students, faculty, and staff who used the shuttle nearby and far away are affected by bus stop location.

Google Maps examined the relationship between socio-economic characteristics near the bus stop location. Looking at the three scenarios given (¼-mile, ½-mile, and 1-mile), the data analysis in Figure 51 showed that Whites are 14.6% closer to the bus stop. They decreased within a half-mile distance (4.9%) and increased by one mile to the bus stop (7.0%).

Figure 51

Percentage of Non-Hispanic White Population

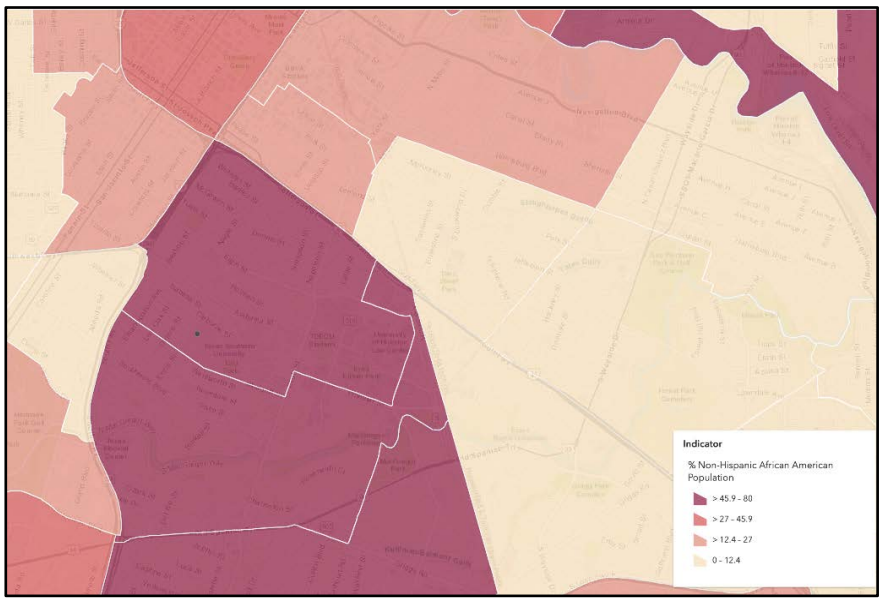


Source: ACS 5-yr Estimates 2015-2019

Whereas African Americans and other people of color, as shown in Figure 52, are less within a ¼-mile distance to bus stops (79.8%), increasing within a ½-mile (84.7%) to the bus stops and further increases (87.7%) within 1-mile distances. This finding supports the Environmental Justice claim that minorities and low-income transit-dependent populations live and walk further to and from bus stops.

Figure 52

Percentage of Non-Hispanic African American Population



Source: ACS 5-yr Estimates 2015-2019

However, The Case of Labor Community Strategy Center v. Los Angeles Metropolitan Transit Authority in 1996 showed inequalities in the distribution of funding and transportation operations primarily used by low-income transit-dependent commuters (Bullard & Johnson, 2000). It showed the inequitable funding and bus transportation operation. Likewise, TSU students, faculty, and staff Third Ward residents who live close and far away are at a disadvantage having to travel further without the driverless shuttle along TSU Tiger Walk, going to Cleburne Street in the Third Ward community. Comparatively, unlike students from Michigan University PWI that participated in the driverless shuttle pilot, most household income is $154,000, and 66% comes from the top 20 percent. At the same time, students at the University of Michigan came from poverty and were in the bottom fifth, making $20,000 or less per year (Harring & Sussman, 2019).

However, along the TSU Campus, Tiger Walk socioeconomic indicators show that median household income was higher closer to the bus stop ($50,029) and reduced farther away from the

bus stop by 1 mile ($13,908). In addition, whites' median family income decreases as traffic density increases (Schweitzer & Valenzuela, 2004). At the same time, lower socioeconomic groups have been shown to travel shorter distances with higher ridership in Utah, according to Farber et al. (2014). Therefore, the average income for faculty and staff employees living near TSU with shorter work commutes between 1 and 5 miles from work (Gorman & Bayer, 2019, p. 4).

Freemark (2020) states that transit service typically for people of color is 37 percent less than their wealthiest counterparts based on population. Recent findings show that Black Americans bear a double disproportionate burden of the current energy system through pollution exposure and excessive expenses due to ongoing wealth and housing disparities (Franzin, 2020). Underfunded public transportation in impoverished U.S. areas is 24 percent worse and is less accessible in urban areas with Black residents than in the fewest (Freemark, 2020). In addition, automated vehicles could also reduce the number of lane kilometers required by increasing lane capacity and lifecycle energy use of the road system in the urban areas with the highest poverty rates falling into the lowest quartile. How much they earn and their education is a practical guide to the lowest and highest income brackets (Gorman & Bayer, 2019).

Likewise, in this study, in Houston's Third Ward neighborhood, the percentage of people below poverty decreases (13.4%) closer to the bus stops and increases farther (54.6%). Furthermore, Rubensson et al. (2020) found that for Stockholm, a disproportionate number of longer trips were taken by lower-income passengers, for which distance-based fare needed to be more equitable. Finally, Wyczalkowski and Huang (2017) analyzed the geographical link between public bus routes and poverty in the Atlanta metropolitan area (Miller, 2018). The authors found that a public bus route in Atlanta's suburban census tracts is associated with an average increase in the poverty rate compared to census tracts without bus routes (Miller, 2018). However, as they highlighted, a fare

policy's equity outcome depends on the geographical distribution of income levels, land use, and travel patterns.

Looking at educational attainment, the percentages of people with less than high school graduates and some college experiences are closer to the bus stops than people within 1 mile. However, percentages of people with bachelor's degrees are lower closer to bus stops (24.4 %) and increase further away from bus stops (44.7 %). Under the circumstances, this exacerbates a pattern of race, class (Bullard, 2004), and a spatial mismatch between jobs, services, and housing (Bullard, 2000). White is significantly (14.6.%) closer to the bus stop (¼- mile). However, they decreased within a 1/2-mile distance (4.9%) and increased by 1 mile to the bus stop (7.0%). The results support the amenity-based theory (Brueckner et al., 1999) that higher-income persons locate themselves in places with excellent proximity to amenities (Malvika, 2021). Undoubtedly, Driverless Shuttle (DS) rideshare platforms reflect that higher-income whites are admittedly more likely to hold discriminatory attitudes toward fellow passengers of different classes and races (Middleton & Zhao, 2019).

In fact, upon investigating numerous challenges faced by respondents along the Tiger Walk, the driverless shuttle traveling at slow speeds was a significant challenge. For instance, morning commutes were longer for undergraduate students and when someone rode the shuttle. Both events are predominant along the Tiger Walk, morning peak hours before 9:00 a.m. and off-peak late after 1:00 p.m. In addition, more people are taking the shuttle and congregating at the central campus at midday. Finally, the long route is a common way by which the volume of pedestrians will reduce during evening classes.

The problems faced by students, faculty, and staff include the Autonomous Shuttle travels at slow speeds, and Blacks are also more likely to live near high-traffic roads than white people

(Howell, 2020). As a result, the shuttle cannot operate without a safety operator; Many students, faculty, and staff along the Tiger Walk are aware of the environmental risks of commuting with the driverless shuttle and other vehicles. Studies have found that Black pedestrians are also more likely to be hit than white pedestrians due to unsafe sidewalks, signage, and lighting in their respective communities (Howell, 2020). Most importantly, Blacks with dark skin may be more likely to get hit by a self-driving car than Whites because automated vehicles may better detect pedestrians with lighter skin tones (Samuels, 2019). In addition, pedestrian safety causes trips to be longer.

The above events result from TSU Shuttle failing to connect with the Metro bus service. Studies have shown that many U.S. impoverished urban areas are disadvantaged and have fewer transit options (Freemark, 2020). Additionally, equity and diversity have a spatial dimension in many places, and poverty is often disproportionately concentrated geographically in communities with high minority populations (Epanty, 2018). Therefore, the proximity of bus stops can make the difference between an affordable community and not (Miller, 2018). Scheduled trips will be shorter as campus commuting decreases.

The findings of this dissertation revealed that students, faculty, and staff who lived close to the bus stop were more impacted than those who lived further away. That is, undergraduates, commuting within ¼-mile, 1/2 mile, and 1 mile along the Tiger Walk into the Third Ward neighborhood. Linear regression analysis shows a significant relationship between race, people with disabilities, shuttle working with metro bus service, and transportation modes. The findings show that people are much more willing to walk to their destination (Cools et al., 2015), which corresponds to the age group of TSU students.

Becker and Axhausen (2017) found that 6 out of 10 studies examined age effects, and younger people were more accepting of automated vehicles than older people. In contrast, Rödel et

al. (2014) found that people aged 36 to 65 have a more positive attitude and a stronger intention to use automated vehicles than those aged 18 to 35. As mentioned, the findings indicate that the youngest, between 18-24, are much more willing to walk to their destination (Cools et al., 2015), corresponding to the age group of TSU students that rode the Autonomous Shuttle along the Campus Tiger Walk. Because few environmental justice studies considered age (see Rigolon, 2017 for an exception), Compared with other studies, our findings expand the range of demographic characteristics for which injustices in access to transit. These findings indicate that sociodemographic characteristics are less influential than domain-specific attitudes (e.g., performance expectancy) in predicting self-reported acceptance of driverless vehicles.

In 2019, Houston METRO was the first public transportation agency to test a driverless shuttle on the TSU Campus Tiger Walk. In 2022–2024, METRO will launch Phase II to offer the first last-mile service between Texas Southern University and the University of Houston, replacing the METRO EasyMile shuttle pilot. The Metropolitan Transit Authority of Harris County METRO, the recipient of the award for provisioning deployment of transit vehicle autonomy, has entered a contract with Perrone Robotics, Inc. ("Perrone"), the leading provider of autonomous vehicle kits and turnkey AV solutions in the industry (Perrone Robotics, 2022). The new shuttle will be a furnished Zeus 400, a mid-size body-on-chassis shuttle bus by Phoenix Motorcars (Perrone Robotics, 2022). Also, an electric shuttle equipped with Level 4 autonomous self-driving and leverage will provide autonomous shuttle service to Texas Southern University, the University of Houston, and Houston's Third Ward (Perrone Robotics, 2022). Moreover, the Zeus 400 complies with the Federal Motor Vehicle Safety Standards (FMVSS) (ADA), Buy America, and the Americans with Disabilities Act (ADA) (Perrone Robotics, 2022).

The Advancing Innovative Mobility Grant from the Federal Transit Administration will be a testing ground for autonomous vehicles (Tatum, 2022). This fund is a part of the Federal Transit Administration's (FTA) Advancing Innovative Mobility (AIM) program, which was awarded in 2022 (Tatum, 2022; Perrone Robotics, 2022). In addition, METRO will continue to be a part of the Automated Bus Consortium, a consortium of national transit agencies and transportation authorities tasked with creating a full-size electric automated bus (Tatum, 2022). This transition will aid transit agencies and MPOs that have addressed racial and socioeconomic disparities in transit bus connectivity. However, they have yet to enforce Autonomous Shuttle regulations in Houston's Greater Third Ward and across the HMA.

5.1 Conclusion

This study used a mixed method to examine transit accessibility for the driverless shuttle along TSU Tiger Walk, going to Cleburne Street in the Third Ward community. The findings reveal that African Americans and other people of color are disproportionately exposed to transit injustice because they are concentrated in neighborhoods with less accessibility. However, the TSU Campus Tiger Walk still has fewer transit options than other Third Ward census tracts that map closer bus stops with higher income. In addition, black respondents with lower educational levels and those with lower income levels were significantly more likely to live and walk a mile from a transit station.

Title VI of the Civil Rights Act of 1964 and Environmental Justice Policy Guidance by the Federal Transit Administration (FTA, 2012) prohibit discrimination based on race, color, national origin, and income. Executive Order (E.O.) 12898: Federal Actions address minority and low-income populations inequalities, extending federal Environmental Justice and nondiscriminatory protection (Cutter, 1995). Thus, unequal access to transportation is an environmental justice issue that elected officials and transit agencies need to address. Further, recent definitions of

environmental justice include age as a variable to consider, particularly older adults and children (Day, 2010; Landrigan et al., 2010).

Research by Rigolon 2017 & Wolch et al. (2005) has supported inequality in transit access for low-income minority groups and environmental injustice alongside inequalities in walking (para. 3). This transportation inequality shows that minority groups would commute further by the Autonomous Shuttle along the TSU Campus Tiger Walk. In addition, socioeconomic status was a stronger predictor of who rode the shuttle. At the same time, race and socio-economics are stronger predictors of who will ride the Autonomous Shuttle from the TSU campus Tiger Walk further into the Third Ward community. This finding aligns with the work by Lyons and Choi (2021). When measured comprehensively, they found that transit access to jobs is better for disadvantaged populations than advantaged populations in five of the six U.S. regions they studied.

The racial and socioeconomic comparison between Third Ward's Block Groups 3127000 and 3128000 reveals that Metro Transit Agency needs to address environmental injustice associated with Future Autonomous Shuttle Vehicles in Houston's Third Ward. Furthermore, these findings question the ability of the Environment Justice Movement (EJM), the Metropolitan Transit Authority of Harris County (METRO), and the Houston-Galveston Area Council (H-GAC) to protect the vulnerable population from environmental injustice. According to Parks et al. (2021), "incorporating transit routes and schedule information into the network analysis continues to be where much of the value of automation can be realized. In addition, novel accessibility metric could assist planners, transit agencies, and decision-makers in identifying priority areas of transit investment to improve access to transit bus stations for underserved disadvantaged groups" (para. 4). "In the past, when those infrastructures were built and when the investments came down from the federal government,

many communities were left out and left behind. We can't make those same mistakes," the Bullard Center for Environmental and Climate Justice director Robert Bullard said (Aguilera, 2023).

5.2 Public Policy Implications

This study examined the impact of an Autonomous Shuttle Transit for a transit-dependent population along the TSU Campus Tiger Walk. The dissertation applied a linear regression analysis to examine whether a driverless shuttle would provide another mode of transportation for a transit-dependent population. Based on the survey evaluation, the spatial analysis showed that a higher proportion of transit-dependent populations are disproportionately exposed to fewer public transit modes, especially along the TSU Campus Tiger Walk.

Although the history of deed restrictions was not examined, the comparison of Third Ward's Block Groups 3127000 and 3128000 shows a similar distribution of racial and socioeconomic indicators around the Third Ward community. This finding reveals that deed restrictions do not address EJ issues and concerns associated with Autonomous Shuttle vehicles. It is essential to re-examine the deed restrictions of subdivisions to address environmental justice concerns appropriately. There is a need for public policy decisions towards Autonomous Shuttle Vehicles, ensuring guidelines for Environmental Justice for local and federal agencies in underserved communities.

This dissertation indicates a need for more public engagement even though the plans were incorporated. As a result, CBOs, advisory boards, federal agencies, and local governments should collaborate in the decision-making process to ensure that a multi-sector engagement approach is an essential step in the decision-making process. In this regard, policy formulation is required, followed by other necessary equity actions. "Equity speaks to the distribution of benefits and burdens" but not to how and to whom policy decisions are made and the interest they serve" (Bullard & Johnson,

1997, p. 27). For example, race-related policy should mandate elected officials to address disproportionate transportation challenges in underserved communities. President Biden, for example, established the Justice 40 initiative, which directs federal agencies, state governments, and local governments to collaborate and address environmental justice challenges in disadvantaged communities.

President Biden, on August 5, 2021, issued an executive order to encourage EV development. The executive order (Appendix D) is a policy instrument that sets a nonbinding goal that half of all new passenger cars and light trucks sold in the United States be zero-emission vehicles by 2030, including battery-electric, plug-in hybrid electric or fuel cell electric vehicles (Samuels & Freemark, 2022). In addition, sections 205 of the executive order include setting a comprehensive plan to create jobs and stimulate clean energy sustainability. The policy instrument also includes consideration of goals and strategies that will aid in incorporating clean and zero-emissions vehicles into federal, local, and tribal fleets, including the Federal Post Office.

Although the executive order does not require this change to occur, recent estimates indicate that electric vehicles could constitute up to 70 percent of all cars on the road by 2050 (Samuels, Freemark, 2022). Other salient sections of the policy instrument include strategies to enhance renewable energy production and rebuilding infrastructure to ensure a sustainable economy. The order reinforces the calls from advocates, sociologists, planners, and practitioners to establish equitable and robust policies tailored toward addressing Autonomous Shuttle electric vehicle impacts, including a nonexclusive list of zero-emission options, such as battery electric, plug-in hybrid electric, and fuel cell vehicles.

5.2.1 Autonomous Vehicle Houston 2040

Between now and 2045, Houston's growth projections of 11 million people (about twice the population of Arizona) will pass Chicago. The region will add over 4 million residents (about twice the population of New Mexico) and 1.5 million new jobs. Trips moving through "hub and spoke" travel corridors will connect Houston and surrounding area town centers with employment districts, which will continue to be the most challenging to serve (Stacey & Meixell, 2019). Many companies are operational, such as Transdev, which has transported 3.5 million people (about twice the population of Nebraska) in its electric self-driving shuttles (Trandev, n.d.). In addition, the variables that drive housing density in the urban core are becoming increasingly fueled by rising land prices.

Gentrification in Houston's Third Ward urban core is where housing construction is being densified at an unprecedented rate. As a result, traffic congestion on city neighborhood streets is increasing at a rate equivalent to that of the highways within the core. AV technology transforms our automobiles, the new ride-hailing car services, public transit vehicles, and systems to be the most challenging trips to serve (Stacey & Meixell, 2019). Autonomous cars will account for up to 75 percent of vehicles on the road by 2040 (Newcomb, 2012). These projections for driverless vehicles will be widely accepted and possibly be the dominant expanded mobility on the road where highway construction results in the demolition, division, and displacement of Black neighborhoods, as well as the destruction of local economies and the consequences of the transportation system, including restricted mobility, concentrated poverty, increased air, and noise pollution, and heightened risk of pedestrian injuries (Bullard, Johnson & Torres, 2004).

5.2.2 Expanded Mobility for Transit – Dependent Riders

Fleets Autonomous Vehicles Electric Shared (FAVES) will advance mobility for people at all income levels, cut pollution and greenhouse gases, and helps make cities more livable (Creger, 2019) However, FAVES represents not just the future of transportation but the chance to address historical inequities in our transportation system. For example, commuter or choice riders contribute to the social exclusion of transit-dependent riders who may be a part of low-income, disabled, or racial minority populations (Chen et al., 2021; Lubitow et al., 2017; Merlin et al., 2021). While we cannot easily erase decades of redlining and other racist policies to help address these issues head-on by paving the way for autonomous vehicles where Black and Latinx still have fewer jobs available and are within a 45-minute commute than white communities.

Autonomous vehicles would also make jobs more accessible to Black people. However, they also have limited access to food considered low-access food desserts, meaning residents need help finding healthy, affordable groceries. Renewable energy sources such as wind and solar play a critical role in a sustainable economy (EV Connect, 2020). However, these sources could be more intermittent and consistent. Therefore, an efficient power grid must capture energy from them when available and store it for distribution when needed (EV Connect, 2020). Vehicle-to-grid, or V2G, technology is innovative charging that allows car batteries to give back to the power grid. It treats these high-capacity batteries as tools to power EVs and backup storage cells for the electrical grid (EV Connect, 2020).

5.2.3 President Obama's Stimulus Package

Under President Obama, the 2009 American Recovery and Reinvestment Act contained incentives for EVs and EV charging stations. Several years later, in 2016, President Obama pledged up to $4.5 billion (about $14 per person in the US) in loans guaranteed for "commercial-scale deployment of innovative electric vehicle charging facilities" (Klass, 2019). These point to lower-income neighborhoods and multifamily residential property investments. Although municipal and school bus fleets projects will benefit non-EV owners, partnerships with private EV charging companies are developing a robust private market for EV charging services.

Since President Biden took office, the White House has introduced two bills to expand EV adoption, one of which included funding for heavily expanded EV charging infrastructure (Lambert, 2021). Public EV charging stations may help reduce the EV adoption barriers affecting these populations. However, EV subsidies have exacerbated racial and socioeconomic inequities through the network effects of charging infrastructure. For example, public charging station location data and public charger access are lower in block groups with below-median household incomes and in those with a Black and Hispanic majority population (Hsu & Fingerman, 2021).

The locations with the highest percentage of multi-unit housing are where access discrepancies to public charges are most noticeable (Hsu & Fingerman, 2021). However, a decreased chance of household charger access makes them essential for EV operation (Hsu & Fingerman, 2021). Black and Hispanic majority block groups are the only race and ethnicity groups that are significantly less likely to have access to any public chargers in their block groups compared to the rest of the state, even after controlling for distance to the nearest highway or freeway, multi-unit housing unit rate, and median household income (Hsu & Fingerman, 2021).

Census tracts with a Black or Hispanic majority have installed fewer rooftop solar energy systems than other census tracts, according to an equality analysis of renewable technology adoption (Sunter et al., 2019). In addition, Canepa et al. (2019) investigated equity in EV adoption regarding ownership and charger availability in disadvantaged communities. They discovered that disadvantaged communities have a lower rate of EV adoption, and owners in these communities have higher incomes and education than the average disadvantaged community resident. Furthermore, residents of low-income communities and multifamily housing (apartments, condos, Etc.) face barriers to charging, such as a lack of charging at home (Preskill, 2018; Axsen & Kurani, 2012; Lopez-Behar et al., 2019), a lack of smartphone access, a lack of charging network subscriptions, a lack of public charging stations in their communities, which have been characterized as "charging deserts," or simply a lack of space (Sevier et al., 2017).

The lack of low-income, underrepresented, and disadvantaged households purchasing Plug-in Electric Vehicles (PEVs) is closely related to the lack of affordable new and used PEV models, inequitable design of incentives, and lack of infrastructure in some communities (Hardman et al., 2021). Most PEV buyers are high-income, home-owning, highly educated, white households. While some research shows change toward lower-income buyers, the change is slow (Hardman et al., 2021). In addition, research shows that lower-income households are less likely to have charging from home and less likely to find public charging in their communities (Hardman et al., 2021).

Low-income, underrepresented, and disadvantaged families are less likely to purchase Plug-in Electric Vehicles (PEVs) due to a scarcity of inexpensive new and used PEV models, inequitable incentive design, and a lack of infrastructure in some places (Hardman et al., 2021).

The bulk of PEV purchasers is high-income, home-owning, well-educated Caucasian households. While some data indicate a shift toward lower-income purchasers, the shift is sluggish (Hardman et al., 2021). According to research, lower-income households are less likely to have to charge at home and are less likely to have access to public charging in their neighborhoods (Hardman et al., 2021). Residents in lower-income neighborhoods need to catch up on the cheaper operating costs of PEV ownership and the air quality improvements that PEVs may provide (Hardman et al., 2021).

5.2.4 Federal Tax Credits for New and Used Electric Vehicles

The federal government in the US has a tax program that provides an incentive for buyers of electric vehicles that dates to the Bush era, and it was expanded during the Obama administration. California, Oregon, and Pennsylvania are examples of states incorporating equity aspects in PEV incentives to address the needs of low-income individuals or those living in air pollution districts or disadvantaged communities (Hardman et al., 2021). Under Biden, the Growing Renewable Energy and Efficiency Now (GREEN) Act reformed the federal EV tax incentives, among other tax programs to help renewable energy. It would give $7,500 in tax credits to every buyer of new electric vehicles qualified for plug-in EVs or fuel cell electric vehicles (FCV) (Barry, 2022).

The Inflation Reduction Act of 2022 changed the rules for this credit for vehicles purchased from 2023 to 2032. At the federal level, the tax credits for EVs (electric cars, vans, trucks, Etc.) operate as money back at the end of the fiscal year you purchased or leased your vehicles based on several factors. The awarded credit is up to $7,500 per vehicle, but how much you get back will depend on your annual income, whether you are filing with someone else, like a spouse, and what electric vehicle you purchased (NARFA, 2023). Under the new Inflation Reduction Act terms, the MSRP of electric vehicles must be $80,000 or less for SUVs, vans, and trucks. MSRPs for all other

electric vehicles must be $55,000 or less (NARFA, 2023). Modified adjusted gross income limits are $150,000 for individuals, $225,000 for heads of households, and $300,000 for joint returns. Any reported annual income below these thresholds should qualify you for some level of the tax credit if your new purchase is a qualifying electric vehicle (NARFA, 2023).

5.2.5 Used Electric Vehicles: Few incentives are available for used EVs (Nobre & Pedrosa, 2018). However, according to the updated conditions of the inflation reduction legislation, used electric vehicles are eligible for federal tax credits. As previously announced, used EVs will now qualify in addition to new automobiles (Doll, 2023). Used electric vehicles (EVs) that meet specific requirements and cost less than $25,000 will be eligible for up to $4,000 in federal tax credits beginning on January 1, 2023 – $75k for single people, $112,500 for heads of families, and $150k for joint returns is the maximum gross income (NARFA, 2023). In addition, the government will offer them point-of-sale refunds and tax benefits to encourage consumers to purchase American-produced EVs. These incentives will ensure that these cars are affordable for all families and made by employees with decent jobs (Doll, 2023). In addition, to build a nationwide network of 500,000 EV chargers by 2030, it will also create grant and incentive programs for state and municipal governments and the business sector while supporting rigorous labor, training, and installation requirements (Doll, 2023).

With assistance from the Department of Energy, the Environmental Protection Agency will introduce a new Clean Buses for school Program as part of President Biden's proposal, which would also replace 50,000 diesel transit vehicles and electrify at least 20% of our fleet of yellow school buses (Doll, 2023). These investments will place us on the path to having 100% clean buses while guaranteeing that the American labor force is prepared to run and maintain this infrastructure of the

twenty-first century (Doll, 2023). Finally, it will electrify the federal fleet, including the US Postal Service, using the extensive instruments of federal procurement (Doll, 2023).

5.2.6 Rideshare: Electric vehicles and shared mobility services are already transforming the transportation industry (Patterson, 2019). Passengers with Black-sounding names face longer wait times for shared rides than passengers with non-Hispanic white-sounding names (Gehrke et al., 2019). In addition, drivers are likelier to cancel rides for riders whose profiles indicate they are people of color. Most ride-sharing or ride-hailing mobility services require a smartphone to install the application for bike sharing and other non-motorized mobility choices. In addition, they may require a bank account or, at minimum, a prepaid card. This digital divide could also exacerbate inequities in access for lower-income people, users without bank accounts, and others who do not have smartphones (Shaheen & Cohen, 2018). Depending on how the technology evolves, AVs could be more affordable than other forms of on-demand transit estimated that the cost of operating an AV would be 80 or 90 cents per vehicle mile. Although more significant than the current costs of an individually owned car (55 cents per mile), this option would be less expensive than Uber, Lyft, and, in some cases, transit fares (Fiol & Weng, 2022).

Nevertheless, across the country, paratransit riders—and people with disabilities in general—frequently face challenges accessing services, such as absentee drivers, late pickups, and incorrect ride charges (Fiol & Weng, 2022). Without flexibility or reliability, paratransit cannot offer people with disabilities adequate control over their schedule and daily lives, which restricts many people's ability to maintain employment and enjoy life to the fullest (Fiol & Weng, 2022). The lower price is also partly a result of the reduction in labor costs in fully self-driving cars, which has other implications for socioeconomic and racial equity among drivers. Providing paratransit through

accessible AVs could reduce costs for local governments, which sometimes subsidize more than 90 percent of paratransit costs for riders (Fiol & Weng, 2022).

5.2.7 Bus Systems: The METRO Shuttle Bus of the Future will include an autonomous vehicle (AV) kit provided by Perrone Robotics under a contract with Houston METRO. In addition, Perrone will provide a Zeus 400 shuttle bus for METRO to operate an autonomous shuttle service between Texas Southern University, Houston's Third Ward, and the University of Houston. This Shuttle of the Future will be an electric shuttle with Level 4 autonomous self-driving and leverage the Federal Transit Administration's Accelerating Innovative Mobility Grant as an Autonomous Vehicle Proving Ground (Tatum, 2022). In addition, METRO will continue its involvement in the Automated Bus Consortium, a national collection of transit agencies and departments of transportation to facilitate the development of a full-size electric automated bus (Tatum, 2022; Perrone Robotics, 2022).

AV shuttle routes are segmented into multiple inks in each direction, with each link starting and ending at two consecutive time-point stops. The schedule headway during the AM and PM peak periods in minutes will be less, increasing during the off-peak. Each time the bus stops, the bus location will be recorded using the GPS receiver. GPS (Global Positioning System) receiver and an APC (Automatic Passenger Counter). The number of passengers boarding and alighting at bus stops will be recorded using the APC. It would avoid empty trips during off-peak hours and thus reduce some costs. Finally, queuing and congestion around stations could be avoided by responding to real-time demand.

5.2.8 Transportation in Third Ward

Everyone is going wireless during their commute, trying to make everything happen simultaneously, connecting to places and things to reduce traffic and save travel time along TSU Tiger Walk and the Third Ward community (Begley, 2019). For example, students in the Law School ordinarily park in the East parking garage. Then walk across Cleburne Street to attend class. Although they do not venture onto the campus much, they have yet to hear of the driverless shuttle. Soon students that wish to commute along the TSU Tiger Walk can take advantage of the driverless shuttle by downloading an app, showing a verification code, then boarding.

Furthermore, it is just an easy automated driverless shuttle that could run 24 hours since one does not need anyone working the vehicle in communities left vulnerable to traffic fatalities by decades of racist housing policy and urban planning. Autonomous vehicles could make our streets safer. Autonomous vehicle (AV) technology continues to grow, expanding mobility for AV for transit-dependent populations in The Third Ward. However, investing in AV infrastructure may reduce the convenience and safety of other modes, revealing the importance of understanding who accesses the various modes and what is required to access those modes safely and conveniently. EV expansion should be designed with equity and affordability to ensure the inclusion of economic groups that could benefit the most. For example, driving fewer cars would communicate with other cars around it, and on the roadway, it will know where speed needs to be maximized. Undoubtedly, this benefit would be limited by each city's existing infrastructure. Moreover, this would make the process easy for workers to commute daily.

In addition, human drivers to software-piloted vehicles could help poor people and non-white communities if the technology can reduce traffic deaths and the air pollution that

disproportionately affects those residents. Autonomous vehicles could also increase transportation options for older people or people with disabilities (Vock, 2022). However, electric vehicle (EV) subsidy policies can unintentionally perpetuate racial and socioeconomic inequalities, reinforce inequitable access to transportation, reduce public transit use, increase the amount of driving, increase congestion, and exacerbate the causes of climate change. As a result, this technological advancement may fall short of its full promise—or even worsen the problems endemic to the automobile-dominated US transportation system (Vock, 2022).

While it may seem inefficient to provide subsidies to the lower income households, it would make sense if the EVs would replace gas guzzlers used by low-income households that release more than double the emissions of the vehicles used by the higher income households (Nguyen, 2020). While this example is overly simplified, the same logic applies to practical policymaking—subsidy programs should consider the heterogeneous environmental benefits of EVs among different income and demographic groups (Nguyen, 2020). Indicators for disadvantaged and non-disadvantaged communities under when AVs, whether transit agencies responded to AVs by maintaining the status quo, removing low-performing routes, or applying AV technology to transit vehicles provided an equity benefit, either mitigating an existing gap in outcomes between demographic groups or reducing the extent to which that gap was expanded. This disparity also exists along race-based lines, with a study finding that Hispanic and African Americans accounted for just 8.4% and 1.4% of new battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), respectively (Nguyen, 2020). This disproportionately low level of ownership among African American and Hispanic residents holds even after controlling for income (Ruben & Lewis, 2016).

5.2.9 Streets: Third Ward investment levels vary across neighborhoods due to past and present policies and practices, with majority-white and low-poverty neighborhoods typically receiving disproportionate capital. At a minimum, Congress should use the White House Justice40 framework (provide at least 40% of total benefits from federal investments in climate and clean energy to underserved communities) in allocating the bill's $370 billion climate funding—investments and benefits that are desperately needed and long overdue (Bullard, 2023). The Moving Forward Act would allocate funds for infrastructure investments for Complete Streets and Safe Routes to Schools in Third Ward, as well as sidewalk and lighting improvement projects and sensing technology by which the AV shuttle vehicle determines its proper path and steers itself along the transit lane by appropriate lane marking roadway. In addition to pavement lane reflectors to sustain the wear and tear of shuttle operations, pedestrian traffic, and weather infrastructure required by vehicle sensing and controls.

Battery charging can be easily miscommunicated by the AV shuttle operator when a third-party location for the equipment installation resulted in an additional cost to upgrade the power supply, equipment provisions, and communication standards between autonomous vehicles used for vehicle-to-vehicle (V2V) communications in 1999. As a result, NHTSA car and device manufacturers spent the following two decades working on a standard for V2V communications. However, the standard that emerged, called Dedicated Short-Range Communications (DSRC), continues to face considerable resistance, including from a competing standard called Cellular-Vehicle-to-Vehicle (C-V2V) (Seamans, 2021). DSRC allows direct communication between two DSRC-enabled devices without relying on an intermediary, such as cellular work, making it fast and deployable in areas without cellular coverage. However, research by Gyawali et al. (2020) suggests that DSRC only works well when two vehicles are in sight of each other and moving slowly. C-V2V

operates through a cellular network, which may limit its ability to function well in remote areas, but it handles communications between vehicles that are moving quickly (Gyawali et al., 2020).

The Biden administration's plan to reverse the FCC's decision would bolster the C-V2V standard relative to DSRC, which may hasten the resolution of the standards battle and favors Wi-Fi over transportation (Seamans, 2021). As a result, it will be necessary for policymakers to consider the tradeoffs associated with using the spectrum. On the one hand, the demand for spectrum for Wi-Fi-enabled devices is a growing and current need. In contrast, there is currently little need for a spectrum for autonomous vehicles—there are not any commercially available, and consumer demand seems low (Seamans, 2021). On the other hand, the spectrum for autonomous vehicles will be a future need, and the economic benefits of autonomous vehicles may outweigh the benefits of additional Wi-Fi (Seamans, 2021).

5.3 Bike lanes: New bike lanes are planned along Blodgett Street in Houston's Third Ward, between Texas Southern University and the University of Houston, to improve commuting along numerous campus corridors (Jorden, 2022). In addition, $11.7 million of the $12.1 million is required for local drainage improvements to slow down bikeways for upgrades to Blodgett, Tierwester, Rosewood, and Sampson streets deep in the Third Ward (Jorden, 2022). Impacted residents and businesses along Blodgett Street have expressed concerns about the potential for increased traffic congestion, limited street parking, and the necessity of bike lanes. The community needed to be adequately engaged in the east-west bike lane to bridge the gap between the Museum District/Midtown and Third Ward destinations, including connections to Texas Southern University, the University of Houston, and other public amenities like Emancipation Park and the Wheeler

Transit Center (Jorden, 2022). Sustainable transport interventions aim to reduce vehicle emissions, improve public transport, and promote active travel (i.e., walking and cycling).

5.3.1 Driverless Cars: The ideal scenario for self-driving cars is when people give up their vehicles and instead opt for a cheap, shared ride in combination with public transit. The service would be of higher quality by offering door-to-door, on-demand, 24-hour transport. Coordination with mobility providers, real-time data monitoring, and responsive, intelligent grid systems will ensure the best use of public transport and minimize congestion. For example, instead of hopping in a car to avoid a rain-soaked wait at the nearest bus stop, one may summon a self-driving car on a smartphone that drives to the nearest Metro station. Alternatively, for about the same price as a Metro Transit ride, one may take a driverless shuttle to a destination in half the time, with a reduced collision risk.

As self-driving technology advances, infrastructure in centralized communication will become increasingly critical. This infrastructure will also have the most influence once many autonomous vehicles are on the road. For example, traffic signals, speed limits, and even driver licenses might become obsolete due to vehicle-to-infrastructure (V2I) communication, allowing vehicles to share their position, destination, and intended path with a central station. Autonomous will be able to find barriers, avoid them, and travel the planned path. However, for effective autonomous operations, cars must communicate with one another (Newcomb, 2012). They could identify hazards, get around them, and stay on the path. A broad shift from human drivers to software-piloted vehicles could help poor people and non-white communities if the technology reduces traffic deaths and the air pollution that disproportionately affects neighborhood residents.

Safety is, of course, a paramount concern on the issue of how to ensure the safety of passengers and react, for example, in the event of accidents. Cities are challenging themselves to step up on safety together. We applaud the focus on safety from the USDOT with their new national strategy and the new funding from Congress in the Bipartisan Infrastructure Law for a new local safety program, Safer Streets and Roads for All (Seamans, 2021). The USDOT's new national approach and the additional cash provided by Congress in the Bipartisan Infrastructure Acts for a new local safety program, Better Streets and Roads for All, reflect the challenge that cities are issuing to each other to increase safety (Seamans, 2021).

As a result of minimizing human error, which the National Highway Traffic Safety Association (NHTSA) says accounts for 94% of crashes, AVs are anticipated to be safer than human-driven automobiles. Just 14% of drivers said they would feel secure riding in an autonomous vehicle in 2021, the same percentage as in the previous study from 2020, although broad usage of AVs should lead to safer roads. Customer perceptions could shift as Level 4 and Level 5 cars are commercially available. Autonomous vehicles should be tested and held to the same standards as the ones we can buy off the lot. Having a safe and reliable vehicle to supplement existing services is critical to the public's widely accepting of autonomous vehicles operating with them on public roads (Seamans, 2021).

City leaders welcome advanced technologies that can improve safety, reduce congestion, and decrease costs within transportation networks. It should be a federal policy to accelerate the testing, deployment, and integration of advanced transportation technologies, such as automated, connected, electric, and shared vehicles, that can increase mobility options and accessibility while simultaneously ensuring safety and reducing emissions, collisions, and congestion. Autonomous

shuttle deployments should be done in close consultation with cities and include a robust public engagement process and appropriate regulations that ensure the unique needs of each municipality.

5.3.2 Metro Third Ward/ City Adapt to Autonomous Vehicles

Houston METRO will provide AV shuttle bus connections between the TSU, U of H, and METRO LRT. Several routes are being considered to extend to reach Cuney Homes—a historic public housing community linked to the LRT station located between the two campus areas for providing access for the economically depressed community of Houston's Third Ward that is adjacent to the University District. In addition, AV buses will be operated between downtown Houston and the Memorial City Mall (Young & Lott, 2022).

Self-driving automobiles must distinguish between a pedestrian's pause as a safety check and a message that the right of way has been given up at stop signs at junctions in the Third ward. Although fleet cars necessitate reconsidering space in roadways, along curbs, and parking lots, more immediate applications may include helping shoppers and guarding a mobile information booth on campus (Abrams, 2016). They will also require innovative electrification and frequent monitoring. To address the "last mile problem"—the final delivery of packages brought by autonomous vehicles—future charging stations may be installed on the road rather than in charging stations (Abrams, 2016).

5.3.3 Routes: Houston METRO's Memorial City route is a premier early deployment. Providing a route that does not require AV buses to make an unprotected left turn across conflicting traffic movements is essential in route planning (Young & Lott, 2022). The current level of development for all autonomous shuttle technology would require the onboard attendant to take

control to perform this type of maneuver. Also of significant importance is the necessity of vehicle-to-infrastructure (V2I) communications at the point that the route would cross the LRT system tracks. This signaling system coordination and roadway infrastructure will require communications links with the AV shuttle as it operates through these complex intersections. V2I is critically essential coordination of multiple signaling systems and the related control of AV movements (Young & Lott, 2022).

5.3.4 Bus Stops: The Third Ward has a less frequent bus route, with a 60-minute headway, on local streets, delayed by traffic lights and cars turning into driveways (Scott, 2020; Spieler, 2020). Some of its stops are no more than a sign on a narrow sidewalk. Things like lighting and a trash bin significantly affect one's perception of the total transit experience. Bus stops must host waiting passengers who will find neither shade nor a place to sit with skateboarders, bicyclists, hover-boarders, wheelchairs, and dogs (Scott, 2020; Abrams, 2016). Pedestrians and bikes use a lot of conventions and subtle cues, near, without accidents-well, sometimes accidents (Scott, 2020; Spieler, 2020).

5.3.5 Model City for Self-driving Shuttles

Columbus intends to define what it means to be a "Smart City" and serve as a model for other cities wishing to integrate innovative technologies fully. Smart Circuit was made possible by the Obama Administration's Smart Cities Challenge. Smart Columbus is a regional smart city initiative co-led by the City of Columbus and Columbus Partnership that includes partnerships with The Ohio State University, Battelle, American Electric Power, and many more (Smart Columbus, 2018). One of Smart Columbus' goals is to create opportunity for Columbus residents by providing better access

to jobs and services while improving the overall safety and efficiency of the transportation network. This proving ground includes testing and deploying connected and autonomous vehicles into the transportation network.

One example is Smart Circuit, an ADA -accessible, electric, self-driving shuttle in Columbus, Ohio. A new route in the Black neighborhood of Linden provides free rides between affordable housing, recreation, public transportation, and more, including testing and deploying connected and autonomous vehicles into the transportation network. However, before self-driving shuttles could be a reality, Smart Columbus had to ensure that the shuttles would operate safely. So, Columbus deployed Ohio's first self-driving vehicle in December 2018; as a result, aligned investments totaling more than $500 million have been made by the region's private, public, and academic institutions to support technology and infrastructure investments that upgrade Columbus' transportation network and help make Columbus the model-connected city of the future (Smart Columbus, 2018).

5.3.6 Biden Administration Federal Funds and Screening Tools

The Climate and Economic Justice Training Tool (CEJST) by the Biden Administration identifies disadvantaged communities. However, despite evidence that race is the most powerful and consistent predictor of environmental burdens, the tool did not expressly include racial demographics as a factor that could push a neighborhood into the disadvantaged category (Sadasivam, 2023). The newly created Beta version of the HBCU Climate and Justice Screening Tool (HCJEST), including information on the indicators to identify disadvantaged communities, can be used side-by-side with (CEJST) to ensure Justice 40 benefits of Federal programs reach

communities that are overburdened by pollution and historic underinvestment (Sadasivam 2023 & King, 2023, para. 4). In addition, it incorporates race/ethnicity and additional environmental factors. Also, sociodemographic profiles provide pertinent information for analyzing transit equity.

5.3.7 EJScreen: The EPA's environmental justice screening tool provides sociodemographic data by CBG (U.S. Environmental Protection Agency, 2014). The groups of interest included in the EJScreen data are low-income and minority households. The EPA defines *minority households* as the percentage or number of minority individuals that are non-white, including multiracial individuals, in a census block group (U.S. Department of Transportation, 1964). Households are designated as low-income when the household income is less than or equal to twice the federal poverty level (U.S. Environmental Protection Agency, 2014). While this example is overly simplified, the same logic applies to practical policymaking—subsidy programs should consider the heterogeneous environmental benefits of EVs among different income and demographic groups.

The White House Environmental Justice Advisory Council (WHEJAC) also leads the Justice40 Project, which provides technical assistance to organizations and networks that serve disadvantaged populations in implementing President Biden's Justice40 Initiative focused on ensuring that the benefits of Federal programs reach communities overburdened by pollution and historic underinvestment. Sanchez said that when California was developing its screening tool, it ran into a similar issue: Some census tracts were surrounded by disadvantaged tracts but were not being flagged as disadvantaged by the tool, despite suffering from similar issues on the ground (Sadasivam & Aldern, 2022). Next, data aggregated by ethnicity and income were appended to spatial data to identify with more significant than average low-income or minority populations. If the minority

population within a block group was more significant than the county average, it was denoted as an equity designation. The last step in equity analysis was prioritizing areas with an equity designation and low transit coverage.

Despite overwhelming evidence that race is still the most effective predictor of environmental and climatic inequities, inequality, and vulnerability, the Climate and Economic Justice Training Tool (CEJST) did not include race as a component (King, 2023). Without question, race and racism have contributed to where pollution has been concentrated in this country, including indicators of race/ethnicity or age. Bullard states, "While excluding race from the CEJST makes it less likely to draw legal challenges, it will likely leave out some residents and communities that are victims of environmental racism and gentrification" (King, 2023). Environmental Justice neighborhoods in Houston's Fifth Ward, Kashmere Gardens, Pleasantville, Manchester, and Sunnyside neighborhoods were assessed to determine the factors contributing to a disadvantaged designation with a clear picture of the EJ in poverty pockets that have been transportation redlined.

5.3.8 Public Participation for Autonomous Vehicle

Preparations: Community engagement must include development deals and initial planning grants to families as a focal point for all engagement; however, the truth is that resident needs are rarely addressed. In most cases, families are ignorant, illiterate, and too unlearned regarding the development process. Its terminology includes an active role in shaping the vehicle's software development. In addition, people of color need more technical skills, including community meetings, consultations, one-on-one conversations with community representatives, teleconference calls, webinars and videos, and other efforts. As a result, for the first-time transit-dependent populations will be able to learn how to use apps for shuttle rides and now have a chance to address technology

that will include multiple languages for people who are not user-friendly in how they get to school, work, and other communities independently, regardless of distance.

Successful engagement opportunities include consultations, roundtables, training sessions, and workshops. In one-on-one conversations, federal, state, and city agencies must work together on timelines with underserved areas to underserved neighborhoods. Agencies should provide cosponsors to provide the community with the resources and share all the planning roles with federal representatives to ensure a well-balanced shift of resources. While the perception may look ill-will, it may be a simple case of staff and consultants for current transit systems. Likewise, overall value to the local community may be a simple case of team and consultants needing to be better informed, even in distressed areas.

Educating the community allows equal participation and provides a means to influence decision-making (NEJAC, 2013). Metro will address its long-range plans, which include Metro's role, the public role, public outreach, benefits, impact, and critical issues. For example, the discussion will cover assorted topics related to driverless vehicle mobility by linking environmental, economic, political, and social analysis of a community (including class) to create a deeper understanding of the causes of climate change and how it will impact environmental justice communities (NEJAC, 2013). The discussion will cover a wide variety of topics related to the driverless vehicle mobility community will address there needs to be more collaboration with public officials at Metro, COH, HGAC, Texas Southern University, and community groups, particularly for the elderly and disabled person, so they can accept driverless shuttle mobility and become educated on the technology and will not be afraid to ride.

Engagement Logistics: Polling discussions during the TSU hearing will cover diverse topics related to driverless shuttle mobility. Stakeholders have many families and job obligations, so convenient meeting times should be early evening weekends. Diverse stakeholders can attend—public transit transportation for people with disabilities childcare should be available when hosting community-oriented meetings (NEJAC, 2013). The conversation would introduce the driverless shuttle transition into the Third Ward. They are traveling from the TSU Tiger Walk campus to the Cuney Homes. Along the route at Cleburne and Ennis, a variety of transportation modes, including Telsa Autonomous automobiles, bikes, walking, scooters, mopeds, motorcycles, bike share, and on-demand services such as Lyft and Uber (Ann Arbor Moving Together Towards Vision Zero, 2019) would be part of community involvement. Participants will provide their opinions regarding implementing a driverless shuttle as a first last-mile mobility solution for people of color in the Third Ward neighborhood.

Community organizations, schools, and colleges for co-hosting meetings partnerships between agencies or project implementers and community-based organizations have the potential to result in the best outreach and community engagement activities (NEJAC, 2013). Co-host workshops with community organizations can provide trusted access to community residents. Many of these community organizations have limited funding for this kind of work, are often engaged in many extraordinary efforts, and their time is valuable. Consider providing a stipend for defined tasks like garnering community input.

Educating Community Equal Participation: Community organizations should also work with foundations and philanthropy to establish State agency-level outreach and advocacy as a significant emerging opportunity for their investment. Closely related to this is linking local, national, and international environmental justice issues (NEJAC, 2013). State and local officials

must collaborate on safe, efficient, and environmentally friendly designs for solving transportation problems. Metro to inform community listeners of current updates. The importance of laws and regulations for the safety of driverless shuttle technology and how it might impact the environment (emissions) battery charging stations.

City leaders welcome advanced technologies that can improve safety, reduce congestion, and decrease costs within transportation networks. It should be a federal policy to accelerate the testing, deployment, and integration of advanced transportation technologies, such as automated, connected, electric, and shared vehicles, that can increase mobility options and accessibility while simultaneously ensuring safety and reducing emissions, collisions, and congestion. Policy implementation should be done in close consultation with cities and include a robust public engagement process and appropriate regulations that ensure the unique needs of each municipality.

Most importantly, security is a significant concern for driverless vehicles and their charge system infrastructures, which may pose a threat during inclement weather, particularly during hurricane season evacuations. Additionally, creating a technology backup plan for vulnerable people of color that works in inclement weather, mastering complex urban and suburban environments, and operating driverless vehicles in an environment with non-autonomous vehicles, buses, train crossings, pedestrians, cyclists, and parked cars. Discussions will address the following:

- The heat-related health risk from AV battery charge queuing will cause a rise in greenhouse gases.
- Congestion from a collector and arterial streets in the Third ward, particularly Cleburne Street and Scott, slow or speed traffic due to rail and managed traffic coordination to 288 and Almeda.

- Long-term stress will cause anxiety due to a lack of understanding of technology in the community to ride buses. In addition to short-term heat stress from waiting an extended time.

Implement short-term goals and long-incrementally over time where traditionally, local governments have had the regulatory powers given to them by the state. However, since autonomous vehicles could revolutionize zoning, many cities are examining their zoning policies. Some cities have tried to regulate Autonomous Vehicles, arguing that they are an untested danger to other vehicles, cyclists, and pedestrians (Larker, 2017).

5.3.9 Major Challenges of Autonomous Vehicles

Black households do not have a smartphone, and transit-dependent populations who live in areas without high-speed broadband coverage have higher poverty, lower population densities, and lower incomes (FDIC, 2017; FCC, 2020). These barriers, as mentioned, hinder access to app-based shared mobility options—safety issues related to vehicle technology and operations. For example, the suspension follows an apparent braking incident in Columbus, Ohio, where one passenger was hurt (Moffat, 2020). In addition, the vehicle cannot operate if a steady rain begins, as the sensor logs heavy rain as an obstacle, and the vehicle slows down or stops. Therefore, if the attendant begins to experience a slow-down due to rain, the vehicle is pulled into the storage location, and unpredictable occurrences like weather, mechanical issues, and software malfunctions abruptly cause alterations in scheduled service.

The battery's depletion rate at a high A/C level was higher with phone charging than without phone charging. As a result, the vehicle was withdrawn by an attendant an hour before its scheduled end of operation – to recharge so it could resume operation as scheduled. However, the A/C level was high, and the vehicle could not complete the planned hours of operation on a single charge due to the increased battery depletion rate, especially with phone charging (TSU AV, 2020). The battery

reached the 20% power level after the TSU AV shuttle operated from 8:00 am to 2:00 pm and again from 5:00 pm to 8:00 pm between 2:00 and 5:00 pm, allowing the vehicle to return to the maintenance bay for battery charging after the morning service period (TSU AV, 2020). During operation in the middle of the day, the attendant must plug the vehicle's power cord into a charging station for several hours (TSU AV, 2020). After that, the shuttle must be returned to service by an attendant for the late afternoon and evening hours. This approach was ideal because there is a natural reduction of student activity on campus during the middle afternoon hours, allowing for vehicle battery charging during low ridership (TSU AV, 2020).

Disproportionate allocation of Environmental Benefits: Aside from the disproportionate allocation of economic benefits towards white and affluent communities, many traditional EV subsidy programs have also resulted in a disproportionate allocation of environmental benefits (Nguyen, 2020). Inefficient allocation is exacerbated by the fact that many BIPOC communities, as previous environmental justice literature has posited, are disproportionately impacted by the harmful effects of emissions from gasoline and electricity (Bosworth & Patty, 2017). Whether or not one agrees with the effectiveness of these subsidies in accelerating the adoption of clean technologies, it is indisputable that these blanket subsidies exacerbate the already alarming racial wealth gap (Malveaux, 2019).

5.4 Transit-Dependent Population: Robbed of Bus Options

Formal Procurement

Formal procurement should be part of federal transit grant programs to increase overall transit ridership and improve transit inequities for Third Ward's transit-dependent population—mandatory plans for when and where the driverless shuttle service would phase into operations.

In addition, the South Side area of Harris County and the Northeastern area of Harris County should be considered for future Autonomous Shuttle Vehicles in Houston.

5.4.1 George Floyd: Resident Remains in Cuney Homes

Community Awareness Improves EJ Zone Connections

Awareness of community needs, and issues of George Floyd's Death has fueled the Federal Choice Neighborhood Initiative Planning grant, incentivizing projects that reconnect communities, increase walkability, and make alternative transportation more desirable, which will price out Cuney homes residents with a transformational Smart City walkable corridor. However, more work must be done considering how driverless shuttles may impact social equity through land use changes, particularly gentrification. Transportation planners must consider that investments in transportation can sometimes cause increases in housing prices, whereas gentrification can displace low-income residents. As such, leaders should enact land use for housing and transportation policies in tandem with transportation investments to ensure residents remain in place.

In addition, DOT, the Department of Housing, Urban Development, and the City of Houston collaborations will raise community awareness for driverless shuttle mobility along the TSU Campus Walk in connection with the Third Ward environmental justice zone where Metro's 9-to-5 suburban service model has excluded the Autonomous Shuttle's impacts on Third Ward's transit-dependent population health, education, employment, and quality of life.

5.4.2 Transportation Planning Environmental Justice Analysis

NEPA Clean Energy Transition

In compliance with the National Environmental Policy Act (NEPA), President Bidens's Executive Order on Environmental Justice, and the Bipartisan law, the USDOT should require planning agencies to conduct a regular equity analysis of Justice 40 transportation investments. This

analysis determines if clean energy infrastructures are an integral part of Transportation Improvement programs and State Implementation plans of solar panel corridors for battery-electric fuel cells and plug-in hybrid zero-emissions driverless vehicles sold to residents in EJ communities. In addition, evaluation criteria should be used for the Houston Galveston Area Council (HGAC) MPO certification and state approval for the planning process.

5.4.3 Robust Transparency for Driverless Shuttles

Racism has always been a factor in transportation for Houston's Greater Third Ward. Even decisions about Autonomous Vehicle Technology can have racist consequences — sometimes, those consequences are deliberate. For example, dismantling oppressed barriers for voiceless people advocating for driverless shuttles must be heard to show how allocated funds address how the population commute to school, work, and other community activities. The participatory collaboration includes robust transparency and public feedback mechanisms for federal rules for transportation investments through Justice40 regarding Autonomous Vehicle Technology. In addition, community involvement will provide an active role in shaping the driverless vehicle's software, broadening the broadband infrastructure developed.

5.4.4 Safety Policies That Look Beyond Skin Color

Safety policies will look beyond skin color and deep into racial algorithms technology, yield properly to body shapes, and recognize various skin tones and mobility aids where Black versus White pedestrians describe macroscopic phenomena such as forward movement and pedestrian flow route/direction dispersion for persons entering Environmental Justice zones. Detecting the crowd flow by geofencing due to unsafe sidewalks, signage, and lighting in public places can help alert the congestion of the channel immediately without bias, policing people of color and other vulnerable

communities from the threat of violence and harassment and making an immediate evacuation policy to prevent the occurrence of extrusion stampede.

The system is composed of human imaging, which detects the EJ zone flow according to the counts and values of readings. With the evaluation in different scenarios, the coverage and moving status of a non-EJ zone crowd can be verified (Fan & Liang, 2017) and stored in the DOT traffic simulation database. Communicating among objects will improve traffic flow at intersections with real-time problems of low or no-car zones reducing pollution in communities surrounding highways.

5.4.5 Policy Recommendation

5.4.5 Justice 40 Initiative

President Biden's Justice40 Initiative is focused on delivering 40 percent of the overall benefits of federal climate, clean energy, affordable and sustainable housing, clean water, and other investments to disadvantaged communities that are marginalized, underserved, and overburdened by pollution and historic underinvestment (King, 2023). In addition, for the first time, allocated funds will be distributed for new economic opportunities for Black Americans, and long overdue investments in Black communities are an essential step in implementing President Biden's Justice40 Initiative and ensuring that the benefits of Federal programs are reaching communities that are overburdened by pollution and historic underinvestment.

5.4.6 Federal Funds Strings Attached: Transportation investments near the TSU campus Tiger Walk and the Cuney homes are making housing more equitable, protecting consumer privacy, fair housing enforcement, and state broadband policies have federal fund strings attached. Infrastructure investments have brought unprecedented social safety net investment, with paradigm-shifting consequences in state and local government. However, the amount available is not the primary limitation—getting money into people's pockets is. For example, the Houston Housing

Authority (HHA) and the City have been awarded a prestigious two-year Choice Neighborhoods Initiative Planning Grant Program (CNI) from the U.S. Department of Housing and Urban Development (HUD).

This grant of $450,000 will be used to would help replace distressed housing with mixed-income housing development centered around the redevelopment of the Cuney Homes, Houston's longest-standing public housing community, located in Historic Third Ward (Herndon, 2022). It is worth noting that under President Obama, a $30 million Choice Neighborhood grant was awarded to San Antonio in 2012 by the U.S. Department of Housing and Urban Development. The goal was to destroy the dilapidated Wheatley Courts and replace it with a secure, walkable, mixed-use neighborhood.

While supply chain concerns and an influx of new residents drive up property costs, housing affordability for all socioeconomic groups remains an issue in Houston's Third Ward (Sessions, 2023). Property owners must be willing to rent to voucher holders for large programs like the Housing Choice Voucher Program to function. The unfavorable impression of voucher holders is even more widespread than the misconceptions about program rules and red tape (Herndon, 2022). If the building continues to be affordable housing, the Public Housing Authority is permitted by HUD to waive tenants' rights (Herndon, 2022). It becomes complicated at this point. No transaction needing private capital can remain affordable with 100% HUD subsidies (Herndon, 2022). Therefore, they combine development agreements with private rentals. Private rents completely alter the contract's nature (Herndon, 2022).

The Justice40 Initiative, announced two years ago, is part of President Biden's Executive Order, Tackling the Climate Crisis at Home and Abroad, creating a government-wide initiative to

deliver 40 percent of the overall benefits of relevant federal investments to disadvantaged communities and tracks performance toward that goal through the establishment of an Environmental Justice Scorecard. In addition, the order initiates developing a Climate and Environmental Justice Screening Tool, building from the EPA's EJScreen identifying disadvantaged communities, supporting the Justice40 Initiative, and informing equitable decision-making across the federal government.

5.4.7 Inflation Reduction Act (IRA)

The Inflation Reduction Act (IRA) is the most crucial piece of climate legislation the federal government has ever passed (King, 2023.) It includes $400 billion (about $1,200 per person in the US) for clean energy and related investments and billions of dollars to prepare for and recover from disasters. In addition, President Biden is spurring manufacturing and job growth to advance our EV future. The Inflation Reduction Act provides incentives for buyers of new and used EVs, credits to help manufacturers retool existing facilities and build new manufacturing in the United States, and grants to deploy zero-emission heavy-duty vehicles to ensure that new government policies help dismantle structural racism and target federal resources to the workers and communities, the senate bill has nearly $ 370 billion investments to address President Biden Justice40 Initiative where provisions and incentives run counter to reducing greenhouse gas emissions and to advance $60 billion (about $180 per person in the US) in environmental justice and health equity see Appendix G (R. Bullard, personal communication, August 12, 2022).

Given the urgency of the climate crisis and its disparate impact on disadvantaged communities, this amount is set aside (Appendix G) (R. Bullard, personal communication, August 12, 2022). To ensure that 40% of the benefits from federal investments for climate and clean energy

benefit disadvantaged low-income, people of color, and environmental justice communities-such as incentives for clean energy technologies, electric vehicles, school buses, and transit, this includes prioritization or targeting of resources to environmental justice are communities and communities impacted by energy transition, such as those where coal-fired power plants or coal mines have closed (R. Bullard, personal communication, August 12, 2022). Thereby helping families who are energy insecure with their electric bills, retrofits, and tax credits to assist with making homes more energy efficient, and targeted investments to address legacy pollution and environmental "hot-spots" created by racial redlining and environmental racism that have contributed to elevated health disparities and climate threats; resources to address inadequate transportation infrastructure and highway projects that have caused displacement, disinvestment, economic isolation, and theft of transformative wealth--Black and other people of color homeowners and business owners (Sering, 2022).

5.4.8 Bipartisan Infrastructure Act (BIA)

Since the Interstate Highway System was built during the Eisenhower administration, the Bipartisan Infrastructure Act represents the most significant devoted investment. However, the University of Michigan Center for Connected and Automated Transportation (CCAT) has received $3 million in federal funding to advance research into connected cars, connected infrastructure, and autonomous vehicles to improve transportation security, mobility, and sustainability (Stabenow, 2023; Riley, 2023; ET Auto, 2023). An earlier grant of USD 2.4 million had been given to the organization by the Department of Transportation (Riley, 2023; ET Auto, 2023). The Bipartisan Infrastructure law created the extra funds (Riley, 2023; ET Auto, 2023) where the effects on the U.S. transportation system—which include easing traffic congestion, enhancing autonomous vehicle safety, boosting mobility through connected infrastructure development and cooperative driving

automation, and strengthening the ecosystem for Connected Autonomous Vehicles—made it possible for the U.S. Department of Transportation to award the funding (Stabenow, 2023).

In comparison, as part of Houston, Metro was selected among projects to receive funding from the Federal Transit Administration's (FTA) Accelerating Innovative Mobility (AIM) grant of $1.5 million. (Tatum, 2022; Perrone Robotics, 2022). Unfortunately, the Bipartisan infrastructure law has not created extra funds for connected cars, connected infrastructure, and autonomous buses that will address critical mobility issues for transit-dependent riders at Texas Southern University, the University of Houston, and Houston's Third Ward community connecting to Metro buses and light rail. In addition, we can strengthen U.S. leadership in electric vehicles and batteries by providing better connections to transit, using "green infrastructure" to handle storm runoff, reducing urban heat island hot spots, building safety features, and curbing air pollution investments in the Bipartisan Infrastructure Agreement and Build Back Better Agenda.

The Bipartisan Infrastructure Law provides over $7 billion (about $22 per person in the US) to ensure domestic manufacturers have the essential minerals and other components required to make batteries, $7.5 billion (about $23 per person in the US) to ensure domestic manufacturers have the essential minerals and other components required to make batteries, $7.5 billion to build a national network of 500,000 EV chargers, and over $10 billion (about $31 per person in the US) for clean transit and school buses, including paving over highways, turning them into boulevards, adding trails and bike lanes, and installing sound barriers the cost of electric vehicles for families, and export American electric vehicles around the world (Fact Sheet, 2022). These once-in-a-generation investments will put America in a position to dominate the future of manufacturing and transportation, create union jobs that pay well, significantly increase domestic manufacturing, lower

the cost of electric vehicles for families, and export American electric vehicles around the world (Fact Sheet, 2022).

5.4.9 Limitations, Recommendations for Future Research

Limitations of this dissertation research were due to the number of respondents from undergraduate Political Science, Administrative Justice, and Psychology classes. In addition, the sampling frame applied was limited to students, faculty, and staff from TSU, a historically black university in the Third Ward community. This limitation excludes other non-HBCU Institution settings within Houston's Greater Third Ward, where transit-dependent populations have fewer transit options. Finally, the potential limitation is qualitative and quantitative in design which examined the in-depth impact of an Autonomous Shuttle on student, faculty, and staff participants but needed to consider data-gathering methodologies such as focus groups and interviews. As with other research inquiries, the limitation of this dissertation calls for some future studies.

5.5 Recommendations

This study examined the Autonomous Shuttle along the TSU Campus Tiger Walk. Therefore, future research should use a qualitative study to examine the Third Ward neighborhood. However, for a more robust, conclusive, and comprehensive study, a larger sample size of students and oral history of fifteen to twenty Third Ward residents can help academics and local and federal agencies better understand Environmental Justice issues in Houston's underserved communities by incorporating Autonomous Shuttle Transit connecting routes and schedule information for Metro’s Bus and Light Rail.

5.5.1 Future Research

As with other research inquiries, the limitation of this dissertation calls for some future studies. This dissertation examined an Autonomous Shuttle along the TSU Campus Tiger Walk in Houston's Greater Third Ward neighborhood. As a result, the study did not cover the University of Houston, a white university, and the nearby neighborhood residents. Therefore, future studies must examine the Autonomous Shuttle's disproportionate impact on transit-dependent populations throughout Houston's Third community.

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APPENDIX A

SHUTTLE EASTBOUND AND WESTBOUND VOLUMES

Appendix A. Shuttle Eastbound and Westbound Volumes

Monday (M), Tuesday (T), Thursday (TH) (8 a.m. to 3 p.m.)

	E A S T B O U N D				W E S T B O U N D		
Station Location	Boarding (M)	Alighting (M)	Boarding	Alighting	Boarding	Alighting	Totals
Spearman	8:00	1	-	9:00	-	-	1
MLK Building	8:02	2	1	8:40	-	2	5
Student Center	8:04	-	1	8:20	2	-	3
Education	8:06	-	1	8:10	-	-	3
	(T)		(T)				
Spearman	9:00	2	-	10:00	-	-	2
MLK Building	9:02	1	-	9:40	-	4	5
Student Center	9:04	-	2	9:20	4	-	6
Education	9:06	-	1	9:10	-	-	1
	(TH)		(TH)				
Spearman	1:00	4	-	2:00	-	-	4
MLK Building	1:02	1	1	1:40	-	3	5
Student Center	1:04	2	4	1:20	3	-	9
Education	1:06	-	2	1:10	-	-	2
Totals		14	14		9	9	45

APPENDIX B

PRINCIPALS OF ENVIRONMENTAL JUSTICE INTRODUCTION

Principles of Environmental Justice

Delegates to the First National People of Color Environmental Leadership Summit held on October 24-27, 1991, in Washington DC, drafted and adopted 17 principles of Environmental Justice. Since then, *The Principles Have* served as a defining document for the growing grassroots movement for environmental justice (Principles of Environmental Justice, 1996).

PREAMBLE

WE, THE PEOPLE OF COLOR, gathered together at this multinational People of Color Environmental Leadership Summit, to begin to build a national and international movement of all peoples of color to fight the destruction and taking of our lands and communities, do hereby re-establish our spiritual interdependence to the sacredness of our Mother Earth; to respect and celebrate each of our cultures, languages and beliefs about the natural world and our roles in healing ourselves; to ensure environmental justice; to promote economic alternatives which would contribute to the development of environmentally safe livelihoods; and, to secure our political, economic and cultural liberation that has been denied for over 500 years of colonization and oppression, resulting in the poisoning of our communities and land and the genocide of our peoples, do affirm and adopt these Principles of Environmental Justice:

1) **Environmental Justice** affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction.

2) **Environmental Justice** demands that public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias.

3) **Environmental Justice** mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living things.

4) **Environmental Justice** calls for universal protection from nuclear testing, extraction, production and disposal of toxic/hazardous wastes and poisons and nuclear testing that threaten the fundamental right to clean air, land, water, and food.

5) **Environmental Justice** affirms the fundamental right to political, economic, cultural and environmental self-determination of all peoples.

6) **Environmental Justice** demands the cessation of the production of all toxins, hazardous wastes, and radioactive materials, and that all past and current producers be held strictly accountable to the people for detoxification and the containment at the point of production.

7) **Environmental Justice** demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation.

8) **Environmental Justice** affirms the right of all workers to a safe and healthy work environment without being forced to choose between an unsafe livelihood and unemployment. It also affirms the right of those who work at home to be free from environmental hazards.

9) **Environmental Justice** protects the right of victims of environmental injustice to receive full compensation and reparations for damages as well as quality health care.

10) **Environmental Justice** considers governmental acts of environmental injustice a violation of international law, the Universal Declaration on Human Rights, and the United Nations Convention on Genocide.

11) **Environmental Justice** must recognize a special legal and natural relationship of Native Peoples to the U.S. government through treaties, agreements, compacts, and covenants affirming sovereignty and self-determination.

12) **Environmental Justice** affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity of all our communities, and provided fair access for all to the full range of resources.

13) **Environmental Justice** calls for the strict enforcement of principles of informed consent, and a halt to the testing of experimental reproductive and medical procedures and vaccinations on people of color.

14) **Environmental Justice** opposes the destructive operations of multinational corporations.

15) **Environmental Justice** opposes military occupation, repression and exploitation of lands, peoples and cultures, and other life forms.

16) **Environmental Justice** calls for the education of present and future generations which emphasizes social and environmental issues, based on our experience and an appreciation of our diverse cultural perspectives.

17) **Environmental Justice** requires that we, as individuals, make personal and consumer choices to consume as little of Mother Earth's resources and to produce as little waste as possible; and make the conscious decision to challenge and reprioritize our lifestyles to ensure the health of the natural world for present and future generations.

The Proceedings to the First National People of Color Environmental Leadership Summit are available from the **United Church of Christ Commission for Racial Justice**, 475 Riverside Dr. Suite 1950, New York, NY 10115 (Principles of Environmental Justice, 1996).

Source: https://www.ejnet.org/ej/principles.pdf

APPENDIX C

EXECUTIVE ORDER 12898

Title 3—

The President

Executive Order 12898 of February 11, 1994

Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

Section 1-1. *Implementation.*

1-101. *Agency Responsibilities.* To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

1-102. *Creation of an Interagency Working Group on Environmental Justice.* (a) Within 3 months of the date of this order, the Administrator of the Environmental Protection Agency ("Administrator") or the Administrator's designee shall convene an interagency Federal Working Group on Environmental Justice ("Working Group"). The Working Group shall comprise the heads of the following executive agencies and offices, or their designees: (a) Department of Defense; (b) Department of Health and Human Services; (c) Department of Housing and Urban Development; (d) Department of Labor; (e) Department of Agriculture; (f) Department of Transportation; (g) Department of Justice; (h) Department of the Interior; (i) Department of Commerce; (j) Department of Energy; (k) Environmental Protection Agency; (l) Office of Management and Budget; (m) Office of Science and Technology Policy; (n) Office of the Deputy Assistant to the President for Environmental Policy; (o) Office of the Assistant to the President for Domestic Policy; (p) National Economic Council; (q) Council of Economic Advisers; and (r) such other Government officials as the President may designate. The Working Group shall report to the President through the Deputy Assistant to the President for Environmental Policy and the Assistant to the President for Domestic Policy.

(b) The Working Group shall: (1) provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations;

(2) coordinate with, provide guidance to, and serve as a clearinghouse for, each Federal agency as it develops an environmental justice strategy as required by section 1-103 of this order, in order to ensure that the administration, interpretation and enforcement of programs, activities and policies are undertaken in a consistent manner;

(3) assist in coordinating research by, and stimulating cooperation among, the Environmental Protection Agency, the Department of Health and Human Services, the Department of Housing and Urban Development, and other agencies conducting research or other activities in accordance with section 3-3 of this order;

(4) assist in coordinating data collection, required by this order;

(5) examine existing data and studies on environmental justice;

(6) hold public meetings as required in section 5–502(d) of this order; and

(7) develop interagency model projects on environmental justice that evidence cooperation among Federal agencies.

1–103. *Development of Agency Strategies.* (a) Except as provided in section 6–605 of this order, each Federal agency shall develop an agency-wide environmental justice strategy, as set forth in subsections (b)–(e) of this section that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. The environmental justice strategy shall list programs, policies, planning and public participation processes, enforcement, and/or rulemakings related to human health or the environment that should be revised to, at a minimum: (1) promote enforcement of all health and environmental statutes in areas with minority populations and low-income populations; (2) ensure greater public participation; (3) improve research and data collection relating to the health of and environment of minority populations and low-income populations; and (4) identify differential patterns of consumption of natural resources among minority populations and low-income populations. In addition, the environmental justice strategy shall include, where appropriate, a timetable for undertaking identified revisions and consideration of economic and social implications of the revisions.

(b) Within 4 months of the date of this order, each Federal agency shall identify an internal administrative process for developing its environmental justice strategy, and shall inform the Working Group of the process.

(c) Within 6 months of the date of this order, each Federal agency shall provide the Working Group with an outline of its proposed environmental justice strategy.

(d) Within 10 months of the date of this order, each Federal agency shall provide the Working Group with its proposed environmental justice strategy.

(e) Within 12 months of the date of this order, each Federal agency shall finalize its environmental justice strategy and provide a copy and written description of its strategy to the Working Group. During the 12 month period from the date of this order, each Federal agency, as part of its environmental justice strategy, shall identify several specific projects that can be promptly undertaken to address particular concerns identified during the development of the proposed environmental justice strategy, and a schedule for implementing those projects.

(f) Within 24 months of the date of this order, each Federal agency shall report to the Working Group on its progress in implementing its agency-wide environmental justice strategy.

(g) Federal agencies shall provide additional periodic reports to the Working Group as requested by the Working Group.

1–104. *Reports to the President.* Within 14 months of the date of this order, the Working Group shall submit to the President, through the Office of the Deputy Assistant to the President for Environmental Policy and the Office of the Assistant to the President for Domestic Policy, a report that describes the implementation of this order, and includes the final environmental justice strategies described in section 1–103(e) of this order.

Sec. 2–2. *Federal Agency Responsibilities for Federal Programs.* Each Federal agency shall conduct its programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin.

Sec. 3–3. *Research, Data Collection, and Analysis.*

3–301. *Human Health and Environmental Research and Analysis.* (a) Environmental human health research, whenever practicable and appropriate, shall include diverse segments of the population in epidemiological and clinical studies, including segments at high risk from environmental hazards, such as minority populations, low-income populations and workers who may be exposed to substantial environmental hazards.

(b) Environmental human health analyses, whenever practicable and appropriate, shall identify multiple and cumulative exposures.

(c) Federal agencies shall provide minority populations and low-income populations the opportunity to comment on the development and design of research strategies undertaken pursuant to this order.

wildlife. Agencies shall consider such guidance in developing their policies and rules.

Sec. 5–5. *Public Participation and Access to Information.* (a) The public may submit recommendations to Federal agencies relating to the incorporation of environmental justice principles into Federal agency programs or policies. Each Federal agency shall convey such recommendations to the Working Group.

(b) Each Federal agency may, whenever practicable and appropriate, translate crucial public documents, notices, and hearings relating to human health or the environment for limited English speaking populations.

(c) Each Federal agency shall work to ensure that public documents, notices, and hearings relating to human health or the environment are concise, understandable, and readily accessible to the public.

(d) The Working Group shall hold public meetings, as appropriate, for the purpose of fact-finding, receiving public comments, and conducting inquiries concerning environmental justice. The Working Group shall prepare for public review a summary of the comments and recommendations discussed at the public meetings.

Sec. 6–6. *General Provisions.*

6–601. *Responsibility for Agency Implementation.* The head of each Federal agency shall be responsible for ensuring compliance with this order. Each Federal agency shall conduct internal reviews and take such other steps as may be necessary to monitor compliance with this order.

6–602. *Executive Order No. 12250.* This Executive order is intended to supplement but not supersede Executive Order No. 12250, which requires consistent and effective implementation of various laws prohibiting discriminatory practices in programs receiving Federal financial assistance. Nothing herein shall limit the effect or mandate of Executive Order No. 12250.

6–603. *Executive Order No. 12875.* This Executive order is not intended to limit the effect or mandate of Executive Order No. 12875.

6–604. *Scope.* For purposes of this order, Federal agency means any agency on the Working Group, and such other agencies as may be designated by the President, that conducts any Federal program or activity that substantially affects human health or the environment. Independent agencies are requested to comply with the provisions of this order.

6–605. *Petitions for Exemptions.* The head of a Federal agency may petition the President for an exemption from the requirements of this order on the grounds that all or some of the petitioning agency's programs or activities should not be subject to the requirements of this order.

6–606. *Native American Programs.* Each Federal agency responsibility set forth under this order shall apply equally to Native American programs. In addition, the Department of the Interior, in coordination with the Working Group, and, after consultation with tribal leaders, shall coordinate steps to be taken pursuant to this order that address Federally-recognized Indian Tribes.

6–607. *Costs.* Unless otherwise provided by law, Federal agencies shall assume the financial costs of complying with this order.

6–608. *General.* Federal agencies shall implement this order consistent with, and to the extent permitted by, existing law.

6–609. *Judicial Review.* This order is intended only to improve the internal management of the executive branch and is not intended to, nor does it create any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity by a party against the United States, its agencies, its officers, or any person. This order shall not be construed to create any right to judicial review involving the compliance or noncompliance

of the United States, its agencies, its officers, or any other person with this order.

William J. Clinton

THE WHITE HOUSE,
February 11, 1994.

[FR Citation 59 FR 7629]

APPENDIX D

JUSTICE40 INITIATIVE FACT SHEET

Justice40 Initiative Fact Sheet

U.S. DEPARTMENT OF ENERGY | Office of Economic Impact and Diversity

Low-income communities of color disproportionally bear the environmental harm and economic burdens of the energy system and do not equitably receive its benefits or have equitable access to decision-making processes. The clean energy transition presents an opportunity to transform communities. **Justice40 is the tool to get there.**

THE JUSTICE40 INITIATIVE

Created under the Biden-Harris Administration, **Justice40 establishes the goal that 40% of the overall benefits of certain federal investments flow to disadvantaged communities (DACs).** The Justice40 Initiative applies to over 145 Department of Energy (DOE) programs and to much of the $62 billion investment in DOE under the Bipartisan Infrastructure Law. The DOE is rolling out programs and funding opportunities that could provide transformational benefits to disadvantaged communities across the country. Community-based organizations, local, state, tribal, and territorial governments, small businesses, and educational institutions can apply to some of these programs and may be able to participate in the development of many more.

COVERED FEDERAL INVESTMENTS → 40% OF THE OVERALL BENEFITS → DISADVANTAGED COMMUNITIES (DACs)

WHAT DOES JUSTICE40 COVER?

J40 Covered Programs: Federal government programs that make investments in one or more of the following seven areas are covered by Justice40:

- Climate change
- Clean energy and energy efficiency
- Clean transportation
- Affordable and sustainable housing
- Training and workforce development
- Remediation and reduction of legacy pollution
- Critical clean water and waste infrastructure

THE BIPARTISAN INFRASTRUCTURE LAW (BIL)

The BIL is a once-in-a-generation, $1.2 trillion investment in our nation's infrastructure that provides the foundation for a more sustainable, resilient, and equitable economy. The BIL provides opportunities to enhance U.S. competitiveness in the world, diversify regional economies to include supply chain and manufacturing industries, create good union jobs, and ensure stronger access to these economic benefits for underserved communities. Learn more about BIL on the Department of Energy's BIL Factsheet.

Source: *https://www.energy.gov/sites/default/files/2022-08/J40%20Fact%20Sheet%208_25_22%20v3.pdf*

Justice40 Initiative Fact Sheet
More about the Justice40 Initiative

HOW DO WE MEASURE AND TRACK BENEFITS?

DOE has set eight **policy priorities** that define the types of energy-related outcomes J40 could deliver to disadvantaged communities (see right). Under J40, DOE Program Offices will establish metrics, measure, and report on the applicable benefits (or disbenefits) that their respective programs can have in a community related to these priorities. Below are examples of benefit metrics.

POLICY PRIORITY	EXAMPLE BENEFIT	EXAMPLE METRIC
Decrease energy burden	Reduction in energy costs due to technology adoption	Annual energy expenditures in DACs before and after program intervention
Decrease environmental exposure and burdens	Reduction in local pollutant emissions	Measurement of local pollutant in DACs before and after program intervention
Increase clean energy access	Increase access to clean energy serving DACs	Percentage of local electricity generation mix from clean energy that serves DACs

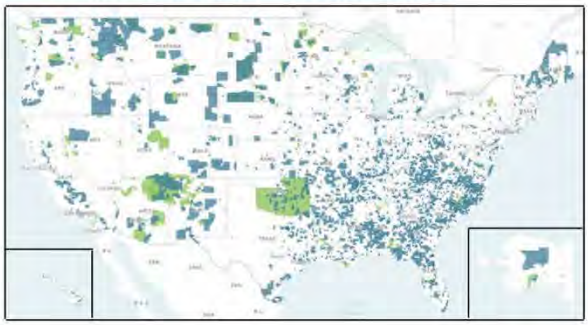
JUSTICE 40 POLICY PRIORITIES

- Decrease energy burden in disadvantaged communities (DACs)
- Decrease environmental exposure and burdens for DACs
- Increase parity in clean energy technology access and adoption in DACs
- Increase access to low-cost capital in DACs
- Increase clean energy enterprise creation and contracting in DACs
- Increase clean energy jobs, job pipeline, and job training for individuals from DACs
- Increase energy resiliency in DACs
- Increase energy democracy in DACs

WHERE ARE THE DISADVANTAGED COMMUNITIES?

A **community** can be either people in **geographic proximity** or people experiencing a **common condition**. **Disadvantage** was measured based on a score across 36 indicators, such as energy burden, housing burden, park access, power outages, cancer incidence, and more. The higher the score, the more disadvantage. Census tracts with at least 30% low income households and disadvantage scores higher than 80 percent of those in their state are considered a disadvantaged community (DAC). DACs are shown in blue and green on the map below, with all territories and tribal lands in green.

DOE DEFINED DISADVANTAGED COMMUNITIES



More information on the DAC indicators and the methodology can be found on the Office of Economic Impact and Diversity's Justice40 Initiative page or by scanning this QR code. You can also find your community in the Department of Energy's Disadvantaged Communities Reporter.

Source: *https://www.energy.gov/sites/default/files/2022-08/J40%20Fact%20Sheet%208_25_22%20v3.pdf*

Source: *https://www.energy.gov/sites/default/files/2022-08/J40%20Fact%20Sheet%208_25_22%20v3.pdf*

APPENDIX E

FACT SHEET:

PRESIDENT BIDEN ANNOUNCES STEPS TO DRIVE AMERICAN LEADERSHIP FORWARD ON CLEAN CARS AND TRUCKS

AUGUST 05, 2021

FACT SHEET: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks

President Biden Outlines Target of 50% Electric Vehicle Sales Share in 2030 to Unleash Full Economic Benefits of Build Back Better Agenda and Advance Smart Fuel Efficiency and Emission Standards

President Biden's Build Back Better Agenda and the Bipartisan Infrastructure Deal invest in the infrastructure, manufacturing, and incentives that we need to grow good-paying, union jobs at home, lead on electric vehicles around the world, and save American consumers money. Today, the President will announce a set of new actions aimed at advancing these goals and increasing the impact of his proposed Build Back Better investments – positioning America to drive the electric vehicle future forward, outcompete China, and tackle the climate crisis.

Specifically, the President will sign an Executive Order that sets an ambitious new target to make half of all new vehicles sold in 2030 zero-emissions vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles. The Executive Order also kicks off development of long-term fuel efficiency and emissions standards to save consumers money, cut pollution, boost public health, advance environmental justice, and tackle the climate crisis.

In addition, and consistent with the President's Day One Executive Order, the Environmental Protection Agency (EPA) and U.S. Department of Transportation (USDOT) will announce how they are addressing the previous administration's harmful rollbacks of near-term fuel efficiency and emissions standards. Through these coordinated notices of proposed rulemaking, the two agencies are advancing smart fuel efficiency and emissions standards that would deliver around $140 billion in net benefits over the life of the

program, save about 200 billion gallons of gasoline, and reduce around two billion metric tons of carbon pollution. For the average consumer, this means net benefits of up to $900 over the life of the vehicle in fuel savings.

These new actions – paired with the investments in the President's Build Back Better Agenda – will strengthen American leadership in clean cars and trucks by accelerating innovation and manufacturing in the auto sector, bolstering the auto sector domestic supply chain, and growing auto jobs with good pay and benefits. That is why today, American automakers Ford, GM, and Stellantis and the United Auto Workers (UAW), will stand with President Biden at the White House with aligned ambition: supporting the President's Build Back Better Agenda and the automakers' need to invest in and grow good-paying union jobs in the United States.

Build Back Better Investment Agenda

The global market is shifting to electric vehicles and tapping their potential to save families money, lower pollution, and make the air we breathe cleaner. Despite pioneering the technology, the U.S. is behind in the race to manufacture these vehicles and the batteries that go in them. Today, the U.S. market share of electric vehicle sales is only one-third that of the Chinese electric vehicle market. The President believes it is time for the U.S. to lead in electric vehicle manufacturing, infrastructure, and innovation, by investing in:

- Installing the first-ever national network of electric vehicle charging stations.
- Delivering point-of-sale consumer incentives to spur U.S. manufacturing and union jobs.
- Financing the retooling and expansion of the full domestic manufacturing supply chain.
- Innovating the next generation of clean technologies to maintain our competitive edge.

Through the investments in the Build Back Better Agenda and Bipartisan Infrastructure Deal, we can strengthen U.S. leadership in electric vehicles and batteries. These once-in-a-generation investments will position America to win the future of transportation and manufacturing and create good-paying, union jobs, dramatically expand American manufacturing, make electric vehicles more affordable for families, and export our electric vehicles around the world.

And, the President has already made a down payment on his vision for U.S. leadership in auto manufacturing. Last month, the Department of Commerce announced $3 billion in currently available American Rescue Plan funds that can be used to advance the domestic electric vehicle industry in communities that have historically been the backbone of our auto industry.

Electric Vehicles Ambition for 2030

Over the last decade, we have seen a transformation in the technology costs, performance, and availability of electric vehicles. Since 2010:

- Battery pack costs dropped by 85 percent, paving the way to sticker price parity with gasoline-powered vehicles.
- Average vehicle range increased dramatically as charging times shortened.
- Electric models available to U.S. consumers expanded to over 40 last year – and growing.

Seeing this shift, countries are sprinting to lead. For example, China is increasingly cornering the global supply chain for electric vehicles and batteries with its fast-growing electric vehicle market. By setting clear targets for electric vehicle sale trajectories, these countries are becoming magnets for private investment into their manufacturing sectors – from parts and materials to final assembly.

President Biden is committed to changing that and delivering for the American people. That is why he will sign an Executive Order that sets a new target of electric vehicles representing half of new vehicles sold in 2030. This builds on the announcements today from automakers, representing nearly the entire U.S. auto market who have positioned around the goal of reaching 40 to 50 percent electric vehicle sales share in 2030. More than a deployment target, it is a goal to leverage once-in-generation investments and a whole-of-government effort to lift the American autoworker and strengthen American leadership in clean cars and trucks. The 2030 target is calibrated to provide time for existing manufacturing facilities to upgrade without stranding assets, upgrades that will be catalyzed by the Build Back Better Agenda, and lean into a path that expands domestic U.S. manufacturing with union workers.

Smart Fuel Efficiency and Emissions Standards

Consistent with the President's Day One Executive Order, the Environmental Protection Agency (EPA) and U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) will announce how they are addressing the previous administration's harmful rollbacks of near-term fuel efficiency and emissions standards. The two agencies' standards work in a compatible fashion through model year 2026, with the NHTSA proposed rule starting in model year 2024 and the EPA proposed rule taking effect a year sooner with model year 2023. The standards build on the momentum from "California Framework Agreement" – an agreement between the State of California and five automakers: Ford, Honda, Volkswagen Group, BMW, and Volvo.

Through these coordinated notices of proposed rulemaking, the two agencies are advancing smart fuel efficiency and emissions standards that would deliver around $140 billion in net benefits over the life of the standards, including asthma attacks avoided and lives saved, save about 200 billion gallons of gasoline, and reduce around two billion metric tons of carbon pollution. For the average consumer, this means net savings of up to $900 over the life of the vehicle from fuel savings.

Building on these near-term steps, the Executive Order that the President will sign kicks off development of long-term fuel efficiency and emissions standards to save consumers money, cut pollution, boost public health, advance environmental justice, and tackle the climate crisis. Specifically, the Executive Order lays out a robust schedule for development of fuel efficiency and multi-pollutant emissions standards through at least model year 2030 for light-duty vehicles and for medium- and heavy-duty vehicles starting as early as model year 2027. The Executive Order also directs agencies to:

- Consult with the Secretaries of Commerce, Labor, and Energy on ways to accelerate innovation and manufacturing in the automotive sector, to strengthen the domestic supply chain for that sector, and to grow jobs that provide good pay and benefits.
- Engage with California and other states leading the way in reducing vehicle emissions.

- Secure input from a diverse range of stakeholders, including representatives from labor unions, industry, environmental justice organizations, and public health experts.

Together, today's announcements would put us on track to reduce greenhouse gas emissions from new passenger vehicle sales by more than 60 percent in 2030 compared to vehicles sold last year, and facilitate achieving the President's goal of 50-52 percent net economy-wide greenhouse gas emission reductions below 2005 levels in 2030.

APPENDIX F

BULLARD CENTER STATEMENT ON THE SENATE INFLATION REDUCTION ACT

Dr. Robert D. Bullard Statement on the Senate Inflation Reduction Act

The Senate Inflation Reduction Act (IRA) has some good things in it that are greatly needed by low-income, people of color and environmental justice communities—such as incentives for clean energy technologies, electric vehicles, school buses and transit. Each of these would help families who are energy insecure with their electric bills, retrofits and tax credits to assist with making homes more energy efficient. Targeted investments will address legacy pollution and pollution hot-spots created by racial redlining and environmental racism that have contributed to elevated health disparities and climate threats. There are now resources to address bad transportation infrastructure and highway projects that have caused displacement, disinvestment, economic isolation, and theft of transformative wealth—Black and other people of color homeowners and business owners.

The 725-page Senate bill has nearly $370 billion investments to address greenhouse gas emissions, and $60 billion (actually $47 billion) to advance environmental justice and health equity. Given the urgency of the climate crisis and the disparate impact on disadvantaged communities, the amount set aside for environmental justice is inadequate. At minimum, Congress should use the White House Justice40 framework (deliver at least 40 percent of the overall benefits from Federal investments in climate and clean energy to disadvantaged communities) in allocating the bill's $370 billion climate funding—investments and benefits that are desperately needed and long overdue.

There are provisions and incentives in the bill that run counter to reducing greenhouse gas emissions and relieving legacy pollution, health threats, and pain and suffering of already overburdened environmental justice communities. This is especially the case in the South and Gulf states where decades of research, reports and books—many written by our own scholars and experts—clearly document the wrong complexion for protection and environmental racism where petrochemical and other polluting industries have created environmental "sacrifice zones" and "Cancer Alleys," where the health of residents in fence-line communities is cheapened.

Once again, the current Senate bill includes gifts—tax credits to these same fossil fuel companies for the unproven carbon capture and storage (CCS), more offshore oil and gas leases, and more pipelines guarantees for new fossil fuel leasing in the Gulf of Mexico—adding unwanted pollution to already overburdened environmental justice communities, inhabited largely by Black, Latino, indigenous and poor residents.

Environmental justice communities once again are placed in a precarious position of having to accept risky and unproven CCS technologies, more pollution, unfair health "trade-offs" and harm in order to get economic, environmental and climate benefits. Many environmental justice groups and coalitions have grave concerns about the risky and unproven technologies being promoted with federal tax dollars. The Senate bill on one hand "giveth" benefits and on the other hand "giveth" more potential health burdens to already vulnerable environmental justice communities. These funding contradictions should not be brushed aside or ignored. The contradictions need to be rigorously assessed and improvements made in the bill to minimize negative impacts that fall disproportionately on our most vulnerable populations and communities wherever they are found.

Source:https://www.bullardcenter.org/blog/bullard-center-statement-on-the-senate-inflation-reduction-ac

APPENDIX G

MODEL GUIDELINES FOR PUBLIC PARTICIPATION

Model Guidelines for Public Participation

An Update to the 1996 NEJAC Model Plan for Public Participation

January 25, 2013
A Report of Recommendations
of the
National Environmental Justice Advisory Council
A Federal Advisory Committee to the U.S. Environmental Protection Agency

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A Federal Advisory Committee to the U.S. Environmental Protection Agency

Source: https://www.epa.gov/environmentaljustice/model-guidelines-public-participation

Exhibit 1

A. Preparation

- ☐ Developing co-sponsoring and co-planning relationships with community organizations is essential to successful engagement. Community engagement could include community meetings, consultations, roundtables, training sessions, workshops, one-on-one conversations with community representatives, teleconference calls, webinars and videos, and other efforts.
- ☐ To ensure successful engagement opportunities, agencies should provide co-sponsors that can provide communities with the resources they need, and share all planning roles with the federal representatives. These roles could include:
  - ☐ Developing a Public Participation Plan that provides the framework for the public process (see Appendix B for sample guidelines to use in developing a Public Participation Plan).
  - ☐ Decision-making.
  - ☐ Development of the activities in the community engagement process, including elements such as:
    - o Establishment of clear goals.
    - o Leadership.
    - o Outreach.
- ☐ Educating the community to allow equal participation and provide a means to influence decision-making. As an example, this could be done by linking environmental, economic, political and social analysis of a community (including class) to begin to create a deeper understanding of the causes of climate change and how it will impact environmental justice communities. Closely related to this is linking local, national, and international environmental justice issues.
- ☐ Regionalizing materials to ensure cultural sensitivity and relevance.
- ☐ Providing a facilitator who is sensitive and trained in environmental justice issues and other issues important to the community, where feasible.

B. Participants

As introduced in Recommendation 2, a steering committee made up of community stakeholders, one committee per policy-making undertaking, or specific environmental projects where policy matters have been decided, should be established in each affected community. This steering committee would be independent of the sponsoring agency but collaborate in the development of the policy or project. To be able to do this, it could be required to have a technical committee to advise the steering committee on technical and financial matters. The agency should not assume that all communities are equal with respect to average educational levels.

The site-specific steering committee or community advisory board should clarify its role(s) and responsibilities, determine the expected outcome of its meetings, and identify ways to generate sustained interest of community members in the environmental justice issues that affect them. The steering committee should assess specific public participation techniques to use to reach all stakeholders. For example, in rural communities, requiring committees can help to build and strengthen local capacities that are otherwise absent for environmental justice communities. In many cases, a steering committee could provide a first opportunity for members of the public to participate as equals with state and federal agency staff in making a decision that will impact their lives, their families and communities. The steering committee should last the length of the project.

All affected stakeholder groups should be considered for membership in the steering committee. These groups include, but are not limited to, the following:

- ☐ Community and neighborhood groups.
- ☐ Community service organizations (health, welfare, and others).
- ☐ Educational institutions and academia.
- ☐ Environmental organizations, including Local Emergency Planning Committees.
- ☐ Industry and business.
- ☐ Medical community.
- ☐ Non-governmental organizations.
- ☐ Religious communities.
- ☐ Spiritual communities.
- ☐ Indigenous peoples.
- ☐ Civic/public interest groups.
- ☐ Unions and other employment related organizations.

Source: https://www.epa.gov/environmentaljustice/model-guidelines-public-participation

NEJAC Recommendations
Model Guidelines for Public Participation
Page 8

C. Engagement Logistics

The following logistics are associated with community meetings as an example of an engagement activity. These logistical considerations, however, should also be applied to other forms of engagement, such as consultations, roundtables, training sessions, workshops, one-on-one conversations with community representatives, teleconference calls, webinars, videos, etc.

I. Where:

- ☐ Meetings and other activities involved in the community engagement process should be accessible to all who wish to attend, when feasible. For example, available public transit, childcare, and access for the disabled should be considered, when feasible.
- ☐ Meetings and other activities involved in the community engagement process must be held in an adequate facility (size and conditions must be considered), when feasible.
- ☐ Where feasible, technology should be used to enhance effective communication, for example: teleconferencing, video conferencing, webinars, adequate translation, etc.

II. When:

- ☐ The time of year and the day and time of meetings and other activities to engage the community should accommodate the needs of affected communities (evening and weekend meetings accommodate working people, and careful scheduling can avoid conflicts with other community or cultural events, for example, harvest time during the fall in agrarian communities).

III. How:

- ☐ An atmosphere of equal participation must be created (avoid using a "panel" or "head table"), where feasible.
- ☐ A two-day meeting, at a minimum, is suggested. For example, the first day could focus on community planning and education, and the second day could focus on open dialogue and engagement among stakeholders.
- ☐ The community and the government should share leadership and presentation assignments, with the steering committee taking the lead role. All stakeholders should be engaged in the planning process.

D. Other Considerations

- ☐ Promote public awareness of multiple chemical sensitivities and provide a chemical and scent-free meeting space.
- ☐ Maintain clear goals by referring to the agenda, but the speakers should not be bound by the agenda.
- ☐ Incorporate cross-cultural exchanges in the presentation of information and the meeting agenda. Provide translators, if needed, for persons with limited English proficiency to ensure engagement of key stakeholders.
- ☐ Provide a professional facilitator who is sensitive to, and trained in, environmental justice issues and other issues relevant to the community.
- ☐ Provide a timeline that describes how the meeting fits into the overall agenda of issues at hand.
- ☐ Coordinate follow-up by developing an action plan and determining who will be responsible for expediting the work products from the process.
- ☐ Provide a sign-in sheet to gather contact information of attendees to facilitate future distribution of information and follow-up.
- ☐ Distribute minutes and a list of action items to all attendees to facilitate follow-up.
- ☐ Visit local organizations to consult in the decision-making. Visiting local organizations during their regular membership meetings serve as a substitute for more general public meetings. There is a captive audience who will listen. These visits should not be aimed at *informing* but instead at *soliciting support* for a desired outcome that is to benefit the community. These visits should be led by the steering committee. Further, not all community organizations will attend the public meetings or have a representative in the steering committee for a variety of reasons. Such visits can be a way to avoid leaving them out of the process by "taking the meeting" to them.

Source: https://www.epa.gov/environmentaljustice/model-guidelines-public-participation

APPENDIX H

CONSCENT FORM

Consent Form

You are invited to participate in a research study Autonomous Shuttle Transit: An Exploratory Case Study and The Future Impact on TSU Campus. This study is being conducted by a doctoral candidate from Texas Southern University.

Study Purpose/Description:
The researcher selected Texas Southern University Campus Tiger Walk to establish whether Environmental Justice has played a role in safeguarding students, faculty, and staff compared to Third Ward's transit-dependent population, which only has subdivision regulations for protecting residents from transportation exclusion.

The research outcome will provide additional evidence to confirm the negative impact of inadequate transit accessibility for those living close to the Texas Southern University Campus Tiger Walk bus stop and further strengthen the scientific foundation to address environmental inequalities in our society. In addition, the researcher will examine the EasyMile driverless shuttle as an additional mode through a questionnaire survey consisting of 35 questions to be administered to students living in Houston's Greater metropolitan area. The survey is expected to be completed between 10 to 30 minutes.

Risk: This research will not cause greater harm or discomfort to the participants other than their time used to respond to the questionnaire and those ordinarily encountered in daily life. However, should any discomfort occur due to the questions asked and issues raised, the psychological risk can be ameliorated by seeking counseling at an expense to be borne by the participant. Therefore, the investigator recommends Dr. Deloris Nelson for the research, located at MCP Professional Services, 2616 South Loop West, and Suite 575: Houston, Texas 77054. For free counseling, contact: Interface-Samaritan Counseling Centers, located at 4803 San Felipe; Houston, Texas 77056.

Benefits: You are not expected to receive any direct benefit because of this research.

Voluntary Participation: Your participation in this study is voluntary. You may choose not to participate at all or have the right to discontinue and withdraw from the study at any time. There is no penalty in any manner for not participating in this study.

Confidentiality: Your identity will not be attached to the data; therefore, you will remain anonymous. Your survey answers will be sent to a link at SurveyMonkey.com, where data will be stored in a password-protected electronic format. Survey Monkey does not collect identifying information such as your name, email address, or IP address. Therefore, your responses will remain anonymous. No one will be able to identify you or your answers, and no one will know whether you participated in the study.

Records: All completed survey data gathered for this research will be protected and stored at my home, which has a security surveillance system. The documents will be kept on a password protected computer accessible only to the investigator.

Electronic consent: Please select your choice below.
By clicking "I agree" below you are indicating that you are at least 18 years old, have read this consent form and agree to participate in this research study. You are free to skip any question that you choose.

Please print or save a copy of this page for your records.

I Agree

I disagree

APPENDIX I

AUTONOMOUS SHUTTLE TRANSIT SURVEY QUESTIONS

Appendices

Appendix I: Autonomous Shuttle Transit Survey Questions

General Instructions:
Please answer each question as thoughtfully as possible and remember there is no right or wrong answer.

Demographics and shuttle and service characteristics

(1) What is your age?

A. 18-24 C. 35-44 E. 65+
B. 25-34 D.45-64

(2) What is your gender?

Male_____ Female_____
I choose not to answer_____

(3) Ethnicity (or Race)

White_____ Hispanic or Latinx_____
Black or African America_____ Native American / American Indian_____
Asian_____ Other_____

(4) What is your classification?

A. Undergraduate
B. Graduate
C. Other

(5) Do you have a valid driver's license?

Yes_____ No_____

(6) What vehicle do you use most on TSU campus?

Passenger car_____ SUV (sport utility vehicle) _____
Motorcycle/scooter _____ I do not drive _____ UV (utility vehicle) _____
Other_____

(7) What transport mode do you use on the TSU campus?

Walk_____ Driverless Shuttle_____
Bike_____ Other_____

(8) What is the Texas Southern University driverless shuttle research project?

A. Is a research project that will help us understand the challenges and opportunities presented by driverless shuttles and how riders, pedestrians, and other vehicles interact with them.

B. A fully automated, 11-passenger, all-electric shuttle manufactured by EasyMile to transport students, faculty, and staff on a non-stop one-mile route at Texas Southern University on Wheeler Street.
C. The shuttle ran from June 2019–February 2020.
D. All the above
E. None of the above
F. I do not know

(9) Have you ever used the driverless shuttle along the TSU Tiger Walk for day to day commuting?

Always_____ Sometimes _____ Never_____
Usually_____ Rarely_____

(10) Who could ride the EasyMile driverless shuttle?

_____ The shuttle was used to transport members of the TSU community.
_____ Guest was required to be at least 18 year and provide Identification to the shuttles safety conductors, if asked.
_____Only TSU students could ride the shuttle.

(11) Was there any preparation needed to ride the shuttle?

_____ No preparation was needed to ride the shuttle.
_____ Riders simple boarded the shuttle and were asked to buckle their seat belts.

(12) What hours did the shuttle operate?

Early 9 a.m. _____ Late after 3 p.m. _____
Before 9 a.m. _____ After 7 p.m. _____
I do not know_____

(13) Could students ride the shuttle from their dorm room to classes?

Yes _____ No_____

(14) How many seats were inside the driverless shuttle?

6_____ 8_____ 10_____ 12_____

(15) How safe is the EasyMile Autonomous Shuttle?

_____ The shuttle's sensors continuously scan the vehicle's surroundings.
_____ The vehicle stops when an obstacle is detected in its path.
_____ As an added measure, a conductor was on board and could manually stop the shuttle for safety, if needed.
_____ None of the above

Attitudinal Questions

(16) What kind of vehicle is the TSU Driverless Shuttle?

_____ The TSU Driverless Shuttle project used the Autonomous Shuttle, manufactured by EasyMile.
_____ The Autonomous Shuttle is an electric driverless shuttle vehicle.
_____ Shuttle is a solar powered vehicle.
_____ Both gasoline and electric vehicles.

(17) How does the EasyMile Autonomous Shuttle drive itself?

_____Extremely familiar _____ Somewhat familiar
_____Not at all familiar _____ Very familiar

(18) Did you like it that the driverless shuttle drives at a low speed?

Always_____ Sometimes _____ Never_____
Usually_____ Rarely_____

(19) Is the Easy Mile Autonomous Shuttle fully automated?

Yes_____ No_____

(20) Is the driverless shuttle easy to understand compared to other existing public transport**?**

Yes_____ No_____

(21) Was there a person on board to oversee the shuttle's operation?

Always_____ Sometimes _____ Never_____
Usually_____ Rarely_____

(22) Would you prefer the automated shuttle to drive without a conductor on board?

Yes_____ No_____

(23) The conductor did not drive the vehicle there is no steering wheel, but the conductor did have the ability to manually stop the shuttle, if necessary, for safety reasons.

Always_____ Sometimes _____ Never_____
Usually_____ Rarely_____

(24) Did you feel comfortable in a vehicle without a steering wheel, gas, or brake pedal?

Yes_____ No_____

(25) Would you prefer to manually steer the automated shuttle?

Likely_____ Unlikely_____

Built Environment

(26) How long was the route?

_____The shuttle route was about a one-mile round-trip.
_____Ran roughly every 15 minutes when one shuttle was in operation.

(27) What route did the shuttle take?

_____The shuttle traveled on a round-trip route along Texas Southern University Campus Tiger Walk near Ennis Street.

_____There were three stops, an east and west stop at the Spearman, and Sterling Student Life Center on Wheeler Avenue, a temporary stop at the library on Tierwester Street.

_____The shuttle travels along Cleburne Street interacting with METRO buses.

_____ None of the above

(28) Did the shuttle drive along the TSU Tiger Walk with other vehicles on the road?
Yes_____ No_____

(29) Is the Easy Mile driverless shuttle being used anywhere else in the world?
Yes_____ No_____

(30) How did the EasyMile driverless shuttle work with METRO bus service?
Always_____ Sometimes _____Never_____
Usually_____ Rarely_____

(31) Is the shuttle operating now?
Yes_____ No _____

(32) Could riders provide feedback about their experience with the TSU Driverless Shuttle?

Always_____ Sometimes _____ Never_____
Usually_____ Rarely_____

(33) Was the shuttle accessible to persons with disabilities?
Yes_____ No_____

(34) Could riders provide feedback more than once?
Always_____ Sometimes_____ Never_____
Usually_____ Rarely_____

(35) Who will receive the survey results?
_____Survey results will be anonymized and provided to TSU industry members. and researchers.
_____ The data will help researchers learn how consumers react and interact with driverless technology, as well as how to design safer vehicles and how to operate them more efficiently.
_____None of the above

Thank you very much for taking the time to answer these questions.