“It’s an Economic Issue”: Expanding Access to Opportunities Across the Cities of Arlington and Grand Prairie, Texas Through Mass Transit

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Table of Contents

Study Purpose and Goals

Researchers in the Colleges of Social Work and Engineering conducted the following study at the request of the Legislature of the State of Texas. The purpose of the overall study is to document current transportation services linking the Cities of Arlington and Grand Prairie, Texas, as well as demand for increased transit that would enhance the economic vitality of the region and the well-being of community members. Specifically, we sought to achieve the following goals.

Study Goals

1. **To identify transit deserts within and between the Cities of Arlington and Grand Prairie, Texas.**
2. **To identify transit attractors within and between the two cities.**
3. **To propose strategies to increase transit connections between the two cities.**

The Context for the Study

To achieve this larger goal, we began by conducting a community-engaged qualitative assessment of transportation resources, gaps, and recommendations for improvement. We solicited the perspectives of key stakeholders within the community, including decision-makers and city planners, transportation planners, businesses and major employers, residents, employees of social service organizations, and members of environmental justice populations. The sampling and a detailed methodology of this phase of the project can be found in the appendices.

History of Public Transit in Arlington and Grand Prairie

For years, Arlington, Texas, has been the largest city in the United States without public transportation services (Anbinder, 2013; Barr, 2017; Barry, 2013). "At its core, Arlington's longstanding lack of public transit stemmed from a basic problem: an unwillingness to think *regionally*" (Anbinder, 2013, para. 6).

In Texas, cities are required to raise their own funding for any bus or rail systems. Elected officials have limited incentive to fund public transportation in the area (Anbinder, 2013; Barry, 2013). Between 1980 and 2013, Arlington voters rejected three referendums proposing large-scale bus services, despite the reported demand for public transit in the area (Anbinder, 2013; Barr, 2017; Barry, 2013). The highways that connect Arlington, Fort Worth, and Dallas are

among the most congested in the world, and drivers in this area spend more time sitting in traffic than in most cities throughout the United States (Anbinder, 2013; Barr, 2017; Barry, 2013).

The two most commonly cited reasons for voting against the referendums in Arlington are: 1) fear of increased crime, and; 2) fear of growth in the City of Arlington (Barry, 2013).

In Grand Prairie, the city has largely focused on its aviation expansion. Beginning in 1929, the City of Grand Prairie welcomed the Curtiss-Wright Airport of Fort Worth-Dallas. In addition to this airport, the city also specializes in manufacturing and distributing defense, commercial airlines, electronic materials, flight simulators, microjets, jets, helicopters, navigation systems, process control systems, airline seats, baggage handling systems, and other avionic systems. According to the City's website, "Grand Prairie's place in the history of American aviation is rich and well-established. With its growing family of aviation and aerospace companies, the city will continue to be a leader in defense, aerospace and emerging technologies in the future" (City of Grand Prairie, 2019).

Community Engagement: Qualitative Study

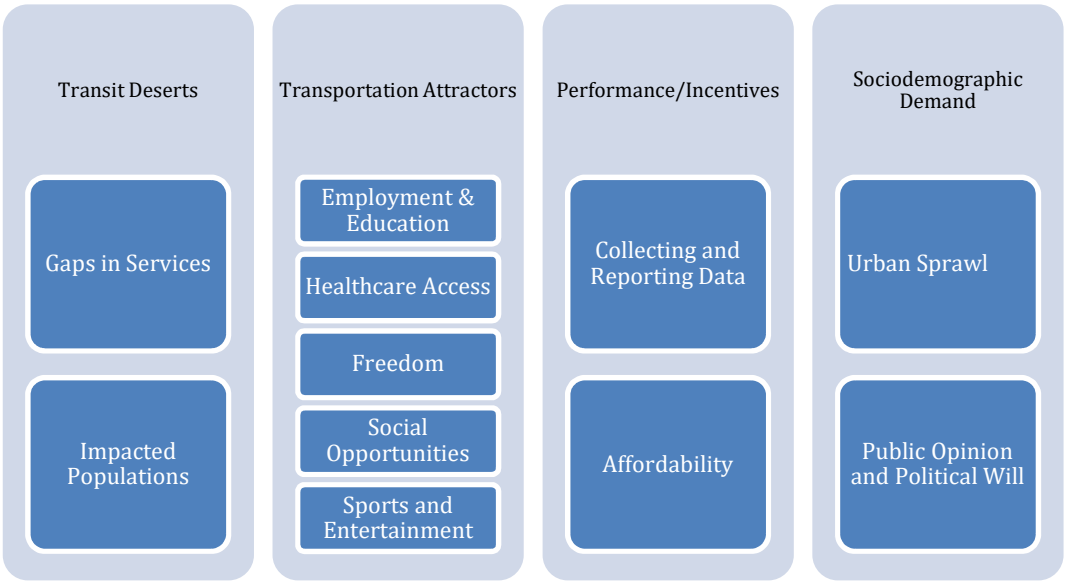
Recognizing the unique history of public transit infrastructure within Arlington and Grand Prairie, we sought input from the community directly in order to develop strategies that best address their needs and concerns. The community sample includes 68 respondents. The sample is largely female (n = 54, 77.9%), middle-aged (m = 46.97, SD = 14.31, *median* = 49.00), Christian (n = 50, 73.5%), and heterosexual (n = 58, 93.5%). Participants range in age from 19 to 69 and report diverse races and ethnicities. About one-third of participants are African American (n = 23, 33.8%), while others identify as Latino/Latina (n = 19, 27.9%), Caucasian (n = 18, 26.5%), Chinese (n = 3, 4.4%), and other (n = 5, 7.4%). 61.2% of respondents have at least a college degree and more than one-quarter of participants have a masters (n = 17, 25.4%) or greater (n = 3, 4.5%).

More than one-quarter of participants report that they do not have access to reliable transportation (n = 17, 25.4%). Most participants (n = 37, 56.9%) have household incomes of less than $60,000 annually, with nearly one-third reporting less than $20,000 annually ($n$ = 21, 32.3%).

All participants either reside in Grand Prairie or Arlington or are employed in Grand Prairie, Arlington, or surrounding cities. Nearly 90% of respondents live (n = 58, 89.2%) and work (n = 54, 84.4%) work in one of the two cities. Of those who live in Arlington or Grand Prairie, nearly one-third (n = 21, 32.3%) have only lived in the cities for less than six months. More than one-quarter of participants have resided in one of the two cities for more than five years (n = 17, 26.2%).

The data indicate the following themes: 1) transit deserts; 2) transportation attractors; 3) performance/incentives, and; 4) sociodemographic demand. Each of the themes also includes subthemes. These themes and subthemes are described below in Figure 1, with representative participant quotes.

Figure 1: Themes and Subthemes



Transit deserts. Transit deserts emerged as a theme throughout the focus groups, whereby individuals repeatedly referred to the lack of transportation services in and between the cities of Arlington and Grand Prairie. Within the theme of transit services, the subthemes of gaps in services and impacted populations were most prominent.

Gaps in services. More than one-quarter of participants in this study (n = 17, 25.4%) do not have access to reliable transportation themselves and, of those who did have access, a majority reported transportation disadvantage among their clients, neighbors, and constituents. One resident summarized, "Obviously the biggest gap in Arlington is that we don't have any mass transit." A social service employee recognized, "Grand Prairie doesn't have any public transportation other than the Grand Connection, which is only for seniors and it only provides rides within Grand Prairie, so it is nearly impossible to leave the city if you are using that program."

While many individuals described populations most at risk of transportation disadvantage in Arlington and Grand Prairie (see subtheme *Impacted Populations*), others noted a lack of geographic coverage in the region. A transportation planner described the cities' lack of funding as a limitation to seamless regional transit, stating, "There is a lack of geographic coverage. Sometimes cities pay for services, but only in their city and not between the cities. They usually only want to cover services within their city limits and then it is a problem when anyone wants to travel outside of the city limits for whatever purpose. They aren't able because it doesn't exist."

An employee of a social service organization described her clients as being limited by the geographic coverage of the available transit services. She reports, "66% of clients who request our services report that they have used the Grand Connection. That's interesting to me because that means that they have additional needs outside of what the service provides. I can't say this for sure, but I am willing to bet that the reason they need additional services is because they have needs outside of their geographic service area."

Impacted populations. All stakeholder groups described populations of individuals that they feel are disproportionately impacted by transportation disadvantage in Arlington and Grand Prairie. Participants overwhelmingly described older adults as well as individuals with disabilities, health conditions, and those living below the poverty line as being most impacted by the lack of transportation in the region. An employee of a social service organization summarized, "We fail our older adults and people who can't afford cars." Another social service organization employee added, "Anyone who needs consistent medical attention is in danger if they can't drive."

Members of marginalized communities, particularly individuals experiencing homelessness, talked of the impact that transportation disadvantage has on low-income families. One respondent reported, "If your car goes out and there's not public transportation and you don't have a large family or any other safety net or support system, without that public transportation, this is a huge domino." Another added, "The car breaks down, you can't get to work. Okay? If you can't get to work, you can't continue paying the rent. If you can't continue paying the rent, what happens? You end up where we are [at the homeless shelter]."

Transportation attractors. Another theme that emerged from the data is transportation attractors. Transportation attractors were reasons that the stakeholders feel that comprehensive transportation should be addressed. The most prominent categories of transportation attractors included employment and educational opportunities, healthcare access, freedom, social opportunities, and sports and entertainment. These categories are listed in the order in which they appeared most often in the focus groups.

Employment and educational opportunities. Members of each stakeholder group described employment and educational opportunities as a benefit to public transportation in and between the Cities of Arlington and Grand Prairie. Some individuals described the impact that these opportunities could have on individuals and families. One resident reported, "In Grand Prairie, we just stuck. I'm just gonna be honest. You know. I don't know what the City Fathers had in mind, but there are a lot of programs that Grand Prairie ISD couldn't do because we don't have bus transportation. There are a lot of internships and jobs our students couldn't do because they don't have any transport. They don't have any bus transportation. And that's the truth. Simple and plain." Another resident explained, "Economically, a corridor would open up more job opportunities for people going back and forth. Right now, people who don't have a car in Arlington might not look for a job in Grand Prairie and vice versa because they can't get there. Public transportation might give people more opportunities to find work." A business owner elaborated, "I think in Grand Prairie there are higher concentrations of jobs, opportunities, and industrial warehouses and whatnot, so a corridor between Arlington and Grand Prairie would be

helpful to bring workers to where the work is." A decision-maker summarized, "I think it would definitely help people in terms of employment if they didn't have to work right by where they live because they don't have transportation. If there was comprehensive transportation linking the two [cities], they would be able to have more employment access, access to other employment opportunities."

Other individuals described how employment and educational opportunities could impact the cities and the State of Texas as a whole. For some, education meant hope for young people in their communities. For example, several residents and members of environmental justice populations described how sometimes groups of people stop trying to find employment when they feel that there is nothing out there for them. They described a low-income neighborhood in Grand Prairie, Dalworth, and talked of their hope that, with comprehensive transportation, the crime rate could reduce because young adults would have a more productive way to spend their time. A resident stated, "Wherever this goes, I hope it gets to the people that need to go to work because you know it's an economic issue because people need to work. People need to be able to get a job. You have these kids who probably would get a job but who are hanging on corners in Dalworth doing whatever because, you know… 'My Mama doesn't have a car. I don't have a car, so I can't get to work.'" Speaking of the same low-income neighborhood, a participant from an environmental justice focus group further described, "This is supposed to be America and the American dream. We gotta give them a way [to succeed]."

Finally, participants described the impact on the Cities themselves. A business owner talked of increased patrons to local businesses, saying, "Traffic to the local businesses would increase. More patrons would access the stores than before. That might create more jobs in and of itself." A transportation planner added, "The biggest benefit would definitely be economically. Any time people have more employment options, everyone benefits." Another transportation planner concluded, "Both cities are trying to revitalize their downtowns. Transportation between the two cities would give people the opportunity to move more freely from place to place to go out to eat or to seek medical care or whatever the needs and desires are."

Healthcare access. After employment and educational opportunities, access to both physical and mental healthcare was the largest transportation attractor. While this theme arose across every constituent group, it was particularly prominent amongst employees of social service organizations and individuals from marginalized or environmental justice communities. Like in the *impacted populations* subtheme, focus group participants talked of individuals with chronic illnesses and disabilities as being disproportionately impacted by transportation disadvantage and its impact on individuals' disease management and overall health. A social service employee summarized, "Anyone with recurring medical appointments in Arlington has trouble getting there from outside of Arlington. That could mean Grand Prairie or other neighboring cities. There just aren't services between the cities. Linking the cities would make a world of difference in the lives of our patients." One social service employee talked of their clients' difficulties getting to dialysis centers regularly. She stated, "We get a lot of calls from people who need to get from Grand Prairie to Arlington for medical reasons. Most of the time our dialysis patients are desperate to get to Arlington for dialysis services." Another participant elaborated, "I looked up transportation-related calls that we get out of Grand Prairie and it is mostly seniors looking for transportation to medical appointments outside of the Grand Prairie

City limits…It looks like about 83% of seniors that request our services are reaching out because of medical needs."

For others, healthcare access was more than getting to and from medical appointments. From a more holistic perspective, some participants viewed upstream factors such as the obtainment of healthy foods and access to places to exercise as critical to both mental and physical well-being. One resident articulated, "It is important to be able to access nutritious foods, particularly for those of us with diabetes and other chronic health conditions. Having transportation could affect health by more than just helping people get to medical appointments. It could mean the world to those who are sick and struggling." Another resident reported, "We actually run a food pantry in Grand Prairie and what I see for transportation is we have we do have the Grand Connection that brings the elderly. They are on a schedule. And there's a lot of times that they can't get them there during our operating hours. And then as far as the general public, we have a lot of people that have to walk to our location to pick up what they need, because they don't have transportation. It really affects the community." A resident concluded, "People have to Uber to get to their basic needs. The clients are spending twenty to thirty dollars to Uber to get their basic needs met, when they come to the food pantry to get it for free. It's counterproductive."

Freedom. The subtheme of freedom came directly from a participant quote. While the word itself came from one individual, the sentiment was echoed throughout the majority of the focus groups. With transportation comes the ability for people to move about freely. As one resident put it, "It's definitely about economics and finances, but there's more. I don't just look at a financial quality of life, but transportation provides a ***freedom*** quality of life. To be able to have the freedom to move. The ability to move, when you don't have a car."

Another common way of phrasing this sentiment was to contrast the idea of comprehensive transportation to the status quo. Many participants referred to the inability to travel freely as being *stuck*. For one member of an environmental justice population, traveling outside of Arlington by any means outside of walking seemed impossible. He summarized, "You can only go to Arlington, you can't go any further. Anything outside of Arlington, you kind of gotta walk."

Social opportunities. Transportation disadvantage, social exclusion, and poverty are intricately linked. While employment, education, and healthcare dominated the discussions of transportation attractors, many participants also discussed social opportunities as a transportation attractor. An employee of a social service organization challenged the group to consider the following, "We often think about employment opportunities, but what about people who are retired or can no longer work? There are more social opportunities available if individuals can access transportation to get there." Another added, "Older adults and individuals with disabilities are severely isolated in this area. If you can't drive, you are stuck at home and wasting away. I hate to phrase it that way, but that is what we often see. Without transportation, they have no social life."

Sports and entertainment. While many social service employees and members of environmental justice populations specifically pointed out that a fixed bus route that only benefitted individuals going to sporting events and other entertainment venues would not reach

the most marginalized communities, others talked of these venues as transportation attractors. One business owner described, "I don't see why Arlington doesn't make it easier to arrive in the city. With public transportation, I would think more people would come into the Entertainment District. The sports stadiums seem to be big attractors, but parking is a huge problem. If you didn't have to drive and then park your car when going to baseball or football games or concerts or whatever, I think that would be really good for sports fans and concertgoers and generate more revenue for the City." A resident further reported, "We [Arlington] brag about being the Entertainment Capital of Texas and we want to bring in all of these businesses and attractors into downtown, but we won't want to bring in transportation to help people get to the businesses and entertainment venues. It just doesn't make sense." Finally, a transportation planner echoed, "Revitalize the downtown. Encourage shopping and visiting. How do you do these things with no transportation?"

Performance/Incentives. The third theme that came from the focus group data included performance indicators and incentives to encourage ridership. Participants overwhelmingly spoke of the desire for data to be collected and reported and for transit providers to focus on affordability in their planning.

Collecting and reporting data. When performance indicators and incentives came into the conversation, many people described what it would take for typical car drivers to start relying on public transportation, if it were available in the area. For these individuals, many believed that the best way to increase ridership was through the publication of data. For example, one resident said, "From my neighborhood, in a personal car, it takes about 25 or 35 minutes to get to Grand Prairie from Central Arlington because of traffic. I think people would be more inclined to take transportation if you could demonstrate that it would be faster." A transportation planner echoed, "Collecting data and making that information public about how it impacts residents, the environment, yada yada would convince people to take transportation." A decision-maker added, "We need to ensure that, if we create systems like corridors between Arlington and Grand Prairie, that we have adequate numbers of riders to keep those going. Sometimes we get pilot programs here and then they don't last. I think that people could be convinced to take public transportation services for the environmental aspect. I think that could inspire people to think about helping out the environment. The environmental impact is important."

Affordability. In addition to collecting and reporting data, individuals described affordability as an incentive to taking public transportation. A resident summarized, "I would think the first step to make it feasible to people is number one, that it be affordable." Employees of social service organizations urged the focus group moderator and other participants to consider the needs of vulnerable communities, too. One woman stated, "We would need to do something to give discounted rates to those who need it. If we have this service, but only the elite or the privileged use it, then it won't serve those with the greatest need. How could we make it cheaper for older adults, Veterans, people who live in poverty, people with disabilities, and those who are unemployed? Other groups of people too, really, just anyone with a real need."

Sociodemographic demand. The final theme included elements that are unique to Arlington and Grand Prairie, particularly due to their urban sprawl, public opinion, and political will toward

public transportation. This theme and subtheme are crucial to this study because it provides a more nuanced perspective, taking into consideration the geographic focus of this study.

Urban sprawl. Many residents and decision-makers described Arlington and Grand Prairie as "too spread out" for fixed route bus systems and alternative forms of public transportation. A decision-maker pointed out, "When you look at the way Arlington is constructed and built, it is truly a huge area—it is 99-square miles, I think. So, a comprehensive system doesn't seem to make sense. There's not the density of other cities. We are just too spread out." A resident voiced his concern, "How much money are we talking about because to get enough buses to truly cover a city that's almost 43 miles long, it's too spread out. You're talking in the millions and millions of dollars and that's just in Grand Prairie, but then that's gonna be able to maybe connect to bus systems in Mansfield, Arlington, or Irving." Another resident concluded, "Bus stops everywhere in Arlington just doesn't make sense. They aren't going to be able to ensure that everyone has a stop within a few blocks of their house because of the way that the city is designed. It won't happen. It can't happen. It would be too big of a commitment infrastructure wise. But a corridor with a central pickup spot or a few pickup spots, maybe one in the center, one in the north, one in the south, one in the east would make more sense."

As an alternative to fixed routes, individuals offered other solutions. One social service employee described, "If there were easier ways to connect the existing services like Via in Arlington, DART, Trinity Metro, if they could all work together to kind of cover the Grand Prairie area, that would work, but it is kind of a tough area to cover. I don't know how you would connect them to cover that area." Another voiced, "Cities and organizations are only concerned about their service area. No one is looking at the bigger picture. What do people do when they need to go just outside of their service area? We need to have service organizations and cities work together toward a warm handoff solution to help people navigate system to system."

The Politics and Optics of Public Transit. In Arlington, in particular, the City has voted down a number of transportation-related referendums. Participants across the focus groups expressed concern that the political will and public opinion in the two cities are not conducive to comprehensive public transit. A decision-maker informed, "I don't know how familiar you are with Arlington as a whole, but Arlington as a city has turned down comprehensive mass transportation or transit proposals countless times—I don't even know how many times it has gone to referendum and has been shut down. It just gets completely shut down."

Others felt that the city was putting money into other alternatives, rather than a fixed route bus system. A business owner spoke, "With the arrival of things like Via and privatized ride services, a comprehensive bus system in a place like Arlington just seems obsolete, but perhaps a drop off type situation with collector points where you could collect people then take them to the inner city of each city would work quite well to get people back and forth from each city. Once you arrive in the other city, you could call an Uber, Via or some other type of system like that to reach your final destination, or you could walk if it were close enough." A resident expressed, "The city [Arlington] is putting quite a bit of money into a driverless car system. I don't know how others feel, but I can say for me personally, I am pretty skeptical about that, but I guess we

will see how that goes…I guess I am just not seeing how that would be viable in a place like Arlington or Grand Prairie. I think that the money being focused on that could be better used in other ways to help people locally with transportation concerns. That's the way I think about it, but I might be sort of outdated. I don't know."

Finally, many individuals thought that conversations and interdisciplinary collaborations are critical to changing the public opinion and public discourse around transportation in and around the two cities. A social service employee noted, "Personally, I think transportation and transit needs are just ignored most of the time. Everybody likes to throw it out there casually, but it is a tough problem to tackle, so it is often overlooked for other things." A transportation planner suggested the cities create forums where professionals can come together from various backgrounds and fields of study to create positive change. He stated, "Cities need to create forums through which transportation providers can collaborate to reduce gaps in service provision. There has to be a way for everyone to work together toward a solution. The city overseeing something like that would be so beneficial." A social service employee concluded, "Cities are the responsible parties for creating transportation infrastructure, so the community really has to get behind the idea. We need representatives from organizations whose clients need transportation services to be more vocal about the transportation issues. I would love to see representatives from hospitals, dialysis centers, disability agencies, day-habs, all of that kind of stuff. Employees should let cities know that their clients need transportation services. We have to advocate for them."

Geo-spatial Analyses

Because the community data indicate transit deserts, including geographic gaps in services and disproportionately impacted populations, we reviewed the nearby transit systems and conducted a geo-spatial analysis. Figure 2 provides a distribution of the population within Arlington and Grand Prairie based on US Census block groups. Figure 3 shows a distribution of the median incomes for these block groups. In both cases, the darkest shade represents the highest quintile of all block groups and the lightest shade represents the lowest quintile.

Figure 2: GIS Population Map

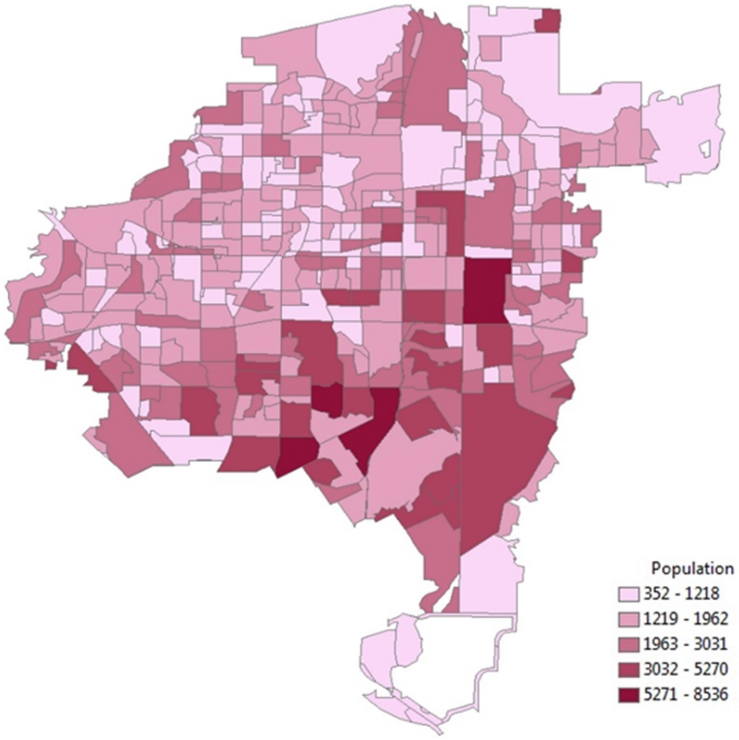

Population
352 - 1218
1219 - 1962
1963 - 3031
3032 - 5270
5271 - 8536

Figure 3: GIS Income Map

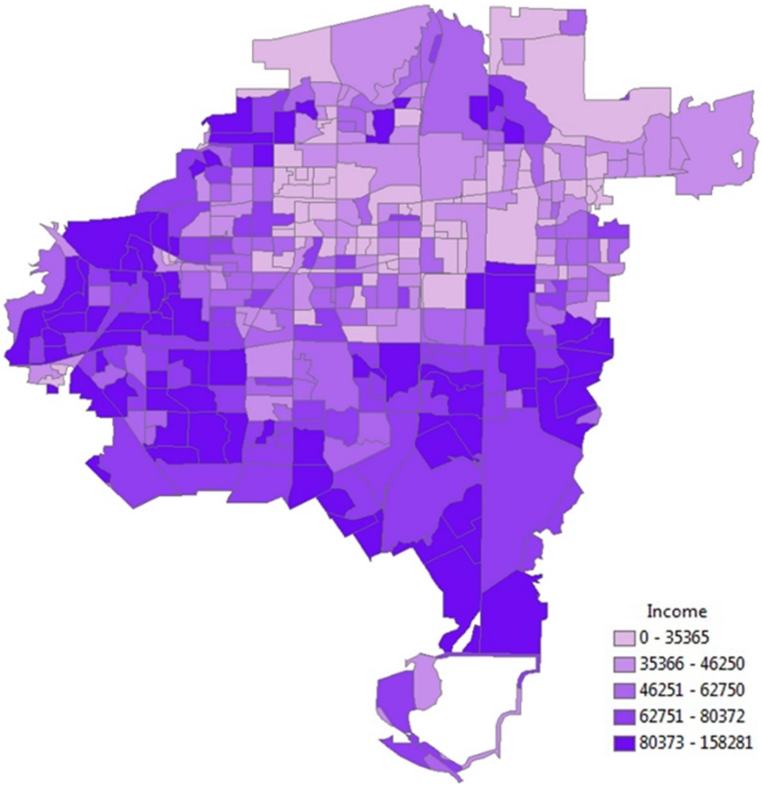
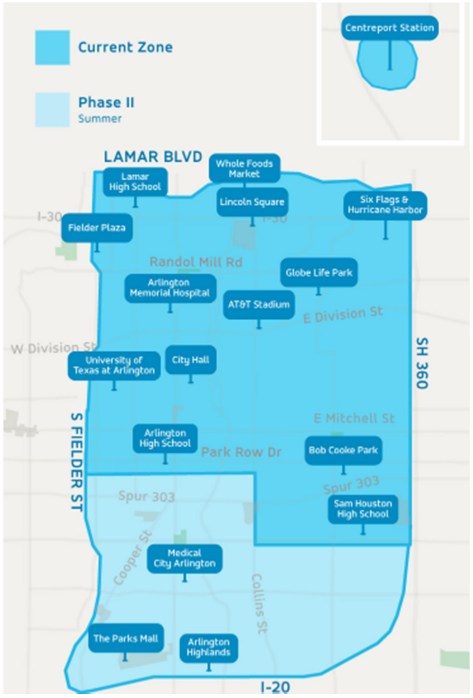


Figure 4: Via Service Coverage

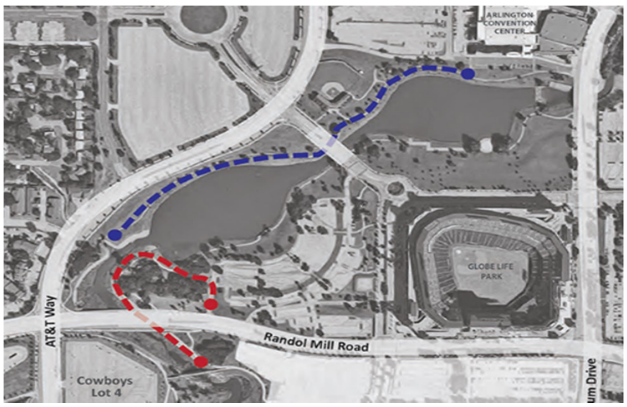


Previous research in Arlington indicates limited public awareness around Via's services and how it can reach transportation-disadvantaged population (Cronley, Murphy, Kenny, & Cochran, n.d.). An Arlington-based community survey conducted in 2018 showed that 83.6% of respondents had never used Via, 11.9% had used Via once, and only 4.5% had used Via more than once (Cronley et al., n.d.). Of those who had used the services, 45.5% were satisfied, 18.2% were somewhat satisfied, and 36.4% were not satisfied with Via's services (Cronley et al., n.d.). The city has announced plans to improve Via's visibility, educating clients and social service providers about its services, and expanding its geographic coverage, with emphasis on jobs-based locations.

Via Rideshare is a cashless service, and thus, not owning a credit card or a smartphone can be a barrier to obtaining Via's services, particularly for individuals who are unbanked and/or lower-income. Council members and other decision-makers have reported that efforts are being made to include "unbanked" populations, including those without credit cards. The City of Arlington has Via vouchers available through Mission Metroplex when clients lack cell phones or credit cards. Via also has a limited number of wheelchair accessible vehicles that can be requested for individuals with disabilities.

Arlington's Milo Autonomous Shuttle. Milo was a battery-powered driverless shuttle that was introduced as a pilot program between August 2017 and August 2018. It provided a free shuttle service in off-street trails around Arlington's Entertainment District. Milo only operated for one hour before and one hour after major events such as public demonstrations, sporting events, and concerts at Globe Life Park and AT&T Stadium. It was wheelchair accessible and users were able to get to their destination along two different routes. Users could board Milo at designated stops (Figure 6) around Richard Greene Linear Park and Robert Cluck Linear Park.

Figure 6: Milo Shuttle Routes



Arlington's Entertainment District Trolley. The Arlington Entertainment District Trolley (Figure 7) is a complimentary seasonal service offered only to guests staying at participating hotels around the Arlington Entertainment District. The trolley is wheelchair accessible and provides access to all major Arlington attractions including Six Flags Over Texas, Hurricane Harbor, AT&T Stadium, Globe Life Ballpark, shopping centers, and the Convention Center. The

trolley's operating season is between the opening of Six Flags in March to the end of baseball season in Fall.

Figure 7: Trolley Partners Pickup and Dropoff Locations

***Arlington's Handitran*.** Handitran bus drivers provide a door-to-door service for older adults and people with disabilities residing within Arlington and Pantego city limits. It is a rideshare service that is free of charge. Individuals must apply and receive a Handitran certification to receive this service. All individuals with disabilities and adults over the age of 65 are eligible to apply. Trips can be scheduled up to 14 days in advance. Handitran has a limited service area, however, and does not operate on Sundays and cannot guarantee a trip, even for individuals with certification. At times, the service has to supplement its buses with taxicabs due to shortages. Handitran's hours of operation are Monday through Friday from 7 am to 10 pm and Saturday from 8 am to 9 pm, but rides must be scheduled Monday through Friday between 8 am and 3 pm.

***Grand Prairie's Grand Connection*.** The Grand Connection transit system in Grand Prairie provides transportation services for individuals over the age of 60 or individuals who have documented physical and/or mental disabilities. This service provides transportation to any location within Grand Prairie city limits. Grand Connection does not charge for transportation services to medical or dental appointments or trips to the Dallas County Department of Health and Human Services. All other locations, however, require a $1 fare each way. Trips can be scheduled up to two weeks in advance, but they must be made at least two working days in advance. Grand Connection's hours of operation are Monday, Wednesday, and Friday from 4 am to 5 pm and Tuesday and Thursday from 7 am to 5 pm. There are no services offered on nights or weekends.

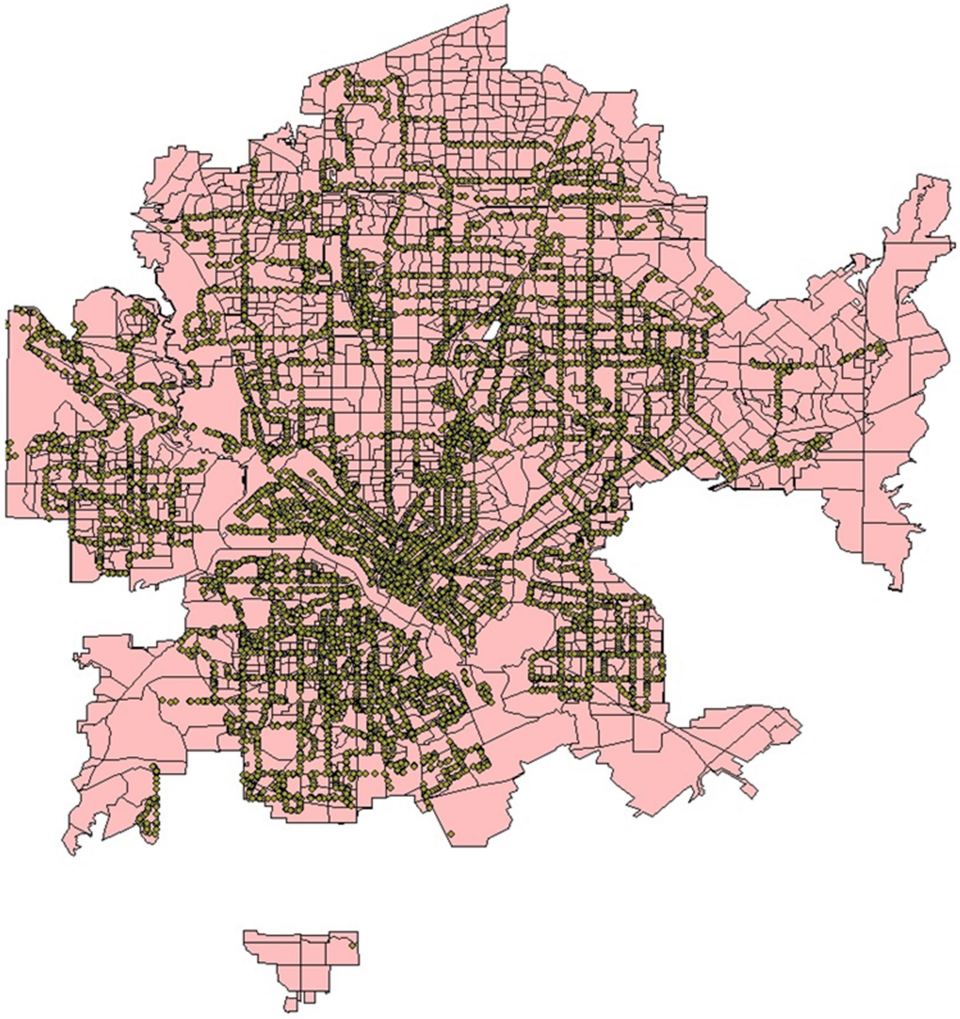
***Grand Prairie's Park and Ride*.** Park and Ride is a facility that provides parking space for individuals who would like to carpool to work and leave their vehicles parked for the day.

***Dallas Area Rapid Transit (DART*).** Dallas Area Rapid Transit (DART) is a public transportation service of buses, commuter rails, and paratransit services that provide transit to more than 220,000 individuals per day over their 700-square-mile service area (Figure 8),

consisting of Dallas and surrounding cities (Dallas Area Rapid Transit [DART], 2018). Cities served by DART include Dallas, Addison, Carrollton, Cockrell Hill, Farmers Branch, Garland, Glenn Heights, Highland Park, Irving, Richardson, Rowlett, Plano, and University Park. DART does not serve passengers in Arlington or Grand Prairie. Single rides range from $1.25 to $2.50 while day passes range from $3 to $12. Passengers can also purchase discounted rides via DART's GoPass mobile application (DART, 2018). Figure 9 shows all of the stops in the DART system.

Figure 8: DART Service Area and Member Cities

Figure 9: Bus Stops for DART



***Trinity Metro*.** Trinity Metro is a public transportation service in Fort Worth, Texas, that consists of bus routes, rail, paratransit, a trolley, and a safari express (Trinity Metro, 2018).

Examples of Transportation Strategies from Suburban Metroplexes

Large metropolitan areas often face transportation challenges because of the urban sprawl that accompanies economic and population growth (Ball & Lawler, 2014; Lord & Washington, 2018). Similarly, they struggle to identify effective transportation strategies that can not only meet the needs of the general population, but also consider the needs of various environmental justice populations, which include individuals with low socioeconomic status, older adults, individuals with disabilities, and other marginalized groups.

Jacobson and Forsyth (2008) urge interdisciplinary teams including transportation engineers, planners, and policy makers to include the general public in creating "greater understanding of the successes and failures of TODs [transit-oriented development projects]" (p. 51). As Arlington and Grand Prairie attempt to address some of the challenges and needs unique to their communities, the experiences of other suburban metroplexes have confronted these issues may improve the process and final outcomes. In their study of transit-oriented development projects, the researchers (Jacobson & Forsyth, 2008, p. 75) outlined the following twelve principles to consider when designing and implementing new transit-oriented solutions:

1) Appreciate that planning and developing great places takes time
2) Engage the public and experts as collaborators and work with activist energy
3) Program spaces for use
4) Invest in maintaining spaces
5) Design at a human scale
6) Provide public spaces that accommodate a variety of uses and users
7) Use design programming strategies to increase safety
8) Allow for variety and complexity
9) Create connections between spaces
10) Design sidewalks and crosswalks for appropriate pedestrian use
11) Integrate transit and transit facilities into the urban pattern
12) Don't forget, but don't overemphasize, car movement and background.

Implementation of outer belts. Outer belts are freeways or limited access roads that cities have implemented as a strategy to improve public transportation infrastructure. Outer belts reduce commute times and traffic congestion by providing a road that surrounds the main

downtown area and allows quick access from one side of the city to the other (Graham, 2018; Lord & Washington, 2018). Some cities that have built outer belt systems include Boston, Houston, Nashville, and Charlotte.

In Massachusetts, the City of Boston constructed I-495, a 30-mile outer ring around the fastest growing area of the city. This outer ring is critical given that approximately one-third of the city's manufacturing jobs are located in this area and recent studies have suggested that, without the outer ring, there would be chronic congestion due to the unprecedented growth (City of Boston, 2014; Griffith, 2017; HNTB Corporation, 2004).

In Houston, Texas, an outer belt project was developed to provide improved access and mobility between Houston and eight surrounding cities. They built the Grand Parkway, a 170-mile route that provides suburb-to-suburb travel (HNTB Corporation, 2004; Verbich, Badami, & El-Geneidy, 2017).

In Nashville, Tennessee, the City of Nashville is working on a plan to construct a 20 to 50-mile outer loop with the goal of increasing economic development in middle Tennessee. The city hopes that this project will relieve traffic congestion, create better through-traffic conditions for individuals travelling long distances, and provide an alternative route that does not force drivers to travel through downtown (Clifton, Bronstein, & Morrissey, 2014; HNTB Corporation, 2004).

In North Carolina, the City of Charlotte is exploring the option of constructing a second outer belt of between 25 and 40 miles. The City of Charlotte has found that their established outer beltway, I-485, a 12-mile loop, has been a cost-effective solution for improved access to suburban and exurban towns (Ashuri & Mostaan, 2015; Corley-Lay, 2015; HNTB Corporation, 2004).

Innovative projects in 2018. While many cities across the nation are relying on outer beltways to improve transportation access between suburbs, other innovative approaches are also being developed across the nation. Tupelo, Los Angeles, Denver, Houston, Seattle, Boston, and Altamonte Springs have all had the press buzzing about their upcoming plans and partnerships to address transportation infrastructure gaps and/or to meet the needs of environmental justice populations.

Through a partnership with Toyota's cooperate good program, the City of Tupelo hopes to address the transportation needs of Mississippians (Cardamone, 2017). Toyota has provided funding for three bus lines. These buses will provide low-cost transportation for individuals with disabilities, older adults, and individuals living below the poverty line. During its pilot phase, the services will be offered Monday through Friday from 5:30 am to 7 pm, with plans to modify the hours of operation as appropriate.

In California, the City of Los Angeles has invested in the creation of light rail extensions, greenways, and bus rapid transit for individuals with low socioeconomic status. The goal of this program is to reduce the total number of miles travelled and increase shared mobility systems (Clarke, 2018).

Denver's public-private partnership is being referred to as Colorado's Eagle P3 Project. The press in Denver has emphasized the importance of this public-private partnership, whereby mutual risk-taking, investment, and commitment are crucial to the success of the project. The 36-mile project will consist of a commuter rail, a University of Colorado A Line, and a line running from downtown Denver to the airport. These lines are projected to reduce transit time significantly, with some reports estimating that it could cut transit time along some routes by more than half (Gallo, 2018; Renne, 2017).

In Texas, the City of Houston is working to create a cost-effective solution to transportation needs using the current infrastructure. The city is working to increase the number of bus riders and the speed of travel by changing existing routes. New routes avoid zigzags, redundant stops in downtown, and are projected to increase ridership by between 5 and 10% (Barnett, 2018; Verbich, Badami, & El-Geneidy, 2017).

Seattle, Washington has the nation's only bus and rail tunnel. The city is now working on bus and bicycle infrastructure, the creation of new rail lines, and the completion of the ST3 rail plan which will include 37 new stations across the city (Kent & Karner, 2018; Lee, Sener, & Jones, 2017).

Through a partnership with the Massachusetts Bay Transit Authority, Boston has developed a performance dashboard to collect real-time data. Preliminary studies of this dispatching decision-support system have been promising, with wait times reduced by between 15 and 21% (Fabian, Sanchez-Martinez, & Attanucci, 2018).

Innovative projects planned for 2019. TEXRail trains, in partnership with Trinity Metro, described above, will make nine stops along a route from Fort Worth to the Dallas-Fort Worth International Airport. The 27-mile rail is expected to draw approximately 8,000 passengers daily, with fares estimated at around $2.50 each way (Associated Press, 2018).

Strategy I: Demand-Driven Model

Individual socio-demographic status such as income and vehicle availability significantly affects transit usage because financial burden might not allow people to drive or to buy a vehicle for their trips. In addition, transit service attributes such as the number of transit lines accessible from a home address or the expected waiting time at the bus stop represent other important indicators for transit usage because riders may consider transit as a viable option for mobility only if the service meets the riders' expectation. Therefore, this study considers three different types of factors – Socio-economic factors, Transit system attributes, and Network characteristics – as potential determinants for transit usage.

Socioeconomic factors considered for this study are as follows:

- Age
- Race
- Number of employers
- Income
- Vehicle availability

Transit system attributes considered for this study include:

- the number of stops per block group
- headway (or the expected time to wait for a bus)
    - If multiple transit lines stop at a station, the average value of the total headway is calculated.

Network characteristics include:

- the number of intersections in a block group
- spatial coverage of bus system

The number of intersections represents the network connectivity and accessibility. The spatial coverage is defined as the proportion of area within a walking distance to the bus stop where the walking distance is assumed to 0.25 mile.

Geography and Socioeconomic Characteristics

Located within Texas (Figure 10), Arlington and Grand Prairie are situated between Dallas and Fort Worth in the greater Dallas-Fort Worth metropolitan area (Figure 11).

Arlington. Arlington, Texas is the 48th most populous city in the United States and the seventh most populous city in Texas (United States Census Bureau, 2017). Located in Tarrant County, Arlington is approximately 100 square miles and is known as the entertainment capital of Texas. Arlington is home to institutions of higher learning, professional sports teams, and

many popular attractions, including but not limited to the University of Texas at Arlington's Main Campus, Tarrant County College's Southeast Campus, Texas Rangers' Globe Life Park, Dallas Cowboys' AT&T Stadium, Six Flags Over Texas, Hurricane Harbor, Texas Live, Theatre Arlington, and the International Bowling Museum and Hall of Fame.

Figure 10: Arlington and Grand Prairie within Texas

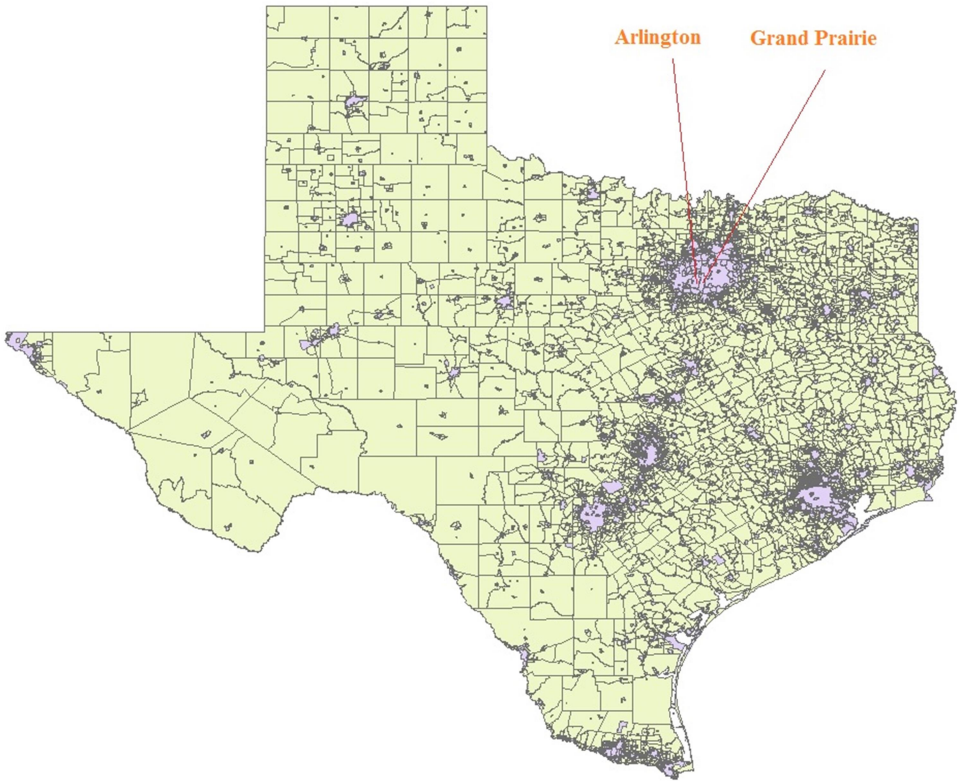
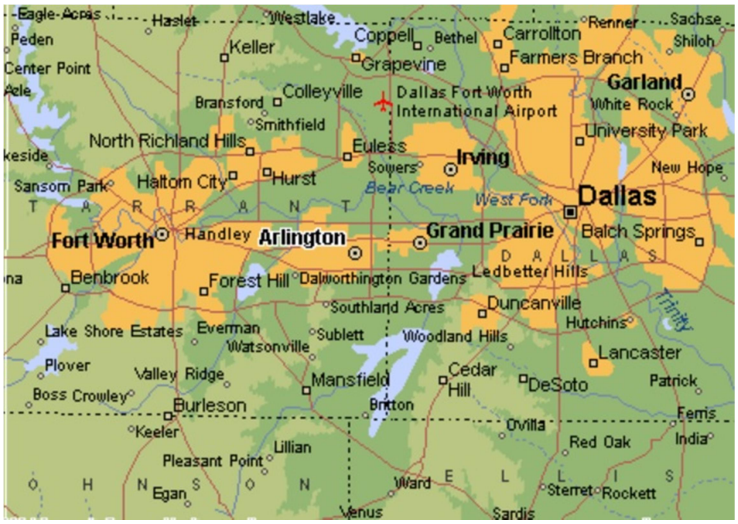


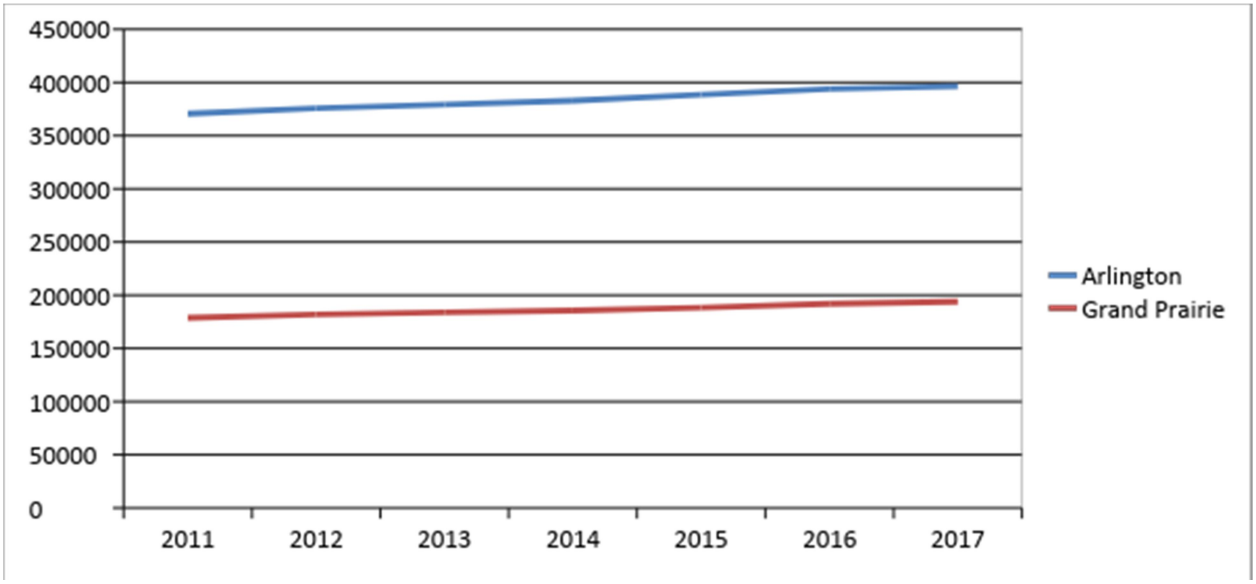
Figure 11: Arlington and Grand Prairie within Tarrant and Dallas Counties



Grand Prairie. Grand Prairie, Texas, is the 15th most populous city in Texas (United States Census Bureau, 2017). It is an 81 square mile city located in Dallas, Tarrant, and Ellis Counties and is known for being one of the nation's largest industrial districts. Grand Prairie is home to the Texas AirHogs minor league baseball team, Lone Star Park thoroughbred horse racing track, and the Verizon Theatre, one of the most technologically sophisticated indoor theaters in the United States (Theatre at Grand Prairie, 2018). The new attractions of The Epic recreation center, the EpicWaters Indoor Park, and in the future the PlayGrand Adventures at Grand Central, a playground for all ages and abilities.

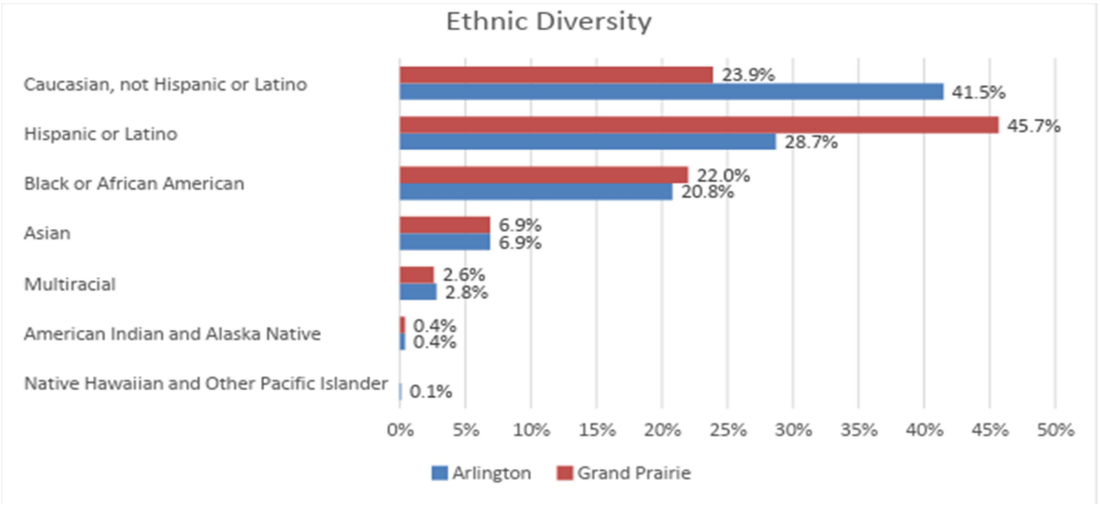
***Socioeconomic Characteristics*.** The latest American Community Survey indicates steady population growth in both Arlington and Grand Prairie (United States Census Bureau, 2017). Between 2010 and 2017 (Figure 12), the populations in Arlington and Grand Prairie grew by 8.5% and 10.5%, respectively (United States Census Bureau, 2017). Arlington currently has an estimated population of 396,400 individuals, and Grand Prairie's population is approximately 193,800 persons (United States Census Bureau, 2017).

Figure 12: Populations of Arlington and Grand Prairie 2011 to 2017



In both Arlington and Grand Prairie, minority populations account for a greater proportion of the total residents than in the overall DFW region. Figure 13 shows the proportion of each racial and ethnic group in the Arlington and Grand Prairie populations. In Arlington, the population largely identifies as non-Hispanic Caucasian (41.5%), followed by Hispanic (28.7%), African American (20.8%), or Asian (6.9%). In Grand Prairie, the population largely identifies as Hispanic (45.7%), non-Hispanic Caucasian (23.9%), African American (22.0%), or Asian (6.9%).

Figure 13: Racial and Ethnic Diversity



The age distribution of the populations within Arlington and Grand Prairie appear similar (Figure 14). The median age of residents is approximately 33.1 years in Arlington and 33.6 years in

Grand Prairie (United States Census Bureau, 2017). Most individuals residing in both Arlington (57.1%) and Grand Prairie (55.8%) are between the ages of 18 and 64 years (United States Census Bureau, 2017). Persons 65 years of age and older make up roughly 10% of the population in Arlington and 8% of the population in Grand Prairie (United States Census Bureau, 2017).

Figure 14: Age Distribution

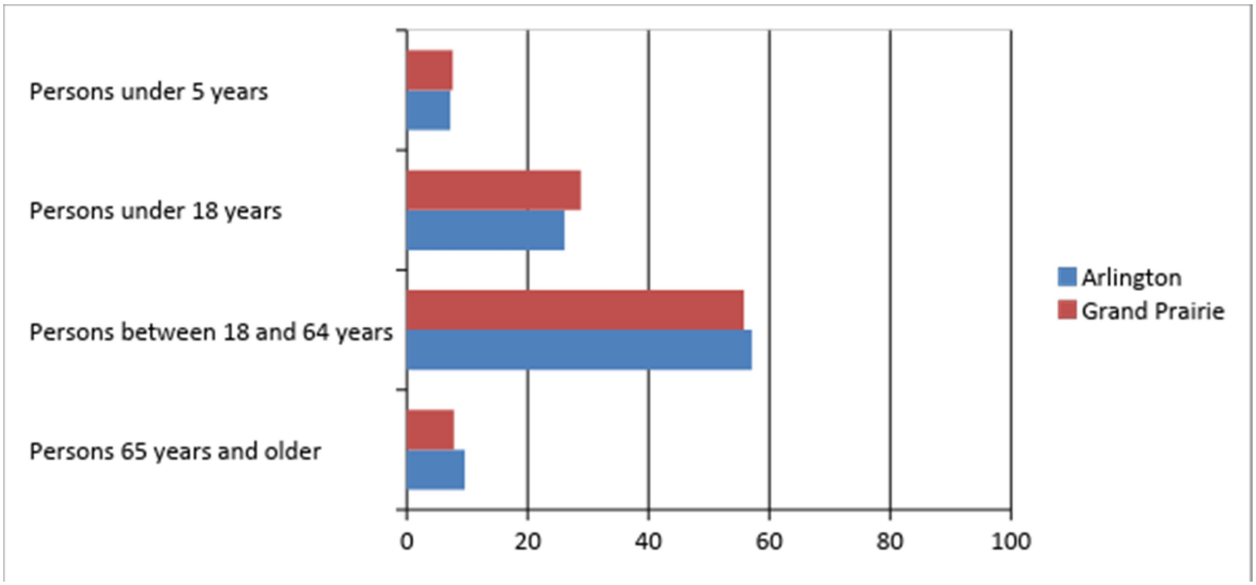
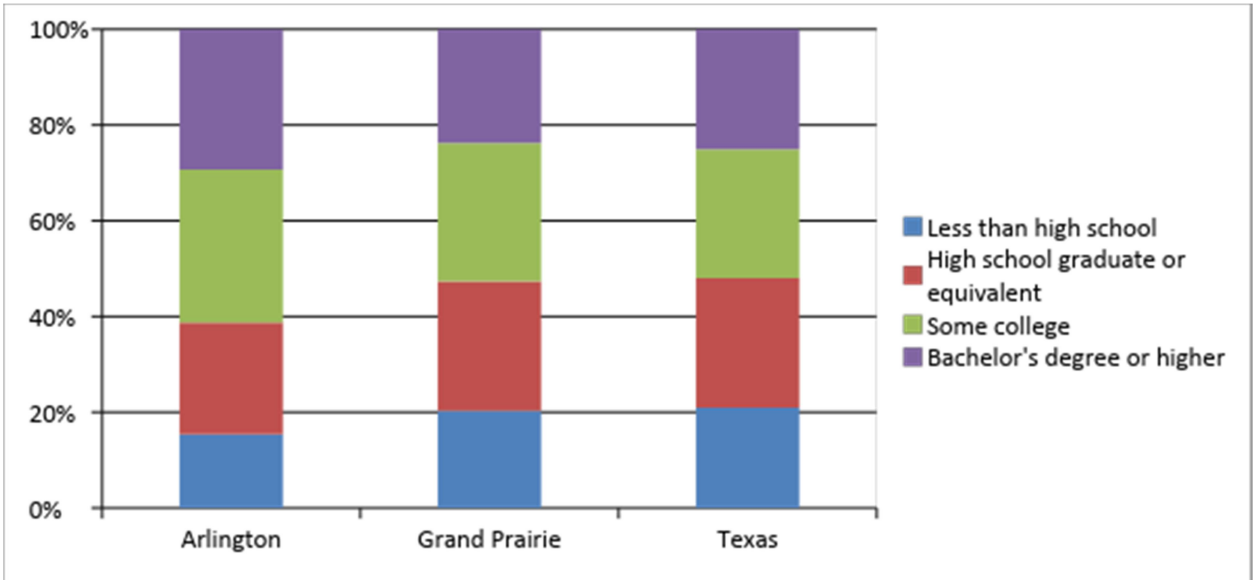


Figure 15 shows that for the adult population over 25 years of age, high school educational attainment in Arlington and Grand Prairie is higher than the larger Texas population (Towncharts Think Tank, 2018). In Texas, appropriately 21% of the population over the age of 25 has less than a high school diploma or GED. This rate is only 15.4% in Arlington and 20.3% in Grand Prairie (Towncharts Think Tank, 2018). For higher education, approximately one-quarter of Texans over 25 have a bachelor's degree or higher. In Arlington, this rate is just over 29%. In Grand Prairie, however, the rate is slightly lower, with fewer than 24% of residents over 25 having a college degree (Towncharts Think Tanks, 2018).

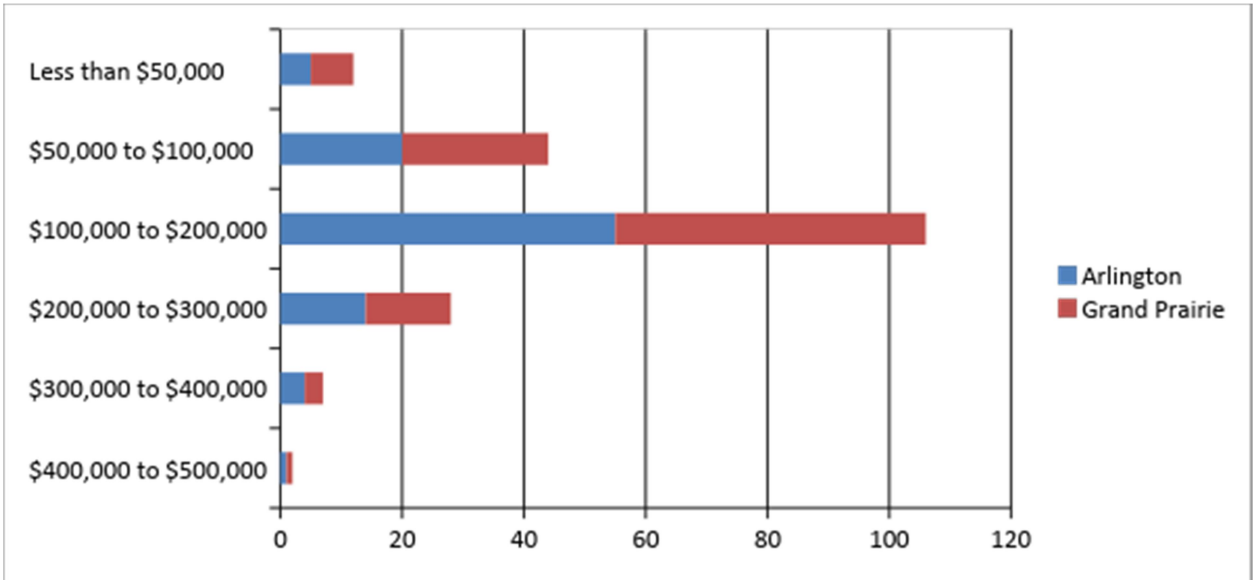
Figure 15: Educational Attainment



Marital status is similar across the two cities. About 48% of adults in Arlington and 53% of adults in Grand Prairie are currently married. 36% in Arlington and 34% in Grand Prairie are single, having never married, while about 10% of adults in both cities are divorced and about 4% in both cities are widowed (United States Census Bureau, 2017). The average household size is 3.0 individuals in Arlington and 3.2 in Grand Prairie (United States Census Bureau, 2017). In 2016, the median household income was $53,574 in Arlington and $60,246 in Grand Prairie (United States Census Bureau, 2017). Approximately 16.6% of households in Arlington and 13.8% in Grand Prairie live below the poverty line (United States Census Bureau, 2017).

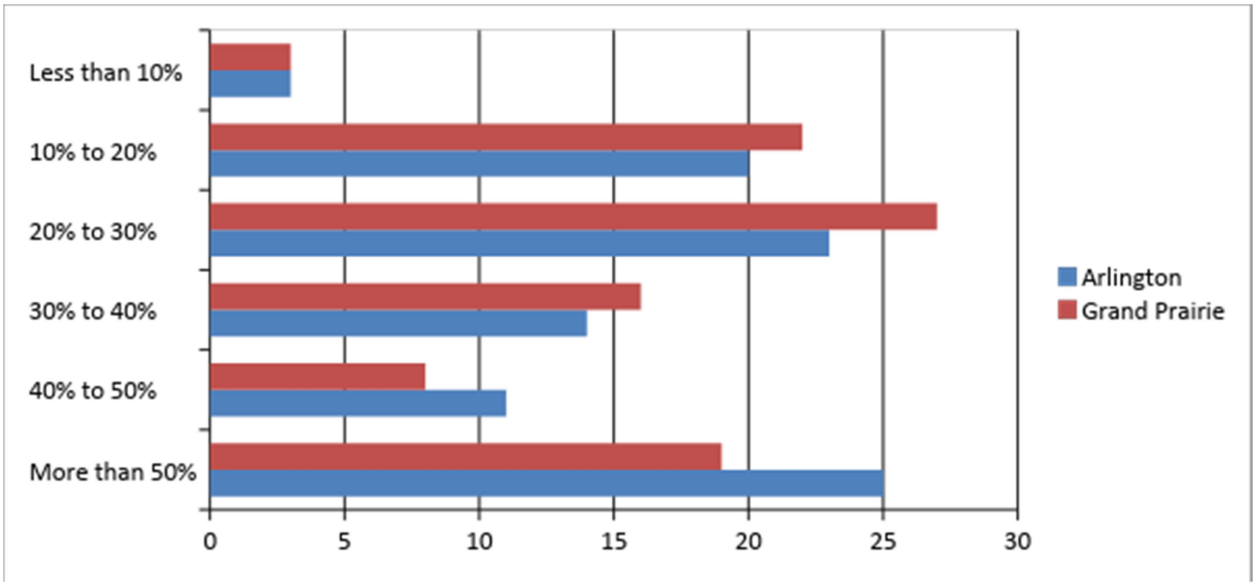
Arlington is a more densely populated city than Grand Prairie, with approximately 147,000 housing units (1535 houses per square mile) compared to about 64,000 (880 houses per square mile; United States Census Bureau, 2017). The median home values for Arlington and Grand Prairie (Figure 16) are approximately $138,000 and $133,000, respectively (United States Census Bureau, 2017).

Figure 16: Home Values



Rental homes and apartments typically run between $500 and $999 monthly for studios and one-bedroom floor plans, while two bedrooms average between $750 and $999 monthly and three bedrooms average between $1000 and $1500 monthly (United States Census Bureau, 2017). In 2017 (Figure 17), about one-quarter of Arlington's renters and about one-fifth of Grand Prairie's renters spent more than 50% of their household income on rent (United States Census Bureau, 2017).

Figure 17: Percent of Household Income Spent on Rent in 2017



Data Sources

National Household Travel Survey (NHTS)

North Texas Council of Governments (NCTCOG) add-on of National Household Travel Survey (NHTS) for the year 2009 is used to collect socio-economic features of the population in the DART service area. When conducting the NHTS, the Federal Highway Administration (FHWA) partners with some state departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and Regional Councils of Government (COGs) to allow these partners to purchase additional survey data for their local areas. These socio-economic features include race, household size, family median income, average age of household members, median education level of household members, gender, vehicle ownership, and the transit usage variable (the total number of times all the household members used public transit in the last month). These variables were collected at a household level.

American Community Survey (ACS)

As an ongoing survey conducted by the U.S. Census Bureau, the ACS collects information on educational attainment, income, language proficiency, migration, disability, employment, and housing characteristics at a Block Group level. In this study, the socioeconomic characteristics of DART serving cities from the most recent years (2012-2016) of ACS 5-year estimates were used. These block group-based features include income, proportion of white and non-white population, population age categories of 19 and under, 20 to 75, and above 75, and proportion of male/female population.

General Transit Feed Specification (GTFS)

The team collected DART schedules and associated geographic information from the GTFS such as stops, stop times (arrival times, departure times), routes, and route directions.

Modeling Approach

This study used a Zero-Inflation model to understand the relationships between transit usage and the predicting variables mentioned above. As the transit usage variable has excessive zeros (because of respondents with no transit use), the model should properly handle such excessive zeros when estimating the relationships between the variables. This study applied zero-inflated negative binomial (ZINB) regression models. The excessive zero counts in transit usage arises from two distinct groups. The first group includes people who have used transit but did not use the service during the survey period while the second group does not have walking access to

transit. The second group appears relatively certain to not use the transit service, which leads to excessive zero outcomes in the survey for the transit usage. This group needs to be distinguished from the first group who use public transit, but happened not to use the service during the survey period. The ZINB captures these two groups by constructing the model into two parts – zero-inflated model and count model – and integrating them as one model. The zero-inflated model analyzes the dataset focusing on the excessive number of zeros to understand who would be in the 'certain' non-users. The count model investigates the transit usage including the first group of people.

Results

As shown in Table 1, the public transit usage was used as the dependent variable with a set of independent variables including transit system attributes, socio-economic factors, and network characteristics for the transit ridership modeling. DART serving block groups are intersected with ACS and NHTS NCTCOG add-on and a total of 468 common block groups and the associated household data were obtained for the transit ridership modeling.

Table 1: Variables for Ridership Modeling

Variable	Description	Type	Data Source
Public_Transit	Frequency of total use of public transit in the past one month for the members of household	Dependent variable	NHTS (NCTCOG)
Age_Mean	Average age of household members	Socio-demographic	NHTS (NCTCOG)
Education_Median	Median education of household members	Socio-demographic	NHTS (NCTCOG)
HH_Vehicle_0	Dummy variable for 0 household vehicle ownership	Socio-demographic	NHTS (NCTCOG)
HH_Vehicle_1	Dummy variable for 1+ household vehicle ownership	Socio-demographic	NHTS (NCTCOG)
HH_Size	Count of household members	Socio-demographic	NHTS (NCTCOG)
Gender_0	Gender of household respondent 0 if male	Socio-demographic	NHTS (NCTCOG)
Gender_1	Gender of household respondent 1 if female	Socio-demographic	NHTS (NCTCOG)
White	Ratio of white population to block group area	Socio-demographic	ACS (2012-2016)
Non_white	Ratio of non-white population to block group area	Socio-demographic	ACS (2012-2016)
Pop_19&minus	Ratio of population of 19 year-old and younger to block group area	Socio-demographic	ACS (2012-2016)
Pop_20to74	Ratio of population of 20- to 74 year-old to block group area	Socio-demographic	ACS (2012-2016)
Pop_75&plus	Ratio of population of 75 year-old and older to block group area	Socio-demographic	ACS (2012-2016)
Income	Median household income for block group	Socio-demographic	ACS (2012-2016)
Median_Age	Meidan age for block group	Socio-demographic	ACS (2012-2016)
Headway	Average headway (per hour) of stops for block group	Transit system	GTFS (DART)
Stops_BG	Number of stops per block group	Transit system	GTFS (DART)
Buffer_BG	Ratio of total buffer area to block group area	Transit system	GTFS (DART)
Intersection_BG	Ratio of number of intersections number to block group area	Spatial	ACS ESRI Shapefiles
Employment_BG	Ratio of number of employments (job locations) to block group area	Spatial	ACS ESRI Shapefiles

The results show (Table 2) that higher income households and the population between 20 and 74 years old more likely represent non-transit users. On the other hand, the higher street connectivity or in DART serving cities tend to attract more transit ridership; higher street connectivity indicates greater walking access. The count model shows that non-white population, population without vehicle availability, women, and younger generation tend to use public transit more frequently than their counterparts. As expected, if an individual has to wait a longer time at a bus station (i.e., higher headway in DART bus transit system), they tend not to use the transit service. However, an individual who is in an area with easier access to transit tends to use transit more often.

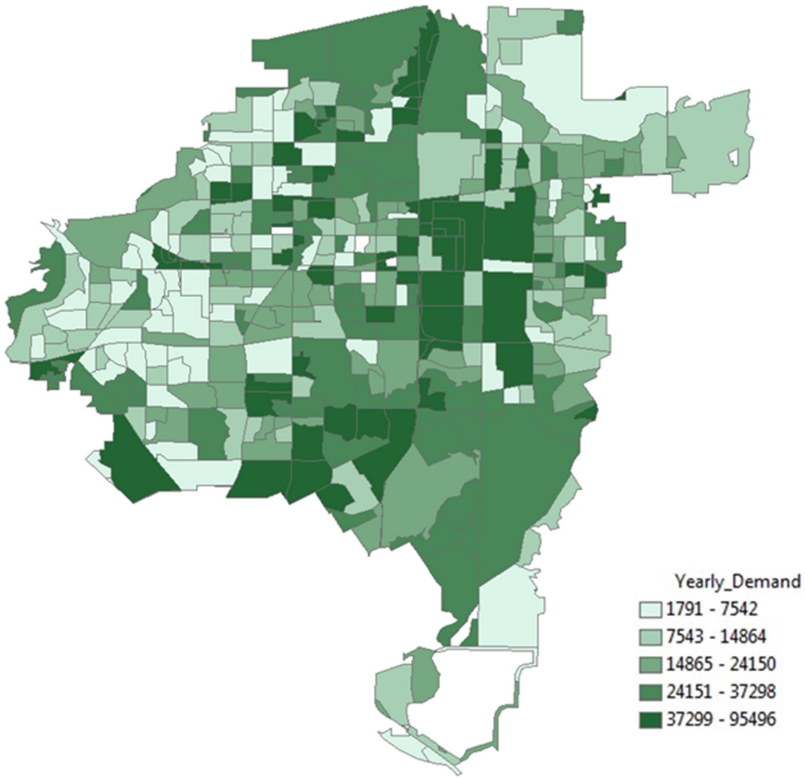
Table 2: Ridership model estimation

Variable	Coefficient	p-value
Zero-Inflation Model		
Intercept	-6.3027	0.0422*
Income	2.7758	0.0394*
Intersection_BG	-1.1183	0.0317*
Pop_20to74	0.1685	0.0422*
Count Model		
Intercept	3.29429	0.0002***
Age_Mean	-0.0710	0.0000***
Non_white	0.2147	0.0006***
HH_Vehicle_0	1.4539	0.0206*
Headway	-1.8121	0.0073**
Gender_1	0.5739	0.0477*
Buffer_BG	1.0782	0.0385*

Demand analysis for Arlington and Grand Prairie

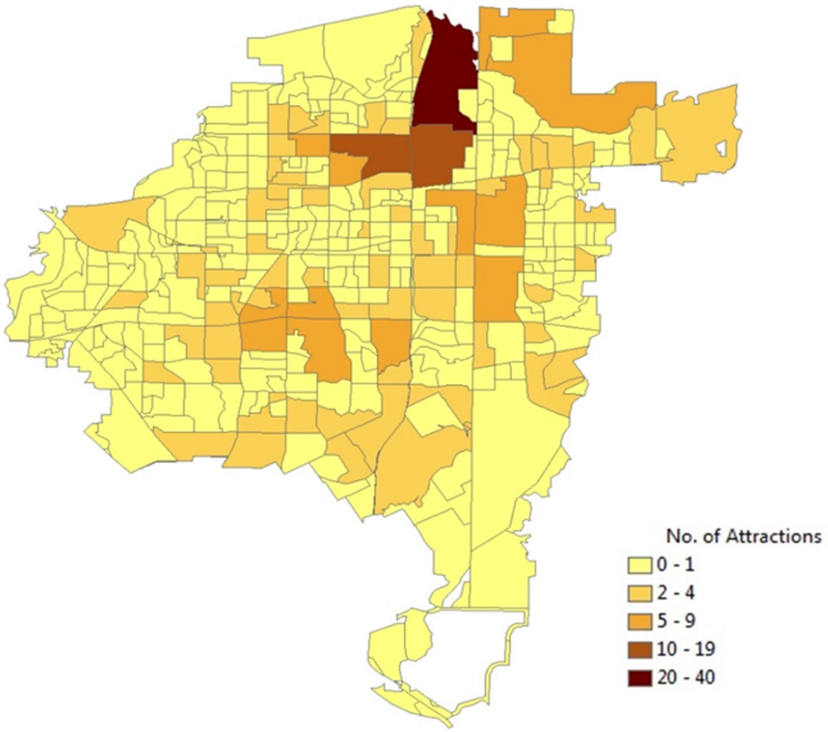
Based on this model, the researchers estimate the transit demand for the cities of Arlington and Grand Prairie as shown in Figure 18. Figure 18 shows the highest quintile of block group level transit demand as the darkest shade. The most recent ACS (2016) is used to extract the data for the independent variables in the model.

Figure 18: Predicted Annual Bus Transit Demand for Arlington-Grand Prairie



The number of trip attractors in Arlington and Grand Prairie appear in Figure 19. The trip attractions include varying types of employment ranging from accommodation and food service, construction, educational service, finance, health care, to retail trade.

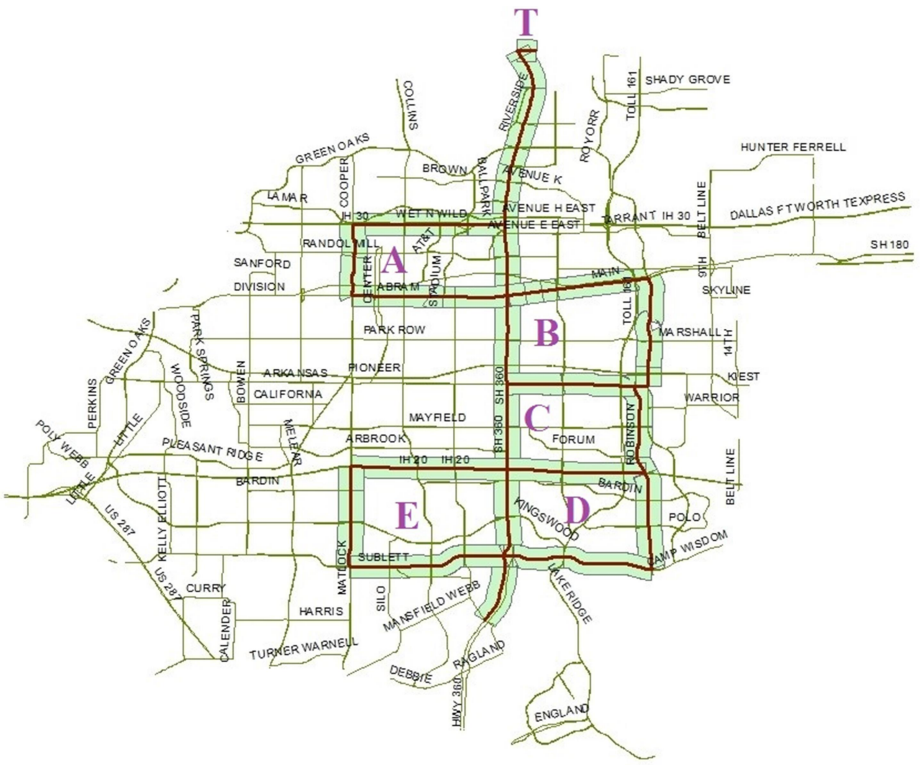
Figure 19: Number of Trip Attractions for Arlington-Grand Prairie



The Strategy

Based on the annual demand and trip attractors, transit systems serving for the two cities were designed as shown Figure 20. A trunk line crossing the region from north to south in the SH-360 (East Arlington and West Grand Prairie) corridor and five loop lines serving smaller regions in Arlington and Grand Prairie were proposed as an initial design.

Figure 20: Proposed Bus Transit Line for Arlington-Grand Prairie: Trunk Line (T) and Loop Lines (A, B, C, D, and E)



The length of the trunk line and the loops of A, B, C, D, and E are 13.9, 9.3, 10.1, 9.3, 10.1, and 10.5 mile, respectively. All of the routes are two-way links, in other words, the trunk line serves both north and south bound busses. The bus system proposed in this project does not include any design (or cost estimation) for parking-ride stations constructions or maintenance yards. However, the total costs of operating a maintenance yard is included in the cost estimation in a later section.

System Specification

Headway

A total of six scenarios are developed to consider various headways for the transit lines as shown in Table 3. Headways applied for the trunk line are 10, 15, and 20 minutes while 15, and 30 minutes are considered for the loop lines (lines A, B, C, D, and E).

Table 3: Headway Scenarios

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Headway for trunk line (T)	10 min	10 min	15 min	15 min	20 min	20 min
Headway for non-trunk lines (A,B,C,D,E)	15 min	30 min	15 min	30 min	15 min	30 min

Travel time and number of buses required for the system

For each transit route, the travel time is estimated based on the length of route and lost time. The team assumes that a bus stops at each station for 25 seconds for loading and unloading passengers. Table 4 shows the round-trip travel times for each line.

Table 4: Travel times (hour) for each transit route

Line	Loop Travel Time (hour)
Trunk line T	1.18
Loop line A	0.39
Loop line B	0.43
Loop line C	0.27
Loop line D	0.43
Loop line E	0.45

The number of buses required for each route is calculated as follows:

$$\text{No. of required buses} = 2 \times \left(\frac{\text{Loop travel time}}{\text{Headway}} + 1\right)$$

Table 5 shows the required fleet size for each headway scenario and required spare bus fleet size. For maintenance, spare buses have to be considered to replace the main fleet, and an additional 20% of the required fleet size is considered as spare bus fleet size.

Table 5: Required Fleet Size and Spare Buses

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Headway Description	10min (T) 15min (L)	10min (T) 30min (L)	15min (T) 15min (L)	15min (T) 30min (L)	20min (T) 15min (L)	20min (T) 30min (L)
Required Fleet Size	44	36	40	32	38	30
Spare Bus Fleet Size	9	7	8	6	8	6

Operating Hours

Operating hours for the proposed Arlington- Grand Prairie bus system is 18 hours from 6:00 am to 12:00 am based on the average operating hours of DART system.

Transit Cost and Performance Estimates

Cost

The study examines the costs associated with purchasing a fleet of buses necessary to provide the proposed operating scenarios and meeting operating costs. The study bases the cost determinations on both typical values and the current operating characteristics of DART.

Capital Costs

In the U.S., most transit agencies use diesel buses, and the price of a diesel bus ranges from $450K to $750K depending on the features of the bus; smaller buses between 35 and 40 feet usually cost around $450K and 60-foot articulated bus have prices closer to $750K (Aber, 2016). MacKechine (2016) identifies the bus propulsion systems as the most important factor affecting the bus price. Hybrid buses, which include a combination of gasoline or diesel and electric motors, and electric buses both have higher capital costs than diesel buses, but they have lower maintenance and fuel costs. MacKechine (2016) shows that electric buses can cost about twice as much as diesel buses in the U.S. (Quarles & Kockelman, 2018) analyzes the costs and qualitative characteristics of battery-electric and self-driving buses. They demonstrate that electric buses currently fail to achieve life-cycle cost-competitiveness, but within next few years they will become life-cycle cost competitive due to the falling prices of batteries. Quarles and Kockelman (2018) also indicate that fully-autonomous buses (without a full-time driver or attendant) appear

cost-competitive even at this time. Any decision to develop a transit system in Arlington and Grand Prairie should perform a detailed sustainability analysis to determine the optimal bus propulsion system for a modern fleet.

Equation 1 indicates the annualized capital cost for the proposed bus system after assuming a 12-year life cycle for each diesel bus, a discount rate of 3%, and a purchase price of $500K.

$$\text{Capital Cost} = 500{,}000 \times 0.1005 * \text{Fleet size} \quad (1)$$

Therefore, Table 6 shows the estimated capital costs for the calculated fleet size for every headway scenario.

Table 6: Estimated Annualized Capital Costs for Each Headway Scenario

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Headway description	10min (T) 15min (L)	10min (T) 30min (L)	15min (T) 15min (L)	15min (T) 30min (L)	20min (T) 15min (L)	20min (T) 30min (L)
Main Fleet Size	44	36	40	32	38	30
Spare Bus Fleet Size	9	7	8	6	8	6
Required Fleet Size	53	43	48	38	46	36
Estimated Capital Cost ($)	$2,653,200	$2,170,800	$2,412,000	$1,929,600	$2,291,400	$1,809,000

These capital costs do not include the costs associated with constructing or purchasing maintenance garages or bus shelters.

Operating Costs

Operating costs typically account for a much greater percentage (87% for DART) of a transit agency's total expenditures. Data gathered by Federal Transit Administration (FTA) (2018) shows that the transit agency location plays a significant role in bus operating cost. The FTA (2018) categorizes performance measures for service efficiency and service effectiveness. Service efficiency performance measures include operating expenses per vehicle revenue mile and operating expenses per vehicle revenue hour. The service effectiveness performance measures include operating expenses per passenger mile, operating expenses per unlinked passenger trip, unlinked trips per vehicle revenue mile, and unlinked trips per vehicle revenue hour. Tables 7 and 8 show service efficiency and service effectiveness performance measures for the different transport modes in the DART system.

Table 7: DART Service Efficiency Performance Measures, 2017 (extracted from FTA 2018)

	Service Efficiency	
Mode	Operating Expenses per Vehicle Revenue Mile	Operating Expenses per Vehicle Revenue Hour
Commuter Rail	$17.34	$390.06
Demand Response	$5.94	$75.25
Demand Response - Taxi	$4.04	$72.16
Light Rail	$17.10	$356.20
Bus	$9.44	$119.99
Street Car Rail	$31.19	$213.60
Vanpool	$0.54	$20.57
Total	$10.00	$152.16

Table 8: DART Service Effectiveness Performance Measures, 2017 (extracted from FTA 2018)

	Service Effectiveness			
Mode	Operating Expenses per Passenger Mile	Operating Expenses per Unlinked Passenger Trip	Unlinked Trips per Vehicle Revenue Mile	Unlinked Trips per Vehicle Revenue Hour
Commuter Rail	$0.68	$13.47	1.3	29.0
Demand Response	$3.18	$38.23	0.2	2.0
Demand Response - Taxi	$3.07	$42.01	0.1	1.7
Light Rail	$0.72	$5.84	2.9	61.0
Bus	$2.22	$8.15	1.2	14.7
Street Car Rail	$10.78	$16.86	1.8	12.7
Vanpool	$0.09	$3.23	0.2	6.4
Total	$1.16	$7.67	1.3	19.8

According to the DART data (FTA, 2018), the hourly operating cost for the DART bus system was $119.99 in 2017, while the rail systems all have higher hourly operating costs and the demand responsive and the vanpool systems have lower hourly operating costs. For estimating the proposed system's operating costs, the authors use the operating expenses per vehicle revenue hour for DART which is about $120/hour, rather than the expenses per revenue mile because the two systems may have significantly different route characteristics. Based on, the DART system performs well with only light rail and vanpool demonstrating better effectiveness. The operating expenses per passenger mile provide somewhat similar results with vanpool, light rail, and commuter rail exhibiting better effectiveness; for this metric, the demand responsive performance does not appear much higher than the bus while for the operating expenses per unlinked passenger trip remained significantly higher. Within the DART system, most of the demand responsive system functions more similarly to the Arlington Handitran and the Grand Prairie *Grand* Connection *systems* rather than the VIA system. Additional future analysis will need to be conducted to compare the effectiveness of mobility on demand systems like VIA with fixed route buses across these effectiveness metrics.

Table 9 shows the estimated operating cost per hour for every headway scenario. For a system that operates eighteen hours per day, the operating costs range from about $35M per year for scenario 1 to about $24M per year for scenario 6.

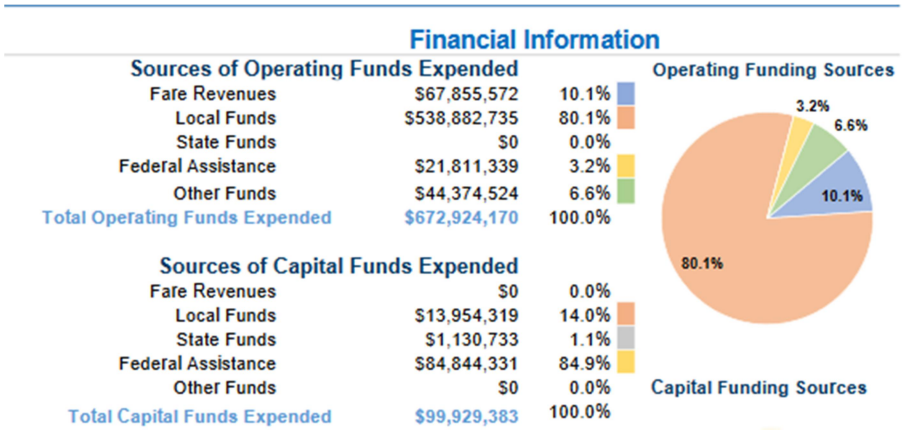
Table 9: Estimated Hourly Operating Costs for each Headway Scenario

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Headway Description	10min (T) 15min (L)	10min (T) 30min (L)	15min (T) 15min (L)	15min (T) 30min (L)	20min (T) 15min (L)	20min (T) 30min (L)
Main Fleet Size	44	36	40	32	38	30
Estimated Operating Cost ($/hour)	$5,280	$4,320	$4,800	$3,840	$4,560	$3,600

Fare Recovery

Figure 21 identifies the sources of operating and capital expenses for DART. DART only achieves a 10% fare recovery, which leaves 80% of the system's operating expenses to be covered by sales tax revenue. Sales tax revenues play on a role (14%) in the capital costs of the DART system, too; however, federal assistance covers most of the capital expenses. Therefore, the capital costs may at least partially be transferred to the federal government.

Figure 21: Sources of DART Expenditures, 2017 (FTA, 2018)



Performance Evaluation

Ridership estimation

These estimates assume that all residents in each block group served by the transit system have access to the transit system, which represents an inflated value for all ridership estimations. The proposed system serves a portion (34%) of the Arlington (including Pantego and Dalworthington Gardens) population (438,742). A greater share (53%) of the Grand Prairie population (225,231) has access to the proposed system. For both cities, the system serves approximately 41% of the total population.

The authors estimate the ridership for each headway scenario using the previously estimated demand model (zero-inflated regression model). Table 10 shows total annual and daily ridership values for the proposed Arlington-Grand Prairie bus system.

Table 10: Estimated Total Annual and Daily Ridership in for each Headway Scenario

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Headway description	10min (T) 15min (L)	10min (T) 30min (L)	15min (T) 15min (L)	15min (T) 30min (L)	20min (T) 15min (L)	20min (T) 30min (L)
Estimated Annual Ridership	6,384,875	4,856,297	6,055,464	4,526,887	5,804,513	4,275,935
Estimated Daily Ridership	17,493	13,305	16,590	12,402	15,903	11,715

The ridership estimates likely over represent the potential ridership because the coverage areas associated with the stops on each route will likely be smaller than the values used for this estimate.

Performance measures

Numerous transportation agencies use transportation system performance measures (PMs) to evaluate their policy, planning, and programming activities (Pickrell and Neumann, 2001), and many of these agencies use of PMs to guide efficient resource allocation (Cambridge Systematics, Inc., 2000). Measuring the performance of a transit system represents the first step toward efficient and proactive management (Bertini and El-Geneidy, 2003). However, picking the ‘‘right’’ measures plays a key role in their effectiveness for impacting agency decisions. Performance-based planning must be merged into an agency’s ongoing planning, management, and decision-making processes (Cambridge Systematics, Inc., 2000) to create a comprehensive

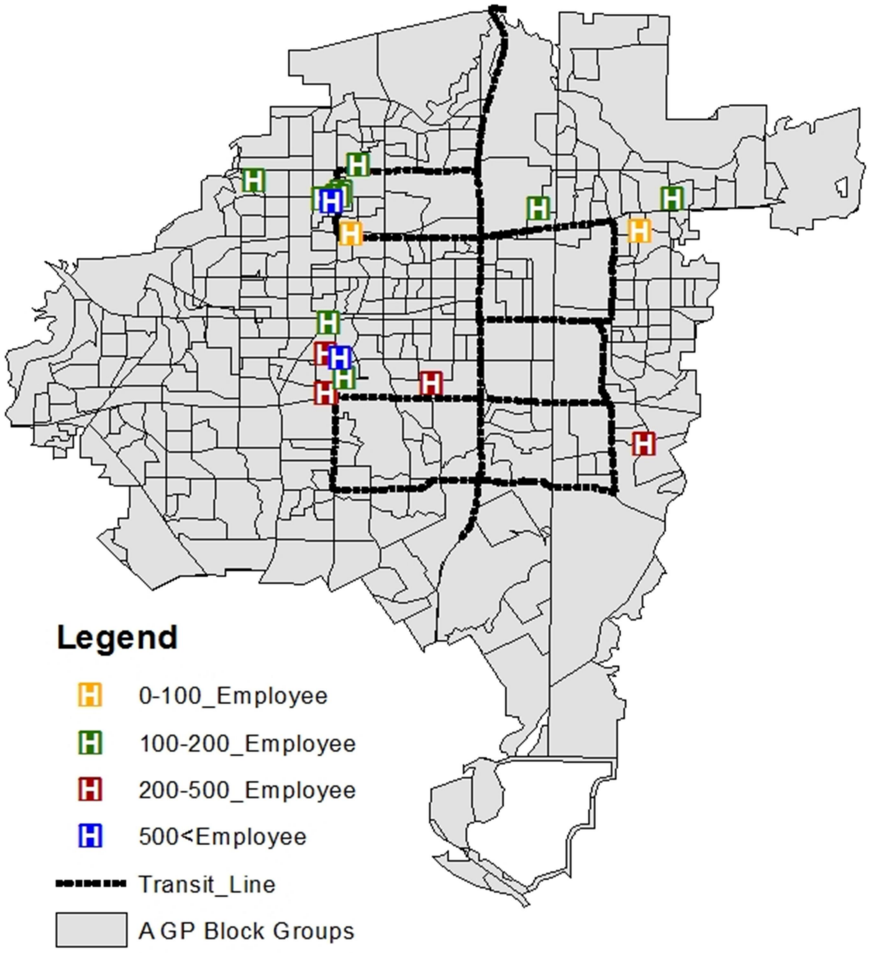
integrated system, and agencies should clearly define PMs that align with overall goals and mission (Meyer, 2001). Therefore, a final set of performance measures must be developed with significant input from city staffs and constituents.

To provide an effective transportation service for Arlington and Grand Prairie, the authors used the opinions of the community to identify key performance measures. The researchers expect that these measures consider resident quality of life and justice for target populations. The community identified equity, access, quick travel, and congestion mitigation as important goals for a new transit service. While an evaluation of congestion mitigation remains beyond the scope of this study, it should be incorporated into future transit studies in Arlington and Grand Prairie. The proposed system's structure attempts to largely address equity issues by operating where higher demand for transit exists; however, equity should also be more extensively investigated in future studies, too. Researchers identify three major performance measures for the proposed Arlington-Grand Prairie transit system that incorporate access and quick travel:

- Health care and social assistance jobs within a 30-minute travel time
- Other jobs within a 30-minute travel time
- Population within a 30-minute travel time

Environmental justice or transit dependent residents typically have limited access to healthcare centers (Arcury et al., 2005). The study uses health care and social assistance jobs as a proxy for health care; however, the type of health care and social services should likely be incorporated into future performance measurement assessments to provide greater clarity to the type and quality of access provided by the transit or mobility on demand system. Figure 22 shows the size of the employment centers for health care and social assistance jobs in Arlington and Grand Prairie. Two clusters of jobs exist. One occurs along Cooper in north central Arlington and the other occurs near I-20 along Matlock Road in south central Arlington. VIA currently serves both of these clusters.

Figure 22: Size of Health Care and Social Assistance Employment Centers in Arlington and Grand Prairie



Reference: NCTCOG Regional Data Center

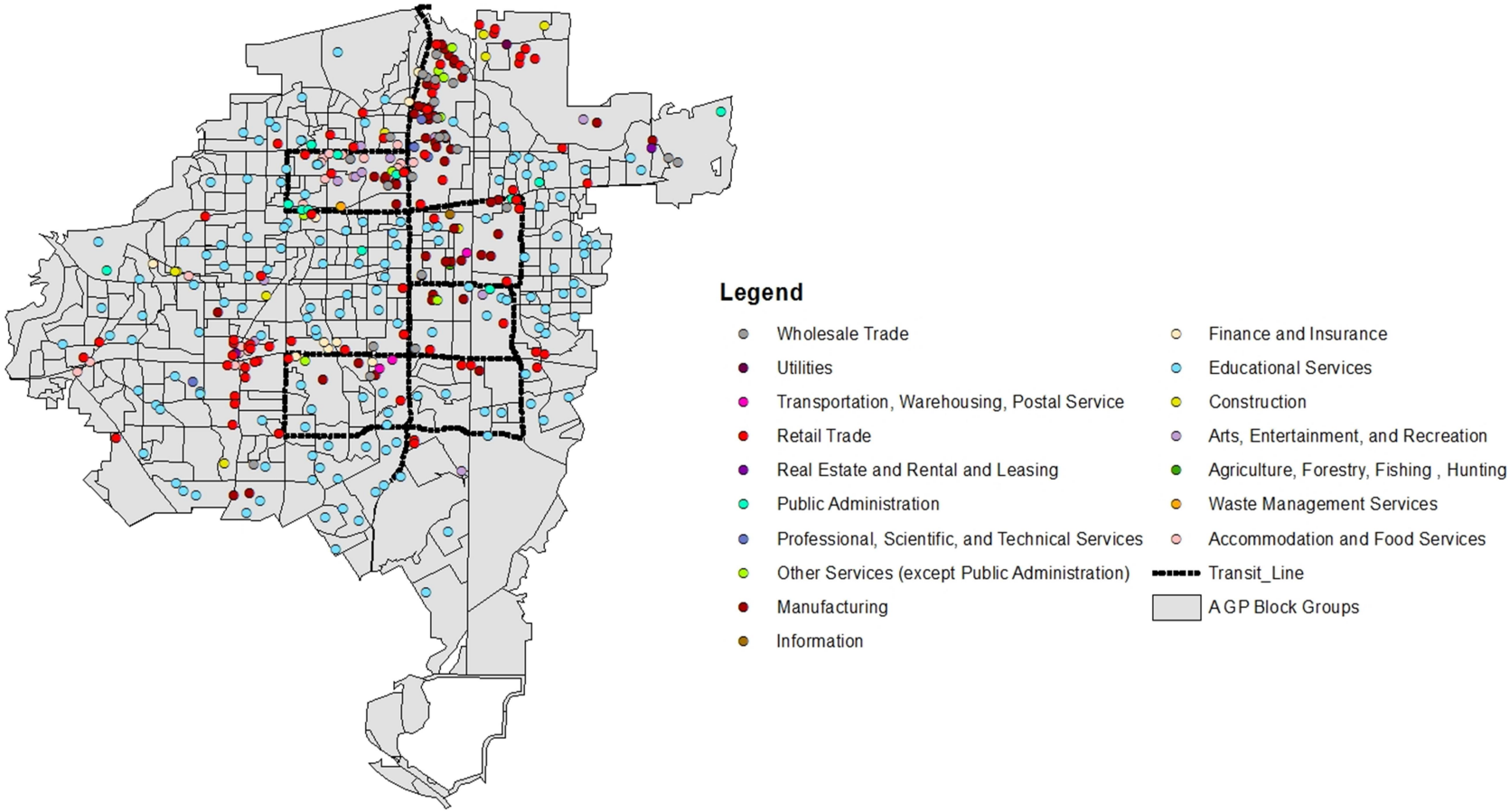
The recognition of the importance of jobs-housing balance has existed for many decades; a jobs-housing balance policy would likely have impact on traffic congestion and air pollution (Giuliano, 1991). For residents, access to employment remains critical and Table 11 identifies the total employees by job category. While this study does not examine the job types and their match with potential transit riders, future studies may consider skill matching and the quality of the job to enhance the performance measure. Figure 23 provides the locations of many of these employment centers based on their classification.

Table 11: Total Employees in Arlington and Grand Prairie by Category

No.	Jobs Type (Land Use)	Total Number of Employees
1	Accommodation and Food Services	2607
2	Administrative, Support, and Waste Management Services	587
3	Agriculture, Forestry, Fishing, Hunting	32
4	Arts, Entertainment, and Recreation	8636
5	Construction	1238
6	Educational Services	17111
7	Finance and Insurance	6987
8	Information	300
9	Manufacturing	22593
10	Other Services (except Public Administration)	1082
11	Professional, Scientific, and Technical Services	708
12	Public Administration	10293
13	Real Estate and Rental and Leasing	250
14	Retail Trade	18111
15	Transportation, Warehousing, Postal Service	500
16	Utilities	350
17	Wholesale Trade	3558
Total		94943

Reference: NCTCOG's Regional Data Center

Figure 23: Location of Employment in Arlington and Grand Prairie by Category



Reference: NCTCOG's Regional Data Center

The final performance measure looks at the amount of population accessible within thirty minutes to serve as a proxy for access to community, commercial and other services and activities. Figures 24 – 26 provide a graphical illustration of the quality of employment, healthcare, and population access provided by the proposed system for the six scenarios.

Figure 24: Total Employment within a 30 Minute Travel Time

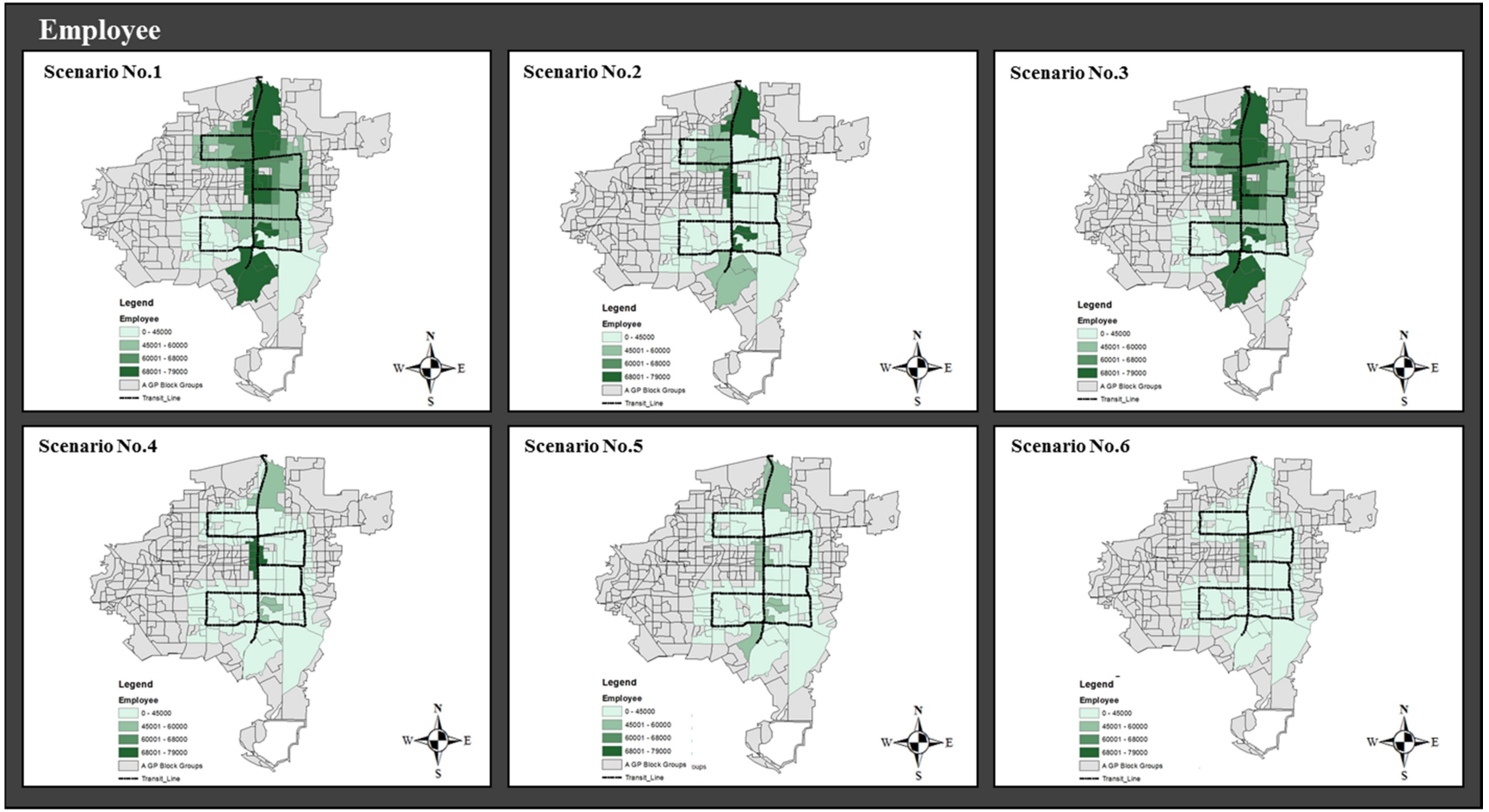


Figure 24 indicates that most of the benefit associated with scenarios 1 and 3 accumulates in north Arlington and north Grand Prairie, which already have the best proximity to the majority of jobs in Arlington and Grand Prairie. Other residents will still have access to these jobs, but their travel time will exceed the typical commute time of thirty minutes. The loop route headways do not provide sufficient access in scenarios 2, 4, and 6 while the trunk line headway limits the access in scenario 5. The best access tends to occur along the primary trunk line.

Figure 25: Health Care and Social Assistance Employment within a 30 Minute Travel Time

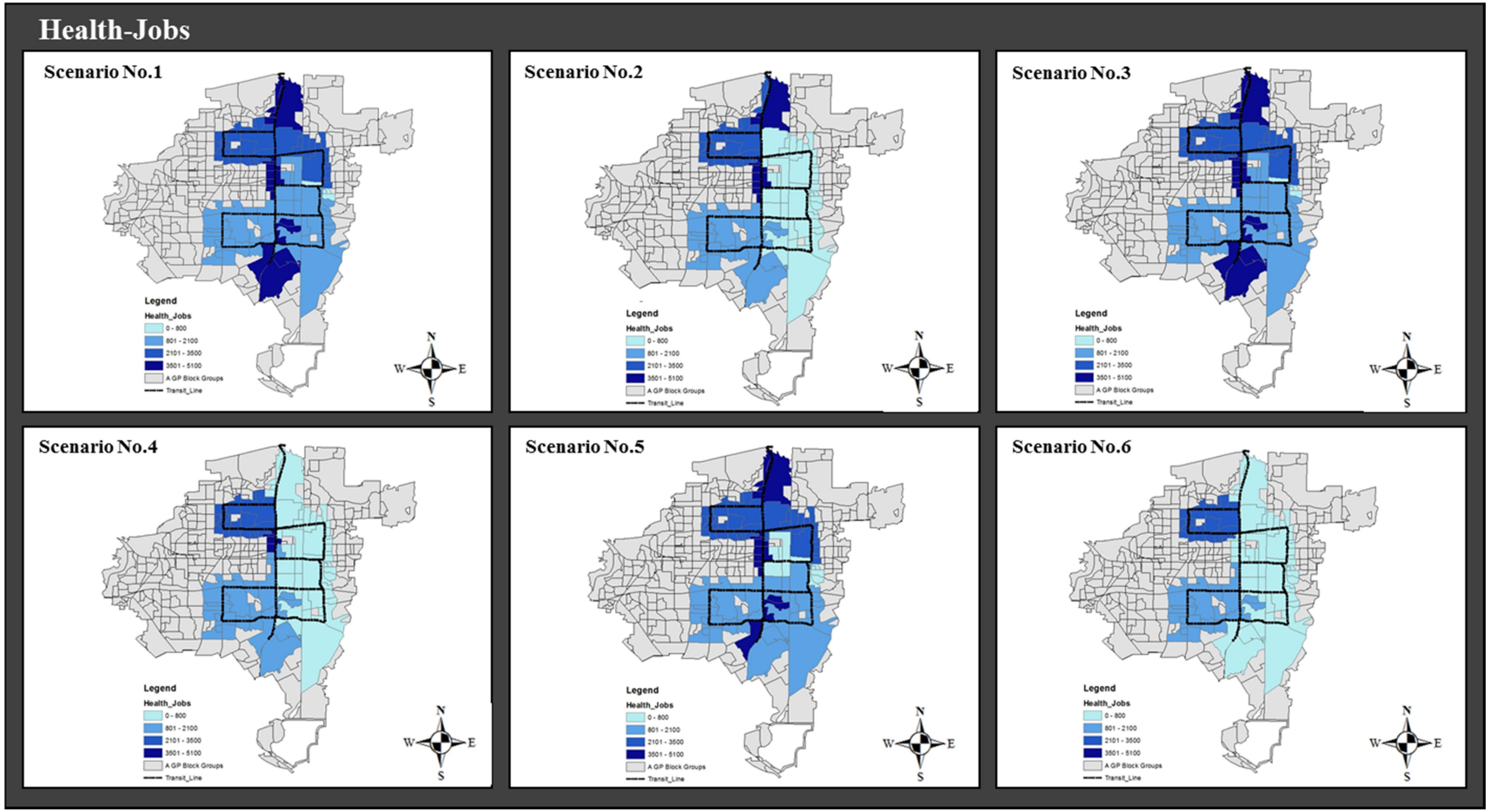


Figure 25 shows that a portion of residents in north Arlington achieve significant access to health care and social assistance under all scenarios, but scenarios 1, 3, and 5 provide good access for most residents. Scenarios 2, 4, and 6 fail to provide much access to health care and social assistance for Grand Prairie residents due to the high loop headways. The trunk line headway appears to be the dominant feature in determining high access to health care within the service area.

Figure 26: Total Population within a 30 Minute Travel Time

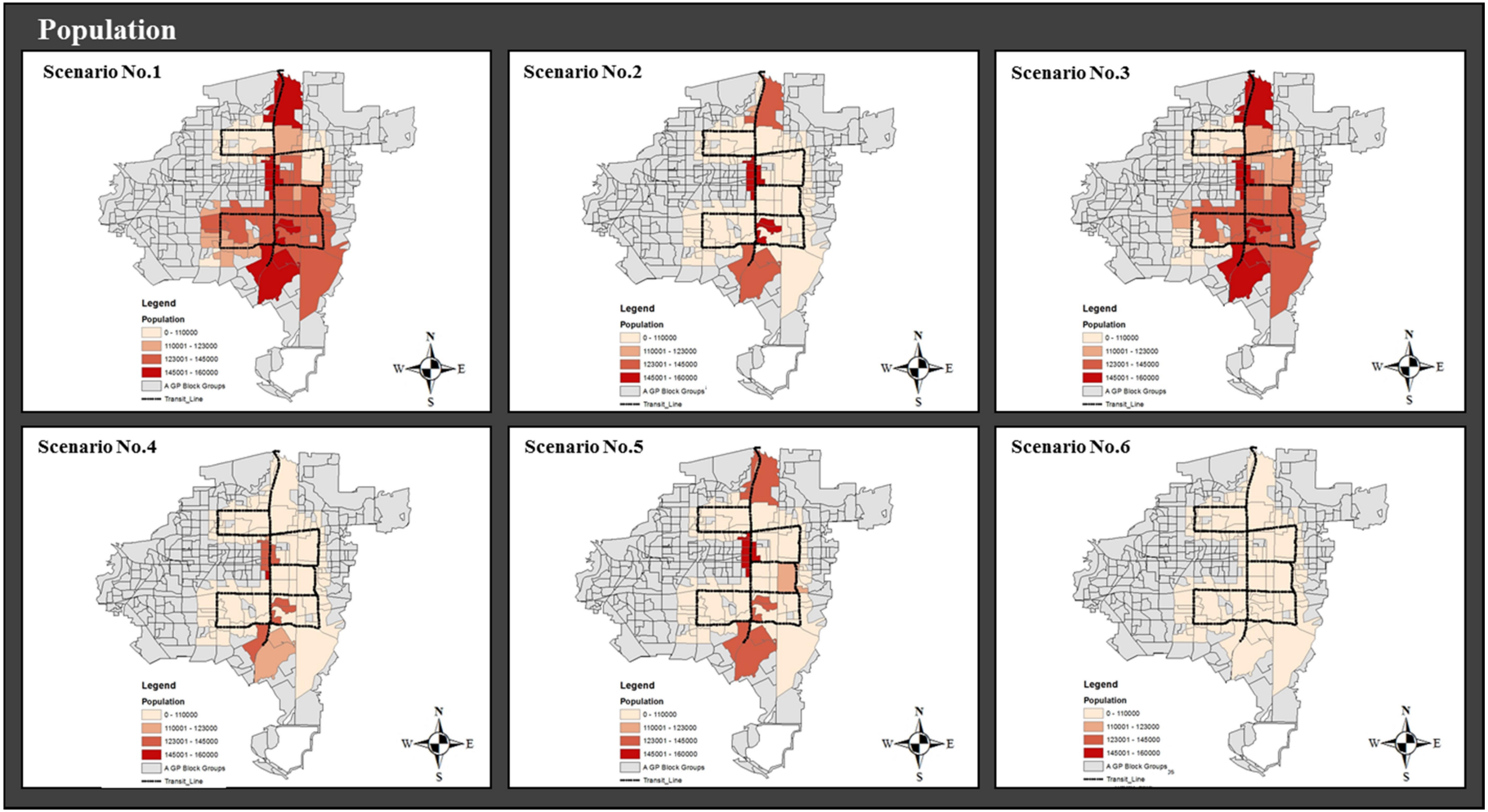


Figure 26 indicates that most of the service area receives significant access to the population under scenarios 1 and 3. The lowest access occurs in scenario 6 where almost all of the service area falls within the lowest access category. Some block groups along the trunk line in scenarios 2, 4, and 5 retain higher levels of access to populations within the two cities.

Table 12 shows the percentage of block groups within the transit service area falling within each employment access category. Scenarios 1 and 3 achieve similar employment access; therefore, increasing the trunk line headway from 10 to 15 minutes may not have a significant impact on access to employment and save over $3M annually; however, this assessment does not include access time at either the origin or destination of the trip, which will decrease system performance. For certain, increasing the trunk route headway to 20 minutes or the loop headways to 30 minutes has a significant impact on access to employment in the service area.

Table 12 Scenarios 1-6: Percentage of Block Groups Falling in each Employment Category

PMs	Categories	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)	Scenario 4 (%)	Scenario 5 (%)	Scenario 6 (%)
Employment	**0-45000**	27.3	67.8	27.3	82.6	77.7	91.7
	45001-60000	28.9	13.2	28.9	9.1	22.3	8.3
	60001-68000	15.7	2.5	17.4	0.0	0.0	0.0
	68001-79000	28.1	16.5	26.4	8.3	0.0	0.0

Table 13 shows the percentage of block groups within the transit service area falling within each health care and services access category. In many scenarios, the access to health care and social services remains reasonable for most block groups in the service area. A change in the loop route headways from fifteen to thirty minutes decreases access while the trunk route headway has a limited impact on access within the service area.

Table 13 Scenarios 1-6: Percentage of Block Groups Falling in each Healthcare and Social Services Category

PMs	Categories	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)	Scenario 4 (%)	Scenario 5 (%)	Scenario 6 (%)
Health-Jobs	**0-800**	3.3	38.8	3.3	45.5	9.9	55.4
	801-2100	38.8	26.4	38.8	31.4	33.9	26.4
	2101-3500	31.4	21.5	33.9	18.2	33.9	18.2
	3501-5100	26.4	13.2	24.0	5.0	22.3	0.0

Table 14 shows the percentage of block groups within the transit service area falling within each population access category. Scenarios 1 and 3 maintain similar levels of performance; however, analysis of the other four scenarios indicates that about 75% of the block groups fall into the lowest quartile range from scenario 1. Scenarios 2, 4, and 5 provide some higher levels of access for a portion of the service area; however, scenario 6 fails to provide high access to anyone in the service area with over 98% of the block groups falling into the lowest category.

Table 14 Scenarios 1-6: Percentage of Block Groups Falling in each Population Category

PMs	Categories	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)	Scenario 4 (%)	Scenario 5 (%)	Scenario 6 (%)
Population	**0-110000**	24.8	77.7	34.7	82.6	74.4	98.3
	11001-123000	26.4	3.3	19.0	2.5	2.5	1.7
	123001-145000	24.8	5.0	22.3	14.0	23.1	0.0
	145001-160000	24.0	14.0	24.0	0.8	0.0	0.0

Limitations

As a preliminary investigation, this study has many limitations. This study uses a sketch planning approach and estimates direct demand model; a direct demand model does not incorporate other competing modes, which makes transit ridership insensitive to changes in other modes and the introduction of new modes like VIA. This study estimates the direct demand model based on DART ridership, but Dallas socioeconomic conditions and the density of the DART transit network differs from the proposed system. The authors do not consider access time in ridership estimations or system performance measures. As a result of these limitations, the ridership estimates provided in this study likely exceed the values that may be obtained from a new service, especially when the service is first introduced. The system also does not achieve the levels of estimated performance because the walking access times on each end of a trip may be significant.

The study does not investigate the current utility that VIA provides to the transportation disadvantaged population in Arlington and its ability to meet their transportation needs. Furthermore, the VIA system's affordability for all residents must be assessed in the future. This study does not analyze fares, which means the proposed system also must be subjected to affordability assessment. The failure to consider fares will have a limited impact on the ridership estimates because transit demand typically remains inelastic with respect to changes in fares. The capital and operating cost estimates do not include any transit infrastructure construction and management (park and ride or bus stop shelters). The actual system costs will require more detailed costing to establish final system cost estimates. These costs should be generated when selecting between alternative transit system and microtransit or mobility on demand (like VIA) configurations that assess the system impacts on the transportation disadvantaged populations.

Conclusions and Recommendations

This chapter provided insight into the public's perceptions of public transit and their expectations for any public transit system in Arlington and Grand Prairie. This chapter's public engagement gathers broad perspectives, but focuses on transportation disadvantaged population, who may receive the greatest benefits from a properly conceived public transit system. This chapter provides one possible configuration for a traditional fixed route transit system that focuses on locations with high transit demand, large numbers of jobs, and health care. The authors provide this sample configuration to illustrate the potential trips served and costs associated with a fixed route system, but do not recommend this as the solution to transportation disadvantage in Arlington and Grand Prairie.

Instead, the authors believe that Arlington and Grand Prairie find themselves uniquely positioned to consider all alternatives for public transit because they find themselves unaffiliated with any existing regional transit agency and its fixed route structure. While congestion mitigation must remain a key tenet for any public transportation system the needs and desires of the transportation disadvantaged populations may be even more important. These populations will not be able to fully participate in society without adequate mobility, which should include more alternatives than inconvenient and time-consuming fixed route transit in low density-built environments. Based on public engagement activities, mobility on demand solutions require careful investigation. These solutions must be able to access a wide range of employment and other opportunities both within Arlington and Grand Prairie and the broader Dallas-Fort Worth metropolitan area. Therefore, the authors recommend Arlington and Grand Prairie engage in a bottom up strategy to develop a public transportation system that adequately meets the needs of the transportation disadvantaged population and provides congestion mitigation benefits. These congestion mitigation benefits and assessments must consider that an innovative and effective public transportation system will likely serve significant latent demand. While the land valuation benefits associated with a fixed route system may not be recognized the provision of a viable and convenient public transportation system may have less significant but broader changes in property valuations. This represents a potential strategy to provide broad benefits and avoid the gentrification that may force transportation disadvantaged populations further from fixed route transit routes.

The overall report provides an exhaustive look at the factors related to the presence/absence of fixed route transit in Arlington and Grand Prairie, but it does not recommend a particular solution. Instead, the report provides two possible strategies for providing fixed route transit in Arlington to illustrate the potential benefits, ridership and costs of providing this service.

City of Arlington Response

This study recognizes the City of Arlington's unique position in transit operation because the City has not historically been tied to a transit authority. However, the report fails to fully elaborate on Arlington's past, present or future transportation initiatives. While the report does mention the City's mobility service such as Milo, the ED Trolley and Handitran, it leaves out any history related to the former commuter bus service between Arlington and Fort Worth and the MAX commuter bus pilot project. It also does not reference the City's annual financial contribution to the TRE commuter rail line that has taken place since 2002. These elements enhance the report to provide a thorough account of Arlington's history related to transportation. The City of Arlington has additional resources that may inform the current state of transportation in Arlington and plans for the future. For example, the study contains little discussion on the City's transportation planning efforts and no mention of the Transportation Advisory Committee (TAC) process that resulted in the recommendations included in the Connect Arlington report. The City also commissioned a HDR study that contains data related to the viability (or lack thereof) for traditional bus service in Arlington. This is important background information and an opportunity to further support the report's recommendation for an alternative solution.

The City recommends an in-depth study of Via to document Via's ability to address community need. The City also recommends a future in-depth cost/benefit discussion related to the proposed bus routes to provide a complete picture of traditional bus service.

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Appendix A: Community Study Methodology

Transportation disadvantage (TD). Transportation mobility is considered a critical domain for livable communities, providing access to social connectivity, health care, civic participation, employment, housing, and other services (Coughlin, 2009; Gonyea & Hudson, 2015). Transportation disadvantage is characterized by a lack of access to adequate transportation options (Currie, Stanley, & Stanley, 2007; Currie et al., 2009; Currie et al., 2010), which can have detrimental implications on life opportunities (Li, Raeside, Chen, & McQuaid, 2012; Lucas & Jones, 2012; Nostikasari, 2015; Turnbull, Muckle, & Masters, 2007).

Environmental justice (EJ) populations. President Clinton, through executive order 12898, provided protection for minority populations and low-income populations as environmental justice (EJ) populations with the purpose of "focus[ing] federal attention on the environmental and human health effects of federal actions…with the goal of achieving environmental protection for all communities" (United States Environmental Protection Agency, 1994).

Transportation mobility is critical for livable communities and is the vehicle that facilitates social engagement, communication and information, civic participation, employment, housing, health and community, respect and inclusion (World Health Organization, 2007). Persons identified as EJ are at an increased risk for TD.

Design. The purpose of this study is to better understand current transit services in Arlington and Grand Prairie, Texas and to gain stakeholder perspectives regarding a corridor linking the two cities. The research team triangulated data sources, addressing the topic from multiple stakeholder perspectives, utilizing qualitative methods to maximize community input and the variety of data collected. Qualitative data allowed us to create a more nuanced understanding of the transportation needs in these two cities and possible solutions that could be implemented to address the current gaps in services.

Specifically, the research team collected data in the form of focus groups with various stakeholder groups. Focus groups were conducted in-person with transportation-disadvantaged client populations and via Zoom, an online conferencing platform, for professional stakeholders. Focus groups were audio recorded and professionally transcribed.

Sample. Participants were recruited using a purposive sampling strategy to ensure representation across a wide array of stakeholder groups. These target groups included: 1) decision-makers and city planners; 2) transportation planners; 3) businesses and major employers; 4) residents; 5) employees of social service organizations, and; 6) environmental-justice (EJ) individuals who are at high risk for transportation disadvantage (e.g., low income adults, individuals with disabilities, and individuals experiencing homelessness). All participants either live or work in or near Arlington or Grand Prairie, self-identify as 18 years of age or older, are English-speaking, able to provide informed consent, and agreed to provide their perspectives regarding transportation needs, challenges, and solutions in Arlington and Grand Prairie.

Decision-makers and city planners. Two focus groups were conducted via Zoom with decision-makers and city planners, spanning both Arlington, Grand Prairie, and surrounding cities.

Transportation planners. Two focus groups were conducted via Zoom with transportation planners in Arlington, Grand Prairie, and surrounding cities.

Businesses and major employers. One focus group was conducted via Zoom with business owners and major employers, although more business owners and major employers were also included in the resident focus groups.

Residents. Two focus groups were conducted via Zoom with residents of the two cities. One focus group was primarily individuals from Arlington while the other group included residents solely from Grand Prairie.

Employees of social service organizations. One focus group was conducted via Zoom with employees of social service organizations in Arlington, Grand Prairie, and surrounding cities.

Environmental justice populations. Three focus groups were conducted with environmental justice populations. Two groups were in person. One was conducted at a homeless shelter in Arlington and the other at a temporary job placement agency in Grand Prairie. The third group was conducted via Zoom with residents from both Arlington and Grand Prairie who were also considered members of EJ populations.

Data Collection and Analysis. The University of Texas at Arlington Institutional Review Board approved this research. All participants signed informed consent documents and were compensated for their time with five-dollar e-gift cards. All focus groups were audio recorded and transcribed. Members of the research team independently read the transcripts line by line, coding the transcripts organically. The team then met together to discuss the coded transcripts and the themes we saw emerging. We reached consensus together for all themes and representative quotes below.