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16. Abstract

Suburban development is occurring near urban areas across America. Often these communities are separated by large masses of land with no linkage to the urban core. Referred to as urban sprawl, this type of development causes a challenge for transportation planners in providing adequate public transportation services to suburban communities. This research applied a transit needs index to assess whether there might be demand for public transportation options between selected Houston suburban counties and the urban core. The research found that several neighborhoods within three selected suburban counties received a high rating on the index and are good candidates for public transportation.

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AN ASSESSMENT OF TRANSIT RIDERSHIP:

INCREASED SUBURBAN TO URBAN PUBLIC TRANSPORTATION OPTIONS

IN HOUSTON, TEXAS

By

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SWUTC/08/473700-00053-1

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November 2008

EXECUTIVE SUMMARY

Sun Belt metropolitan regions are experiencing population growth in suburban communities, and a portion of the suburbanites are commuting to the urban core for employment. These suburban communities are developing outside the urban core and often are separated by large masses of land with no linkage to the urban core. This phenomenon known as urban sprawl is occurring in the Houston metropolitan region. Urban sprawl causes a challenge for transportation planners to provide adequate public transportation services in suburban communities. This challenge is replicated not only throughout the Houston metropolitan region, but also in other regions of the country.

Although the Houston urban core remains the largest populated area, an increasing number of people, who migrate to the Houston metropolitan region are settling in one of the many suburban counties and commuting to the urban core for employment.

Some of these communities are served by limited Park and Ride service. This work assesses whether there is a need for increased public transportation options between selected Houston suburban counties and the urban core. Current and forecasted population levels were analyzed in the Houston eight county region to determine the population trend during the next thirty years. The three suburban counties that were forecasted to increase the most in population were analyzed in this research.

A travel time index designed to determine the need for transit in the urban areas was modified and applied to the three most populous suburban counties. A portion of the work analyzed freeway segments that connect the suburban counties and urban core and showed automobile travel times during peak periods are escalating as an increased number of people settle in suburban counties. The research found that several neighborhoods within the three suburban counties received a high rating on the index and are good candidates for public transportation. As the population in the Houston metropolitan region increases throughout the next thirty years, and freeway space remains congested, transportation planners will be required to develop innovative strategies to attract suburban commuters from their private automobiles to utilize

additional means of transportation during peak periods. This index can help identify those communities that are candidates for public transportation.

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CHAPTER 1

INTRODUCTION

Traffic congestion during peak hour travel periods has become a prevailing issue in U.S. Sun Belt metropolitan regions. The majority of the time spent commuting occurs during the two peak periods when highways are congested with commuters and other travelers. As the metropolitan regions in Sun Belt cities expand further from the urban core, and into developing suburban counties additional modes of transportation will be required to persuade commuters from their private automobiles. Enhanced commuter options will by no means eliminate traffic congestion during peak hour travel periods, but assist in traffic congestion relief on highways during these periods.

Sun Belt metropolitan regions experiencing population growth in suburban counties are beginning to cope with this phenomenon by focusing on expanding service into these developing suburban counties. These communities are beyond the traditional urban transit provider's service area, which causes a challenge for transportation professionals when trying to provide adequate service. Coordination between the urban transit provider and the adjacent suburban county has the potential to attract suburban commuters from their private automobiles, and increase public transportation ridership. This benefits both the metropolitan region and urban transit agency.

Background

For the past 50 years metropolitan regions across the nation have experienced a population shift outward from inner city communities into suburban communities. In a study on the cost of sprawl, Burchell (2002) indicates urban sprawl refers to largely unplanned, rapid, and expansive growth of metropolitan areas into traditional suburbs over a large area. Urban sprawl is occurring in Sun Belt metropolitan regions located in the south and west such as Atlanta, Dallas-Ft. Worth, Houston, and Phoenix just to name a few. As these suburban counties mature metropolitan regions are becoming suburbanized and decentralized. In a study of metropolitan magnets for international and domestic migrations (Frey, 2003) migration has been heavily slated in the south

and west as people relocate from northeastern cities. An increased number of people have descended on these Sun Belt metropolitan regions, and the roadways are unable to accommodate the increased population.

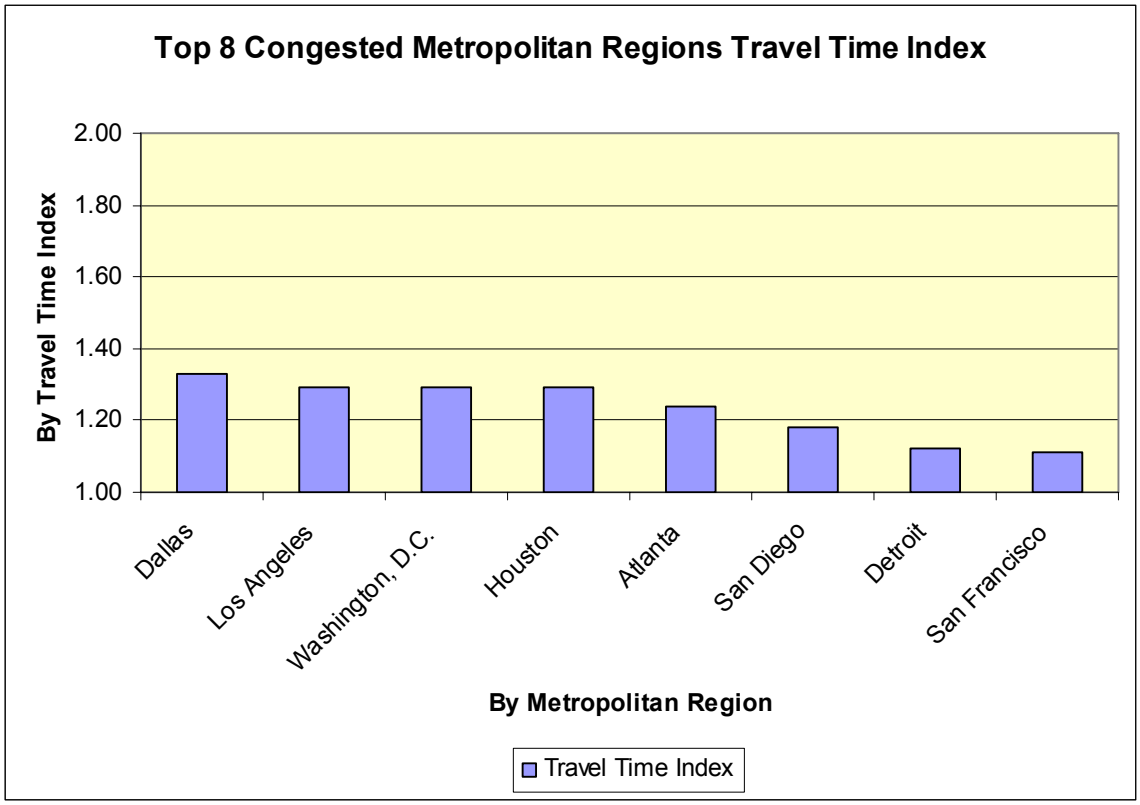
Commute travel times in Sun Belt cities are quickly worsening because the metropolitan region tends to be more spread out than older traditional northeastern cities. At the same time, very little additional highway capacity has been added in these regions. As Sun Belt cities continue to grow outward, the urban transit provider will need to develop innovative strategies to attract choice riders to alter their travel modes from private automobile to alternate means of transportation for work related trips during peak hour travel periods.

How Bad is Peak Hour Traffic Congestion?

Traffic congestion has worsened throughout the past 20 years. Congestion has specifically worsened in Sun Belt metropolitan regions where population growth has occurred in suburban counties. Increased congestion has started to impact Americans in many aspects of their lives. Americans are not only experiencing stop-and-go traffic on highways during peak hour travel periods, but congestion has started to linger outside the classified peak periods. Peak periods usually stretch for two or three hours in the morning and evening in metropolitan regions with a population over one million. Large metropolitan regions such as Atlanta, Houston, Los Angeles, and San Francisco are experiencing three to four hour peak period travel conditions.

The Texas Transportation Institute (TTI) measures traffic congestion using the travel time index in metropolitan regions to determine the extra percentage of travel time commuters spend traveling during peak periods. The travel time index is the ratio of the total time required to drive a freeway segment during peak periods to the time it takes to drive the same freeway segment during off peak periods. For instance, if it takes 30 minutes to drive to work during peak periods and during off peak periods it takes 25 minutes, the travel time index is 1.2. Thus, travel times during peak periods are 20 percent longer than during non-peak periods. As shown in Figure 1, the travel time index of the eight most congested metropolitan regions ranges from 1.11 to 1.33. Commuters in the Dallas-Ft. Worth metropolitan region experience the most traffic

congestion during peak periods. In the Dallas-Ft. Worth metropolitan region travel times are 33 percent longer during peak periods than during non-peak periods. Although the San Francisco metropolitan region ranks third as the most congested region, traffic delays during the peak period are the shortest among the top eight congested regions. In the San Francisco metropolitan region travel times are 11 percent longer during peak periods as compared to during non-peak periods. Hence, traffic congestion is occurring during the majority of the day in the San Francisco metropolitan region (Texas Transportation Institute, 2007).



Source: Texas Transportation Institute, 2007

Figure 1. Top 8 congested metropolitan regions travel time index

Causes of Traffic Congestion

In a study of the causes of traffic congestion (TCRP, 1999) traffic congestion is the result of several root causes interacting with one another. These factors all play a role in slowing down the flow of traffic on freeways from suburban communities to the urban core. The following six factors play a role in everyday traffic congestion:

- **Bottlenecks** occur when highway capacity lessens or is otherwise disrupted causing a clog at the narrowest part of a group of roadways. Bottlenecks may be caused by the number and width of lanes merging at interchanges and roadway alignments.
- **Traffic incidents** are occurrences that interrupt the normal flow of traffic. The most common types of traffic incidents include crashes, breakdowns, and debris in travel lanes.
- **Work Zones** are construction activities on the roadway that result in physical changes to the highway environment. These changes may include a reduction in the number or width of travel lanes, lane diversions, elimination of shoulders and event / temporary road closures.
- **Weather** is an environmental condition leading to changes in driver behavior. As a result, normal traffic flow is reduced.
- **Traffic Control Devices** are intermittent disruption of traffic flow by controlled devices such as railroad grade crossings and poorly timed signals, contributing to increased traffic congestion and travel time variability.
- **Fluctuations in Normal Traffic** is when the day-to-day variability in demand leads to some days with higher traffic volumes than others. Varying demand volumes superimposed on a system with fixed capacity also result in variable travel times. For instance, Monday and Friday are generally less congested days because people are more likely to take these two days off from work.

The interaction of these traffic congestion variables vary greatly from day-to-day and freeway-to-freeway. On any given day one or more of these variables are occurring on freeways, causing increases in commute travel times from suburban counties to the urban core. One day a commuter might encounter no traffic and good weather, while

the next day traffic may be heavy due to inclement weather and traffic incidents. The combination of these variables interacting together will certainly cause fluctuations in travel times throughout the five-day work week.

Problem Statement

A population shift is occurring in Sun Belt metropolitan regions. People are settling in suburban counties, and commuting to the urban core for employment. These suburban counties are developing in areas outside the urban transit agency service area resulting in minimum-to-no transit service to or within the county. Thus, suburbanites are required to drive their private automobiles for both work related and personal trips to and from suburban communities. This contributes to increased traffic congestion between the outlying county and the central city during peak periods, and during off-peak periods in communities within the suburban county.

Suburban counties are low density areas that consume more land than inner areas consisting of predominately single family homes. The single family homes are spaced further apart, separated by lawns, landscaping, roads or parking lots as opposed to city living with dense settings. These suburbanites are also dependent on automobiles as a primary means of transportation. Everyday activities such as shopping, errands, commuting to work and school require the use of automobiles since the area is isolated from the urban core, and places are spread out. An additional method to describe urban sprawl is leap-frog development. This type of development refers to the lack of relationship between subdivisions. Leap frog development can be found in Sun Belt metropolitan region Houston area suburban cities such as Sugar Land, Pearland, and the Woodlands, which are separated by large masses of land with no linkage to the Houston urban core. The urban transit agency (METRO) is unable to adequately serve these suburban cities, in part due to the lack of connectivity. Therefore, suburbanites drive to the urban core and other employment centers for work. This contributes to increased traffic congestion during peak hour travel periods.

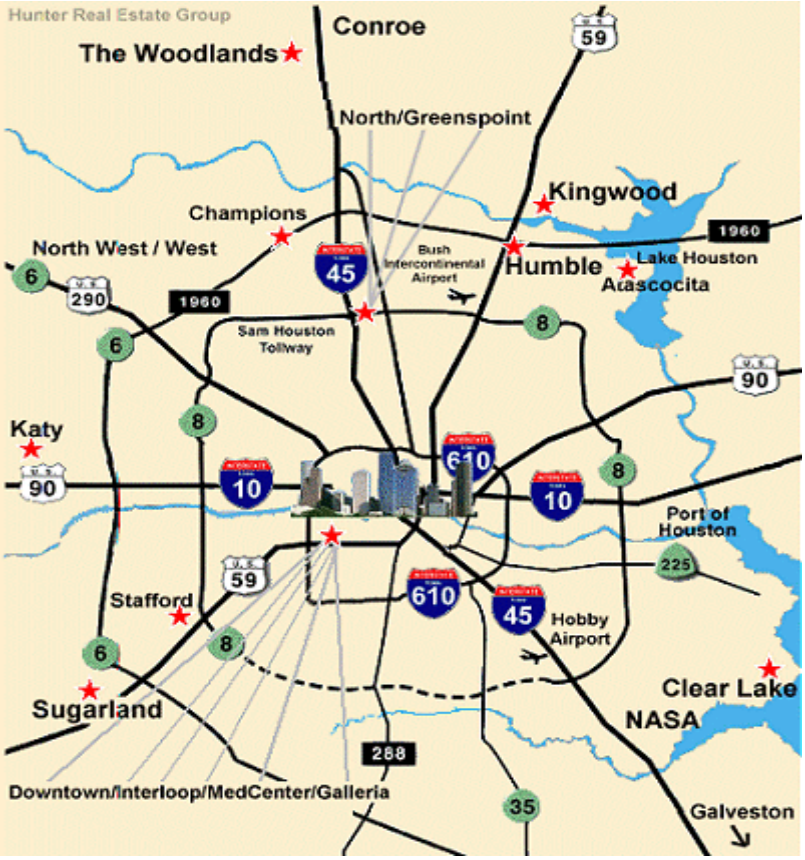
Research was undertaken on the Houston metropolitan region to determine where population growth is occurring within the region, and if providing increased public transportation options suburban neighborhoods would be conducive for transit. This

research is being undertaken to assess whether providing increased public transportation options in Sun Belt metropolitan regions could address the problem of traffic congestion on the highways during peak hour travel periods by attracting transit riders. Conducting research on providing additional modes of transportation in Sun Belt metropolitan regions is important because transportation professionals can utilize this study as a guide for addressing traffic congestion on highways in their perspective regions. Previous research results have described this is a critical issue in Sun Belt metropolitan regions in America that needs to be addressed as people continue to migrate to these regions. The regions were not built to accommodate the large number of people, and in order to control the congestion on highways several mechanisms will be required in the future. These mechanisms include providing increased public transportation services, implementing tolls on highways, telecommuting, and staggered work hours just to name a few. If one or more of these tactics are successfully implemented there are benefits to the users of the public transportation system, public transit agencies, the metropolitan region, and employers. Chapter 2 will discuss in further detail previous research that has been conducted on providing increased mobility options in Sun Belt metropolitan regions.

This research is significant because it will help transportation professionals in the Houston metropolitan region realize that as the population increases in suburban counties, there may be a market for transit and additional modes of transportation such as Light Rail Transit (LRT), Bus Rapid Transit (BRT), and Commuter Rail Transit (CRT) may be required to transport a portion of the estimated six million people who are expected to reside in the region by 2025. This research will assess population growth in Houston suburban counties to determine if there is a need for increased suburban public transportation options to the urban core. The goal of this thesis is to enhance the knowledge base for transportation professionals' decision-making process when determining new markets to provide public transportation services. The following three objectives will be addressed: 1) Quantify the level of population growth occurring in Houston suburban counties, 2) Apply the Travel Time Index formula for Houston suburban counties to the urban core, 3) Ascertain whether a public transit need exists in Houston counties to the urban core using the Commuter Need Index.

Houston Metropolitan Region

The Houston metropolitan region consists of eight counties spanning over 7,705 square miles. As in the case of other Sun Belt metropolitan regions a portion of the people are migrating to Houston suburban counties, and commuting to the urban core for work related trips. The Houston region is known for its extensive freeway system. As shown in Figure 2, three distinctive freeway rings encircle the region – 1) IH 610 approximately six miles from downtown, 2) Sam Houston Tollway / Beltway 8 approximately ten miles from downtown, and 3) FM1960 / Highway 6 approximately fifteen miles from downtown. Typical conversations describe communities inside Beltway 8 as the urbanized area, and communities outside Beltway 8 as the suburban area. Over the past 50 years population growth has dispersed across the ringed freeways. The area around Highway 6 had the largest growth in the 1980s and early 1990s, with a reversal occurring by 1998 resulting in more infill development for the areas inside Beltway 8 (Lang, 2002). While the population is increasing in suburban counties they lag far behind Harris County population totals.



Source: Hunter Real Estate Group, 2007

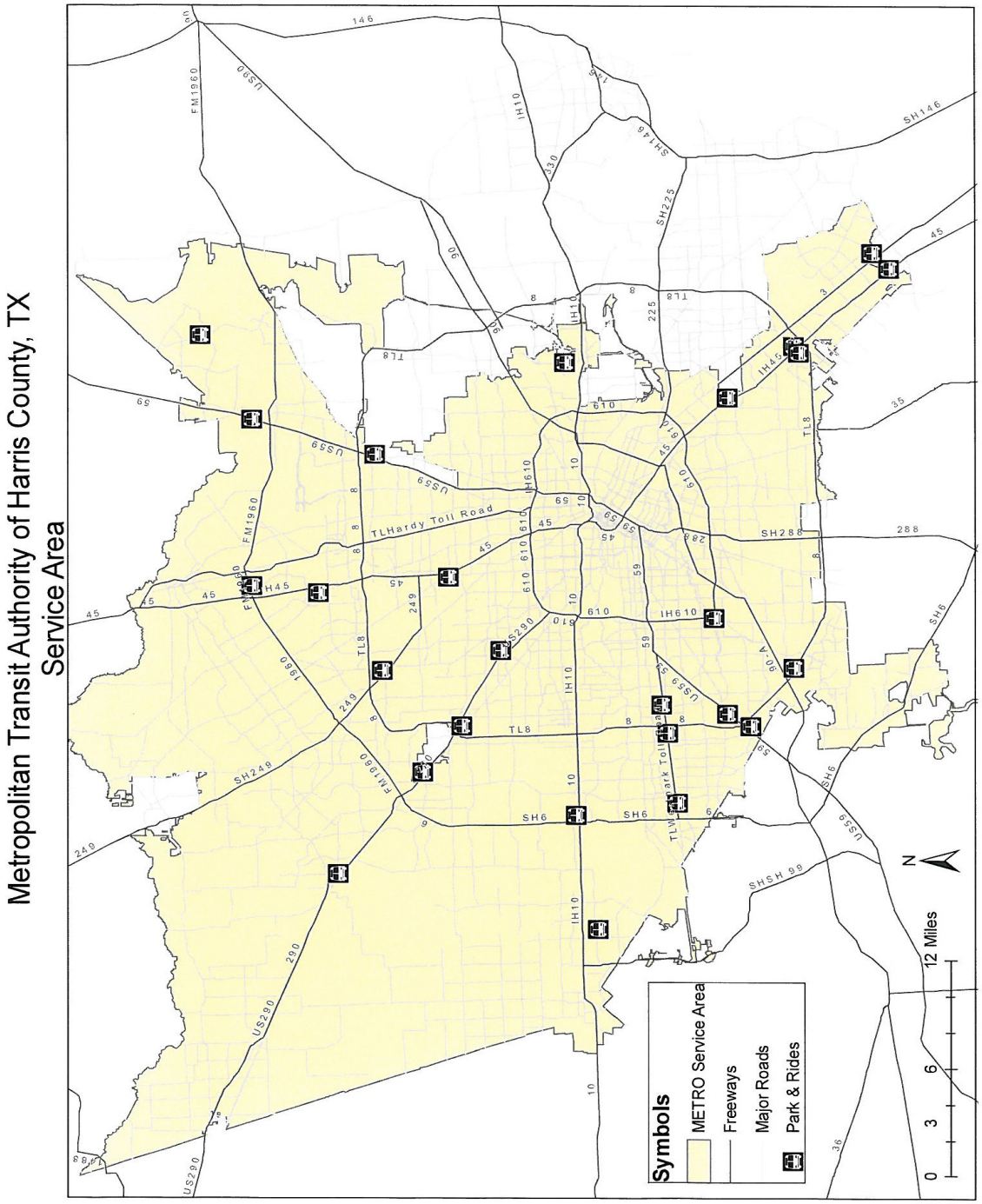
Figure 2. Houston Freeway System

The public sector entered the public transit arena beginning in the 1950s, when cities began to purchase transit companies from private businesses that had operated transit routes during the prior several decades. Houston, one of the fastest growing cities in the southwest United States was the last major city to convert its transit company from private to public control in 1975. In the early years, bus service was operated under the City of Houston. Three years later, in 1978, Harris County citizens voted to establish the Metropolitan Transit Authority of Harris County (METRO) with an independent one percent sales tax base, which commenced operation in January 1979. During this time period, Houston as many other cities in the nation were experiencing substantial residential growth in vacant land farthest from downtown. Simultaneously, employment in the urban core increased. In response METRO added numerous

crosstown routes and an extensive park and ride system. METRO also implemented a network of transit centers, designed to intercept passengers several miles from the urban core and facilitate travel to the multiple employment centers, which are miles from the central business district (METRO, 1992).

Today METRO is responsible for providing transit service to one of the largest spans of area within Texas. As the urbanized area expands into developing suburban counties the agency has responded by expanding its park and ride system to currently consist of 27 park and ride locations.[1] As shown in Figure 3, the current park and ride locations provide a connection from outlying suburban communities to four employment centers. METRO and these counties are working in conjunction to develop public transportation service into the areas, and suburban commuter service between these counties and the urban core.

[1] As of August 2007, METRO has 27 park & ride locations throughout the Houston metropolitan region.



Source: METRO, 2007

Figure 3. Metropolitan Transit Authority Service Area, 2007

Summary

Chapter 1 established why there is a need to conduct research on increasing mobility options in Sun Belt metropolitan regions between suburban counties and the urban core during peak hour travel periods. Urban sprawl was defined and determined as one of the reasons traffic congestion is increasing in Sun Belt metropolitan regions. The problem statement and topic were introduced, and described how this research will address the need for providing increased mobility options between the two areas. The goal and objectives were also introduced. The chapter concluded with an introduction to the Houston metropolitan region to include population levels throughout the past two decades, and current public transportation options offered throughout the region in particular to suburban commuters.

Chapter 2 discusses previous research that has been conducted on increasing transportation mobility options between suburban counties and the urban core. The literature review will focus on previous research that relates to the objectives introduced in Chapter 1. Population trends in Sun Belt metropolitan regions will be analyzed to determine if other regions are experiencing rapid growth in suburban counties while employment generators remain within the urban core. The benefits to increasing suburban to urban transportation mobility options will also be discussed. The literature review will conclude with presenting models that are used to evaluate traffic congestion on highways between suburban counties and the perspective urban core. Additionally models that are used to assess whether there is a need for public transit services will be discussed.

Chapter 3 presents the goal and objectives of this research. The methodology used to present the findings will also be described. This section will provide a rationale for the regions that will be analyzed. The procedures used to determine if there is a need for increased public transportation services in Houston suburban counties will be presented.

Chapter 4 discusses the results of this work. Preliminary analysis leading to this research discovered that in Atlanta transit travel times were competitive with automobile travel times. In the case of Houston, transit travel times were not competitive with automobile travel times. As a result, a higher number of commuters travel by

automobile in Houston. To add breadth to the preceding study, this research will use previous literature and methods described in Chapter 3 to assess whether there is a need to focus on increasing mobility options between Houston suburban counties and the urban core.

Finally, Chapter 5 provides a synthesis of the findings and provides recommendations for transit agencies to increase ridership between developing suburban counties and the urban core. Findings from this work and previous literature will determine if there is an increased need for public transportation options between suburban counties and the urban core. The findings from this research can be applied to other Sun Belt metropolitan regions experiencing urban sprawl with increased traffic congestion between the suburban county and the urban core.

CHAPTER 2

LITERATURE REVIEW

As Sun Belt metropolitan regions experience urban sprawl, transit agencies will need to provide enhanced transportation mobility options between suburban counties and the urban core. This literature review will present findings from previous research that suggests there is a need to increase commuter service between suburban counties and the urban core. Previous literature is presented from studies that suggest:

1. Population levels in Sun Belt metropolitan regions are increasing, and providing increased public transportation options will aide in the relief of traffic congestion.
2. Travel time indexes are good indicators to evaluate where traffic congestion is occurring during peak hour travel periods.
3. Transit need index models can use demographic data to predict the need for increased public transportation services in Sun Belt metropolitan regions.

Sun Belt Metropolitan Region Population Growth

According to Pollard (2002), the latest Census stated that the average American spent 27.7 minutes commuting to work in 2000 as compared to 22.0 minutes in 1990; this is an increase of 5.7 minutes or 26 percent. Pollard goes on to discuss that while the average commute travel times to work have increased, less than five percent of Americans commute to work via public transportation. This is down from more than five percent from the 1990 Census. Increased commute travel times have been a result of rapid growth in Sun Belt metropolitan regions in the South and West during the past two decades. According to the report Metro America in the New Century: Metropolitan and Central City Demographic Shifts Since 2000 (Frey, 2005) between 1960 and 2004:

- 34 U.S. metropolitan regions population doubled, and
- 17 U.S. metropolitan regions population tripled.

Frey goes on to state that the growth in these regions have been driven by “low cost / high development” occurring in the suburban counties where there is mass areas of land to develop for lower cost as opposed to older Northeastern cities which are land constrained. As shown in Table 1, the 15 fastest growing metropolitan regions between

1960 and 2004 are located in southern and western regions. While Las Vegas leads with the highest percent change, the three largest cities in Texas: Austin, Dallas, and Houston are all among the top fastest growing cities in the U.S. The Houston metropolitan region, the focal point of this research, population increased from 1,601 million to 5,180 million; this is a 224 percent growth over the 44-year period.

Table 1. Fastest Growing Large Metropolitan Regions: 1960 - 2004

RANK	METROPOLITAN REGION	POPULATION CHANGE (%)	POPULATION SIZE (000s)	
			2004	1960
1	Las Vegas-Paradise, NV	1,200	1,651	127
2	Phoenix-Mesa-Scottsdale, AZ	412	3,715	726
3	Orlando, FL	371	1,862	395
4	Austin-Round Rock, TX	369	1,412	301
5	Riverside-San Bernardino-Ontario, CA	368	3,793	810
6	Sarasota-Bradenton-Venice, FL	346	652	146
7	Oxnard-Thousand Oaks-Ventura, CA	301	798	199
8	Colorado Springs, CO	294	576	146
9	McAllen-Edinburg-Pharr, TX	264	658	181
10	Miami-Ft. Lauderdale-Miami Beach, FL	258	5,362	1,497
11	Raleigh-Cary, NC	251	915	261
12	Tuscon, AZ	241	907	266
13	Atlanta-Sandy Springs-Marietta, GA	239	4,708	1,388
14	Houston-Baytown-Sugar Land, TX	224	5,180	1,601
15	Dallas-Ft. Worth-Arlington, TX	221	5,700	1,778

Source: Brookings Institute, 2005

As Sun Belt metropolitan regions expand further outward, transportation professionals attempt to determine strategies that will not only attract suburban commuters, but will provide benefits to providing increased public transportation services. Chen, Higgins, Lewis, et al. (2006) conducted research on regional public transportation solutions for intercity commute options. The study discussed that constant growth in rural areas and extensive suburban development have contributed to increasing numbers of people needing adequate public transportation to and from nearby cities. These enhanced transit services require coordination between the transit agency and local citizens to yield the greatest return. The study found that public

transportation has the following four major benefits: 1) Benefits to Public Transit Passengers, 2) Benefits to Transit Agencies, 3) Benefits to Metropolitan Areas, and 4) Benefits to Employers.

Benefits to Public Transit Passengers

Increased public transportation options provide the greatest benefit to users of the system. If suburban commuters are provided with multiple transportation choices, transit agencies have the potential to attract these riders out of their private automobiles to utilize public transportation. Transportation professionals should focus their innovative strategies on this customer base when planning enhanced transportation mobility options in suburban communities. This group of people has access to several travel modes that include carpool and vanpool. Transportation professionals should also recognize an increased number of low-income, blue collar commuters are relocating to suburban communities. This group of commuters has less access to private automobiles, and may be forced to rely on limited public transportation choices from the suburban communities (Sugure, 2000).

The greatest impact for suburban commuters who utilize public transportation is the cost savings. In a recent study on transportation cost analysis (Litman, 2002), transit passengers in automobile dependent communities, and a household with two employed adults generally own two automobiles. The annual cost associated with owning two automobiles is approximately $10,000 per year. The report goes on to describe that in suburban communities where public transit is readily accessible, suburban commuters have the potential to save approximately $5,000 per year. As gasoline prices continue to increase, the cost savings of utilizing public transportation increases.

Benefits to Transit Agencies

The main goal for transit agencies when implementing transit service in suburban communities is to increase ridership. Transit agencies that plan properly and work in conjunction with the suburban community will be able to develop a clear understanding of their customer base and demand. Agencies will understand which types of service

suburban commuters in their area will benefit from the most, and can effectively expand their service area more appropriately to meet the growing demands of potential customers. This can lead to credibility of the agency within the community and people may rely on the system more, resulting in increased utilization of the system.

Examples of successful planning are found in Sun Belt metropolitan regions such as Dallas and Denver. The Dallas Area Rapid Transit (DART) focused on planning with the community when expanding the system into suburban communities. In a study on Sun Belt cities looking to light rail to connect the dots (Kay, 2000) DART focused on intensive planning with suburban communities when planning new lines. Light rail lines that connected suburban communities with the urban core experienced increased ridership, and as a result DART has future plans to expand the system. DART has been so successful with light rail transit attracting new passengers in suburban communities that the agency is planning to expand the system to the airport and into developing suburban cities such as Carrollton, and Rowlett. The expansion will allow for a connection between Dallas suburban communities, the airport, and downtown. According to an article in the Dallas Business Journal (Allen 2006), a $700 million grant funded by the Federal Transit Administration will assist in the expansion of 21 miles of light rail lines by 2013 into Dallas suburban counties experiencing population growth. The plan calls for two additional lines “Orange Line” linking the airport with downtown, and the “Green Line” expanding into suburban cities north of the urban core.

As in the case of Dallas, the Denver Regional Transit (RTD) experienced increased transit use between suburban counties and the urban core after the implementation of light rail transit. According to Miller (2006), nearly 50 percent of LRT riders previously used private automobiles, and nearly 60 percent of the riders on the Southwest light rail extension line are new public transit riders. RTD’s story is unique in the sense that the agency was not aggressive in luring suburban commuters to the system when it opened in the 1990s. Miller goes on to state that the first line exceeded ridership projections by 18 percent within the first year, and the number was constrained because the agency did not provide enough parking spaces at stations. The demand for additional modes of transportation between Denver suburban counties and the urban core were so enormous that parking spaces were filled up by 7:30 a.m. This required

RTD to increase the parking capacity, and initiate a plan to build additional light rail stations.

Based on RTD's success with light rail in suburban communities, the agency has planned the T-Rex expansion project into suburban communities west, northwest, and east of Denver. The five-year project will consist of 19 additional miles of LRT into these communities (RTD, 2007). Not only will the lines connect suburban communities with downtown Denver, but the line will provide service to the University of Denver, the University of Colorado Hospital, Cherry Creek Shopping Center, and the Denver Zoo.

Benefits To Metropolitan Area

If metropolitan regions around the nation provide adequate public transportation options, an increased number of suburban commuters may shift their travel modes, having several impacts on the local area. As discussed in Chapter 1, increased public transportation options have the potential to relieve traffic congestion in heavily traveled corridors. According to the American Public Transit Association (2006), enhanced public transportation options for suburban commuters has the potential to reduce road congestion, reduce travel time, and connect and extend transportation networks throughout the region.

According to the 2005 Texas Transportation Institute (TTI) Annual Urban Mobility Report, enhanced transportation mobility options from suburban communities has been successful in reducing road congestion and costs in America's 85 largest urban areas. The report describes the role of public transportation in reducing roadway congestion during peak periods. Increased peak hour public transportation services have the potential to improve transportation capacity by providing several travel mode options. According to Schrank (2005), public transportation lines that do not intersect roads can be particularly reliable as they are not affected by the collisions and vehicle breakdowns that plague the roadway systems. In addition, most rail systems can operate during inclement weather, and are not impacted by roadway congestion.

Reduced Roadway Congestion has the greatest impact on enhanced transportation mobility options during peak hour travel periods. According to Anthony Downs (2004) freeway traffic congestion will never be eliminated, however, creative

mechanisms can reduce traffic during heavily traveled hours. Downs goes to state, "if travel time (including getting to the station, waiting, and getting from the station at the other end to the final destination) is less prolonged on transit than on roads, people will move from roads onto the transit system" (Downs, 22). When and if these commuters shift to fixed-route public transit systems the system will become overcrowded with passengers. This creates another issue with overcrowding of transit vehicles during peak periods.

Travel Time Reduction also has the potential to attract suburban commuters out of their private automobiles and onto public transportation. According to BWC Network News (2006), the Mayor of Houston initiated a flexible workplace campaign, Flex in the City, to reduce weekday travel times on Houston's already overcrowded freeways. Flex in the City encourages major corporations in employment centers to provide employees with the option to work alternate hours one week, in exchange for a previously arranged day off the following work week. A two week travel time analysis on two of Houston's freeways – I-45 North Freeway and US 59 Southwest Freeway concluded that there was a 1.7 minute travel time savings for commuters. According to a press release by the Mayor of Houston (White, 2006), the average travel time during the week before the Flex in the City program started was 29.7 minutes as compared to 28 minutes during the Flex in the City program. This equates to 906 hours less a day of commuters on the two freeways. White described that of the 1,434 employee commuter participants surveyed:

- 860 or (68 percent) of the respondents said "Commute travel times were faster than before the Flex in the City program was implemented."
- 832 or (58 percent) of the respondents said "Stress levels during commuting were lower than week before the Flex in the City program was implemented."
- 1,377 or (96 percent) of the respondents said "Their productivity levels at work were the same or higher than the week before the Flex in the City program was implemented."
- 717 or (50 percent) of the respondents said "They plan to continue working in a flexible work schedule (if employer permits) as a result of participating in the Flex in the City Program."

Data from the Flex in the City program are continuously collected on the freeways, and a report will be presented after a year's worth of data is available.[2]

Connecting and Extending Transportation Networks with more than one mode of transportation also has the potential to attract suburban commuters. Transit agencies throughout the nation participate in programs or work in conjunction with additional transit agencies in their perspective region to connect existing systems. The New Jersey Transit has created a station that connects the largest number of suburban rail lines in America. As a joint effort through public and private partnership, the Secaucus Transfer station was developed in Newark, New Jersey connecting 11 of the 12 lines in northern New Jersey. The Secaucus Transfer Station will allow riders commuting from New Jersey suburban communities increased public transportation options by descending on the station, and providing a connection to Midtown Manhattan with a travel time reduction of approximately 15 minutes (Ritter, 2002).

Benefits To Employers

According to the American Public Transit Administration (2007), there are tax savings available for employers who pay for employees transit cost. Most transit agencies allow employers within the service area to buy transit passes for distribution to employees at no charge. Employers who participate in these programs are able to deduct the cost a business expense. This transit commuter benefit also provides an attractive alternative to expensive parking in downtown. While many companies have offered parking benefits for years, employers are beginning to recognize tax-free transit commuter benefits as an environmentally responsible way to help their employees, while reducing congestion and cutting pollution in the community. As an added benefit, employees arrive at work relaxed because they have avoided congested peak period drives.

Companies located in proximity of transit lines are starting to recognize the benefit of locating near transit centers. In Atlanta, Bell South consolidated its offices around three of MARTA's rail stations. The most notable station is the Lindbergh Station, where in a joint development with Bell South office space, retail, hotels, condos,

[2] At the time this report was prepared the final report was not available.

and apartments are located around the station (Vespermann, 2001). The revenue generated from the lease agreement contributes to MARTA's operating budget. MARTA, BellSouth and Carter and Burgess are members of the Buckhead Area Transportation Management Association (BATMA) and developed a transportation management plan that encourages the use of transit by employees, residents and visitors traveling to and from Lindbergh City Center.

Travel Time Studies

There have been numerous studies on estimating travel time values during different travel conditions. In a study on how the demand for travel is derived (Mokharian, 2001), the average commuter commits 60 – 90 minutes to travel. Research found that the value of time is most important to commuters. Many Americans live and work in a fast pace environment. A report by the Victoria Transport Policy Institute (2002) discusses models that evaluate travel time cost, which is a major aspect of the planning process. There are two values that are used to determine how commuters value travel time. The first value of travel time (VTT) refers to the cost of time spent in transport, including the waiting time. The second values of travel time savings (VTTS) refers to the benefits commuters receive from reduced travel time. The report summarizes the following:

- A survey of U.K. rail passengers found that many use their time for productive activities such as working (30% some of the time and 13% most of the time), reading (54% some of the time and 34% most of the time), resting (16% some of the time and 4% most of the time), and talking to other passengers (15% some of the time and 5% most of the time) (6).
- Highway construction traffic delays can impose significant travel time costs and spillover effects on other roadways. For some projects, such delays can offset significant portion of projected travel time savings (6).
- Pratt estimates that ridesharing (car and vanpooling) typically adds 10 – 12 minutes per trip compared with drive alone (6).
- Travel time costs tend to be significantly higher under congested and unpredictable travel conditions. Researchers suggest that travel time costs

under congested conditions be calculated at 2.5 times that of overall travel time savings (7).

A study conducted by the U.S. Federal Highway Administration (FHWA, 2006) identifies four travel reliability indicators:

- **95th percentile travel times.** Reflects the longest travel time during a ten or twenty day period. The travel time is reported in minutes or seconds (24).
- **Buffer Index.** Reflects the extra travel time commuters should add to the average trip time to ensure an on-time arrival at their destination. The buffer index is computed as the difference between the 95th percentile and average travel times, divided by the average travel time. The index is reported as a percentage. For example, a 40% buffer index means that for a trip that averages 20 minutes, commuters should plan for an additional 8 minutes to reach their destination (20 minutes * 40% = 8 minutes). The extra 8 minutes to reach the destination are considered buffer time (24).
- **Planning Time Index.** Reflects the total travel time required to provide an adequate buffer time, including both typical and unexpected delay. The planning time index compares near-worst cast travel time to a travel time in free-flow traffic. For example, a planning time index of 1.60 means that a 20-minute trip in free-flow traffic requires 32 minutes of total time planned (20 minutes * 1.60 = 32 minutes) (25).
- **Frequency that congestion exceeds some thresholds.** Reflects the degree which congestion exceeds a performance standard. The frequency is expressed as the percent of days or time that travel times exceed X minutes or travel speeds fall below Y mph. This is relatively easy to compute if continuous traffic data is available, and reported for weekdays during peak hour travel periods (25).

Transit Need Index

Previous research has been calculated on predicting the need for transit services in particular areas. Most public transportation agencies have focused their planning efforts within the urbanized area were transit services can most effectively serve

customers. During the past decade agencies in Sun Belt metropolitan regions have begun to focus their efforts on developing models to predict the need for transit in suburban counties. Research found that most transportation professionals use the travel demand forecasting for regional transportation planning. The model is a four step process that uses the following:

1. Trip Generation: The number of trips that will be made
2. Trip Distribution: The destination of the trips
3. Mode Choice: How the trips will be divided among the available modes of travel
4. Trip Assignment: Predict the route trips will make.

Planners for the Metropolitan Transit Authority used this modeling process for METRO Solutions 2025 Plan.[3] According to a report conducted by HDR / S.R. Beard & Associates, the travel demand process was used to develop the US 90A Commuter Rail that will connect the Texas Medical Center (second largest employment center) and Fort Bend County (HDR, 2005). The long range travel demand model was used to generate future year ridership forecasts. As a result of the travel demand process five scenarios were developed for the proposed commuter rail service. The scenarios vary according to the level of land development assumed to occur near the proposed commuter rail stations by the forecasted year. Since quantifying the relationship between a new transportation investment and the resulting land use has always been a major challenge in ridership modeling, it is not a good practice to use overly optimistic land use assumptions in travel demand modeling.

S.R. Beard & Associates also used a transit need index for the planning process of METRO's proposed five LRT lines. Variables that influence the need for transit services such as population density, income, auto ownership, and poverty were analyzed to determine if there is an actual need the LRT lines in the proposed corridors. Figure 4 shows the transit need index results for the proposed University Line. The transit needs index reflects a combination of population density, households with zero automobiles, income distribution, and poverty levels showing that there is a low, medium, high, and very high need for LRT service for some portions west of the current

[3] METRO Solutions 2025 is the Authority's plan to expand transit services in the Houston metropolitan region.

Main Street Line and high east of the Main Street Line. The medium need sections of the line are mostly residential in which the majority of the people would originate their trip. As the proposed line reaches the end of the route, the need for transit becomes higher. The model used for the research is one of the models designed to determine where there is a need to increase public transportations within the Houston metropolitan region. Although the model is not 100% exact, it gives planners an idea where public transportation services are most practical.

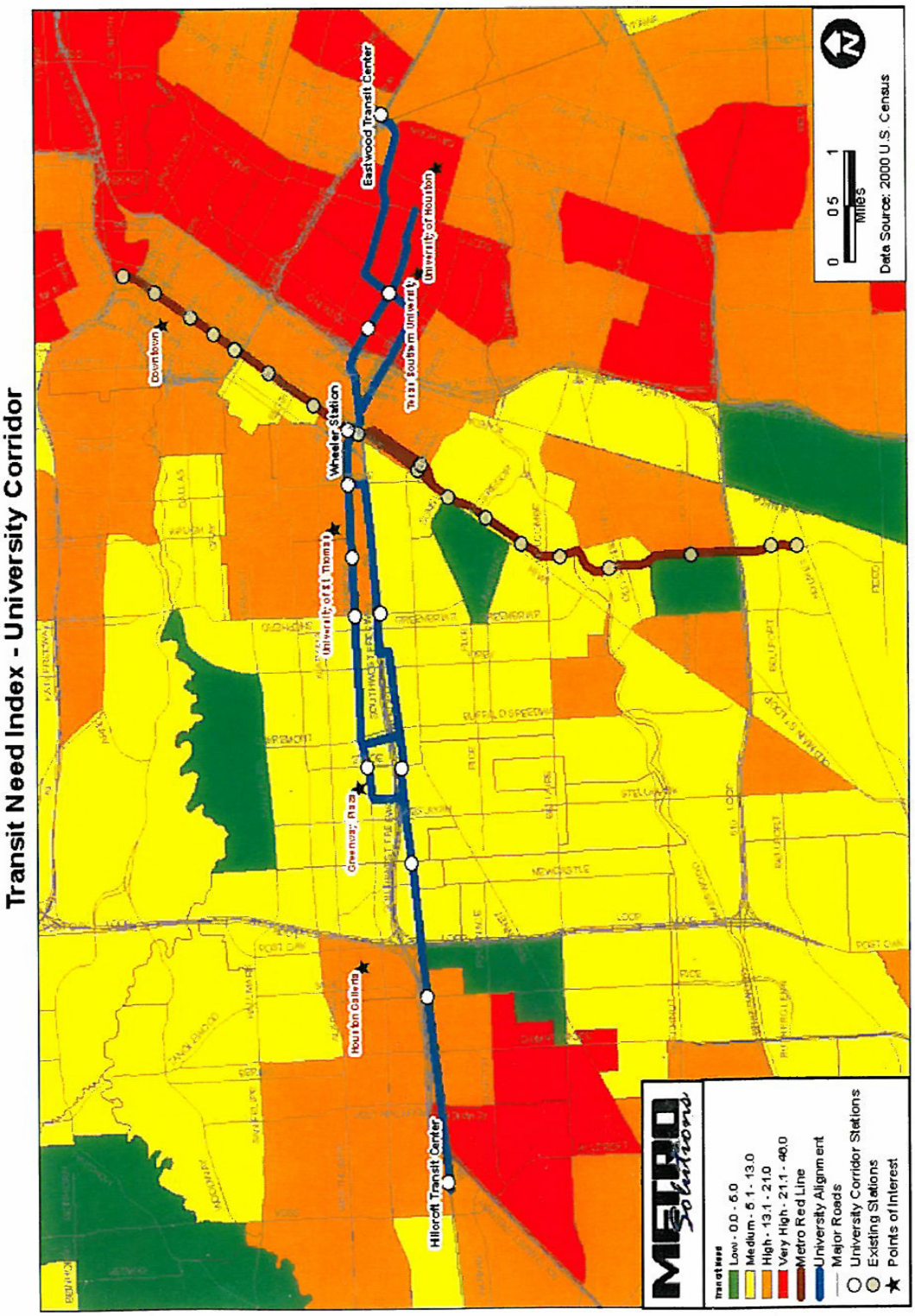


Figure 4. University Corridor Plan, 2006

CHAPTER 3

DESIGN OF STUDY

This chapter discusses how this research examined if there is a need for increased commuter services between select Houston suburban counties and the urban core. The goal and objectives of the work are also described. The chapter concludes with the methodology used to assess the objectives of the research, and the procedures used throughout this work.

Goal and Objectives

The goal of this work was to enhance the knowledge base for transportation professionals' decision-making process when determining new markets to provide public transportation services. An analysis of quantitative data assessed whether there is a need for increased public transportation options between maturing Houston suburban counties and the urban core. The three objectives for this research were as follows:

1. Quantify the level of population growth occurring in Houston suburban counties.
2. Apply the Travel Time Index formula for Houston suburban counties to the urban core.
3. Ascertain whether a public transportation need exists from Houston suburban counties to the urban core using the Transit Need Index.

Methodology

The methodology used in the research assessed whether there was a need for increased public transportation options in Houston suburban counties. First, population levels throughout the region were analyzed. Then the travel time index and commuter need index were applied to the region's three fastest growing suburban counties. The travel time index determined the percentage of extra travel time spent traveling between the counties and the urban core during peak hour travel periods. The commuter need

index provided quantitative data to suggest suburban commuters may perhaps utilize public transportation to the urban core if the services were offered.

Population Growth

As described in Chapter 2, rapid population growth is occurring in Sun Belt metropolitan regions. For the purpose of this research, population growth in Houston suburban counties were examined. The Houston metropolitan region consists of eight counties, in which Harris County is the largest county where the city of Houston is located. The remaining seven suburban counties are located outside the city of Houston, making up the remainder of the region. Quantitative data collected from the Census Bureau and the Houston – Galveston Area Council (H-GAC) determined which suburban counties are experiencing the greatest population growth. Census Bureau data from 1990 and 2000 determined the population percent change in the suburban counties during the ten year period. Population forecast data collected from H-GAC determined which suburban counties are forecasted to increase throughout the next 30 years. The population data collected from the suburban counties were analyzed and the three counties that displayed the highest population growth between 1990 and 2000, and are forecasted to remain as the three largest counties were assessed.

Travel Time Index

After the three suburban counties were determined the travel time index was applied to the counties. The travel time index was derived from the 2003 Annual Report of Freeway Mobility and Reliability (Texas Transportation Institute, 2004). The index measured traffic congestion intensity during three time periods:

1. Morning Peak Period (6 a.m. – 9 a.m.)
2. Midday Period (9 a.m. – 4 p.m.)
3. Evening Peak Period (4 p.m. – 7 p.m.)

To determine the travel time index, congestion intensity was measured on freeway segments between major intersections from the suburban county to the urban core. The travel index determines the percentage of extra travel time spent during a peak period trip as compared to non-peak period trip. As shown below, the travel time

index is the ratio of average peak period travel time to a free-flow travel time. Free-flow travel times were considered to be speeds at 60 mph on the freeways. For instance, a value of 1.30 means peak period travel times are 30 percent longer than during non-peak period travel times.

$$\text{Travel Time Index} = \frac{\text{Average Travel Time (Minutes)}}{\text{Free - Flow Travel Time (Minutes)}}$$

Commuter Need Index

After determining where the travel times are highest between the suburban county and urban core, the commuter need index was applied to the counties. The commuter need index was developed by Linda Cherrington[4] as a tool to estimate public transit demand as a function of demographics. S.R. Beard / HRD Consultants at METRO implemented the index into the planning process for proposed transit services in Houston. The index provides consultants with demographic data suggesting ideal locations for transit services such as Light Rail Transit (LRT), Bus Rapid Transit (BRT), and Commuter Rail Transit (CRT) throughout the region. This thesis will attempt to apply the transit need index to Houston suburban counties, to determine if there is a need for commuter services between the suburban county and urban core. In order to accurately apply the commuter need index to a suburban market, the index was modified from the original settings. Due to the homogeneity of the results from formulating the index as METRO consultants applied the index, variables that are related to influencing the need for suburban public transportation were included in the results of this thesis. The variables used in thesis were determined by assessing Houston suburban county demographics and selecting variables that would most likely assess the need for commuter services.

The first step of the commuter need index is to select the study area. For this thesis the study areas were the communities within the three suburban counties identified as anticipating population growth. The commuter need index requires that the study area is compared to a reference area to determine if there was a transit need for

[4] Texas Transportation Institute, 2002

the study area as a whole county. For this thesis the reference area is the perspective suburban county. After the study area and reference area were determined, factors that influence the need for suburban public transit services were selected. The index suggests that selecting the five factors that influence the need for public transit services are chosen for analysis. Based on the recommendation of the consultants, the following factors were selected and analyzed in this thesis:

- Population,
- Population Density,
- Mean Travel Time to Work,
- Number of people who commute to work.

Census data were then collected on these variables to determine the index for each community within the county. The index of each community was determined by the following formula:

$$\text{Index} = \frac{\text{Community (Variable)}}{\text{Total County (Variable)}}$$

After the indexes were determined for each variable within the community, a weight from one (low) to five (high) were applied to each variable based on how the variable influences if there is a need for public transportation from the suburban county to the urban core. A weight of five was applied to the population density index, while the mean travel time to work index and number of people who commute to work index were weighed a one. This was repeated for the additional two indexes. Collectively the three indexes equal a combined weight of seven.

Finally, the commuter need index for each community was calculated as the sum of all of the indexes, and multiplied by the weight. For instance, to determine the commuter need index for a locale the population density index is multiplied by the weight of the index. This is calculated for each index, and sum of all the indexes determine the commuter need index. As shown in Table 2, the standard deviation formula was then applied to each community's transit need index. This determined the transit need for each community ranging from very low to very high. For the purpose of

this thesis, communities with a transit need of very high are discussed in the findings section.

Table 2. Commuter Need Index Formula

TRANSIT NEED	FORMULA
Very Low	Weight – 1.5 * STDEV (Transit Need Index)
Low	Weight – 0.5 * STDEV (Transit Need Index)
Medium	Weight + 0.5 * STDEV (Transit Need Index)
High	Weight + 1.5 * STDEV (Transit Need Index)
Very High	> High Transit Need Index

Procedures

The analysis conducted in this research provided quantitative data to support whether agencies providing public transportation services within the Houston metropolitan region should focus on increasing service from suburban counties to the urban core. The procedures conducted were as follows:

Task 1: Reviewed previous literature on increasing public transportation ridership from suburban counties to the urban core.

Task 2: Described population trends in the Houston metropolitan region.

Task 3: Identified the three Houston suburban counties that are forecasted to increase the most in population.

Task 4: Conducted travel time index study between the three suburban counties and urban core.

Task 5: Conducted transit need index study on three suburban counties.

Task 6: Analyzed and compared data for three suburban counties.

Task 7: Discussed the results from the analysis.

Task 8 : Prepared the final report.

CHAPTER 4

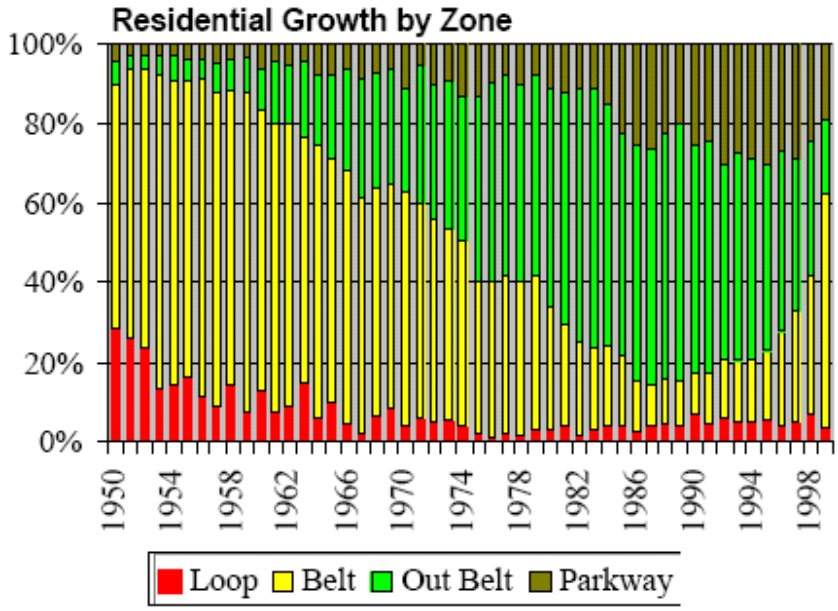
RESULTS AND DISCUSSION

This chapter discusses the results for increased public transportation options between Houston suburban counties and the urban core. Based on the goal and objectives described in Chapter 3, this chapter assesses whether there is a need for increased public transportation services from three suburban counties to the urban core. Population levels were analyzed within the metropolitan region to determine which counties are experiencing growth, and are forecasted to continue growing throughout the next thirty years. The travel time index and commuter need index were then applied to the counties. The results of the analyses are discussed in this chapter.

Houston Metropolitan Regional Growth

According to the 2035 Regional Growth Forecast (H-GAC, 2005) the Houston eight-county metropolitan region population is forecasted to increase throughout the next 30 years. As in the case of other Sun Belt metropolitan regions, a considerable number of people are expected to establish themselves in one of the seven suburban counties. Currently the urban public transportation system does not provide service to the counties, therefore commuters travel to the urban core via one of the freeways. As described in Chapter 1, Houston's three distinctive freeway rings encircle the region – 1) IH 610 approximately six miles from downtown, 2) Sam Houston Tollway / Beltway 8 approximately ten miles from downtown, and 3) FM1960 / Highway 6 approximately fifteen miles from downtown. The freeway sections within Beltway 8 are near or have reached maximum capacity during peak hour travel periods, and there is little-to-no capacity for the thousands of people expected to migrate to the region. As these freeways reach capacity, transportation professionals will be required to develop innovative strategies that will entice people from their private automobiles with increased public transportation options along with competitive travel times. As shown in Figure 5, from the middle of the century to the late 1970s the population was growing fastest between IH 610 and Beltway 8 and declined during the 1980s. While the population was declining within Beltway 8 during the 1980s, the population was

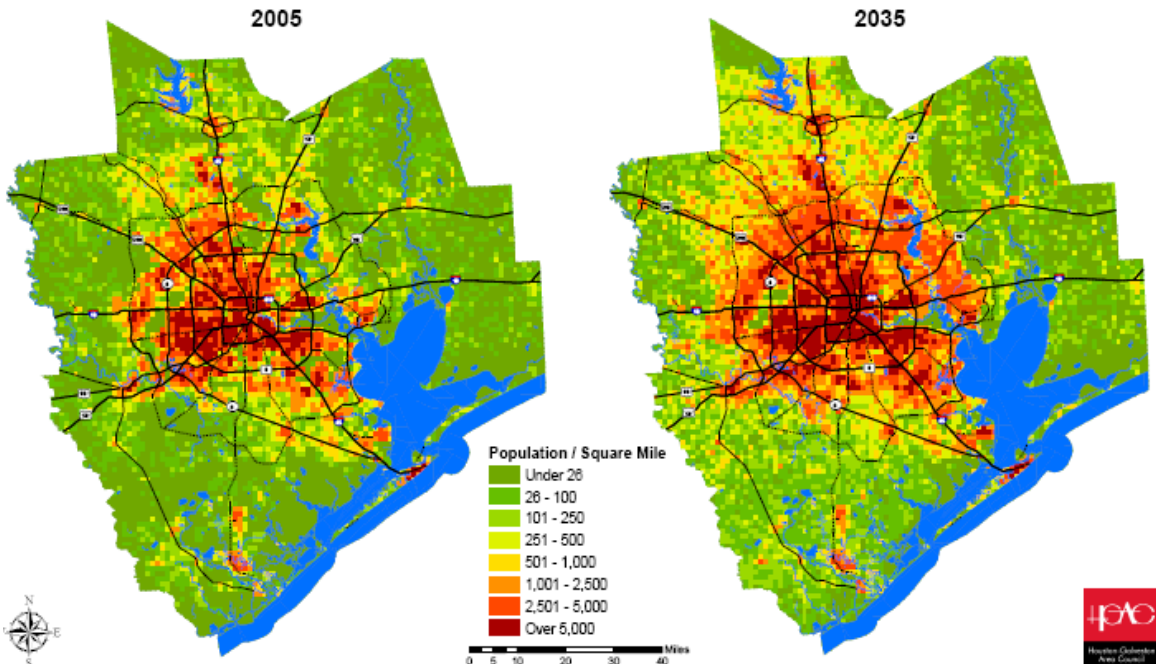
increasing between Beltway 8 and Highway 6 as the region's population settled further away from the urban core. By the late 1990s the population started to increase inside Beltway 8 again, while the population also continues to increase beyond Beltway 8.



Source: Blueprint Houston, 2005

Figure 5. Residential Population Growth by Zone in the Houston Metropolitan Region

Regional population forecasts for the next thirty years suggest the Houston metropolitan region's population will continue to increase. In addition to the population increasing between IH 610 and Beltway 8, a number of suburban areas beyond Beltway 8 are forecasted to have over 5,000 persons per square mile by 2035 (Census Bureau, 2000). As shown in Figure 6, by 2035 an increased number of people are forecasted in outlying suburban counties south and southwest of Houston. An increased number of people are also forecasted to locate in suburban communities north of Houston along Highway 6. This predicts a percentage of the population is expected to grow away from the urban core and into suburban counties.



Source: Houston – Galveston Area Council, 2005

Figure 6. Houston Metropolitan Regional Population Density

The population is forecasted to increase in the eight counties surrounding Houston. For the purpose of this thesis, population growth was assessed in the three largest suburban counties. According to population forecasts the three largest populated suburban counties will remain as the largest in 2035 (H-GAC, 2005). As shown in Table 3, Fort Bend County is currently the largest populated suburban county within the region, and is expected to remain the largest. In 2005 the population of Fort Bend County was 446,000, and according to the 2035 population forecasts the county will remain the largest with approximately 958,000 residents. Montgomery County is currently the second largest populated suburban county, and is expected to retain this rank. In 2005 the population of Montgomery County was 374,000, and according to the 2035 population forecasts the county will have approximately 865,000 residents. Currently, Brazoria and Galveston counties have comparable populations. According to population forecasts Brazoria County will surpass the population of Galveston County

by 84,000 residents in 2035 (H-GAC, 2005). Therefore, Brazoria County is forecasted as the third largest suburban county within the region.

Table 3. Houston Metropolitan Regional Population Growth by County

COUNTY	YEAR 2005	YEAR 2015	YEAR 2025	YEAR 2035
Brazoria County	279,000	348,000	421,000	496,000
Chambers County	31,000	38,000	46,000	53,000
Fort Bend County	446,000	597,000	775,000	958,000
Galveston County	277,000	322,000	374,000	412,000
Harris County	3,774,000	4,394,000	5,075,000	5,840,000
Liberty County	80,000	96,000	113,000	131,000
Montgomery County	374,000	515,000	680,000	865,000
Waller County	39,000	51,000	64,000	80,000
TOTAL	**5,300,000**	**6,361,000**	**7,548,000**	**8,388,600**
Harris County Total	3,774,000	4,394,000	5,075,000	5,840,000
Suburban County Total	1,526,000	1,967,000	2,473,000	2,548,600

Source: HGAC, 2005

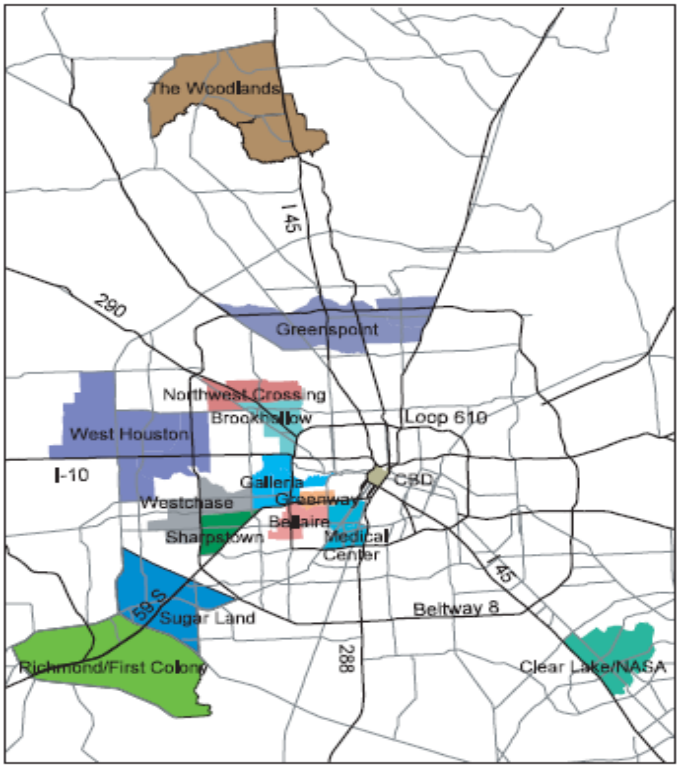
As the population increases in the suburban counties, Harris County will remain the largest populated county within the region. Fort Bend, Montgomery and Brazoria County's are expected to grow faster than Harris County in terms of percentages. However, Harris County will gain twice as many people than all the suburban counties combined. In 2005 there were over three million residents living in Harris County and by 2035 and estimated five million residents will live in Harris County. The combined population of the seven counties is forecasted to be only 2.5 million people. While an increased number of people will be moving inside Beltway 8, a higher percentage of people will locate outside Beltway 8 in suburban counties.

As the population increases in suburban counties outside Beltway 8, the majority of the employment centers will remain inside Beltway 8. There are eight employment centers located throughout the Houston metropolitan region. As shown in Table 4, in 2000 there were 680,000 employees combined working in the eight employment centers, and a total 875,000 employees are expected to work in the employment centers by 2025 (H-GAC, 2005). As the number of employees increase in all the employment centers, the highest employment concentration will remain within two employment centers, 1) Downtown, and 2) Texas Medical Center. Currently, the

Downtown employment center is the largest employment center, and by 2025 will have an estimated 179,000 employees working in the downtown employment center. The Texas Medical Center is the second highest employment center, and there are a forecasted 149,000 employees expected to be working in the area by 2025.

Table 4. 2005 – 2025 Houston Metropolitan Region Employment Centers

EMPLOYMENT CENTER	2000		2025	
	EMP	% OF EMP	EMP	% OF EMP
CBD	154	7.1%	179	5.2%
Uptown / Galleria	116	5.3%	141	4.1%
Medical Center	88	4.0%	108	3.1%
West Houston	80	3.7%	127	3.7%
Greenspoint	67	3.1%	107	3.1%
Greenway	65	3.9%	80	2.3%
Westchase	57	2.6%	75	2.2%
Sugar Land	48	2.2%	70	2.0%
Clear Lake	42	1.9%	63	1.8%
Northwest Crossing	40	1.8%	55	1.6%
Brookhollow	40	1.9%	56	1.6%
Sharpstown	35	1.6%	48	1.4%
The Woodlands	32	1.4%	61	1.8%
Bellaire	18	8.0%	26	0.7%
Richmond	10	5.0%	29	0.8%
TOTAL	**892**	**41.0%**	**1,225**	**35.3%**
Total (Inside Beltway)	680	39.3%	875	25.3%



Source: HGAC, 2007

Figure 7. Houston Employment Centers

Houston Metropolitan Region Traffic

The Houston metropolitan region has two peak periods, 1) morning peak period: 6 a.m. – 9 a.m., and 2) evening peak period: 4 p.m. – 7 p.m. As shown in Figure 8, during an average weekday 73 percent of the congestion occurs during the two peak periods. During the evening peak period, 46 percent of the congestion occurs as compared to 27 percent during the morning peak period. Hence, traffic delays are 19 percent higher during the evening peak period than the morning peak period (Texas Transportation Institute, 2004). The remaining hours of congestion are spread across the non-peak periods. During the midday (9 a.m. – 4 p.m.), 23 percent of the traffic congestion occurs. This is almost as great as during the morning peak periods. For instance, if 200,000 vehicles travel the freeways during the 12-hour time period; 18,000 will travel during the morning peak period; 7,667 will travel during the midday hours; and 30,667 will travel during evening peak period.

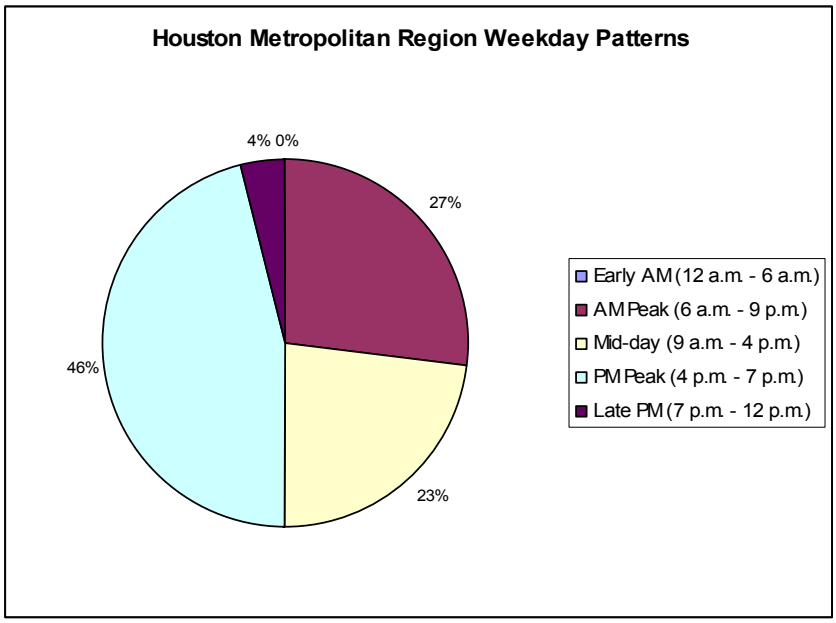


Figure 8. Houston Metropolitan Region Weekday Traffic Patterns

Traffic congestion is also prevalent in other large metropolitan regions. During an average weekday, 67 percent of the weekday traffic congestion occurs during the two peak periods in the top ten congested metropolitan regions (Texas Transportation Institute, 2004). Table 5 shows that 26 percent and 42 percent of the traffic congestion occurs during the morning and evening peak periods respectively. While Los Angeles ranks number one has the most congested metropolitan region, weekday traffic congestion during the peak periods are higher in San Diego. On an average weekday, 77 percent of the traffic congestion occurs during the two peak periods in San Diego. While the Atlanta metropolitan region ranks number two as the most congested region, weekday traffic congestion during the peak periods are the shortest of the top ten most congested regions.

Houston, the fourth largest U.S. city ranks seventh as the most congested metropolitan region. During both the morning and evening peak period, traffic congestion ranks third among the most congested regions. Traffic congestion during the morning peak period is comparable to congestion in San Diego. Both regions experience 27 percent of the traffic congestion during the morning peak period.

Table 5. Top 10 Most Congested Cities Weekday Traffic Congestion

RANK	METROPLOITAN REGION	MORNING PEAK	EVENING PEAK	TOTAL
1	Los Angeles	25%	38%	63%
2	Atlanta, Ga.	18%	37%	55%
3	San Francisco	40%	34%	74%
4	Washington, D.C.	24%	33%	57%
5	Dallas-Fort Worth	15%	53%	68%
6	San Diego	27%	50%	77%
7	Houston	27%	46%	73%
8	Detroit	28%	44%	72%
9	Orlando, Fla.	NA	NA	NA
10	San Jose, Calif.	NA	NA	NA
Average		26%	42%	67%

Source: Texas Transportation Institute, 2005

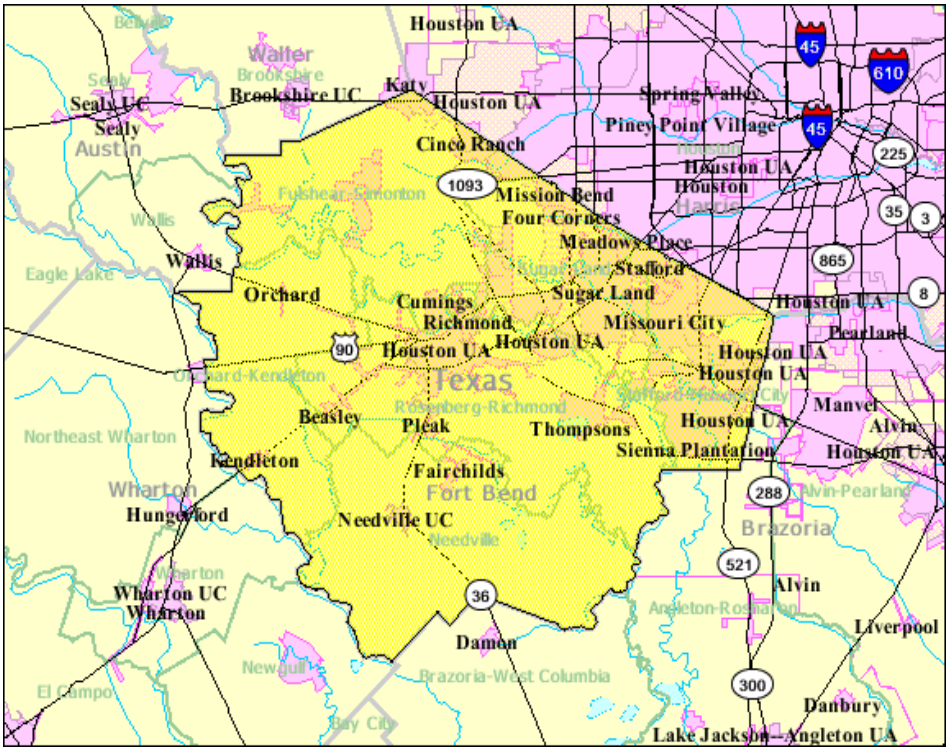
Increased Houston Suburban Public Transportation Options

As previously discussed, the Houston metropolitan region is experiencing an influx of people migrating to the suburban counties. Population levels in the three largest suburban counties were assessed for this research. Out of the seven suburban counties, Fort Bend, Montgomery, and Brazoria County are forecasted as the largest three counties by 2035. Fort Bend and Brazoria counties are located south and southwest of the urban core, and Montgomery County is located north of the urban core. As the population increases in these suburban counties, an increased demand for public transportation options to the urban core may arise as the freeways reach maximum capacity. The following sections provide quantitative data that examines whether planning for increased public transportation options between the three suburban counties and urban core should be undertaken.

Fort Bend County

Fort Bend County is forecasted as the largest suburban county within the Houston eight-county metropolitan region. As shown in Figure 9, Fort Bend County is located southwest Houston. The county consists of 24 neighborhoods covering 886

square miles. The 2006 population estimates of Fort Bend County were 493,187 as compared to a population of 225,421 in 1990 (Census Bureau, 2007). This is a population increase of 267,766 or + 118.8 percent over a 16-year period.



Source: 2000 U.S. Census Bureau

Figure 9. Fort Bend County City Limits

The travel time index was used to determine how long Fort Bend County commuters spend traveling between the urban core during peak periods utilizing the US 59 Southwest Freeway. The travel time index was determined for two freeway segments linking Fort Bend County and the urban core. Traffic congestion data were collected by two directional volumes on the freeway segments. The travel time of the two segments were averaged to determine the percentage of extra travel time spent during the peak periods as compared to non-peak periods. The first freeway segment is the 8.31 mile stretch between Wilcrest and IH 610, and the second freeway segment is the 7.40 mile stretch between IH 610 and the I-45 North Freeway. Collectively there are

15.71 miles of freeway linking Fort Bend County and the urban core. During the morning peak period, traffic congestion occurs northbound on the Southwest Freeway towards the urban core and southbound towards Fort Bend County during the evening peak period.

The highest percentage of extra travel time occurs during the first freeway segment when commuters start their trip. During the first freeway segment of a commuter's trip in both the morning and evening peak period, they spend more than 60 percent more time traveling than during non-peak periods. During the evening peak period the travel time index is the highest between the intersection of the North and Southwest Freeways and IH 610 West. As shown in Table 6, commuters spend 62 percent more time traveling between this segment than during non-peak periods. By the time commuters reach the last freeway segment during their trip traffic delays are far less. Overall, commuters spend more time traveling during the evening peak periods. Commuters spend 16 percent more time traveling home than traveling to work in the mornings.

Although traffic congestion on the Southwest Freeway was assessed for the southbound direction during the evening peak period, the northbound freeway segment between IH 610 West and the intersection of the Southwest and North Freeways has the highest percentage of extra travel time during the peak periods. Between this segment commuters spend 122 percent more time traveling towards the downtown freeway interchanges before continuing to the US 59 Eastex Freeway or connecting to one of the other two freeways.[5]

[5] US 59 Southwest Freeway changes name and direction in downtown Houston to the US 59 Eastex Freeway

Table 6. Fort Bend County Travel Time Index on Southwest Freeway

FREEWAY SECTION	LENGTH	MORNING PEAK	MIDDAY	EVENING PEAK	AVERAGE PEAK PERIOD
INBOUND					
Wilcrest to IH 610 W	8.31	**1.60**	1.09	1.11	1.36
IH 610 W to I-45 / US 59	7.40	**1.07**	1.14	2.22	1.65
TOTAL	15.71	**1.34**	1.12	1.67	1.50
OUTBOUND					
I-45 / US 59 to IH 610 W	7.40	1.24	1.06	**1.62**	1.43
IH 610 W to Wilcrest	8.31	1.01	1.02	**1.38**	1.20
TOTAL	15.71	1.13	1.04	**1.50**	1.31

Source: Texas Transportation Institute, 2004

The commuter need index study determined whether there is a need for increased suburban public transportation choices between Fort Bend County and the urban core as a demand-response to increased population in the county. Currently, users of commuter service drive to the METRO West Bellfort Park & Ride Lot for service to the urban core. As discussed in Chapter 3, the results of the three variables (Population Density, Commute to Work, and Mean Travel Time to Work) that most influence the need for suburban commuter service are discussed in this section. Table 7 represents the results from the commuter need index when the weight for each variable's index was set to five, and all other variables index were set to one. Analyzing the variables in this way enables assessment of the strength of each variable in the index. Also, individual communities' transit needs can be viewed across the three variables. The commuter need index may show that there is no need or continuum of low, medium, high and / or very high need for commuter services.

Table 7. Fort Bend County Suburban Commuter Need Index

CITY	POPULATION DENSITY INDEX		COMMUTE TO WORK INDEX		MEAN TRAVEL TIME INDEX	
	Index	Need	Index	Need	Index	Need
Arcola	8.5	Medium	5.6	Medium	7.0	Medium
Beasley	9.2	Medium	7.1	Medium	7.0	Medium
Cumings	4.6	Medium	6.0	Medium	6.0	Medium
Fifth Street	33.3	Very High	10.9	High	10.9	High
Four Corners	15.0	High	8.2	Medium	9.1	High
Fresno	11.2	Medium	7.3	Medium	8.4	High
Fulshear	3.1	Medium	5.8	Medium	6.9	Medium
Greatwood	23.3	High	10.8	High	10.9	High
Kendleton	7.4	Medium	6.4	Medium	7.4	Medium
Meadows Place	67.3	Very High	19.7	Very High	18.2	Very High
Missouri City	24.8	High	11.0	High	10.6	High
Needville	21.0	High	9.3	High	9.2	High
New Territory	36.1	Very High	12.4	Very High	13.3	Very High
Orchard	15.7	High	9.5	High	9.4	High
Pecan Grove	21.5	High	10.4	High	10.4	High
Pleak	7.9	Medium	7.5	Medium	6.8	Medium
Richmond	36.8	Very High	12.2	Very High	12.0	Very High
Rosenberg	15.9	High	8.3	Medium	7.9	Medium
Sienna Plantation	3.6	Medium	6.6	Medium	7.0	Medium
Simonton	6.8	Medium	7.8	Medium	8.4	High
Stafford	30.3	Very High	12.2	Very High	10.9	High
Sugar Land	33.7	Very High	12.5	Very High	12.0	Very High
Thompsons	2.4	Medium	5.9	Medium	6.4	Medium

The commuter need index shows that in most of the communities, although the order of the weights changed, the need for commuter services remained the same. Of the 24 communities examined within Fort Bend County, 17 of the communities need for commuter services remained the same. In every case, the commuter need index for five of the communities – Sugar Land, Richmond, Meadows Place, New Territory, and Stafford remained very high as the order of the weights changed. This suggests these four communities are good candidates for commuter services. When the population density index was weighed a five, the numeric value of the index increased significantly suggesting that density influences the need for the commuter services the most. Appendix A shows the complete commuter need index table for Fort Bend County, and all the index values.

Sugar Land is the largest populated community within Fort Bend County, and in every instance the commuter need index results show Sugar Land as a very high transit need for commuter service to the urban core. When the population density index weight was set to five, the commuter need index was 33.7; this is a fourth place ranking for a need for commuter services. When the weight for the commute to work index and mean travel time to work index were set to five, the index for Sugar Land was 12.5, a second place ranking only second behind Meadows Place. When the mean travel time to work index weight was set to five, the index value was the third highest, the same as the Richmond. Based on the fact that the need for commuter services remained very high in Sugar Land across all indicators proves there is indeed a need for commuter services in the largest suburban community within Fort Bend County.

Missouri City is the second largest populated community within Fort Bend County and is currently the only community directly served with commuter services to one employment center, the Texas Medical Center. During the past five years ridership has continual decreased on the transit route that links Missouri City and the TMC. Such as in the case of Sugar Land, when the population density index was weighed a five the index was significantly higher than when the remaining two index weight were set to five. Missouri City is the second highest populated community within Fort Bend County, however the land size area is spread out which decreases the population density. The values of the commute to work index and the mean travel time to work index were 11.0 and 10.6 respectively, suggesting that there is a population of people who are commuting to the urban core for employment.

Of all the communities analyzed within Fort Bend County, **Richmond** is the farthest community from the urban core, and the commuter need index suggests there is also a market for commuter services. According to the 2006 census estimates, the population of Richmond was 13,660, and is located approximately 40 miles from the urban core. The commuter index need suggests there is a very high need for commuter services between the community and the urban core. When population density index was weighed at five, the value was 36.8, ranking only second behind Meadows Place. The index values for the commute to work and mean travel time to work also ranked among the top five when the index was set to five respectively.

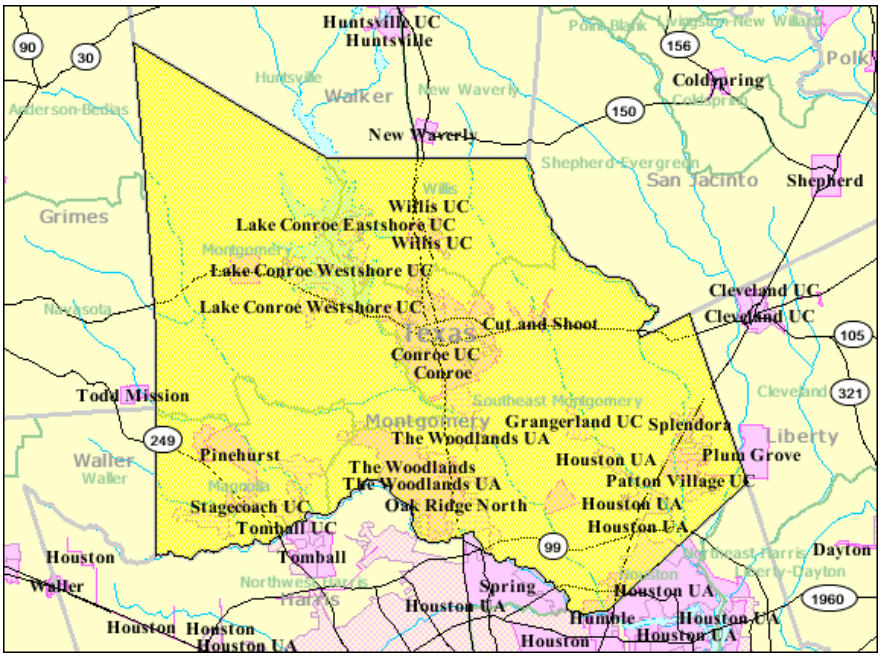
Overall the commuter index for Fort Bend County suggests there is a need for suburban commuter services to the urban core. As shown in Table 8, five of the 24 communities have very high need for commuter services, in which the communities are either among the largest populated or closest in vicinity to the urban core. There were also comparable transit need values for the additional communities. Five of the communities transit need index results were high. Missouri City the only community currently with commuter service show results of five. This is due in part to that the city covers a large area, in which a portion of the city is urban and portion of the city is rural.

Table 8. Fort Bend County Commuter Need Values

TRANSIT NEED INDEX	# OF COMMUNITIES W/ TRANSIT NEED VALUE	PERCENTAGE
Medium	8	33.3%
High	5	20.8%
Very High	5	20.8%
Mixture	6	25.0%
TOTAL	24	100.0%

Montgomery County

Montgomery County is forecasted as the second largest suburban county within the Houston eight-county metropolitan region. As shown in Figure 10, Montgomery County is located north of the urban core. The county consists of 17 communities over 1,077 square miles. The 2006 population estimates of Montgomery County were 398,290 as compared to 182,201 in 1990 (Census Bureau, 2007). This is a population increase of 216,089 or +118.6 percent over a 16-year period. Commuters of the Montgomery County suburban area have three commute route options to the urban core: 1) I-45 North Freeway, 2) US 59 Eastex Freeway, and 3) Hardy Toll Road. For the purpose of this thesis, the first two freeways were used for discussion since they are heavily used by commuters during peak periods without any congestion control mechanism.



Source: U.S. Census Bureau, 2000

Figure 10. Montgomery County City Limits

The travel time index was used to determine how much longer Montgomery County commuters spend traveling between the urban core during peak periods utilizing either the I-45 North Freeway or the US 59 Eastex Freeway. First, the travel time index analysis was conducted on the North Freeway. The travel time index was determined for the four freeway segments linking Montgomery County and the urban core. The travel time index of the four segments was averaged to determine the percentage of extra travel time spent during the peak periods as compared to non-peak periods. The first freeway segment is the 5.40 mile stretch between Hardy Toll Road and FM 1960; the second freeway segment is the 7.00 mile stretch between FM 1960 and Aldine Bender; the third freeway segment is the 8.20 mile stretch between Aldine Bender and Crosstimbers; and the fourth freeway segment is the 2.50 mile stretch between Crosstimbers and the I-10 Freeway. Collectively there are 23.10 miles of freeway between the four segments. During the morning peak period traffic congestion occurs southbound on the North Freeway towards the urban core, and northbound during the evening peak period towards Montgomery County.

The percentage of extra travel time spent commuting is comparable during the two peak periods. As shown in Table 9, travel times are only three percent longer during the evening peak period as compared to the morning peak period. During the evening peak period commuters spend 34 percent more time traveling home than during non-peak periods, and 31 percent more time traveling to work than during non-peak periods. While commuters spend comparable times traveling during peak periods, there are periods during the commute when travel times are extreme. The first freeway segment leaving downtown during the evening commuters spend 75 percent more time traveling than during non-peak periods.

Although the travel times along the first freeway segment in the evening are extreme, as commuters commute continues traffic congestion declines. By the time commuters reach Aldine Bender the travel times are only three percent longer than during non-peak periods. Traffic congestion remains at this level for the remainder of the commute trip home. The traffic congestion levels during the morning peak period are also comparable between the same freeway segments. This suggests that traffic congestion lessens farther away from the urban core.

Table 9. Montgomery County Travel Time Index on North Freeway

FREEWAY SECTION	LENGTH	MORNING PEAK	MIDDAY	EVENING PEAK	AVERAGE PEAK PERIOD
INBOUND					
Hardy Toll Road to FM 1960	5.40	**1.08**	1.01	1.00	1.04
FM 1960 to Aldine Bender	7.00	**1.03**	1.02	1.05	1.04
Aldine Bender to Crosstimbers	8.20	**1.60**	1.11	1.21	1.41
Crosstimbers to I-10	2.50	**1.51**	1.07	1.04	1.28
TOTAL	23.10	**1.31**	1.05	1.08	1.19
OUTBOUND					
I-10 to Crosstimbers	2.50	1.02	1.17	**1.75**	1.39
Crosstimbers to Aldine Bender	8.20	1.04	1.12	**1.55**	1.30
Aldine Bender to FM 1960	7.00	1.01	1.01	**1.03**	1.02
FM 1960 to Hardy Toll Road	5.40	1.01	1.00	**1.03**	1.02
TOTAL	23.10	1.02	1.08	**1.34**	1.18

Source: Texas Transportation Institute, 2004

The second commute route for Montgomery County commuters to the urban core is the US 59 Eastex Freeway. The travel time index was determined for the three freeway segments linking Montgomery County and the urban core. The travel time of the three segments were averaged together to determine the percentage of extra travel time spent during the peak periods as compared to non-peak periods. The first freeway segment is the 5.10 mile stretch between Towsen and the Sam Houston Parkway; the second freeway segment is the 10.00 mile stretch between Sam Houston Parkway and IH 610 North; and the third freeway segment is the 4.45 mile stretch between IH 610 North and the I-45 North Freeway. Collectively there are 19.55 miles of freeway linking Montgomery County and the urban core via the Eastex Freeway. During the morning peak, period traffic congestion occurs on the 59 Eastex Freeway southbound towards the urban core and northbound towards Montgomery County during the evening peak period.

The travel time index for Montgomery County commuters on the North Freeway is higher during the morning peak period than during the evening peak period. As shown in Table 10, during the morning peak period commuters spend 29 percent more time traveling than during the non-peak period, while during the evening peak period commuters spend 13 percent more time traveling home than during non-peak periods. Commute travel times are 16 percent longer during the drive to work as compared to the drive to home. Hence, commuters spend twice as long traveling to work than commuting home.

Traffic delays are the highest during the last freeway segment in the morning peak period, and during the first freeway segment in the evening peak period. During the morning peak period commuters spend 83 percent more time traveling between IH 610 North and the I-45 North Freeway into downtown. This is the highest travel time for any single segment on the Eastex Freeway. During the evening peak period commuters spend 22 percent more time traveling during the first freeway segment leaving downtown. This suggests the most congestion occurs during the freeway segments that connect into the downtown employment center.

Table 10. Montgomery County Travel Time Index on Eastex Freeway

FREEWAY SECTION	LENGTH	MORNING PEAK	MIDDAY	EVENING PEAK	AVERAGE PEAK PERIOD
INBOUND					
Townsen to Sam Houston Pkwy	5.10	**1.00**	1.00	1.00	1.00
Sam Houston Pkwy to IH 610 E	10.00	**1.04**	1.01	1.00	1.02
IH 610 E to I-45 N	4.45	**1.83**	1.07	1.07	1.45
TOTAL	19.55	**1.29**	1.03	1.02	1.16
OUTBOUND					
I-45 N to IH 610 E	4.45	1.00	1.05	**1.22**	1.11
IH 610 E to Sam Houston Pkwy	10.00	1.00	1.01	**1.02**	1.01
Sam Houston Pkwy to Townsen	5.10	1.00	1.01	**1.15**	1.08
TOTAL	19.55	1.00	1.02	**1.13**	1.07

Source: Texas Transportation Institute, 2004

The commuter need index study determined if there is a need for increased suburban public transportation choices between Montgomery County and the urban core as a demand-response to increased population in the county. Currently users of public transportation drive to the METRO Spring Park & Ride Lot on the North Freeway and the Townsen Park & Ride Lot on the Eastex Freeway for commuter service to urban core. As discussed in Chapter 3, the results of the three variables (Population Density, Commute to Work, and Mean Travel Time to Work) that most influence the need for suburban commuter service are discussed in this section. Table 11 represents the results from the commuter need index when the weight for each variable's index was set to five, and all other variables index were set to one. Analyzing the variables in this way enables assessment of the strength of each variable in the index. Also, individual communities' transit needs can be viewed across the three variables. The commuter need index may show that there is no need or continuum of low, medium, high and / or very high need for commuter services.

Table 11. Montgomery County Suburban Commuter Need Index

CITY	POPULATION DENSITY INDEX		COMMUTE TO WORK INDEX		MEAN TRAVEL TIME INDEX	
	Index	Need	Index	Need	Index	Need
Conroe	19.5	High	9.2	High	8.1	Medium
Cut and Shoot	9.7	Medium	7.0	Medium	7.4	Medium
Magnolia	11.8	Medium	7.9	Medium	8.6	High
Montgomery	4.0	Medium	6.7	Medium	6.6	Medium
Oak Ridge North	49.7	Very High	16.2	Very High	15.3	Very High
Panorama Village	34.2	Very High	12.1	High	11.5	Very High
Patton Village	14.4	Medium	8.0	Medium	9.1	High
Pinehurst	6.2	Medium	5.9	Medium	5.6	Medium
Porter Heights	10.8	Medium	8.2	Medium	8.4	Medium
Roman Forest	18.0	High	9.5	High	9.7	High
Shenandoah	23.9	High	11.1	High	9.9	High
Splendora	13.3	Medium	8.5	Medium	9.0	High
Stagecoach	9.5	Medium	8.9	High	8.7	High
The Woodlands	44.7	Very High	14.6	Very High	14.5	Very High
Willis	23.9	High	9.5	High	9.4	High
Woodbranch	14.4	Medium	8.9	High	9.0	High
Woodloch	52.6	Very High	18.1	Very High	15.7	Very High

As in the case Fort Bend County, the commuter need index for Montgomery County shows that the need for commuter services in communities measuring very high remains the same even when the value of the weights were changed. Of the 17 communities that were examined within Montgomery County, 10 of the communities need for commuter services remained the same as the weighed for the index varied. In every case, the commuter index for three of the communities – Oak Ridge North, The Woodlands, and Woodloch remained very high as the value of the weights changed. This suggests these there is a very high need for commuter services for these three communities. When the population density index was weighed a five, the numeric value of the index increased significantly suggesting that population density influences the need for the commuter services the most. All three of these communities are located just north of the Harris County border.

Currently **The Woodlands** is the only community with direct commuter service to the urban core.[6] The Woodlands is the largest populated community within

[6] The Woodlands Express has four Park & Ride locations in the Woodlands providing service to both the downtown and TMC employment centers.

Montgomery County, and in every instance the commuter need index results show that The Woodlands has a very high transit need market for commuter service to the urban core. Additionally, of the three communities with a very high need for commuter services, The Woodlands ranked third highest in each instance.

Woodloch is the first community located just north of the Harris County border line, with a population of 2,365 according to the 2006 population estimates. The need for commuter services ranked highest in Woodloch in every instance when the weight was set to five. As shown in the Table 12, the population density index, commute to work index, and mean travel time to work index were 52.6, 18.1, and 15.7 respectively. This was the highest index value for each category when the values were set five. Due to Woodloch's close vicinity to the urbanized area, the population is denser which is reflected in the index value.

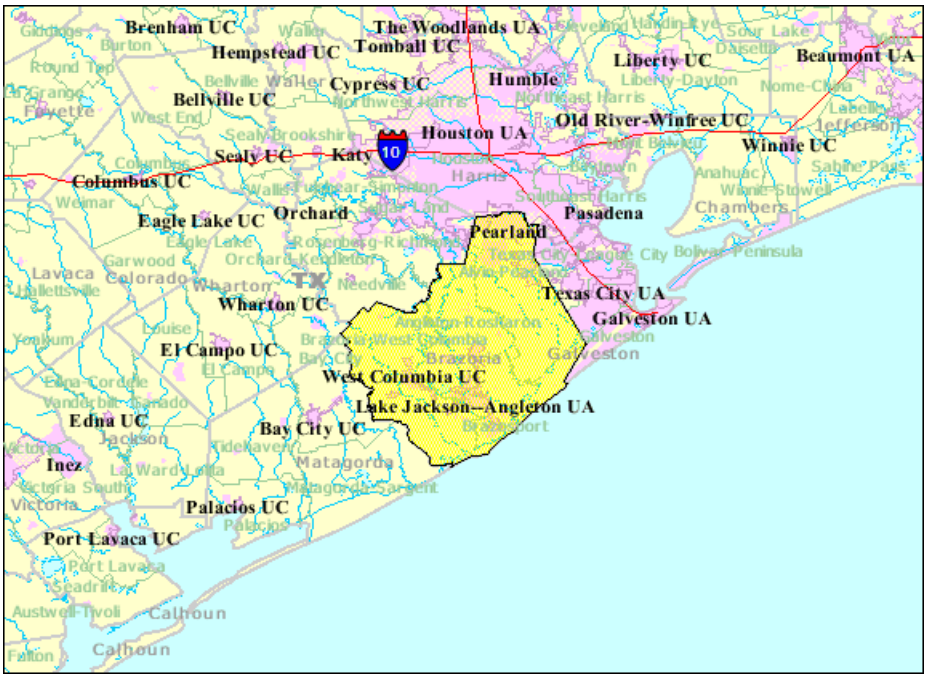
Overall the commuter index also suggests there is a need for commuter services between Montgomery County and the urban core. As shown in Table 14, three of the 17 communities have very high transit need results. The further out the communities are from the urban core, the need for transit decreases. The results also show that three additional communities – Roman Forest, Shenandoah, and Willis have a high need for commuter services. These three communities are located just further north of three communities with a very high need for commuter services. There are five communities in which the commuter need results show there is a medium need for commuter service to the urban core.

Table 12. Montgomery County Commuter Need Index Values

TRANSIT NEED INDEX	# OF COMMUNITIES W/ TRANSIT NEED VALUE	PERCENTAGE
Medium	5	29.4%
High	3	17.6%
Very High	3	17.6%
Mixture	6	35.3%
TOTAL	17	100.0%

Brazoria County

Brazoria County is forecasted as the third largest suburban county within the Houston eight-county metropolitan region. As shown in Figure 11, Brazoria County is located south of the urban core. Brazoria County consists of 25 communities over 1,597 square miles. The 2006 population estimates of Brazoria County were 287,898 as compared to 191,707 in 1990 (Census Bureau, 2007). This is a population increase of 96,191 or + 50.2 percent over a 16-year period.



Source: Census Bureau, 2000

Figure 11. Brazoria County City Limits

The travel time index was used to determine how much longer Brazoria County commuters spend traveling to the urban core utilizing SH 288. The travel time index was determined for the two freeway segments linking Brazoria County and the urban core. The travel time index of the two segments was averaged to determine the percentage of extra travel time spent during the peak periods as compared to non-peak periods. The first freeway segment is the 7.20 mile stretch between FM 518 and IH 610

South, and the second freeway segment is the 4.80 mile stretch between IH 610 South and the US 59 Southwest / Eastex Freeway interchange. Collectively there are 12.00 miles of freeway linking Brazoria County and the urban core. During the morning peak periods traffic congestion occurs on SH 288 northbound towards the urban core, and southbound towards Brazoria County in the evening.

The percentage of extra time spent traveling between IH 610 South and the US 59 Freeway (inside the Loop) is comparable during the two peak periods. As shown in Table 13, during the morning peak period commuters spend 36 percent more time traveling than non-peak periods during this freeway segment. During the evening peak period, commuters spend 35 percent more time traveling than non-peak periods during the same freeway segment for the reverse commute. Thus, the percentage of extra travel time spent between this segment are virtual the same during the two peak periods. During the evening peak period, traffic congestion increases as commuters approach Brazoria County. The percentage of extra travel time spent commuting increases from 35 percent to 41 percent during the last freeway segment into Brazoria County (City of Pearland). This suggests traffic congestion worsens as commuters go farther into the county.

Table 13. Brazoria County Travel Time Index

FREEWAY SECTION	LENGTH	MORNING PEAK	MIDDAY	EVENING PEAK	AVERAGE PEAK PERIOD
INBOUND					
FM 518 to IH 610 S	7.20	**1.14**	1.02	1.09	1.12
IH 610 S to US 59	4.80	**1.36**	1.01	1.02	1.19
TOTAL	12.00	**1.25**	1.02	1.06	1.15
OUTBOUND					
US 59 to IH 610 S	4.80	1.01	1.02	**1.35**	1.18
IH 610 S to FM 518	7.20	1.01	1.01	**1.41**	1.21
TOTAL	12.00	1.01	1.02	**1.38**	1.20

Source: Texas Transportation Institute, 2004

The commuter need index study determined whether there is a need for increased suburban public transportation choices between Brazoria County and the urban core as a demand-response to increased population in the county. Currently

there is no direct commuter service between Brazoria County and the urban core. As discussed in Chapter 3, the results of the three variables (Population Density, Commute to Work, and Mean Travel Time to Work) that most influence the need for suburban commuter service are discussed in this section. Table 14 represents the results from the commuter need index when the weight for each variable's index was set to five, and all other variables index were set to one. Brazoria County spreads over 100 miles from the Houston urban core, thus only communities located approximately 40 miles from the core were included in the commuter need index.

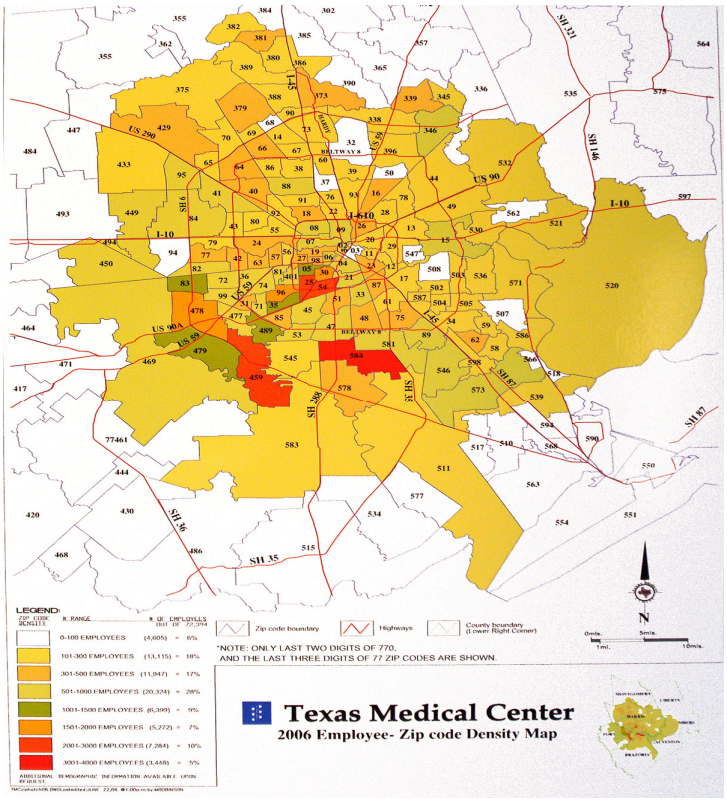
Table 14. Brazoria County Commuter Need Index

	POPULATION DENSITY INDEX		COMMUTE TO WORK INDEX		MEAN TRAVEL TIME INDEX	
CITY	Index	Need	Index	Need	Index	Need
Alvin	42.9	Very High	14.3	Very High	14.4	Very High
Brookside Village	32.8	High	12.5	High	12.3	Very High
Hillcrest	56.3	Very High	16.9	Very High	17.2	Very High
Iowa Colony	7.0	Medium	7.1	Medium	9.2	High
Liverpool	16.3	Medium	9.2	High	9.9	High
Manvel	6.7	Medium	7.8	Medium	8.3	Medium
Pearland	36.9	Very High	13.9	Very High	13.5	Very High

The commuter index shows that of the seven communities, three communities closest to the Houston metropolitan have very high transit need index although the value of the weights changes. In every case, the commuter need index for the three communities – Pearland, Hilcrest, and Alvin remained very high as the value of the weights changed. This suggests there is a very high need for commuter services for these three communities. When the population density index was weighed a five, the numeric value of the index increased significantly suggesting that once again population density influences the need for commuter services. Appendix C shows the complete commuter need index table for Brazoria County, and all the index values.

Pearland is the largest populated community within Brazoria County, and in every instance the population density index, commute to work index, and mean travel time work index ranked third of the communities analyzed. As in the case of suburban cities with large populations, the population is dispersed over a larger area than

urbanized cities. Additional transit needs research conducted on Pearland found that a high number of residents commute to the Texas Medical Center. The 2006 Texas Medical Center Employee – Zip Code Density Map shows there is a high concentration of employees who live in Brazoria County (TMC, 2007). As shown in Figure 12, of the 72,394 TMC employees five percent live in zip code 77584 along SH 288. The City of Pearland is located within this zip code, and according to the 2006 population estimates 68,305 people live in the city (Census Bureau, 2006). Based on the density map, approximately 3,620 people who live in Pearland work in the TMC. Currently these commuters have two commute route options to the TMC – 1) Drive to the METRORail Fannin South Park & Ride Station, and connect to METRORail to continue their trip to the TMC, or 2) Drive directly to the TMC employment center along SH 288. When the population density index was set to five, the transit need index was 36.9 which suggests there is a concentration of people in Pearland, who would potentially use transit. Based on the increased travel times, proximity to the urban core, and percentage of residents who work in the TMC with no public transportation commute options, the city of Pearland would be a good market for commuter services.



Source: Texas Medical Center, 2006

Figure 12. Texas Medical Center Employee Zip Code Map

The additional two communities with a very high need for commuter services were Alvin and Hilcrest, which are located closer to the Houston urban core than Pearland. **Hilcrest** located approximately 25 miles from Harris County, had the highest values for all three indexes when the weights were varied. **Alvin**, located approximately 30 miles from Harris County, had the second highest values for all three indexes when the indexes varied. These results suggest that the closer the community to the urban core, the more of a need for commuter services between the suburban community and urban core in this instance.

Overall the commuter index suggests there is a need for commuter services for communities within a 40 miles radius of the Houston urban core. As shown in Table 15, three of the 7 communities have very high transit need results. The farther the communities are from the urban core, the need for transit decreases. Of the seven

communities, none of the index results displayed a high need for commuter service, although Manvel results show there is a medium need for commuter service.

Table 15. Brazoria County Commuter Need Index Values

TRANSIT NEED INDEX	# OF COMMUNITIES W/ TRANSIT NEED VALUE	PERCENTAGE
Medium	1	14.3%
High	0	0.0%
Very High	3	42.9%
Mixture	3	42.9%
TOTAL	7	100.0%

Houston Suburban County Comparison

Of the freeway segments analyzed in the three suburban counties the travel time index was 1.0 or higher during the midday hours; still there are minimal traffic delays during the midday hours. With the exception of Brazoria County, the travel time index for the midday was higher for the freeway segments closest to the urban core as compared to the freeway segment nearest to the suburban county. For instance, during the midday, travelers on the North Freeway northbound spend 17 percent more time driving between downtown and Crosstimbers. Therefore, there is an all day travel time disadvantage for commuters who utilize this freeway.

While there is some travel time delay throughout the day, several of the travel indexes were extreme during the peak periods. Commuters on the Eastex Freeway experience the highest travel time delay during the morning commute. Although there is minimal traffic congestion along the freeway segments closest to the suburban areas, travel times increase drastically between the freeway segments closest to the downtown employment center. This would be a good market for suburban public transportation because although traffic congestion farthest out is relatively low, congestion increases significantly between freeway segments connecting downtown.

Overall, travel times are slightly higher during the evening peak period than during the morning peak period for the three suburban counties analyzed. As shown in

Table 16, commuters spend 30 percent more time traveling to work than during non-peak periods, and 34 percent more time commuting home than during non-peak periods. For instance, if during free-flow travel periods the travel time is 35 minutes between Sugar Land and downtown, during the peak periods commuters will spend 46 minutes commuting. Increased public transportation options have the potential to decrease this travel time by a minimum of one-fourth by operating part way on the high occupancy vehicle lanes.

Table 16. Suburban County's Travel Time Index Comparison

SUBURBAN COUNTY FREEWAY	MORNING PEAK	EVENING PEAK
Fort Bend County	1.34	1.50
Montgomery County – North Fwy	1.31	1.34
Montgomery County – Eastex Fwy	1.29	1.13
Brazoria County	1.25	1.38
Average	**1.30**	**1.34**

Source: Texas Transportation Institute, 2004

Of the three suburban counties analyzed, the commuter need index results suggested each county was a good market for increased suburban public transportation to serve the urban core. As the weight for each index (Population Density, Commute to Work, and Mean Travel Time) were set to five and the other two set to one, commuter need value remained the same. Table 17 shows that the need for commuter service varies from medium to very high in the three suburban counties. In a number of communities the indicators varied when the values of the variables were changed. A community may have ranked high on one variable and medium on another variable. This resulted in a mixed set of indicators, rather than consistency across indicators. Fifteen of the transit need index values were a combination of medium-high or high-very high. Eleven of the communities have a very high need for commuter services. Lastly, of the three counties combined, fifteen communities transit need index value were mixed. For example, the values were a combination of high-very high or medium-high, etc. In Montgomery and Brazoria County the communities with a very high need for

commuter service were located closest to the urban core. In the case of Fort County, communities as far as 40 miles out (Richmond) displayed results that suggest there is a very high need for commuter service.

Table 17. County Commuter Need Index Comparison

COUNTY	MEDIUM	HIGH	VERY HIGH	MIXED	**TOTAL**
Brazoria	1	0	3	3	**7**
Fort Bend	5	3	3	6	**17**
Montgomery	8	5	5	6	**24**
TOTAL	**14**	**8**	**11**	**15**	**48**

In the case of Pearland in Brazoria County, this would be the best market to implement commuter service to the urban core since traffic delays are so great. This suggests the demand for public transportation services need is increasing outside the urban transit providers' service area in suburban cities that are 30 plus miles away from the urban core. The population is not only increasing in large suburban cities such as Pearland, Sugar Land, and the Woodlands, but bedroom cites such as Richmond are starting to display there is a need to implement commuter services between the area and the urban core. At a minimum these locales need a connection to the current public transportation system which would provide a connection to the urban core. As an increased number of people locate in suburban counties, the travel times will increase between the county and the urban core. Public transportation can be a demand-response to aid in traffic congestion relief. This will result in decreased travel times for commuters during peak periods.

CHAPTER 5

SUMMARY OF FINDINGS

Throughout the next thirty years approximately two million additional people are forecasted live in the Houston metropolitan region. A number of the people are anticipated to settle in suburban counties such as Fort Bend, Montgomery, and Brazoria and will commute to urban core for employment. Findings from this research suggest increased suburban transportation mobility options are needed from the three largest contiguous suburban counties to the Houston urban core. Transportation professionals will need to focus on providing innovative strategies to attract these commuters from private automobiles to utilize alternate means of transportation. Both Fort Bend and Montgomery County's population are forecasted to double within the next thirty years. The travel time index and transit need index results suggest a percentage of the residents in these counties will commute to the urban core as the employment centers increase. The population of Brazoria County is also forecasted to increase significantly, and data proved a considerable number of Pearland residents will commute specifically to the Texas Medical Center. The following conclusions were derived from this work:

Increased commuter services should be implemented in Fort Bend County. Fort Bend County is forecasted as the largest suburban county within the Houston metropolitan region. Of the seven suburban counties analyzed Fort Bend County's population is forecasted to increase the most by 2035. Results from the travel time index and transit need index suggest increased commuter services are needed between Fort Bend County and the urban core. There is a growing demand for service in the city of Richmond and Rosenberg which are the farthest away from the urban core. The travel time index found that commuters spend more time commuting during both the morning and evening peak periods in Fort Bend County than the other two suburban counties analyzed. These commute travel times will only increase throughout the years as people migrate to Fort Bend County and if additional suburban commuters are not attracted to utilize public transportation.

Suburban commuter service should be implemented in Brazoria County (City of Pearland) and the urban core (Texas Medical Center). The current Texas Medical Center employee zip code density map shows a concentration of Pearland residents work in the Texas Medical Center. The travel time index results show traffic congestion increases during the evening peak period as commuters enter the suburban area. In the case of the other suburban counties, traffic congestion decreases as commuters enter their perspective county. Limited commuter service options are available to residents in the other counties, whereas there is no commuter service available to Brazoria County residents. This suggests commuter service may alleviate traffic congestion between the suburban county and urban core because the traffic delays decrease as commuters enter the county.

Recommendations

Increased public transportation services between the three suburban counties and to the urban core will not eliminate traffic congestion in the Houston metropolitan region, but will lessen the demand for limited roadway space. If planned and configured properly with the suburban county, an increased number of commuters may be attracted to utilize the system. In order to attract suburban commuters the following actions should be evaluated:

- Extend limited commuter service beyond the traditional transit service area into bedroom communities per the very high ratings in the transit need index.
- Conduct market research on current and perspective suburban commuters to tailor the service to their demand.
- Introduce amenities that will entice suburban commuters out of their private automobiles. The amenities could include real time arrival and departure information at park and ride locations, wireless internet connections on board vehicles, and service information available on their cell phones.

If these recommendations are evaluated and properly implemented they have the potential to increase transit ridership and alleviate traffic congestion during the peak

periods. Additional research is required to determine if the above recommendations will indeed increase transit ridership and aid in the relief of traffic congestion.

This research focused on the need for public transportation from the three largest suburban counties to the urban core in the Houston metropolitan region. The four additional suburban counties can be analyzed to determine if there is a need for commuter service to the urban core. Additionally, increased suburban public transportation options to Houston's other employment centers – Greenway Plaza, Greenspoint, Uptown – Galleria, and Westchase can be analyzed. Further research can also be conducted to determine if there is a need for increased public transportation options in additional Sun Belt metropolitan regions. Research methods used to determine the findings for the Houston metropolitan region can be used as a model for other Sun Belt metropolitan regions that are experiencing a population growth in suburban counties and employment centers located in the urban core. As people migrate to suburban counties and commute to the urban core for employment, freeways will remain at capacity during the peak periods and travel times will continue to increase. Thus, increased public transportation options are suggested to help alleviate the congestion.

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APPENDIX A:

Fort Bend County Commuter Need Index

1. Population Density Index

Weight				5			1		1	7	
Total County Area	354,452	886.1	400.0	1.0	163,614	46.2%	1.0	32.3	1.0	7.0	
Fort Bend County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to work Index	Mean Travel Time to Work	Mean Travel Time to Work Index	Transit Need Index	Transit Need
Arcola	1,048	1.9	548.7	1.4	316	30.2%	0.7	32.3	1.0	8.5	Medium
Beasley	590	1.0	590.0	1.5	255	43.2%	0.9	29.5	0.9	9.2	Medium
Cumings	683	3.1	220.3	0.6	284	41.6%	0.9	29.4	0.9	4.6	Medium
Fifth Street	2,059	0.8	2,542.0	6.4	723	35.1%	0.8	24.3	0.8	33.3	Very High
Four Corners	2,954	2.9	1,036.5	2.6	1,240	42.0%	0.9	35.9	1.1	15.0	High
Fresno	6,603	9.0	734.5	1.8	2,658	40.3%	0.9	36.9	1.1	11.2	Medium
Fulshear	716	8.2	87.6	0.2	290	40.5%	0.9	37.4	1.2	3.1	Medium
Greatwood	6,640	3.9	1,689.6	4.2	3,365	50.7%	1.1	36.1	1.1	23.3	High
Kendleton	466	1.1	439.6	1.1	183	39.3%	0.9	35.0	1.1	7.4	Medium
Meadows Place	4,912	0.9	5,225.5	13.1	2,651	54.0%	1.2	25.9	0.8	67.3	Very High
Missouri City	52,913	29.1	1,817.7	4.5	26,500	50.1%	1.1	32.4	1.0	24.8	High
Needville	2,609	1.7	1,534.7	3.8	1,105	42.4%	0.9	29.0	0.9	21.0	High
New Territory	13,861	5.1	2,723.2	6.8	5,763	41.6%	0.9	36.1	1.1	36.1	Very High
Orchard	408	0.4	1,073.7	2.7	214	52.5%	1.1	36.0	1.1	15.7	High
Pecan Grove	13,551	8.8	1,546.9	3.9	6,854	50.6%	1.1	34.9	1.1	21.5	High
Pleak	947	2.0	473.5	1.2	475	50.2%	1.1	29.1	0.9	7.9	Medium
Richmond	11,081	3.9	2,812.4	7.0	4,408	39.8%	0.9	26.7	0.8	36.8	Very High
Rosenberg	24,043	21.3	1,130.9	2.8	10,246	42.6%	0.9	27.0	0.8	15.9	High
Sienna Plantation	1,896	16.5	115.3	0.3	908	47.9%	1.0	36.9	1.1	3.6	Medium
Simonton	718	2.0	353.7	0.9	372	51.8%	1.1	41.6	1.3	6.8	Medium
Stafford	15,681	6.9	2,269.3	5.7	8,193	52.2%	1.1	26.7	0.8	30.3	Very High
Sugar Land	63,328	24.9	2,541.3	6.4	30,510	48.2%	1.0	29.6	0.9	33.7	Very High
Thompsons	236	8.4	28.2	0.1	103	43.6%	0.9	34.6	1.1	2.4	Medium
									-1.5 StDev	(16.1)	Very Low
									-0.5 StDev	(0.7)	Low
									+0.5 StDev	14.7	Medium
									+1.5 StDev	30.1	High
											Very High

2. Commute to Work Index

Weight				1			5		1	7	
Total County Area	354,452	886.1	400.0	1.0	163,614	46.2%	1.0	32.3	1.0	7.0	
Fort Bend County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to work Index	Mean Travel Time to Work	Mean Travel Time to Work Index	Transit Need Index	Transit Need
Arcola	1,048	1.9	548.7	1.4	316	30.2%	0.7	32.3	1.0	5.6	Medium
Beasley	590	1.0	590.0	1.5	255	43.2%	0.9	29.5	0.9	7.1	Medium
Cumings	683	3.1	220.3	0.6	284	41.6%	0.9	29.4	0.9	6.0	Medium
Fifth Street	2,059	0.8	2,542.0	6.4	723	35.1%	0.8	24.3	0.8	10.9	High
Four Corners	2,954	2.9	1,036.5	2.6	1,240	42.0%	0.9	35.9	1.1	8.2	Medium
Fresno	6,603	9.0	734.5	1.8	2,658	40.3%	0.9	36.9	1.1	7.3	Medium
Fulshear	716	8.2	87.6	0.2	290	40.5%	0.9	37.4	1.2	5.8	Medium
Greatwood	6,640	3.9	1,689.6	4.2	3,365	50.7%	1.1	36.1	1.1	10.8	High
Kendleton	466	1.1	439.6	1.1	183	39.3%	0.9	35.0	1.1	6.4	Medium
Meadows Place	4,912	0.9	5,225.5	13.1	2,651	54.0%	1.2	25.9	0.8	19.7	Very High
Missouri City	52,913	29.1	1,817.7	4.5	26,500	50.1%	1.1	32.4	1.0	11.0	High
Needville	2,609	1.7	1,534.7	3.8	1,105	42.4%	0.9	29.0	0.9	9.3	High
New Territory	13,861	5.1	2,723.2	6.8	5,763	41.6%	0.9	36.1	1.1	12.4	Very High
Orchard	408	0.4	1,073.7	2.7	214	52.5%	1.1	36.0	1.1	9.5	High
Pecan Grove	13,551	8.8	1,546.9	3.9	6,854	50.6%	1.1	34.9	1.1	10.4	High
Pleak	947	2.0	473.5	1.2	475	50.2%	1.1	29.1	0.9	7.5	Medium
Richmond	11,081	3.9	2,812.4	7.0	4,408	39.8%	0.9	26.7	0.8	12.2	Very High
Rosenberg	24,043	21.3	1,130.9	2.8	10,246	42.6%	0.9	27.0	0.8	8.3	Medium
Sienna Plantation	1,896	16.5	115.3	0.3	908	47.9%	1.0	36.9	1.1	6.6	Medium
Simonton	718	2.0	353.7	0.9	372	51.8%	1.1	41.6	1.3	7.8	Medium
Stafford	15,681	6.9	2,269.3	5.7	8,193	52.2%	1.1	26.7	0.8	12.2	Very High
Sugar Land	63,328	24.9	2,541.3	6.4	30,510	48.2%	1.0	29.6	0.9	12.5	Very High
Thompsons	236	8.4	28.2	0.1	103	43.6%	0.9	34.6	1.1	5.9	Medium
									-1.5 StDev	2.1	Very Low
									-0.5 StDev	5.4	Low
									+0.5 StDev	8.6	Medium
									+1.5 StDev	11.9	High
											Very High

3. Mean Travel Time to work Index

Weight				1			1		5	7	
Total County Area	354,452	886.1	400.0	1.0	163,614	46.2%	1.0	32.3	1.0	7.0	
Fort Bend County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to work Index	Mean Travel Time to Work	Mean Travel Time to Work Index	Transit Need Index	Transit Need
Arcola	1,048	1.9	548.7	1.4	316	30.2%	0.7	32.3	1.0	7.0	Medium
Beasley	590	1.0	590.0	1.5	255	43.2%	0.9	29.5	0.9	7.0	Medium
Cumings	683	3.1	220.3	0.6	284	41.6%	0.9	29.4	0.9	6.0	Medium
Fifth Street	2,059	0.8	2,542.0	6.4	723	35.1%	0.8	24.3	0.8	10.9	High
Four Corners	2,954	2.9	1,036.5	2.6	1,240	42.0%	0.9	35.9	1.1	9.1	High
Fresno	6,603	9.0	734.5	1.8	2,658	40.3%	0.9	36.9	1.1	8.4	High
Fulshear	716	8.2	87.6	0.2	290	40.5%	0.9	37.4	1.2	6.9	Medium
Greatwood	6,640	3.9	1,689.6	4.2	3,365	50.7%	1.1	36.1	1.1	10.9	High
Kendleton	466	1.1	439.6	1.1	183	39.3%	0.9	35.0	1.1	7.4	Medium
Meadows Place	4,912	0.9	5,225.5	13.1	2,651	54.0%	1.2	25.9	0.8	18.2	Very High
Missouri City	52,913	29.1	1,817.7	4.5	26,500	50.1%	1.1	32.4	1.0	10.6	High
Needville	2,609	1.7	1,534.7	3.8	1,105	42.4%	0.9	29.0	0.9	9.2	High
New Territory	13,861	5.1	2,723.2	6.8	5,763	41.6%	0.9	36.1	1.1	13.3	Very High
Orchard	408	0.4	1,073.7	2.7	214	52.5%	1.1	36.0	1.1	9.4	High
Pecan Grove	13,551	8.8	1,546.9	3.9	6,854	50.6%	1.1	34.9	1.1	10.4	High
Pleak	947	2.0	473.5	1.2	475	50.2%	1.1	29.1	0.9	6.8	Medium
Richmond	11,081	3.9	2,812.4	7.0	4,408	39.8%	0.9	26.7	0.8	12.0	Very High
Rosenberg	24,043	21.3	1,130.9	2.8	10,246	42.6%	0.9	27.0	0.8	7.9	Medium
Sienna Plantation	1,896	16.5	115.3	0.3	908	47.9%	1.0	36.9	1.1	7.0	Medium
Simonton	718	2.0	353.7	0.9	372	51.8%	1.1	41.6	1.3	8.4	High
Stafford	15,681	6.9	2,269.3	5.7	8,193	52.2%	1.1	26.7	0.8	10.9	High
Sugar Land	63,328	24.9	2,541.3	6.4	30,510	48.2%	1.0	29.6	0.9	12.0	Very High
Thompsons	236	8.4	28.2	0.1	103	43.6%	0.9	34.6	1.1	6.4	Medium
									-1.5 StDev	2.8	Very Low
									-0.5 StDev	5.6	Low
									+0.5 StDev	8.4	Medium
									+1.5 StDev	11.2	High
											Very High

APPENDIX B:

Montgomery County Commuter Need Index

1. Population Density Index

Weight				5			1		1	7	
Total County Area	293,768	1,076.81	272.8	1.0	134,118	45.7%	1.0	32.9	1.0	7.0	
Montgomery County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to Work Index	Mean Travel Time to Work	MTT to Work	Transit Need Index	Transit Need
Conroe	36,811	37.9	972.0	3.6	16,393	44.5%	1.0	23.4	0.7	19.5	High
Cut and Shoot	1,158	2.7	425.7	1.6	473	40.8%	0.9	32.5	1.0	9.7	Medium
Magnolia	1,111	2.1	529.0	1.9	495	44.6%	1.0	37.1	1.1	11.8	Medium
Montgomery	489	4.6	107.0	0.4	237	48.5%	1.1	33.6	1.0	4.0	Medium
Oak Ridge North	2,991	1.2	2600.9	9.5	1,583	52.9%	1.2	30.2	0.9	49.7	Very High
Panorama Village	1,965	1.1	1770.3	6.5	853	43.4%	1.0	26.6	0.8	34.2	Very High
Patton Village	1,391	2.1	678.5	2.5	555	39.9%	0.9	37.5	1.1	14.4	Medium
Pinehurst	2,274	9.0	251.8	0.9	873	38.4%	0.8	25.1	0.8	6.2	Medium
Porter Heights	1,490	3.2	470.0	1.7	721	48.4%	1.1	37.1	1.1	10.8	Medium
Roman Forest	1,279	1.5	864.2	3.2	614	48.0%	1.1	36.2	1.1	18.0	High
Shenandoah	1,503	1.3	1192.9	4.4	810	53.9%	1.2	28.5	0.9	23.9	High
Splendora	1,275	2.1	604.3	2.2	592	46.4%	1.0	38.2	1.2	13.3	Medium
Stagecoach	455	1.2	382.4	1.4	262	57.6%	1.3	40.0	1.2	9.5	Medium
The Woodlands	55,649	23.9	2330.4	8.5	25,622	46.0%	1.0	32.5	1.0	44.7	Very High
Willis	3,985	3.3	1211.2	4.4	1,548	38.8%	0.9	27.2	0.8	23.9	High
Woodbranch	1,305	2.0	669.2	2.5	636	48.7%	1.1	36.0	1.1	14.4	Medium
Woodloch	247	0.1	2744.4	10.1	163	66.0%	1.4	27.3	0.8	52.6	Very High
									-1.5 StDev	(15.8)	Very Low
									-0.5 StDev	(0.6)	Low
									+0.5 StDev	14.6	Medium
									+1.5 StDev	29.8	High
											Very High

2. Commute to Work Index

Weight				1			5		1	7	
Total County Area	293,768	1,076.81	272.8	1.0	134,118	45.7%	1.0	32.9	1.0	7.0	
Montgomery County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to Work Index	Mean Travel Time to Work	MTT to Work	Transit Need Index	Transit Need
Conroe	36,811	37.9	972.0	3.6	16,393	44.5%	1.0	23.4	0.7	9.2	High
Cut and Shoot	1,158	2.7	425.7	1.6	473	40.8%	0.9	32.5	1.0	7.0	Medium
Magnolia	1,111	2.1	529.0	1.9	495	44.6%	1.0	37.1	1.1	7.9	Medium
Montgomery	489	4.6	107.0	0.4	237	48.5%	1.1	33.6	1.0	6.7	Medium
Oak Ridge North	2,991	1.2	2600.9	9.5	1,583	52.9%	1.2	30.2	0.9	16.2	Very High
Panorama Village	1,965	1.1	1770.3	6.5	853	43.4%	1.0	26.6	0.8	12.1	High
Patton Village	1,391	2.1	678.5	2.5	555	39.9%	0.9	37.5	1.1	8.0	Medium
Pinehurst	2,274	9.0	251.8	0.9	873	38.4%	0.8	25.1	0.8	5.9	Medium
Porter Heights	1,490	3.2	470.0	1.7	721	48.4%	1.1	37.1	1.1	8.2	Medium
Roman Forest	1,279	1.5	864.2	3.2	614	48.0%	1.1	36.2	1.1	9.5	High
Shenandoah	1,503	1.3	1192.9	4.4	810	53.9%	1.2	28.5	0.9	11.1	High
Splendora	1,275	2.1	604.3	2.2	592	46.4%	1.0	38.2	1.2	8.5	Medium
Stagecoach	455	1.2	382.4	1.4	262	57.6%	1.3	40.0	1.2	8.9	High
The Woodlands	55,649	23.9	2330.4	8.5	25,622	46.0%	1.0	32.5	1.0	14.6	Very High
Willis	3,985	3.3	1211.2	4.4	1,548	38.8%	0.9	27.2	0.8	9.5	High
Woodbranch	1,305	2.0	669.2	2.5	636	48.7%	1.1	36.0	1.1	8.9	High
Woodloch	247	0.1	2744.4	10.1	163	66.0%	1.4	27.3	0.8	18.1	Very High
									-1.5 StDev	1.9	Very Low
									-0.5 StDev	5.3	Low
									+0.5 StDev	8.7	Medium
									+1.5 StDev	12.1	High
											Very High

3. Mean Travel Time to work Index

Weight				1			1		5	7	
Total County Area	293,768	1,076.81	272.8	1.0	134,118	45.7%	1.0	32.9	1.0	7.0	
Montgomery County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to Work Index	Mean Travel Time to Work	MTT to Work	Transit Need Index	Transit Need
Conroe	36,811	37.9	972.0	3.6	16,393	44.5%	1.0	23.4	0.7	8.1	Medium
Cut and Shoot	1,158	2.7	425.7	1.6	473	40.8%	0.9	32.5	1.0	7.4	Medium
Magnolia	1,111	2.1	529.0	1.9	495	44.6%	1.0	37.1	1.1	8.6	High
Montgomery	489	4.6	107.0	0.4	237	48.5%	1.1	33.6	1.0	6.6	Medium
Oak Ridge North	2,991	1.2	2600.9	9.5	1,583	52.9%	1.2	30.2	0.9	15.3	Very High
Panorama Village	1,965	1.1	1770.3	6.5	853	43.4%	1.0	26.6	0.8	11.5	Very High
Patton Village	1,391	2.1	678.5	2.5	555	39.9%	0.9	37.5	1.1	9.1	High
Pinehurst	2,274	9.0	251.8	0.9	873	38.4%	0.8	25.1	0.8	5.6	Medium
Porter Heights	1,490	3.2	470.0	1.7	721	48.4%	1.1	37.1	1.1	8.4	Medium
Roman Forest	1,279	1.5	864.2	3.2	614	48.0%	1.1	36.2	1.1	9.7	High
Shenandoah	1,503	1.3	1192.9	4.4	810	53.9%	1.2	28.5	0.9	9.9	High
Splendora	1,275	2.1	604.3	2.2	592	46.4%	1.0	38.2	1.2	9.0	High
Stagecoach	455	1.2	382.4	1.4	262	57.6%	1.3	40.0	1.2	8.7	High
The Woodlands	55,649	23.9	2330.4	8.5	25,622	46.0%	1.0	32.5	1.0	14.5	Very High
Willis	3,985	3.3	1211.2	4.4	1,548	38.8%	0.9	27.2	0.8	9.4	High
Woodbranch	1,305	2.0	669.2	2.5	636	48.7%	1.1	36.0	1.1	9.0	High
Woodloch	247	0.1	2744.4	10.1	163	66.0%	1.4	27.3	0.8	15.7	Very High
									-1.5 StDev	2.7	Very Low
									-0.5 StDev	5.6	Low
									+0.5 StDev	8.4	Medium
									+1.5 StDev	11.3	High
											Very High

APPENDIX C:

Brazoria County Commuter Need Index

1. Population Density Index

Weight				5			1		1	7	
Total County Totals	241,767	1,597.4	151.3	1.0	104832	43.4%	1.0	28.0	1.0	7.0	
Brazoria County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to Work Index	Mean Travel Time to Work	Mean Travel Time to Work Index	Transit Need Index	Transit Need
Alvin	21,413	17.3	1,234.9	8.2	9,463	44.2%	1.0	29.1	1.0	42.9	Very High
Brookside Village	1,960	2.1	928.9	6.1	904	46.1%	1.1	28.4	1.0	32.8	High
Hillcrest	722	0.4	1,640.9	10.8	313	43.4%	1.0	29.8	1.1	56.3	Very High
Iowa Colony	804	5.8	139.3	0.9	332	41.3%	1.0	41.0	1.5	7.0	Medium
Liverpool	404	1.0	425.3	2.8	180	44.6%	1.0	34.1	1.2	16.3	Medium
Manvel	3,046	23.3	130.7	0.9	1,492	49.0%	1.1	35.2	1.3	6.7	Medium
Pearland	37,640	35.9	1,047.6	6.9	19,156	50.9%	1.2	30.0	1.1	36.9	Very High
									-1.5 StDev	(21.4)	Very Low
									-0.5 StDev	(2.5)	Low
									+0.5 StDev	16.5	Medium
									+1.5 StDev	35.4	High
											Very High

2. Commute to Work Index

Weight				1			5		1	7	
Total County Totals	241,767	1,597.4	151.3	1.0	104832	43.4%	1.0	28.0	1.0	7.0	
Brazoria County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to Work Index	Mean Travel Time to Work	Mean Travel Time to Work Index	Transit Need Index	Transit Need
Alvin	21,413	17.3	1,234.9	8.2	9,463	44.2%	1.0	29.1	1.0	14.3	Very High
Brookside Village	1,960	2.1	928.9	6.1	904	46.1%	1.1	28.4	1.0	12.5	High
Hillcrest	722	0.4	1,640.9	10.8	313	43.4%	1.0	29.8	1.1	16.9	Very High
Iowa Colony	804	5.8	139.3	0.9	332	41.3%	1.0	41.0	1.5	7.1	Medium
Liverpool	404	1.0	425.3	2.8	180	44.6%	1.0	34.1	1.2	9.2	High
Manvel	3,046	23.3	130.7	0.9	1,492	49.0%	1.1	35.2	1.3	7.8	Medium
Pearland	37,640	35.9	1,047.6	6.9	19,156	50.9%	1.2	30.0	1.1	13.9	Very High
									-1.5 StDev	1.5	Very Low
									-0.5 StDev	5.2	Low
									+0.5 StDev	8.8	Medium
									+1.5 StDev	12.5	High
											Very High

3. Mean Travel Time to work Index

Weight				1			1		5	7	
Total County Totals	241,767	1,597.4	151.3	1.0	104832	43.4%	1.0	28.0	1.0	7.0	
Brazoria County	Population	Land Size (Total Area)	Population Density	Population Density Index	Commuting to Work	% Commute to Work	Commute to Work Index	Mean Travel Time to Work	Mean Travel Time to Work Index	Transit Need Index	Transit Need
Alvin	21,413	17.3	1,234.9	8.2	9,463	44.2%	1.0	29.1	1.0	14.4	Very High
Brookside Village	1,960	2.1	928.9	6.1	904	46.1%	1.1	28.4	1.0	12.3	Very High
Hillcrest	722	0.4	1,640.9	10.8	313	43.4%	1.0	29.8	1.1	17.2	Very High
Iowa Colony	804	5.8	139.3	0.9	332	41.3%	1.0	41.0	1.5	9.2	High
Liverpool	404	1.0	425.3	2.8	180	44.6%	1.0	34.1	1.2	9.9	High
Manvel	3,046	23.3	130.7	0.9	1,492	49.0%	1.1	35.2	1.3	8.3	Medium
Pearland	37,640	35.9	1,047.6	6.9	19,156	50.9%	1.2	30.0	1.1	13.5	Very High
									-1.5 StDev	2.2	Very Low
									-0.5 StDev	5.4	Low
									+0.5 StDev	8.6	Medium
									+1.5 StDev	11.8	High
											Very High