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Frequent Network Bus Systems:
An Analysis of Houston's Bus Re-Imagining's Impact on Access

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Frequent Network Bus Systems:
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Abstract

Frequent Network Bus Systems:
An Analysis of Houston's Bus Re-Imagining's Impact of Access

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The aim of this report is to demonstrate the potential impact of a from-scratch redesign of the Houston, Texas bus system on communities within the city. It discusses the theory behind the new system, including the role of frequent networks, all-day service, gridded coverage, and perceptions of transfers. In addition, it reflects on the necessary political backing, technical expertise, and large scale public outreach efforts inherent in a successful transit system redesign for a city of over 2 million. Finally this paper analyses the impact of the new system by comparing how various Houston communities access has been altered though socio-economic, commute pattern, and employment lenses.

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Chapter One: Introduction

What is the role of transit in a city? Is it a tool to address questions of equity between neighborhoods and communities? Is it a tool to address congestion and it's ever increase toll on cities economies? A tool which supports and aids development and design of economically profitable urban form? Or a vital to the reduction of VMT, carbon emissions and the inherent environmental harm automobiles carry with them? Each and all of these questions are often understood to be truth by those who believe them. And in turn many transit agencies find themselves directed in various paths by people who think transit serves the same purpose as them.

In truth all of these are better viewed as outcomes of transit, not as its primary purpose. The primary role of transit should be viewed the same as the primary role of driving, or walking, or biking. Transits role is to allow the most amounts of people to access where they want to get to within a city, and to get them there when they want (usually as quickly as possible). Transit is a means to an end, the end being the ability to move freely within a city.

This is the basic principle behind a new wave of transit system redesigning happening across the United States. Coined 'Abundant Access'[i] this new transit theory promises a cost neutral way to redesign transit systems. Often using the same buses and operating costs these redesigns were first picked up by smaller cities. Salem, OR[ii], and Bellevue, WA[iii] followed by larger cities such as Indianapolis, IN[iv], and Raleigh, NC[v]. Houston, Texas has been the largest and most high profile city yet to undergo this redesign process[vi].

Looking to address a startling lack of transit ridership for a city of its size, Houston looked to these 'Abundant Access' principles as a tool to reinvigorate and jumpstart its struggling transit system. The redesign process, termed a 'System Re-Imagining'[vii], was a three-year process that through publicly defined goals and outcomes took a blank slate approach to redesigning the entirety of Houston METRO[1]'s bus system.

This report will look at the theory behind this new wave of transit deigns, the process which Houston METRO underwent in order to create a brand new transit system for a population over 2.2 million people and will analysis Census and LEHD data in order to determine the impact this new system will have on the community.

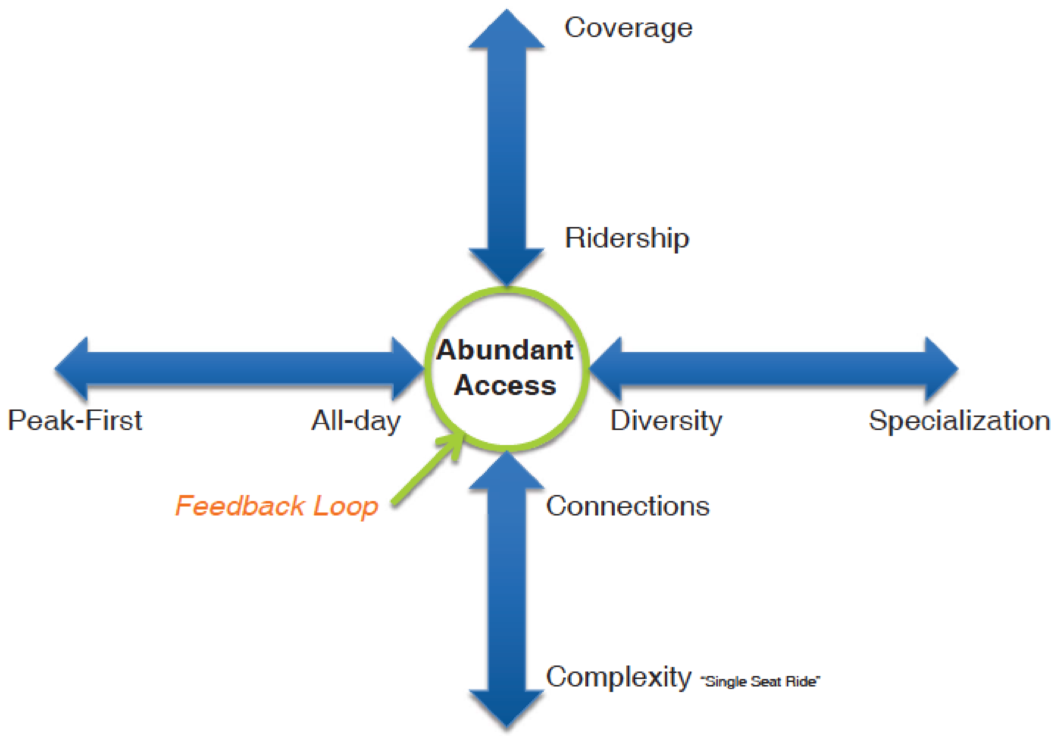
[1] METRO: Metropolitan Transit Authority of Harris County

Chapter Two: Literature Review

Traditionally bus system design is targeted to compete with work commute trips, running in radial patterns from inner suburbs where workers live to their central business district employment. This pattern has been in existence and remains in existing long since central business districts lost their place as urban job centers. Newer development patterns have created suburban office parks, employment districts in the form of university campuses, medical districts, and more recently in tech jobs locating within urban areas in order to attract young workers wanting urban lifestyles.

Through all of this buses have consistently retained their traditional routes, perhaps adding new lines to attempt to capture some of these changes. Over time bus systems have found themselves locked in to a system pattern which has become outdated, running a system for development patterns and users who have changed beneath their feet. In recent years the alternative abundant access of bus system development has emerged. Aiming to address these failings and present a version of transit which can compete with the car in more than just work commute trips. Promising a potential solution, which when implemented with urban development, can allow for sustainable people-over-car development patterns and in turn. Creates safer streets, attracts young professionals back into the city, and allow for the denser development that allows economic development to strive[viii].

Figure 1 - Abundant Access Theory: Transit System Design Trade-offs

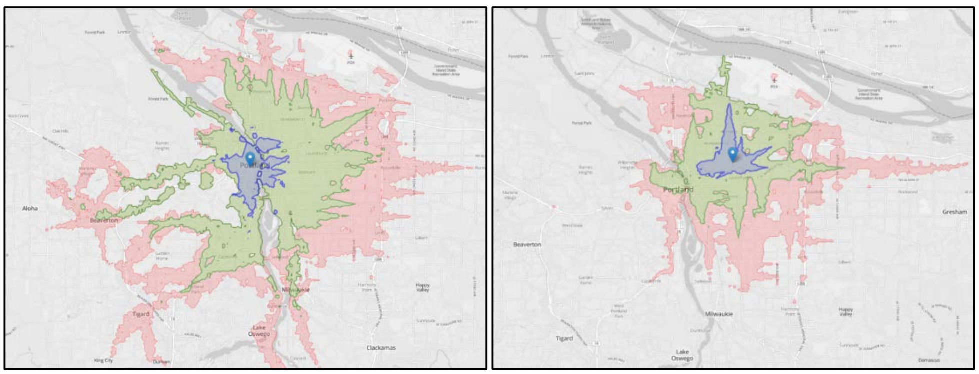


Coverage vs Ridership (Rename) Jarrett Walker + Associates
METRO Re-Imagining Process Presentation

ABUNDANT ACCESS

The principle of abundant access is not simply where can I reach by transit, but how soon can I get there. Transit's inherent weakness is waiting times[ix], but through the application of systems with focus on frequent service network allowing for ridership goals, with all day service, a system dependent upon connections to increase range, and a gridded network with non-radial lines overall abundant access is expanded. A visualization of this theory is isochrone mapping showing how far you can move within a city using transit at any given moment.

Map 1 - Isochrone Maps: Transit mobility differences between downtown and north Portland, OR



(www.humantransit.com)

This changes the idea of transit to can I reach a single destination to how much freedom of movement do I currently have. Helping potential users to visualize a way of life without the need of an automobile. These maps, integrating wait times, show how much of the city is accessible at 15 minutes (blue), 30 minutes (green), and 45 minutes (red) dependent on where your origin points is.

Coverage Goals v. Ridership Goals

Transit agencies face an essential issue, which often goes unaddressed or overlooked when performance goals are created. This issue is comes down to how a community views transit role. Transit is often viewed as a basic need for low income or at risk communities, meaning that transit agencies should maintain basic level of service to as many of these communities as possible. At the same time almost all transit agencies in the US are given directives to minimize cost to the taxpayer, meaning that transit should be run like a private enterprise focusing primarily on high ridership routes in dense corridors in order to cover operating costs.

Coverage System

Coverage goals allow transit agencies to look to equity issues, ensuring that all residents of a city are given access to mobility to jobs and services. A primarily coverage bus system would run lines to all areas of a city, no matter how spread out or suburban in form. Due to this spread out form costs would limit most lines to only a few buses per day. This would guarantee every resident had access to transit, but only at a few moments of the day reducing the amount of use each line served. An example of this would be a stop in which the first bus arrives after the rider's job would start each morning; access is there but meaningless.

Ridership System

In contrast a ridership-focused service would look like a private enterprise bus system, such as the new system appearing in San Francisco.[x] Running only at morning and evening commutes times these private buses run at higher costs between Silicon Valley at downtown San Francisco targeting tech workers currently sitting in traffic. There is no attempt at equity and prices are raised to cover operating costs, pricing the service out for most even if the route served their needs. In public transit these lines would be along direct high-density corridors, mimicking where most cities have placed or hope to place rapid transit services such as Light Rail or Bus Rapid Transit service.

Peak First Service v All-Day Service

While on its surface all transit service may appear to be the same a strong distinction emerges in how transit agencies view their role in the community. This division comes down to if transit is viewed as a peak first service, meaning that morning and evening commutes to and from work are its primary role, or if all-day service is the primary objective allowing city residents the ability to access transit as a primary mode for more than just commute trips. . While this may seem like an argument of semantics the reason the distinction is important lies in how a transit agency defines its role in the community.

Peak First Service Theory

Peak service focus is a common sense approach to transit. Trip generation and ridership models are based of commute patterns and transit engineering teaches that the A to B home to work trip is the most transit competitive it makes sense for transit to target these trips.[xi] An example of a purely peak commute transit service would be Houston's successful park and ride system.[xii] Running buses down HOV lanes from Houston's large suburbs to city center these services allow commuters to avoid traditional congestion. The abundant access theory does not argue that these systems can't be highly successful and shouldn't exist. It simply shows how applying these peak commute service to the local bus system creates barriers to transit use. Peak service theory at the local transit level leads to high frequency at peak commute hours a little to no service mid-day and on weekends, as there are less commute jobs at these times.

All-Day Base Service Theory

What all-day service allows for is a more sustainable lifestyle that many cities, including Houston, are striving towards. All day focus allows users the security needed to reduce car ownership, meaning that two car households will know if they reduce to one their access to transit will exist at all times, not just in morning evening commute times. This allows transit to begin competing will car ownership and not simply commuting car ownership. Transit can be taken on weekends or for quick coffee trips during the day. It's important for transit agencies to understand that the ability to reduce car ownership is vital for transit success. One the initial investment is placed in car ownership; both in the car itself and also in the land necessary to park the car, the incentive to take transit dramatically drops.[xiii] Once the investment is placed into car ownership it becomes the lowest barrier mode for the household.

SPECIALIZATION OF LINES V. DIVERSITY OF LINES

Similar to complexity vs connections this argues that lines should run geometrically as opposed to destination based. Traditional systems run in a radial pattern between suburbs and central business districts, but in most mid to large scale cities are poly centric making traditional radial systems inefficient often requiring users to make a transfer downtown only to take another radial line to their destination. A diverse line places the central business district or main node near the middle of the line allowing easy transferring along the gridded network.

Specialized Destination Based Routes

Most cities developed their transit systems based off of where the lines have always run. In Houston, and most major cities, you can find lines named after streets that no longer exist or running the same route as the old streetcar.[xiv] This is due to transit services expanding slowly over time to meet new demands and destinations. This often leads to lines being designed between destinations from campus or an entertainment district to downtown. As mentioned this leads to scenarios where a potential rider wanting to connect to a destination other than the central business district needing to transfer via downtown, often adding significant time over driving. Meaning that while access exists it is not mode competitive in any sense.

Diverse Geometric Based Routes

The counter to this traditional route design and growth it a frequent network grid. Implemented in Portland, OR[xv] and San Francisco[xvi] in the past decades a frequent grid mimics many of the same benefits as a street grid does for automobile movement. The key to a gridded system is geometric distribution of frequent lines across a city .This allows access to any destination downtown or otherwise with the use of multiple frequently running bus lines. This system only works with frequent service due to the need to transfer between multiple bus lines, something most transit agencies still strive to avoid.[xvii]

SYSTEM COMPLEXITY V. SYSTEM CONNECTIONS

Traditionally in transit design there has existed a theory that transfers, meaning the need to change bus lines mid-trip, should be minimized. (CITATION) [xviii]While this theory makes sense when considering rider convince in a traditional infrequent bus service in which a transfer may add as much as an hour of wait time to a trip, frequent service grids remove wait time barriers and change the dynamics of how bus systems can operate. (CITATION)[xix]

Complex Point to Point Lines

Traditional bus systems designed using four-step modeling[xx]look at the most dense origin and destination traffic analysis zones (TAZs) in a city. Ramping up peak service to meet commute demand the remaining services look to run between areas with the highest potential ridership, considering demographics and travel survey trends. The result of this model are bus lines which run infrequently bus attempt to mimic automotive travel, meaning creating the best possible point to point service for the largest group of users. When a system only runs buses at headways between 30 minutes and one hour at off peak times it makes sense to maximize users who can time their trips around transit.

Connections Requiring Transferring

As covered before a frequent grid network allows for an alternative approach to how transfers are addressed. When running frequent lines it becomes possible for a rider to make a transfer with a maximum 15 minute wait time, much lower during peak hours. Important to note about this change in transit approach is how many transit agencies still punish users for transferring, requiring a second bus fare for transfers being a common policy for many agencies.[xxi] With the introduction of smart transit cards or even simple timed transfer slips it becomes easy to allow users to purchase a transit fare for a set amount of time leaving transfers free. Meaning that riders purchase a trip from origin to destination not a seat on each bus they board. This allows the bus system to become more efficient, non-radial, and frequent increasing mode competitiveness with cars.

ABUNDANT ACCESS FEED BACK LOOP

Finally the abundant access illustration highlights a feedback loop in the system. This is due to the potential of these design tradeoffs buttressing each other. The easiest to understand is the need for connection through easy traders with you want a gridded network to succeed. In addition a ridership system, meaning frequent service competitive with cars, also needs to run all-day base services in order for low and zero car households to exist. While each of these tradeoffs can benefit a systems ridership they need to be implemented as a complete strategy to gain their full potential benefits.

Chapter Three: Houston Texas

Bus System Re-Imagining

The ability for Houston to undergo the process to completely eliminate their existing bus system and start from scratch required strong political support, the technical ability to improve the existing system, and a strong commitment to public outreach as backlash from this proposal remained as high an obstacle to success as the others.

Political Leadership

The political support for this plan came primarily from two sources. On April 1st, 2010 Christof Spieler was appointed to the Houston METRO board of directors. A civil engineer by trade Spieler has stated he believes he is the first transit board director to be appointed due to blogging[xxii], having run a transit advocacy blog (www. Intermodality.us) about the Houston region since 2005 and being a proud transit rider Spieler was key in identifying the Re-Imagining opportunity and punishing for the technical consulting team necessary for its success. In addition Mayor Annise Parker brought high-level support to the process having a proven track record of taking on similar issues with traditionally low political reward to risk ratio[xxiii]. Without these two political leaders it's hard to imagine a scenario in which this a clean slate system re-design would have been achievable.

Technical Ability

The technical support for this process came primarily from Jarrett Walker + Associates. (JW+A) Working from the abundant access theory referenced in the last section. With experience working with cities across the US and internationally JW+A has been implementing its frequent network grid and abundant access theory in increasingly largest cities in the US. With the promise to increase ridership and provide transit in a more sustainable form two smaller cities in the Northwest Salem, OR[xxiv] and Bellevue, WA[xxv] were the first to attempt the shift. While some midrange cities such as Raleigh, N[xxvi]C are currently in the redesign process Houston will be the largest recent example for implementing a from-scratch redesign.

Education and Outreach

A large reason why total system redesigns are uncommon lies in the outreach challenge facing the process. In general transit redesign brings political risk due to the large impact changes have to current users, and the challenge in getting potential users interested in the process. For this process to succeed Houston must convince its current users they will not lose their current level of service and convince current non-users that they should be invested in a new system.

This challenge was meet through a large outreach and education focus within the process[xxvii]. Involving as many stakeholders as possible and using the opportunity to educate on transit system design, agency goals and community opportunities which the new system could provide.

THE RE-IMAGINING PROCESS

Timeline

Table 1 - Process Timeline

METRO Transit System Re-Imagining Timeline	
Project Stage	Description
Existing Conditions	Understand METRO service area and transit system; what is working? ; where are challenges?
Public Input on Goals and Trade-offs	Educate and inform public about the project collect feedback on project goals and potential trade-offs.
Defining Goals	Define goals and service standards to guide transit system design.
Core System Planning	Develop draft of Re-Imagined Transit System Plan, optimized to meet the defined goals.
Defining Outcomes	Analyze potential impact of drat Transit System plan including benefits and impacts.
Public Outreach on Proposed Plan	Share Re-Imaged Transit System Plan with public for comment and feedback.
Refine and Finalize	Refine plan and finalize 5-year Transit Service Plan.
Adopted by City Council	February 11th, 2015
Implemented	August 1st, 2015

Table adopted from METRO stakeholder taskforce presentation.

The Houston Bus System Re-Imagining is the public name given to the creation and adoption of the 5-year transit service plan. The process began in May 2013[xxviii] and ended with official adoption by Houston city council on February 11th, 2015[xxix] with the actual changes to service occurred on August 1st, 2015.[xxx] The primary consultant in the process was Jarrett Walker + Associates the group behind the theory of abundant access and the recent trend in bus system redesign. Houston will be the largest example of this process in recent years, with Portland, OR and San Francisco, CA having adopted frequent network grids more than a decade ago.

With such a large focus of the redesign theory based in the realm of tradeoffs in transit service community buy in and public outreach were a key focus of the process. Below is a list of represented organizations and community groups in the stakeholder taskforce.

KEY FACTORS LEADING TO RE-IMAGINING

During the process five factors[xxxi] were identified as key reasons why a network redesign was needed. These factors were also taken into consideration during stakeholder and technical redesign in order to better inform the process.

Factor One: Public Request

During a recent long range planning process conducted by Houston METRO public comments were collected on the current state and potential improvement opportunism. Among these were large amounts of comments requesting better frequency of service and calls to simplify the system.

Factor Two: Need to Redefine Goals

As describe in abundant access theory it is vital for a transit agency to clearly place ridership and coverage goals in context within the agencies larger role in the community. As part of the Re-Imagining process it was determined that Houston METRO needed to reassess and clarify its agency goals.

Factor Three: Houston Is Changing

Houston's infamous lack of planning, combined with the economic success if has found in recent years has led to pockets of dense development patterns, notable a large increase in jobs and housing densities to the west of the traditional downtown. The redesign process is seen as an opportunity to allow Houston's traditional bus network to catch up with the city's new urban form.

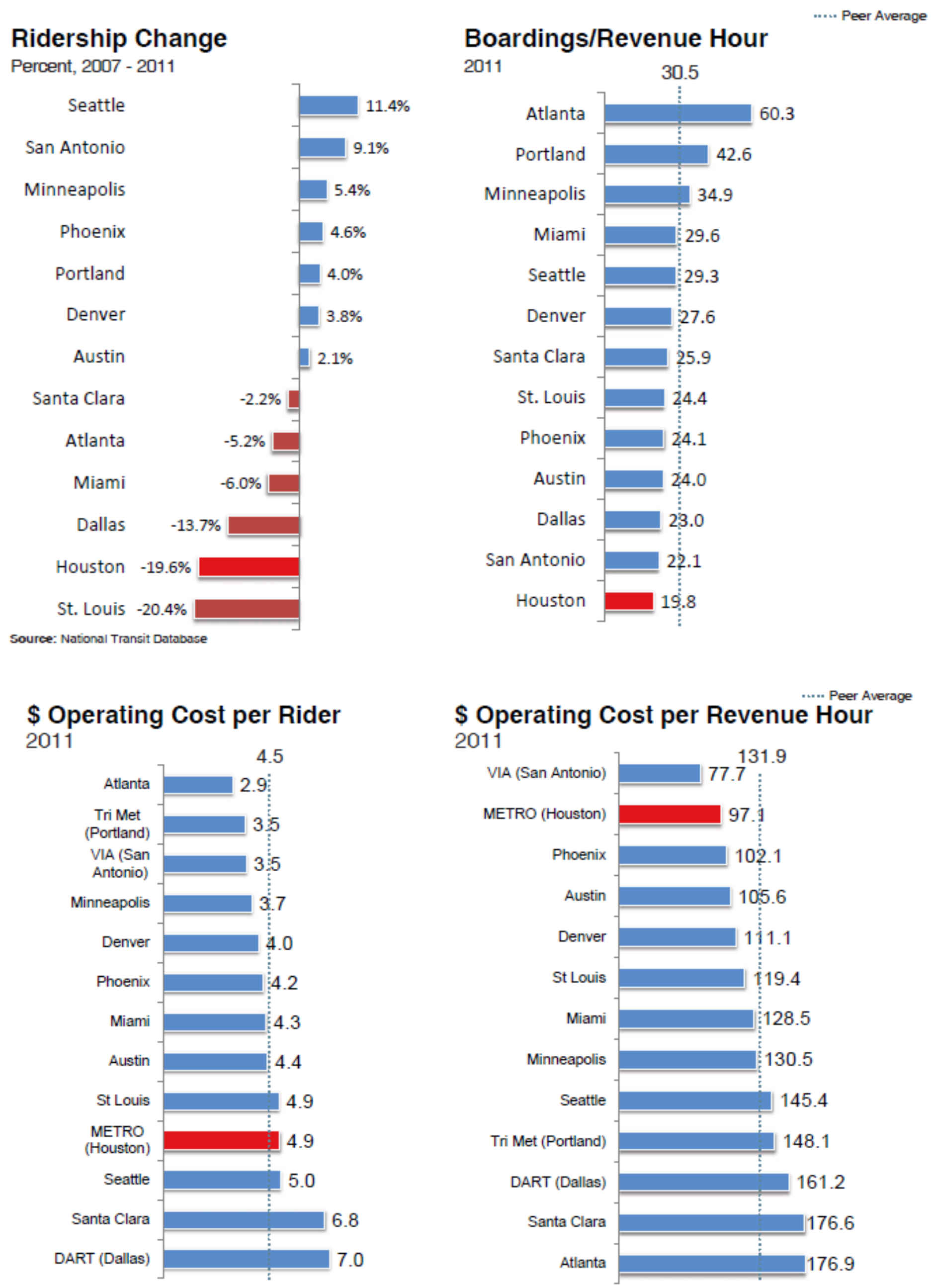
Factor Four: New Light Rail Lines

On January 1st, 2004 Houston introduced the city's first light rail line.[xxxii] The Red line ran north-south through historic north side of Houston. Success saw the Red line expanded to 7.5 miles in December 2013. Combined with the recent additions of the Purple Line, a 6.6 mile southeast connection, and the Green Line, a 3.3 mile link to east Houston, many of Houston's high ridership bus lines in the downtown became obsolete for redundant services.[xxxiii] The redesign process is seen as a way to best reassign this freed up bus service to more needed places.

Factor Five: History and Peer Performance

During the most recent recession Houston METRO saw a dramatic decrease in ridership, a trend observed nationwide.[xxxiv] Unfortunately for METRO ridership numbers never recovered to pre-recession levels as seen in comparable cities.[xxxv]

Figure 2 - Peer Average Comparisons from METRO Re-Imagining Presentation



Houston METRO Reimagining, “System Reimagining: Project Update.”

RE-IMAGINING STAKEHOLDERS

Stakeholder Taskforce Representatives

- METRO Member Cities and Harris County
- Neighborhood and Management Districts
- Educational Institutions
- Health Care Providers
- Social Service Providers
- Disability Advocacy Groups
- METRO Riders
- METRO Customer Advisory Committee
- Non-Profits and Advocacy Groups
- Other Governmental Agencies
- Real Estate Developer Groups
- METRO Staff

This taskforce meet regularly throughout the process and importantly also attended courses taught by Jarrett Walker + Associates teaching transit theory through practical examples and lessons on transit operation principles. Emphasis was placed on connecting the process with as many of those impacted in the community as possible. With attention paid to incorporating early on in the process any stakeholders who may find themselves suppressed and upset by outcomes of the process.

System Design Objectives And Outcomes

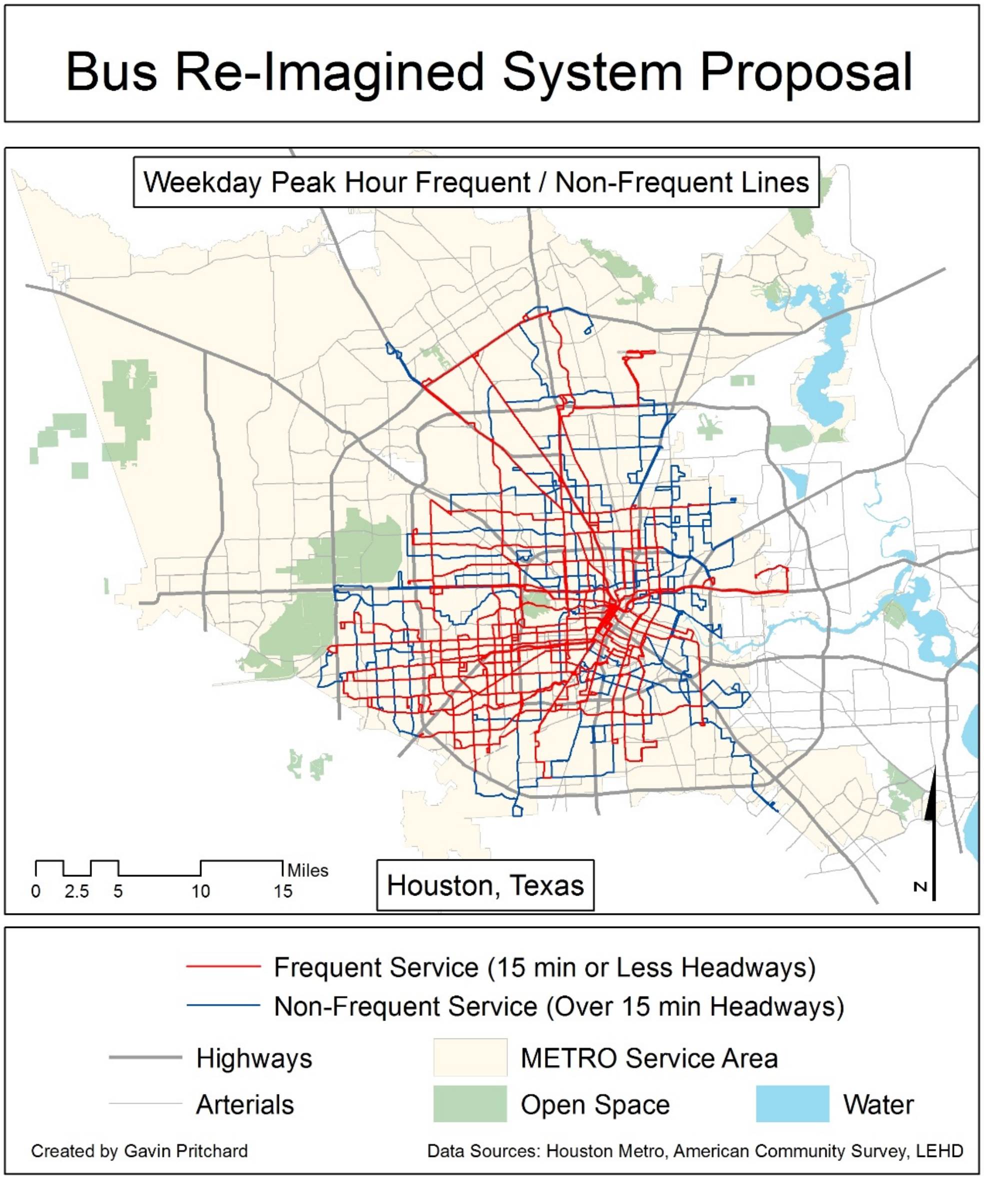
Through stakeholder meetings and the Re-Imagining process a ridership to coverage ratio of 80% ridership focus to 20% coverage focus was determined the best distribution for Houston METRO. Using this as the basis for the new network design key objectives were set by stakeholders and utilized in the redesign process by consultants and Houston METRO staff.

1. Establishing a 'Frequent Network'
2. Expansion of All-Day Service
3. Matching the System to the City

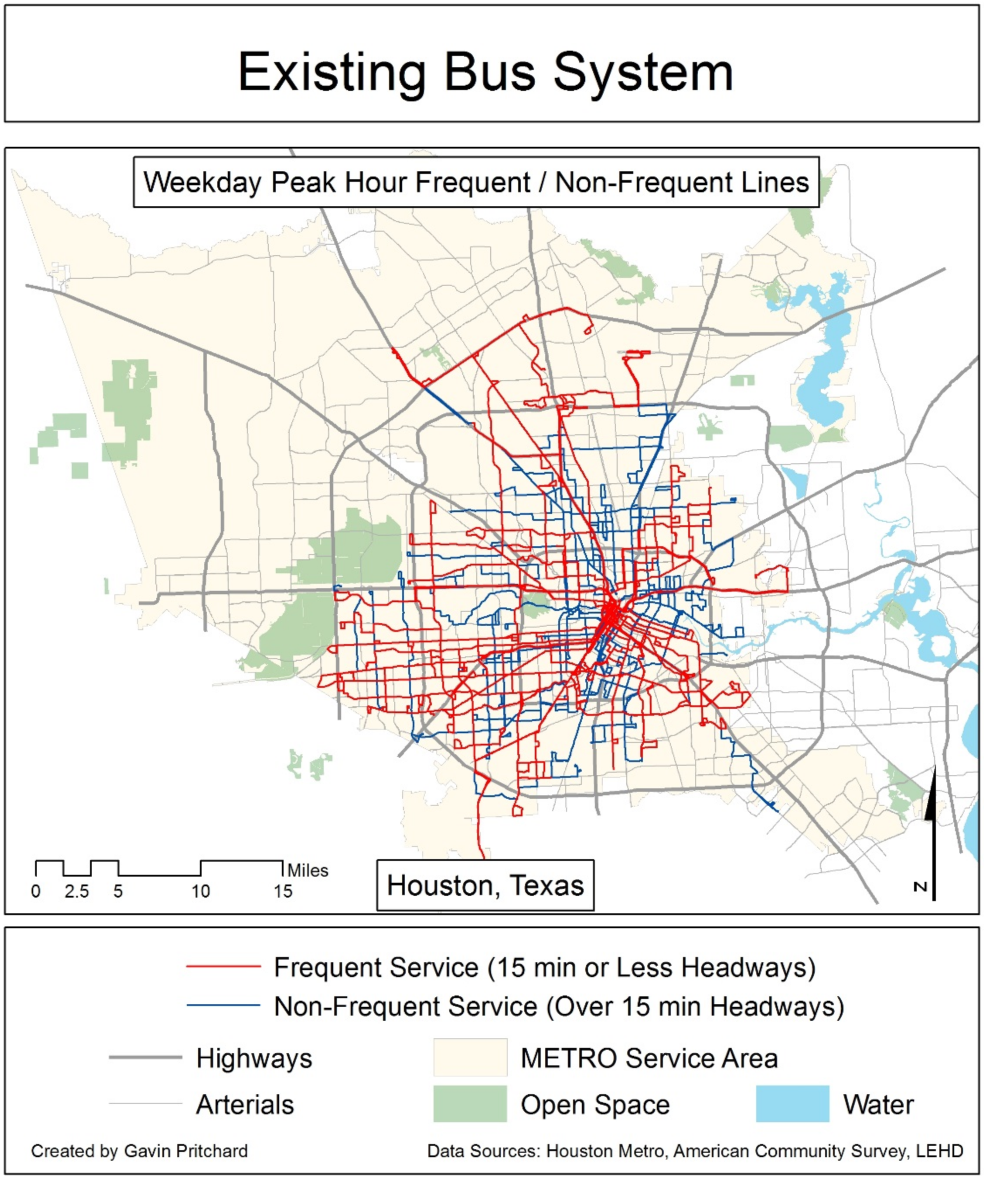
The three key objectives[xxxvi] for the new system were a focus in the formation of a frequent network grid as the new core of the system, an expansion of weekend services to allow for a more diverse use of the system, and finally to take the opportunity to update the transit system to the current development pattern of the city reintegrating newer employment and housing districts currently underserved by the existing traditional system.

This report looks at how the proposed abundant access based Re-Imagined bus network compares to the existing traditional system to see if it indeed matches to the objective set by stakeholders. This analysis also looks how the newly proposed network affects existing communities within the city of Houston.

Map 2 - Map of the Proposed Houston METRO Re-Imagined Bus System



Map 3 - Map of the Existing Houston METRO Bus System



Chapter Four: Methodology

PURPOSE OF REPORT

The purpose of this report is to reveal how the new Re-Imagined bus system, with promises of higher ridership and improved access, will impact Houston communities. This is achieved through comparing how the old and new systems will provide access to overall housing and employment, at multiple levels of demographics.

TIME OF DAY AND FREQUENT SERVICE

Key to this report is the analysis of bus service at multiple times through the day helping to reveal not just where buses run, but when they are available. The analysis looks at frequent and non-frequent services at Weekday Peak, Weekday Non-Peak and All Day Weekend Times. Weekday Peak is defined as the average typical headway for morning (7 am to 10 am) and evening (4 pm to 7 pm) peak times. Weekday Non-Peak, also called midday and evening service, is a reflection of the base level of service available. For this report Non-Peak is defined midday (Noon), as most lines run equivalent or less evening service. Finally All Day Weekend service is considered as an average without peaks due to the reducing in commuting on weekends. Frequent service is defined as headways, a bus arriving, every 15 minutes or less, while Non-Frequent is defined as headways every 16 minutes or more, though typical Non-Frequent service is nearer to 30 minute headways,

Table 2 - Table of Time of Day and Service Levels Analyzed

Time of Day Service	Frequent Lines	Non-Frequent Lines
Weekday Peak	>=15 min Headways	<15 min Headways
Weekday Off Peak	>=15 min Headways	<15 min Headways
Weekend	>=15 min Headways	<15 min Headways

ANALYSIS DATA

Data collected for this analysis consists of three main types: Spatial data, Residential data, and Employment data.

Spatial Data

Spatial data for this report consists of the excising bus service, the newly implemented Re-Imagined service, service boundaries, and Census data boundaries.

Houston-Galveston Area Council (H-GAC)

Houston-Galveston Area Council (H-GAC) makes spatial data publicly available through their website, including the METRO's service area, bus routes and stops. This data includes information on bus line numbers, which were used to identify frequent and non-frequent services at peak, non-peak and weekend timeframes.

Houston METRO Re-Imagining Process

As part of the Re-Imagining process the proposed system shape file was made available to the public. Unfortunately no bus stops had yet been identified only a line shape files of the routes. This limited the analysis to comparing the existing and Re-Imagined routes without any stop information. While the ability to use point shape file of stops would allow a network GIS analysis, a simple aerial line buffer still provides an acceptable comparison when apply equally to both networks.

American Community Survey Data

In order to capture a representation of how communities will be impacted by the system change the most recently available American Communities Survey (ACS) data was used. 5 year estimates 2009-2013 data was chosen, while the 5 year estimates may miss some of the more recent changes to resident demographics the overall accuracy reflects a more precise reflection of Houston's communities.

Block Group Level

Whenever possible all residential data was collected at block group level, allowing for the finest grain analysis possible. The following table details what data sets were collected.

Table 3 - 2009-2013 Block Group Level ACS Data Collected

American Community 2009 – 2013 Survey (5-Year Estimates)		
Basic Demographics		***Commuting Trends***
Population	**Education**	**Average Travel Time to Work**
Total Population	Less than High School	Less than 10 minutes
Male	High School Degree	10 to 19 minutes
Female	Some University	20 to 29 minutes
	University Bachelor's Degree	30 to 39 minutes
Age Groups	Master's Degree or Above	40 to 59 minutes
17 and Under Years Old		60 to 89 minutes
18 to 34 Years Old	**Ethnicity**	90 Plus minutes
35 to 44 Years Old	Hispanic	
45 to 64 Years Old	White (Non-Hispanic)	**Commute Mode to Work**
65 and Older Years Old	Black (Non-Hispanic)	Working Aged Adults
	Asian (Non-Hispanic)	Autonomies (Drive Alone)
Transit Dependent (Under 17 or Over 65)	Other (Non-Hispanic)	Automobile (Carpool)
		Transit
Millennials (18 to 34 Years Old)		Bicycle
		Walk
		Work from Home

Census Tract Level

The one exception to collecting block group data was in looking at household vehicle ownership numbers. Although this data is only available at census tract levels, the ability to capture zero, low and high vehicle households is a viability tool in understating potential impact of transit access may have in allowing for reduced automobile reliance. For this report Zero, Low and High vehicle households are defined bellow.

Table 4 - Zero, Low and High Vehicle Households by Census Tract

Zero, Low and High Vehicle Households by Census Tract	
Household Type	**Definition**
Zero Vehicle Household	A zero vehicle household is a household of any size with zero registered vehicles.
Low Vehicle Household	A low vehicle household is a household of any size with at least one less registered vehicle then residents.
High Vehicle Household	A high vehicle household is a household of any size with at least one more registered vehicle then residents.

Longitudinal Employer-Household Dynamics (LEHD) LODES Data

Table 5 - 2012 LEHD Origin-Destination Employment Statistics Data Collected

LEHD 2012 Origin-Destination Employment Statistics (LODES)		
General Employment	**Employment by Income**	**Employment by Field**
Total Jobs	$1,250 per Month and Under	Retail Trade
	$ 1,251 to $3,333 per Month	Professional, Scientific, or Technical
Employment by Age	$3,334 per Month and Over	Educational Services
Under 29 Years Old		Health Care and Social Assistance
30 to 54 Years Old	**Employment by Education**	Accommodation and Food Services
Over 55 Years Old	Less than High School	Public Administration
	Advanced Degree (Master's Degree or Above)	

Geographical Information Systems (GIS)

The analysis was conducted using ESRI ArcGIS software as the primary program. The steps taken within ArcGIS are detailed through the tools used in the analysis.

Proximity Buffer Tool

Access to bus transit was defined through a quarter mile buffer, this reflects the 5-minute walk shed to transit. The ¼ mile buffer is a standard for local non rapid transit services. There is some argument that the ½ mile buffer used for LRT and BRT may be applicable for frequent service local bus lines this report uses a flat ¼ mile buffer for all comparisons. Using the proximity buffer tool in ArcGIS Frequent and Non-Frequent lines were determined at Peak, Off Peak and Weekend schedules.

Table 6 - Definition of ArcGIS Tool: Buffer

Proximity Buffer Tool	Using the set distance measurement of ¼ mile, the buffer tool creates a geodesic ring around the select bus lines. Approximating a 5 minute walking as the crow flies walk shed.

Overlay Intersect Tool

Block group and census tract shape files were joined to the ACS data described above allowing for and the ArcGIS Intersect tool to extract only the areas which overlay each other. While this does not affect the internal attributes of the demographic fields it does provide the new area of each clipped block group or census tract.

For the LEHD LODES dataset all data is represented with longitude and latitude information. Meaning that a simple intersect tool provides only those data points residing within the walking buffer.

Table 7 - Definition of ArcGIS Tool: Intersect

Overlay Intersect Tool	Using the joined ACS data joined to block group or census tract shape files, the Intersect tool allows for the area and attributes to be clipped at the buffered distances. While the area is representative of the final results, the ACS data is not affected by this intersect.

Aerial Interpolation

Once Intersected shape files are made with all intersecting block groups, or census tracts allowing the joined demographics to be viewed. This creates an issue when intersected block groups or census tracts are not entirely within the quarter mile buffer around bus lines. The shape file attributes continue to reflect the entire block group or census tract attributes. This issue is resolved through the use of aerial interpolation, the creation of a weighting factor based on the area difference between the original block group or census tract and the area of the intersected one. While this weighting system has some inherent flaw, in that it assumes an equal distribution of residents across the entire block group or census tract, the resulting weighted demographic results are more accurate with it applied. Additionally this weighting method is used for all results, meaning that any small system error is doesn't reflect the final comparisons.

Table 8 - Definition of Aerial Interpolation Weighting Method

Aerial Interpolation	Weighting the ACS data is achieved through the creating of a weighting factor based on area. The original block group or census tract area is divided by the intersected area.

SYSTEM AND COMPARISON TABLES

The resulting data was placed into table form, allowing for comparisons of each time of data and frequency of service against the overall service boundary results, meaning all possible users within the system. These results can then be compared against each other, offering a shift table broken down by time of day and by frequency of service. The results from this process are detailed in the next section.

Chapter Five: Analysis and Results

SERVICE COVERAGE COMPARISON

Spatial Comparisons

Time of Day

Comparing existing service with the new Re-Imaged network at the total system level no time of day considerations are taken into account. This looks at the system how most transit maps display showing where transit access exists, but ignoring when access exists.

Table 9 - Impact on System Lines and Miles: Total System

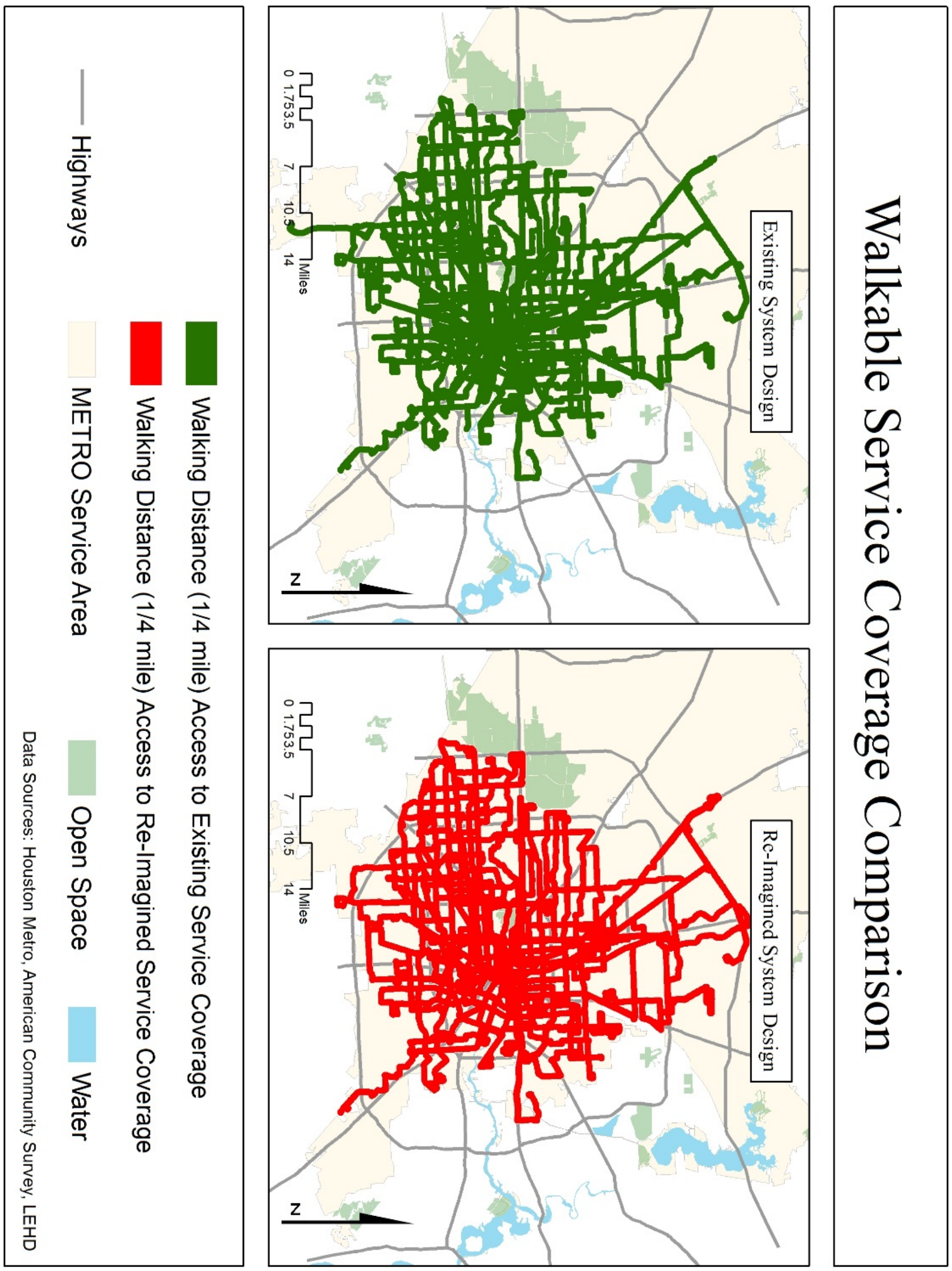
Total System	Number of Lines
Existing System	91
Re-Imagined System	103
Difference	**12**

Data Source: Metropolitan Transit Authority of Harris County

Frequency and Total Lines

With time of day and frequency not being taken into consideration results show that in total the shift from the existing to the new Re-Imagined system will introduce 12 new lines to the overall system.

Map 4 - Comparison Map of Walkable Service Coverages



Route Distribution Comparison

Looking at change sing to system route distribution at the entire service level it is clear the when frequency is not taken into account the system appear very similar. Exceptions to this are the elimination of a line extending far past the core to the south, and the creation of new connections, appearing as corners, to the northwest of the city center.

Demographic, Commute and Employment Comparisons

The difference in coverage between the existing and Re-Imagined systems is negligible, 0% to 3% shifts, at the whole system coverage level in both demographic and commute tables. This would appear to reflect the fact that the system was designed in a zero cost method, meaning that changes to the system are frequency and efficiency based more then added service.

Employment results did reflect an increase in select fields. With an percent changes of over 2% for total jobs in coverage, high income ($3,334 per Month and Over), increase in job field of ‘Professional, Scientific, Technical Service, and of jobs requiring a Master’s Degree of Higher it appear that the new system captures more of Houston’s medical and tech districts which have emerged in recent years.

Table 10 - Demographic Shifts: Service Coverage

Demographics Comparison:	Total System Coverage	
Population	Total	Percent Change
Male	114	0.01%
Female	-759	-0.04%
Total	-644	-0.04%
Age Groups		
17 and Under	-2192	-0.22%
18 to 34	1537	0.16%
35 to 44	-432	-0.04%
45 to 64	230	0.03%
65 and Over	108	0.04%
Transit Dependent (Under 17 or Over 65)	-2085	-0.11%
Millennials (18 to 34)	1537	0.16%
Education		
Less Than High School	-5294	-1.13%
High School	-623	-0.12%
Some University	2281	0.39%
University	3176	0.72%
Master's Degree or Above	1658	0.68%
Ethnicity		
Hispanic	-12275	-0.86%
White (Non-Hispanic)	4794	0.42%
Black (Non-Hispanic)	2015	0.27%
Asian (Non-Hispanic)	4118	1.61%
Other (Non-Hispanic)	704	1.24%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 11 - Commute Shifts: Service Coverage

Commute Comparison:	Total System Coverage	
Avg. Travel Time to Work	Total	Percent Change
Less than 10 minutes	758	0.58%
10 to 19 minutes	979	0.24%
20 to 29 minutes	252	0.07%
30 to 39 minutes	96	0.03%
40 to 59 minutes	1105	0.49%
60 to 89 minutes	68	0.06%
90 Plus minutes	171	0.57%
Commute Mode Used		
Working Aged Adults (16+)	3528	0.21%
Automobile	4338	0.33%
Carpool	-872	-0.45%
Transit	53	0.09%
Bicycle	-126	-2.16%
Walked	39	0.15%
Work from Home	98	0.17%
Automobile Ownership		
Total Vehicles	4175	0.34%
Zero Car Households	-106	-0.12%
Low Car Households	444	0.08%
High Car Households	364	0.44%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 12 - Employment Shifts: Service Coverage

Employment Comparisons:	Total System Coverage	
General Employment	Total	Percent Change
Total Jobs in Service Area	1784646	
Total Jobs in Coverage	37422	2.10%
Employees by Age		
Under 29	7503	1.83%
30 to 54	23116	2.22%
Over 55	6803	2.03%
Employees by Income		
$1250 / Month and Under	2973	0.99%
$1251 to $3333 / Month	8156	1.38%
$3334 / Month and Over	26293	2.95%
Employees by Field		
Retail Trade	3901	2.17%
Professional, Scientific, Technical Services	5069	3.51%
Education Services	540	0.32%
Health Care and Social Assistance	74	0.04%
Accommodation and Food Services	1980	1.58%
Public Administration	323	0.58%
Employees by Education		
Less than High School	2814	1.25%
Master's Degree or Higher	11070	2.77%

Source: Longitudinal Employer-Household Dynamics (LEHD) LODES Dataset

WEEKDAY PEAK SERVICE COMPARISON

Spatial Comparison

Time of Day

Weekday peak service looks at frequent, 15 minutes or less headways, and non-frequent, more than 15 minute headways, during peak commute times. For this report peak commute times are defined as 7am to 10 am, for AM peak, and 4pm to 7pm, for PM peak.

Table 13 - Impact on System Lines and Miles: Weekday Peak Service

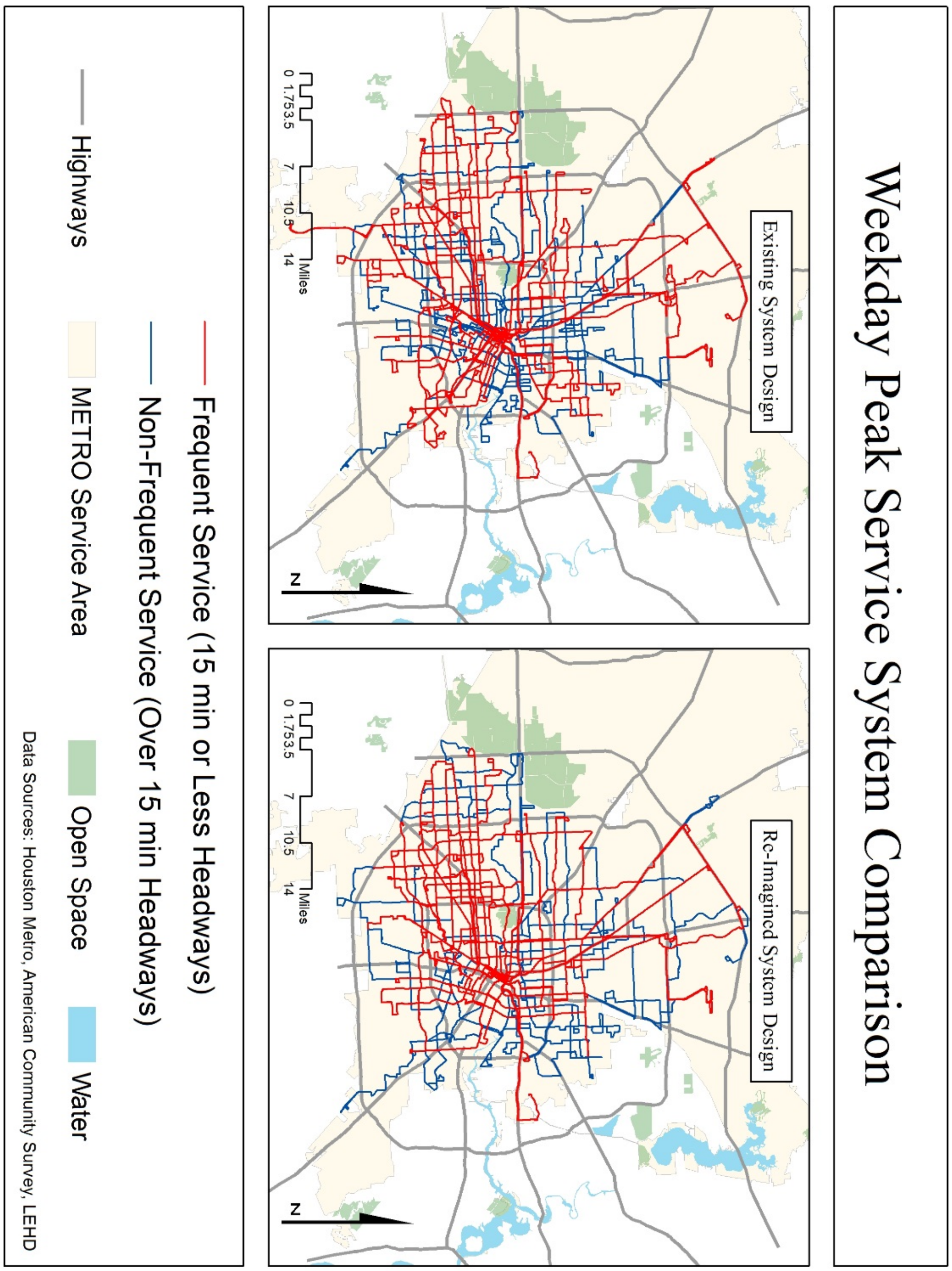
Weekday Peak	Frequent Lines	Non-Frequent Lines
Existing System	64	45
Re-Imagined System	58	45
Difference	**-6**	**0**

Data Source: Metropolitan Transit Authority of Harris County

Frequency and Total Lines

Interestingly the new Re-Imagined system reduces the number of frequent lines by six. While this seems counterintuitive the remaining time of day analysis will show how this is part of the new systems redistribution of frequent service from a peak first service to all day base level of service. The loss of these six lines was also minimized by improvements to spatial distribution and the elimination of the traditional radial system pattern.

Map 5 - Comparison Map of Weekday Peak Service Frequent and Non-Frequent Coverage



Route Distribution Comparison

Looking at the spatial route distribution of the new Re-Imagined system compared to the existing traditional system reflects how the underlying goals and theories of transit service effect line pattern. Most clearly seen in how the Re-Imagined system reduced to overall number of frequent service lines in the downtown core, relying on efficient transfers to retain the access to downtown while freeing up bus lines to more efficiently cover the city.

Demographic, Commute and Employment Comparisons

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Weekday peak service, even with the loss of six frequent service lines, still saw increases in access to frequent service lines for the total population at over 39%. This would indicate the implementation of the frequent network grid more evenly across the city and the reduction of frequent lines overlapping in city center played a huge role in increasing access.

Commute tables show increased coverage of frequent service lines to commuting with less than 29 minute average commute times, as well as transit supportive alternative transportation mode increasing access at over 30% The exception being vehicle ownership, zero, low and high car households all reducing in access.

Employment access to frequent service lines is the one area which showed no improvement in the new Re-Imagined system and even reduced in access for education field jobs by -6%.

Table 14 - Demographic Shifts: Weekday Peak Service Frequent and Non-Frequent

Demographics Comparison:	Weekday Peak Frequent		Weekday Peak Non-Frequent	
Population	Total	Percent Change	Total	Percent Change
Male	359185	20.06%	-70726	-3.95%
Female	358451	19.84%	-61725	-3.42%
Total	717635	39.90%	-132452	-7.37%
Age Groups				
17 and Under	175998	17.89%	-11964	-1.22%
18 to 34	210167	22.25%	-56363	-5.97%
35 to 44	190852	19.15%	-34850	-3.50%
45 to 64	161034	19.11%	-28251	-3.35%
65 and Over	67676	22.07%	-15658	-5.11%
Transit Dependent (Under 17 or Over 65)	243674	12.64%	-27622	-1.43%
Millennials (18 to 34)	210167	22.25%	-56363	-5.97%
Education				
Less Than High School	105046	22.34%	-13475	-2.87%
High School	94013	18.47%	-7412	-1.46%
Some University	105972	17.98%	-18024	-3.06%
University	96986	21.89%	-32911	-7.43%
Master's Degree or Above	65544	26.93%	-28720	-11.80%
Ethnicity				
Hispanic	284530	20.04%	-37223	-2.62%
White (Non-Hispanic)	207458	18.37%	-74662	-6.61%
Black (Non-Hispanic)	160687	21.83%	-12012	-1.63%
Asian (Non-Hispanic)	54051	21.17%	-6356	-2.49%
Other (Non-Hispanic)	10909	19.22%	-2198	-3.87%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 15 - Commute Shifts: Weekday Peak Service Frequent and Non-Frequent

Commute Comparison:	Weekday Off Peak Frequent		Weekday Off Peak Non-Frequent	
Avg. Travel Time to Work	Total	Percent Change	Total	Percent Change
Less than 10 minutes	14814	11.32%	-11979	-9.15%
10 to 19 minutes	49770	12.00%	-36690	-8.84%
20 to 29 minutes	42016	11.64%	-30155	-8.36%
30 to 39 minutes	32421	9.04%	-24656	-6.87%
40 to 59 minutes	15362	6.76%	-12005	-5.29%
60 to 89 minutes	6280	5.80%	-5490	-5.07%
90 Plus minutes	2794	9.38%	-1838	-6.17%
Commute Mode Used				
Working Aged Adults (16+)	170360	10.08%	-127554	-7.55%
Automobile	126857	9.61%	-95449	-7.23%
Carpool	20100	10.33%	-15680	-8.06%
Transit	7771	13.67%	-5711	-10.05%
Bicycle	1170	20.05%	-1062	-18.19%
Walked	4682	17.57%	-3347	-12.56%
Work from Home	6902	11.73%	-4742	-8.06%
Automobile Ownership				
Total Vehicles	127588	10.27%	-96048	-7.73%
Zero Car Households	13262	14.56%	-9953	-10.93%
Low Car Households	46172	8.51%	-36717	-6.77%
High Car Households	7630	9.21%	-5733	-6.92%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 16 - Employment Shifts: Weekday Peak Service Frequent and Non-Frequent

Employment Comparisons:	Weekday Peak Frequent		Weekday Peak Non-Frequent	
General Employment	Total	Percent Change	Total	Percent Change
Total Jobs in Coverage	-3352	-0.32 %	-299395	-16.78%
Employees by Age				
Under 29	-702	-0.31 %	-63077	-15.39%
30 to 54	-860	-0.14 %	-175288	-16.86%
Over 55	-1790	-0.90 %	-61030	-18.22%
Employees by Income				
$1250 / Month and Under	-1140	-0.68 %	-46099	-15.27%
$1251 to $3333 / Month	351	0.11 %	-93894	-15.86%
$3334 / Month and Over	-2563	-0.47 %	-159402	-17.89%
Employees by Field				
Retail Trade	874	0.93 %	-18567	-10.33%
Professional, Scientific, Technical Services	1296	1.46 %	-35365	-24.49%
Education Services	-6973	-6.43 %	-54760	-32.02%
Health Care and Social Assistance	7714	5.31 %	-20525	-9.99%
Accommodation and Food Services	1035	1.37%	-22670	-18.09%
Public Administration	-619	-1.33%	-17773	-31.87%
Employees by Education				
Less than High School	-1448	-1.18%	-33354	-14.83%
Master's Degree or Higher	746	0.30 %	-80482	-20.16%

Source: Longitudinal Employer-Household Dynamics (LEHD) LODES Dataset

WEEKDAY OFF-PEAK SERVICE COMPARISON

Spatial Comparison

Time of Day

Weekday off peak service looks at frequent, 15 minutes or less headways, and non-frequent, more than 15 minute headways, during off peak commute times. For this report off peak commute times were established as noon level of services.

Table 17 - Impact on System Lines and Miles: Weekday Off Peak Service

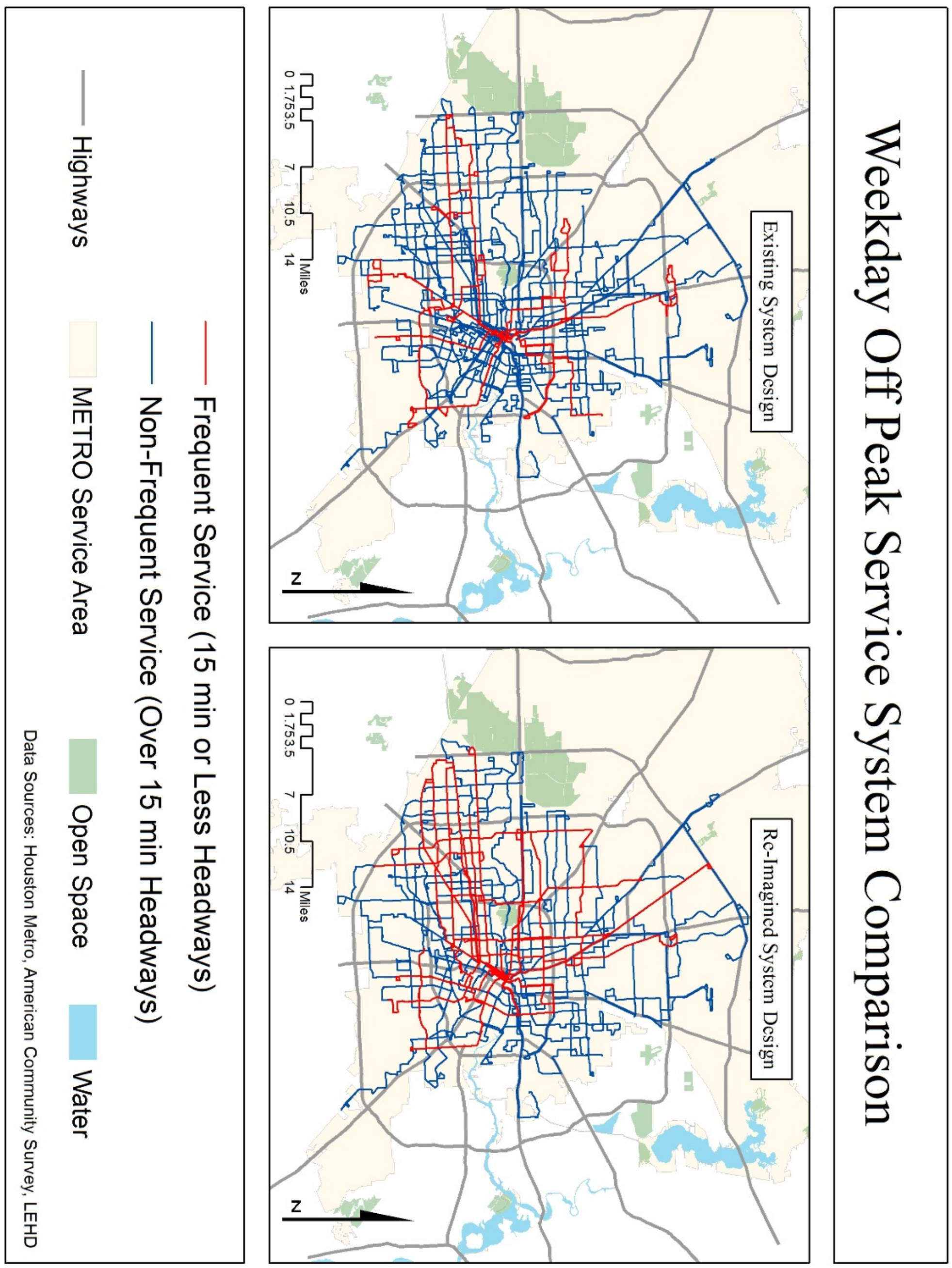
Weekday Off Peak	Frequent Lines	Non-Frequent Lines
Existing System	12	82
Re-Imagined System	31	72
Difference	**19**	**-10**

Data Source: Metropolitan Transit Authority of Harris County

Frequency and Total Lines

The shift in off peak frequent and non-frequent lines reveals how the new Re-Imagined systems shift toward all day base service affects transit lines. Gaining nineteen new frequent service lines across the network gives dramatically more abundant access coverage then the existing system.

Map 6 - Comparison Map of Weekday Off-Peak Service Frequent & Non-Frequent Coverage



Route Distribution Comparison

The spatial route distribution of off peak frequent and non-frequent lines visually shows how the frequent gridded network increases overall abundant access to Houston residents. When divided between frequent and non-frequent lines it becomes easy to see the old system's reliance on traditional radial service patterns. While this retains frequent access to the downtown core during off peak hours the new frequent grid allows broader access to the entire city.

Demographic, Commute and Employment Comparisons

Results show an increase of access to frequent services lines over 18%, with the age group benefiting the most being millennials, at over 10%. Additionally the lowest, less then high school, and highest, bachelors, masters or above, education divisions both gained over 10% increases in frequent access.

Commuting results while reflecting less positive benefits then peak services still had strong increases in frequent access for commutes with average commute times at 29 minutes or less, as well as strong, over 10% increases, in transit competitive alternative transportation modes. Off peak zero and low car households were an exception, exceeding access improvements over peak time comparable.

Employment tables show overall increased access to frequent lines at over 12%, with the fields benefiting highest being retail, food services, and health care. In general employment at off peak times saw improvements at over 10%.

Table 18 - Demographic Shifts: Weekday Off-Peak Service Frequent & Non-Frequent

Demographics Comparison:	Weekday Off Peak Frequent		Weekday Off Peak Non-Frequent	
Population	Total	Percent Change	Total	Percent Change
Male	167022	9.33%	-128688	-7.19%
Female	166290	9.20%	-128885	-7.13%
Total	333311	18.53%	-257573	-14.32%
Age Groups				
17 and Under	78726	8.00%	-62193	-6.32%
18 to 34	99519	10.54%	-77385	-8.19%
35 to 44	90855	9.12%	-69456	-6.97%
45 to 64	76371	9.06%	-58143	-6.90%
65 and Over	30117	9.82%	-23159	-7.55%
Transit Dependent (Under 17 or Over 65)	108843	5.64%	-85352	-4.43%
Millennials (18 to 34)	99519	10.54%	-77385	-8.19%
Education				
Less Than High School	47437	10.09%	-39311	-8.36%
High School	40516	7.96%	-34425	-6.76%
Some University	50368	8.55%	-41292	-7.01%
University	48845	11.03%	-32044	-7.23%
Master's Degree or Above	32429	13.33%	-19728	-8.11%
Ethnicity				
Hispanic	126467	8.91%	-111535	-7.86%
White (Non-Hispanic)	106440	9.43%	-76547	-6.78%
Black (Non-Hispanic)	67127	9.12%	-50662	-6.88%
Asian (Non-Hispanic)	28192	11.04%	-14973	-5.86%
Other (Non-Hispanic)	5085	8.96%	-3856	-6.80%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 19 - Commute Shifts: Weekday Off-Peak Service Frequent and Non-Frequent

Commute Comparison:	Weekday Off Peak Frequent		Weekday Off Peak Non-Frequent	
Avg. Travel Time to Work	Total	Percent Change	Total	Percent Change
Less than 10 minutes	14814	11.32%	-11979	-9.15%
10 to 19 minutes	49770	12.00%	-36690	-8.84%
20 to 29 minutes	42016	11.64%	-30155	-8.36%
30 to 39 minutes	32421	9.04%	-24656	-6.87%
40 to 59 minutes	15362	6.76%	-12005	-5.29%
60 to 89 minutes	6280	5.80%	-5490	-5.07%
90 Plus minutes	2794	9.38%	-1838	-6.17%
Commute Mode Used				
Working Aged Adults (16+)	170360	10.08%	-127554	-7.55%
Automobile	126857	9.61%	-95449	-7.23%
Carpool	20100	10.33%	-15680	-8.06%
Transit	7771	13.67%	-5711	-10.05%
Bicycle	1170	20.05%	-1062	-18.19%
Walked	4682	17.57%	-3347	-12.56%
Work from Home	6902	11.73%	-4742	-8.06%
Automobile Ownership				
Total Vehicles	127588	10.27%	-96048	-7.73%
Zero Car Households	13262	14.56%	-9953	-10.93%
Low Car Households	46172	8.51%	-36717	-6.77%
High Car Households	7630	9.21%	-5733	-6.92%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 20 - Employment Shifts: Weekday Off-Peak Service Frequent & Non-Frequent

Employment Comparisons:	Weekday Off Peak Frequent		Weekday Off Peak Non-Frequent	
General Employment	Total	Percent Change	Total	Percent Change
Total Jobs in Coverage	223546	12.53%	-169054	-9.47%
Employees by Age				
Under 29	54891	13.40%	-40872	-9.97%
30 to 54	127101	12.22%	-94621	-9.10%
Over 55	41554	12.41%	-33561	-10.02%
Employees by Income				
$1250 / Month and Under	43348	14.36%	-34117	-11.30%
$1251 to $3333 / Month	80068	13.53%	-58615	-9.90%
$3334 / Month and Over	100130	11.24%	-76322	-8.57%
Employees by Field				
Retail Trade	31921	17.76%	-20769	-11.55%
Professional, Scientific, Technical Services	18775	13.00%	-17175	-11.89%
Education Services	24974	14.60%	-26938	-15.75%
Health Care and Social Assistance	37330	18.17%	-15256	-7.43%
Accommodation and Food Services	22086	17.63%	-16907	-13.49%
Public Administration	-81	-0.15%	-5025	-9.01%
Employees by Education				
Less than High School	27173	12.08%	-20305	-9.03%
Master's Degree or Higher	53310	13.35%	-40598	-10.17%

Source: Longitudinal Employer-Household Dynamics (LEHD) LODES Dataset

WEEKEND SERVICE COMPARISON

Spatial Comparison

Time of Day

Weekend analysis considers frequent and non-frequent services, but not time of day as peak commute hours are less relevant to the majority of workers.

Table 21 - Impact on System Lines and Miles: Weekend Service

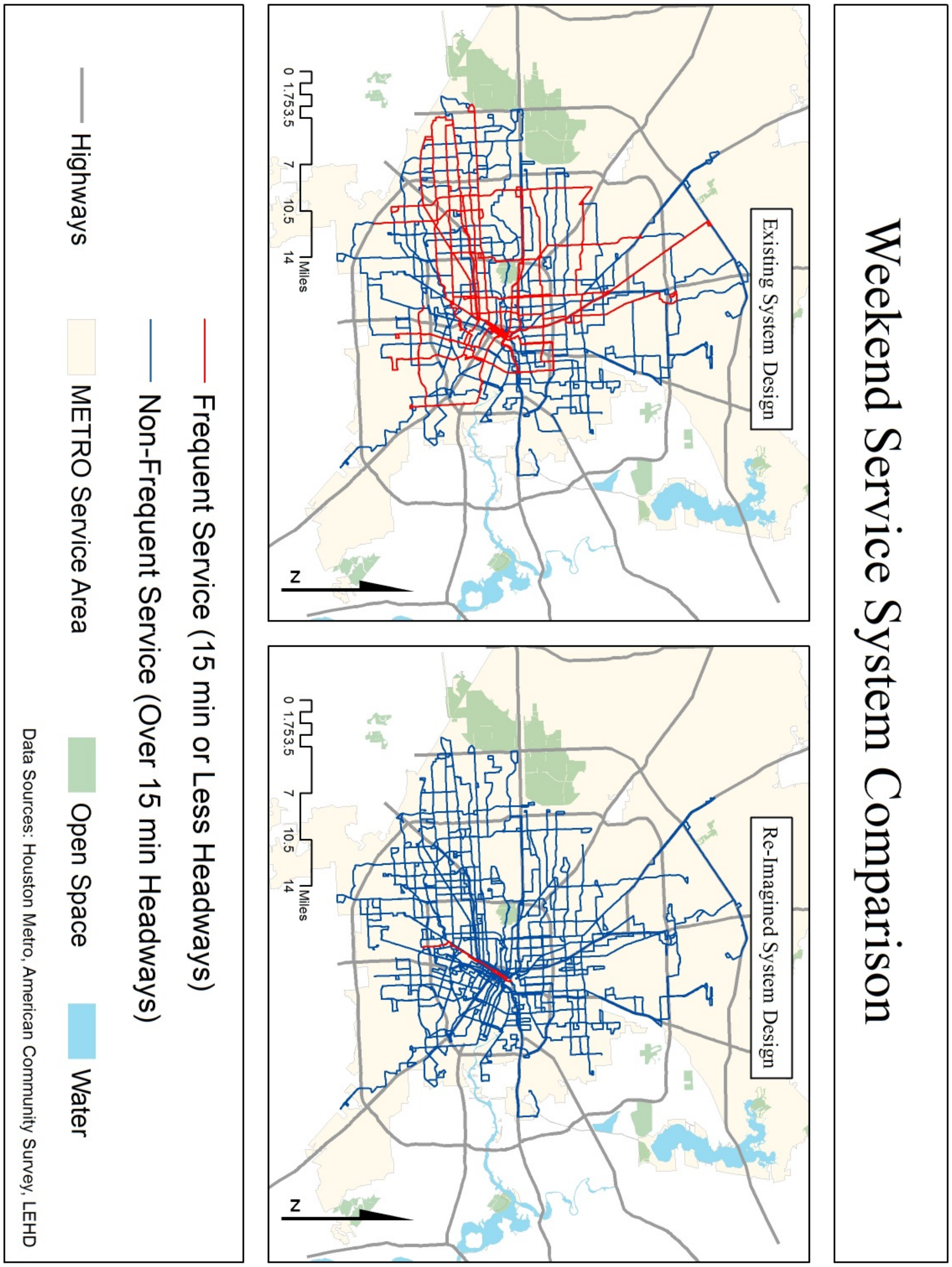
Weekend Service	Frequent Lines	Non-Frequent Lines
Existing System Saturday	1	77
Existing System Sunday	1	64
Re-Imagined System (Saturday and Sunday)	31	72
Difference Saturday	**30**	**-5**
Difference Sunday	**30**	**8**

Data Source: Metropolitan Transit Authority of Harris County

Frequency and Total Lines

Again the impact of the Re-Imagined system on weekend accessibility is dramatic. In order to retain an all-day base level of service equivocate between weekday and weekend service thirty new frequent lines had to be introduced to the system. It becomes easy to see the argument for how traditional transit service patterns require vehicle ownership with the lack of useable transit services for weekend non-work purposes.

Map 7 - Comparison Map of Weekend Service Frequent and Non-Frequent Coverage



Route Distribution Comparison

Again the spatial route distribution of off peak frequent and non-frequent lines visually shows how the frequent gridded network increases overall abundant access to Houston residents. Allowing for equivalent access to a frequent transit grid for non-commute trips allows for transit to compete with other modes for more than just work commute trips. This allows for more sustainable zero and low car households to emerge.

Demographic, Commute and Employment Comparisons

With the addition of 30 new frequent lines on weekends, in keeping with the Re-Imagined system theory of all day base service, weekend access to frequent lines jumped over 40%. Notable shifts include the millennial age group and high and low educational attainment groups all rising over 20% access to frequent service lines.

Commute tables continue to reflect the new focus on frequent lines during weekend time period with dramatic, 20%+ rises in most categories. This includes zero car households increasing access to frequent transit by over 34%.

Employment results show total jobs in coverage of the new frequent network increasing at over 30% for almost every possible category. This includes notable 39% increases in access to jobs in Education and Food service fields. The lowest increase in employment access to frequent service was public administration, which was an increase of over 25%.

Table 22 - Demographic Shifts: Weekend Service Frequent and Non-Frequent

Demographics Comparison:	Weekend Frequency		Saturday Non-Frequent		Sunday Non-Frequent	
Population	Total	Percent Change	Total	Percent Change	Total	Percent Change
Male	368765	20.60%	-126258	-7.05%	-57509	-3.21%
Female	363585	20.12%	-125026	-6.92%	-52703	-2.92%
Total	732350	40.72%	-251283	-13.97%	-110212	-6.13%
Age Groups						
17 and Under	177525	18.05%	-59807	-6.08%	-23394	-2.38%
18 to 34	221829	23.48%	-76412	-8.09%	-39479	-4.18%
35 to 44	195564	19.62%	-67381	-6.76%	-28206	-2.83%
45 to 64	162770	19.32%	-55540	-6.59%	-21166	-2.51%
65 and Over	65320	21.30%	-22968	-7.49%	-9296	-3.03%
Transit Dependent (Under 17 or Over 65)	242845	12.59%	-82775	-4.29%	-32690	-1.70%
Millennials (18 to 34)	221829	23.48%	-76412	-8.09%	-39479	-4.18%
Education						
Less Than High School	118807	25.27%	-46299	-9.85%	-28638	-6.09%
High School	96740	19.00%	-34423	-6.76%	-15509	-3.05%
Some University	104418	17.72%	-35209	-5.98%	-11828	-2.01%
University	90422	20.41%	-28335	-6.40%	-8913	-2.01%
Master's Degree or Above	61459	25.25%	-18753	-7.71%	-7559	-3.11%
Ethnicity						
Hispanic	312408	22.00%	-117610	-8.28%	-64071	-4.51%
White (Non-Hispanic)	191044	16.92%	-60953	-5.40%	-17366	-1.54%
Black (Non-Hispanic)	161931	21.99%	-52507	-7.13%	-23088	-3.14%
Asian (Non-Hispanic)	57081	22.36%	-17843	-6.99%	-5524	-2.16%
Other (Non-Hispanic)	9660	17.02%	-2370	-4.18%	-162	-0.29%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 23 - Commute Shifts: Weekend Service Frequent and Non-Frequent

Commute Comparison:	Weekend Frequency		Saturday Non-Frequent		Sunday Non-Frequent	
Avg. Travel Time to Work	Total	Percent Change	Total	Percent Change	Total	Percent Change
Less than 10 minutes	30908	23.62%	-10247	-7.83%	-4747	-3.63%
10 to 19 minutes	101558	24.48%	-34437	-8.30%	-16417	-3.96%
20 to 29 minutes	84815	23.51%	-31001	-8.59%	-14387	-3.99%
30 to 39 minutes	72594	20.24%	-25308	-7.06%	-10802	-3.01%
40 to 59 minutes	31757	13.98%	-10100	-4.45%	-2472	-1.09%
60 to 89 minutes	15372	14.19%	-4833	-4.46%	-1783	-1.65%
90 Plus minutes	5387	18.08%	-1766	-5.93%	-586	-1.97%
Commute Mode Used						
Working Aged Adults (16+)	355687	21.06%	-122366	-7.24%	-53347	-3.16%
Automobile	261010	19.76%	-87036	-6.59%	-32479	-2.46%
Carpool	43452	22.33%	-16652	-8.56%	-8646	-4.44%
Transit	18729	32.95%	-7401	-13.02%	-5474	-9.63%
Bicycle	2458	42.12%	-1132	-19.40%	-849	-14.54%
Walked	9856	36.98%	-3590	-13.47%	-2720	-10.21%
Work from Home	13297	22.60%	-4674	-7.95%	-2153	-3.66%
Automobile Ownership						
Total Vehicles	271752	21.88%	-91679	-7.38%	-42937	-3.46%
Zero Car Households	31480	34.57%	-12093	-13.28%	-9129	-10.02%
Low Car Households	102123	18.83%	-34866	-6.43%	-14708	-2.71%
High Car Households	15705	18.96%	-5061	-6.11%	-1786	-2.16%

Source: American Community Survey (ACS) 2009-2013 (5-Year Estimates)

Table 24 - Employment Shifts: Weekend Service Frequent and Non-Frequent

Employment Comparisons:	Weekend Frequency		Saturday Non-Frequent		Sunday Non-Frequent	
General Employment	Total	Percent Change	Total	Percent Change	Total	Percent Change
Total Jobs in Coverage	565167	31.67%	-117455	-6.58%	-43033	-2.41%
Employees by Age						
Under 29	133378	32.55%	-28237	-6.89%	-12077	-2.95%
30-54	325316	31.28%	-66194	-6.37%	-22666	-2.18%
Over 55	106473	31.79%	-23024	-6.87%	-8290	-2.47%
Employees by Income						
$1250 / Month and Under	102708	34.03%	-24956	-8.27%	-13056	-4.33%
$1251 to $3333 / Month	187909	31.75%	-44683	-7.55%	-21903	-3.70%
$3334 / Month and Over	274550	30.81%	-47816	-5.37%	-8074	-0.91%
Employees by Field						
Retail Trade	63200	35.16%	-10586	-5.89%	-2937	-1.63%
Professional, Scientific, Technical Services	47384	32.81%	-7783	-5.39%	3707	2.57%
Education Services	66746	39.03%	-20468	-11.97%	-17406	-10.18%
Health Care and Social Assistance	69959	34.05%	-15101	-7.35%	-9935	-4.84%
Accommodation and Food Services	49037	39.14%	-11684	-9.33%	-6451	-5.15%
Public Administration	14416	25.85%	-2258	-4.05%	-1754	-3.15%
Employees by Education						
Less than High School	70305	31.26%	-16672	-7.41%	-7305	-3.25%
Master’s Degree or Higher	131168	32.85%	-25697	-6.44%	-7176	-1.80%

Source: Longitudinal Employer-Household Dynamics (LEHD) LODES Dataset

Chapter Six: Conclusions

The analysis clearly showed how the new system design retains an effectively equal number of Houstonians with access to transit, but through the new gridded frequent network and all-day service patterns was able to extend 'Abundant Access', or auto-competitive transit service to a larger amount of communities within Houston.

While these numbers appear to be promising for increasing ridership numbers for the city of Houston it's important to remember that key to METRO's success will be in attracting more riders for a more diverse trip patterns then the traditional system. This means getting community members to take the bus to the market or entertainment on weekends, or to use transit as a primary mode, with safety nets of frequent lines promising short waits if a bus is missed. It also means the availability of car share services, employee flex times, and multimodal integration allowing for transit to become a primary but not sole mode for access across the city.

Technical Outcomes

These results clearly reflect how the Re-Imagining process looked to shift underlying assumptions of how transit operates in the city of Houston. Building on the premise of a base first service model, the new system provides greater access to frequent service by location, due to the expanded frequent grid, and time of day, due to the increase in frequent off peak and weekend services. Again with the process working as an existing resources plan, meaning that the redesign used the current operating cost as a limitation, this system hopes to provide greater transit access at equivalent cost.

NON-TECHNICAL OUTCOMES

The Re-Imagining process was brave, with many examples and studies reflecting how easily attempts to improve efficiency or alter bus lines can create immediate backlash from transit users.[xxxvii] These feelings are understandable with large cuts common in time of recession; fear of transit accessibility can limit employment opportunities and increase transit costs for venerable citizens. In addition feedback on these processes are far more likely to get public feedback from current users, and little to no feedback from potential riders currently un-served or underserved by the existing system. This is how systems end up with the more politically feasible, but inefficient, frequent service lines running on top of existing local lines. This compromise is more acceptable to existing users, but sacrifices an improved or expanded overall system, which doesn't cannibalize ridership from its own lines.

Rider Outrage and Outreach

A good example of how to address this challenge was seen in the Houston Re-Imagining process. In looking for ways to meet its 20% of service toward service goals METRO looked to new technologies in an attempt to minimize transit service reduction and maximize coverage based access, the solution found was a 'Flex' bus service.[xxxviii] Flex service buses are tend to be smaller than standard buses and have non-fixed routs, either free floating within a neighborhood or running a general route which can be deviated from. Working within a set service area, usually a neighborhood, these buses can be summoned by potential riders through the internet, or a phone call to the dispatch center, similar in action to many rural dial-a-ride services.

When this technology was suggested it was approved by the stakeholder groups, whom had education and examples presented on how the service would work, but when the draft plan became public there was a large backlash from neighborhoods in the northeast of Houston. Largely suburban communities which had been determined to have been overserved by the existing bus network these neighborhoods felt that they were getting an unfair deal.[xxxix]

The Re-Imagining staff worked with these neighborhood associations in education on how the new system is constructed and why their traditionally high service low ridership areas were seeing reduction in services. In the end the neighborhoods didn't want the Flex service buses, and were given standards lines, through spaced and timed properly for their suburban land form. The flex service will be put into place in neighborhoods to the northwest, and METRO hopes that in time as knowledge of the newer system spreads flex service will become seen as an excellent alternative method in addressing suburban coverage bus service.

Vital Role of Perception

Important to note on transit system success is public perception of how a service runs in contrast to technical standards. Multiple studies have be published citing the fact that perception of bus speeds, levels of service and convenience can all be improved without any significant improvements made on the technical operations side. Centering around reducing and eliminating barriers to transit use, integrating transit usage into everyday life, and providing potential users with easy access to information on how transit will improve their lives.

New Marketing Opportunities

Another outcome from this process is the newly formed ability for METRO to market itself. Frequent service allows the transit agency something it didn't have in the past, a mode competitive product. This trend has been seen growing across the country even in cities, which haven't introduced the frequent grid network. Cities like Portland[xl], Seattle[xli], Minnesota[xlii] all have marketing campaigns, signage, and system maps which call out and promote this 15 minute headway freedom of mobility message.

Real Time Information and Frequent Networks

This perception of transit has been shown again and again to be a key factor to success; the implementation of real time data allows riders to feel at ease about missing buses and shortens perceived wait times effectively improving perceived headway and services levels, not captured by many metrics.[xliii]

Similar is the impact of frequent service lines, if properly running headway of 15 minutes or less, studies have found that this level of service breaks a barrier where the need to check bus schedules and exert effort in planning is replaced with more convenient arrive and ride mentality to catching frequent service buses.[xliv]

Technical Solutions to Dwell Time

While perception can play a huge role in how users experience transit there have been a few technical solutions to reducing dwell time, the amount of time a bus stops to pick up and/or drop off customers, known for years. Technological advancements in recent years have allowed these known solutions to be employed.

The first is simple, if you want to get people onto and off of a bus it is faster to use two doors than one.[xlv] While this seems simple the issue of paying a fare is the largest barrier. Commonly only seen on traditional buses in highly crowded areas, this two door loading method has become standard proactive for Bus Rapid Transit[xlvi] and holds promise to be mimicked by standard frequent bus lines.

The technological reason for this implementation is the transit pass smart card, which Houston has recently enacted. Using radio-frequency identification (RFID) or swipe cards boarding time can be reduced dramatically and occur at both bus doors. In addition smart cards allow their users to automatically load money, allowing use without calculating the need of a day pass or transfer ticket, users simply swipe their transit card, if two purchases are made in a single 24 hour period a day pass is automatically applied, meaning the no third purchase is possible as the user swipes their card. Similarly this system allows for easy transfers, a vital component to a successful frequent service grid system, automatically charging or transferring a payment as the card is swiped on the transferred bus.[xlvii]

FORGING SUCCESS

It is important to note that the technical aspects of the Re-Imagining process played only a minor part in the successful redesign, adoption and implementation of the new system. It is hard to see how this effort could have been achieved without the political will and support to propose it and not disintegrate at initial apprehension and fear any transit proposal faces from a correctly suspicious user base. Without technical knowledge of bus system intricacies optimizing frequent lines by scheduling shifts, potential implementation of flex transit services, and the ability to effetely educate as well as communicate with the public. Without comprehensive stakeholder inclusion and support insuring that no one is surprised by the undertaking or left feeling disenfranchised and upset. Together these columns form the structure that allows for a system wide undertaking on a service which can create citywide outrage at the corridor scale.

Chapter Seven: Future Work

SPATIAL DATA

While this report stands alone as an examination predicting potential impact the new frequent system has on the present community there are potential avenues to explore this topic further including the integration of land use and street patterns, more detailed examinations of how communities can access specific land uses, and the integration of sidewalk presence and bike facilities in increasing potential walk and bike shed distance farther increasing transit accessibility to Houston residents.

Network Analysis Extension

As covered earlier in the report, at the time of analysis bus stops along the new lines were not yet publicly available. By delaying specific stop placement the Re-Imagining process continued with their overall system philosophy, avoiding small direct user arguments in favor of taking the wide view. With the system actively in use after August 1, 2015 these stops are now known and could be integrated into the analysis. The use of bus stop, point files, over bus line, line files, allow for the use of Arc Map's Network Analysis extension. This would allow the defined 5–minute walk shed, or ¼ mile buffer to be run along the street network, shrinking the overall buffer size and giving a more accurate representation of how street patterns affect access.

Access to Specific Land Uses and Amenities

The introduction of spatial data into the analysis process is another aspect that this report could be built upon. This includes changes in how land uses are served between the two plans. While some of this information is captured through the LEHD and ACS data, spatial information on parcels allows for access to more specified uses. This includes analyzing how the Re-Imagined system differs from the existing in access to grocery stores, schools, green space, and medical facilities among others.

Multimodal Integration and Support

Finally with the potential for multimodal integration to both expand the access shed to transit, strong integration can easily grow the overall coverage areas of bus lines. While these efforts entail buy-in from the transit agency in making buses bike accessible, or providing safe and secure bike lockers some of the impact can be estimated through the integration of spatial bike network files. Analysis could include viewing how many roadway bike facilities, tiered by quality, intersect with the Re-Imagined system.

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Appendix

	Service Area	Xbus Weekday Freq		NewBus_Weekday_Freq	
Spatial Form Data	Total	Total	Service Area Percentage	Total	Service Area Percentage
Route Miles		2407		991	
Number of Routes		64		58	
ACS 5yr (2009-2013) at Block Group Level					
Population	3597136	419132	11.7%	1136767	31.60%
Area	36333425677	8027789760	22.1%	5895047593	16.22%
Households	1406981	188243	13.4%	512783	36.45%
Avg HH Size	2.56	2	87.1%	2.22	86.71%
Median Income	$ 61,309	51490	84.0%	55693	90.84%
Male	1790151	213552	11.9%	572736	31.99%
Female	1806984	205580	11.4%	564031	31.21%
Age Groups					
17under	983580	100492	10.2%	276491	28.11%
18-34	944581	132291	14.0%	342458	36.26%
35-44	996764	109928	11.0%	300779	30.18%
45-64	842706	90379	10.7%	251413	29.83%
65over	306618	36424	11.9%	104100	33.95%
Young/Old (17under/65over)	1928161	136917	7.1%	380591	19.74%
Millinial (18-34)	944581	132291	14.0%	342458	36.26%
Education					
Less HS	470226	72886	15.5%	177933	37.84%
HS	509030	58040	11.4%	152053	29.87%
Some Uni	589250	56602	9.6%	162574	27.59%
Uni	442973	45600	10.3%	142586	32.19%
Masters (+)	243356	33592	13.8%	99136	40.74%
Race					
Hisp	1419795	189273	13.3%	473804	33.37%
White (Non-Hisp)	1129058	94339	8.4%	301797	26.73%
Black (Non-Hisp)	736242	98430	13.4%	259117	35.19%
Aisan (Non-Hisp)	255291	31920	12.5%	85971	33.68%
Other (Non-Hisp)	56750	5169	9.1%	16079	28.33%

	Service Area	Xbus Weekday Freq		NewBus_Weekday_Freq	
ACS 5yr (2009-2013) at Block Group Level	Total	Total	Service Area Percentage	Total	Service Area Percentage
Commute Data					
Avg. Travel Time to Work	1630476	188682	11.6%	526896	32.32%
Less then 10	130865	17631	13.5%	48062	36.73%
10 to 19	414886	55780	13.4%	155514	37.48%
20 to 29	360822	45120	12.5%	131023	36.31%
30 to 39	358660	41460	11.6%	110704	30.87%
40 to 59	227094	16771	7.4%	49472	21.78%
60 to 89	108356	9244	8.5%	23876	22.03%
90 Plus	29793	2676	9.0%	8244	27.67%
Mode Used					
Working Ageed Adults (16+)	1689304	195563	11.6%	546144	32.33%
Auto	1320573	140755	10.7%	402436	30.47%
Carpool	194607	24309	12.5%	66842	34.35%
Transit	56843	11871	20.9%	28961	50.95%
Bicycle	5837	1557	26.7%	3640	62.37%
Walked	26650	5939	22.3%	14613	54.83%
Work from Home	58829	6882	11.7%	19249	32.72%
ACS 5yr (2009-2013) at Census Tract Level					
Total Vechicles	1461261	489364	33.5%	425091	29.09%
Zero Car Households	91067	51975	57.1%	47682	52.36%
Low Car Households	542427	196997	36.3%	159719	29.45%
High Car Households	82828	28790	34.8%	24623	29.73%

	Service Area	Xbus Weekday Freq		NewBus_Weekday_Freq	
LEHD Data (2011) in Lat/Long Form	Total	Total	Service Area Percentage	Total	Service Area Percentage
Total Jobs in Service Area	1784646		0.0%	1784646	100.00%
Total Jobs in Coverage	1784646	1040508	58.3%	1037156	58.12%
Workers Under 29	409786	228737	55.8%	228035	55.65%
Workers 30-54	1039895	612518	58.9%	611658	58.82%
Workers Over 55	334965	199253	59.5%	197463	58.95%
Low Paying Jobs (1250/mth Under)	301823	167986	55.7%	166846	55.28%
(1251 to 3333/mnth)	591846	328429	55.5%	328780	55.55%
High Paying Jobs (3333/mnth Over)	890977	544093	61.1%	541530	60.78%
Retail	179761	93856	52.2%	94730	52.70%
Professional, Sciecntific, etc…	144409	88527	61.3%	89823	62.20%
Education	171022	108472	63.4%	101499	59.35%
HealthCare	205465	145244	70.7%	152958	74.44%
Food Services	125295	75558	60.3%	76593	61.13%
Public Admin	55770	46445	83.3%	45826	82.17%
Jobs Less then HS	224935	122999	54.7%	121551	54.04%
Jobs advanced Degree	399300	251577	63.0%	252323	63.19%

	Xbus_Weekday_NonFreq		Newbus_Weekday_NonFreq	
Spatial Form Data	Total	Service Area Percentage	Total	Service Area Percentage
Route Miles	576		577	
Number of Routes	45		45	
		B7		
ACS 5yr (2009-2013) at Block Group Level				
Population	851519	23.67%	851519	23.67%
Area	5423571584	14.93%	5423571584	14.93%
Households	346762	24.65%	346762	24.65%
Avg HH Size	2.46	96.05%		0.00%
Median Income	53810	87.77%	53810	87.77%
Male	421077	23.52%	421077	23.52%
Female	430442	23.82%	430442	23.82%
Age Groups				
17under	229928	23.38%	229928	23.38%
18-34	234316	24.81%	234316	24.81%
35-44	225124	22.59%	225124	22.59%
45-64	192131	22.80%	192131	22.80%
65over	77633	25.32%	77633	25.32%
Young/Old (17under/65over)	307561	15.95%	307561	15.95%
Millinial (18-34)	234316	24.81%	234316	24.81%
Education				
Less HS	146010	31.05%	146010	31.05%
HS	128632	25.27%	128632	25.27%
Some Uni	121262	20.58%	121262	20.58%
Uni	82181	18.55%	82181	18.55%
Masters (+)	52723	21.67%	52723	21.67%
Race				
Hisp	397458	27.99%	397458	27.99%
White (Non-Hisp)	179781	15.92%	179781	15.92%
Black (Non-Hisp)	217903	29.60%	217903	29.60%
Aisan (Non-Hisp)	45892	17.98%	45892	17.98%
Other (Non-Hisp)	10486	18.48%	10486	18.48%

	Xbus_Weekday_NonFreq		Newbus_Weekday_NonFreq	
ACS 5yr (2009-2013) at Block Group Level	Total	Service Area Percentage	Total	Service Area Percentage
Commute Data				
Avg. Travel Time to Work	368725	22.61%	368725	22.61%
Less then 10	30056	22.97%	30056	22.97%
10 to 19	100446	24.21%	100446	24.21%
20 to 29	86055	23.85%	86055	23.85%
30 to 39	84779	23.64%	84779	23.64%
40 to 59	40200	17.70%	40200	17.70%
60 to 89	20105	18.55%	20105	18.55%
90 Plus	7084	23.78%	7084	23.78%
Mode Used				
Working Ageed Adults (16+)	380044	22.50%	380044	22.50%
Auto	290215	21.98%	290215	21.98%
Carpool	46461	23.87%	46461	23.87%
Transit	15903	27.98%	15903	27.98%
Bicycle	1677	28.72%	1677	28.72%
Walked	7030	26.38%	7030	26.38%
Work from Home	11319	19.24%	11319	19.24%
ACS 5yr (2009-2013) at Census Tract Level				
Total Vechicles	287479	19.67%	287479	19.67%
Zero Car Households	28414	31.20%	28414	31.20%
Low Car Households	123703	22.81%	123703	22.81%
High Car Households	18173	21.94%	18173	21.94%

	Xbus_Weekday_NonFreq		Newbus_Weekday_NonFreq	
LEHD Data (2011) in Lat/Long Form	Total	Service Area Percentage	Total	Service Area Percentage
Total Jobs in Service Area	1784646	100.00%	1784646	100.00%
Total Jobs in Coverage	596458	33.42%	596458	33.42%
Workers Under 29	130282	31.79%	130282	31.79%
Workers 30-54	353704	34.01%	353704	34.01%
Workers Over 55	112472	33.58%	112472	33.58%
Low Paying Jobs (1250/mth Under)	87256	28.91%	87256	28.91%
(1251 to 3333/mnth)	191224	32.31%	191224	32.31%
High Paying Jobs (3333/mnth Over)	317978	35.69%	317978	35.69%
Retail	54302	30.21%	54302	30.21%
Professional, Sciecntific, etc…	43111	29.85%	43111	29.85%
Education	108829	63.63%	45212	26.44%
HealthCare	108829	52.97%	108829	52.97%
Food Services	37430	29.87%	37430	29.87%
Public Admin	24957	44.75%	24957	44.75%
Jobs Less then HS	71027	31.58%	71027	31.58%
Jobs advanced Degree	142049	35.57%	142049	35.57%

	Xbus_Midday_Freq		NewBus_Midday_Freq	
Spatial Form Data	Total	Service Area Percentage	Total	Service Area Percentage
Route Miles	263		550	
Number of Routes	12		31	
ACS 5yr (2009-2013) at Block Group Level				
Population	419132	11.65%	752443	20.92%
Area	2228584258	6.13%	3574914903	9.84%
Households	188243	13.38%	339411	24.12%
Avg HH Size	2.23	87.09%	2.22	86.71%
Median Income	51490	83.99%	56328	91.88%
Male	213552	11.93%	380573	21.26%
Female	205580	11.38%	371870	20.58%
Age Groups				
17under	100492	10.22%	179218	18.22%
18-34	132291	14.01%	231810	24.54%
35-44	109928	11.03%	200783	20.14%
45-64	90379	10.72%	166750	19.79%
65over	36424	11.88%	66541	21.70%
Young/Old (17under/65over)	136917	7.10%	245760	12.75%
Millinial (18-34)	132291	14.01%	231810	24.54%
Education				
Less HS	72886	15.50%	120323	25.59%
HS	58040	11.40%	98557	19.36%
Some Uni	56602	9.61%	106970	18.15%
Uni	45600	10.29%	94445	21.32%
Masters (+)	33592	13.80%	66021	27.13%
Race				
Hisp	189273	13.33%	315741	22.24%
White (Non-Hisp)	94339	8.36%	200779	17.78%
Black (Non-Hisp)	98430	13.37%	165557	22.49%
Aisan (Non-Hisp)	31920	12.50%	60113	23.55%
Other (Non-Hisp)	5169	9.11%	10254	18.07%

	Xbus_Midday_Freq		NewBus_Midday_Freq	
ACS 5yr (2009-2013) at Block Group Level	Total	Service Area Percentage	Total	Service Area Percentage
Commute Data				
Avg. Travel Time to Work	188682	11.57%	352140	21.60%
Less then 10	17631	13.47%	32445	24.79%
10 to 19	55780	13.44%	105550	25.44%
20 to 29	45120	12.50%	87136	24.15%
30 to 39	41460	11.56%	73882	20.60%
40 to 59	16771	7.38%	32133	14.15%
60 to 89	9244	8.53%	15524	14.33%
90 Plus	2676	8.98%	5470	18.36%
Mode Used				
Working Ageed Adults (16+)	195563	11.58%	365923	21.66%
Auto	140755	10.66%	267613	20.26%
Carpool	24309	12.49%	44409	22.82%
Transit	11871	20.88%	19642	34.56%
Bicycle	1557	26.68%	2727	46.73%
Walked	5939	22.28%	10621	39.85%
Work from Home	6882	11.70%	13783	23.43%
ACS 5yr (2009-2013) at Census Tract Level				
Total Vechicles	153604	10.51%	281192	19.24%
Zero Car Households	19144	21.02%	32406	35.59%
Low Car Households	58014	10.70%	104187	19.21%
High Car Households	8618	10.40%	16248	19.62%

	Xbus_Midday_Freq		NewBus_Midday_Freq	
LEHD Data (2011) in Lat/Long Form	Total	Service Area Percentage	Total	Service Area Percentage
Total Jobs in Service Area	1784646	100.00%	1784646	100.00%
Total Jobs in Coverage	555551	31.13%	779097	43.66%
Workers Under 29	115431	28.17%	170322	41.56%
Workers 30-54	332998	32.02%	460099	44.24%
Workers Over 55	107122	31.98%	148676	44.39%
Low Paying Jobs (1250/mth Under)	76854	25.46%	120202	39.83%
(1251 to 3333/mnth)	163575	27.64%	243643	41.17%
High Paying Jobs (3333/mnth Over)	315122	35.37%	415252	46.61%
Retail	34430	19.15%	66351	36.91%
Professional, Sciecntific, etc…	47908	33.18%	66683	46.18%
Education	68528	40.07%	93502	54.67%
HealthCare	78216	38.07%	115546	56.24%
Food Services	32715	26.11%	54801	43.74%
Public Admin	42100	75.49%	42019	75.34%
Jobs Less then HS	61122	27.17%	88295	39.25%
Jobs advanced Degree	143863	36.03%	197173	49.38%

	Xbus_Midday_NonFreq		NewBus_Midday_NonFreq	
Spatial Form Data	Total	Service Area Percentage	Total	Service Area Percentage
Route Miles	1906		1017	
Number of Routes	82		72	
ACS 5yr (2009-2013) at Block Group Level				
Population	1588632	44.16%	1331059	37.00%
Area	9316894791	25.64%	7865916648	21.65%
Households	683978	48.61%	569923	40.51%
Avg HH Size	2	90.85%	2	91.35%
Median Income	55017	89.74%	54517	88.92%
Male	794811	44.40%	666123	37.21%
Female	793821	43.93%	664936	36.80%
Age Groups				
17under	405482	41.23%	343289	34.90%
18-34	461822	48.89%	384437	40.70%
35-44	420605	42.20%	351150	35.23%
45-64	354338	42.05%	296195	35.15%
65over	143688	46.86%	120529	39.31%
Young/Old (17under/65over)	549171	28.48%	463819	24.05%
Millinial (18-34)	461822	48.89%	384437	40.70%
Education				
Less HS	258470	54.97%	219159	46.61%
HS	224813	44.16%	190387	37.40%
Some Uni	230986	39.20%	189694	32.19%
Uni	178242	40.24%	146198	33.00%
Masters (+)	116713	47.96%	96985	39.85%
Race				
Hisp	707476	49.83%	595941	41.97%
White (Non-Hisp)	389116	34.46%	312569	27.68%
Black (Non-Hisp)	374078	50.81%	323416	43.93%
Aisan (Non-Hisp)	96337	37.74%	81364	31.87%
Other (Non-Hisp)	21625	38.11%	17769	31.31%

	Xbus_Midday_NonFreq		NewBus_Midday_NonFreq	
ACS 5yr (2009-2013) at Block Group Level	Total	Service Area Percentage	Total	Service Area Percentage
Commute Data				
Avg. Travel Time to Work	717493	44.01%	594681	36.47%
Less then 10	63255	48.34%	51276	39.18%
10 to 19	205585	49.55%	168895	40.71%
20 to 29	174044	48.24%	143889	39.88%
30 to 39	154512	43.08%	129856	36.21%
40 to 59	72556	31.95%	60552	26.66%
60 to 89	35440	32.71%	29950	27.64%
90 Plus	12101	40.62%	10263	34.45%
Mode Used				
Working Ageed Adults (16+)	741888	43.92%	614334	36.37%
Auto	554950	42.02%	459502	34.80%
Carpool	92347	47.45%	76667	39.40%
Transit	34729	61.10%	29018	51.05%
Bicycle	4322	74.06%	3261	55.86%
Walked	17401	65.29%	14054	52.74%
Work from Home	24395	41.47%	19653	33.41%
ACS 5yr (2009-2013) at Census Tract Level				
Total Vechicles	568890	38.93%	472842	32.36%
Zero Car Households	59358	65.18%	49405	54.25%
Low Car Households	227208	41.89%	190491	35.12%
High Car Households	34099	41.17%	28365	34.25%

	Xbus_Midday_NonFreq		NewBus_Midday_NonFreq	
LEHD Data (2011) in Lat/Long Form	Total	Service Area Percentage	Total	Service Area Percentage
Total Jobs in Service Area	1784646	100.00%	1784646	100.00%
Total Jobs in Coverage	1249482	70.01%	1080428	60.54%
Workers Under 29	277791	67.79%	236919	57.82%
Workers 30-54	732934	70.48%	638313	61.38%
Workers Over 55	238757	71.28%	205196	61.26%
Low Paying Jobs (1250/mth Under)	203689	67.49%	169572	56.18%
(1251 to 3333/mnth)	398766	67.38%	340151	57.47%
High Paying Jobs (3333/mnth Over)	647027	72.62%	570705	64.05%
Retail	119259	66.34%	98490	54.79%
Professional, Sciecntific, etc…	109009	75.49%	91834	63.59%
Education	121700	71.16%	94762	55.41%
HealthCare	166719	81.14%	151463	73.72%
Food Services	91682	73.17%	74775	59.68%
Public Admin	50322	90.23%	45297	81.22%
Jobs Less then HS	149442	66.44%	129137	57.41%
Jobs advanced Degree	297936	74.61%	257338	64.45%

	Xbus_WeekendFreq		NewBus_Weekend_Freq	
Spatial Form Data	Total	Service Area Percentage	Total	Service Area Percentage
Route Miles	15		551	
Number of Routes	1		31	
ACS 5yr (2009-2013) at Block Group Level				
Population	20093	0.56%	752443	20.92%
Area	2228584258	6.13%	3574914903	9.84%
Households	10629	0.76%	339411	24.12%
Avg HH Size	2	73.94%	2	86.71%
Median Income	51490	83.99%	56328	91.88%
Male	11809	0.66%	380573	21.26%
Female	8284	0.46%	371870	20.58%
Age Groups				
17under	1693	0.17%	179218	18.22%
18-34	9981	1.06%	231810	24.54%
35-44	5219	0.52%	200783	20.14%
45-64	3980	0.47%	166750	19.79%
65over	1221	0.40%	66541	21.70%
Young/Old (17under/65over)	2914	0.15%	245760	12.75%
Millinial (18-34)	9981	1.06%	231810	24.54%
Education				
Less HS	1516	0.32%	120323	25.59%
HS	1817	0.36%	98557	19.36%
Some Uni	2553	0.43%	106970	18.15%
Uni	4023	0.91%	94445	21.32%
Masters (+)	4562	1.87%	66021	27.13%
Race				
Hisp	3333	0.23%	315741	22.24%
White (Non-Hisp)	9735	0.86%	200779	17.78%
Black (Non-Hisp)	3626	0.49%	165557	22.49%
Aisan (Non-Hisp)	3032	1.19%	60113	23.55%
Other (Non-Hisp)	594	1.05%	10254	18.07%

	Xbus_WeekendFreq		NewBus_Weekend_Freq	
ACS 5yr (2009-2013) at Block Group Level	Total	Service Area Percentage	Total	Service Area Percentage
Commute Data				
Avg. Travel Time to Work	9749	0.60%	352140	21.60%
Less then 10	1537	1.17%	32445	24.79%
10 to 19	3992	0.96%	105550	25.44%
20 to 29	2321	0.64%	87136	24.15%
30 to 39	1288	0.36%	73882	20.60%
40 to 59	376	0.17%	32133	14.15%
60 to 89	152	0.14%	15524	14.33%
90 Plus	83	0.28%	5470	18.36%
Mode Used				
Working Ageed Adults (16+)	10236	0.61%	365923	21.66%
Auto	6603	0.50%	267613	20.26%
Carpool	956	0.49%	44409	22.82%
Transit	913	1.61%	19642	34.56%
Bicycle	269	4.61%	2727	46.73%
Walked	765	2.87%	10621	39.85%
Work from Home	486	0.83%	13783	23.43%
ACS 5yr (2009-2013) at Census Tract Level				
Total Vechicles	9440	0.65%	281192	19.24%
Zero Car Households	926	1.02%	32406	35.59%
Low Car Households	2064	0.38%	104187	19.21%
High Car Households	543	0.66%	16248	19.62%

	Xbus_WeekendFreq		NewBus_Weekend_Freq	
LEHD Data (2011) in Lat/Long Form	Total	Service Area Percentage	Total	Service Area Percentage
Total Jobs in Service Area	1784646	100.00%	1784646	100.00%
Total Jobs in Coverage	213930	11.99%	779097	43.66%
Workers Under 29	36944	9.02%	170322	41.56%
Workers 30-54	134783	12.96%	460099	44.24%
Workers Over 55	42203	12.60%	148676	44.39%
Low Paying Jobs (1250/mth Under)	17494	5.80%	120202	39.83%
(1251 to 3333/mnth)	55734	9.42%	243643	41.17%
High Paying Jobs (3333/mnth Over)	140702	15.79%	415252	46.61%
Retail	3151	1.75%	66351	36.91%
Professional, Sciecntific, etc…	19299	13.36%	66683	46.18%
Education	26756	15.64%	93502	54.67%
HealthCare	45587	22.19%	115546	56.24%
Food Services	5764	4.60%	54801	43.74%
Public Admin	27603	49.49%	42019	75.34%
Jobs Less then HS	17990	8.00%	88295	39.25%
Jobs advanced Degree	66005	16.53%	197173	49.38%

	Xbus_Sat_NonFreq		Xbus_Sun_NonFreq		NewBus_Weekend_NonFreq	
Spatial Form Data	Total	Service Area Percentage	Total	Service Area Percentage	Total	Service Area Percentage
Route Miles	1658		1397		1017	
Number of Routes	77		64		72	
ACS 5yr (2009-2013) at Block Group Level						
Population	1582342	43.99%	1441270	40.07%	1331058.725	37.00%
Area	8807641717	24.24%	7999063182	22.02%	7865916648	21.65%
Households	681853	48.46%	623219	44.29%	569923.3994	40.51%
Avg HH Size	2	90.77%	2	90.46%	2.335504606	91.35%
Median Income	53978	88.04%	53098	86.61%	54516.75	88.92%
Male	792381	44.26%	723632	40.42%	666123.0975	37.21%
Female	789961	43.72%	717638	39.71%	664935.6271	36.80%
Age Groups						
17under	403096	40.98%	366684	37.28%	343289.4072	34.90%
18-34	460849	48.79%	423917	44.88%	384437.2401	40.70%
35-44	418531	41.99%	379356	38.06%	351149.8134	35.23%
45-64	351735	41.74%	317362	37.66%	296195.2318	35.15%
65over	143497	46.80%	129826	42.34%	120529.3766	39.31%
Young/Old (17under/65over)	546594	28.35%	496509	25.75%	463818.7839	24.05%
Millinial (18-34)	460849	48.79%	423917	44.88%	384437.2401	40.70%
Education						
Less HS	265458	56.45%	247797	52.70%	219158.6559	46.61%
HS	224810	44.16%	205897	40.45%	190387.1575	37.40%
Some Uni	224903	38.17%	201521	34.20%	189693.7489	32.19%
Uni	174532	39.40%	155110	35.02%	146197.6408	33.00%
Masters (+)	115738	47.56%	104544	42.96%	96984.85892	39.85%
Race						
Hisp	713551	50.26%	660012	46.49%	595940.8681	41.97%
White (Non-Hisp)	373522	33.08%	329935	29.22%	312568.9471	27.68%
Black (Non-Hisp)	375923	51.06%	346504	47.06%	323415.9414	43.93%
Aisan (Non-Hisp)	99207	38.86%	86888	34.03%	81364.42761	31.87%
Other (Non-Hisp)	20139	35.49%	17931	31.60%	17768.54038	31.31%

	Xbus_Sat_NonFreq		Xbus_Sun_NonFreq		NewBus_Weekend_NonFreq	
ACS 5yr (2009-2013) at Block Group Level	Total	Service Area Percentage	Total	Service Area Percentage	Total	Service Area Percentage
Commute Data						
Avg. Travel Time to Work	712373	43.69%	645875	39.61%	594681.2124	36.47%
Less then 10	61523	47.01%	56022	42.81%	51275.92107	39.18%
10 to 19	203332	49.01%	185312	44.67%	168894.9991	40.71%
20 to 29	174891	48.47%	158276	43.87%	143889.0971	39.88%
30 to 39	155164	43.26%	140658	39.22%	129856.395	36.21%
40 to 59	70652	31.11%	63024	27.75%	60551.56266	26.66%
60 to 89	34783	32.10%	31733	29.29%	29950.22228	27.64%
90 Plus	12029	40.38%	10850	36.42%	10263.01517	34.45%
Mode Used						
Working Ageed Adults (16+)	736700	43.61%	667681	39.52%	614333.9509	36.37%
Auto	546538	41.39%	491981	37.26%	459501.7109	34.80%
Carpool	93319	47.95%	85313	43.84%	76667.34209	39.40%
Transit	36419	64.07%	34492	60.68%	29017.67267	51.05%
Bicycle	4393	75.26%	4109	70.41%	3260.601506	55.86%
Walked	17644	66.21%	16774	62.94%	14053.83104	52.74%
Work from Home	24327	41.35%	21806	37.07%	19652.73858	33.41%
ACS 5yr (2009-2013) at Census Tract Level						
Total Vechicles	564521	38.63%	515779	35.30%	472841.5778	32.36%
Zero Car Households	61498	67.53%	58534	64.28%	49405.13278	54.25%
Low Car Households	225357	41.55%	205198	37.83%	190490.8434	35.12%
High Car Households	33426	40.36%	30151	36.40%	28365.43284	34.25%

	Xbus_Sat_NonFreq		Xbus_Sun_NonFreq		NewBus_Weekend_NonFreq	
LEHD Data (2011) in Lat/Long Form	Total	Service Area Percentage	Total	Service Area Percentage	Total	Service Area Percentage
Total Jobs in Service Area	1784646	100.00%	1784646	100.00%	1784646	100.00%
Total Jobs in Coverage	1197883	67.12%	1123461	62.95%	1080428	60.54%
Workers Under 29	265156	64.71%	248996	60.76%	236919	57.82%
Workers 30-54	704507	67.75%	660979	63.56%	638313	61.38%
Workers Over 55	228220	68.13%	213486	63.73%	205196	61.26%
Low Paying Jobs (1250/mth Under)	194528	64.45%	182628	60.51%	169572	56.18%
(1251 to 3333/mnth)	384834	65.02%	362054	61.17%	340151	57.47%
High Paying Jobs (3333/mnth Over)	618521	69.42%	578779	64.96%	570705	64.05%
Retail	109076	60.68%	101427	56.42%	98490	54.79%
Professional, Sciecntific, etc…	99617	68.98%	88127	61.03%	91834	63.59%
Education	115230	67.38%	112168	65.59%	94762	55.41%
HealthCare	166564	81.07%	161398	78.55%	151463	73.72%
Food Services	86459	69.00%	81226	64.83%	74775	59.68%
Public Admin	47555	85.27%	47051	84.37%	45297	81.22%
Jobs Less then HS	145809	64.82%	136442	60.66%	129137	57.41%
Jobs advanced Degree	283035	70.88%	264514	66.24%	257338	64.45%

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