Carnegie Mellon
Heinz College
Center for Economic Development

Recommendations for Implementing Bus Rapid Transit in Pittsburgh's Oakland-Uptown-Downtown Transit Corridor

Systems Synthesis Project Final Report
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Prepared for: Port Authority of Allegheny County

Prepared by: Shenshen Cao
Yang Hu
Wenjuan Jiang
Paul Karam
Cristina Melo
Carlos Patino
Timothy Seidel
Yunyue Wu

Project Team

Advisor

Christopher Paul, PhD, RAND

Team Leaders

Paul Karam

Timothy Seidel

Board Relations

Yunyue Wu

Project Team

Shenshen Cao

Yang Hu

Wenjuan Jiang

Cristina Melo

Carlos Patino

Advisory Board

Port Authority of Allegheny County

Steve Bland, CEO
Wendy Stern, Assistant General Manager
David Wohlwill, Manager of Extended Range Planning

Center for Economic Development at Heinz College

Greg Lagana, Director of Projects

Members at Large

Lucinda Beattie, V.P. Transportation, Pittsburgh Downtown Partnership
Scott Bricker, Bike Pittsburgh
Andrew Dash, Senior Planner, Department of City Planning
Richard Feder, Consultant, Trans Associates
Court Gould, Sustainable Pittsburgh
Tom Halloran, Director, Community & Legislative Relations Center, Urban Redevelopment Authority
Lynn Heckman, Assistant Director-Transportation Initiatives, Allegheny County Economic Development
Christopher Hendrickson, Civil Engineering, Carnegie Mellon University
Tom Klevan, Southwestern Pennsylvania Commission
Darryl C. Phillips, Lead Traffic Engineer, Parsons Brinckerhoff
Mavis Rainey, Executive Director, Oakland Transportation Management Association
Patrick Roberts, Principal Transportation Planner, Department of City Planning
Chris Sandvig, Pittsburgh Community Reinvestment Group
Rick Stafford, Traffic 21, Carnegie Mellon University
Wanda Wilson, Oakland Planning and Development Corporation

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Executive Summary

Overview

In January 2011, the Heinz Systems Project Team undertook a research project on behalf of the Port Authority of Allegheny County (PAAC) examining issues surrounding the potential implementation of a Bus Rapid Transit (BRT) System in Pittsburgh's Oakland-Uptown-Downtown transit corridor. The Federal Transit Administration (FTA) defines BRT as "*an enhanced bus system that operates on bus lanes or other transitways in order to combine the flexibility of buses with the efficiency of rail. By doing so, BRT operates at faster speeds, provides greater service reliability and increased customer convenience.*"

BRT systems increase ridership and usability by offering amenities usually associated with light rail service. Exact details of different BRT systems vary widely, but most implementations include many common elements such as limited stops, upgraded stations, and, in some cases dedicated lanes to increase the speed and efficiency of service to create this association.

The Pittsburgh region and PAAC were actually early adopters of at least one of the concepts associated with BRT – the idea of running buses on a dedicated roadway. The East, West, and South Busways – dedicated lane bus services featuring limited stops and a closed access roadway – serve as early examples of how buses could be used as a cost effective alternative to light rail systems.

While the busways serve the region well, PAAC identified the development of on-street BRT in up to eight corridors as a priority in its 2007 Transit Development Plan. Among the corridors identified for possible implementation of an on-street BRT is the Oakland-Uptown-Downtown corridor, which runs through the city's hill district.

PAAC's Chief Executive Officer, Steve Bland, is currently an executive fellow with the Center for Economic Development at Carnegie Mellon University's Heinz College. It is in this capacity that Bland, and by extension PAAC approached Heinz College with a project for the Master of Science in Public Policy and Management (MSPPM) program's student systems synthesis class. Systems projects serve as the capstone course for students in the MSPPM program.

The Recommendations for Implementing Bus Rapid Transit in Pittsburgh's Oakland-Uptown-Downtown Transit Corridor project, for which this is the final report, was completed by a Heinz Systems Project Team between January 15 and April 29, 2011. At the outset of the project, the team was charged with two major tasks - to develop a series of case studies of other BRT implementations and to examine the feasibility, barriers, and recommendations to implementing a potential BRT system in the corridor.

The project team determined that the best way to meet PAAC's charge was to begin by examining general research on BRT to identify key issues that would need to be addressed as part of a BRT implementation in the corridor. Having specific issues that PAAC would need to address allowed the team to focus its efforts in terms of researching other cities' approaches to BRT. It also allowed the group to meet its second task by focusing efforts on issues that would directly affect implementation of BRT in the Oakland-Uptown-Downtown corridor.

Issue Identification

To begin identifying issues that would affect PAAC's proposed implementation; the project team gathered and reviewed existing research on BRT systems from around the world. This review led the project team to identify more than 50 issues that would potentially need to be addressed as part of PAAC's BRT implementation. From this initial list of issues, the project team developed a series of criteria to rank the issues according to their importance. After ranking the initial issues, the project team identified nine specific issues for further research, which included:

- Financing alternatives for the Oakland-Uptown-Downtown BRT
- Potential of the BRT to stimulate investment in the Corridor
- Stop selection: criteria and recommendations
- Corridor integration: connecting the BRT with other transit options
- Travel blending: potential marketing programs for the BRT
- Station signage and mapping: best practices and recommendations
- Intelligent transportation systems: technology and BRTs
- Branding: best practices
- Public perception: current rider views

The issues preliminarily identified were presented to the project team's Advisory Board in February 2011. With the advisory board's advice, the team proceeded with its research.

Financing Alternatives for the Oakland-Uptown-Downtown BRT

After researching other implementations of BRT systems across the country, the project team found that 50%-80% of funding for system implementation usually comes from federal sources. In all current cases, revenue generated from the BRTs only partially covered the operational costs of the systems.

Based on case studies and conversations with PAAC, the project team supports PAAC's plan to pursue a federal Small Starts grant as part of its efforts to fund the creation of a BRT system for the Oakland-Uptown-Downtown corridor. The project team also recommends that PAAC focuses marketing efforts for the BRT on attracting more "choice riders," those who use public transit as a preferred alternative to a personal vehicle as compared to those riders who will use the system because it is their sole means of transportation. One of the most sustainable financial streams, as our project believes, is from revenue generated by more riders. In addition, PAAC should look to augment its marketing efforts for the system by partnering with major businesses along the proposed corridor.

Potential of the BRT to Stimulate Investment in the Corridor

As part of its research on ways to encourage investment along the corridor, the project team examined the efforts of three other BRT implementations – the Cleveland Health Line, the Boston Silver Line, and the Ottawa Transitway. Additionally, the team examined the recently finished Transit Revitalization Investment District (TRID) Planning Study conducted in Mount Lebanon and Dormont Borough, both suburbs of Pittsburgh.

Based on the experiences and results of these three BRT systems, the team made a number of recommendations about ways that PAAC and its regional partners could encourage investment along the corridor. In addition to specific examples of ways that PAAC and other agencies operating in the corridor can encourage private investment, the group also recommends that PAAC encourages the City of Pittsburgh to begin a TRID planning study for the corridor.

Stop Selection: Potential Criteria and Recommendations

A hallmark of BRT is its ability to reduce travel times and increase efficiency along its route. A portion of this time savings is realized by reducing the number of stops made, thus selecting the appropriate stops along the BRT route is an important factor in the overall system design.

To address questions about stop selection, the project team examined best practices for BRT stop selection. Based on these best practices, the project team created a map of the corridor that incorporated a number of factors that affect the selection of stops, including jobs located within walking distance of the stop (1/4 mile), total population within the same distance, and total ridership for all existing stops.

From these basic criteria, the project team proposed two alternative stop selection scenarios along Fifth Avenue. Although this only scratched the surface of all the criteria that will ultimately weigh into the final selection of stops, the scenarios show how changing the weight of various criteria can change the stop locations in the corridor.

In addition to the core factors examined, the project team made a number of recommendations for additional criteria PAAC should consider in their ultimate stop selection process.

Corridor Integration: Connecting the BRT with Other Transit Options

Corridor integration examines how the proposed BRT will integrate with other existing travel options in the corridor. The project team examined the corridor and identified three major questions PAAC needs to address as part of the proposed BRT, which include:

- How do route crossings affect stop selection?
- What are PAAC's options for existing service in the corridor?
- Are there other transit options in the corridor and how should they be integrated into the new BRT system?

The project team recommends that BRT stops be located in close proximity to existing local service stops in the corridor, but should not be co-located. Therefore, BRT and local service stops should be spaced at least a half block apart to avoid congestion at stops. Furthermore, the project team recommends removing local service within the corridor if possible to avoid overcrowding. The close proximity of a parallel route to the Fifth Avenue corridor examined provides an opportunity to maintain local services nearby without slowing the BRT within the corridor.

The project team also found a number of bike routes running in and along the corridor. Incorporating this transit option could broaden the potential riders available. To integrate this amenity, we recommended incorporating bicycle parking at BRT stations in the corridor, as well as potentially allowing bicycles to be brought into the BRT buses themselves.

Travel Blending: Potential Marketing Programs for the BRT

Travel Blending, and its offshoot program IndiMark, are individual marketing efforts aimed at increasing use of public transit and “green” transit options. Both direct marketing efforts focus on engaging a small audience in a targeted geographic region through multiple two-way communications. Successful implementations examined include programs in Sydney, Australia and Portland, Oregon.

While a full Travel Blending program may exceed PAAC’s expected resources allocated to BRT, the project team identified a number of key elements that could be incorporated in a similar marketing effort, which include:

Regional Targeting – Focusing on key neighborhoods around the BRT will allow PAAC to engage “choice riders” most likely to use the BRT.

Focus on Multiple Forms of Transit – While such a marketing effort will ultimately raise awareness of public transportation in general, the broadened scope of what constitutes alternative transit will increase the overall appeal of the marketing efforts.

Partnership – Partnering with local community and business groups will allow PAAC to broaden its marketing reach.

Repeated Contact – The success of this type of marketing effort relies on the idea that PAAC will have repeat contact with its target audience. Any similar effort to those examined will need to include repeated contact with households in the target area. The project team made some observations on how these additional contacts might be accomplished.

Station Signage and Mapping –Best Practices and Recommendations

As part of efforts to differentiate BRT service from other local bus services, some cities have developed signage and mapping schemes that reinforce the association of BRT with light rail services. The project team examined best practices in station signage and researched the signage in use by other BRT systems. The team then identified a number of key elements of signage that

PAAC should incorporate, including:

- Stop names
- Route names and destinations for all routes serving the stop
- Span and frequency of service
- Service schedule for low-frequency routes

Additionally, the project team proposes that PAAC develop a new system map to help riders better understand and use public transit in the region. As part of this effort, PAAC needs to examine all routes in the city and decide which routes constitute local service and which are part of regional transit. The regional lines should be included on the system map to illustrate how to move throughout the region using public transit.

Intelligent Transportation Systems – Technology and BRTs

Intelligent Transportation Systems (ITS) are advanced communications technologies used to enhance transportation system performance. Although many technologies are included in ITS, the project team focused on three in particular.

Real-time Information – These are technologies used by transit agencies to track buses in real time. The project team examined how this information can be passed to riders and how PAAC can use this information to improve service in the corridor.

Transit Signal Priority – These are technologies used to speed BRT vehicles through traffic lights when running on shared roadways with other auto traffic. Various implementations of these systems were examined, focusing on the time savings and cost to implement this technology.

Fare Collection Alternatives – Various ways of collecting fares were examined with a focus on the costs and time savings of two main collection alternatives: off-board and on-board fare collection. The project team recommends that PAAC continue with its current policy of onboard fare collection, but eliminate the option for on-board cash payments to expedite boarding times.

Branding – Best Practices

A major characteristic of BRT systems is that they are perceived to be more similar to light rail service than local bus service. This differentiation is partly due to how transit authorities market the BRT service. Certain aspects of branding reinforce the association to light rail service and target the “choice riders” that PAAC hopes to attract to increase ridership.

As part of the project team’s research, other BRT marketing efforts were assessed. Key factors in other cities’ efforts included playing on city nicknames and incorporating things such as public art into the system design. These ideas help attract potential riders and help create an air of uniqueness for the systems. PAAC should incorporate these ideas into its efforts to promote the BRT and brand it as a unique, fast and convenient alternative to other transit options in the region.

Public Perception - Current Rider Views

Finally, a ridership survey was created in conjunction with PAAC and administered by the project team. 267 in-person interviews were conducted of riders in the corridor between March 17 and March 25, 2011. The survey examined why riders use public transit and focused on rider preferences for transit service in the corridor. Key findings include:

- Lack of car ownership is the main reason for using PAAC's services.
- Frequency and reliability are key features to retain customers as riders.
- Riders are relatively satisfied with the frequency of buses in the corridor.
- Riders are relatively dissatisfied with capacity, except the retired.
- Riders are satisfied with the speed of service.
- Riders believe that cleanliness could be improved.
- Riders are satisfied with fare collection.
- Riders are willing to walk an average (median) of 4.5 additional minutes to reach their stop.

List of Acronyms

APC – Automated passenger counters
APTA – American Public Transportation Association
AVL – Automatic Vehicle Location
BID – Business Improvement District
BRA – Boston Redevelopment Authority
BRT – Bus Rapid Transit
CAD – Computer-aided dispatch
CADS – Computer-aided dispatch and scheduling
CATS – Charlotte-Area Transit System
CED – Center for Economic Development
CDTA – Capital District Transportation Authority
CMAQ – Congestion Mitigation and Air Quality Program
CPW – Community Planning Workshop
DTS – Department of Transportation Services (Honolulu, Hawaii)
ECC – Euclid Corridor Committee
EmX – Emerald Express (Eugene, Oregon's BRT)
FTA – Federal Transit Administration
GAO – Government Accountability Office
GCRTA – Greater Cleveland Regional Transit Authority
IndiMark – Individual Marketing
ITDP – The Institute for Transportation and Development Policy
ITS – Intelligent Transportation Systems
KCATA – Kansas City Area Transportation Authority
LTD – Lane Transit District
LYNX – The Central Florida Regional Transportation Authority
MBTA – Massachusetts Bay Transit Authority
NYSERDA – New York State Energy Research and Development Authority
MTA – Los Angeles County Metropolitan Transportation Authority
OBID – Oakland Business Improvement District
PA – Public Address
PAAC – Port Authority of Allegheny County
PDP – Pittsburgh Downtown Partnership
POP – Proof-of-Payment
PPP – Public-Private Partnerships
TCRP – Transit Cooperative Research Program
TIF – Tax increment financing
TOD – Transit-oriented development
TRID – Transit Revitalization Investment District
TSP – Transit Signal Priority
URA – Urban Development Authority of Pittsburgh
VMS – Variable Messaging Signs

1. Introduction

This study of issues surrounding a potential Bus Rapid Transit (BRT) System in the Oakland-Uptown-Downtown corridor was produced by a team of graduate students at the H. John Heinz III College at Carnegie Mellon University. The research and recommendations were undertaken as part of the Spring 2011 Systems Synthesis capstone course at the college.

BRT systems are enhanced bus systems that are becoming a popular alternative to light rail transit in cities across the country and around the world. The lower costs of implementation have aided in their popularity. In addition, these systems seek to attract riders that normally ignore bus transit as a transportation option. This is accomplished by associating the BRT systems with light rail transit through elements such as station designs, unique bus designs and marketing efforts.

The initiating agency for this project was the Port Authority of Allegheny County (PAAC), who provided valuable input throughout the process to aid in our investigation. This included making recommendations for general areas of interest to the organization, as well as, giving additional input for various aspects of the project, such as helping to develop questions for a ridership survey.

This document is designed with the following primary audiences in mind: PAAC staff, the outside consultant that will be conducting the Alternatives Assessment which is scheduled to begin in the summer of 2011, and the Center for Economic Development at Heinz College. The secondary audience includes members of various regional agencies and community organizations operating in the Oakland-Uptown-Downtown corridor.

The issues examined in this report were generated by the project team as being among those that will have the most potential impact on the implementation of a BRT system in the corridor. Once the issues were identified and approved by the project's Advisory Board, issue area research began. This included reviewing best practices as set out by various federal agencies and non-profits involved in BRT system design, studying how existing BRT systems approached various issues in their implementations, and making recommendations for PAAC based on the specific circumstances of the proposed corridor.

This report represents the sum total of our efforts from January through April 2011. Due to time limitations, it is by no means comprehensive, but should be a useful jumping off point for further research on the BRT in the Oakland-Uptown-Downtown corridor.

2. Issue Identification and Prioritization

2.1. Issues Identified

To determine which issues will have the most potential impact on the implementation of a BRT system in Pittsburgh, the project team created a list of 36 potential issues. These issues were based on initial literature review, interviews with advisory board members and case studies. The 36 issues identified were placed into six broad categories, and are listed below (definitions for each issue are in Appendix A.).

Design and Branding

Corridor integration

Park-and-ride

Taxis

Parking regulation

Congestion charging and road pricing

Day restrictions by license plate number or vehicle occupancy (HOV)

Station Infrastructure

Dedicated running ways (busways)

Quality of streetscape

Economic Development

Analysis of potential by-products

Assessment of investment opportunities around stations and corridor

Impact on automobile use

Transfer center outside downtown

Transit-oriented development (TOD)

Land Development

Density (population/housing)

Increase in property value/tax revenue

Integration with land use policies

Parking configuration (commuters, riders, shared)

Marketing

Brand identity and contextual design
Attracting more “choice riders”
Travel Blending

Community Impact

Public perception
Public engagement
Reducing road supply

Financing

Private participation
Financing alternatives
System sustainability

Operation

Travel time
Mode connections at transit stations
Quality of service
Ridership forecast
Safety
Fare collection
Signal priority
Real-time information
Station security

2.2. Ranking Criteria

After determining the 36 issues, a list of 9 criteria was produced based on interviews with advisory board members, background reading and the criteria for the Small Starts Program (Federal Transit Authority, 2010) that are applicable to the proposed corridor. Each criterion was given a weight based on each individual project member's research findings, and placed into one of three broad categories (Table 1).

	Selection Criteria	Weight
Strategic Fit	Cost efficiency	15%
	Feasibility/ease of implementation	15%
	Probability of quick results	10%
Impact	Economic impact	15%
	Community impact	15%
	Environmental impact	10%
Feasibility	Potential savings in the future	10%
	Service quality (reliability and efficiency)	5%
	Improvement potential for defect reduction	5%
Total		100%

Table 1. Ranking criteria that are applicable to the proposed corridor.

2.3. Prioritization Matrix

A structured prioritization matrix was then used to identify key issues that will have the most potential impact on the implementation of a BRT system in Pittsburgh. Each project team member was rated all 36 issues for each of the 9 criteria with a 1, 2 or 3, where 1 indicates low priority, 2 indicates medium priority and 3 indicates high priority. Each issue was weighed against the 9 criteria and the outcome was eight (the number of members in the project team) sets of individual scores for each of the 36 issues.

2.4. Analysis and Results

2.4.1. Averaging

The results were then analyzed by calculating the average score for each individual issue based on scores that team members gave. The top ten issues were highlighted, and are listed below.

Category	Issue	Average	Rank
Design and Branding	Congestion and charging the road	2.324	1
Design and Branding	Dedicated running ways (busways)	2.279	2
Operations	Ridership forecast	2.266	3
Marketing	Travel blending	2.249	4
Operations	Travel time	2.240	5
Economic Development	Transit-oriented development	2.186	6
Operations	Real-time information	2.161	7
Operations	Mode connections at transit stations	2.143	8
Financing	Private participation	2.141	9
Design and Branding	Corridor integration	2.139	10

Table 2. Top 10 issues identified and average importance rating across all team members.

2.4.2. Frequencies of Highest Rated Issues

Next, the ten issues rated the highest by each team member were calculated. From these lists, the issues were aggregated by frequency representing the total number of times team members count the issue in their top ten priority list, and are listed below.

Issue	Frequency Count
Dedicated running ways	6
Congestion charging and road pricing	5
Station infrastructure	5
Travel time	4
Land development	4
Mode connection at transit stations	4
Fare collection	4
Transfer station outside downtown	4
Station security	3
Travel blending	3
Private participation	3
Ridership forecast	3
Corridor integration	3

Table 3. Frequency table representing the total number of times team members listed the issue in their top ten priority list.

2.5. Issues for Further Analysis

Based upon the common findings from the averaging score card and frequency tables, nine issues were decide upon for further analysis. These issues are not only significant to the implementation of the BRT system, but also within our armory of expertise and limited timeframe.

- Financing alternatives for the Oakland-Uptown-Downtown BRT
- Potential of the BRT to stimulate investment in the Corridor
- Stop selection: criteria and recommendations
- Corridor integration: connecting the BRT with other transit options
- Travel blending: potential marketing programs for the BRT
- Station signage and mapping: best practices and recommendations
- Intelligent transportation systems: technology and BRTs
- Branding: best practices
- Public perception: current rider views

3. Cases Reviewed

In this report, the following regions' BRT systems were reviewed.

3.1. Albany, New York

Name – BusPlus

Year of operation - 2011

Length of Routes - 16 miles

Operated by - Capital District Transportation Authority (CDTA)

Reviewed in the following sections - Financing Alternatives

3.2. Boston, Massachusetts

Name: The Silver Line

Year of operation - 2002[1]

Length of Routes - 4.1 miles

Operated by - Massachusetts Bay Transit Authority (MBTA)

Reviewed in the following sections - Investment Opportunities and Economic Development along the BRT Corridor, Intelligent Transportation System, Public Perception and Branding

3.3. Cleveland, Ohio

Name: The Health Line

Year of operation - 2008

Length of Routes - 9.8 miles

Operated by - Greater Cleveland Regional Transit Authority (GCRTA)

Reviewed in the following sections - Financing Alternatives, Investment Opportunities and Economic Development along the BRT Corridor, Station Signage and Mapping, Fare Collection Alternatives, Public Perception and Branding

[1] The system consists of three sections and has been implemented gradually since 2002. For further information, please refer to http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp90v1_cs/Boston.pdf

3.4. Eugene, Oregon

Name - The Emerald Express (EmX)

Year of operation - 2007

Length of Routes - 4 miles

Operated by - Lane Transit District (LTD)

Reviewed in the following sections - Financing Alternatives, Public Perception and Branding

3.5. Kansas City, Kansas

Name - The Metro Area Express (MAX)

Year of operation - 2005

Length of Routes - 6 miles

Operated by - Kansas City Area Transportation Authority (KCATA)

Reviewed in the following sections - Financing Alternatives, Station Signage and Mapping

3.6. Honolulu, Hawaii

Name - City Express

Year of operation - 1999 (Route A), 2000 (Route B)

Length of Routes - 19 miles (Route A), 8 miles (Route B)

Operated by - Department of Transportation Services (DTS)

Reviewed in the following sections - Public Perception and Branding

3.7. Los Angeles, California

Name - The Orange Line

Year of operation - 2005

Length of Routes - 14 miles

Operated by - Los Angeles County Metropolitan Transportation Authority (MTA)

Reviewed in the following sections - Intelligent Transportation System, Public Perception and Branding, Station Signage and Mapping

3.8. Oakland, California[2]

City - Oakland, CA

Name - The San Pablo Rapid Line

Year of operation - 2003

Length of Routes - 14 miles

Operated by - Alameda-Contra Costa Transit District

Reviewed in the following sections - Public Perception and Branding

3.9. Ottawa, Ontario

Name - The Transitway

Year of operation - 1983

Length of Routes - 29 miles

Operated by - OC Transpo

Reviewed in the following sections - Investment Opportunities and Economic Development along the BRT Corridor

3.10. Orlando, Florida

Name - Lymmo

Year of operation - 1997

Length of Routes - 2.3 mile

Operated by - The Central Florida Regional Transportation Authority (LYNX)

Reviewed in the following sections - Intelligent Transportation System, Public Perception and Branding

[2] The San Pablo Rapid route runs through seven cities, Oakland, Emeryville, Berkeley, Albany, El Cerrito, Richmond, and San Pablo, and two counties, Alameda and Contra Costa (Cheryl Thole, 2006).

4. Financing Alternatives

4.1. Introduction

Securing funding to cover capital costs is a key issue for Bus Rapid Transit (BRT) projects. Conventional sources of funding come from federal and state governments. However, as competition for federal funding intensifies, some BRT systems are looking to the private sector for funding. Some domestic and international cases show new ways of incorporating the private sector into the development and implementation of BRT.

This section examines a selection of case studies that provide an overview of the different alternatives for funding BRT project.

Most of the dollar amounts in this section were converted into 2010 dollars using the CPI inflation calculator from the U.S. Bureau of Labor Statistics. The CPI inflation calculator uses the average Consumer Price Index for a given calendar year. This data represents changes in prices of all goods and services purchased for consumption by urban households (BLS Inflation Calculator).

However, figures for costs and funding breakdowns were shown in original dollar amounts for the following reasons:

- For most of the cases, while project cost breakdowns are available, it's not clear which year's dollars those amounts represent.
- The budget (or funding) spread across several years and the costs were spent throughout the project phase, so ideally they need to be converted year by year. However, the detailed information is not available.
- While funding/cost breakdowns (absolute values) can give a sense of the scale of the projects in terms of financing, a more meaningful comparison is the proportion of each source / expense in the discussion of the case studies.

Access to different funding sources depends on the nature of the project and the total capital cost. The range of capital costs is reviewed to give context to the analysis of selected case studies' available funding opportunities. The following cost estimates include capital and operational costs, and are taken from two reports: The General Accounting Office's (GAO) report on mass transit and the Transit Cooperative Research Program's (TCRP) Bus Rapid Transit Practitioner's Guide.

The GAO's report compares BRT and light rail systems. While capital costs for BRT systems are lower than capital costs for light rail systems (United States General Accounting Office, 2001), no system shows a clear advantage in terms of operating costs. One key characteristic about BRT systems is their higher degree of flexibility (features included in the system) in terms of design and implementation. As a result of this flexibility, capital cost estimates range from as little as $253,259 per mile (figures in 2010 dollars) to

$69.65 million per mile (United States General Accounting Office, 2001). The following figure shows an estimate of the increments in capital cost when adding features to the system. These figures come from the aforementioned GAO report. Capital costs for the busway approach correspond to the average for nine busways built in four cities – Houston, Los Angeles, Miami and Pittsburgh. Capital costs for systems that relied on shared lanes (e.g. High-Occupancy-Vehicles lanes) correspond to the average for eight of these BRT systems in five cities – Dallas, Denver, Houston, Seattle and San Diego. Finally, the capital costs for basic systems (those limited to arterial streets with either exclusive use or no dedicated right-of-way, and include improvements such as signal priority) correspond to the average for three lines in two cities – Los Angeles and Orlando.

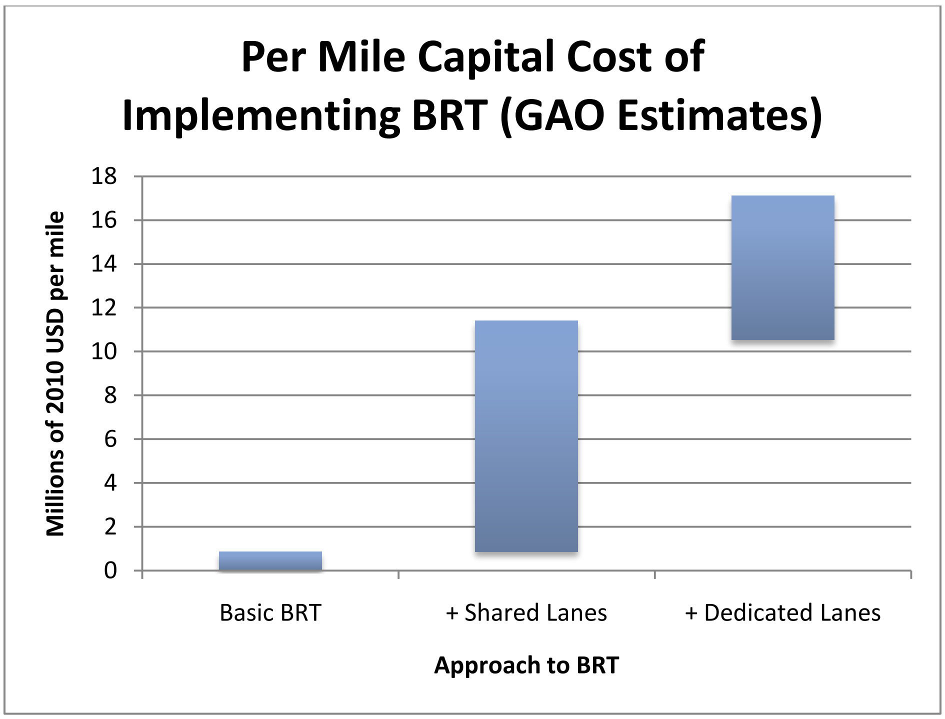

Figure 1. Per mile capital cost of implementing BRT (GAO Estimates).

The cost components included in these estimates are the following:

- Busways (or buslanes)
- Station structures
- Park-and-ride facilities
- Communications
- Improved traffic signal systems
- Vehicles (if special buses are needed)

Regarding operating costs, the GAO report estimates costs per hour of operation (regardless of the number of passengers carried), costs per mile traveled, and costs per passenger trip. For Pittsburgh's busways, the report estimated an operating cost of $187 per hour (2011 dollars), $11.15 per mile, and $2.83 per passenger. These figures are based on the examination of two BRT busways existing in Pittsburgh at the time: the East Busway and the South Busway. The West Busway was not included since it was not open in 1999.

TCRP's Bus Rapid Transit Practitioner's Guide disaggregates the cost according to the BRT components included in the project. The cost estimates range from $1.15 to $379.78 million per mile (2010 dollars), but the most expensive projects, which were Boston and Seattle, included tunnels (Transit Cooperative Research Program, 2007).

TCRP's cost estimates are based on the degree of segregation of the BRT. Capital costs include development costs such as land acquisition, construction and engineering. These costs also depend on the geographical location of the BRT system. Therefore, this report argues that even though past experience is a good starting point for cost estimates, it is necessary to assess the expected cost based on the particular design and scope of each BRT. Consistent with the GAO's report, the TCRP report suggests capital costs are directly impacted by the number of features included. The range of costs is large due to the flexibility of BRT systems. For example, grade-separated busways cost between $6.93 and $57.72 million per mile. At the lower level of complexity and infrastructure requirements, at-grade busways on dedicated right-of-way lanes cost between $6.93 and $57.72 million per mile. A full summary of costs per lane per mile is presented in the following chart. This information is taken from the TCRP's report (Transit Cooperative Research Program, 2007) and cost figures were in 2010 dollars.

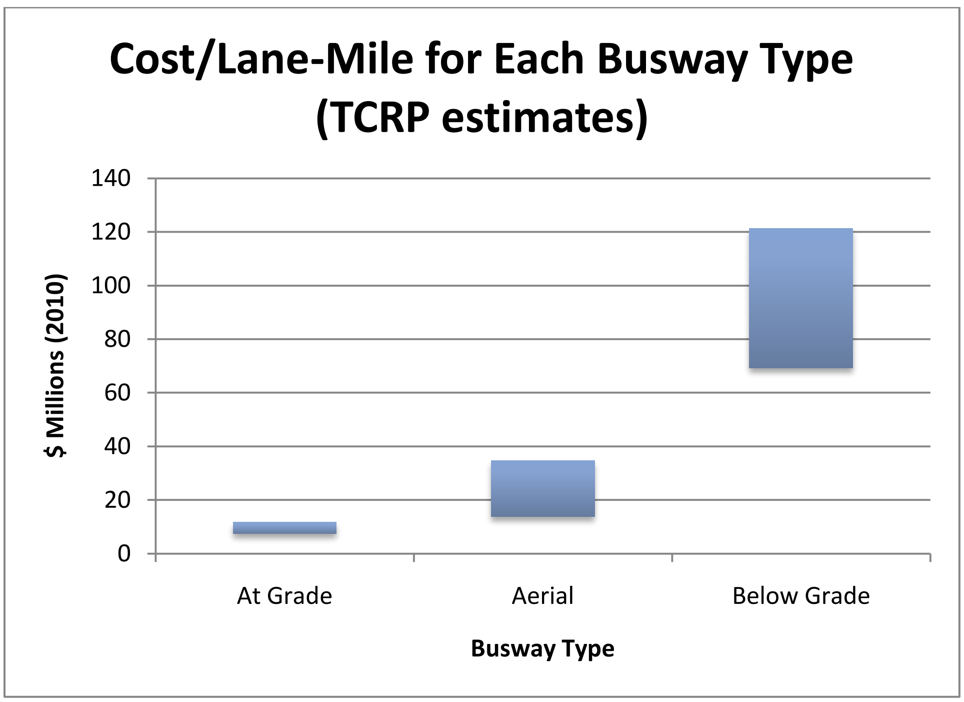

Figure 2. Cost per lane per mile for based on busway type (TCRP Estimates).

At the system-level, costs vary significantly depending on the characteristics of the development. According to TCRP, systems similar to the one intended for the Oakland-Uptown-Downtown Corridor, costs per mile do not exceed $18.47 million (2010 dollars) (Transit Cooperative Research Program, 2007).

4.2. Funding Alternatives

4.2.1. Federal Funding Sources

The main source of funding for BRT projects is the federal government. Four BRT systems are analyzed in-depth later in this section and from these case studies it was found that roughly 50% to 80% of capital funding comes from federal sources. However, as competition for federal funds intensifies, more BRT systems have started to look to the private sector as a source of funding.

The most common federal sources of funding include:

- New Starts Program
- Small Starts Program
- Bus and Bus Facilities Program
- Urbanized Area Formula Grants
- Highway Funding and Flexible Funds
- Fixed Guideway Modernization
- Tax Increment Financing Districts

4.2.1.1. New Starts Program (Section 5309)

The Federal Transit Administration's (FTA) New Starts program is the federal government's primary financial resource for supporting locally planned, implemented, and operated transit "guideway" capital investments (Introduction to New Starts). New Starts projects are defined as projects whose sponsors requested $75 million or more in New Starts funds or anticipated a total capital cost of $250 million or more (49 USC 5309(d)). New Starts projects are evaluated and rated on a set of defined project justification and local financial commitment criteria(Ferderal Transit Administration, 2011).

While the level of New Starts funding is not very high, the proportion allocated for BRT projects is relatively low compared to that for other projects such as light rail. This is due to the lower cost of BRT projects, and the fixed guideway requirement excludes BRT project that operate on arterial roadways. In the past, New Starts would provide up to 80% of project costs, but due to significantly increased demand, the program now typically provides no more than 50% of project cost (Callaghan, 2007).

4.2.1.2. Small Starts Program (Section 5309)

In the 2005 Transportation Reauthorization Bill, Congress created the Small Starts funding category for small-scale, low cost capital projects which includes BRT.

Eligible projects can request less than $75 million in Small Starts funding for a total project capital cost of less than $250 million. Additionally, eligible projects must either use a fixed guideway for at least 50% of the project length in the peak period, or are corridor-based bus projects with 10 minute peak/15 minute off-peak headways or better while operating at least 14 hours per weekday (Major Capital Investments (New Starts & Small Starts)).

Compared to the New Starts program, the Small Starts program has lower requirements and allows projects to apply for up to 80% of the total costs. Also, some of the New Starts' rating requirements were eliminated and the application process has been streamlined. Furthermore, in 2007, FTA established eligibility parameters for Very Small Starts projects (projects with capital costs under $25 million), a subset of the lowest-cost Small Starts that follow a even more simplified project development and evaluation process (Small Starts).

While Small Starts is encouraging more transit authorities implementing BRT projects to apply for Section 5309 grants, the funding levels for this program are low. This is because FTA wants to use New Starts and Small Starts funding as a means of funding more projects and leveraging state, local, and other federal financial resources.

The President's Budget for FY 2010 requested over $1.5 billion for the New Starts program and $174 million for the Small Starts program. Among the 16 projects that qualified under the Small Starts program, 13 are BRT projects (Federal Transit Administration, 2009).

4.2.1.3. Bus and Bus Facilities Program (Section 5309)

The Bus and Bus Related Equipment and Facilities program provides capital assistance for new and replacement buses, related equipment, and facilities. It is an optional program to supplement formula funding in both urbanized and rural areas(Bus and Bus Facilities (5309, 5318)).

BRT projects can use these funds for bus acquisition, bus maintenance and administrative facilities, passenger amenities such as shelters and stop signs, transportation centers, intermodal terminals, and park and ride facilities. Although single grants are small, typically ranging from $50,000 to $15 million (Other Potential Federal Funding Sources), the program is attractive because only a 20% local match is required (Callaghan, 2007).

This program has proven to be a good source of supplemental support for BRT. Some BRT projects have met up to half their budget needs with bus capital funds. The Kansas City Area Transportation Authority supplied about one-third of the MAX project budget from $8.3 million in bus capital earmarks and half of the Las Vegas MAX budget came from $9.65 million in bus capital funds (Other Potential Federal Funding Sources).

4.2.1.4. Urbanized Area Formula Grants (Section 5307)

This program provides transit capital and operating funds for urbanized areas with a population greater than 50,000. Grants can be used for planning, engineering design and evaluation of transit projects, as well as, other technical transportation-related studies, capital investments in bus and bus-related activities such as replacement of buses, overhaul of buses, rebuilding of buses, crime prevention and security equipment and construction of maintenance and passenger facilities (Urbanized Area Formula Program). Urbanized areas with populations greater than 200,000 may only use these funds for capital investment while areas with populations under 200,000 can also use it to subsidize operating costs.

Like the Bus and Bus Related Equipment and Facilities program, formula funds only require a 20% local match. However, small cities that can use the funds for operating costs are unlikely to divert them to capital projects. Several systems have used them as supplemental funds. The New Britain Busway, Community Transit Swift BRT, Eugene EmX, Las Vegas MAX and Boston Silver Line II all used formula funding grants for non-vehicle expenses (Callaghan, 2007).

4.2.1.5. Highway Funding and Flexible Funds

Cities can use federal highway dollars for a variety of purposes, including transit, through programs like the Congestion Mitigation and Air Quality Program (CMAQ). CMAQ funds can be used to support transportation projects in air quality non-attainment areas. Eligible projects must contribute to the attainment of the national ambient air quality standards by reducing pollutant emissions from transportation sources (Flexible Funds/Transfers). CMAQ funds are useful because they can be used to fund all project phases and only require an 11.47% local share (Other Potential Federal Funding Sources).

Despite the small size of the grant and heavy competition, some cities have used CMAQ successfully. Cleveland secured CMAQ funds to cover 80% of its BRT operation cost from 2009 to 2011, which is detailed below in the case study of Cleveland's Health Line (see section 4.3.3).

4.2.1.6. Fixed Guideway Modernization (Section 5309)

This program supports capital projects to modernize or improve existing fixed guideway systems (any transit service that uses exclusive or controlled rights-of-way or rails) (Fixed Guideway Modernization). Though it was originally designed to support the renovation of rail transit systems, the New Britain busway, which will operate on an abandoned railroad right-of-way and on shared right-of-way with Amtrak, was able to secure $14.06 million from this program (Callaghan, 2007). Thus, other projects that face the same situation might consider using this fund.

4.2.2. Private Funding Sources

In addition to the federal funding, some BRT systems are relying on bonds or tax referenda. However, some additional tools such as joint development and public-private partnerships incorporate the private sector.

4.2.2.1. Joint Development

This approach is usually used to develop specific transit facilities such as transfer centers or stations. The joint development involves the transit system and the community, where transit property is leased to the community for other development purposes. For example, the IBM Tower built next to a station in Atlanta generated billions of dollars in revenues in less than six years after its construction (Transit Cooperative Research Program, 2003).

4.2.2.2. Public-Private Partnerships

Public-Private Partnerships (PPP) occurs when a government entity and a private agent work together to provide a public service. In most cases, the private agent assumes most of the financial, technical and operational risk in the project, but benefits from being able to collect revenue.

PPP is a funding alternative that is present in many infrastructure projects. The majority of projects in the US that involved PPP were infrastructure projects such as highways. Charlotte's Transportation Center is as a good example of the benefits of incorporating the private sector into public services. In many other countries such as Brazil and Colombia, PPP initiatives have been developed in order to provide transportation projects with an alternate source of funding. In these two countries, BRT systems have been implemented with the support of the private sector.

4.3. Case Studies

The following case studies illustrate how cities similar to Pittsburgh developed and funded their BRT systems.

4.3.1. Eugene, Oregon

4.3.1.1. System Overview

In 1996, Lane Transit District (LTD) started to develop a BRT system as part of a regional transportation plan. In 2007, the first BRT line, the EmX Green Line, began operation in the Franklin corridor. The 4-mile route links the systems two main hubs: downtown Eugene and downtown Springfield. Developed with 10 stations, 60% of the corridor operates on exclusive right-of-way, while the remainder of the route runs on curbside bus lanes with signal priority and queue jump lanes (BRT Policy Center: Eugene, Oregon, 2007). There are 4 vehicles running in the system with a service frequency of 10 minutes during weekday peak and 20 minutes during off-peak and weekends. The current ridership is 2,700 boardings per weekday and is projected to have a 40% growth over 20 years.(EmX FAQ). The EmX implemented several Intelligent Transportation Systems (ITS) technologies, including Transit Signal Priority (TSP), Automated Vehicle Locator (AVL), Automated Passenger Counters (APC), and computer-aided dispatching (CAD) (Cheryl Thole A. C., 2009).

Since then, LTD has expanded its BRT system and added a second corridor – the Gateway EmX Extension which began operation in 2011. Currently, a third corridor in West Eugene is in the planning phase (EmX Background).

4.3.1.2. Capital Costs

The total project cost of the Franklin Corridor was approximately $25 million, or $6.25 million per mile. The capital cost breakdown is shown in the following table (Cheryl Thole A. C., 2009).

	Original Budget	Actual Cost	Actual Cost (%)
Design/Consulting Service	2,445,474	2,619,500	10.67%
Property Acquisition	1,350,000	1,006,450	4.10%
Construction Costs	12,797,246	12,469,480	50.78%
Miscellaneous Costs/Utilities	476,000	517,170	2.11%
Plan Review/Permits/Inspections	250,000	545,610	2.22%
Construction Support Costs	1,300,000	1,463,840	5.96%
Project Contingency	930,936	-	0.00%
Total Scope	19,549,656	18,622,050	75.84%
Vehicles	5,500,000	5,932,070	24.16%
Total	**25,049,656**	**24,554,120**	100.00%

Table 4. Capital costs breakdown for EmX Franklin Corridor.[3]

The major cost drivers for this project are construction costs and vehicle purchases, which represent 50.78% and 24.16% of the total capital cost respectively. The construction costs were very high because 60% of the corridor consists of exclusive bus lanes. Construction included underground utilities, curb realignments, landscaping and stations (EmX History). EmX purchased 6 stylized BRT buses from New Flyer, for $980,000 each. These are hybrid-electric buses with multiple door entries on both sides. Since there were no such buses available in the North American market, LTD partnered with Cleveland's transit agency and had New Flyer develop its first 60-ft BRT-style bus for the two agencies. Now there are several manufacturers promoting BRT stylized buses so the cost is relatively lower (BRT Policy Center: Eugene, Oregon, 2007).

[3] Capital costs breakdown was obtained from FTA's evaluation report and the costs numbers were obtained from Lane Transit (2008). However, while it's uncertain that those numbers represent which year's nominal dollars, they were not converted into 2010 dollar amount here .

4.3.1.3. Funding Source

The EmX funding consisted of 80% from federal sources while 20% from local funds. More than half of the total cost is funded by the New Starts program (Section 5309). The breakdown is as follows:

	Sources	Amount [USD million]	Percentage of Total [%]
Federal Funding	New Starts (Section 5309)	$13.3	53.2%
	Formula Funds (Section 5307)	$6.7	26.8%
Subtotal		$20.0	80.0%
State and Local Funding	Lane Transit District, funded from a dedicated portion of local payroll tax	$5.0	20.0%
Subtotal		$5.0	20.0%
Total		$25.0	100%

Table 5. EmX funding breakdown (Cheryl Thole A. C., 2009).[4]

4.3.1.4. Conclusion

Compared to other BRT projects, the cost of Eugene's EmX is relatively low, with main cost drivers being construction and vehicle purchases. LTD's $5 million investment successfully leveraged $20 million federal funds.

4.3.2. Cleveland, Ohio

4.3.2.1. System Overview

In 2005, the Greater Cleveland Regional Transit Authority (GCRTA) began to build its BRT system, the Health Line in the Euclid Corridor, which began operating in 2008. The Health Line connects Cleveland's central business district with Cleveland's University Circle and major cultural, medical and educational district. More than half of the 9.8 mile route operates in an exclusive median busway beginning in Public Square and changes to the curb at University Circle. The buses running in the BRT system are aerodynamic 62-foot Euclid Corridor Vehicles, featuring GPS communication, hybrid engine technology, multiple door boarding, security cameras, text display, and audio announcement. There are 58 stations in the corridor equipped with fare vending machines,

[4] The federal funding was included in the 2003-2004 fiscal year budget. However, FTA's evaluation report does not specify the year of the state and local funding allocation. Assuming that they were 2003 dollars, total federal funding was then $23.70 million (in 2011 dollar amount) and state and local funding was $5.93 million.

emergency phones, interactive kiosks, raised platform floors, real time text display and station signage. Ridership is forecasted to be about 29,500 passengers per day, including 2,400 daily new riders in 2025 (RTA HealthLine Project Overview).

4.3.2.2. Capital Costs

The total cost of the project is $168.4 million, or $17.18 million per mile. While the detailed breakdown is not available, compared to other BRT systems, the major difference of Cleveland's BRT is the relatively lager scale of reconstruction along the corridor, which is probably the major driver of costs. The Health Line project involved a complete building-face-to-building-face reconstruction of Euclid Avenue, including exclusive bus lanes, pedestrian zone enhancements, roadway reconstruction and design, traffic signal equipment installation, elimination of on-street parking and relocation of loading zones (RTA HealthLine Project Overview).

4.3.2.3. Operational Costs

Since the Health Line is determined to be a Congestion Mitigation Air Quality (CMAQ) eligible service and eligible for operating assistance for the period of August 1, 2009 through October 26, 2011, the project has obtained $3 million in 2009, $5.7 million in 2010 and is seeking $4.8 million in 2011 from CMAQ funding (GCRTA Calendar Year 2011 HealthLine Vus Rapid Transit Operation). CMAQ funds are crucial to maintaining the Health Line service because it during the years they were used, they covered 80% of the operating costs.

4.3.2.4. Funding Sources

	Sources	Amount [USD million]	Percentage of Total [%]
Federal Funding	New Starts (Section 5309)	$82.2	48.8%
	FTA Rail Mode	$0.6	0.4%
Subtotal		$82.8	49.2%
State and Local Funding	State of Ohio	$50.0	29.7%
	NOACA (Northeast Ohio Area Wide Coordinating Agency)	$10.0	5.9%
	Greater Cleveland Regional Transportation Authority	$17.6	10.5%
	City of Cleveland	$8.0	4.8%
Subtotal		$85.6	50.8%
Total		$168.4	100%

Table 6. Cleveland Health Line funding breakdown (RTA Euclid Corridor Transportation Project: Current Funding Allocation).[5]

Federal funding covers about 49% of the Health Line's cost, while the other 50% is funded through state and local sources.

Since BRT can operate on mixed-use roadways, state and local capital infrastructure or maintenance budgets can be utilized as sources of BRT funding for road construction, streetscape improvements and traffic signal upgrades. This strategy was used by Cleveland when the GCRTA did a complete re-build along a portion of the Euclid Avenue, which included roadway reconstruction and pedestrian zone enhancements using state and local funding (Funding BRT in the US).

4.3.2.5. Conclusion

The Cleveland Health Line cost $168.4 million, which is mainly due to the reconstruction of the corridor, the longer length of the corridor and a substantial number of stations. While federal funds covered about half of the costs, state and local funding also played an important role. This is because FTA's current cost effectiveness criterion makes it extremely difficult to achieve a high rating if more than 50% of funding is requested from New Starts (Funding BRT in the US Federal Funding Sources: New Starts).

[5] Because the actual funding was apportioned in several years and GCRTA does not specify the year when the data were collected, they are not converted into 2010 dollars.

4.3.3. Kansas City, Kansas

4.3.3.1. System Overview

MAX, the original BRT line in Kansas, opened in 2005 and has a total length of 6 miles. MAX has a dedicated BRT bus lane and its successes were partially due to its partnerships with the city, the communities and corporations. In addition, financing via existing funding resources also helped with it earlier success (KCATA, 2008).

In 2006, Kansas began planning the Troost MAX, which is an expansion of existing BRT line. The plan and construction work were completed between 2008 and 2009. In late 2009 and early 2010, the Troost MAX opened. It covers over 13 miles, has 44 stations and contains 34 signal-prioritized intersections (KCATA, 2008).

4.3.3.2. Capital Cost and Funding Source

The capital cost of MAX was $21 million, with 80% supported by federal funding, and 20% supported by local funding (KCATA, 2008). Below is a breakdown of the $21 million capital cost for the MAX (KCATA, 2008):

- $ 2.9 Planning, Design & Engineering
- $ 4.3 Vehicles and Inspections
- $ 2.3 Street Paving Construction
- $ 1.8 Traffic Signal and Signal Priority
- $ 8.5 Stop Construction / Installation
- $ 0.7 Admin, Easements, Utility & Legal

The capital cost of Troost MAX was proposed as $39.7 million, or approximately $3 million per mile. Similar to MAX, 80% of the funding is from federal sources, while 20% comes from local sources (KCATA, 2008). Below is a breakdown of the capital cost (KCATA, 2008):

- $ 3.2 Planning, Design & Engineering
- $ 5.9 BRT Vehicles (Includes 3 Hybrids)
- $ 0.4 Support Facilities (Maintenance)
- $ 3.5 Paving, Streetscape, Sidewalk
- $ 2.5 Systems (Signals, Signs, TVM)
- $12.6 Stations & Park-and-Rides
- $ 1.3 Admin, Easements, Utility & Legal

Since the author of the source where the data were cited did not specify in which year these dollar values were calculated, and also because the breakdown of capital cost came across several years, all the dollar values mentioned above are not converted into current values.

4.3.3.3. Conclusion

The BRT system in Kansas is a successful case of the Small Starts program. Both MAX and the extended service, Troost MAX, had 80% of their capital costs funded by the federal government.

4.3.4. Albany, New York

4.3.4.1. System Overview

The BRT project in Albany, New York operates on the New York Route 5 corridor. It is 16 miles long and stretches from downtown Albany to downtown Schenectady. It has 72 signalized intersections, and since the system was not completely equipped with dedicated lanes, it operates on semi-dedicated lanes that were adapted (Bus Rapid Transit Policy Center).

The corridor was once the main street in the area. However, along with market shift and land use changes, the corridor declined. The idea of building BRT in the corridor came out of the purpose of revitalizing the corridor, focusing on the neighborhoods and communities along the corridor (Bus Rapid Transit Policy Center).

4.3.4.2. Capital Cost

The whole project was completed in three phases. The total capital cost throughout the three phases was $25 million (Bus Rapid Transit Policy Center).

	Total Cost [USD Million]	Percentage of Total [%]
Stations	$6.4	25.6%
Vehicles	$10.5	42.0%
ITS	$4.3	17.3%
Queue Jumper[6]	$0.9	3.5%
Park-and-Ride	$4.5	18.0%

Table 7. Albany's BRT total capital cost breakdown.[7]

In Albany's BRT capital costs, vehicle purchases were the dominant cost. Ten 40-foot low floor buses and 21 feeder minibuses were purchased. For the purpose of easy identification

[6] "A queue jumper is a lane on an approach to a traffic bottle-neck location that is reserved for buses or serves a bus-only movement" (Hinebaugh & Díaz, Characteristics of Bus Rapid Transit for Decision-Making, 2009, p. 2.4).

[7] Since the author of the source where the data were cited did not specify in which year these dollar values were calculated, and also because the breakdown of capital cost came across several years, all the dollar values mentioned above are not converted into current values.

and branding, buses were painted at the cost of $75,000 in Phase 2 (Bus Rapid Transit Policy Center).

Station construction came as the second largest cost. In total, there are 20 stations along the corridor, and all are branded with BRT images and a signs showing the stations' name. In order to make stations more pedestrian friendly, Albany spent money on renovating the sidewalks, which included, lighting, bike racks, emergency and public phones, vending machines, security cameras and restrooms. Additionally, off-board fare collection facilities, park-and-ride facilities, and real-time travel information signage were also included in the stations (Bus Rapid Transit Policy Center).

4.3.4.3. Funding Sources

Albany used funding resources from the federal, state and local governments, as well as, private sources. Based on limited information from the Bus Rapid Transit Policy Center, federal funding was $4 million, or 8.9% of the total funding, while local funding was $41 million. Below is a breakdown of the local funding:

- BRT Study: $175,000
- Bus rapid transit features: $12 million
- Highway rehabilitation and enhancement: $25 million
- Signals and other improvements: $4 million

Phase 1 was fully covered by federal, state, local and private funding. Federal funding was approximately 19% of the total funding sources, state and local funding was about 80%, and private funding was 1% (Federal Transit Administration). Funding sources include:

State and Local funds:

- STP-Flex
- State Dedicated Fund
- Albany/BID funds
- Schenectady/Metroplex funds
- State and local sources
- New York State Energy Research and Development Authority (NYSERDA)

State and local funds played a more important role in funding the BRT system in Albany. The BRT system in Albany was less dependent on federal funding. Six different local and state funding sources were sufficient to support the system.

4.3.4.4. Conclusion

Compared to other BRT systems, state and local funds played a more important role in funding the BRT systems in Albany. The BRT system in Albany was less dependent on federal funding. Six different local and state funding sources were sufficient to support the system.

4.4. Findings and Recommendations

In the cases examined, the capital costs of BRT projects are mainly funded through federal sources. Figure 3 shows that for most of the cases 50% - 80% of funding came from federal sources.

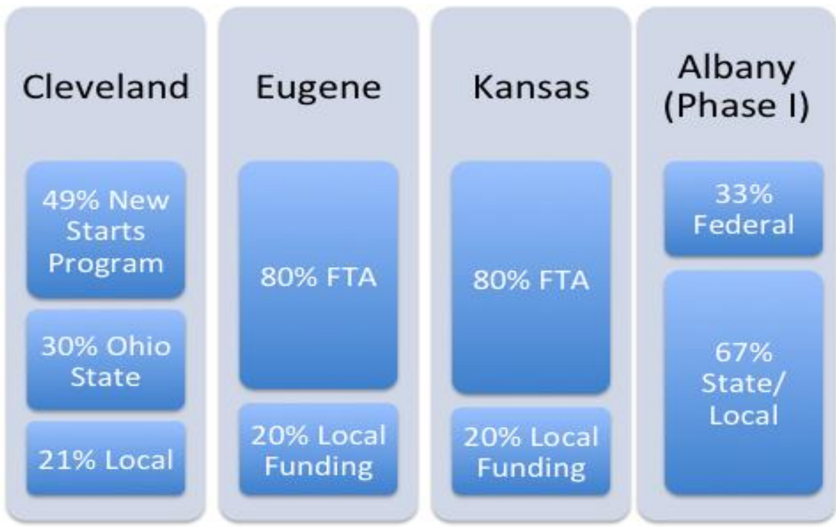

Figure 3. Overview of capital costs breakdown for Cleveland, Eugene, Kansas and Albany's BRT systems.

In addition, operational costs are partially covered by revenues from increased ridership, local taxes and federal transfer funds. However, operational costs are still subsidized. Thus, using appropriate marketing strategy to attract "choice riders" will be one potential revenue driver.

Though some international cases report private participation through concessions, private participation in the cities examined is limited to advertising.

Charlotte-Area Transit System (CATS) demonstrated a successful case of utilizing transit real estate advertising. CATS signed a five-year, $2.6 million contract with a transit advertising company, allowing exclusive advertising rights on all the buses and light rail in the system. The contract would also guarantee CATS a $5 million profit through the five years. In the earlier stage, the advertisement in CATS was not cost-effective. Later, the contract helped CATS to manage advertisement in a more effective way, to cover costs, and to avoid a rise in bus fares (Sonuparlak, 2011).

According to the analysis on PAAC's financial reports from Fiscal Year 2006 to Fiscal Year 2010, *Other Income*, this includes advertisement income, accounts for no more than 4.1% in the past five years. In 2010, only $2,438,020 came from *Other Income* (Port Authority of Allegheny County, 2010), which means there is potential room for increasing revenues from advertisement.

5. Investment Opportunities and Economic Development along the BRT Corridor

5.1. Introduction

Bus Rapid Transit (BRT) and public transportation in general, has the potential to create investment opportunities in the areas it operates. Investments can range from the city repaving the sidewalk around a BRT station to a developer building a retail or commercial complex near a BRT stop. To maximize the benefits of investing along a BRT corridor, the transit authority has to work closely with the governments, community groups, non-profits and businesses that have an interest in the corridor. This has to be done early in the BRT planning stage so investments can coincide with the implementation of the BRT.

New investments not only bring in new tax revenue, but also help the BRT become sustainable and incorporate it into the neighborhoods it resides in. This happens because new businesses, developments and other investments bring in new workers and customers who may choose to use BRT, increasing ridership and revenue.

To find best practices for promoting investment along a BRT corridor, three cities – Cleveland, Boston and Ottawa – were examined. These cities were all successful in attracting new investments after, and during, their BRT implementation process. Additionally, some of the many community groups and government entities in the Oakland-Uptown-Downtown BRT corridor were examined. This is because many of them have already created investment plans or visions of what their community should look like. PAAC needs to work closely with them in the BRT planning process to maximize the potential investment opportunities along the Oakland-Uptown-Downtown BRT corridor.

5.2. Case Studies

5.2.1. Overview

To determine best practices of investing along the BRT corridor, Cleveland, Boston and Ottawa were examined due to their similarities to Pittsburgh and their success in capitalizing on investment opportunities. Below (Table 8) is an overview of all three case studies, which reflects the economic impact the BRT had on the area and some of the influencing factors and redevelopment policies that encouraged investments.

	Year BRT Started	Economic Impact	Some Influencing Factors and Redevelopment Policies
Cleveland (Health Line)	2008	$4.3 billion	Land assembly/banking initiatives, streetscape improvements, TIFs, housing assistance, art in transit program, and various tax abatements, credits and incentives
Boston (Silver-line)	2002	$1.7 billion	Parking space freeze, the City renovated two major public properties in corridor, Boston Redevelopment Authority (BRA) sold property along the corridor to developers at a reduced price if affordable housing was built, BRA made one neighborhood more walk able
Ottawa (Transitway)	2001	$1.4 billion	Station areas are mixed-use centers, direct incentives for TOD, new zoning laws, TOD policy focused on high density residential not just commercial

Table 8. Summary of economic impacts and redevelopment policies in Cleveland, Boston and Ottawa.

5.2.2. Cleveland, Ohio

5.2.2.1. Project Overview

Cleveland's Health Line runs along Euclid Avenue, and it is similar to Pittsburgh's proposed BRT in that it connects Cleveland's Central Business District (the region's largest employment center) with the Cleveland's University Circle area (the second largest employment center) and major cultural, medical and educational districts. Before implementing the Health Line, Euclid Avenue had major construction done, which included underground infrastructure and in some parts building-face to building-face construction. This construction planted roots for new investments later on.

5.2.2.2. Economic development

The Greater Cleveland Regional Transit Authority (GCRTA) established an economic development plan, which it will implement through 2025 (Brinckerhoff, 2010). Over $4.3 billion has already been invested along the Health Line's route, which includes the rehabilitation of old buildings into housing and retail centers, new construction for business startups, and major expansions of universities, museums and hospitals (complete statistics in Figure 4). New enterprises like bioscience and tech firms now proudly call Euclid Avenue home and the corridor leads the state in job creation and research. Ushering in a new era for Cleveland, the Health Line is pumping new life into the economy of the city (Henke, Dupage County, 2010).

Figure 4. Details and locations of investments along the Health Line's corridor (Brinckerhoff, 2010).

According to DeRosa (2008), by 2025, it is expected that Euclid Avenue will create:

- 7.9 million square feet in commercial development
- More than 5,400 new or renovated residential units
- $1.3 billion in capital investments
- $62.1 million generated in annual local taxes
- $1.9 million in annual GCRTA sales tax revenues
- 13,000 new jobs

Strong support from city officials, non-profits, and community development corporations helped the BRT Corridor become a success. These community development corporations represent the Downtown, Midtown and University Circle areas. The public and private sectors actively promote the economic development program for the Health Line (Breakthrough Technologies Institute, 2008).

GCRTA announced many attractive financial incentives for developers including:

- Land assembly and land banking initiatives
- Streetscape improvements
- GCRTA's Art in Transit Program
- Tax-increment financing
- Tax abatements
- Federal Empowerment Zones
- City loans and grants
- Brownfield incentives
- Ohio Job Creation Tax Credit
- Historic Preservation Tax Credit

- Cleveland-Cuyahoga County Port Authority financing
- City officials established the “First Five” program
- “*Circle Living*” housing assistance program

5.2.2.3. Possible Actions Pittsburgh Could Take

- Increase cooperation with local governments, community groups, businesses, universities, and community visions.
- The Urban Redevelopment Authority (URA) and community groups could assist developers in securing financing
- Community groups could help developers chose the right area for their development
- Encourage the City of Pittsburgh to provide financial incentives for transit-oriented development (TOD)

5.2.3. Boston, Massachusetts

5.2.3.1. Project Overview

The Silver Line is the Massachusetts Bay Transportation Authority’s (MBTA) sole BRT line, which operates in two sections. The first runs from Dudley Square in Roxbury to downtown Boston and South Station, mostly via Washington Street (which is very comparable to Pittsburgh’s Uptown), with buses operating in reserved lanes. The second runs from South Station to several points in South Boston and to Logan Airport in East Boston, partly in a dedicated bus tunnel and on dedicated surface right-of-way. Riders can transfer between the two sections at South Station (Breakthrough Technologies Institute, 2008).

5.2.3.2. Economic Development

The City renovated major public properties – The Massachusetts Port Authority owned several properties on the Waterfront, and to promote economic development in conjunction with the implementation of the BRT, they renovated some of these properties. This helped convince investors of City’s long-term commitment to the corridor.

Parking control – During the redevelopment of the seaport district, the Massachusetts Department of Environmental Protection implemented a parking freeze for non-residential parking in South Boston. This encouraged developers to ensure easy access to transit from their developments (Breakthrough Technologies Institute, 2008).

Reduced land prices – The Boston Redevelopment Authority (BRA) owned a number of properties along Washington Street and lowered many of the properties’ prices on the condition that developers built affordable housing. This not only increased economic development along the corridor but also increased consumers in the area. Table 9 summarizes the money spent on newly constructed and renovated real estate along the BRT corridor broken down by neighborhood. However, only some of these investments can be attributed to the BRA reducing land prices.

	New Construction	Renovation	Total
Downtown-Chinatown	$704,000,000	$37,000,000	$741,000,000
South End	$313,159,000	$107,500,000	$420,659,000
Dudley Square	$18,700,000	$38,399,000	$57,099,000
Total	$1,035,859,000	$182,899,000	$1,218,758,000

Table 9. Summary of real estate investments adjacent to the Silver Line route, by neighborhood (Federal Highway Administration of US Department of Transportation).

Redevelopment along the corridor – In 1999, the BRA announced the South Boston Waterfront Pubic Realm Plan, in which the Waterfront would become a walkable mixed-use city neighborhood that included manufacturing, residential and commercial districts (Massachusettes Bay Transportation Authority, 2011). A list of investments along the Silver Line's route and their locations is displayed in Figure 5.

Figure 5. Economic development of Boston Sliver line (Brinckerhoff, 2010).

5.2.3.3. Possible Actions Pittsburgh Could Take

- The URA could reduce land prices in Uptown with the stipulation that affordable housing be developed, which may attract more developers. This may be hard to do since property prices in Uptown vary.
- The City of Pittsburgh could invest in public properties in the corridor, showing

commitment to investors and encouraging new investments in the corridor.

5.2.4. Ottawa, Ontario

5.2.4.1. Project Overview

Ottawa connected their light rail, the O-train, with their BRT, the Transitway, to maximize transportation options and efficiency. Ottawa's O-Train is a light-rail service beginning from the Greensboro Station to the Bay View Transitway station. The whole distance is about five miles (OCtranspo, 2011).

5.2.4.2. Economic Development

Give the top priority of transit investment – A transportation strategy was established to promote TOD along this corridor, which created a strong base for later developments.

Simplified approval process for developments around the corridor – A faster, simpler approval process for projects along the corridor attracted more developers who wanted a quick return on their investment. Other selling points for properties along the corridor included the attractive, vibrant and walkable streetscape and the new amenities along the sidewalks.

Eliminate free parking for federal employees – To promote TOD, the federal government started to reduce free parking for their employees. For every bus stop in the area, about 25 parking slots were reduced at downtown retail centers.

Develop "Transitway-oriented projects" – Ottawa used the Transitway to stimulate economic growth around its corridor. Ottawa's TOD focused on mix-use communities, which attracted new, large investments. The Transitway became a selling point for the prospective tenants and the real estate market in general. The corridor attracted a wide range of uses, which supported the high-density developments. Ottawa's land use policies helped create several major retail centers located along this corridor. (Breakthrough Technologies Institute, 2008). Some of the new developments and how they connect with Ottawa's BRT are shown in Figure 6.

Figure 6. Commercial investments around one of the Transitway's stations (Henke, Dupage County, 2010).

5.2.4.3. Possible Actions Pittsburgh Could Take

- Implement a mix-use zoning development plan in the BRT corridor with the cooperation of community groups, businesses, universities, community visions and the City of Pittsburgh.
- Encourage the City to streamline their development approval process for TOD related developments, which will help developers get a quicker return on their investments.
- Encourage businesses to freeze, or even reduce employee parking, especially downtown, which would not only decrease traffic, but also increase the usage of BRT and other public transit options.

5.3. Transit Revitalization Investment Districts (TRID)

5.3.1. Overview of TRID

In 2004, the General Assembly of Pennsylvania passed a bill "empowering municipalities, counties and public transportation agencies to work cooperatively to establish Transit Revitalization Investment Districts (TRID). The purpose of the TRID is to make it easier to achieve transit-oriented development by establishing a geographic area that could be used for incremental tax revenue. The bill also encourages public-private partnerships in TRID development and implementation. TRIDs also encourage community involvement in the planning of where the boundaries of the TRID should be (Pennsylvania General Assembly, 2004).

Before a TRID can be made, local municipalities must undertake a planning study with involvement from transportation agencies, the county and community development agencies. This planning study includes grants from the state, with local municipalities putting in additional money. Also, public meetings must be held to explain TRID implementation and other approaches that could be used. Once a TRID is in place, a portion of tax revenue generated from within the TRID must to be used for public transportation within the TRID, and may not be used elsewhere (Pennsylvania General Assembly, 2004). The TRID bill was designed for rail and bus ways; however, BRT is not excluded (National BRT Institute, 2009).

Since local governments lead TRID studies, the City of Pittsburgh would have to take the lead on a TRID planning study for the Oakland-Uptown-Downtown corridor. There are currently two TRID studies being led by the City of Pittsburgh. The first is for the South Hills Junction on Mt. Washington, and the second is for East Liberty. Even though the City is currently conducting two studies, it is recommended that PAAC encourage the City of Pittsburgh to conduct a TRID planning study for the BRT corridor.

5.3.2. South Hills Transit Revitalization Investment District Planning Study

From June 2007 to May 2008 the municipalities of Dormont and Mt. Lebanon partnered with the Allegheny County Department of Economic Development and PAAC. The study was funded by a $75,000 grant from the Pennsylvania Department of Community and Economic Development to both Dormont and Mt. Lebanon who each supplied $25,000, which made a total of $200,000 available for the study. The study examines a ½ mile radius around three light rail stations, looking at "land use, population, employment and infrastructure." Other issues presented include "planned improvements to infrastructure and land developments," as well as, "an assessment of properties potentially available for development" (Mt. Lebanon, 2008).

The Planning Study focuses on three TRID strategies: existing residential streets, commercial districts and strategic opportunity sites. The study has a strong focus on strategic opportunity sites and how "the added value of new sales, fix-ups, and infill development" can help pay for streets and transit. The Planning Study also suggests the use of tax incremental financing over 20 years to build up strategic opportunity sites (South Hills TRID Study Presentation, 2008) (South Hills TRID Final Report, 2008) (Pennsylvania General Assembly, 2004).

5.4. Potential Investment Resources

5.4.1. Urban Redevelopment Authority of Pittsburgh (URA)

The URA is the biggest entity in Pittsburgh that deals with acquiring and selling properties within the city. According to the URA's website (2011):

> *The URA is responsible for the acquisition and disposition of various properties for the purpose of assembling sites for redevelopment. It also acts as agent for the City of Pittsburgh in assembling properties*

for City-sponsored projects.

The URA works closely with our partner community development corporations throughout the City of Pittsburgh to identify and target sites for redevelopment

The URA makes it easy for developers to find and acquire land. They have a list of property they own and are trying to sell. These properties are displayed in a map for the following neighborhoods:

- Central Business District
- Bluff
- Crawford-Roberts
- West Oakland
- Central Oakland
- South Oakland
- North Oakland

These properties are shown below (Figure 7-Figure 14) to help visualize where potential investments opportunities in the corridor are located. Current general zoning codes (commercial, residential, etc.) were added to help visualize what types of properties are around those up for sale by the URA. The zoning can also help developers choose a site in a zone they are looking to develop, although zoning laws are not too difficult to change. It is important to note that because the URA owns these properties, some of them zoned as Government. Historic sites are also shown because these areas have historic preservation laws tied to them. Developments that used tax incremental financing (TIF) in 2008-2009 are shown to help visualize what parcels are still being paid off. Since the TIFs are from a couple of years ago, the data may have changed; some sites may have been paid off and new TIFs may have been added.

The following maps all use this legend.

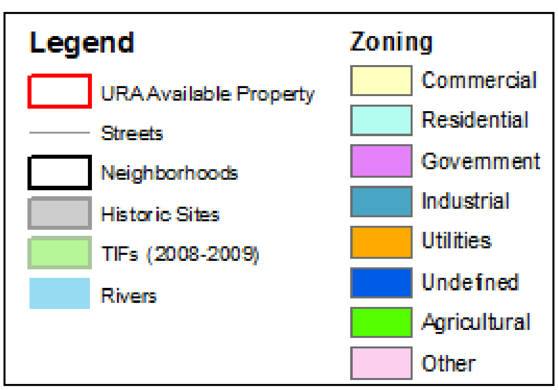

Figure 7. Legend for all the URA property maps.

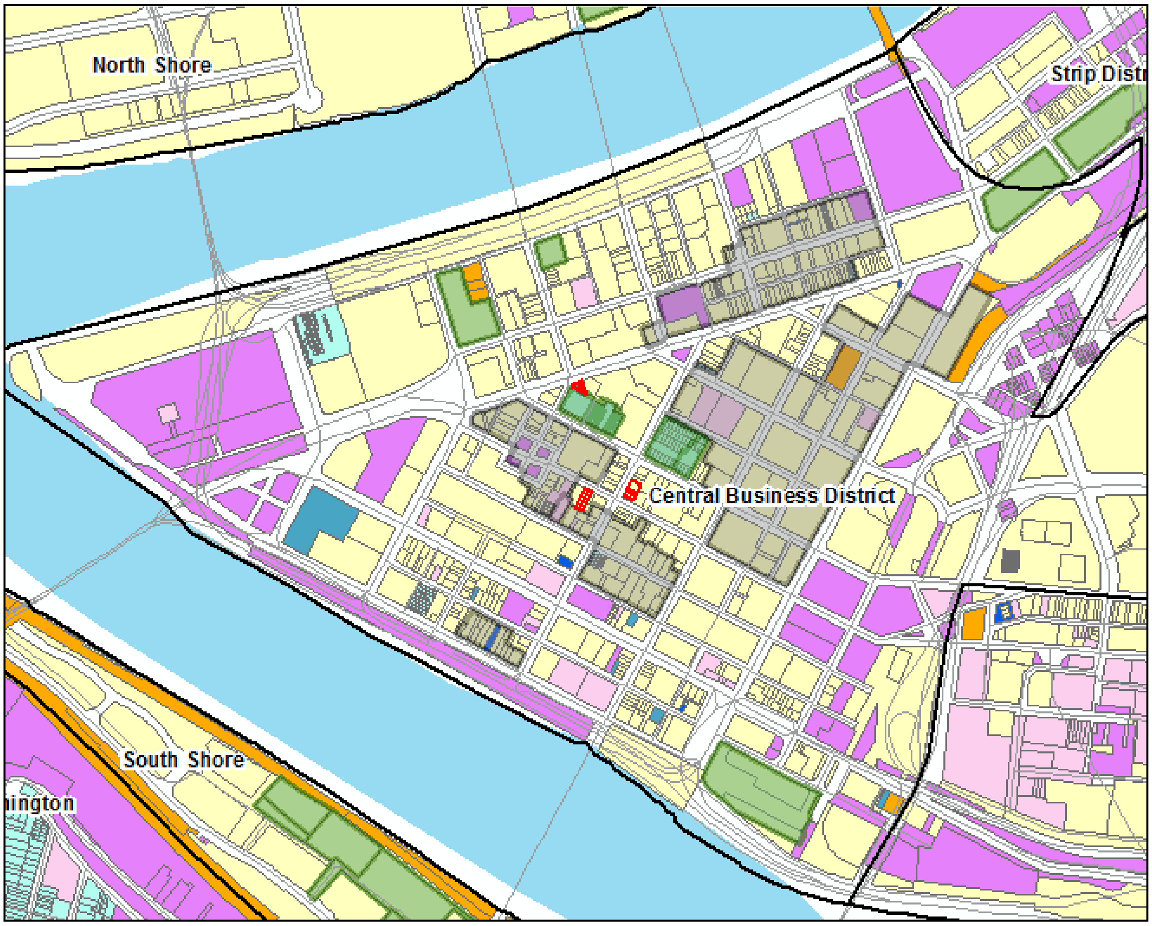

Figure 8. URA Owned Property: Central Business District overview.

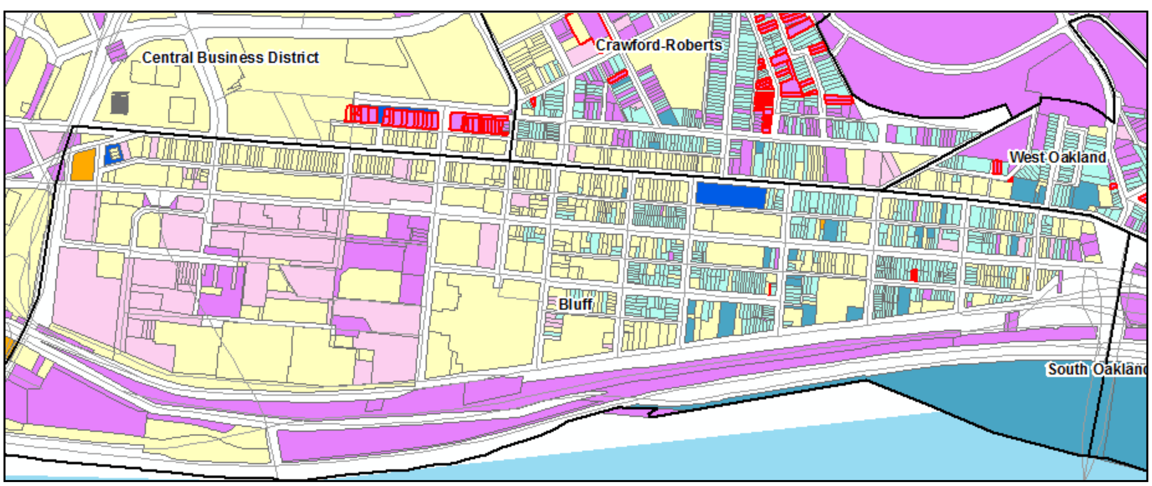

Figure 9. URA Owned Property: Uptown overview.

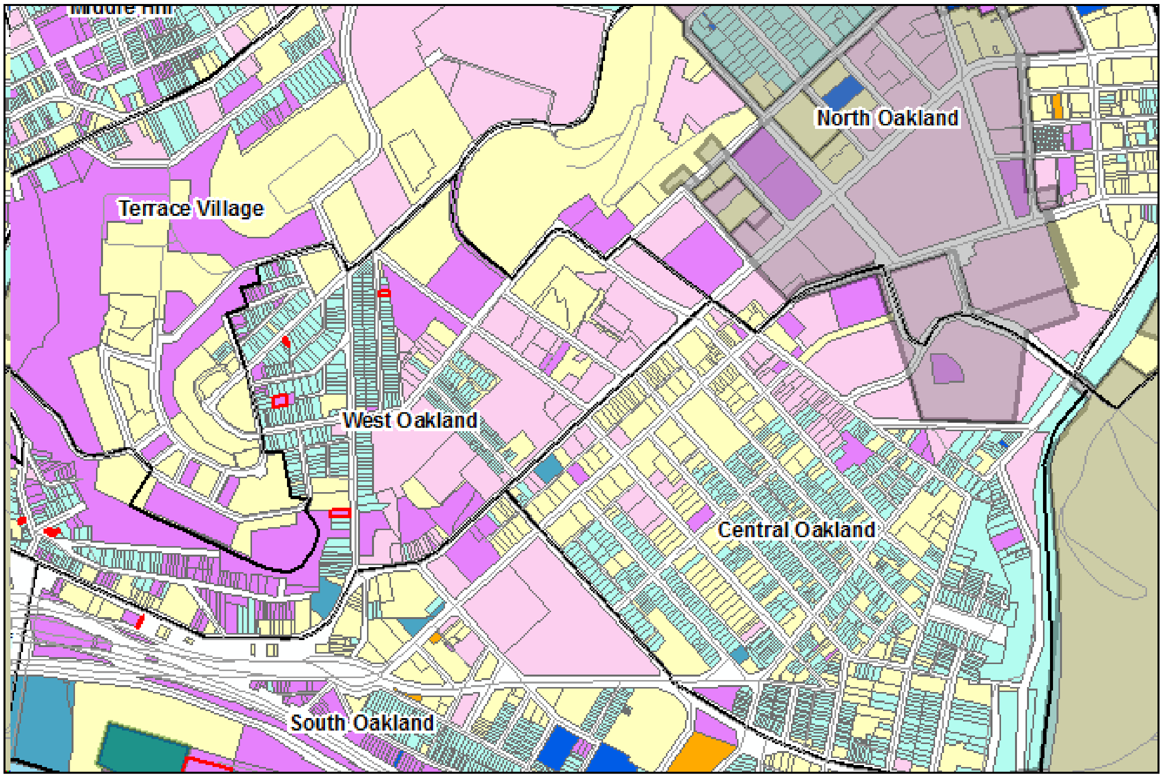

Figure 10. URA Owned Property: Oakland area overview.

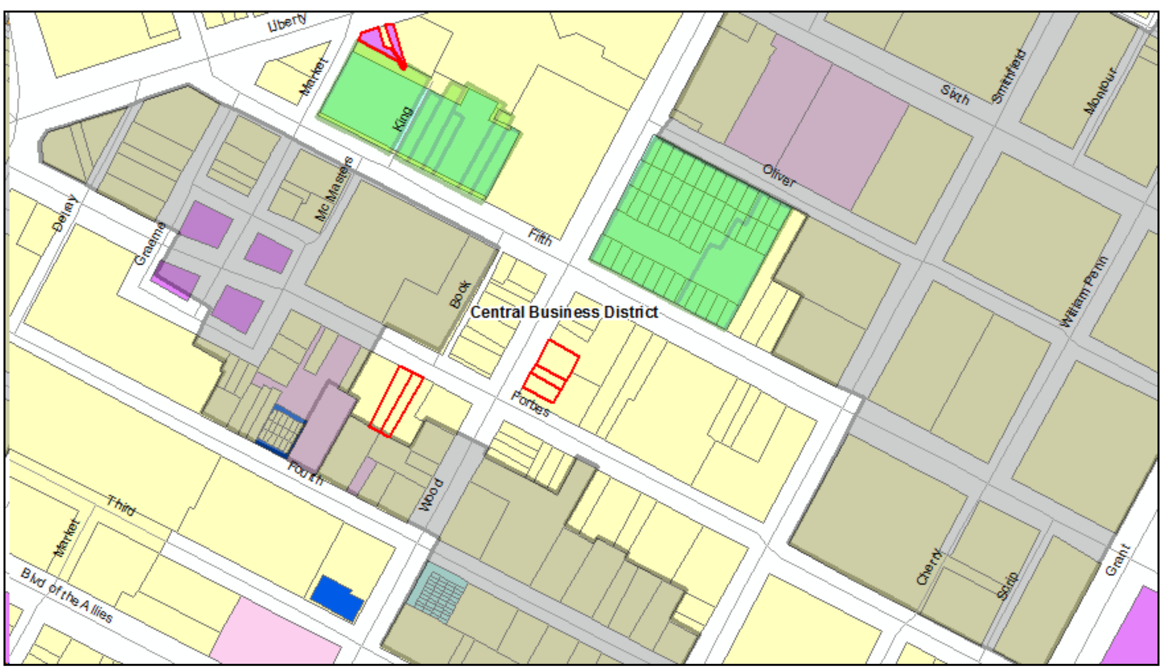

Figure 11. URA Owned Property: Forbes at Wood and Liberty at Market in the Central Business District.

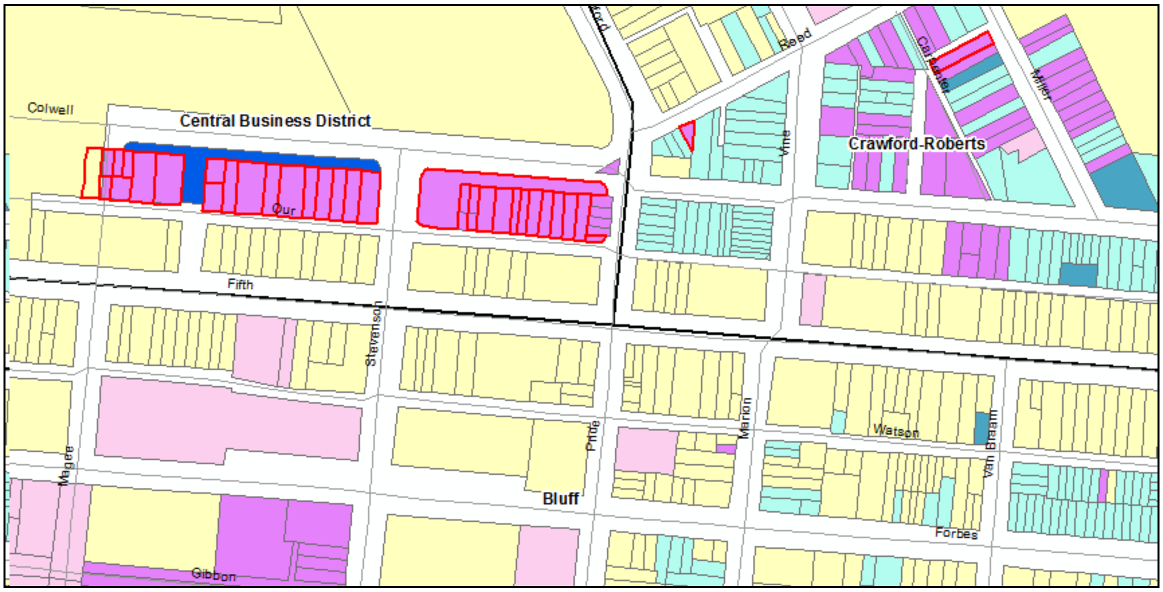

Figure 12. URA Owned Property: North of Fifth at Stevenson in the Central Business District and Crawford-Roberts areas.

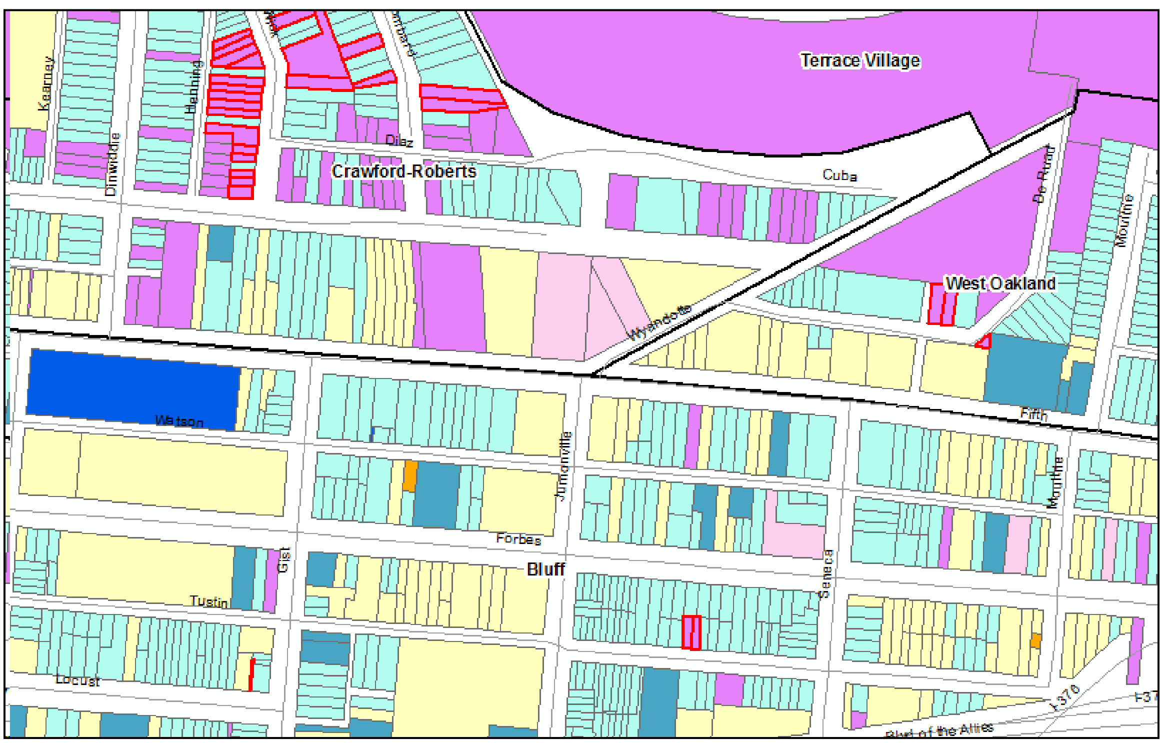

Figure 13. URA Owned Property: throughout the Crawford-Roberts and Uptown areas.

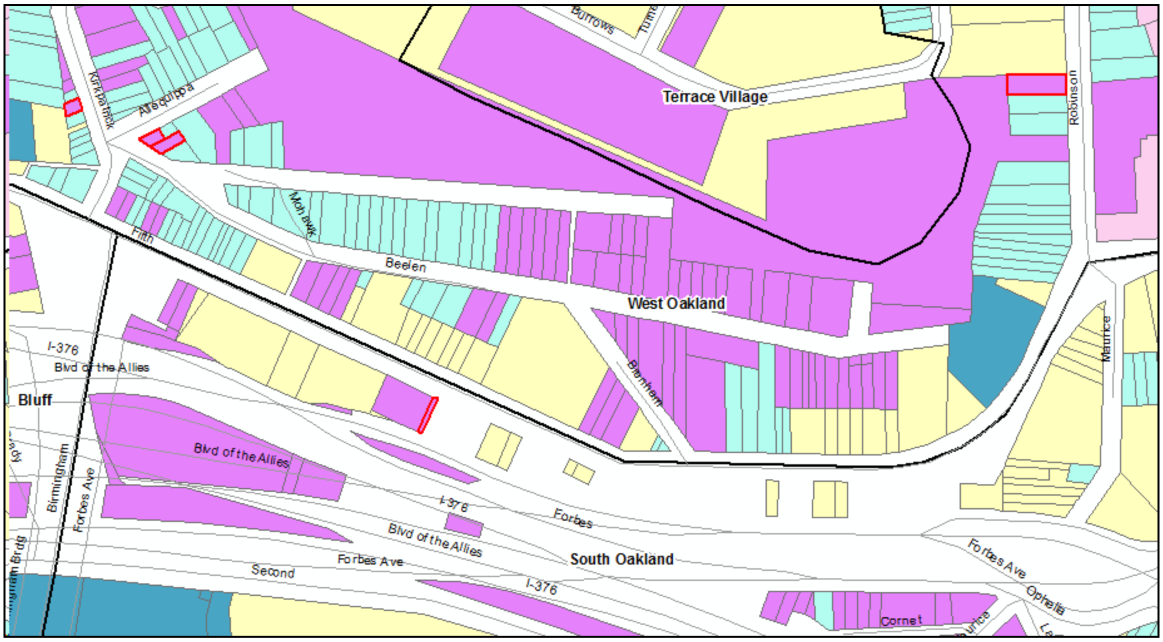

Figure 14. URA Owned Property: In the West and South Oakland areas.

5.5. Potential Investment Strategies by Neighborhood

Different community groups in the Oakland, Uptown and Downtown neighborhoods have different visions of what their areas should look like. This leads to many different opinions and ideas for what Pittsburgh should look like, and where tax dollars should go. Consequently, PAAC should include community groups in the planning process to maximize investments around BRT stations. Even though this is not an exhaustive list, it is a start, listing the major community groups and visions in the Oakland, Uptown and Downtown neighborhoods.

5.5.1. Oakland

Oakland is home to many businesses, universities, non-profits and cultural institutions, which include UPMC, the University of Pittsburgh, Carnegie Mellon University, Carlow University and the Carnegie Cultural Complex. The Oakland area's four square miles boasts more than 38,000 jobs, 100,000 daily visitors and 20,000 residents. Also, there are more than 60,000 bus riders that pass through Oakland on the average workday, and 23,000 of those riders get off in Oakland. Oakland's location within Pittsburgh and its boundaries are displayed in Figure 15 and Figure 16. Oakland's boundaries .Figure 16 respectively (Oakland Task Force, 2010).

Figure 15. Oakland's location within the City of Pittsburgh (Oakland Task Force, 2010).

Figure 16. Oakland's boundaries (Oakland Task Force, 2010).

5.5.1.1. Innovation Oakland

Innovation Oakland is an initiative of the Oakland Task Force, who partnered with many institutions that reside in Oakland, such as the Oakland Business Improvement District, Carlow University, Carnegie Mellon University, UPMC and the University of Pittsburgh. According to Innovation Oakland's vision,

> *Innovation Oakland is a technology-based approach to neighborhood transformation introducing new ways of thinking about how community assets, public spaces and commercial corridors contribute towards the economic prosperity of Oakland and of the greater Western Pennsylvania region (Oakland Task Force, 2010, p. A4).*

The Innovation Oakland Report was released in 2010 and includes a four-phase course of action "*to use technology to deliver a physical and digital network of iconic way-finding and artistic environments*". The report focuses on ways to improve signage, branding and the general streetscape in Oakland. This includes making the area more pedestrian, bike and bus friendly by either removing most of the signage or making the signage similar and consistent. Also, phone applications and future kiosks around the neighborhood will help pedestrians find their way through the city, as well as, find new places to go (Oakland Task Force, 2010).

5.5.1.2. Oakland Business Improvement District

The Oakland Business Improvement District (OBID) encompasses the Forbes and Fifth Corridor in Oakland (Figure 17). OBID helps build partnerships between businesses and property owners while improving the cleanliness, appearance and safety in Oakland. OBID also attracts, retains and promotes businesses and economic development through marketing and event coordination. OBID keeps businesses competitive by implementing strategic revitalization strategies and keeping businesses informed of local and national trends (Oakland Business Improvement District, 2011).

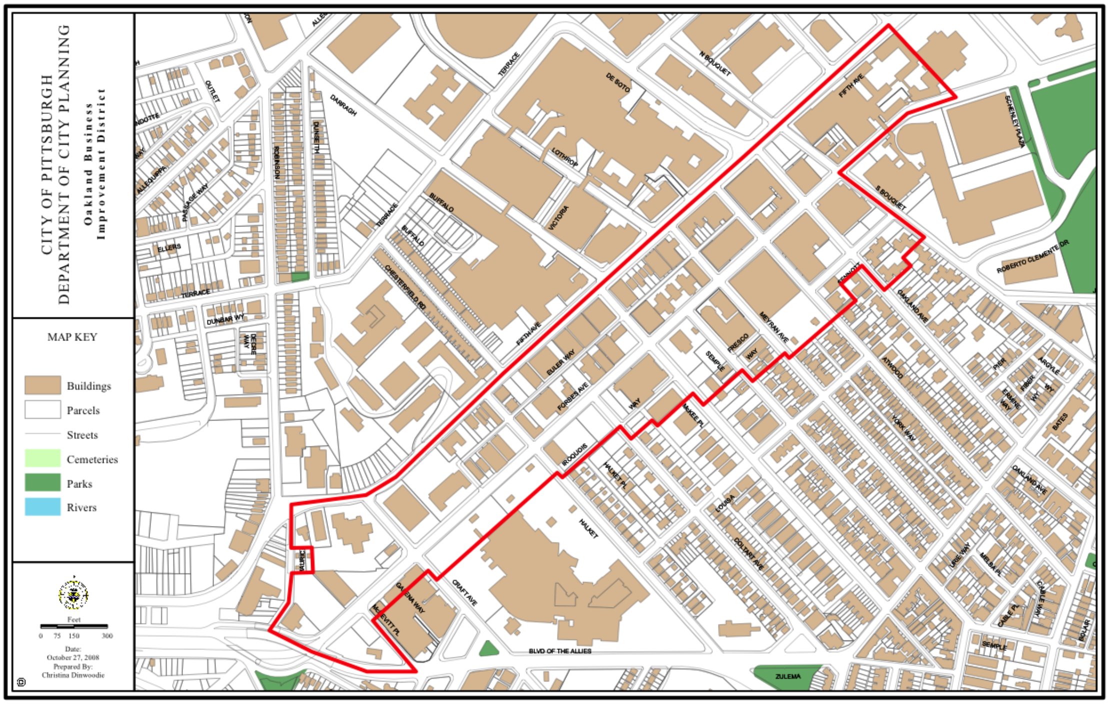

Figure 17. The Oakland Business Improvement District's boundaries (Oakland Business Improvement District, 2011).

5.5.2. Uptown

The Uptown area is defined as the combination of four neighborhoods: Fifth Forbes, The Bluff, Central Uptown and Soho (Figure 18). Even though Uptown's population is just over 700 (not including the 3,500 student population), there are about 44,000 transit riders that pass through Uptown via Fifth and Forbes every day. The main employers in Uptown are Duquesne University, UPMC Mercy Hospital and the Pittsburgh Penguins (Uptown Partners, 2009) (Uptown Partners, 2010).

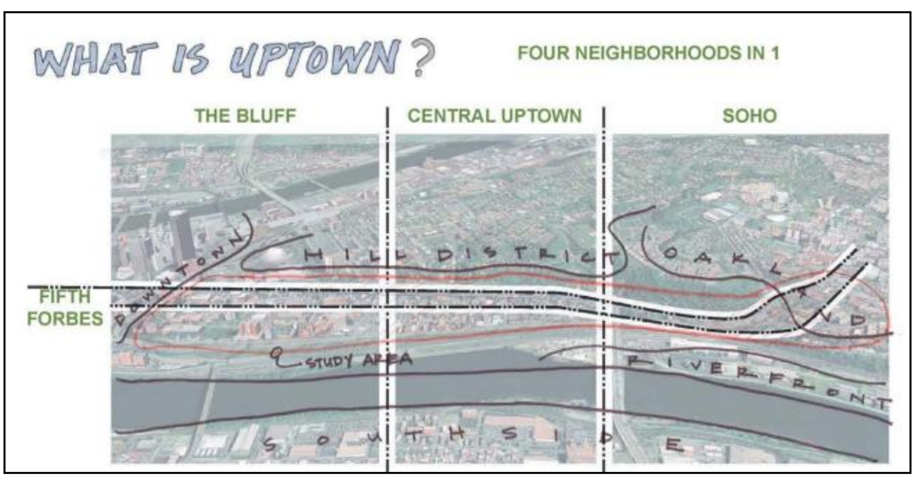

Figure 18. The four neighborhoods that make up Uptown (Uptown Partners, 2009).

5.5.2.1. Uptown Community Vision

Many different entities came together to create the Uptown Community Vision, including the Uptown Partners, Hill Economic Corporation, Oakland Planning and Development Corporation, Leadership Pittsburgh, Pittsburgh City Planning, and the URA. The vision recommends bringing in new residents, focusing on young professionals, and developing commercial and office markets focusing on medical and educational office space.

The Uptown Community Vision focuses on nodes of development, as seen in Figure 19, with the primary node located at Pride Street. Pride Street developments are to be concentrated on Fifth Avenue and Forbes Avenue, including retail, residential, professional office space, public parking and streetscape improvements. Pride Street will also become a transit hub by creating a safe pedestrian, transit-oriented area. The Uptown Community Vision also encourages the connectivity of Uptown through new trails and green spaces throughout the neighborhood.

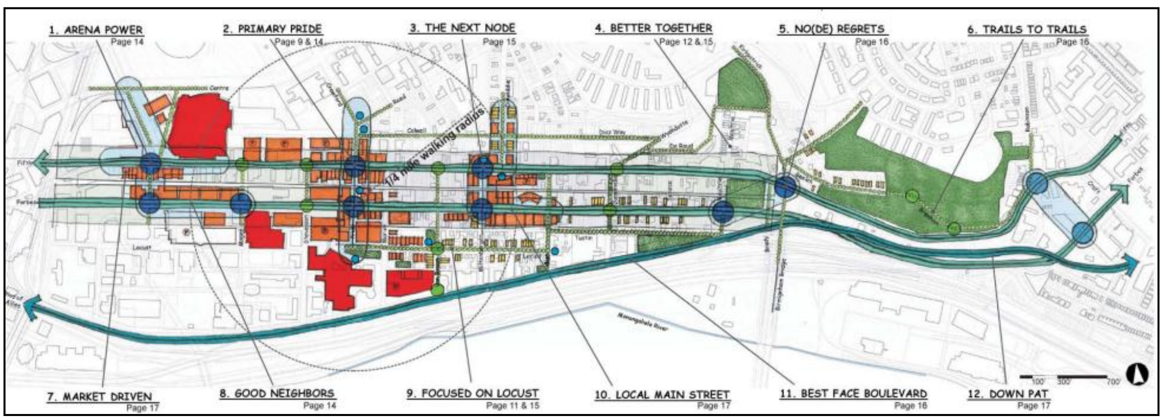

Figure 19. Node of development and other future development plans based on the Uptown Community Vision (Uptown Partners, 2009).

Guidelines for new developments will be created to improve the predictability of private investments. Also, residential development strategies will be established to ensure that sustainable housing is created. Uptown contains a lot of street and surface parking that can be developed which will increase the use of transit. However, one challenge is a private party who owns many parking lots in Uptown and has a different vision for the lots. These properties are displayed in Figure 20 (Uptown Partners, 2009).

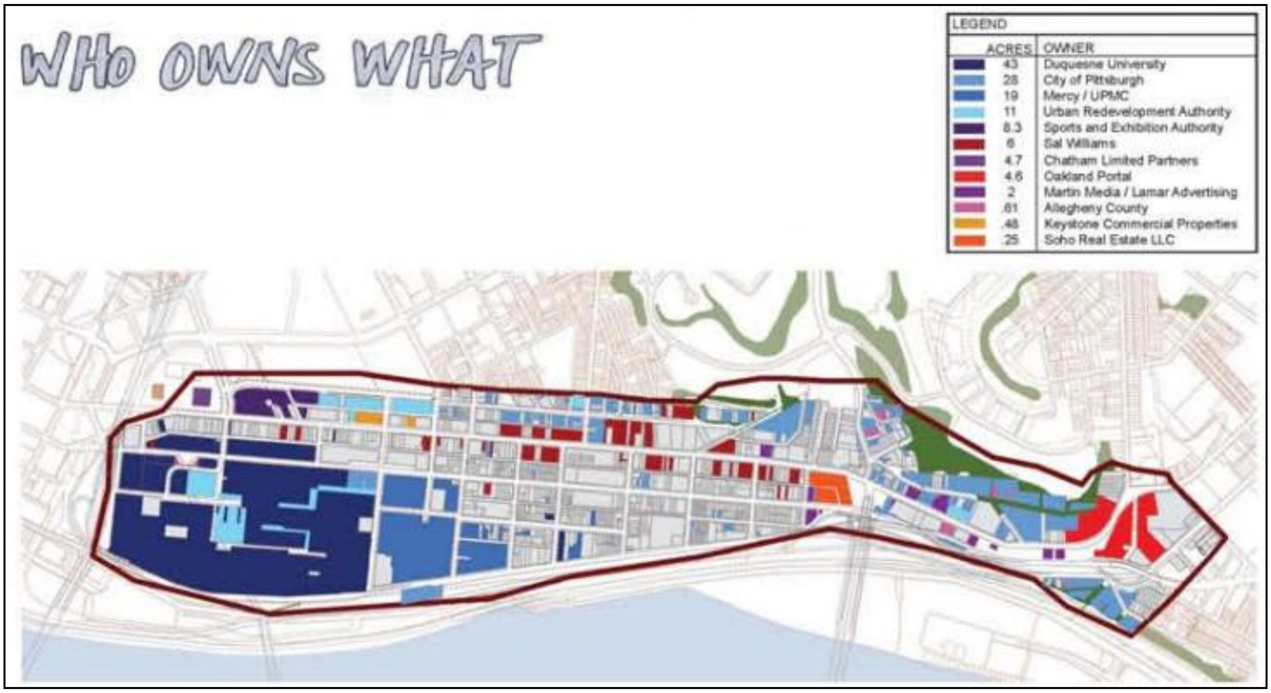

Figure 20. Map of property owners and what properties they own in Uptown (Uptown Partners, 2009).

5.5.2.2. Developer's Handbook

In February 2010, the Uptown Partners, Oakland Planning and Development Corporation and Hill House Economic Development created a handbook for developers and potential investors. This paper was written after, and complements, the Uptown Community Vision. It includes reasons to invest in Uptown, market trends and what funding sources are available from both the public and private sectors (Pittsburgh Central Collaboration, 2010).

5.5.2.3. Hill District Master Plan

The Hill District Master Plan is chaired by Council Member Daniel Lavelle and has been the effort of Hill residents and 20 local and state entities including governments, community groups, foundations and authorities. The Hill District Master Plan was created in March 2011 and some of its key elements include:

- Guidelines for new housing developments, land use and public art
- Community groups should get priority to acquire vacant land
- Developments must avoid displacement of residents and businesses
- Hill District residents must have an opportunity to provide input in the planning and development process of new development proposals
- Improve transportation networks to the city and within the Hill
- Protect against developers holding on to vacant land for financial gain in the future

Key elements specific to the Uptown area (Figure 21) include:

- Stabilizing the area by identifying strategic sites for residential investment
- Connecting Uptown to Crawford-Roberts and the Lower Hill

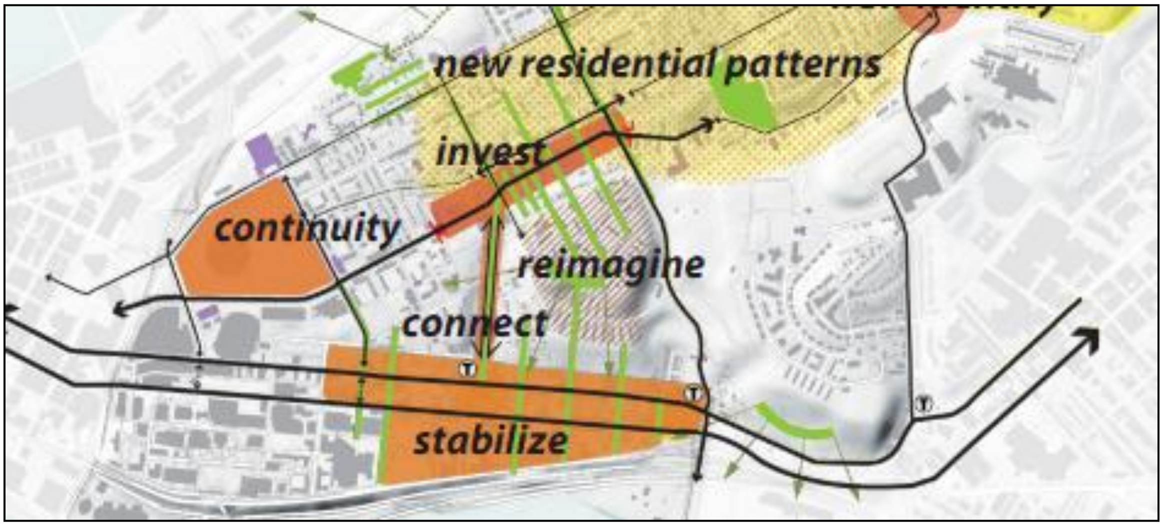

Figure 21. Map of the Hill District Master Plan's key elements (Greater Hill District Master Plan, 2011).

5.5.3. Downtown

The Downtown area, or Golden Triangle, has about 4,000 residents in its 0.8 square miles. It boasts many major corporations including U.S. Steel Corporation, PNC, H.J. Heinz, PPG Industries, Allegheny Technologies and WESCO International. The Downtown area has approximately 140,000 jobs and over 1,600 residents (not including approximately 900 students). Downtown is also home to the Cultural District, which includes Heinz Hall, many businesses, and green spaces, such as Market Square and Pointe State Park. Downtown Pittsburgh also enjoys a free fare zone for public transit, which is shown below in Figure 22.

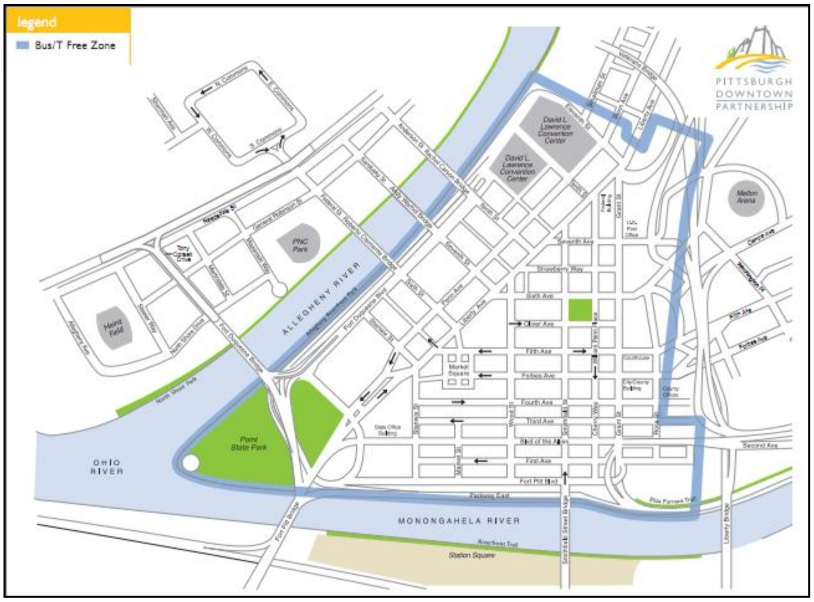

Figure 22. The boundaries for Downtown's free fare zone (Pittsburgh Downtown Partnership, 2011).

5.5.3.1. Pittsburgh Downtown Partnership

The Pittsburgh Downtown Partnership (PDP) supports improvements, cleans public spaces, facilitates safety and markets the Downtown area and its businesses. To help achieve these goals, the PDP created a Downtown Business Improvement District (its official boundaries are in Figure 23). The PDP also advocates for public policy that helps the Downtown area, such as trying to obtain more affordable housing and parking. The PDP also works with different transit and parking agencies to ensure further economic growth Downtown. The PDP has many economic development strategies, such as:

- Generating new Downtown investments by stimulating interest in new residential and commercial developments, while retaining existing developments
- Continuing the marketing of Market Square as a major Downtown destination
- Coordinating successful events Downtown
- Continuing the advancement of "Downtown Pittsburgh as one of America's great urban centers" vision (Pittsburgh Downtown Partnership, 2009)

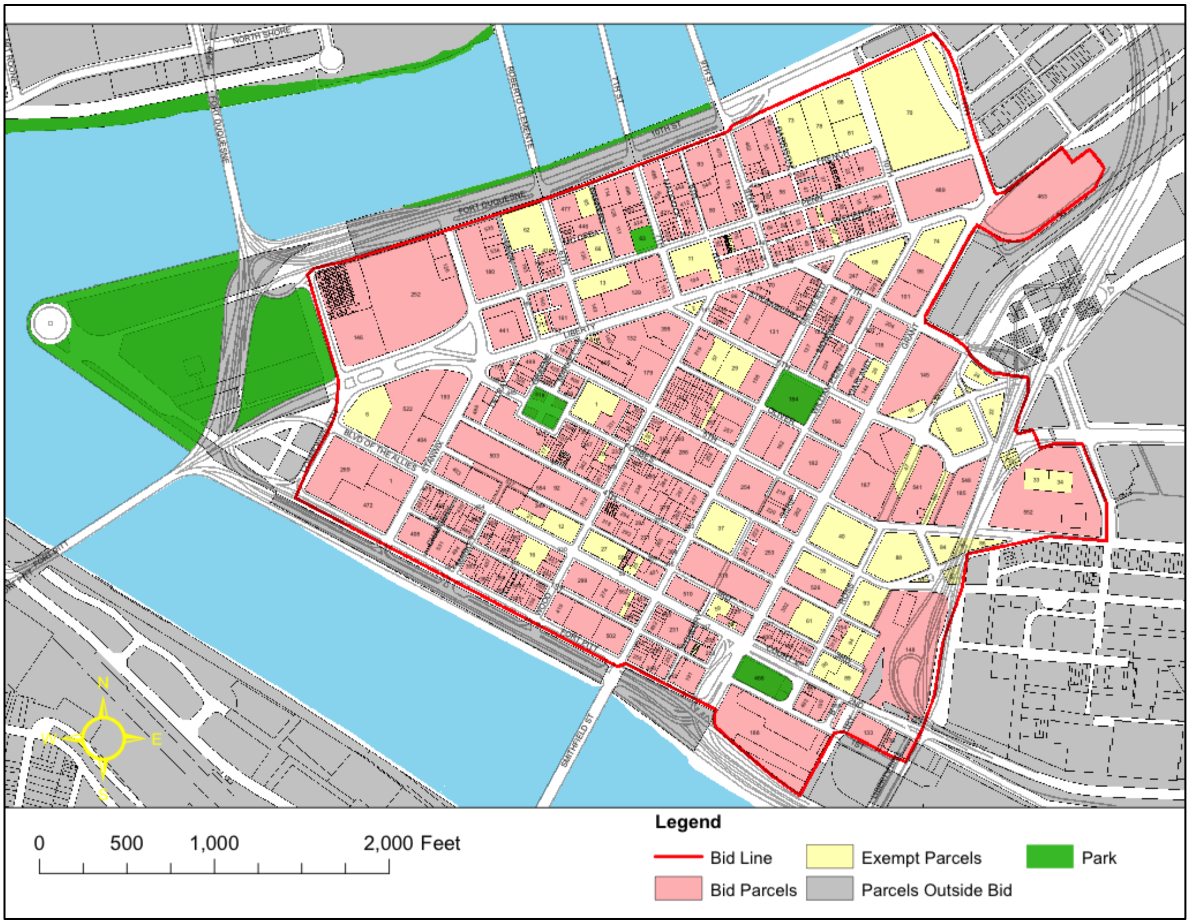

Figure 23. The Downtown Business Improvement District's boundaries (Pittsburgh Downtown Partnership, 2011).

5.5.4. Other Potential Investments Groups

Many groups have a stake in the Oakland, Uptown and Downtown corridor including universities, local governments, health institutions and businesses located in the area. Although this paper does not mention these entities, or all of the non-profits, community groups and visions, it is recommended that they all be included in the BRT planning process to maximize investments

6. Stop Selection

6.1. Introduction

Bus Rapid Transit (BRT) is able to obtain higher service speeds than regular buses because of many factors including the use of technology, dedicated lanes and reducing the number of stops in its route. Since there is a reduction of the number of stops in a BRT route compared to local buses, the stops have to be selected very carefully and have to maximize access to riders and key destinations, such as job centers, universities, commercial districts and hospitals. Many other criteria also need to be considered when selecting a BRT stop.

A list of criteria needed to select BRT stops was created by examining two papers. From the list of criteria, a few were chosen to be used in the stop selection process based on data availability. The data was then visualized and analyzed by creating GIS maps of the Oakland-Uptown-Downtown corridor. From this analyses, and based on the criteria chosen, two stop selection alternatives were recommended.

6.2. Literature Review

Two papers were examined to collect input criteria for the stop selection process. The first paper is *Bus Rapid Transit Planning Guide* published by The Institute for Transportation and Development Policy (ITDP). This paper was examined because it provided a comprehensive look at BRT planning and included 21 authors, from various organizations across the world. The next paper examined was the *Recommended Practices for BRT Services Design* by the American Public Transportation Association (APTA). This paper was examined because it comes from a recognized institution and had input from nine different transit experts across different cities in North America.

6.2.1. Corridor Selection Criteria from Bus Rapid Transit Planning Guide

The ITDP (Hook, 2007) established six main criteria to select a corridor for a new BRT system, including:

- Maximize the number of beneficiaries of the new BRT system
- Minimize the negative impact of general traffic
- Minimize operational costs
- Minimize environmental impacts
- Minimize political obstacles to implementation
- Maximize social benefits, especially to lower- income groups

6.2.2. Stop Selection Criteria from Recommended Practices for BRT Services Design

The APTA 2008 (APTA, 2008) broke down station location criteria into two categories: stop spacing and stop location.

6.2.2.1. Major Factors to Consider for Stop Spacing

Maximum acceptable and desirable walking distances – Typically, acceptable walking distance is between 1/4 and 1/3 mile (which is approximately a 5 - 10 minute walk). It is also affected by other factors, such as:

- The level of activity in the area
- The area's density
- The number of transit options in the area (local buses, BRT, light rail, etc.)
- If the stop is the same or opposite direction of where riders are going

Availability of parallel local services – Far station spacing (stations spaced significantly beyond the desirable walking distance) may require the retention of parallel local services. If there is an initial decision to retain parallel local services, spacing BRT stations beyond normal walking distances will speed up the service and may be the most efficient way to operate the system.

Speed and service objectives of the BRT – Farther station spacing is also appropriate if the main objective of the BRT service is simply to connect major activity centers (e.g. transit hubs, park-ride facilities) or if the alignment does not follow a typical arterial-type transit corridor.

Every BRT system uses different stop distances based on specific criteria that applies to the area it operates in. The following tables are a summary of the shortest, longest and average stop distances for nine different BRT systems. Table 10 represents on-street BRTs and Table 11 represents BRTs that use busways.[8]

[8] Note that some of the longest distances represent express portions of a route rather than the more typical rapid transit designs

	Shortest	Longest	Average
Cleveland – Health Line	0.13 mi (0.20 km)	0.50 mi (0.81 km)	0.20 mi (0.32 km)
Boston – Silver Line	0.10 mi (0.16 km)	1.90 mi (3.06 km)	0.32 mi (0.52 km)
Eugene – Emx	0.24 mi (0.38 km)	0.98 mi (1.58 km)	0.42 mi (0.68 km)
Las Vegas – MAX	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.50 mi (0.81 km)
Los Angeles – Metro Rapid	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.70 mi (1.13 km)
York Region – Viva	0.16 mi (0.26 km)	3.07 mi (4.94 km)	0.93 mi (1.50 km)
Halifax – MetroLink	0.45 mi (0.73 km)	7.70 mi (12.40 km)	3.28 mi (5.28 km)

Table 10. Distances between stations for various on-street BRT systems.

	Shortest	Longest	Average
Pittsburgh	0.51 mi (0.82 km)	1.70 mi (2.74 km)	0.97 mi (1.56 km)
Los Angeles – Orange Line	0.54 mi (0.87 km)	2.20 mi (3.54 km)	1.10 mi (1.77 km)

Table 11. Distances between stations for various busway BRT systems.

6.2.2.2. Major factors to consider for stop location

- Location of major destinations, activity nodes and population
- Location of major cross streets and transfer points
- Density and land use patterns in the corridor

6.2.2.3. Other factors for both station spacing and location

- Existing development and proposed development
- Availability of pedestrian infrastructure (e.g. sidewalks)
- Quality of pedestrian environment (trees, block spacing, store fronts, street furniture)
- Width of streets
- Stops shared with or separate from conventional service
- Near-side versus far-side stops
- Topography
- Weather
- Customer demographics (e.g. seniors, disabled)
- Typical spacing for non-BRT service (bus and rail) in the region

- Local conditions and expectations
- Urban design opportunities

6.2.2.4. Other considerations for Pittsburgh

- The politics behind where stops are located and who owns nearby property
- Property acquisition for stops where stations will be built

6.3. Stop Selection Process

6.3.1. Selecting Fifth Avenue over Forbes Avenue

Fifth Avenue was chosen for the street on which BRT stops will be located. This is due to many concerns about Forbes Avenue and the Oakland-Uptown-Downtown corridor in general, including:

- Ridership (total ons and offs) at each stop along Forbes Avenue is relatively lower than at parallel stop on Fifth Avenue.
- In some parts of the corridor, Fifth Avenue is wider than Forbes Avenue.
- Since the two avenues are parallel, close to each other and share some of the same bus routes, the implementation of BRT on one will have an impact on the other. This impact includes the possible shift of local bus and car traffic from one street to the other.
- On average, the distance between Fifth Avenue and Forbes Avenue is relatively small, about two blocks or 380 feet. Therefore, if the stops selected on Fifth Avenue were moved to Forbes Avenue, they would have comparable access to riders and destinations.

If Forbes Avenue is considered, there can be at least three different designs of the corridor:

- Both Inbound and Outbound on Fifth Avenue
- Both Inbound and Outbound on Forbes Avenue
- Inbound on Fifth Avenue and Outbound (part of the route) on Forbes Avenue

6.3.2. Proposed BRT Route

Since Fifth Avenue was chosen for the BRT route, stops at both ends were analyzed to determine the termini. Fifth Avenue at Craig Street was selected as the terminus on the east end and Fifth Avenue at Liberty Avenue was selected as the terminus on the west end. These termini make the potential BRT route 3.2 miles.

The reasons these stops were chosen include the following:

- ***Fifth Avenue at Craig*** – It is chosen as the starting point because in the Oakland area the only other major stop east of Craig Street is Fifth Avenue at Morewood.

However, Fifth Avenue at Craig has a much higher ridership than Fifth Avenue at Morewood.

- ***Fifth Avenue at Liberty*** – It is chosen as the end point, because it lies at the end of the proposed corridor and near the end of Fifth Avenue.

6.3.3. Main Criteria Evaluated to Select Stops

- ***Stop Usage*** - The ridership data came from PAAC ridership counts from 2008. This data includes total ons, total offs, and total ons and offs for the average weekday. The inbound and outbound ridership data was aggregated for each stop, because the total usage of each stop is important for selecting stop placement.
- ***Total ridership***, ***population*** (2010 US Census), ***jobs*** (US Census, 2009) and ***number of local bus stops within 1/4 mile*** (1,320 feet) of the chosen stops were all examined (see below for explanation of 1/4 mile radius).
- ***Distance between each BRT stop*** - The distances between each BRT stop can vary based on the characteristics (ridership, local bus stops in the area, population, jobs, etc.). There is also a tradeoff between service speed and the number of stops due to loading time. The more stops in a BRT system, the slower the service speed will be. The current standard for BRT stop spacing is 500 meters or 1,640 feet (Hook, 2007).
- It also should be noted that there is an algorithm (located in Appendix C.) to calculate the optimal distances between each stop. This algorithm was not used due to the time necessary to collect all the information on the variables, but should be considered in the future (Hook, 2007).

6.3.3.1. Walking Distance

1/4 mile is considered as approximately a 5 - 6 minute walk, assuming a walking speed of 2.5 miles per hour. 1/4 mile was chosen based on the TOD research results shown in Table 12.

Jurisdiction	Walking Distance Referenced	
Mass Transit Administration (Maryland)	1500 feet	0.28 mile
Mid-America Regional Council (Kansas City, Missouri)	1500 feet	0.28 mile
NJ Transit (New Jersey)	1320 – 2640 feet	0.25-0.5 mile
Ontario Ministry of Transportation	1320 feet	0.25 mile
Regional Plan Association (NY, CT, NJ Tri-metro area)	1320 feet	0.25 mile
Snohomish County Trans. Authority (Snohomish City, Washington)	1000 feet	0.19 mile

Table 12. Walking distances around stops used by various transit authorities (Fairfax County Panning Commission TOD Committee, 2006).

6.4. Possible Alternatives for BRT Stops

6.4.1. Alternative 1

6.4.1.1. Recommended Stops

- Fifth Avenue at Craig
- Fifth Avenue at Thackeray
- Fifth Avenue Ave at Halket
- Fifth Avenue at Wyandotte
- Fifth Avenue at Magee
- Fifth Avenue at 6th
- Fifth Avenue at Smithfield (optional)
- Fifth Avenue at Liberty

6.4.1.2. Stop Selection by Neighborhood

6.4.1.2.1. Oakland

Considering the large amount of ridership in this area when choosing BRT stops, more emphasis is put on the distance between each stop. This ensures that the stops are reasonably spaced to capture the majority of potential users within an acceptable walking distance. Since stops in Oakland share similar characteristics, corridor integration should play an important role when selecting stops.

6.4.1.2.2. Uptown

Due to lower ridership, lower population and fewer jobs in Uptown, selecting stops in this area is more difficult. Also, stops in Uptown share similar characteristics. Examining stops between Fifth Avenue at Halket (end of Oakland) and Fifth Avenue at 6th (start point of Downtown), Fifth Avenue at Magee was chosen as one of the Uptown BRT stops, because it is close to both Mercy Hospital and Duquesne University. Next, stops between Fifth Avenue at Magee and Fifth Avenue at Halket were examined. Considering the distance between each proposed BRT stop and key characteristics at the stop, three potential stops were examined: Fifth Avenue at Faleder Monuments, Fifth Avenue at Moultrie and Fifth Avenue at Wyandotte. From this comparison, the stop selected was Fifth Avenue at Wyandotte. This examination is found below in Table 13 and Figure 24 through Figure 29.

With longer distances between proposed BRT stops in Uptown, local buses should operate as a supplement to the system so people who live and/or work between each BRT stop can access public transportation if needed.

Stop	Within 1/4 Mile				Nearby Features
	Ridership	Population	Jobs	Local Stops	
5th at Faleder Monuments	4062	723	271	19	
5th at Moultrie	3607	1263	3271	27	Meyers Plumbing & Heating Supply
5th at Wyandotte	3415	1409	4204	25	Center for Hearing and Deaf Services, Solutions Transportation,

Table 13. Stop Selection Alternative 1: Uptown stop characteristics comparison.

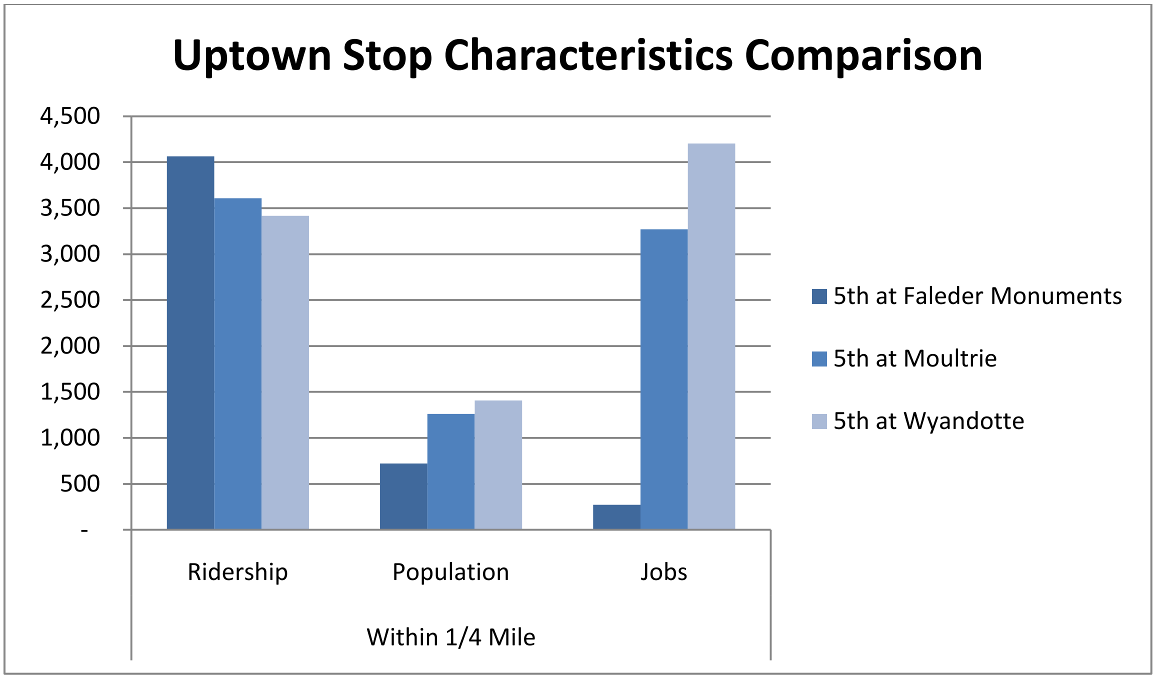

Figure 24. Stop Selection Alternative 1: Uptown stop characteristics comparison histogram.

All of the following maps use this legend.

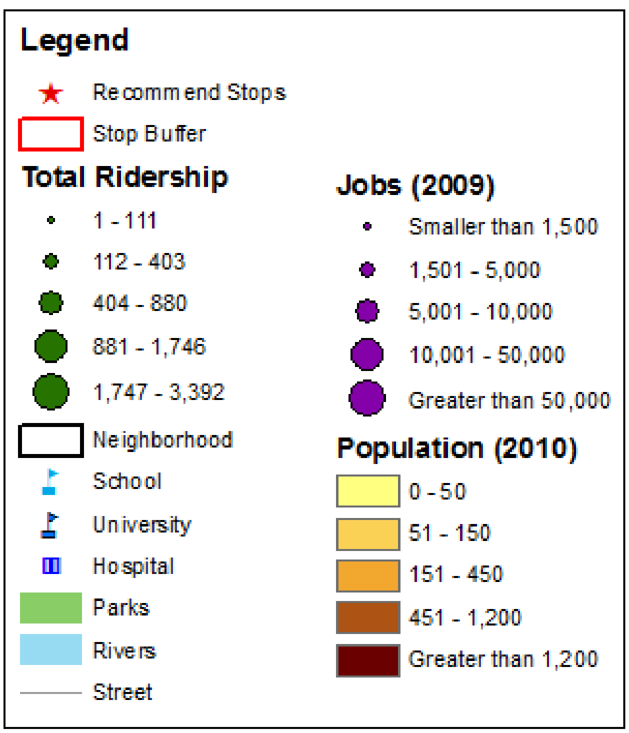

Figure 25. Legend for all stop selection maps.

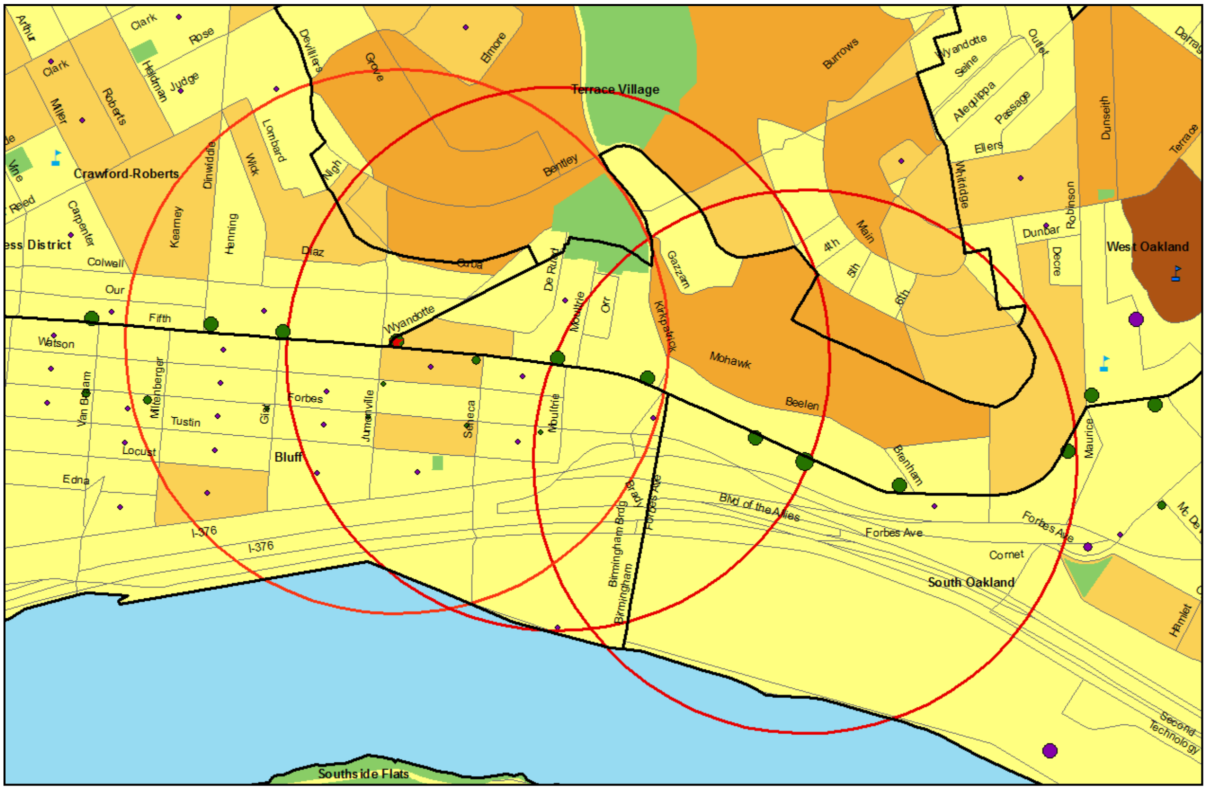

Figure 26. Comparison of Three Potential Uptown Stops – Fifth Avenue at Wyandotte Street, Fifth Avenue at Moultrie Street, and Fifth Avenue at Faleder Monuments.

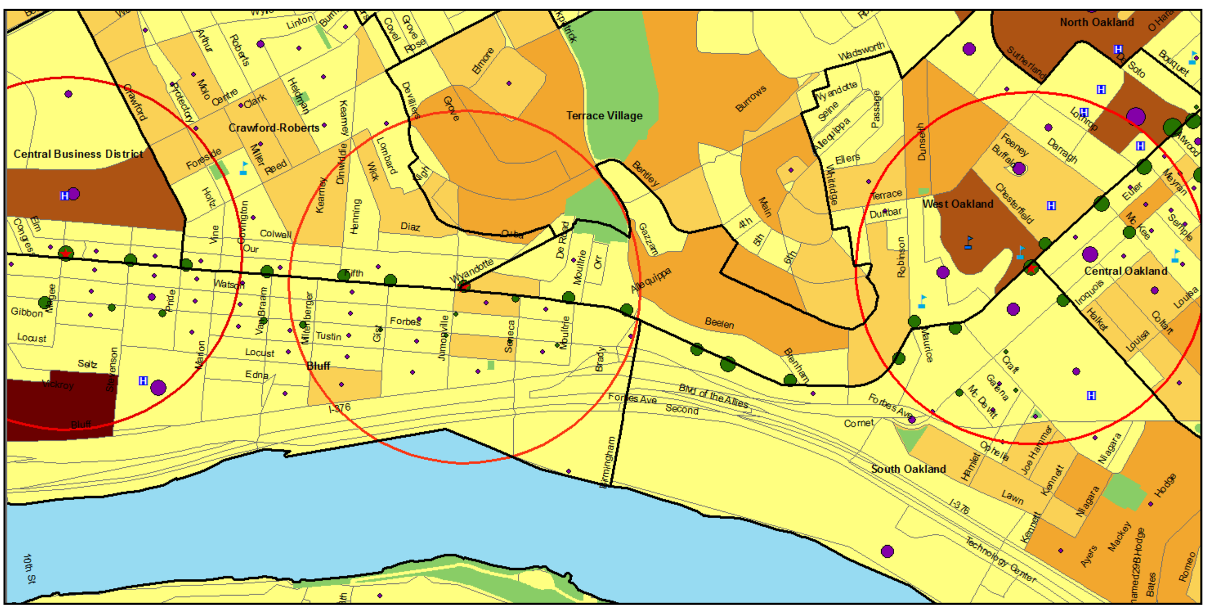

Figure 27. Stop Selection Alternative 1: Uptown comparison for Fifth Avenue at Wyandotte Street.

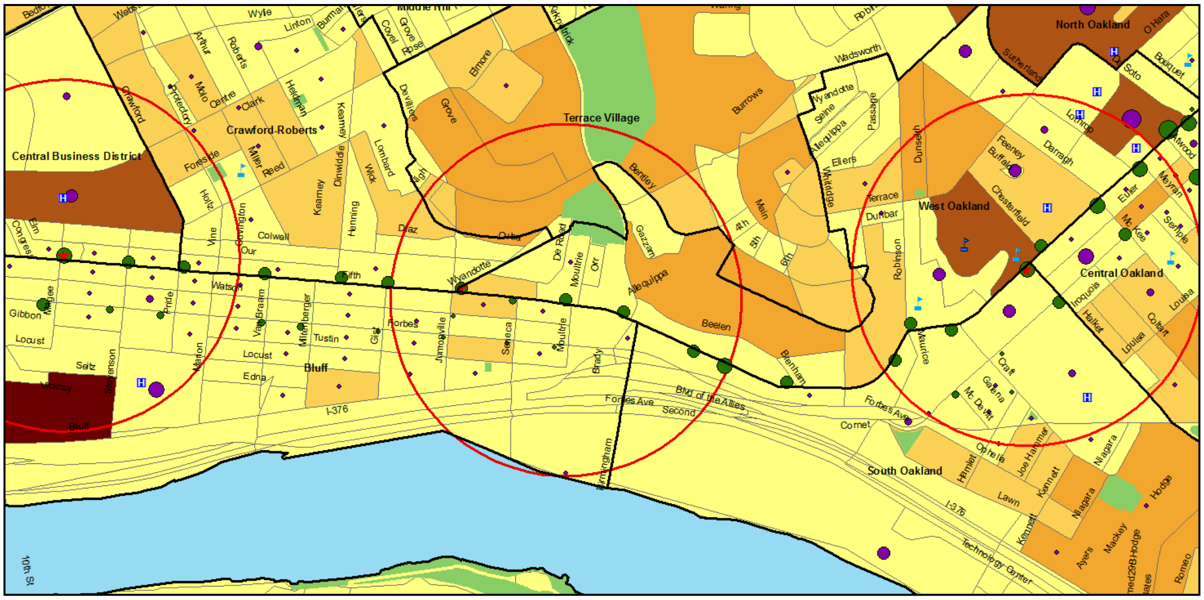

Figure 28. Stop Selection Alternative 1: Uptown comparison for Fifth Avenue at Moultrie Street.

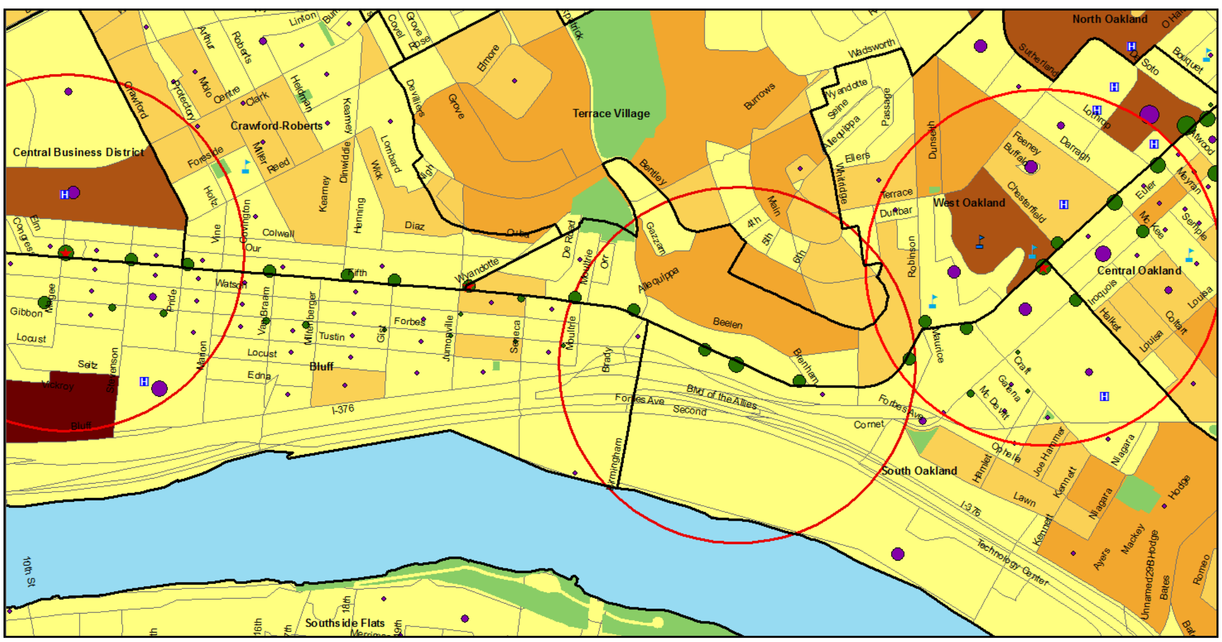

Figure 29. Stop Selection Alternative 1: Uptown comparison for Fifth Avenue at Faleder Monuments.

6.4.1.2.3. Downtown

Since the Downtown area has a higher population density with much larger ridership and more jobs, three stops are recommended. However, this creates shorter distances between each BRT stop compared to Oakland and Uptown. The trade off is speed versus the amount of ridership captured. Considering this tradeoff, Fifth Avenue at Smithfield is an optional stop, which keeps some flexibility in the design of the system. Since there are few stops in

Downtown, one possibility is to have local buses connect to the BRT stops, which would expand coverage in Downtown.

6.4.1.3. A Closer Look at the Selected Stops

6.4.1.3.1. Stop 1 – Fifth Avenue at Craig Street

Reasons this stop was selected:

- It is at one of the ends of the BRT Oakland-Uptown-Downtown Corridor
- It has a high ridership compared to stops that are close by
- It is near a large population north of Fifth Avenue
- It includes many schools and shops in its ¼ mile radius
- Compared to Morewood, it has a much higher ridership

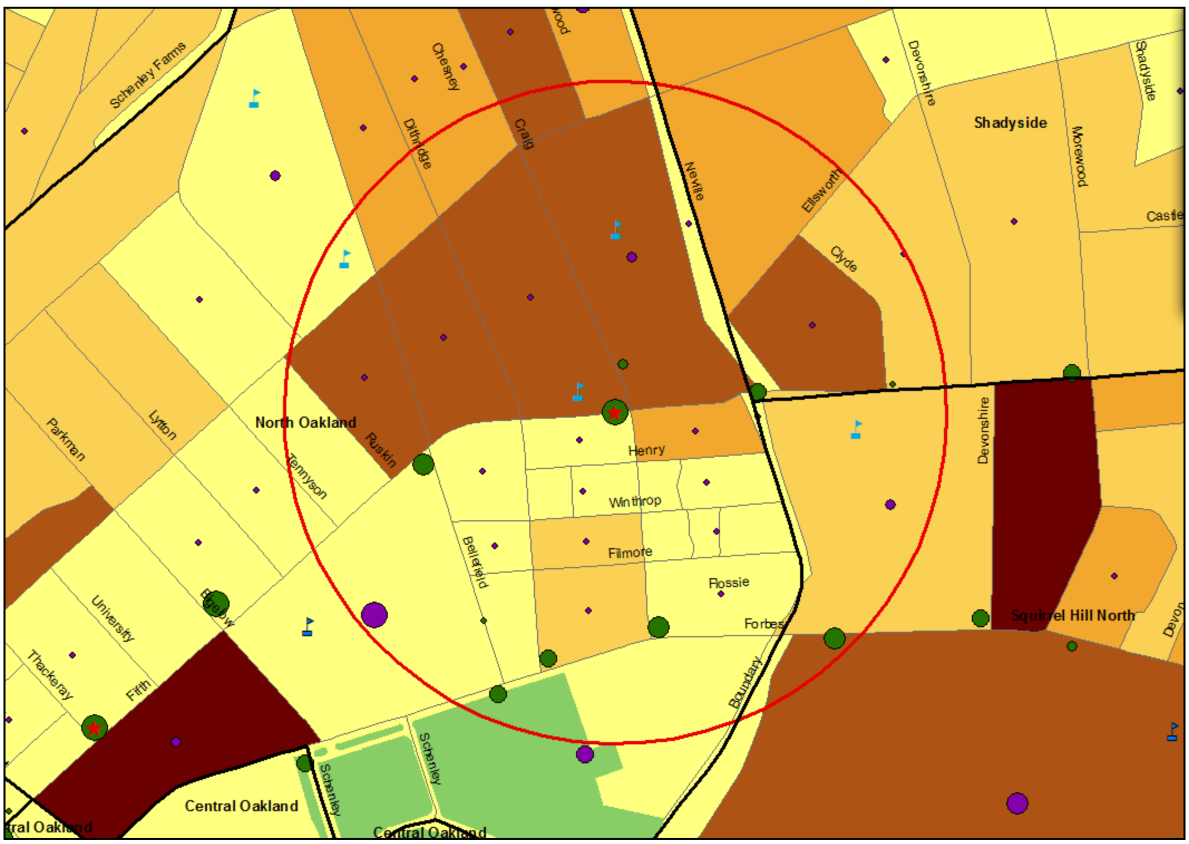

Figure 30. Stop Selection Alternative 1: Fifth Avenue at Craig Street.

6.4.1.3.2. Stop 2 – Fifth Avenue at Thackeray Avenue

Reasons this stop was selected:

- It has a high ridership compared to stops that are close by
- It is near a large population south of Fifth Avenue
- Includes many schools and hospitals in its ¼ mile radius
- Compared to Bigelow, it is farther from the stop at Craig Street and still includes much of the University of Pittsburgh's campus in its ¼ mile radius
- Compared to Atwood, it includes the University of Pittsburgh's campus in its ¼ mile radius and still includes the hospitals at Atwood
- It is ¼ mile between two of the largest job centers in Pittsburgh: UPMC Presbyterian and The University of Pittsburgh, which includes the Cathedral of Learning

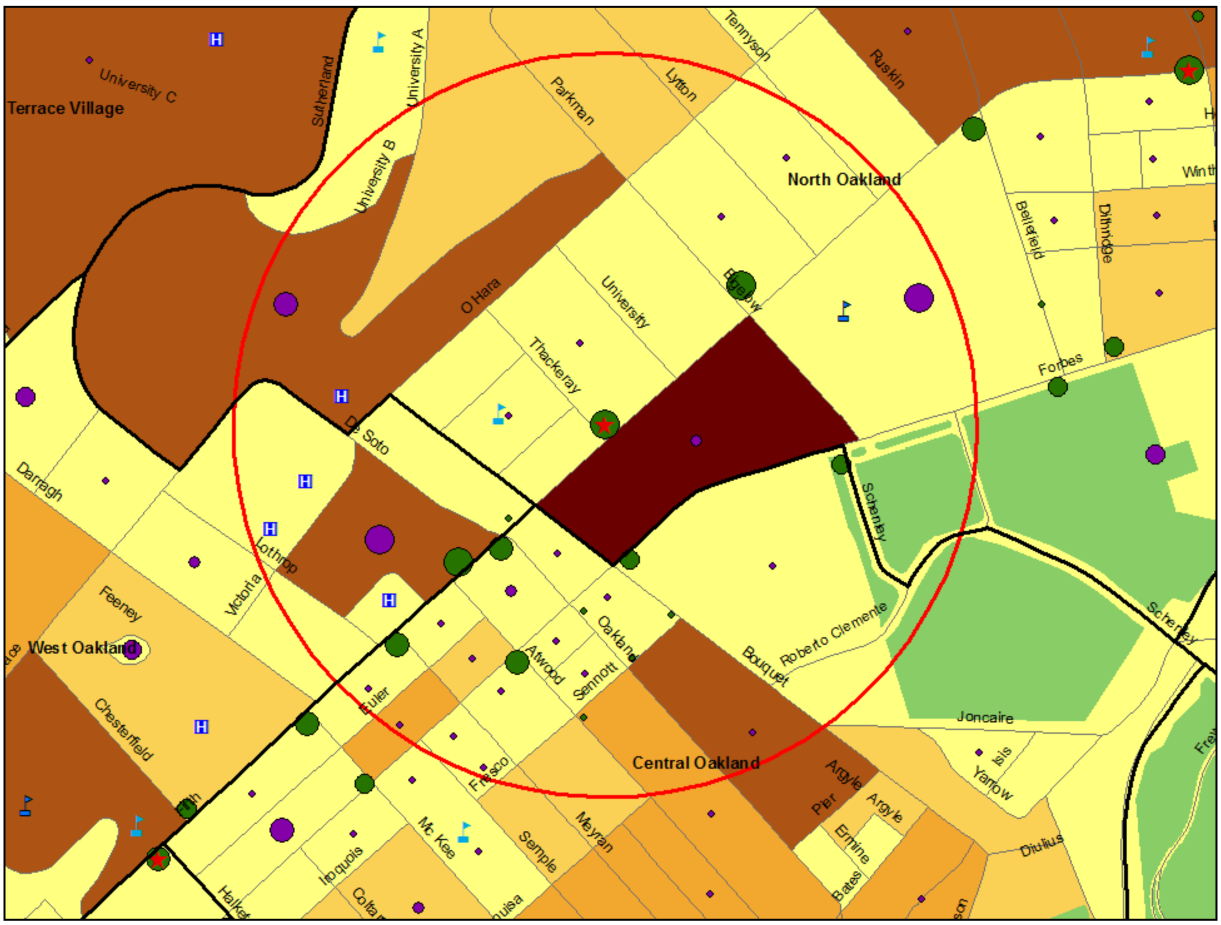

Figure 31. Stop Selection Alternative 1: Fifth Avenue at Thackeray Avenue.

6.4.1.3.3. Stop 3 – Fifth Avenue at Halket Street

Reasons this stop was selected:

- It is the first BRT stop when entering Oakland from Uptown
- It has a high ridership compared to stops that are close by
- It includes Carlow University and some hospitals in its ¼ mile radius
- Compared to McKee, it is farther from the previous BRT stop at Thackeray
- Compared to Craft, it has more destinations all around, whereas Craft has very few destinations to its west

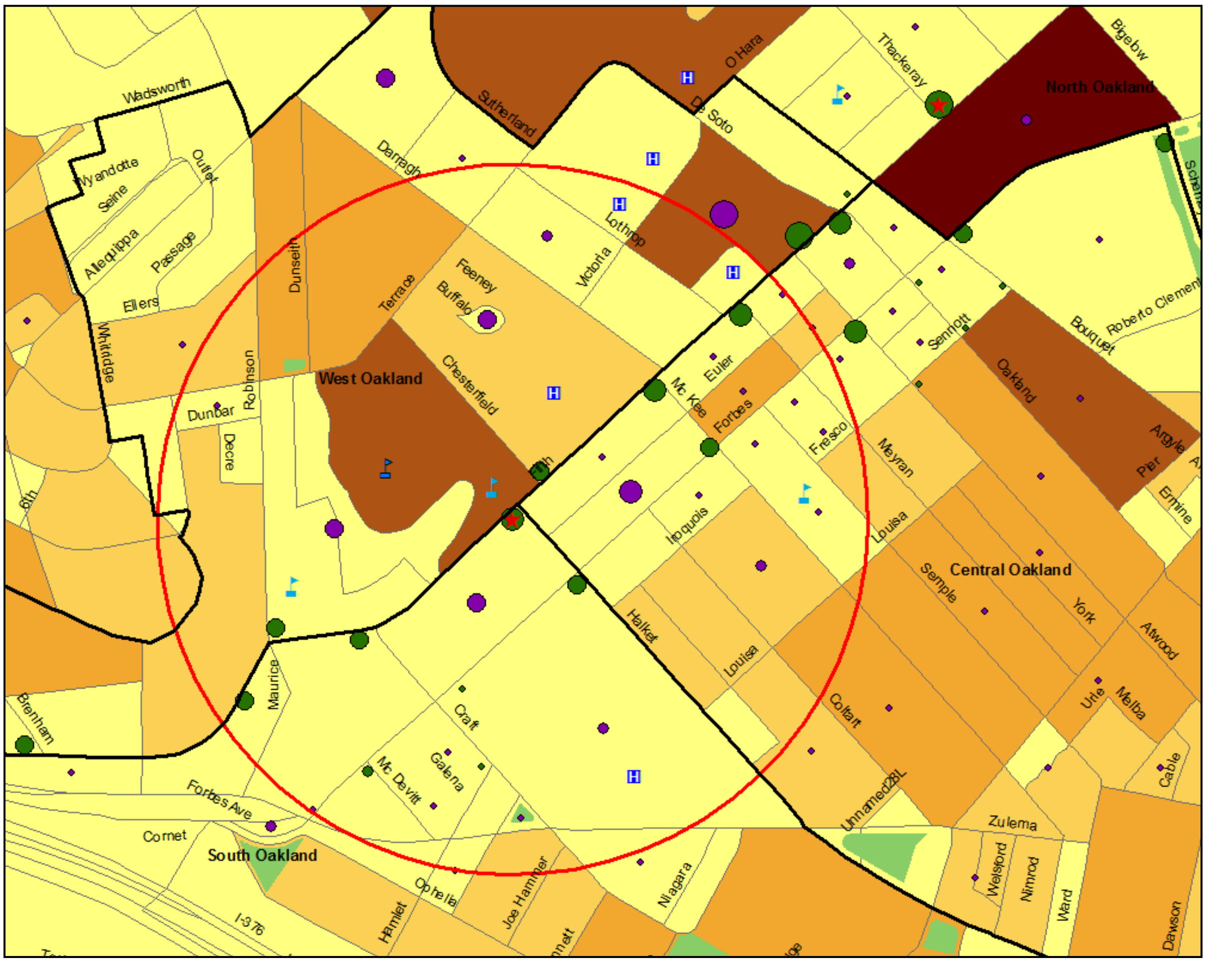

Figure 32. Stop Selection Alternative 1: Fifth Avenue at Halket Street.

6.4.1.3.4.   Stop 4 – Fifth Avenue at Wyandotte Street

Reasons this stop was selected:

- It is 0.9 miles away from the previous BRT stop at Halket; any farther may be considered an unacceptable walking distance
- It has a comparable ridership to stops that are close by
- It includes more population and jobs in its ¼ mile radius than nearby stops
- It is an area of possible growth, investment and development

Figure 33. Stop Selection Alternative 1: Fifth Avenue at Wyandotte Street.

6.4.1.3.5. Stop 5 – Fifth Avenue at Magee Street

Reasons this stop was selected:

- It is 0.6 miles away from the previous BRT stop at Wyandotte
- It includes three major destinations within its ¼ mile radius: Duquesne University, UPMC Mercy and Consul Energy Center
- Compared to Chatham Square, it includes UPMC Mercy, whereas Chatham Square does not
- Compared to Stevenson, it includes more of Duquesne University than Stevenson does

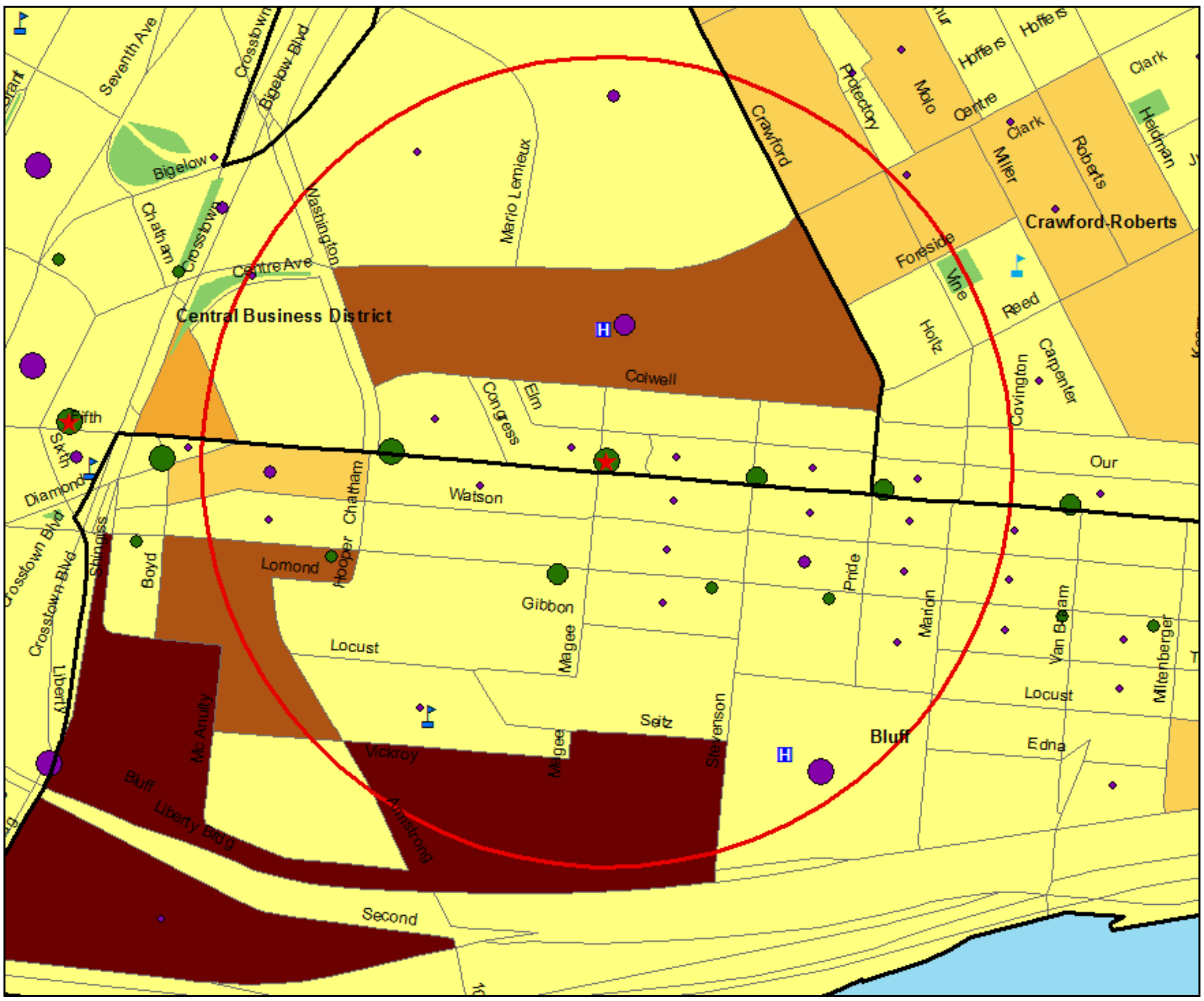

Figure 34. Stop Selection Alternative 1: Fifth Avenue at Magee Street.

6.4.1.3.6. Stop 6 – Fifth Avenue at 6th Avenue

Reasons this stop was selected:

- It is the first stop when entering Downtown from Uptown
- It includes many major destinations within its ¼ mile radius, including the US Steel Building and Robert Morris College
- It is the most evenly spaced stop between the selected BRT stops at Magee Street and Smithfield Street

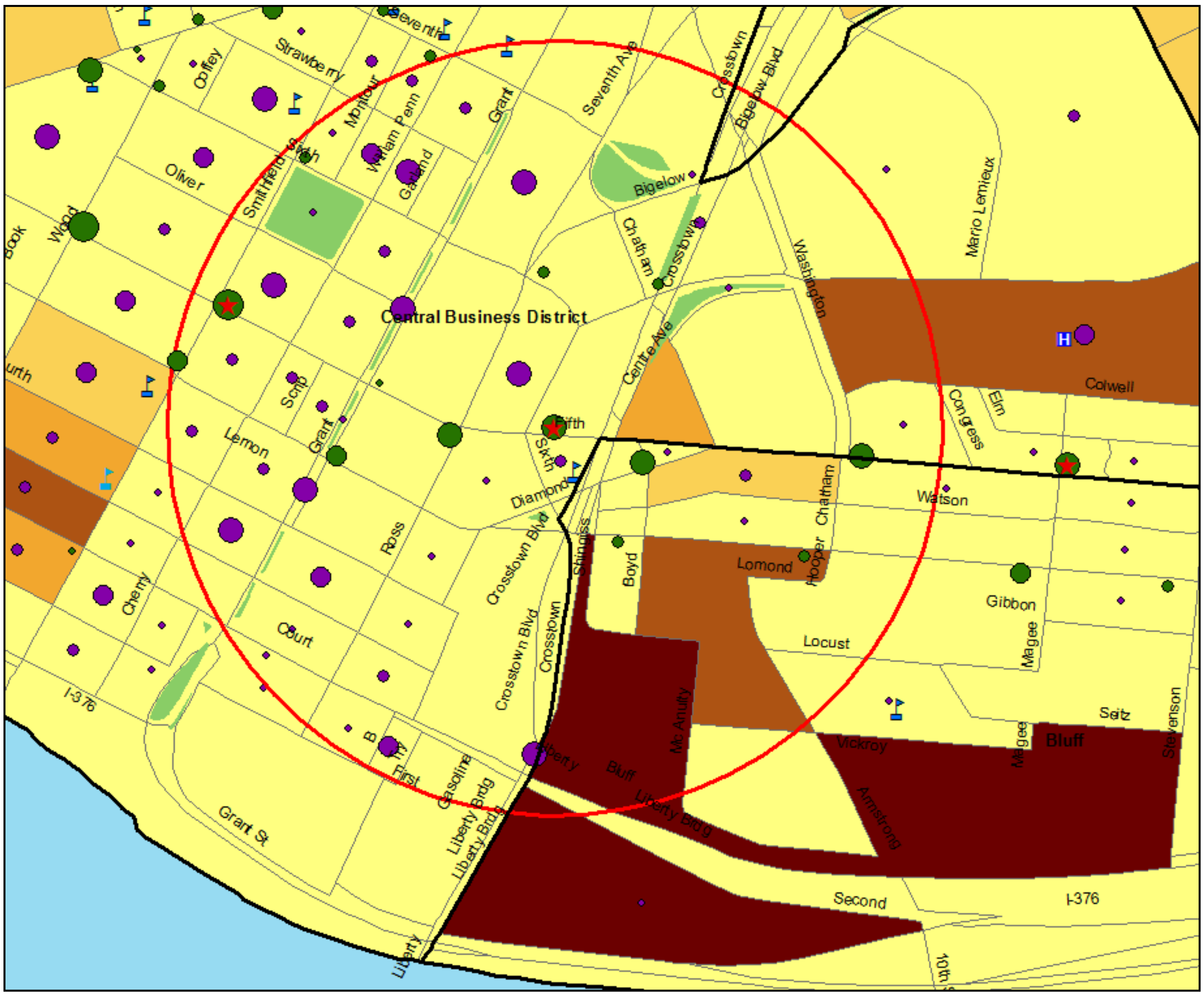

Figure 35. Stop Selection Alternative 1: Fifth Avenue at 6th Avenue.

6.4.1.3.7. *Stop 7 – Fifth Avenue at Smithfield Street*

Reasons this stop was selected:

- It is almost exactly in the center of the Central Business District
- It includes many major destinations within its ¼ mile radius, including the Carnegie Library and Macy's
- It is the most evenly spaced stop between the selected BRT stops at 6th Avenue and at Liberty Avenue

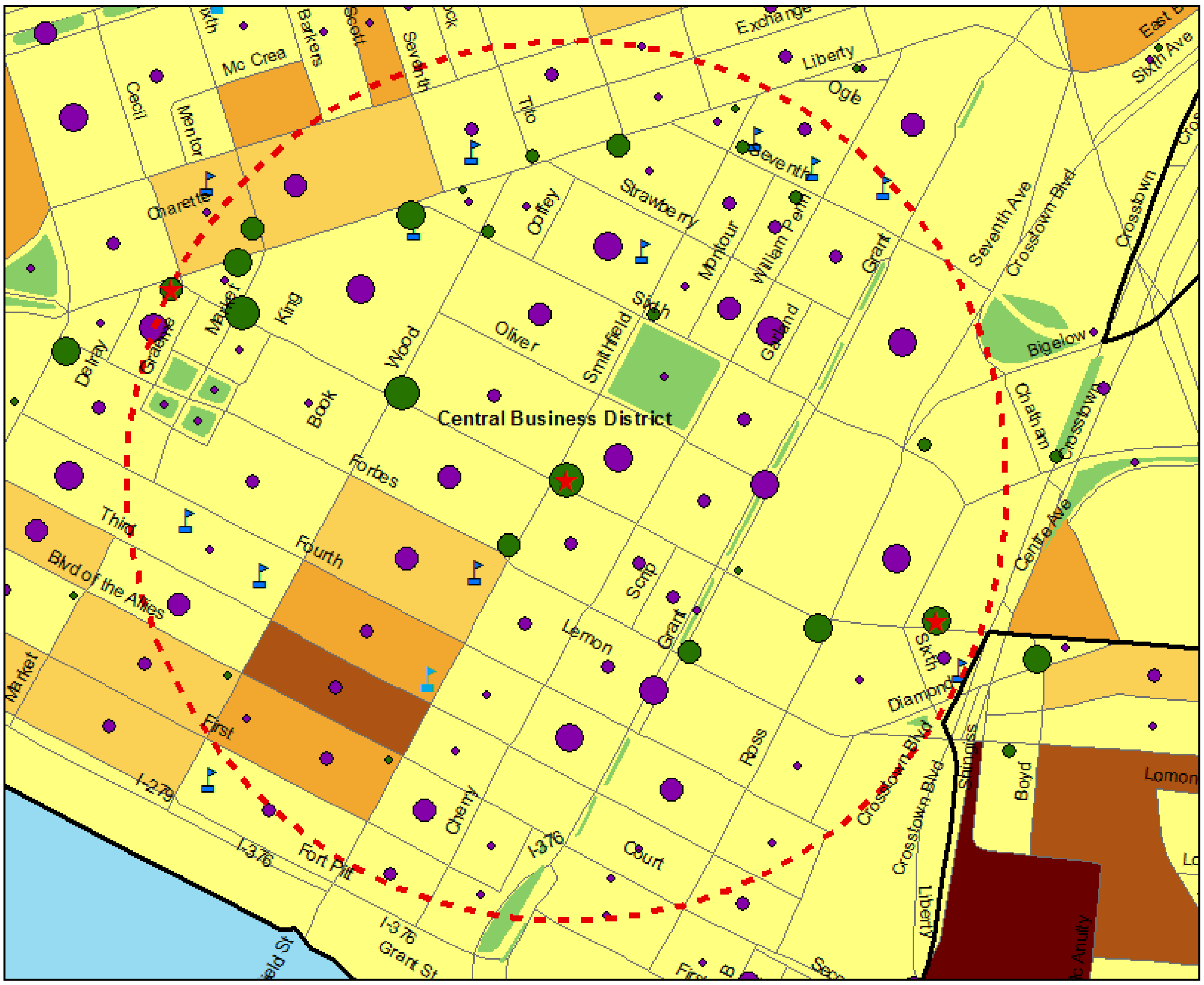

Figure 36. Stop Selection Alternative 1: Fifth Avenue at Smithfield Street.

6.4.1.3.8. Stop 8 – Fifth Avenue at Liberty Avenue

Reasons this stop was selected:

- It is near the end of Fifth Avenue and the end of the Oakland-Uptown-Downtown Corridor
- Its ridership may not be as high as nearby stops, but it is located very close to those stops
- It includes more population and more jobs in its ¼ mile radius, than nearby stops
- It is near many major downtown destinations

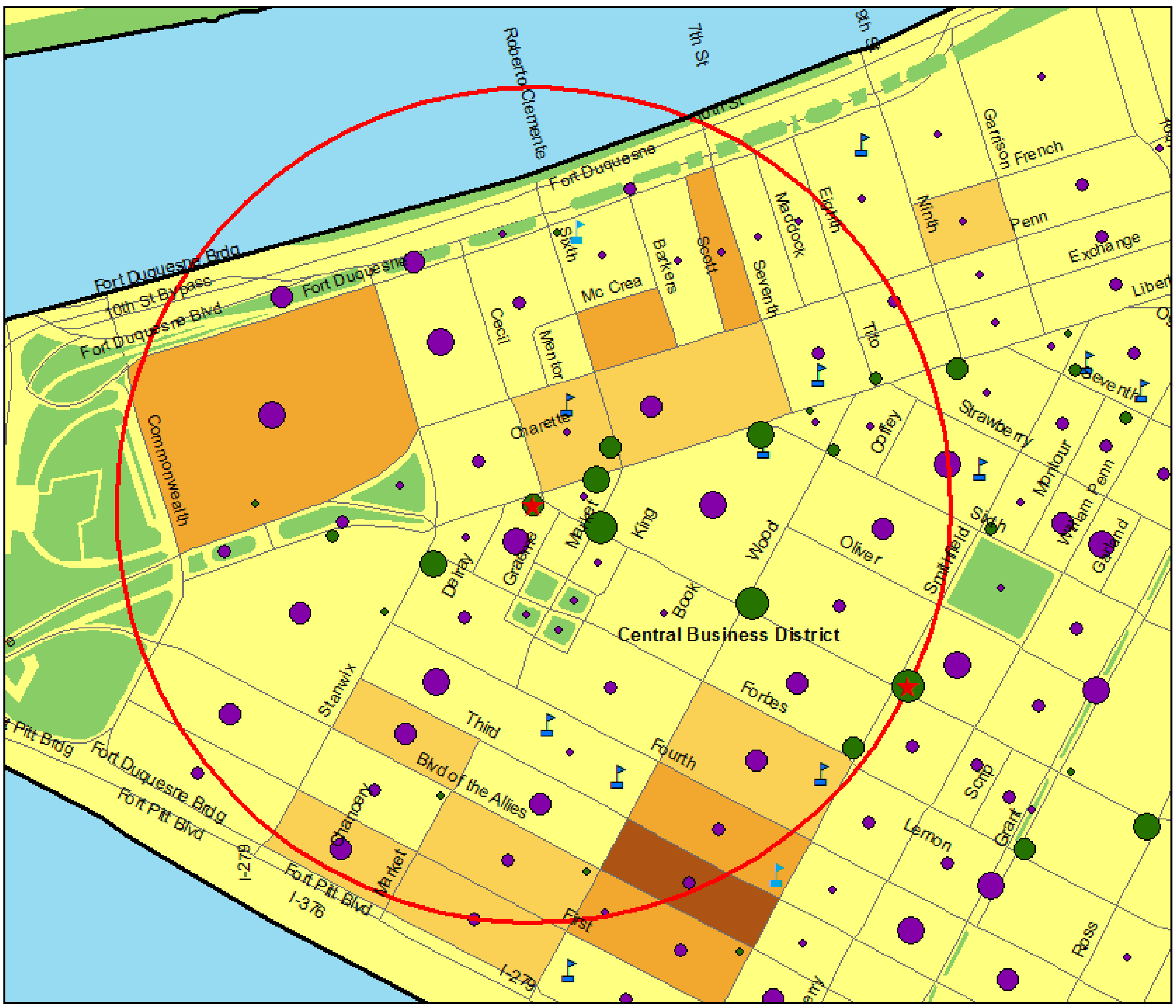

Figure 37. Stop Selection Alternative 1: Fifth Avenue at Liberty Avenue.

6.4.1.3.9. Various Corridor Views

The following maps are to help visualize how Alternative 1 fits into the Oakland-Uptown-Downtown BRT corridor. These maps also illustrate how the proposed BRT stops interact with each other.

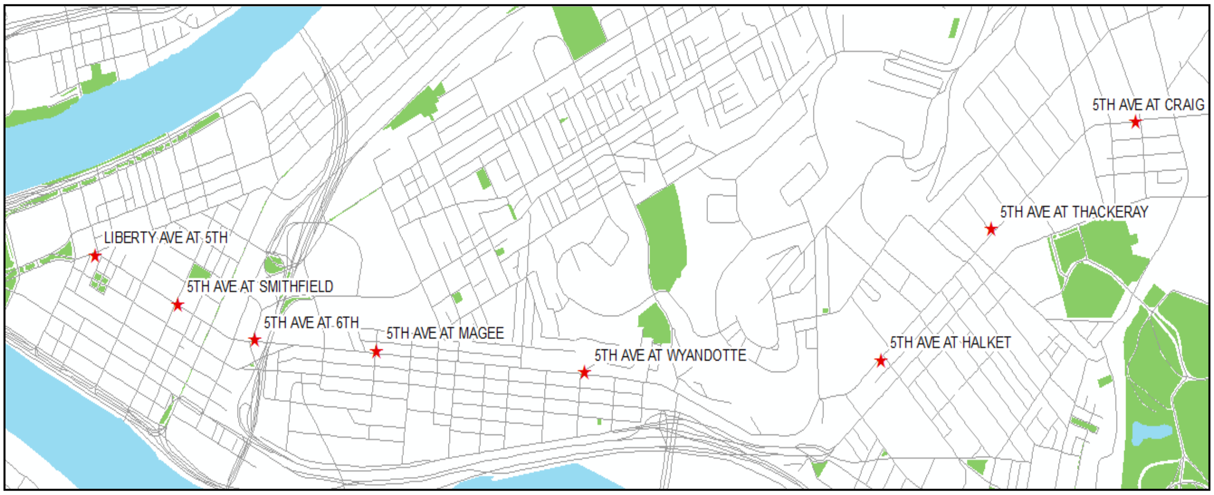

Figure 38. Stop Selection Alternative 1: Whole corridor view with stop names.

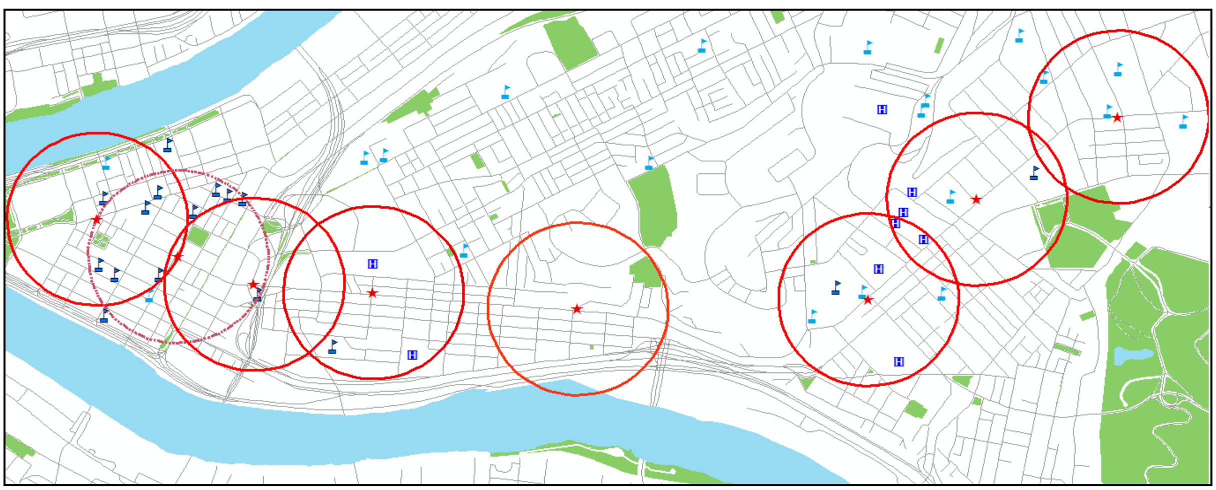

Figure 39. Stop Selection Alternative 1: Whole corridor view with 1/4 mile buffers, schools, universities and hospitals.

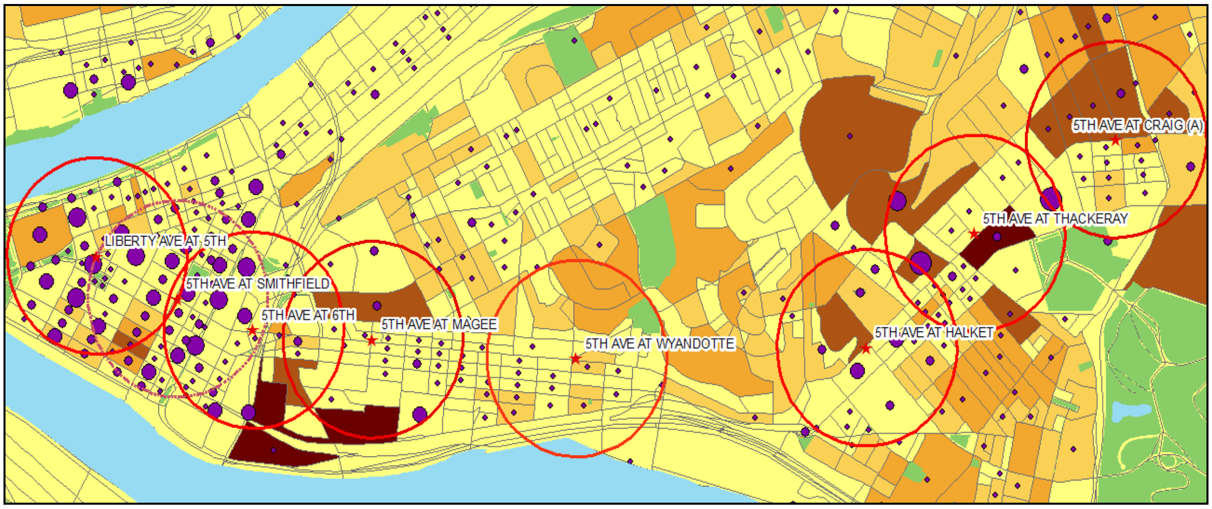

Figure 40. Stop Selection Alternative 1: Whole corridor view with 1/4 mile buffers, jobs and population.

6.4.1.4. Characteristics of Selected Stops

The following table is a summary of each stop and their information based on the GIS analysis that was conducted. The visual analysis of each stop is shown above, but the exact numbers are located in the table below. The criterion in the table includes the following:

Ridership:

- Ons – total number of riders that got on a bus at that stop during a weekday
- Offs – total number of riders that got off a bus at that stop during a weekday
- Total – the sum of ons and offs for that stop
- ¼ Mile – the total number of ons and offs within the stop's ¼ mile buffer

Population: ¼ Mile – the total population within the stop's ¼ mile buffer

Jobs: ¼ Mile – the total number of jobs within the stop's ¼ mile buffer

Stop: ¼ Mile – the total number of bus stops within the stop's ¼ mile buffer

Distance from Previous Stop – the distance from each stop to the stop before it (starting in Oakland and going Downtown)

Nearby Features – key destinations within the stop's ¼ mile buffer

Area	Stop	Ridership				Population	Jobs	Stops	Distance from Previous Stop	Nearby Features
		Ons	Offs	Total	¼ mile	1/4 mile	1/4 mile	1/4 mile		
Oakland	5th at Craig	1,168	2,224	3,392	11,765	4,152	117,616	43		Cathedral of Learning, Churches, Craig Street commercial district, CMU Software Engineering Institute, Carnegie Museum of Art and Natural History, Carnegie Library
Oakland	5th at Thackeray	1,220	1,845	3,065	13,801	5,820	260,535	36	0.5 miles	University of Pittsburgh, Litchfield Towers, UPMC, Forbes' retails, bars and restaurants
Oakland	5th at Halket	838	488	1,326	8,540	1,740	49,930	38	0.4 miles	Carlow University, Center for Medical Genetics, Magee Women's Hospital, UPMC, National Kidney Foundation
Uptown	5th at Wyandotte	169	253	422	3,415	1,409	4,204	25	0.9 miles	Center for Hearing and Deaf Services, Solutions Transportation
Uptown	5th at Magee	196	860	1,056	4,727	4,166	37,361	23	0.6 miles	Duquesne University, UPMC Mercy Hospital, Council Energy Center
Downtown	5th at 6th	600	418	1,018	9,601	872	236,530	48	0.3 miles	Robert Morris College, US Steel Building, UPMC, PNC Bank, Federal Reserve Bank of Cleveland: Pittsburgh Branch, BNY Mellon, Macy's, Pittsburgh City Council, City Planning Building, Allegheny County Human Resources
Downtown	5th at Smithfield	1,188	801	1,989	14,857	1,228	327,667	81	0.2 miles	Port Authority of Allegheny County, Carnegie Library of Pittsburgh, Macy's, Saks Fifth Ave
Downtown	5th at Liberty	421	88	509	12,411	2,108	245,539	61	0.2 miles	Highmark, PNC Plaza, Pittsburgh Symphony, Restaurants, KNL Gate Center, Pittsburgh Cultural District

Table 14. Stop Selection Alternative 1: Detailed characteristics of selected stops.

Alternative 1 was compared to existing BRT stop distances to make sure it fell within the ranges of the seven other on-street BRTs.

	Shortest	Longest	Average
Cleveland – Health Line	0.13 mi (0.20 km)	0.50 mi (0.81 km)	0.20 mi (0.32 km)
Boston – Silver Line	0.10 mi (0.16 km)	1.90 mi (3.06 km)	0.32 mi (0.52 km)
Eugene – Emx	0.24 mi (0.38 km)	0.98 mi (1.58 km)	0.42 mi (0.68 km)
Las Vegas – MAX	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.50 mi (0.81 km)
Los Angeles – Metro Rapid	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.70 mi (1.13 km)
York Region – Viva	0.16 mi (0.26 km)	3.07 mi (4.94 km)	0.93 mi (1.50 km)
Halifax – MetroLink	0.45 mi (0.73 km)	7.70 mi (12.40 km)	3.28 mi (5.28 km)
Proposed Pittsburgh BRT – Alternative 1	**0.2 mi**	**0.9 mi**	**0.44 mi**

Table 15. Stop Selection Alternative 1: Distance of stops selected compared to other on-street BRT systems.

Since there are fewer stops in the proposed Pittsburgh BRT system, some stops may get over-crowded, which could be particularly problematic where sidewalks are narrow and pedestrian traffic is extensive. However, this can be at least partially mitigated by increasing the frequency of BRT buses.

6.4.2. Alternative 2

Using the same criteria used in Alternative 1, Alternative 2 has five stops which are more spread out. The entire system can achieve a higher operating speed with this design and it will still capture many riders and destinations.

6.4.2.1. Recommended Stops

- Fifth Avenue at Craig
- Fifth Avenue at Atwood
- Fifth Avenue at Pride
- Fifth Avenue at 6th
- Fifth Avenue at Liberty

6.4.2.2. Stop Selection by Neighborhood

6.4.2.2.1. Oakland

Considering ridership, jobs and population, Fifth Avenue at Atwood is chosen. While the distance between the two BRT stops at Atwood and Craig is a little bit longer, there is only a one and a half block gap between the two stops' ¼ mile radii.

6.4.2.2.2. Uptown

In addition to the criteria used above, the Uptown Community Vision is also considered in selecting stops in Uptown. Fifth Avenue at Pride was selected because it not only captures the majority of the riders and jobs in this area, but Pride is also the primary development node and a transit hub in the Uptown Community Vision (Uptown Partners, 2009).

However, noticing that there is a large gap between this stop and the previous one (Fifth Avenue at Atwood), local bus services are needed to provide enough access to riders who use the corridor in-between these two BRT stops. Furthermore, with the future development of Uptown, more BRT stops will need to be considered.

6.4.2.2.3. Downtown

In this alternative, Fifth Avenue at Smithfield (which is optional in Alternative 1) was eliminated. However, the stops at Fifth Avenue at 6th and Fifth Avenue at Liberty were kept. While the two stops are quite equally spaced, their ¼ mile radii still cover the majority of Downtown.

6.4.2.3. A Closer Look at the Selected Stops

Only stops that are different from Alternative 1 are included.

6.4.2.3.1. Stop 2 – Fifth Avenue at Atwood Street

Reasons this stop was selected:

- It includes more population, more riders and more jobs in its ¼ mile radius than nearby stops
- It also covers the major destinations in this area: UPMC and University of Pittsburgh

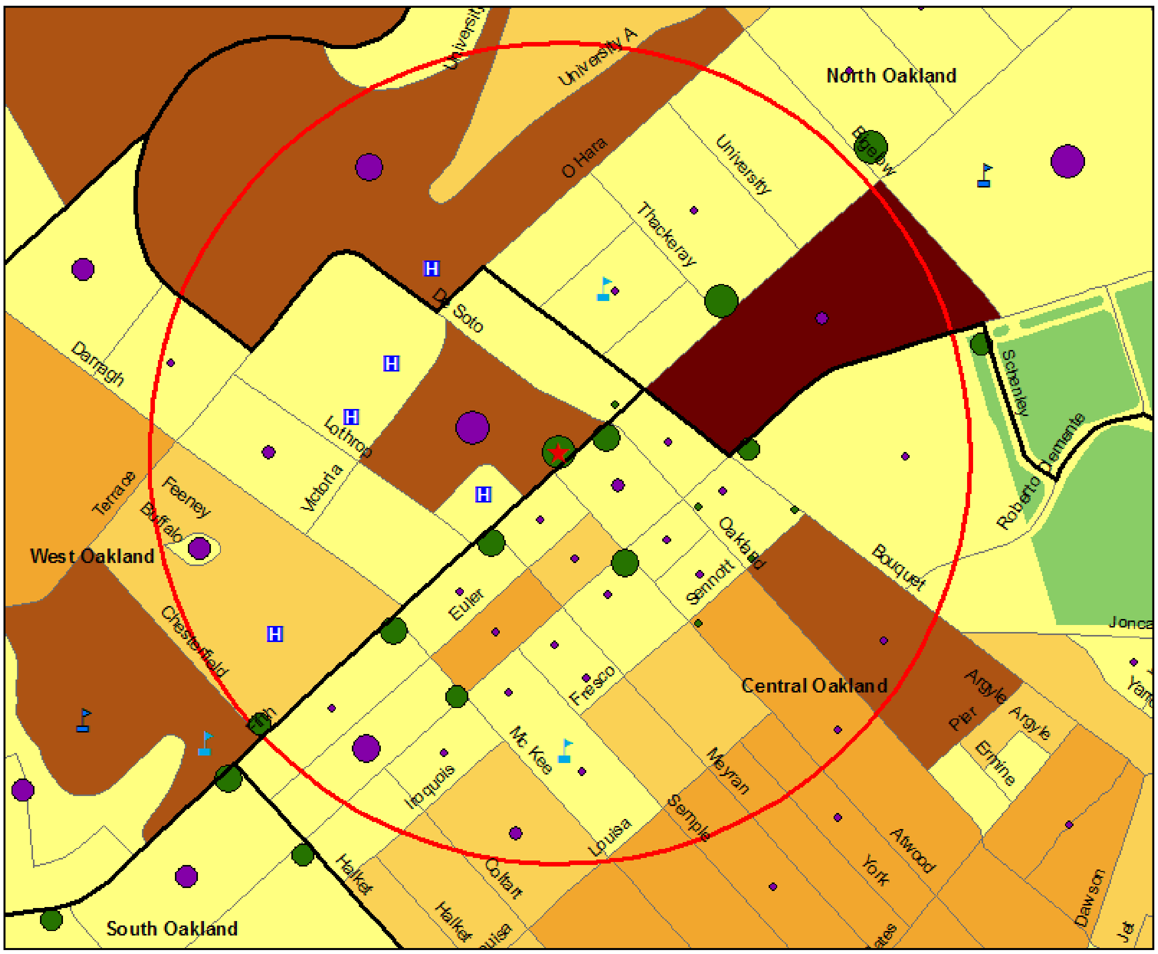

Figure 41. Stop Selection Alternative 2: Fifth Avenue at Atwood Street.

6.4.2.3.2. Stop 3 – Fifth Avenue at Pride Street

Reasons this stop was selected:

- It captures the majority of riders, jobs and population in this area
- It is viewed as the primary development node in the Uptown Community Vision
- It is near UPMC Mercy

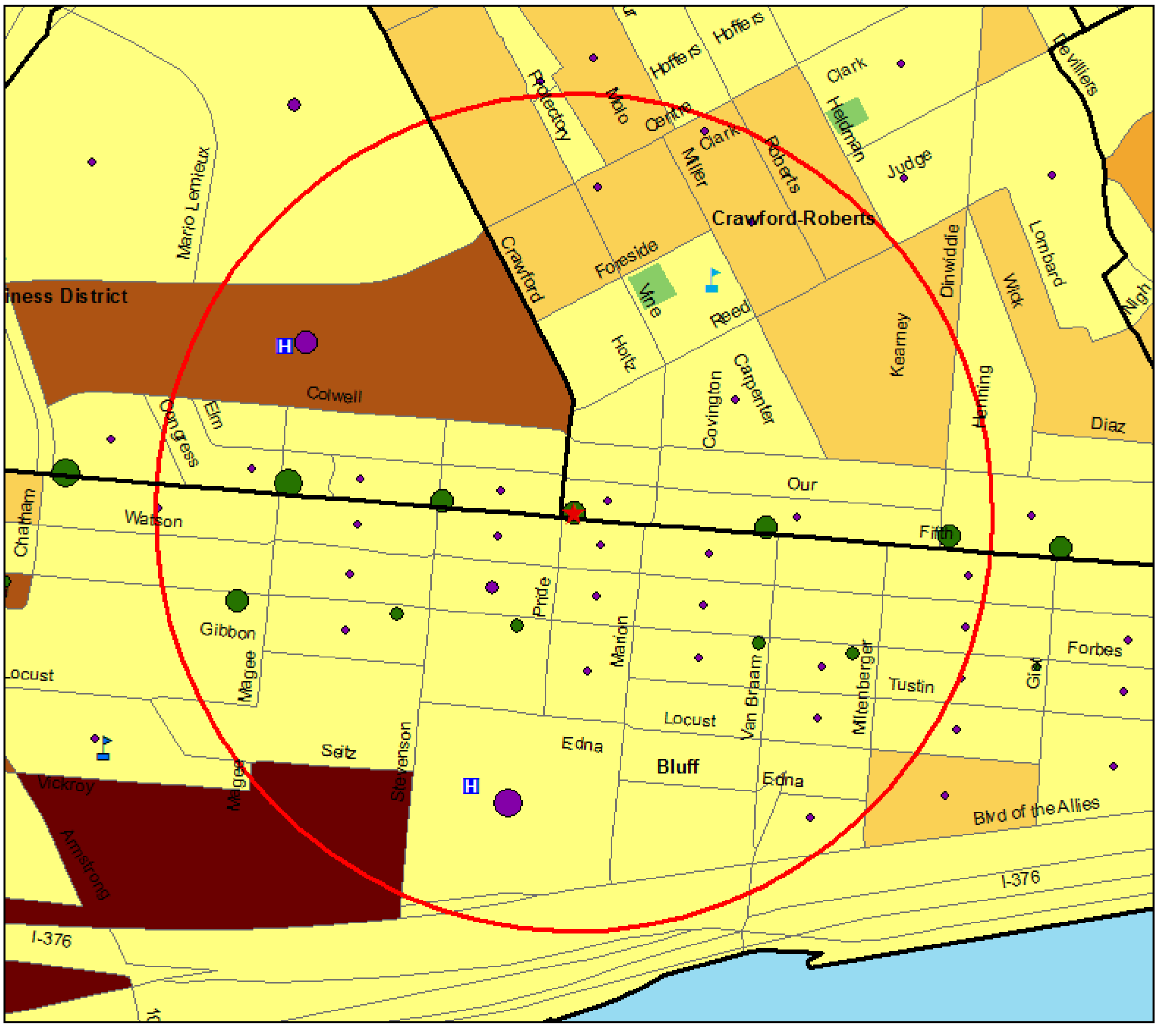

Figure 42. Stop Selection Alternative 2: Fifth Avenue at Pride Street.

6.4.2.3.3. Various Corridor Views

The following maps are to help visualize how Alternative 2 fits into the Oakland-Uptown-Downtown BRT corridor. These maps also illustrate how the proposed BRT stops interact with each other.

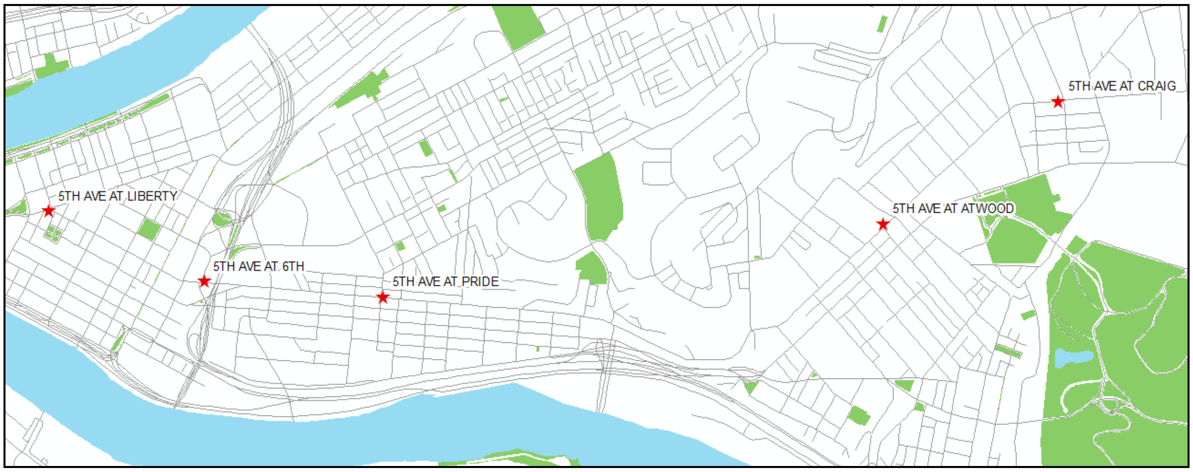

Figure 43. Stop Selection Alternative 2: Whole corridor view with stop names

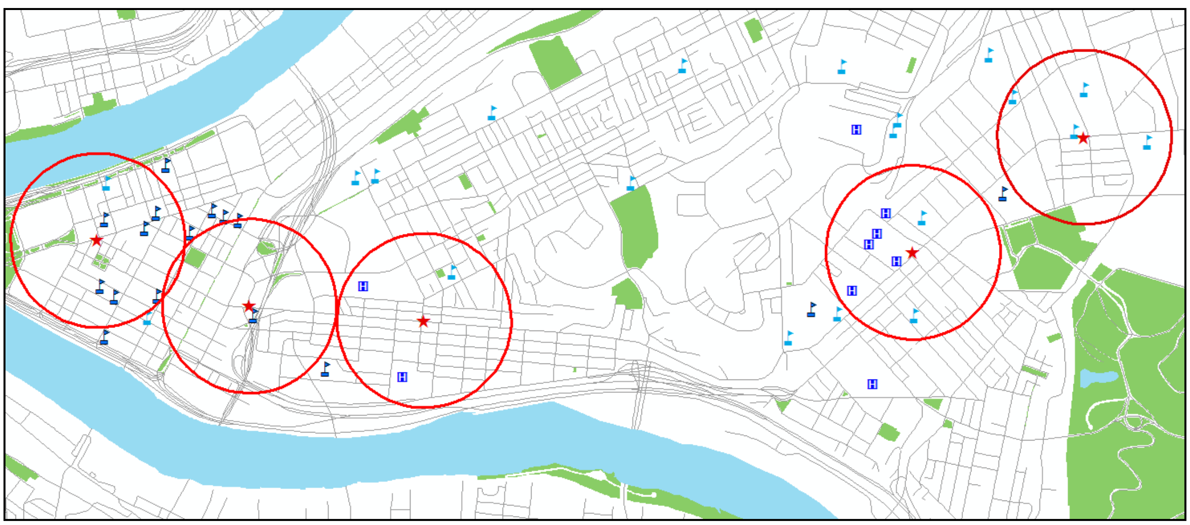

Figure 44. Stop Selection Alternative 2: Whole corridor view with 1/4 mile buffers, jobs and population.

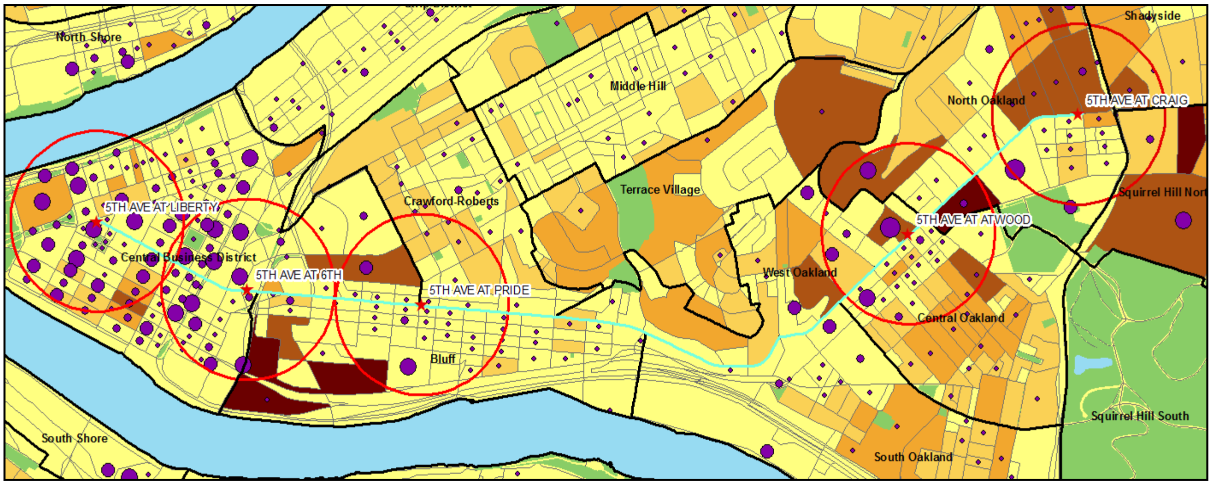

Figure 45. Stop Selection Alternative 2: Whole corridor view with 1/4 mile buffers, jobs and population.

6.4.2.4. Characteristics of Selected Stops

The following table is a summary of each stop and their information based on the GIS analysis that was conducted.

	Stop	Ridership				Population	Jobs	Stops	Distance from Previous Stop	Nearby Features
		Ons	Offs	Total	¼ mile	1/4 mile	1/4 mile	1/4 mile		
Oakland	5th at Craig	1,168	2,224	3,392	11,765	4,152	117,616	43		Cathedral of Learning, Churches, Craig Street commercial district, CMU Software Engineering Institute, Carnegie Museum of Art and Natural History, Carnegie Library
Oakland	5th at Atwood	904	1,162	2,066	12,464	6,508	183,780	14	0.6 miles	University of Pittsburgh, UPMC, Forbes Avenue retail and restaurants
Uptown	5th at Pride	123	322	445	4,913	1,589	30,478	10	1.6 miles	UPMC Mercy Hospital, Consol Energy Center, Uptown Community Vision Primary Investment Help
Downtown	5th at 6th	600	418	1,018	9,601	872	236,530	48	0.3 miles	Robert Morris College, US Steel Building, UPMC, PNC Bank, Federal Reserve Bank of Cleveland: Pittsburgh Branch, BNY Mellon, Macy's, Pittsburgh City Council, City Planning Building, Allegheny County Human Resources
Downtown	5th at Liberty	421	88	509	12,411	2,108	245,539	61	0.2 miles	Highmark, PNC Plaza, Pittsburgh Symphony, Restaurants, KNL Gate Center

Table 16. Stop Selection Alternative 2: Detailed characteristics of selected stops.

Alternative 1 was compared to existing BRT stop distances to make sure it fell within the ranges of the seven other on-street BRTs.

	Shortest	Longest	Average
Cleveland – Health Line	0.13 mi (0.20 km)	0.50 mi (0.81 km)	0.20 mi (0.32 km)
Boston – Silver Line	0.10 mi (0.16 km)	1.90 mi (3.06 km)	0.32 mi (0.52 km)
Eugene – Emx	0.24 mi (0.38 km)	0.98 mi (1.58 km)	0.42 mi (0.68 km)
Las Vegas – MAX	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.50 mi (0.81 km)
Los Angeles – Metro Rapid	0.25 mi (0.40 km)	1.00 mi (1.61 km)	0.70 mi (1.13 km)
York Region – Viva	0.16 mi (0.26 km)	3.07 mi (4.94 km)	0.93 mi (1.50 km)
Halifax – MetroLink	0.45 mi (0.73 km)	7.70 mi (12.40 km)	3.28 mi (5.28 km)
Proposed Pittsburgh BRT – Alternative 2	0.2 mi	1.6 mi	0.54 mi

Table 17. Stop Selection Alternative 2: Distance of stops selected compared to other on-street BRT systems.

7. Corridor Integration

7.1. Introduction

When designing a BRT system, it is necessary to understand it as part of a broader transportation system. In order to take full advantage of a BRT system, the system has to provide as many connections with other transportation modes as possible.

A major element to ensure BRT's success is its ability to attract a number of riders that allow the system to be economically feasible. In this process, a key step is to understand and promote the different ways users can access the system. As explained in the BRT Planning Guide, "if customers cannot reach a station comfortably and safely, then they will cease to be customers" (Institute for Transportation & Development Policy).

Riders could access the Oakland-Uptown-Downtown BRT by walking, biking, driving, taking a taxi or using local buses, the T-Rail or the East Busway. The BRT corridor should also consider integration with long distance buses and trains, such the Megabus and Amtrak stations in Downtown. Each potential access mode to the BRT system should be analyzed, looking for ways to promote these connections.

Integration with other modes of public transportation is particularly important because riders should be able to move through the city using only public transportation. Integration refers not only to physical connections between the systems, but also to complementary marketing, promotion and unification of fare structures. The relationship between the BRT and existing parallel bus routes is also important in integrating the BRT into the Oakland-Uptown-Downtown corridor.

7.2. Corridor Integration Affects Stop Selection

Due to the geographic constraints of the Oakland-Uptown-Downtown corridor, the BRT route will likely overlay with existing local bus routes and bicycle trails throughout the corridor. This brings a great potential to integrate these systems through stop selection and services offered in the BRT system. A Corridor Integration map (Figure 46) was created at the outset of the research process.

The map shows the intersections of various transportation alternatives along the corridor. Bicycle lines are identified as dotted lines running in and along various streets throughout the corridor. In the downtown area, T line light rail stations, and junction points with the existing East Busway, as well as locations of nearby auto and bicycle parking locations throughout downtown.

The circles at the intersections along 5th Avenue in the corridor indicate the number of bus routes that use the intersection as a stop. The larger circles indicate that more buses use the intersection as part of their route. Corridor Integration map shows potential stops based not only on the general on-board/off-board numbers for the existing system, as seen in the Stop

Selection map, but where stops might be located to best integrate the BRT with other transportation alternatives in the corridor.

Figure 46. Corridor Integration: Map of various transportation alternatives that need to be integrated into the BRT system.

7.3. Approaches to Parallel Bus Routes

In order to reduce travel time with the BRT, PAAC could consider reducing or eliminating local bus services that run in parallel to the BRT corridor. This would reduce congestion and help alleviate potential slowdowns and blockages for the BRT. However, this is not the only option. Different cities have taken different approaches to this situation.

7.3.1. Eugene, Oregon

When the EmX BRT service was implemented in Eugene, there was an existing bus route, Route 11, which overlaid the BRT corridor. The decision was to eliminate the overlaying portion of the Route 11. The EmX BRT now provides a better and faster service than the eliminated portion of Route 11 used to provide (APTA Standards Development Program, 2010).

7.3.2. York, Ontario

After the Viva BRT was introduced in York, some of the demand for buses running parallel to the BRT corridors shifted to the new BRT service. Consequently, York reduced the frequency of some of those buses, especially Route 99 on the busiest corridor (APTA Standards Development Program, 2010).

7.3.3. Halifax, Nova Scotia

After the introduction of the MetroLink BRT, Halifax studied the ridership levels and decided that the new ridership was enough to maintain the existing bus routes running in parallel to the new BRT services. An important factor in this decision was the long distance between the BRT stations, ranging from 0.5 - 2 miles within developed urban areas, and up to 8 miles in less developed areas (APTA Standards Development Program, 2010).

7.3.4. Pittsburgh's Situation

PAAC has three basic options for approaching the question of how to handle local bus services along the corridor and in parallel routes. Looking at other services, a number of factors were identified that should be taken into consideration when PAAC is making their decision on this topic.

	Leave All Routes Halifax, Nova Scotia	**Reduce Routes** York, Ontario	**Eliminate All Routes** Eugene, Oregon
Existence of alternate parallel running way (Forbes from downtown to Oakland)			✓
BRT can handle full capacity of existing ridership plus additional riders			✓
High cost of maintaining additional Routes			✓
Potential for intersect of the multiple services (congestion)			✓
Potential to easily transfer to a local route from the BRT	✓	✓	
Long distance between BRT stations	✓	✓	

Table 18. Criteria to handle parallel local bus service based on Halifax, York and Eugene's BRT systems.

Table 18 was generated by the project team to indicate how various factors affect the three basic options for handling local bus service in the corridor. A checkmark in the table indicates that a local factor supports the corresponding route handling alternative. For example, the existence of a nearby parallel route to the proposed corridor (Forbes Avenue) supports the idea that PAAC should eliminate local service in the BRT corridor on 5th Avenue. Additionally, we have assumed that PAAC will take the existing and potential ridership of the BRT into consideration and will adjust BRT service to allow for not just existing ridership, but potential increased ridership when laying out the system.

Regarding ridership, a great deal of research on the part of PAAC will have to be done to determine what the initial and continuing ridership numbers will be for the new system. A 2005 Bus Rapid Transit Ridership Analysis from the U.S. Department of Transportation's

Federal Transit Administration indicated the following for various BRT services across the country (Table 19). All cities indicated saw large increases in the percentage of riders post launch, including major gains in the percentage of "choice riders" using the system. Planning for these increases must be a part of the overall planning for the system to allow not only for existing riders, but regular increases as well.

Transit Agency and Corridor	Percent Increase in Ridership Levels	Percent Increase in "Choice Riders"
AC Transit - 72R	66%	32%
Los Angeles MTA		
Wilshire/ Whittier	42%	67%
Ventura	27%	67%
Boston MBTA - Silver Line	84%	
Las Vegas RTC - MAX	>35%-40%	24%
Phoenix RAPID	N/A	33%

Table 19. Effect of BRT service on transit ridership based on various BRT systems (Peak, Henke, & Wnuk, 2005).

7.4. Bicycle Integration

7.4.1. Introduction

Among the factors that can affect the success of implementing BRT is how well it integrates with other transportation options. One of the options identified for potential integration is the numerous bicycle trails that run in, around and through the corridor.

Incorporating bicycles into the system provides a number of benefits. Among these is the idea that allowing for bicycle integration increases the distance customers can travel to reach a BRT station.

There are two basic options for riders who choose to use bicycles to get to a BRT station. The most bicycle-friendly option involves allowing cyclists to bring their bicycles onto the BRT buses themselves, storing them either in the bus or mounted to the bus using bicycle racks (Institute for Transportation & Development Policy). Bicycle racks have already been incorporated into ten PAAC local bus routes. Additionally, riders are allowed to bring bicycles on board the PAAC's T systems at certain stops (Port Authority of Allegheny County).

A second option would be slightly less intrusive for non cycling riders of the system. Instead of allowing bicycles on the buses themselves, some systems have incorporated secure bicycle parking facilities at stations. This would give riders a safe place to store their bicycles before they board the BRT.

7.4.2. Case Studies

7.4.2.1. Cleveland, Ohio

When Cleveland began planning for its Health Line service, it was able to leverage opportunities to incorporate bicycling not only at its stops, but in its entire system design. Due to Cleveland's extensive infrastructure improvements, the transit authority was able to incorporate bicycle lanes along much of its entire BRT route. This was facilitated by the fact that Cleveland rebuilt its entire road and sidewalk structure building to building as part of its implementation. In their implementation, they were able to include the following in their design (Schipper, 2008):

- Typical right of way width – 99 ft
- Vehicle lanes – 12 ft
- Transit lanes – 11 ft
- Left turn lanes – 10 ft
- Curb to right of way – 11 ft min, 23.5 ft max
- Sidewalk pedestrian zone – 6 ft min
- Parking bay width – 8 ft
- **Bike lanes – 5 ft**
- Platform width – 12 ft
- Median width – 4 ft min, 12 ft max
- Shy distance – 1 ft

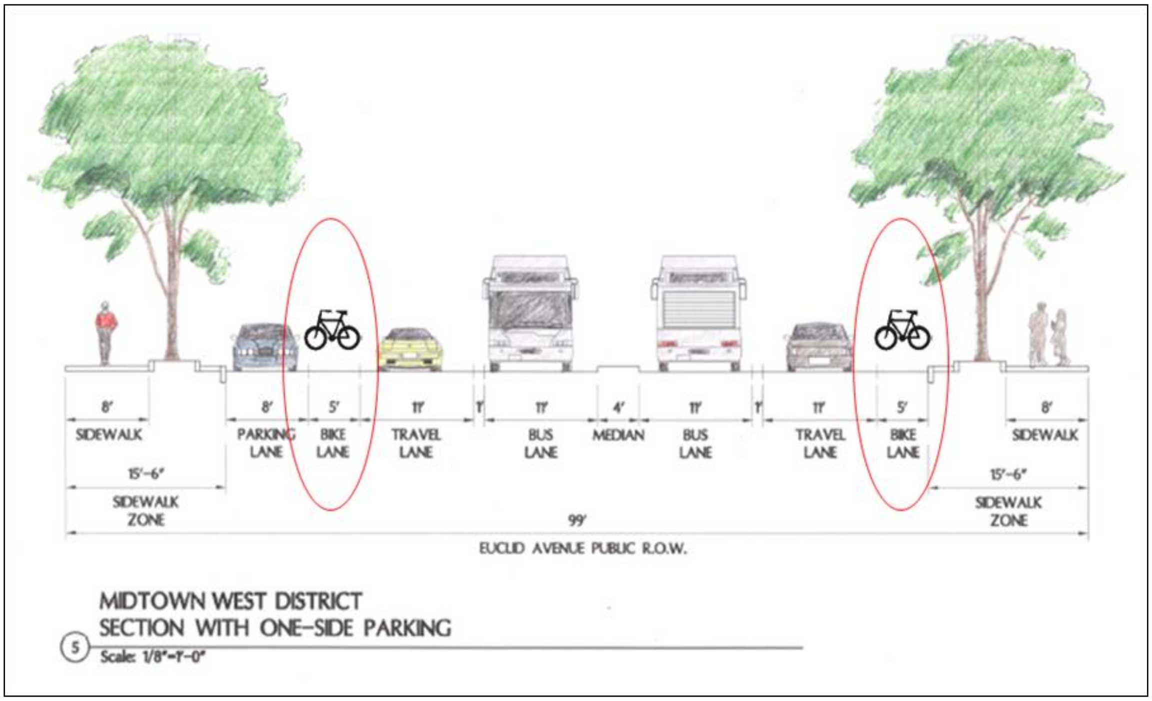

Figure 47. Cleveland's road and sidewalk elements and their lengths (Schipper, 2008).

7.4.2.2. Lessons Learned

Accessibility for BRT stations - Incorporation of bicycles allowed Cleveland to capture users from farther away.

Allow bikes inside the buses - Not only was Cleveland able to incorporate support for bicycle lanes as part of its BRT implementation, the transit authority continued its support of bicycling in the design of the buses themselves. Cleveland's BRT buses have designated space inside to allow cyclists to bring their bicycles on board.

However, there are limits to this convenience. Depending on the crowding of the system, a cyclist will not be allowed to bring a cycle onto the bus if there are too many passengers already on board. This could be a problem with in some implementations, especially during peak hours.

7.4.3. Alternatives and Recommendations

PAAC has two basic options for incorporating bicycles into their BRT service. They can either offer bicycle parking at its new stations or can allow riders to bring bicycles onto the buses. Each option provides benefits and drawbacks to both PAAC and its riders.

The less intrusive option would be to incorporate bicycle parking into its station designs (Figure 48). This would allow riders to travel further to reach a BRT station and increase potential ridership. PAAC would have to address a number of issues if it elects to use this option. First, adding bicycle parking into the designs of the stations themselves would increase the size of the stations. Additionally, PAAC would to provide some measures of security for bicycles left at stations. An unsafe storage facility would discourage cyclists from considering the BRT as a transit option.

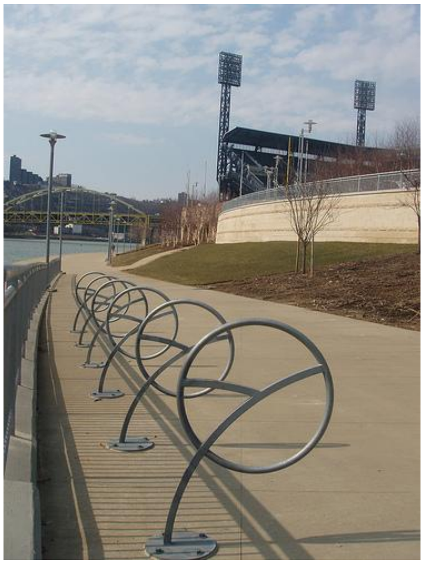

Figure 48. Bicycle parking posts in Pittsburgh

Figure 49. Bicycles on a BRT in Portland.

The second option is to allow riders to bring their bicycles with them on the bus (Figure 49). Unfortunately, this alternative comes with its own drawbacks. First, allowing bicycles onto the system would increase potential for congestion at BRT stations, as well as, on the buses themselves. Second, riders with bicycles could slow boarding. Finally, if PAAC elected to allow bicycles only on external racks, it could have a profound impact on fare collection. The need to allow riders to access the front or rear of the bus would likely eliminate the option of a fully off board collection system, or it could lead to greatly increased boarding times.

While the convenience of on board bicycle storage is likely the more attractive option for cyclists, it may not be the best alternative for PAAC. At least for the initial implementation, PAAC should limit itself to bicycle parking at stations or use external bicycle racks if the chosen fare collection system will allow for this option.

8. Travel Blending

8.1. Introduction

The concept of travel blending grew out of the efforts of Sydney, Australia to reduce greenhouse gas levels in and around the city before the 2000 Olympic Games. At the time, efforts focused on using a targeted direct marketing effort to encourage residents to reduce dependence on personal automobile transportation and adopt public transportation. The effort was unique in that it attempted to change attitudes towards public transit without employing government regulations to change the behavior of the traveling public.

Travel Blending in general involves conducting in-depth research on the travel behavior of individuals. This program uses direct marketing pieces to suggest behavior changes and tracks and collects feedback from the population it targets. Its end goal is to change the public's behaviors and attitudes towards traveling, such as:

- Planning travel and activities in advance
- Using public transportation as much as possible
- Planning activities so as many things as possible are done in the same location or at the same time

Travel Blending can help people make large reductions in private vehicle use through small changes in their behavior. A study by TravelSmart Australia concluded that people who use public transportation one day per week have the potential to reduce their weekday peak automobile use by 20% (TravelSmart Australia, 2003).

In the decade since Sydney's effort, travel blending efforts have been attempted in cities throughout the world as part of efforts to encourage the use of public transportation. For the most part, the programs all share common elements of targeted communications at a regional audience that has easy access to the public transit mode being promoted, but may not be maximizing their use of the system (Litman, 2003).

In addition to the targeted marketing effort, some travel blending efforts have also involved follow up interviews with voluntary participants. The purpose of these interviews is twofold. First, they reinforce and explain to participants the ways in which they can improve their usage of public transportation. Additionally, these interviews have been used to collect feedback from users of the system. This feedback is used to identify small, incremental improvements to the transportation system that make public transportation more appealing to more riders and improve both service and ridership.

The program involves contacting households in a particular area (usually one well served by transit) in order to identify people who are most receptive to changing their travel behavior, then supplying them with information such as public transit guides, cycling maps and information on other mobility management services. Residents are even offered a household visit by a travel planning expert. Feedback from these interviews is used to identify ways to improve local transportation services.

8.2. Case Studies

8.2.1. Sydney, Australia

8.2.1.1. Program Overview

Travel Blending as a programmatic idea started in Sydney, Australia. The program was developed as part of the Australian government's "Clean Air 2000" effort. The aim of the overall program was to reduce pollution caused by car travel in Sydney ahead of the city's hosting the Olympic Games in 2000 (Rose, 2001).

8.2.1.2. The Main Procedure of the Program

Stage	Period	Description
Kit 1: Understanding Travel Blending	1 week	A letter of introduction: a "how and why" booklet explaining the issues associated with increasing vehicle use and introducing the Travel Blending concept. This is signed by a relevant local figure, such as the Mayor or State Transportation Minister. A "before" travel diary is issued and help is offered to help them to complete this program.
Kit 2: Rethinking your travel	4 week	An analysis and summary of the travel diary. Suggestions will be provided based on a personal analysis to help people rethink their travel.
Kit 3: Continuing to make a difference	1 week	After explaining the importance to complete the program, people are encouraged to continue the program and make a positive change.
Kit 4: Continuing Travel Blending	1 week	A summary of previous travel and identification of the difference made since the beginning of the program. A log book is provided to encourage people to continue to monitor their travel.

Table 20. Summary of Travel Blending kits used in Sydney, Australia including their descriptions and time periods (TravelSmart Australia, 2003).

8.2.1.2.1. Kit 1: Understanding Travel Blending

A letter of introduction is sent out and explains the "why and how" issues. "Why" describes the advantages of using public transportation and the disadvantages of using a private vehicle. "How" addresses the problems listed in the "Why" part and how these problems can be overcome.

The targeted population will use a one week diary to record all travel details, including the destination, purpose, transportation mode, and start and end time of the trip. Once completed, the diary is returned.

8.2.1.2.2. Kit 2: Rethinking Your Travel

After the diaries are returned, data processing can be conducted. After this data is analyzed, feedback is given back to the target population. The feedback sheet summarizes personal travel habits and can help the target population rethink their travel. The feedback sheet includes personal Travel Blending tips, which encourages the reduction of private automobile use. Additionally, a goal card is provided to record personal Travel Blending goals, in which the target population has four weeks to reach.

8.2.1.2.3. Kit 3: Continuing to Make a Difference

With the suggestion of rethinking their travel, the target population will receive another one week diary, with the purpose of measuring the impact of Travel Blending. Once completed, the diary is returned.

8.2.1.2.4. Kit 4: Continuing to Practice Travel Blending

The final kit includes a travel activity summary that identifies all changes made during this process and more tips to improve the target population's travel. The changes are measured by the distance of travel and emissions of the vehicles used. At last, a simple log book will be provided to help people continue to practice Travel Blending.

8.2.2. Portland, Oregon

In the spring and summer of 2006, the City of Portland launched an IndiMark (Individual Marketing) program in the cities of Salem-Keizer, Eugene, and Bend, Oregon. The goal of the project was to reduce private vehicle use and promote environmentally friendly modes of transportation such as walking, bicycling, ridesharing and public transportation (Socialdata America, Ltd, 2007). The program was contracted out to Social Data America, a part of the company that had initially created the concept of individualized marketing efforts as a way to increase public transit usage.

Throughout the spring and summer, residents in the targeted locations who requested information received promotional pieces regarding transit options in the area. Materials distributed included:

- 821 tote bags containing over 8,000 informational materials
- 200 stop specific bus schedules were distributed in Salem-Keizer and Eugene
- 95 detailed public transportation and bicycle trip plans were created and delivered in all three areas
- 40 home visits were conducted to answer questions about bicycling, walking and public transportation

According to a report from Oregon Department of Transportation, the pilot program did return results. Ultimately, the report noted that trips for environmentally friendly

Modes of transportation increased from 113 to 148 trips per person per year (an increase of 31%) as a result of the campaign.

Additionally, the concept of IndiMark has continued in Portland after the initial program. Rebranded as SmartTrips, the program has continued to market various forms of environmentally friendly modes of transportation in the city. Most recently, the program launched the "green line" in 2010. SmartTrips Green Line targeted 33,000 households and 3,500 businesses in the East side of the city (City of Portland Bureau of Transportation, 2010).

As part of the SmartTrips Green Line IndiMark effort, multiple marketing efforts were launched targeting a variety of alternative transportation options, which included:

SmartTrips Green Line Residential Order Form - Delivered to all targeted areas at campaign outset. Allowed residents to request further information about various transit options.

SmartTrips Green Line Newsletter - Produced 5 newsletters over the course of the year with information about the program and various transportation options.

Southeast Portland Walking/Bicycling Map - Delivered to all residents who requested information. A northeast and a southeast version was produced and delivered to their appropriate audiences.

Ten Toe Express Walking Campaign - Walking promotion including a digital pedometer, a copy of the Southeast or Northeast Portland Walking/Bicycling Map, a guided walk schedule, and a Short Tripper coupon book. The Ten Toe Express collateral was garnered a corporate sponsor to offset its costs.

Senior Strolls - Offered 22 different strolls between May and October, ranging in length from 1 - 2.5 miles. Kits for Senior Strolls were sent based on the SmartTrips order form, articles in senior publications, or schedules left at senior residential facilities and area community and senior centers.

Portland by Cycle - Program included Portland by Cycle kit with accessories and information, Portland by Cycle rides and workshops, Women on Bikes rides and clinics, bicycle helmet distribution, Get Lit bicycling lights distribution and individualized bike route planning.

Women on Bikes - The Women on Bikes program held 11 rides, two bonus rides and six clinics.

SmartTrips Business - Partnered with Portland employers citywide to promote commute options, while supporting area businesses by encouraging neighbors to walk and bike to local shops.

Events/OptionsMobile - A hybrid vehicle modified to act as a mobile display and tabling event car was at six outreach events in the SmartTrips Green Line area. Twenty trained volunteers, known as Options Ambassadors, helped staff these events.

TriMet Transit Information and Services - Personalized transit information including the 2 - 4 closest transit stops to the resident as well as schedules for that specific stop.

SmartTrips Events Calendar - Delivered to every person who ordered information about one of the programs. Included a list of all events that were part of the SmartTrips Green Line program.

SmartTrips Web and Email Communications - Employed social media as well as recurring email communications to maintain contact with residents throughout the program area.

While Portland's SmartTrip program goes well beyond the scope of engaging users about a single mode of transportation, it is important to understand how the individualized, holistic approach to promoting transportation options functioned. The SmartTrip program used multiple marketing efforts to target various subgroups with the opportunity to build the interconnectivity of mass transit with other alternative modes of transportation.

8.3. Travel Blending & Indimark in Pittsburgh

The two cases investigated both increased transportation use through targeted marketing programs. While Pittsburgh might not want to become involved in such an intense effort, there are some lessons and takeaways from these cases that could prove useful in Pittsburgh. One of the most important aspects of the program is their potential to engage "choice riders" in how they can benefit from the public transit options that are a part of the corridor and the East End of Pittsburgh more broadly.

8.3.1. Multi-Modal Multi-Use Transportation

The most important lesson from these efforts is that in both cases, Sydney and Portland targeted multiple modes of transportation. While the efforts were created to raise awareness of their main public transportation options, both took a holistic view of transit options incorporating "green ideas" to broaden their appeal and to show that transportation is about more than moving people to and from their working environment. Including both recreation and personal use in their efforts helped to broaden the appeal to end users.

8.3.2. Partnership

Both programs were able to broaden their reach through partnerships. This approach requires more coordination on the part of PAAC, but additional support can be sought out from groups including community organizations, interest groups (such as those that advocate bicycle transportation in the city), and local businesses. Adding these groups into the mix of traditional marketing communications would allow PAAC to greatly increase its marketing reach and reinforce its message in multiple places and channels.

8.3.3. Repackaging of Existing Content

An additional benefit to PAAC is that, especially with the IndiMark format, there is no need to reinvent the wheel of content. Many of the collateral pieces – local bus schedules, bike tour route plans, walking tour route plans – have already been created either by PAAC or one of the potential partner organizations mentioned above.

The most labor intensive piece of content would likely be an event calendar showing events that promote alternate transportation options. This would require getting some partner groups to organize and promote the events in order to manage the workload of all parties involved.

Additionally, any coupons or business promotions from various geographically based business associations would need to be committed and planned ahead of the launch of the marketing effort. While this is not a small task in and of itself, it is something that PAAC should consider.

8.3.4. Repeated Contact

Along with partnerships and a variety of content pieces, it would be important to sustain the effort if PAAC elects to peruse any type of Travel Blending marketing effort. A single push is simply not enough to sustain this type of marketing. Regular contact and the targeting of a specific geographic region are a major factor in the success of these efforts. Things like creating collateral pieces for hand out at various community events in the region are an important part of reinforcing the effort. In addition, regular contact through a mailing pieces, such as a quarterly newsletter as was used in Portland, play a large role in keeping the messages in the front of the users' minds.

8.3.5. Final Recommendations

While the traditional Travel Blending effort as seen in Sydney was successful, it came at the costs of a large amount of time, effort and commitment from all involved. The later iteration in the IndiMark program of Portland was much less intensive and generally used a broader and less targeted approach to these individual marketing efforts.

A marketing plan for the BRT corridor that includes the above aspects of Travel Blending and IndiMark marketing do have the potential to increase ridership, specifically "choice riders." PAAC would need to be fully committed to the effort and would need full buy-in and support from the many interest groups, community groups and business organizations in the targeted region in order to make an effort such as this a success.

9. Station Signage and Mapping

9.1. Introduction

Station signage and mapping are both highly important in terms of BRT implementation, as well as, for the general success of PAAC. With all the effort that goes into creating a new transportation alternative, it would be easy to take an “if you build it they will come” attitude toward this part of the project. Doing so would come at a great cost to the BRT’s overall prospects for success.

In terms of station signage, it is hard to separate the signage the stations use from the overall station design in terms of promoting service. It is important to identify a number of key pieces of information that should be communicated to riders and potential riders, but these must be incorporated into the overall design of the station as a promotional vehicle for service in general.

Additionally, a number of implementations of BRT have also incorporated design elements from subway mapping into their mapping design for BRT routes. This aids in making the signage not only easier to read, but also reinforces the concept that BRT is a rail-like means of transit.

9.2. Basic Elements

To begin examining the issue of station signage, a number of basic elements were identified. At a bare minimum, the Federal Transit Administration identifies a number of key elements that should be included as part of a BRT implementation, which include FTA (Federal Transit Administration):

- The name of the stop
- Route names and destinations for all routes serving the stop
- Span of service and frequency of service
- Service schedule for low-frequency routes
- A system map

9.3. Case Studies

With these descriptions as a start, other cities incorporation of their brands, as well as, the idea of designing mapping in the subway style into their designs can be examined. Three examples of these concepts are the Cleveland Health Line, the Kansas City MAX, and the Los Angeles Metro Orange Line.

9.3.1. Cleveland, Ohio

Figure 50. One of the Health Line's BRT stations.

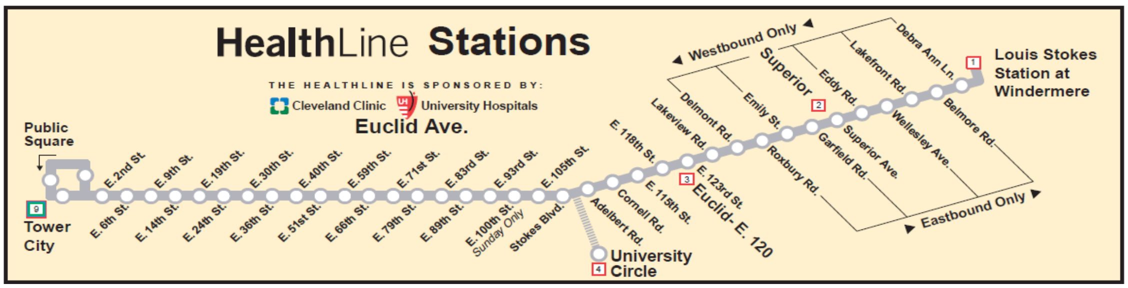

Figure 51. The Health Line's map, which includes stations' names, select locations and the route.

9.3.2. Kansas City, Kansas

Figure 52. One of the MAX's BRT stations.

Figure 53. The MAX's map, which includes stations' names, park-and-ride locations and the route.

9.3.3. Los Angeles, California

Figure 54. One of the Metro Orange Line's BRT stations.

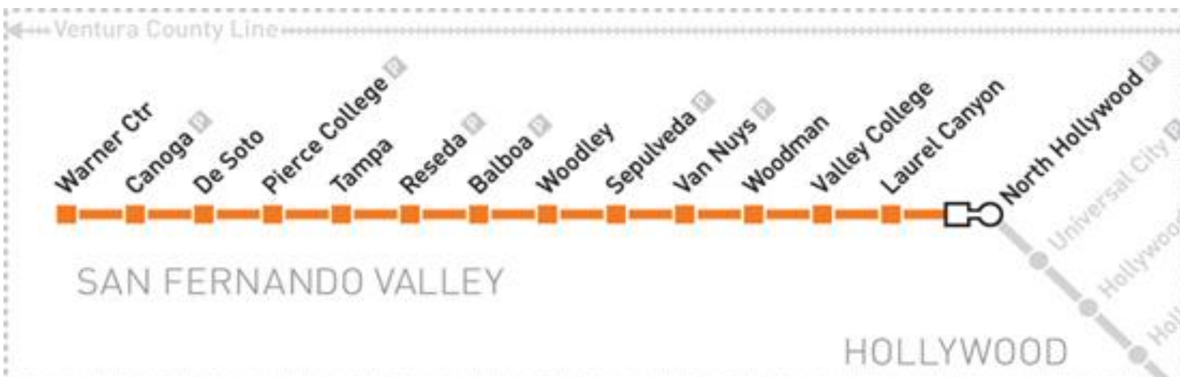

Figure 55. Part of the Orange Line's map, which includes stations' names, neighborhoods and the route.

9.4. Considerations for Pittsburgh

Based on these implementations, we can see that the basic FTA's basic guidelines will be a good starting point for PAAC as it considers its designs for station signage. However, this should only be a starting point for PAAC's signage design. A number of additional informational elements should be considered for display at PAAC stops. Additional information might include a number of other things such as:

- Local area information for the vicinity of the stop as seen in Cleveland
- Real Time Travel information as seen in numerous of BRT implementations
- PAAC Contact information – phone and website address
- Public post for local information

PAAC should also consider some additional information to be included at its BRT stops. Additional information might include a number of other things such as:

- Local area information for the vicinity of the stop as seen in Cleveland
- Real Time Travel information as seen in numerous of BRT implementations
- PAAC Contact information – phone and website address
- Public post for local information

9.4.1. Pittsburgh System Map

In terms of the BRT system map, Pittsburgh should focus on using design elements that convey the idea of BRT as light rail. At the top-most level this means creating a visual representation with design elements similar to those in the samples above. However, PAAC should not stop at BRT implementation. PAAC has an opportunity with this implementation to consider how this line fits into the overall public transportation system in Pittsburgh. It should ensure that the idea that the Oakland-Uptown-Downtown BRT is seen not as a standalone vehicle, but as part of a larger system of public transit throughout the region.

To accomplish this goal, PAAC should consider adding system maps to stops both within the Oakland-Uptown-Downtown BRT corridor, as well as, throughout the system, focusing on similar transit level systems. These would include the East, West, and South Busways and the T-Lines.

The one area where this becomes an issue is in the North. PAAC would need to consider how it would handle station designation if it needs to pick up a local bus to show coverage in the general area. For example, in the central North, the O, O12, and O5 lines could all be possibilities. If these services maintain a larger number of stops compared to the Busways or the T-Lines, then PAAC might consider highlighting only some stops along the routes.

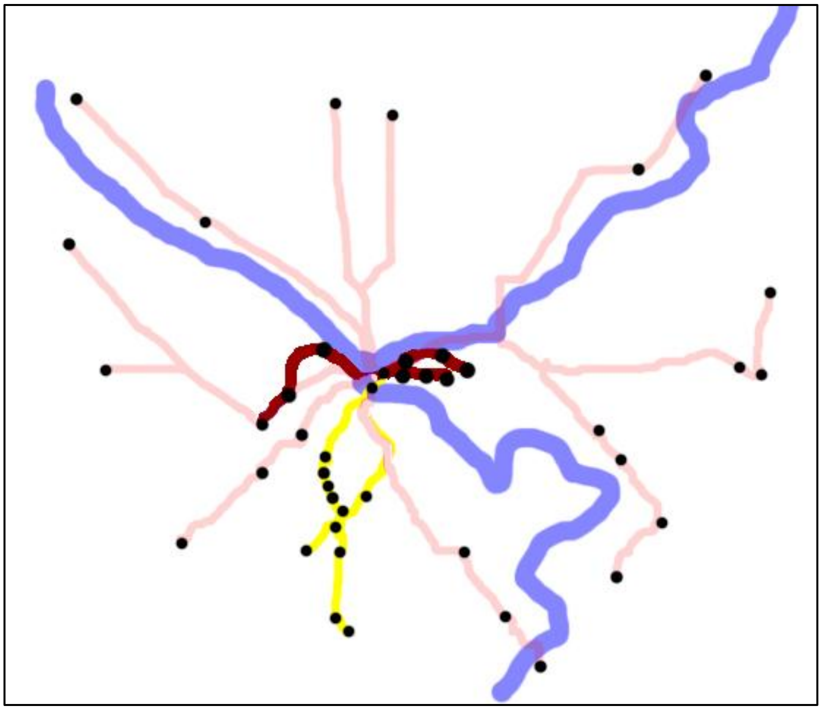

Figure 56. An example of a Pittsburgh System Map.

10. Intelligent Transportation Systems

10.1. Introduction

Intelligent Transportation Systems (ITS) are advanced communications technologies, treatments and strategies used to enhance transportation system performance. ITS is considered one of the major elements of BRT because it can improve the flow of a transit system with relatively small capital investment, by adding refinements to the system rather than major changes (Roberts, et al., 2008). ITS enhance system performance (Kittelson& Associates, Inc., 2003) by increasing safety, operational efficiency and quality of service. ITS also provides riders reliable and timely information, improving their convenience and overall riding experience (Diaz, et al., 2004).

Although many ITS technologies can be utilized for BRT systems, three specific ITS technologies were focused on because of their relevance, potential benefits and feasibility in the Oakland-Uptown-Downtown BRT corridor.

10.2. Real-time Information

10.2.1. Introduction

Real-time information technology, translated to real-life application and benefits to passengers, is a technology that communicates real-time information about next-bus arrival through various channels and forms, such as real-time signs at bus stops, online trip designers and cell phone applications.

Essentially, real-time information involves accurate automatic location of vehicles and communication to passengers of their waiting time. Combined with a computer-aided dispatch (CAD), the system will be able to better optimize trip numbers, thus lowering operational costs.

Typical real-time information equipment includes an on-vehicle computer, displays on street and off-route monitors, a communication system, console and data services, web, WAP Wireless Application Protocol and SMS customer information.

As implied by queuing psychology, if a person is aware of their waiting time when in a queue, their patience level increases. Real-time information systems are important in the sense that it not only serves as a psychological pacifier for passengers, but also serves as an effective tool to monitor bus services (High School Operations Research).

In addition to improved customer service, there are several other benefits associated with the application of a real-time information system on BRT vehicles, such as:

Better system control - With real time information, the system can distribute service times much easier.

Improved bus safety - In an emergency, the control center will be able to locate a vehicle with the help of Automatic Vehicle Location (AVL). However, this brings about a concern that some drivers may not want to be tracked.

Efficient system integration - Transferring from one transit mode to another is made easier by integrated real time scheduling system.

Easier follow-up analysis - Data collected in through AVL will provide valuable basis for performance evaluation study in the future (APTA Standards Development Program, 2010).

10.2.2. Technologies Involved in Real-Time Information

10.2.2.1. Automatic Vehicle Location (AVL)

Vehicles are located by receiving traffic data from the GPS system that is installed in the vehicle. AVL can: (1) enhance communication between vehicles and the control center, (2) optimize demand-response scheduling and (3) provide real-time traveler information.

The cost of installing onboard GPS equipment ranges from $500 to $2,000 per vehicle and complete implementation costs range from $4,000 to $10,000 per vehicle. The cost saving side of the technology stems from system planning improvements that reduces bus service cost (FTA, 2007).

10.2.2.2. Display System

Display systems are devices that deliver accurate information about pre-trip, en-route, station/ terminal, or in-vehicle information. Delivery and communication options include: street signs, vehicles, public places, stations, web and SMS (ACIS).

10.2.2.3. Computer-Aided Dispatch and Scheduling (CADS)

Combined with AVL, the system can better accommodate schedules and optimize the number of trips provided.

10.2.3. Case Studies

Table 21 shows selected case studies and a summary of real-time information technologies that they implemented. The Boston Silver Line and Orlando LYMMO are examined more closely because they adopted different ITS strategies. The Boston Silver Line incorporated the three major real-time information technologies simultaneously due to virtually little constraints on their budget, and Orlando LYMMO adopted a phased strategy to implement real-time information technologies.

	Real-time information technology
Boston Silver Line	CAD/AVL (Cost: CAD-AVL system $750,000)
Orlando LYMMO	PAS (Passenger Advisory System)/AVL
Honolulu	CAD/AVL
Oakland San Pablo	AVL
Eugene EmX	Automated Passenger Counter (APC) sensors/AVL
Las Vegas Max	APC/CAD/AVL

Table 21. Summary of real-time information components used by various BRT systems.

10.2.3.1. Boston, Massachusetts

The Silver Line incorporates several ITS components, including "Automatic Vehicle Location (AVL) and Computer-Assisted Dispatching (CAD); Public Address and Variable Messaging Signs (PA/VMS); Traffic Signal Priority (TSP); and real-time passenger information." The vendor for all of the equipments is Siemens. The Silver Line also adopted Automatic Vehicle Monitoring, which uses Maximus software.

The Silver Line, as its branding promise indicates, provides high-tech experience to passengers that is conveyed through its smart kiosks "with schedule information, variable message boards, police call boxes, area maps, and bikeracks" (Marin & Terrell, 2005).

MBTA's Silver Line - Taxpayers Get Less for More

The kiosk is installed with an LED variable message sign (VMS) that is connected to MBTA's central computer. The display system can have "service updates, emergency messages, or notices of a service disruption in real time." The system also has a bus countdown that informs passengers of next bus arrival time.

10.2.3.1.1. Automatic Vehicle Location (AVL) and Computer-Aided Dispatching (CAD)

All Silver Line vehicles are equipped with a GPS system and on-board computer which periodically sends the bus location information to the central console. The central console receives the information and sends it back to a route map. The CAD system contains Hastus scheduling software that provides updates about the route information.

10.2.3.1.2. Public Address (PA) and Variable Messaging Signs (VMS)

The PA system broadcasts stop announcements in the bus and at the station. The information is displayed on an LED VMS inside the vehicle.

10.2.3.1.3. Considerations for Pittsburgh

Throughout the design and development of ITS information for the Silver Line, MBTA reported unanticipated complexities regarding the systems application. "Signal priority has not been implemented more than three years after project opening; it was delayed due to both construction and software issues" (Boston Silver Line Washington Street BRT Demonstration Project Evaluation, 2005).

10.2.3.2. Orlando, Florida

LYMMO buses are installed with a tracking system to provide real-time information. This system determines the exact location, destination and arrival time. Computerized kiosks are installed with audio/visual tracking to provide real-time information. LYMMO plans to incorporate a multi-modal control center in its future development plans. The multi-modal control center will "interphase with light-rail system and inter-city transit."

LYMMO's buses are operated upon demand-based scheduling and can better avoid bunching because of its AVL system.

10.2.4. Lessons Learned & Recommendations

The BRT Guide summarized a list of decision factors to decide what specific ITS technologies to use for a specific system (Arias, et al., 2007). Even though cost is the top most concern for PAAC, looking at the future trend of public transit, PAAC's BRT should have ITS, the differentiating feature from traditional bus systems.

PAAC should adopt ITS in a phased manner and create a priority list of the right mix of technologies that may improve customer service given their tight budget.

Currently no PAAC buses have AVL devices, and AVL is the core technology to real-time information. People who are in need of transit information have to call PAAC helpline or text the control system to retrieve schedule data (Port Authority of Alleghany County, 2010).

During the initial stage of BRT implementation, PAAC should actively seek for options and substitutes that can provide passengers real-time information with a limited budget. One of the substitutes raised by Traffic 21, a CMU led initiative, is to come up with a mobile phone application to track real-time information. Using crowd sourcing, the system would costs very little compared to other options because the display system would be users' smart phones that are connected to the AVL system composed of other application users (Traffic21 Funded Projects).

Another option to real-time information is the MyNextBus model. MyNextBus is a partnership between educational institutions and transit service providers to provide low-cost real-time information to passengers. Chicago was the original model, and then Seattle did it for less by making data from the AVL system open to the public. MyNextBus does not have to go through a bidding process and whoever feels that they have the capacity to deal with the AVL data can launch their real-time information service (NextBus Inc., 2008).

10.3. Transit Signal Priority

10.3.1. Introduction

Transit vehicle prioritization technologies are methods that alter signal timing at intersections to give priority to BRT buses. Active signal priority is a real time priority technique that adjusts traffic signals according to the presence of buses at the intersection, rather to using only historic information, as passive signal priority does. The most common implementation of active signal priority gives BRT buses a little extra green time or a little less red time at traffic signals. The intent is to reduce the overall delay of vehicles at traffic signals, as traffic signal delay is often the most significant cause of travel time delays on urban streets. This technology can be implemented for buses using their own right-of-way or sharing the road with mixed traffic.

Fundamental parts of the system include the strategies used to grant priority to BRT buses, and the specific parameters used. The main strategies are:

Green extension - This extends a green light for a BRT bus approaching an intersection that has green light, but is soon to turn yellow. It is one of the most effective strategies, because it does not require additional clearance intervals (Smith, Hemily, & Ivanovic, 2005).

Early Green - This shortens the red light for a BRT bus approaching an intersection that has a red light.

Actuated Transit Phases - This uses special phases that are only displayed when a BRT bus is approaching an intersection, such as an exclusive left turn phase for BRT buses.

There are some guidelines to consider when defining the parameters for the green extension and early green strategies (Arias, et al., 2007):

- The extension of a green light for a side street has to consider the amount of pedestrians wanting to cross the street, so the extension of the red light at the BRT corridor is limited.
- There should be a maximum amount limiting how long a green light can be extended and how long a red light can be truncated in the BRT corridor.
- Generally, the early green strategy is not applied in the same cycle the green extension strategy is applied.

The following diagram illustrates the main components of the system and their interaction: Detection System, Priority Request Generator, Priority Control Strategies and System Management (Smith, Hemily, & Ivanovic, 2005).

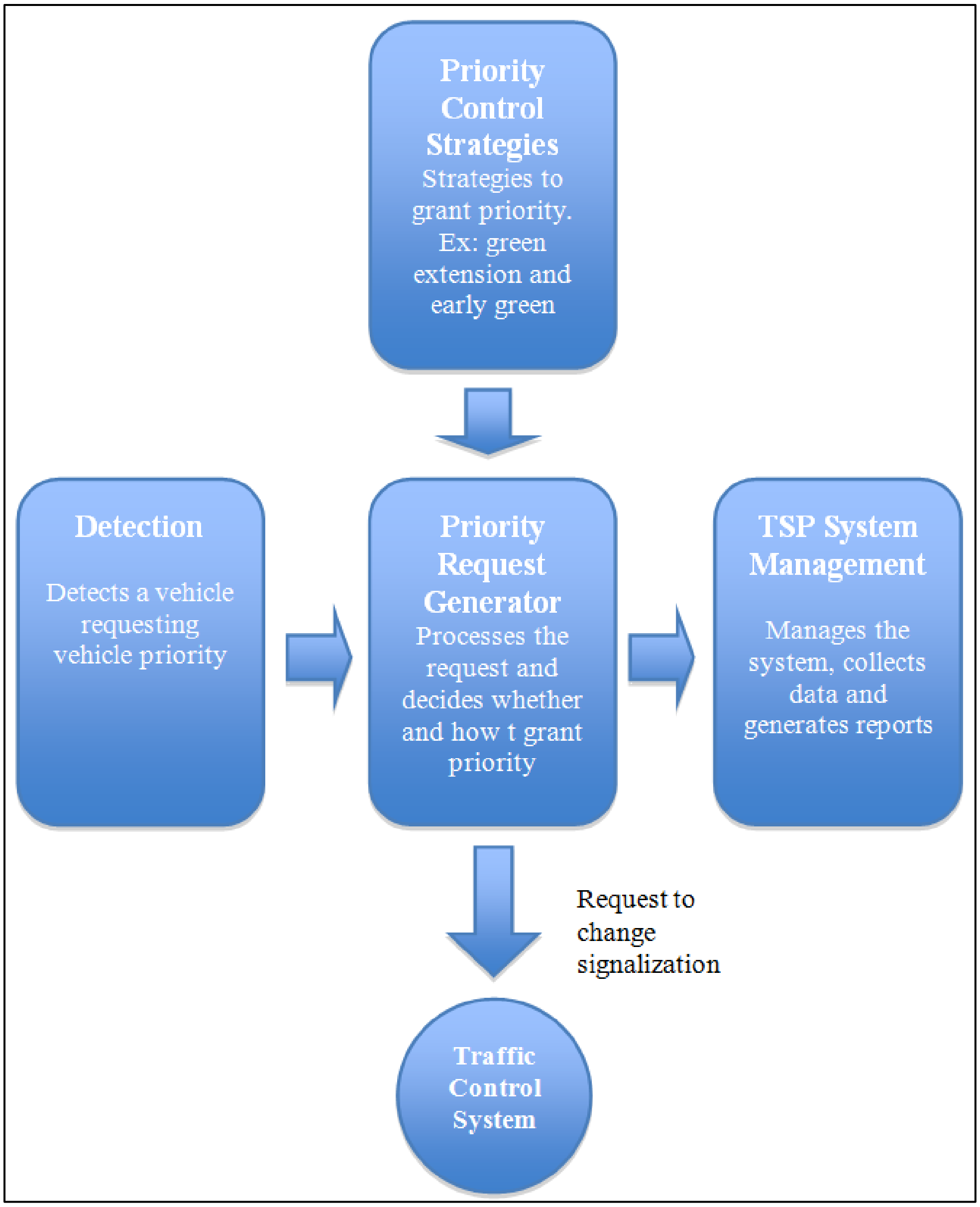

Figure 57. The main components of a Transit Signal Priority system and their interactions.

These parts of the system are translated into the following hardware and software components:

Emitters - Located in the buses, they send signals to request priority.

Receivers - Located at the intersections, they receive requests from the approaching buses.

Phase selector - Interface with the traffic signal controller, it validates the request and forwards the request to the traffic signal controller if the priority is granted.

Software - The software necessary for system operations.

Control box and controller - The hardware and software connected to the traffic signal, providing operational control of a signalized intersection.

Interface to AVL - An optional component for integrating TSP and AVL systems. It allows having “smart” buses, that know their location in time and space, and therefore it is possible to know if the bus is behind schedule and incorporate this information into the strategies to grant priority.

A Federal Transit Administration study (Hinebaugh & Díaz, 2009) determined the estimated costs for these components, including investment, operational and maintenance costs. However, the costs in the following table should be used only as a reference because costs are dependent on the configuration of the system and there can be substantial differences when considering TSP systems with different capabilities.

System/Subsystem	Unit	Capital Cost Range		Annual Operational & Maintenance Costs	
		Low	High	Low	High
Emitters	Vehicle	$900	$1,100	$40	$50
Receivers	Intersection	$1,000	$2,000	$40	$80
Phase Selector	Intersection	$1,800	$2,000	$75	$80
Software	System	$50,000	$100,000	$5,000	$10,000
Control box and controller	Intersection	$8,000	$10,000	$320	$400
Interface to AVL	System	$25,000	$25,000	$2,500	$2,500

Table 22. Estimated cost of Transit Signal Priority components (Hinebaugh & Díaz, 2009).

10.3.2. Benefits and Detriments

The benefits of a TSP system depend on the specific implementation chosen. However, in general TSP systems decrease congestion and signal delays, improving travel times (in general, time travel savings are about 15% (Smith, Hemily, & Ivanovic, 2005) and reducing wait times and travel time variability. This facilitates schedule adherence and decreases recovery time[9]. The indirect benefits include enhanced system image and public perception, because a faster system is more attractive for riders (Niles & Jerram, 2010) and this also can lead to an increase in ridership. Also, faster speeds result in more efficient operating costs. Finally, TSP systems have an additional “green” component because less idling of buses generates fewer pollutants.

The main potential negative impact of TSP systems is delays to non-priority traffic. The

[9] According to Smith, H., Hemily, B. & Ivanovic, M. (2005), recovery time is “time built into a schedule between arrivals and departures, used for the recovery of delays caused by traffic conditions and service incidents."

TSP Handbook reported the results of surveying 24 transit agencies in 2005 that had implemented TSP systems in the country, stating the agencies reported minimal disruption to traffic flow. Helping to achieve these good results is the fact that many cities re-timed their traffic signals outside the BRT corridor, to be better integrated with the TSP system.

10.3.3. Case Studies

10.3.3.1. Los Angeles, California

Interest in improving traffic signalization was triggered by the results of a survey showing that the main complaint of bus riders in the L.A. area was that the service was too slow and unreliable. Then a study detected that 24% of experienced delay was caused by red lights.

Los Angeles first implemented TSP in 1990, but this case study focuses on the TSP implementation for the Metro Rapid Bus BRT system, which was started in 2000. Metro Rapid Bus included TSP as one of the 8 key BRT attributes to be implemented in the first phase of the project (Niles & Jerram, 2010).

As of 2005, the first phase was completed, 9 corridors had been incorporated in the TSP system, with 654 intersections and 283 buses equipped for TSP use on BRT corridors.

The system uses early green, green extension and phase holds to give preference to all buses that are not early. The agency reports that green extension has been the most successful strategy because "[it] saves entire red time. Turning buses are detected from the previous intersection so they have time to check in for the left turn pocket" (Smith, Hemily, & Ivanovic, 2005).

Los Angeles County Metropolitan Transportation Authority (MTA) reported the cost of the TSP system in the first phase was "probably over $10 M for design and signal work –software controllers, transponders, design and construction" (Smith, Hemily, & Ivanovic, 2005). The budget for the second phase, consisting of 17 lines, was $23.5 million.

A large initial investment in software was required, which was the largest expense in the project, followed by transponders and cabinets. Controllers were $3,000 each. MTA reported an average cost on the order of $30,000 per intersection, not including transponders, which cost was about $100 per bus (Smith, Hemily, & Ivanovic, 2005).

In terms of benefits and detriments, the typical impact on side street traffic is a one-second delay per vehicle per cycle, so motorists have not noticed the difference. On the other hand, LADOT and Metro estimated up to 25% reduction in bus travel times (Smith, Hemily, & Ivanovic, 2005) (Hinebaugh & Díaz, 2009).

10.3.3.2. Portland, Oregon

TriMet implemented some pilot projects to incorporate TSP to its service in the early 1990's. These unsuccessful pilot projects led to inconclusive results and were abandoned, mainly because the hardware and software were not mature enough at that time.

TriMet implemented the “Streamlining Project” in a joint effort with the City of Portland between 2000 and 2005. Its goal was to improve service to all passengers and provide operating efficiencies to TriMet (Koonce, Ryus, Zagel, Park, & Parks, 2006). A key part of the program was the implementation of TSP at 250 intersections, equipping 650 buses in the 8 corridors in the first phase of the project. As of 2005, the second phase was expected to include 370 additional intersections.

TriMet uses green extension and red truncation as priority control strategies. Priority is granted only to buses 30 seconds or more late, and the system is integrated with an AVL system to obtain this information.

At intersections with pedestrian recalls (pedestrian push button), the maximum amount the walk time can be shortened is limited to follow the 4-second minimum walking time recommended by the Manual on Uniform Traffic Control Devices (MUTCD).[10]

The initial budget was $5 million, but the revised budget was $5.8 million. TriMet reported about $5 million spent to cover city expenses related to the project, consultancy and upgrade the central system, while about $5 million was spent in receivers, labor, etc. A more detailed breakdown of costs is shown in Figure 58 (Smith, Hemily, & Ivanovic, 2005).

[10] The MUTCD, administrated by the Federal Highway Administration, recommends a minimum walk time of 7 seconds, but a 4-second walk time is allowed for intersections with specific characteristics, such as low pedestrian volumes (FHWA, 2004).

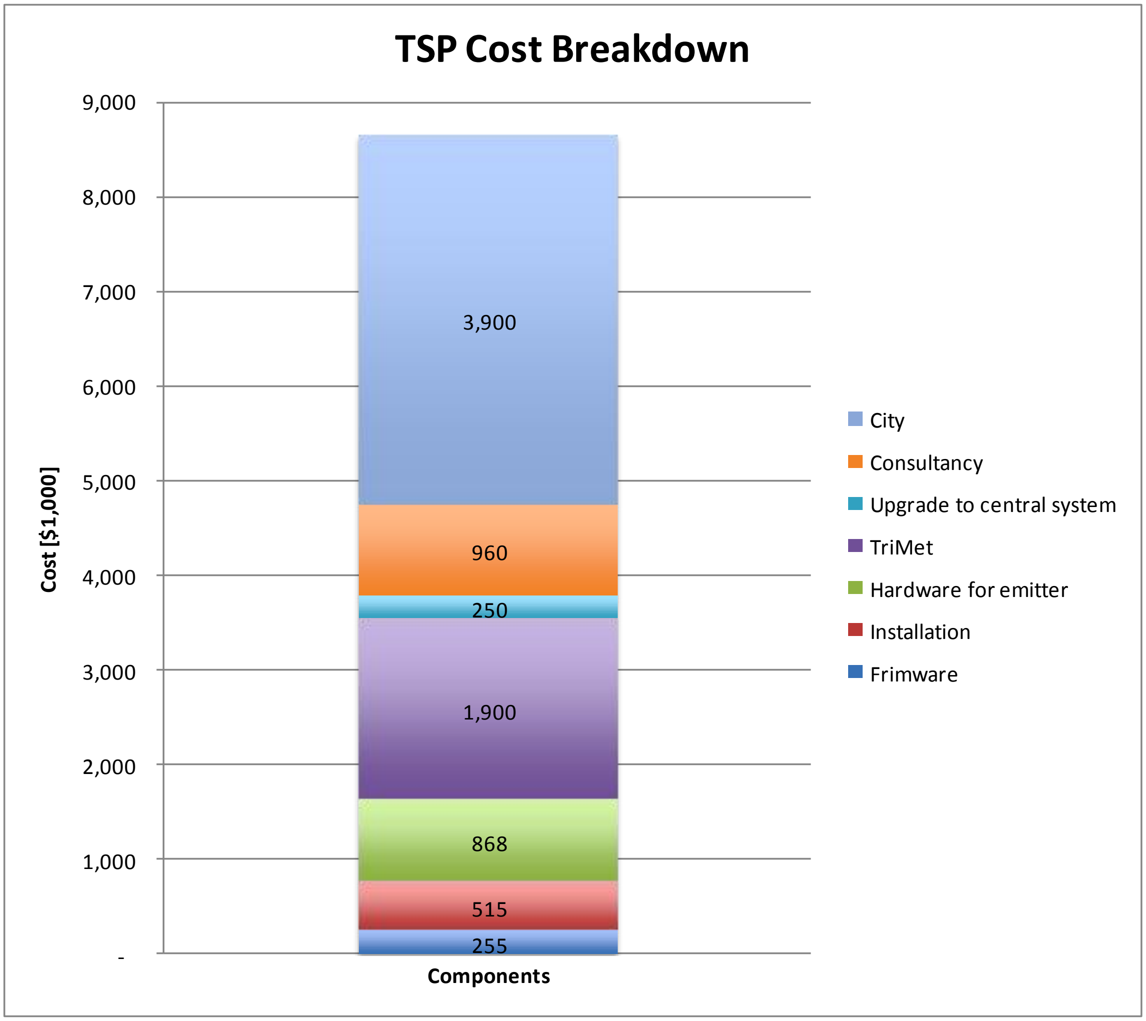

Figure 58. Transit Signal Priority Cost Breakdown for Portland.

The average cost per intersection was about $10,000 for intersections where no vehicle detection equipment was installed before. This was not always the case, because some intersections were already equipped with this technology, which was already in place and being used to grant priority to fire trucks.

Portland has positively evaluated their TSP program. It reduced recovery time and increased reliability. As a consequence, in 2000 TriMet was able to avoid adding one additional bus to their Line 4 (Smith, Hemily, & Ivanovic, 2005). It has also been reported that TriMet experienced 10% improvement in travel time and 19% reduction in travel time variability (Hinebaugh & Díaz, Characteristics of Bus Rapid Transit for Decision-Making, 2009).

10.3.4. Considerations for Pittsburgh

Despite the success in these two cities, PAAC needs to consider some local constraints before committing to TSP, including:

TSP requires equipment at intersections that control traffic signals to be to be upgraded or replaced all together.

TSP requires approval by and coordinating with third parties. It requires approval by the City of Pittsburgh, which owns the traffic lights. Also, since the city maintains the signals, coordination is required to maintain the equipment at intersections, or when upgrades are needed.

There are important crossing streets in Downtown, where little time can be granted to avoid a significant traffic impact on those streets.

10.4. Fare Collection Alternatives

10.4.1. Introduction

Fare Collection is an important aspect of the BRT design. Decisions made in this field will directly affect revenue and boarding time, and will have several repercussions in other important aspects, such as ridership.

Regarding fare collection, there are three components that must be decided:

Fare collection process - Whether the fare is collected on-board or off-board the bus.

Payment options - How the fair is actually paid, such as cash, tokens, smart cards, etc.

Fare structure - This includes price strategy (flat fare vs. fare differentiation by distance, time or zones), transfer policy, and other decisions related to pricing levels.

These three aspects are interrelated and include technological and policy decisions. Since PAAC already decided to incorporate the use of smart cards on their local buses, the fare collection process will be focused on because it is the most important decision at this time for PAAC.

10.4.2. Fare Collection Process

The main impact of the fare collection process is on boarding times. Congestion at stations is usually the bottleneck point for most BRT systems (Arias, et al., 2007). Therefore, deciding the best fare collection process for the Oakland-Uptown-Downtown corridor is essential.

Fare collection methods can be classified as the following:

On-board payment - The fare is paid or validated after boarding the bus.

- On-board cash: The driver collects the fare in cash.
- On-board validation: This uses cards, tickets or tokens.

Off-board payment - The fare is paid before boarding.

- Proof-of-Payment (POP): Requires fare enforcement officials to check riders' receipts.
- Barrier-enforced payment: Uses turnstiles to control access; riders are not allowed to enter the station without first paying.

The Transit Capacity and Quality of Service Manual (Kittelson& Associates, Inc., 2003) reports observed boarding times for different payment methods, when all passengers board through a single door, and the door is being only used for boarding at that time.

	Boarding Time [seconds/passenger]
Off-board payment	2.25 to 2.75
Single Ticket or Token	3.4 to 3.6
Exact Change	3.6 to 4.3
Swipe or Dip Card	4.2
Smart Card	3.0 to 3.7

Table 23. Boarding times for various fare collection methods when using a single door-channel.

It is clear that the slowest payment method is cash, even if exact change is required. We can also see that off-board payment is the fastest option, but the gains are not very significant. This category also includes passengers using bus passes, free transfer fees and buses using pay-on-exit. However, the main advantage of off-board payment is that it allows multiple-door boarding.

For multiple-door boarding, the concept of door-channel is introduced. A two-channel door is a door wide enough to allow two passengers to use it at the same time. Therefore, two door channels can be the result of two single-channel doors or one double-channel door.

The same manual reports boarding times for multiple door-channels. In this case, the reported figures are estimated boarding times and not observed ones, as in Table 23.

Available Door Channels	Boarding Time [seconds/passenger]
1	2.5
2	1.5
3	1.1
4	0.9
6	0.6

Table 24. Boarding times when using multiple door-channels based on the number of available door channels.

The use of low-floor buses reduces the boarding times by 0.5 seconds in the case of single door-channel (Table 23) and by 20% in the case of multiple door-channels (Table 24). Therefore, a low-floor bus with three double-channel doors has an estimated boarding time of 0.48 seconds per passenger. Other publications maintain that boarding times as low as 0.3 seconds can be achieved using off-board payment (Arias, et al., 2007).

The cost of the different payment options depend on the specific configuration adopted. Estimated costs of different components are included in Appendix D. Generally, payment using cash on-board is the most inexpensive methods, and the slowest, as well. On-board validation using smart cards is the second cheapest option but it depends on how the smart card is charged with money. If vending machines are used, then the cost will be similar to proof-of-payment (POP) methods. However, POP requires enforcement, which will increase the operating cost because enforcement officers' salaries have to be covered. Finally, the most expensive option is barrier-enforcement methods because special infrastructure has to be built, and security staff is needed at the stations.

As a general rule, systems having shorter boarding times are more expensive. What alternative is the most cost-effective depends on the levels of ridership. The advantage of off-board payment increases when ridership increases, because boarding times become more critical and average costs decrease. For example, the transport agency in Goiânia (Brazil) estimates that off-board payment is cost justified only if there is more than 2,500 riders per hour per direction (Arias, et al., 2007).

The fare collection decisions have very technical aspects, requiring the evaluation of boarding times and cost of different alternatives, and the use of ridership levels to find the best cost-effective alternative. Nevertheless, the following discussion about each alternative can serve as a starting point:

On-board payment - Whether using cash or smart cards, the driver is responsible for verifying fares, which slows the boarding and only allows front door boarding. The boarding process is also delayed anytime a passenger is not ready to pay, and has to search for their money or smart card. Typically there is little evasion when the driver is overseeing the payment process.

Proof-of-Payment (POP) - Requires fare enforcement officials to control evasion, which brings an additional cost to the system and evasion can never be completely controlled. On the other hand, officials' presence on the buses increases safety.

Barrier-enforced - Needs more infrastructure and space, but conveys an image of higher quality. Security staff is also required at stations.

10.4.3. Case Studies

10.4.3.1. Cleveland, Ohio

The Cleveland Health Line features multiple BRT elements designed to improve travel time, such as off-board payment. Cleveland implemented a POP system, providing ticket vending machines at stations and other vendor locations across the city. Roaming fare enforcement officials randomly select buses for inspection. Cleveland has reported a level of 4% evasion.

The system has flat fare and trip cards, which are more expensive but allow transfer. The system also offers daily, weekly and monthly passes.

There have been accusations of racial profiling in the fare enforcement process. However, the transit agency has denied these accusations, indicating that officers inspect all passengers on the bus.

Cleveland had to implement a special program to decrease juvenile fare evasion. Although 7% of their riders were juvenile, 36% of fare evaders were juvenile. The law did not allow Cleveland fine juvenile in the same manner adults were fined. On February 1st, 2011 Cleveland started the "Juvenile Violation Fare Program" that allows them to fine juvenile fare evaders. The program has several steps, ranging from a warning to being sent to the Juvenile Court for prosecution (RTA, 2010).

10.4.3.2. Los Angeles, California

The Los Angeles Metro Rapid is an incremental system built over an existing route. Metro Rapid has a pay-on-board system, that accepts cash and paper passes. There are electronic fare boxes for on-board validation and flat fare is used.

A survey collected after the system was implemented showed that off-board payment was the top priority for operators, out of five potential enhancements. Off board-collection was rated with 9.0 based on a 0 - 10 scale where 10 meant "extremely important". Customers ranked off-board payment as their third top priority (8.3 out of 10), but multiple-door entry and exit was ranked second (Kittelson& Associates, Inc., 2007), illustrating that improving boarding time through multiple-door boarding enabled by off-board payment was a desirable characteristic for both operators and customers.

Initially off-board payment would be implemented in the second phase. However, stations are located on sidewalks in urbanized corridors and are designed to use little space; therefore, there was no room for vending machines (Niles & Jerram, 2010).

10.4.4. Considerations for Pittsburgh

For Pittsburgh, an off-board POP system would offer the best solution, given that it would allow for boarding of buses through all bus doors. This payment system, combined with three wide doors in low-floor buses would allow boarding times around half a second per passenger.

However, this system would require enforcement officers to check payment on buses, but this would also be an opportunity to improve bus safety. Additionally, PAAC would need to allow space at its stops for vending machines. Finally, and most importantly, this payment method requires legislation designed to support POP.

If any of the previous restrictions cannot be overcome, PAAC could use smart cards for its BRT, which would be aligned with its decision to use smart cards on local buses. However, even with low-flow buses, the boarding time would range between 2.5 and 3.2 seconds per passenger.

Finally, the Oakland-Uptown-Downtown corridor could have barrier-enforced payment in the most congested stations, possibly only during rush hour, and use on-board smart cards at any other station or time.

11. Public Perception

11.1. Introduction

Public perception plays a key role in the success of the BRT effort in the region. How riders view the existing service can help Port Authority prioritize both the issues raised in this report as well as the myriad other issues that will be raised as part of its implementation. An important first step in this process is to determine some baseline of attitudes about existing service in the Oakland-Uptown- Downtown corridor.

As an effort to better understand rider attitudes towards and perceptions of the existing service in the corridor, a ridership survey was conducted through in-person interviews of bus riders in the corridor. This survey was conducted to help pave the way for further community engagement in the BRT project, as well as, to highlight areas that the BRT should potentially address based on community attitudes toward existing services.

Interviews were conducted in-person through an interview format at stops throughout the corridor. Each interview lasted between five and ten minutes and at any given stop, all riders waiting for a bus were asked to participate, but participation was voluntary. Stops and interviewees were selected in a random manner to guarantee trustworthy results. The questionnaire and interview guide are shown in Appendices E and F respectively.

11.2. Riders Profile

The ridership survey was conducted between March 17th and March 25th of 2011. 267 surveys were collected among riders located along the corridor. Among the surveyed population, 55% of the interviewees were interviewed at a stop in Oakland, 12% were interviewed at a stop in Uptown and 32% were interviewed while waiting at a stop in Downtown. Among the participants, 59% of them were female while 41% were male. 55% of the interviews were conducted during peak hours –between the hours of 7am - 10 am and 3pm - 7 pm.

11.2.1. Frequency of Use

Among the riders interviewed, 52.81% were defined as frequent users – those who estimated that they rode a bus ten or more times per week on average. Additionally, 24.34% of those interviewed estimated their ridership as occasional – riding between 4 to 10 times a week, while 22.85% of riders were low-frequency riders, estimating their weekly ridership to be less than 4 times.

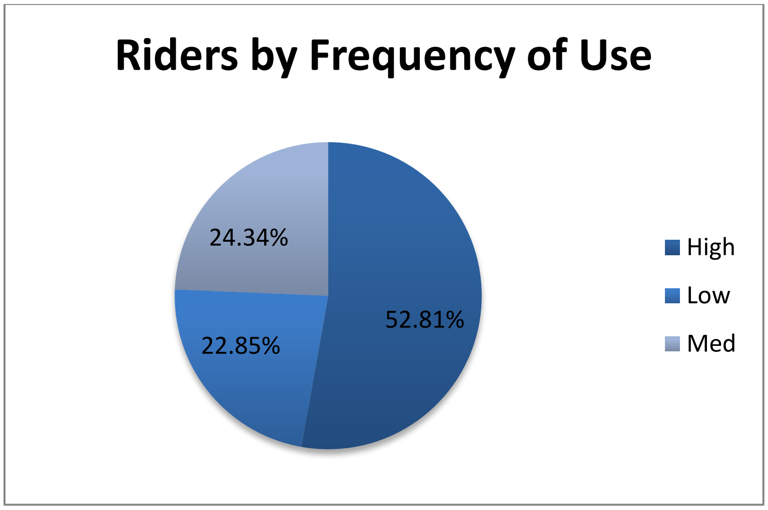

Figure 59. Ridership Survey: Percentage of riders by frequency of use.

11.2.2. Age Distribution

Of the 267 interviews conducted, 8% of respondents identified themselves as being over the age of 65. Additionally, 20% self-identified as being between the ages of 45 and 65, and an additional 42% were between the ages of 25 and 45. Finally, 31% identified their age as being are less than 25 years old.

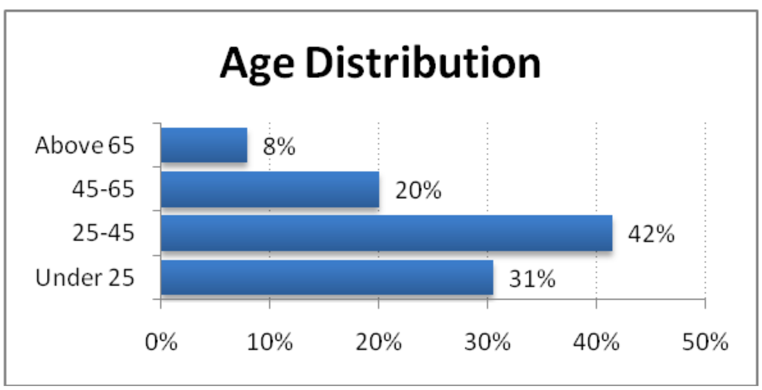

Figure 60. Ridership Survey: Riders' age distribution.

11.2.3. Occupational Profile

Regarding the riders' occupations, 34.46% of those interviewed identified themselves as being students.

The largest group consisted of the "other" category which included both those who identified themselves as working or unemployed. The smallest identified group consisted of retirees, which accounted for 5.62% of those surveyed. Additionally, 19.85% of riders fell into the "not reported" category, which consisted of those riders that did not disclose an occupation.

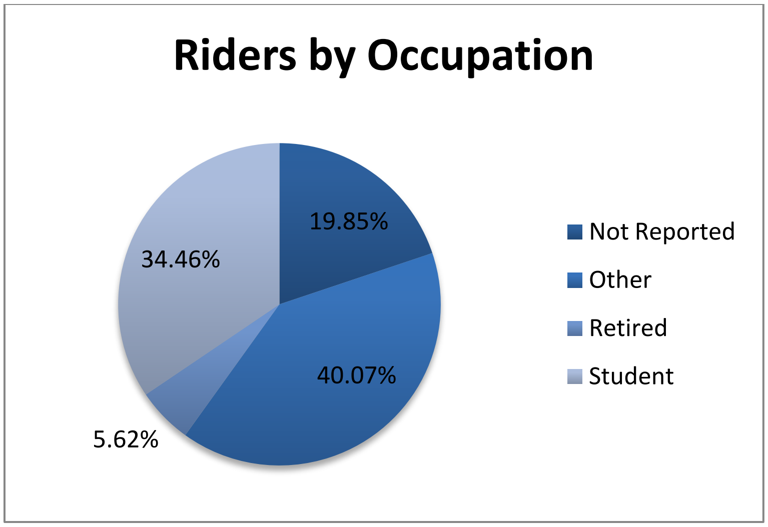

Figure 61. Ridership Survey: Percentage of riders by occupation.

11.3. Findings

11.3.1. Car Ownership Stands as the Main Reason for Using the PAAC's Service

In terms of what attracts users most to use public transit, 56% responded that they did not have a car, therefore buses are their only means of transport while other accountable reasons include convenience (29%), no need to park (22%), high gas prices (12%), eco-awareness (9%) and reliability (3%).

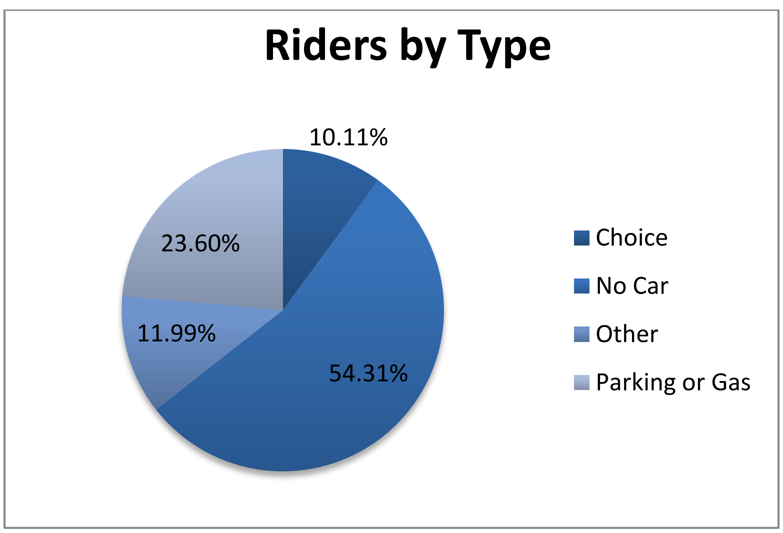

Figure 62. Ridership Survey: Percentage of riders by type.

11.3.2. Potential "Choice Riders"

10.11% of the respondents shared some of the characteristics of so called "choice riders." That is their reasons for using the bus as a mode of transit included convenience, reliability and eco-awareness. "Choice riders" are those riders that do not have to ride public transit because they have other means by which to travel but choose to ride public transit nonetheless.

When those that identified the costs of parking or gas – implying that these riders also have alternate means of personal transit, but choose not to use that mode – are added in, then 33.71% of the riders interviewed are "choice riders."

The above reasons for riding public transit coupled with the fact that these same riders identified themselves as owning a vehicle indicate that they ride the bus because of a personal decision, not because the bus is their only means of transportation.

11.3.3. Frequency and Reliability are Key Features to Retain Current Customers

One of the survey's questions asked riders to identify features of bus services that were important to retain them as customers. The two features that are most important to customers are frequency and reliability.

Speed, one of the hallmarks of most BRT systems, placed fourth among the factors identified. However, this could be in part due to the relative shortness of the overall corridor.

Still, the BRT implementation has the potential to address all the major factors identified by users with one notable exception. 9% of riders surveyed indicated that the distance they needed to travel to reach a stop was a factor in retaining them as a customer. One of the easiest ways to improve travel speed in this corridor is to reduce the number of stops within the corridor, but will increase the distance of the nearest stop for some customers. PAAC will need to do further research to better understand which factor is more important in its overall efforts to improve service.

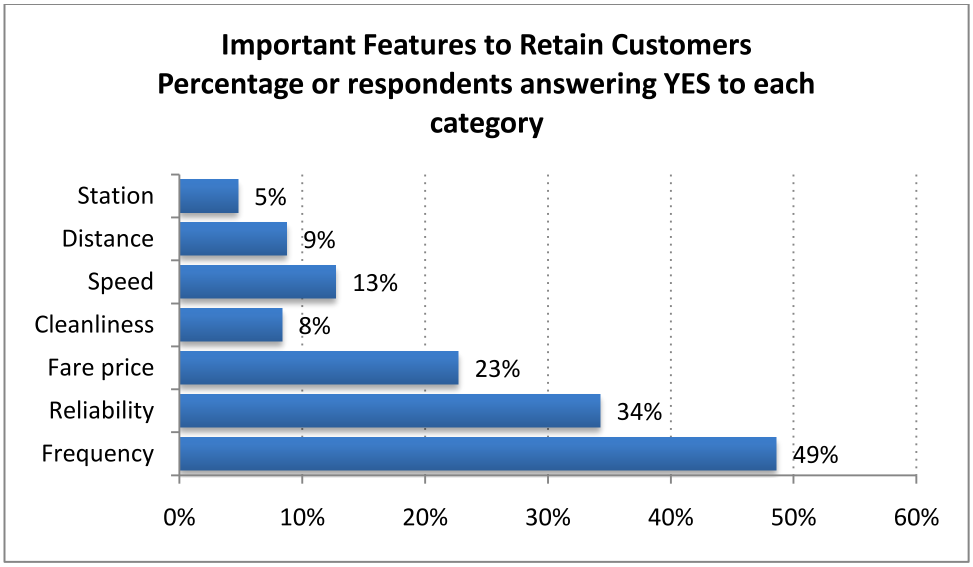

Figure 63. Ridership Survey: Features to retain customers.

11.3.4. Customers are Willing to Double Their Walking Times to Bus Stops

Of the 267 riders interviewed, walk times to reach a bus station varied widely. The shortest walk time was 30 seconds while the longest walk was 35 minutes. The bulk of the riders interviewed walked between 3 and 5 minutes to reach their desired stops. The median walk time was 5 minutes.

Riders were also asked what their acceptable walking time to reach a bus stop was. Riders were generally willing to double their walk time to access a bus stop with the median acceptable walk time being 10 minutes. The largest portion of respondents identified a walk time of between 5 and 10 minutes as being acceptable. Additionally, on average men were willing to increase their walking time more than women. Men indicated that a walk time of 11.6 minutes was acceptable, while women only indicated an acceptable walk time of 9.5 minutes.

To analyze the data another way, the individual current walk times were subtracted from the same individual's acceptable walk time. The graph below shows each individual's willingness to walk. A small portion, 5% of those interviewed, are already walking further than they are willing to and an additional 19% indicated that they were at the limit of their willingness to walk to reach a bus stop.

On the other hand, 76% of respondents indicated that they would be willing to increase their time spent walking to their bus stop. In fact, 43% of interviewees were willing to increase their walk time by up to 5 minutes and an additional 34% were willing to increase their walk time by 5 minutes or more. The median additional walking time for all riders interviewed was 4.5 minutes.

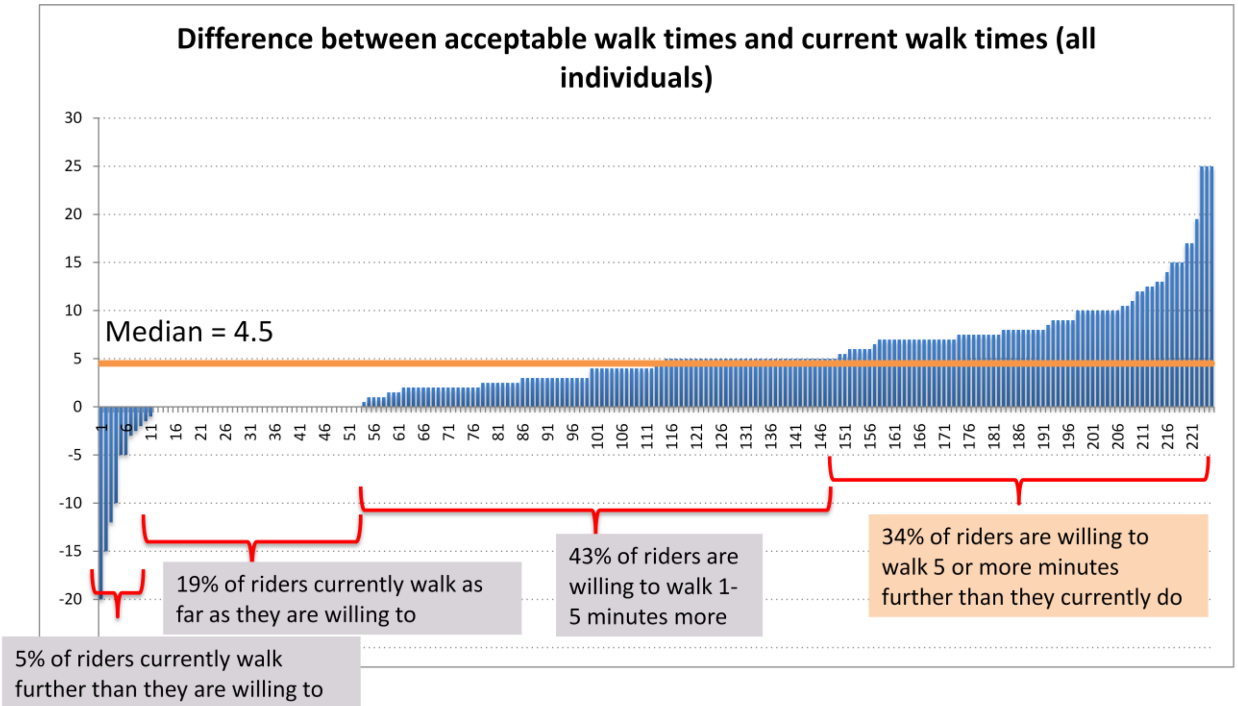

Figure 64. Ridership Survey: Difference between acceptable and current walk times.

11.3.5. Every Group is Willing to Double Their Walking Time to Bus Stops

Each group's current and acceptable walking times were analyzed and it was found that each group is willing to double their current walking time. The retired population currently walks about 7 minutes on average to a bus stop, but is willing to walk up to 13 minutes.

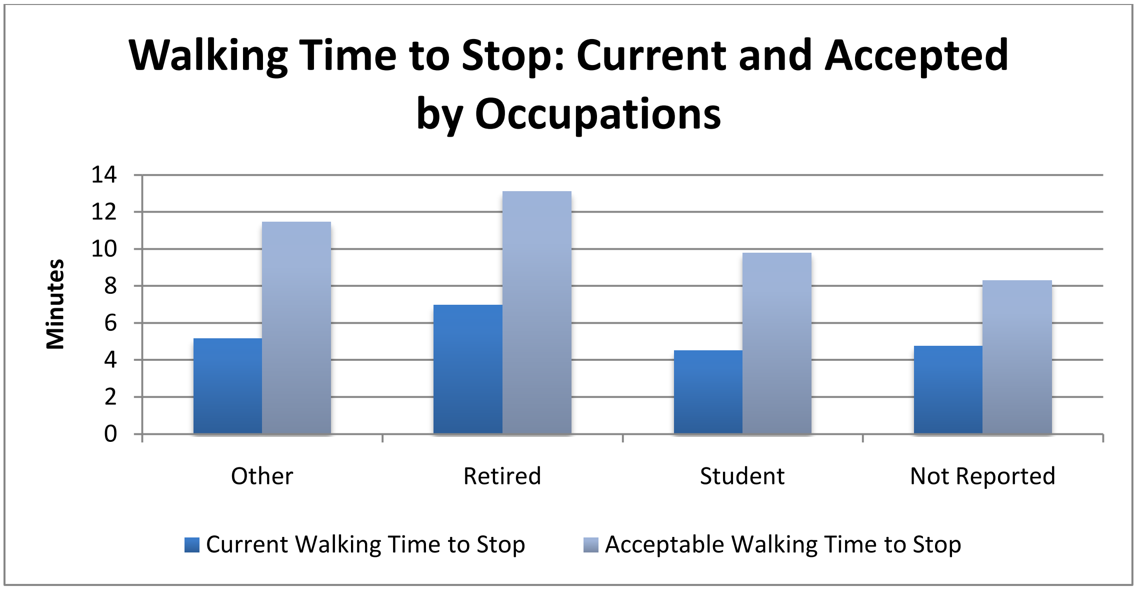

Figure 65. Ridership Survey: Current and acceptable walking time by occupation.

	Average of Weekly Frequency	Average of Current Walking Time [Minutes]	Average of Acceptable Walking Time [Minutes]
Other	8.12	5.15	11.46
Retired	6.05	6.96	13.12
Student	7.20	4.51	9.79
Not Reported	6.96	4.76	8.29
Grand Total	7.46	4.96	10.40

Table 25. Ridership Survey: Travel frequency, average walking times and average acceptable walking times by occupation.

11.3.6. All Groups Satisfied with the Frequency of Buses

While 49% of the riders interviewed indicated that frequency was a major factor in retaining them as customers, these same interviewees indicated that they were generally satisfied with the existing frequency of busses in the corridor. In fact, 81% of student riders, 87% of retired riders and 79% of other riders indicated that they were either neutral or satisfied with the existing frequency of buses in the corridor.

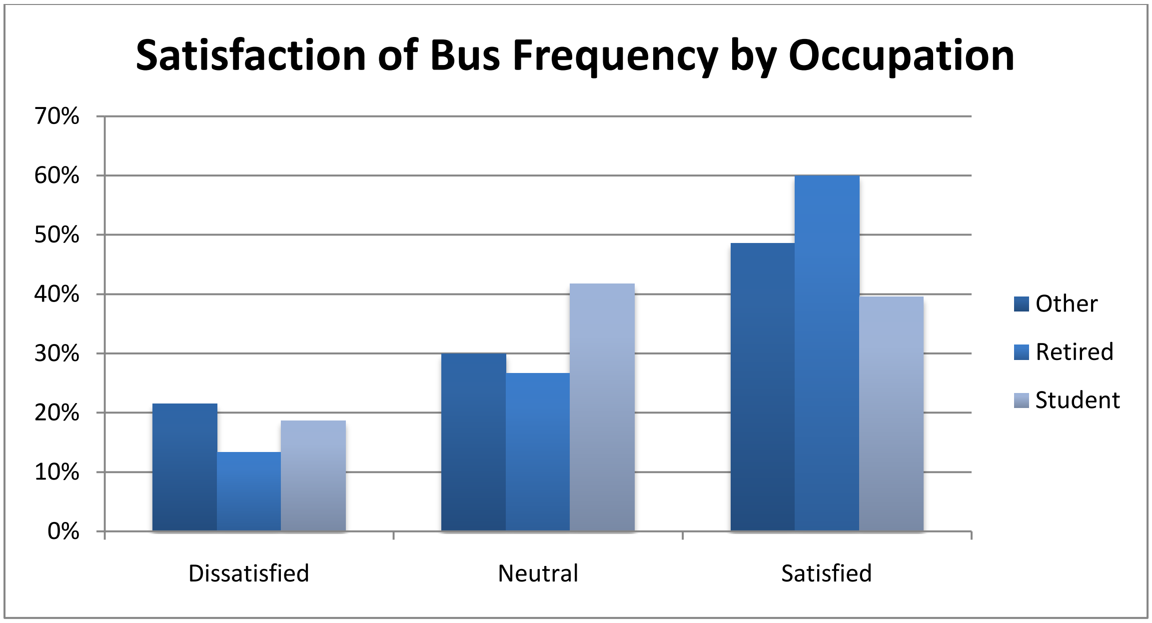

Figure 66. Ridership Survey: Satisfaction of bus frequency by occupation.

11.3.7. Non-Choice Riders Show Discontent with Current Frequency

While riders in general were satisfied with the frequency of busses in the corridor, non-choice riders – those who use public transit because they do not own a car – were least likely to rate frequency as satisfactory. More than half the riders interviewed who were identified as "choice riders" or those who cited the cost of gas or parking as reasons to take the bus were satisfied with frequency. However, only 36% of the non-choice riders interviewed rated bus frequency as satisfactory.

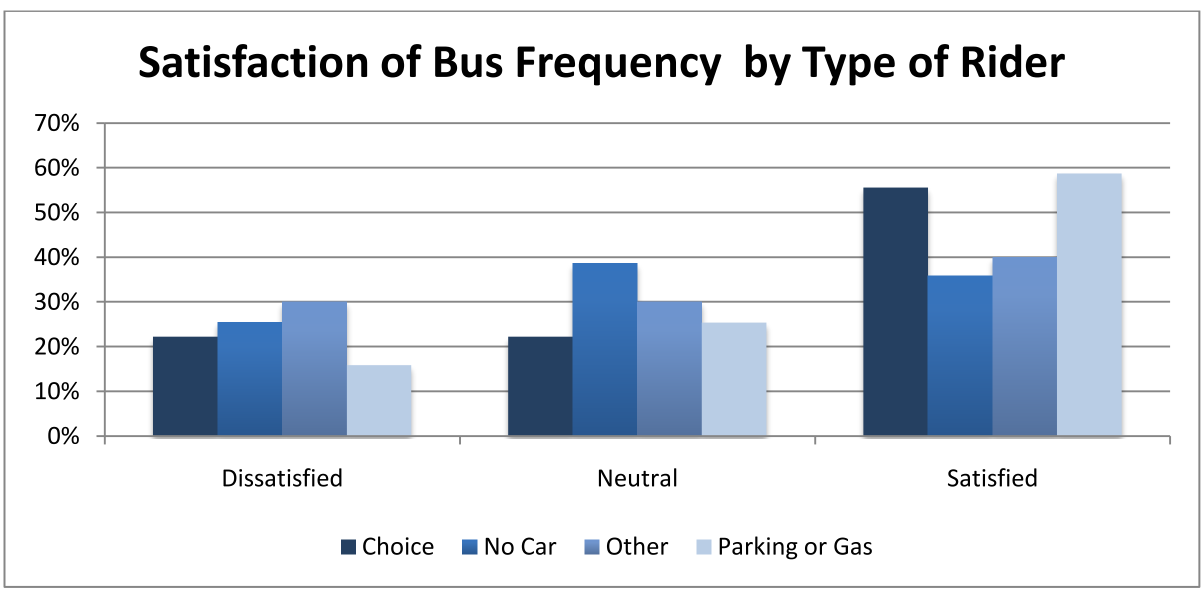

Figure 67. Ridership Survey: Satisfaction of bus frequency by type of rider.

11.3.8. Capacity is an Issue for the Riders That are Not Students or Retired

While frequency of buses was generally considered satisfactory, the capacity of the busses, or how crowded the buses are, seemed to be much more of an issue. This was especially true for the other category, which included people who ride the bus to work. The largest portion of these riders interviewed indicated that buses along the corridor were over crowded. For other rider groups, this was less of an issue, but there was still general dissatisfaction with the overcrowding of buses along the corridor.

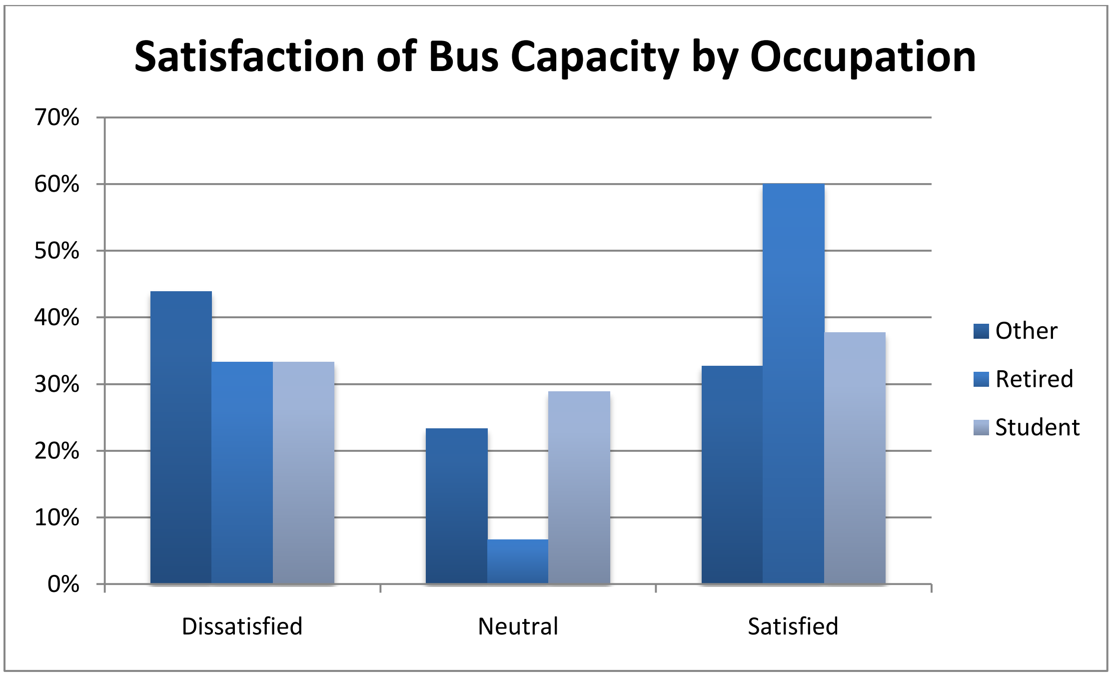

Figure 68. Ridership Survey: Satisfaction of bus capacity by occupation

However, time of day also played a role in satisfaction with the capacity of buses operating in the corridor. When comparing rush hour riders to non-rush hour riders surveyed, half of the rush hour riders were dissatisfied with the capacity of buses and only 34% of non-rush hour riders were dissatisfied with the capacity of buses. Only 27% of rush hour riders said that they were satisfied with capacity of buses in the corridor, but 42% of non-rush hour riders were satisfied with capacity of buses in the corridor.

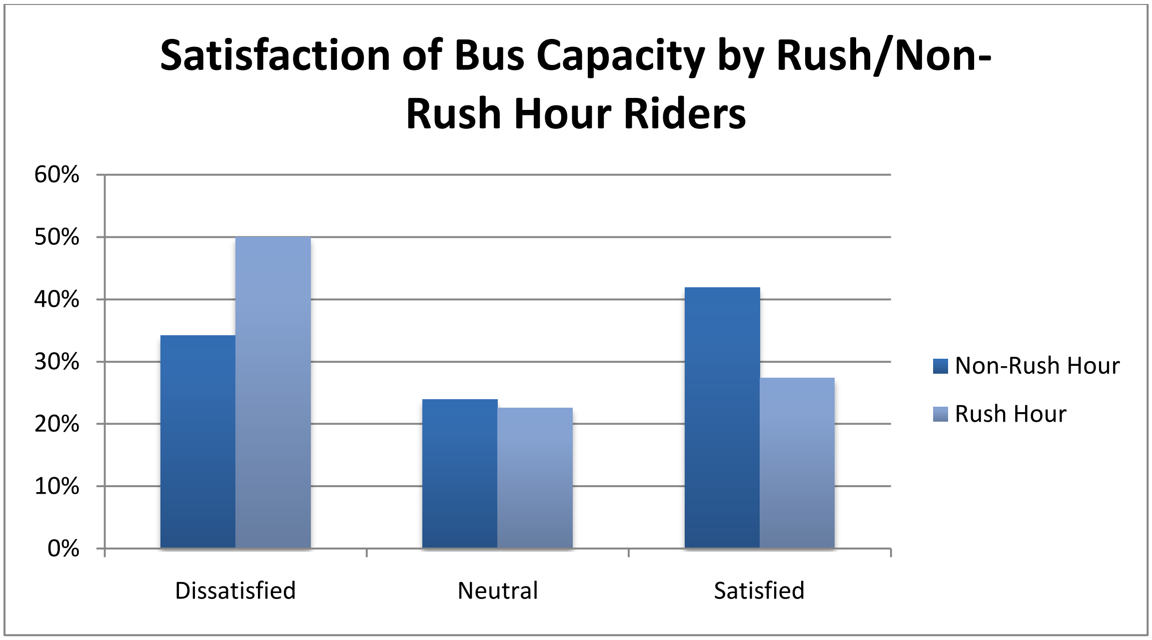

Figure 69. Ridership Survey: Satisfaction of bus capacity by rush/non-rush hour riders

While it is not ideal to generalize outside of the interview population for the ridership survey, the result does indicate that for those interviewed, PAAC should consider looking into the possibility of increasing service or capacity during rush hour. Non-rush hour service, while generally rated better than rush hour service, only fared slightly better overall. Therefore, PAAC should further research ridership in the corridor to ensure that adequate service is maintained as part of the BRT implementation.

Discussions with PAAC have indicated another factor that is potentially leading to the overall dissatisfaction with capacity in the corridor. PAAC indicated that heavy traffic in the corridor often leads to delays in busses, especially during rush hour. This creates backups in the system and leads to scenarios where two and sometimes three busses of the same line can arrive at a stop consecutively, with the first two being overcrowded and the last one being empty.

PAAC needs to seriously consider adding a real time travel information system to alleviate overcrowding. Allowing users to know what busses are coming next and their estimated arrival times at various stops along the corridor could help to allow passengers to make decisions about boarding an overcrowded bus or waiting for a few minutes to catch the next bus, which may be less crowded. Additionally, an information system able to indicate not only the arrival time, but also the capacity of the next bus arriving would even better inform riders in making this decision.

11.3.9. Riders are Satisfied with the Speed of the Service

While the frequency of bus service and crowding were both found to be issues among riders interviewed, speed of service from boarding to destination is not an issue in the corridor. In fact, at least half of interviewees indicated that they were satisfied with travel times within the corridor. Students were the least likely to be satisfied with the speed of service, but even among students, only 17% were dissatisfied with service speed.

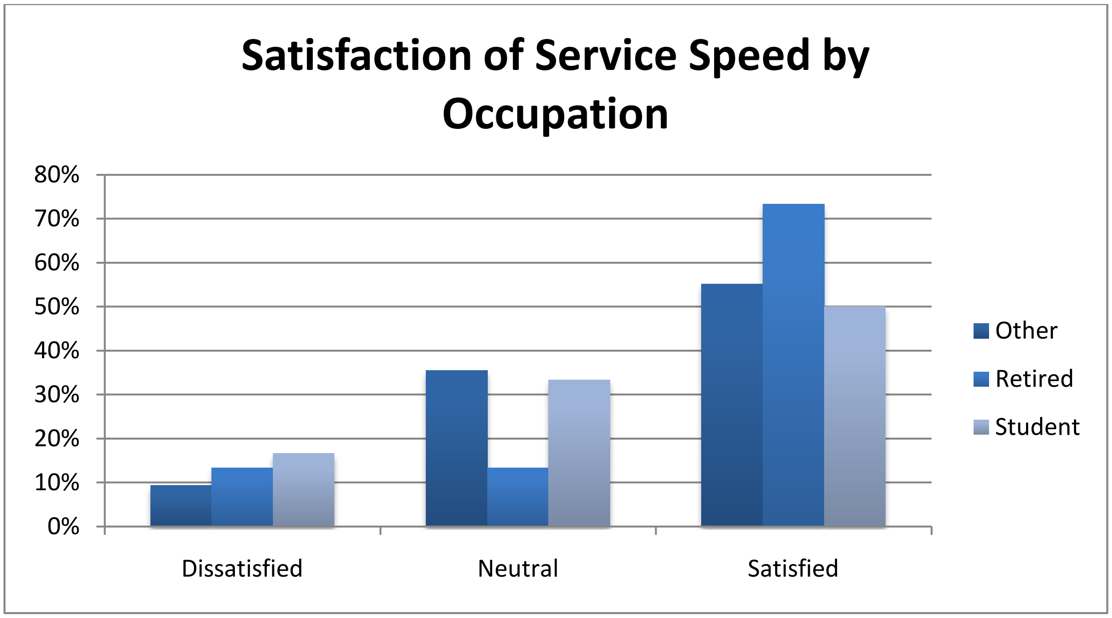

Figure 70. Ridership Survey: Satisfaction of service speed by occupation

11.3.10. Riders Believe Cleanliness Could Improve

Nearly 60% of those riders interviewed who identified themselves as retired indicated that they were satisfied with the cleanliness of the buses. However, the largest portion of both students and others were dissatisfied with existing cleanliness on buses in the corridor.

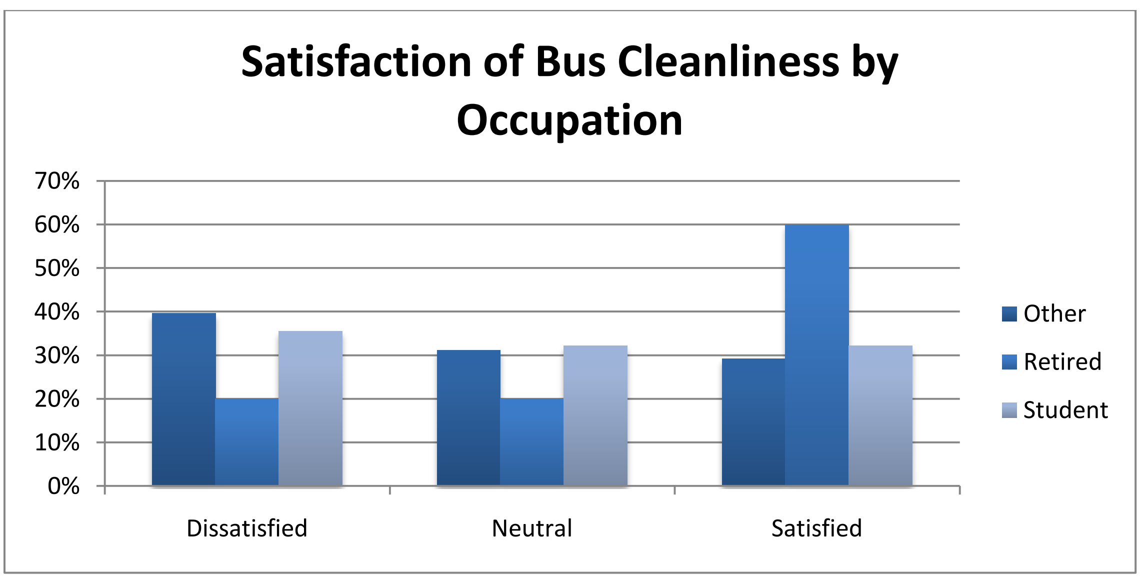

Figure 71. Ridership Survey: Satisfaction of bus cleanliness by occupation

Adding new buses specifically designed for the BRT would help address the concerns of these riders in the short term, but maintaining cleanliness on the new service would still be an issue. PAAC will need to consider how things like regular cleaning of BRT buses can affect ridership. Additionally, polices on eating and drinking, as well as, enforcement of these policies could help maintain the appearance and cleanliness of the BRT buses. The design of advertising space on the insides of the busses should also be examined as part of the BRT bus designs, because smaller and fewer advertisements can reduce visual clutter and increase the perception of cleanliness.

11.3.11. All Groups are Satisfied with the Current Fare Collection Process

Among the issues examined in the survey, fare collection showed high satisfaction among all riders interviewed. More than half of the students, retired and other riders were satisfied with the current fare collection process.

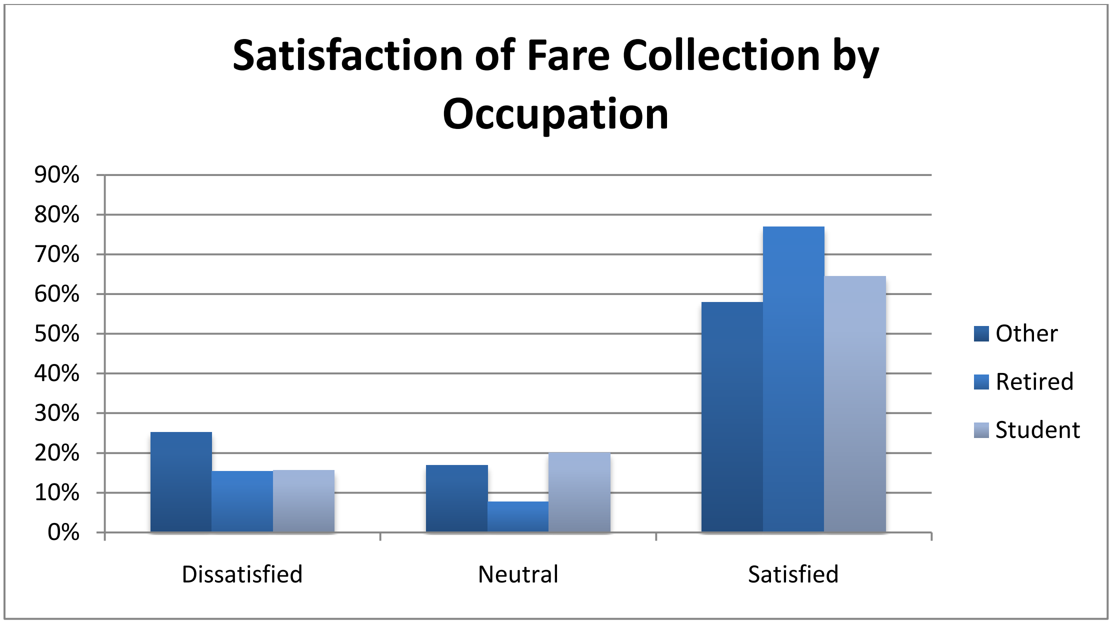

Figure 72. Ridership Survey: Satisfaction of fare collection by occupation

While rider satisfaction in this area is high, PAAC should still address some questions associated with fare collection methods as part of the BRT implementation.

11.3.12. Shelter Design Satisfaction Differs by Occupation

Shelter design was also examined in the survey. Retirees were the most satisfied with the existing system, with more than 60% of this group rating the current shelter designs satisfactory. However, 44% of students and 45% of others interviewed were dissatisfied with the existing shelter designs.

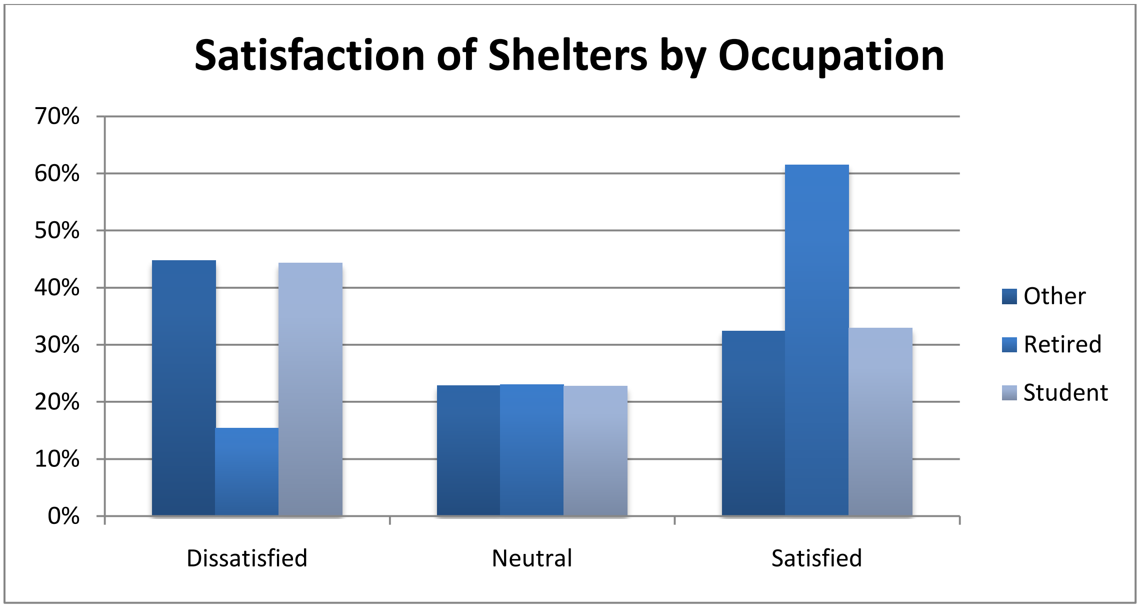

Figure 73. Ridership Survey: Satisfaction of shelters by occupation.

Given that many of the existing stops lack any type of shelter, it is not surprising that many riders are not satisfied with the current shelters in the corridor. This is partly due to the lack of space along the corridor to incorporate anything more than a sign post indicating the existence of a stop, and will need to be addressed when designing the BRT system. Part of conveying the idea that the BRT is more akin to a light rail system is designing a distinct and dedicated stop shelter. Many of the stops in the existing system will not reinforce this message and must be addressed.

11.4. Recommendations Based on the Ridership Survey

This snapshot of riders in the Oakland-Uptown-Downtown corridor has established a baseline of public perceptions regarding service in the corridor. The corridor services a variety of rider types including students, retirees, working riders and other groups, all of whom use the bus system for a variety of reasons. The largest portion of riders rely on public transit as their sole means of transportation, although some riders also cited cost of parking and gas, as well as, eco-friendliness as reasons for uses public transit. The potential BRT system in the corridor will need to cater to a wide variety of users with varied reasons for using the system.

As part of the survey, a number of factors were identified to retain riders in the corridor. These factors include frequency and reliability of service, fare prices, cleanliness and speed of service. The BRT implementation will need to address these issues in its planning and design stages.

One issue cited by riders as important was distance traveled to access the system. Most riders indicated that they would be willing to increase the time they walk to reach a station to access the system. This supports the idea that PAAC should reduce the number of stops in the BRT corridor to increase speed along the route. Reducing the number of stops would also allow PAAC to identify locations throughout the corridor that could support larger, more developed stations that can support additional amenities for riders. This will also allow for better promotion of the service and associate it with light rail style travel, which may increase ridership and attract more “choice riders.”

12. Branding

12.1. Introduction

Branding BRT systems is important because BRT is a relatively new idea faced with challenges to change people's perceptions about rubber-tired transportation systems. "The negative stigma of existing bus systems may be a formidable barrier to overcome in selling any bus-based concept." To establish a unique branding strategy in hopes of changing people's perception regarding bus-based transportation will help "create an identifiable, marketable and common theme that extends across the product and all related touch points, such as opportunities the customer has to interact with the brand" (Association, Bus Rapid Transit Practitioner's Guide, 2007).

The difficulty of this issue is that changing people's perception is hard to quantify or get data on. Disregarding the difficulty, a unique branding strategy may "clearly differentiate transit service," "enhance outreach efforts," "increase customer loyalty," "improve employee satisfaction and retention," "increase brand value" and "attract other development activities" (Association, BRT Branding, Imaging and Marketing, 2010).

In order to brand BRT service, three components need to be identified: who, what and how. The "who" component involves "identifying and characterizing the target audience," "what" is about "determining the 'brand promise' to be made to the audience" and the "how" part involves "determining how all the audience 'touch points' will communicate the brand." After identifying the above three components of BRT's branding strategy, a more specific marketing plan will be needed which "includes the system's name and logo, a media strategy and a public education plan" (Association, BRT Branding, Imaging and Marketing, 2010).

To address issues related to the branding of the new BRT, other implementations from across the country have been examined. Each region has put their own twist on creating a unique identity for their BRT systems. From across these implementations a series of best practices have been identified to aid PAAC in its own branding and promotional efforts for the Oakland-Uptown-Downtown corridor BRT.

12.2. Best Practices Summary

The table below summarizes six BRT services across the nation including their branding keywords and brand uniqueness:

	Service	Keywords	Brand Uniqueness
Eugene Oregon	EmX	Green, Dedicated Website, Public engagement, How-to Guide, Stakeholder Public Perception Workshop	Environmentally friendly
Orlando	Lymmo	Moveum, Daily Deal Discounts, Dedicated Website	Artistic
Cleveland	Health Line	Public meetings; Political champions	Naming rights bid off
Boston	Silver Line	Silver, Marketing Campaign	Metro quality service
Honolulu	CityExpress!	Ask Me Program; Advertisement with Local Businesses; Fare Waive	Employment opportunities for the disabled
San Pablo, Oakland	Rapid	Promotion Logo Gears; Whistle Stop; Innovative Media Involvement-"Live your life in the fast lane"	Media outlet

Table 26. Branding best practices based on various BRT systems.

12.2.1. Eugene, Oregon

Equivalent organization to PAAC - Lane Transit District (LTD)

Keywords - Green, Dedicated Website, Public engagement, How-to Guide, Stakeholder Public Perception Workshop

12.2.1.1. Green

The Eugene EmX stands for Emerald Express. While Eugene Oregon is known as the emerald city, LTD decided to adopt green as its BRT line's theme color. The green color also projects one of its service promises, which is to be environmentally friendly. Before the implementation of EmX, LTD conducted an environmental review specifically addressing the potential influence EmX will bring to the region's environment (EmX Franklin Corridor BRT Project Evaluation Final Report, 2009).

12.2.1.2. Dedicated website

The EmX BRT line has a dedicated website navigated away from the LTD website. The website is consistent to the main website regarding its design, structure and navigation functions. The navigation bar on top of the website remains the same as the main website as illustrating general information about riding LTD buses, fares and organization introduction. The major components of the website include how-to videos, including how to use an EmX ticket machine and how to bring your bike on EmX. Other information includes EmX's extension notice, history of EmX and FAQ. The route information is available both online and can be downloaded in a PDF including a route map and schedule table for work-day and weekend services (EmX Website).

12.2.1.3. Public Engagement

Community outreach was one of EmX's major focuses designing its corridor. Throughout the corridor study, LTD held public workshops, open houses and public hearings for various stakeholders and absorbed the stakeholders' interest into the development of the project. Stakeholders are classified into five groups: (1) city planning staff, (2) community groups, (3) local businesses, (4) LTD staff and (5) policy makers. Interviews were conducted around the interviews' role in the BRT development, their potential contributions and goals, cost and benefit of BRT.

In cooperation with Community Planning Workshop (CPW), an affiliated organization within Department of Public Policy and Management, University of Oregon, LTD held a series of focus group meetings to share information, identify strengths, weaknesses and opportunities that BRT could bring to the region among planning staff and community groups.

Besides focus groups, CPW, together with LTD, distributed surveys among local businesses to gain perception of EmX, EmX development and its effects on local businesses. The community also took part in the perception survey (EmX Franklin Corridor BRT Project Evaluation Final Report, 2009) (Oregon, 2009).

12.2.1.4. Marketing and Community Outreach

LTD made regular efforts to communicate with local property owners through "one-on-one visits, email updates, press release, media interviews and coffee and chat sessions." A free how-to guide is available to the public at each BRT stop (EmX Franklin Corridor BRT Project Evaluation Final Report, 2009).

12.2.2. Orlando, Florida

Equivalent organization to PAAC - The Central Florida Regional Transportation Authority (LYNX)

Keywords - Moveum, Daily Deal Discounts, Dedicated Website

12.2.2.1. Moveum

The LYMMO system was marketed towards residents and merchants since its initial development and the project was continuously covered by a local monthly publication. Bus stations have artistically themed LYMMO logos on them and the buses are decorated in different artistic themes which they call "a moving museum or Moveum." Every once in a while, the buses are repainted and changed to another artistic theme (Lymmo BRT Project Evaluation Final Report, 2003).

12.2.2.2. Daily Deal Discounts

In addition to the creative "Moveum" idea, LYMMO has daily discount deals open to its riders from merchants along the corridor. Every rider, with a valid rider pass, would be able to enjoy the everyday deal when they have a coupon stamped on their pass. LYMMO also has riders enter raffles on an ongoing basis to retain "choice riders" (Lymmo BRT Project Evaluation Final Report, 2003).

12.2.2.3. Dedicated Website

LYMMO has a dedicated website where people can use various functions. The basic functions through the website include schedule look-up, trip planner, bus ticket purchase and interestingly enough, van pool. Lynx provides "vanpools and bus pass programs where LYNX provides the van, the maintenance and the insurance" while the customers are in charge of providing the driver and finding their own passengers. "The Vanpool program offers tax benefits for employers and employees. Plus, individuals who participate in LYNX vanpools qualify for the "Emergency Ride Home" program offered by reThink and the Florida Department of Transportation." The van pooling idea can be of value to Pittsburgh's potential BRT system since the many riders of the proposed corridor bus services are from the universities along the route. It could solve the over-capacity problem if we have a similar program where PAAC cooperate with the universities on a van pool program like what LYNX provides now (Lymmo Website).

12.2.3. Cleveland, Ohio

Equivalent organization to PAAC - Greater Cleveland Regional Transit Authority (GCRTA)

Keywords - Naming Rights Bid off for System Maintenance; Public meetings; Political champions

12.2.3.1. Naming Rights Bid off for System Maintenance

Health Line's naming rights were bid off for yearly maintenance of the BRT system. The Cleveland Clinic and University Hospital promised to pay $250,000 for 25 consecutive years for maintaining the BRT system (RTA Website).

12.2.3.2. Public Meetings

Throughout the development of the project, GCRTA involved itself with myriads of public meetings. During the initial stage, GCRTA held large public meetings in gyms and auditoriums to answer questions that people might have regarding how the project would spend tax dollars. GCRTA later addressed the needs and concerns of specific groups of people, such as churches along the corridor, local business, healthcare employees and students.

Along with public meetings, GCRTA created the Euclid Corridor Committee (ECC) which closely worked with different stakeholder groups. The responsibilities of GCRTA also include "promoting certain types of development in the community, offering guidance, and allocating funds."

GCRTA was careful to inform the local businesses along the corridor about any inconvenience expected throughout the construction and how to deal with them. They tried different communication channels including "email, posters, visits, etc." to make sure that they would not lose too much business. Furthermore, GCRTA worked with the City of Cleveland to provide loans to the businesses to cover the loss (RTA Website).

12.2.3.3. Political champions

Another approach that GCRTA assumed was to work with community group champions and political champions to promote the project together and assist with community buy-in (RTA Website).

12.2.4. Boston, Massachusetts

Equivalent organization to PAAC - Massachusetts Bay Transit Authority (MBTA)

Key words - Silver, Marketing Campaign

12.2.4.1. Silver

The idea of having a theme color on its BRT system is based on MBTA's color code named subway system. Each of its subway lines is named after a primary color, for instance, red line and green line. Having a color code will allow people to relate BRT to a variation of light rail instead of buses. The use of color silver also suggests to the public that the BRT service is technology-oriented and advanced because "from racing cars to rockets, the use of the color silver symbolizes speed and high-technology" (Boston Silver Line Washington Street BRT Demonstration Project Evaluation, 2005).

12.2.4.2. Marketing Campaign

MBTA launched a major marketing campaign which included designing the Silver Line logo which could be used on websites and print materials. MBTA also had an opening day event for the Silver Line's ribbon cutting (Boston Silver Line Washington Street BRT Demonstration Project Evaluation, 2005).

12.2.5. Honolulu, Hawaii

Keywords - Ask Me Program; Advertisement with Local Businesses; Fare Waive Promotion

The City of Honolulu adopted multiple branding strategies towards promoting CityExpress! The most innovative approach that they took was employing people returning to work from injuries and providing schedule information to passengers as customer service representatives. Also, businesses along the corridor were asked to promote together with the City of Honolulu specifically to provide discount deals to CityExpress! riders. During the first week of operation, the fare was waived to attract people to try the service (Honolulu BRT Project Evaluation Final Report, 2006).

12.2.6. Oakland, California

Key Words - Logo Gears; Whistle Stop; Innovative Media Involvement-"Live your life in the fast lane"

The San Pablo AC Transit hired a marketing team along with the development process to appeal to public interest. AC Transit distributed among employees and the public gears printed with the Rapid logo to win support. AC Transit also held a "Whistle Stop" tour where the BRT vehicle went to communities along the corridor and had performance and celebration to better educate the public about the new transit system.

Media was also a useful outlet to brand and market the Rapid where a commercial themed "Live Your Life in the Fast Lane" went on air for several months and advertisements about the Rapid were shown before movies in local theatres (San Pablo BRT Project Evaluation Final Report, 2006).

12.2.7. Recommendations Based on Case Studies

PAAC needs to create a unique identity for its BRT system - Looking at other successful BRT implementations, the key step of branding is to create a unique identity for Pittsburgh's Oakland-Uptown-Downtown BRT. Having a unique identity will not only help with future marketing endeavors, but also change people's perception by differentiating BRT with normal bus services. A unique identity also implies brand promises that PAAC wish to convey to its customers.

PAAC needs to notify and involve the public as much as possible - Successful implementation involves rigorous efforts engaging the public into the BRT implementation process. Previous BRT implementations in other cities were successful to a large extent by changing people's perception about bus-based transit systems, and constantly engaging stakeholders throughout planning, developing and implementing processes. PAAC should conduct further analysis about the stakeholders for a Pittsburgh BRT who are not directly involved in the implementation process. These people, including communities impacted, local businesses, universities, institutions and hospitals need to be continuously informed about the development.

Proper amount of media outlet - Media can be a tool of information sharing, marketing and community outreach. Media outlet involves information sharing and advertising, which falls under a marketing plan which is addressed as below.

PAAC needs a marketing plan for its BRT system - The major goal of BRT, unlike normal bus services, is to attract "choice riders." This group of people is seeking something of quality, not merely a means of transportation. As the ridership survey indicates, the main reason more than half of the people travel by bus along the proposed corridor is due to lack of other means of transportation. This shows that BRT has potential along the corridor, especially since parking in Downtown and Oakland can be expensive and parking spaces are limited. A marketing plan will help attract people who are not accustomed to bus services by providing daily deals, promotions and propaganda campaigns.

13. Analysis of Other Issues

From the initial list of 36 issues important to consider when implementing BRT, only some were examined in-depth. The rest of the issues are briefly discussed, and some are combined due to similarities.

13.1. Park and Ride, Taxis

BRT systems should provide parking facilities adjacent to popular public transport stations, and integrate taxis as complementary services that can effectively extend the coverage of the transit system's service area.

To find best practices and analyze Pittsburgh, other cities can be examined and GIS can be used to map out current park and rides, taxi garages and street parking. Also, site suitability test can be done to find locations for new park and rides and how to link them, and existing park and rides, to the BRT route.

13.2. Parking Regulation

Parking regulation can be used to discourage the use of private vehicles. The right amount of parking regulation can encourage people to use BRT. This will not only increase ridership, but also decrease road traffic.

Both Ottawa and Boston successfully used parking regulations to increase BRT ridership and redevelop the community along the corridor. During the redevelopment of Boston's seaport district, the Massachusetts Department of Environmental Protection implemented a parking freeze for non-residential parking in South Boston. This encouraged developers to ensure easy access to transit from their developments (Breakthrough Technologies Institute, 2008). In Ottawa, the federal government started to reduce free parking for its employees. Additionally, for every bus stop in the area, about 25 parking slots were reduced at downtown retail centers.

13.3. Parking Configuration

Parking Configuration is the effect parking will have on implementing BRT and/or the affect implementing BRT will have on parking, both on-street and lots.

To analysis this issue, the following items need to be considered (USAF, 2007):

- Inventory of total parking spaces within a specific area
- Analyzing specific problems, such as location or deficiency of visitor or reserved parking areas and employee parking
- Parking duration and turnover rates

- Park-and-ride lots: it allows stations, especially those without significant development, to attract passengers from a wide area around BRT stations. Since BRT service can be routed off the primary running way, regional park-and-ride facilities can also be located off the running way. This arrangement can link BRT service with existing parking lots, potentially reducing capital investment costs (Hinebaugh, National BRT Institute, 2009; Hinebaugh & Díaz, Characteristics of Bus Rapid Transit for Decision-Making, 2009).

Figure 74. Park-and-ride sign.

13.4. Congestion Charging and Road Pricing

Congestion charging and road pricing is charging for the use of a road or area during a certain time period. This policy can curb traffic demand and decrease traffic congestion, pollution and fuel use. Moreover, it can help manage road space for peak traffic and generate some revenue (Replogle, 2006).

Examining London, Singapore and Germany, the following steps are needed to implement congestion charging and road pricing (Replogle, 2006) (The World Resources Institute (WRI) Center for Sustainable Transport, 2006):

- Determine an implantation plan, including the method of charging, for instance, Area License fee, or corridor time-of-day tolls. Also, how the revenue is spent should be clarified before implementation.
- Investigate the technological developments and their implications.
- A cost benefit analysis should be done to decide the road pricing schemes and their impact on other economic policy instruments, including implications on reduction of pollutants.
- Recognize supportive institutional and policy framework for the introduction of road pricing.
- Conduct a suitability analysis, looking at how it can implemented in the Pittsburgh transportation system, specifically the BRT.

13.5. Building a Transfer Center

A transfer center can spur economic development in the area it is located, as well as, increase BRT ridership by connecting other modes of transportation, such as subways, busways and local buses.

Some cities that have successfully built transfer centers include Eugene, Charlotte, Corpus

Christi, and Cedar Rapids. GIS can be used to determine the best location for a transfer center, which would include factors such as, where different modes of transportation meet and where land is available.

13.6. Increase in Property Value/Tax Revenue

BRT will have an impact on property values, and thus tax revenues, along the corridor. This is an additional reason to establish BRT in a suitable area.

Based on other cities that were successful in boosting property values and tax revenues, the following can be done (Federal Transit Administration, 2009) (Nelson, 2010):

- Review and analyze cities that, previous to implementing BRT, had property values and tax revenues similar to Pittsburgh's BRT corridor.
- Interview property stakeholders in the corridor, including community groups, real estate agents, decision makers and business owners.
- Conduct an econometric analysis of BRT impacts of property value and tax revenue.
- Examine other cities that implemented successful TOD programs along the corridor.

13.7. Day Restrictions by License Plate Number or Vehicle Occupancy

Driving restrictions, such as day restrictions by license plate number or lane restrictions based on vehicle occupancy, can limit private vehicle use. These restrictions can provide travel time savings and improve trip time reliability for vanpools, carpools and buses, which will encourage individuals to shift their transit mode away from driving alone. This method will increase people per vehicle, which can maximize the utilization of road (Gilbert Gedeon, 2005).

When restricting a lane based on vehicle occupancy, some key points that need to be addressed include (Gilbert Gedeon, 2005):

- Capacity of lanes and alternatives for using excess capacity
- Exemptions for environmentally friendly vehicles
- Exemptions for law enforcement and public transportation vehicles

13.8. Station Infrastructure

Stations are a critical link between a BRT system, its customers and other transit services. Stations should be clearly identified for BRT through both visual features and physical elements, such as those elements that improve boarding times (Hinebaugh, National BRT Institute, 2009).

The National BRT Institute has a comprehensive analysis of station infrastructure, which includes the station location, station type, passenger amenities, curb design, platform layout, passing capability and station access. Also, they include an alternatives comparison analysis in terms of cost and benefit.

13.9. Dedicated Running Ways (Busways)

Dedicated running ways for BRT are physically segregated lanes that are permanent and exclusive for the use of public transit vehicles. These dedicated lanes let buses travel freely without congestion, which provides a time advantage compared to mixed-flow running ways. They can also represent be used for emergency vehicle traffic.

A traffic simulation has to be done to test the feasibility of a dedicated BRT lane. Also, the lane should be the most direct route and have the smallest number of grade crossings (The American Public Transportation Association, 2010). Cleveland, Boston and Singapore all have dedicated lanes which successfully offer high frequency and time guarantees to customers. However, these cities have parallel lines to shift displaced traffic.

13.10. Integration with Land Use Policies

Land use policies affect a BRT's implementation, and a BRT's implementation also affects land use policies. Integrating land use policies with BRT will support the TOD and have a larger impact on the economic development along the corridor (Vincent, 2006).

13.11. Quality of Streetscape

BRT systems can change urban roadway designs and other conditions that impact street users and nearby residents. Quality streetscapes integrated with a BRT system will not only attract more riders, but also increase the corridor’s investments. Both Boston and Cleveland added quality streetscape improvements (Roderick B. Diaz, 2004).

13.12. Impact on Automobile Use

BRT systems impact automobile use and traffic in general. Since BRT can provide customers high quality (safe, reliable and fast) public transportation, it may gain some automobile users. However, a BRT system needs to minimize the negative impact on regular automobile use. For example, corridor selection, using dedicated or mixed-used lanes, and BRT stop selection should take into account the impact on automobile use.

13.13. Density (Population/Housing)

Population density will have an effect on where to locate the BRT routes and stations. The higher density of population and jobs represents higher demand for public transit. BRT can help improve high density areas’ transportation and attract more people that live and work along the corridor. Also, TOD programs and financial incentive policies for the corridor need a sufficient amount population to support them. The population density for the Oakland-Uptown-Downtown corridor is displayed below.

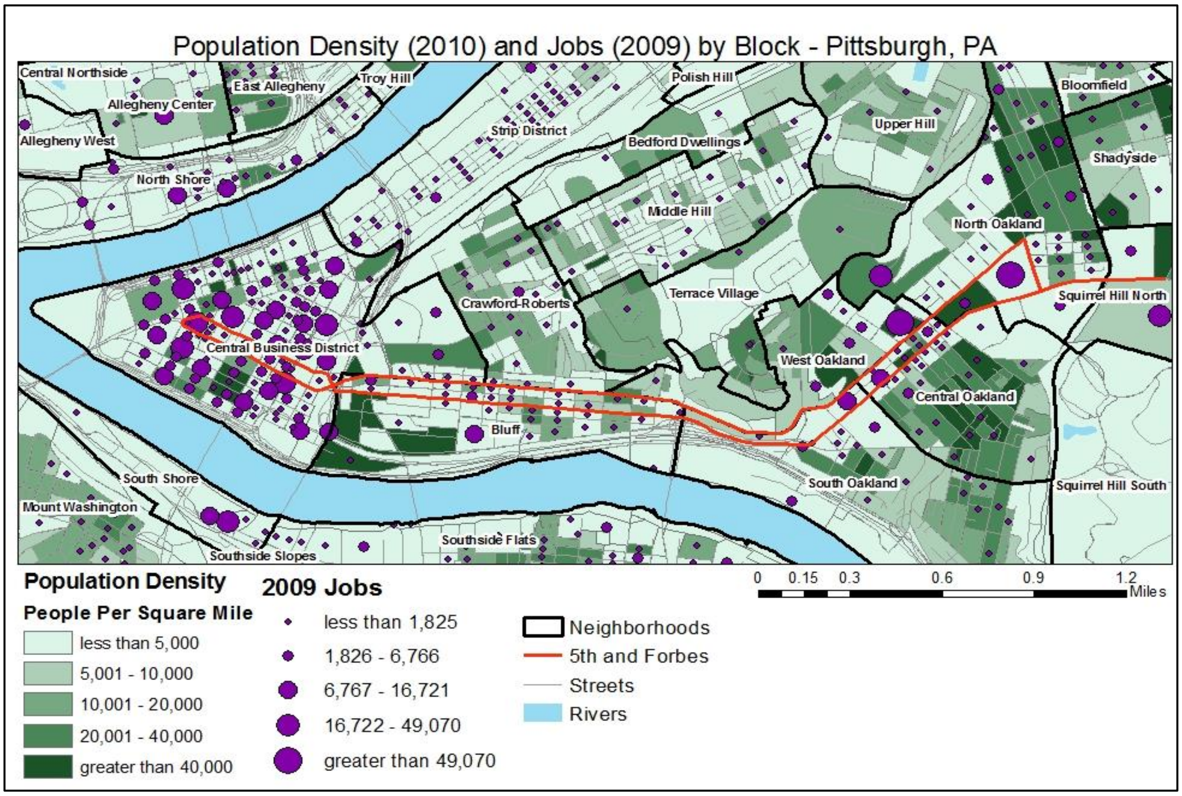

Figure 75. Map of population density and jobs in the Oakland-Uptown-Downtown corridor.

13.14. Brand Identity & Contextual Design

Brand Identity represents how a particular product is viewed among the set of other product options available. Brand identity is necessary in BRT systems so passengers can distinguish BRT services from other transit services. Contextual Design refers to how well a BRT system demonstrates a premium, quality design and is integrated with the surrounding communities (Characteristics of Bus Rapid Transit for Decision-Making, 2009).

While BRT is viewed as a cost-effective solution to urban mobility problems, the role of BRT is becoming increasingly associated with the wider objective of congestion reduction. If BRT is to be perceived as more than just a social service, it must be able to attract “choice riders” by distinguishing itself from other travel modes. Thus, brand identity and contextual design play an important role in creating a unique identification for BRT. This is essential for the BRT system to be successful in attracting “choice riders” and to improve publicity (Helen Tann, 2009).

Some studies have examined the differences in opinions of different transit services. With the development of BRT systems in many U.S. cities, many case studies are also available. However, to implement best practices locally, city planners need to obtain information at the local level from surveys, focus groups, etc.

13.15. Attracting More "Choice Riders"

"Choice riders" are riders who don't "need" to use public transportation, but marketing and advertising strategies can be used to persuade them to do so.

One attribute associated with BRT is the intent to attract potential "choice riders" to use the service. A "choice rider" will be attracted to a transit choice that they perceive as more closely resembling the quality experience of light-rail than that of a bus (Helen Tann, 2009).

To attract more "choice riders," planners first need to find the BRT attributes that are most important to them in order to incorporate those attributes into the BRT system and then use branding and marketing strategies to build a positive public perception.

13.16. Public Engagement

Public engagement is important in the decision making process of a BRT system, and necessary for it to succeed. With more public engagement BRT planners will be able to gain more information regarding the public perceptions and interests in order to identify issues, concerns and opportunities for the BRT (Authority, 2007). Also, through this interaction the planners can inform riders about the system and build a positive and supportive public perception.

13.17. Private Participation

Private investment in public transit infrastructure can take many forms including Public-Private Partnerships (PPPs) and Build-Operate-Transfer (BOT) schemes. The idea is that the private sector provides investment capital in exchange for a concession agreement that gives the investor the right to collect some revenue stream, like part of the fare, or to develop real estate along the corridor on state land. Despite some cases that used private funds for vehicle procurement and fare systems, private investment has not been used extensively to finance BRT projects. However, private participation can be an attractive alternative for public sector planners who face constraints from traditional financing approaches (Bus Rapid Transit Planning Guide, 2007).

Though practices of private participation are still small, interesting and innovative cases can be found and studied. For example, the Cleveland Health Line was able to sell the naming rights under a 25-year agreement with local hospitals (Budget Challenges). Since these practices are very corridor-specific, building such a partnership needs substantial consideration of local conditions.

13.18. Reducing Road Supply

Since the implementation of a BRT system sometimes requires difficult-to-negotiate changes in how road space is designed and regulated, it also offers the opportunity to fundamentally change how surface street space is regulated and organized with the potential to improve economic and social conditions in the city (Bus Rapid Transit Planning Guide, 2007).

While a BRT system takes road space and sometimes uses lanes exclusively, it affects the road supply for the other modes of transit, such as private vehicles. From this perspective, a BRT system will create disincentives to use private vehicles. Expecting to improve public transit service through BRT, car usage reduction in the city can help increase public transit ridership, alleviate congestion, reduce air pollution and enlarge public space. With all these great prospects, the effect of reducing road supply still needs serious consideration in the process of travel blending and corridor integration.

13.19. Analysis of Potential By-Products

While there is no standard definition for by-products of BRT, by-products refer to the environmental quality of a region in terms of the health and well-being of the public, as well as, the attractiveness and sustainability of both the natural and urban environments. Environmental quality can be measured by technology, ridership and system effects. Technology effect is the reduction of bus emissions via the propulsion of technology, such as using clean-energy vehicles. Ridership effect is the effect of the increase in public transit ridership and decrease in private vehicles. System effect refers to congestion and vehicle emission reduction (Cheryl Thole A. C., 2009).

Analyzing potential by-products can be an important part in evaluating the impact of a BRT project and achieving its objectives. While emissions reduction can be calculated based on technologies that will be adopted, the effects of ridership and congestion alleviation need to be forecasted.

13.20. System Sustainability

Long-term financial sustainability of a public transportation project is highly dependent upon the on-going operating costs of the system, which includes vehicle amortization, labor, fuel, maintenance and spare parts. The level of operating costs relates to the expected BRT fare levels, which will in turn affect the affordability of the system (Bus Rapid Transit Planning Guide, 2007).

Ideally, a self-sustainable BRT system should be able to cover its operating costs through fare revenues in the long run. However, the level of fare price also depends on the service of the system and riders' sensitivity to price. Systems that require on-going subsidies might face financial strains that end up affecting the effectiveness of the BRT (Bus Rapid Transit Planning Guide, 2007).

13.21. Travel Time

From the perspective of riders, the total travel time is composed of travel time from origin to transit station, travel time from entering station to vehicle platform, vehicle waiting time, vehicle boarding time, vehicle travel time, vehicle alighting time, travel time from vehicle platform to station exit and travel time from station exit to final destination (Bus Rapid Transit Planning Guide, 2007).

Travel time savings is one of the most important determinants of a BRT system to attract riders. Within a BRT system, travel time savings can maintain current riders, induce more frequent use of the system and attract "choice riders" (Characteristics of Bus Rapid Transit for Decision-Making, 2009).

13.22. Quality of Service

The quality of a BRT systems service includes customer information, system professionalism, safety and security, amenity features, segmentation of services and other service measures (Bus Rapid Transit Planning Guide, 2007).

The quality of customer service is directly related to customer satisfaction which will ultimately affect ridership and long-term financial sustainability (Bus Rapid Transit Planning Guide, 2007). This is more important to BRT systems than to conventional bus services, because BRT systems are intended to attract more "choice riders" by providing higher quality services.

Quality of service does not necessarily have to be expensive. Rather, many of the features have a relatively low-cost to implement and are low-tech in nature (Bus Rapid Transit Planning Guide, 2007), such as system maps and signage.

13.23. Ridership Forecast

To analyze the demand of a potential BRT system, ridership forecasts must be made. Realistic and reliable ridership forecasts are essential to size the system's design features, develop service plans, estimate capital and operating costs, and perform an alternatives analysis and cost-benefit comparisons.

Forecast horizons for FTA New Starts funding include the baseline year, the opening year, the year when ridership reaches maturity, and a design year usually 20 years into the future. For smaller-scale projects, travel time, service frequency and fare elasticity can be used to carry out the forecast. For larger-scale projects, more complicated models need to be used. One option is the traditional four-step process, which includes trip generation, trip distribution, mode split and trip assignment (Bus Rapid Transit Practitioner's Guide (TCRP Report 118), 2007).

13.24. Safety and Station Security

Safety and security are essential in the design of BRT stations so riders feel safe while they are waiting for a bus. Adequate vandal-resistant and easily maintained lighting should be provided. Passengers should be able to see and be seen from locations within the station and from outside space. Abrupt or blind corners should be avoided. Security equipment such as emergency call boxes and cameras can be installed. Stations need to be barrier-free and comply with ADA guidelines (Bus Rapid Transit Practitioner's Guide (TCRP Report 118), 2007).

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15. Appendices

Appendix A. **Issue Definitions**

Corridor integration - Integration (physical connection, complementary marketing, promotion and unification of fare structures) with other public transport systems, such as T light-rail and local buses services in, and outside of the corridor

Park-and-ride - Provide parking facilities adjacent to a popular public transport stations to extend the coverage of the transit system's service area

Taxis - Integrate taxis as complementary services that can effectively extend the coverage of the transit system's service area

Parking regulation - Use of parking regulation as a disincentive to automobile use

Congestion charging and road pricing - Placing a monetary value on using the road space during peak travel times

Day restrictions by license plate number or vehicle occupancy (HOV) - Limit automobile travel at a particular time and/or place; e.g. day restrictions by license plate number or lane restrictions based on vehicle occupancy

Station infrastructure - Station design elements that improve boarding and alighting times; e.g. at-level platform boarding

Dedicated running ways (busways) - Use of physically segregated lanes that are permanently and exclusively for the use of public transportation vehicles

Quality of streetscape - Changes in urban roadway design and conditions that impact street users and nearby residents

Analysis of potential by-products - Analysis of the potential by-products of BRT, and their impact on the community

Assessment of investment opportunities around stations and corridor - Assessment of the investment opportunities around the BRT stations and its route

Impact on automobile use - The impact BRT will have on automobile use, automobile owners, and traffic

Transfer center outside downtown - The impact on the community of creating a transfer center either downtown or outside downtown

Transit-oriented development (TOD) - Assessment of how new transit-oriented developments that will come about due to BRT's implementation will impact the community

Density (population/housing) - The affect population density will have on where to locate the BRT route and stations

Increase in property value/tax revenue - The impact on property values around the corridor that implementing BRT will have

Integration with land use policies - The affect land use policies will have on BRT's implementation, and/or the affect BRT's implementation will have on land use policies

Parking configuration (commuters, riders, shared) - The affect parking will have on BRT's implementation, and/or the affect BRT's implementation will have on parking (parking includes street and lots)

Brand id and contextual design - The name and connotations of the BRT line, its buses, and the design of collateral materials (route maps, fare-cards, etc.)

Attracting more "choice riders" - Marketing and advertising strategies used to target riders who don't "need" to use BRT for transportation, but could be persuaded to use the service by choice

Travel blending - How to promote the ease of transitions between various modes of public and private transportation; how maps and other collateral pieces convey the ease of use of not only the BRT, but the entire transportation system

Public perception - How the public views BRT in comparison with normal bus service and other transportation options

Public engagement - To what extent the public feels engaged in the decision making process of developing the BRT

Reducing road supply - Potential needs and effects of the creation of dedicated BRT lanes in the corridor

Private participation - Evaluation of financing alternatives that include the participation of private entities such as hospitals, universities, private businesses, etc., which are positively impacted by the system

Financing alternatives - With the context of PAAC's funding crisis and many services being cut off, what will be the financing alternatives for BRT project?

System sustainability - Will the potential BRT system be self-sustainable?

Travel time - Total time that a passenger takes to go from one end to the other; the idea is to explore whether or not the expected improvement has a value for the customers

Mode connections at transit stations - Assessment of interconnection with other public transportation systems

Quality of service - Quality of service includes wait time at the station, information provided to the customers, among other service measures

Ridership forecast - Methodologies to improve forecasting performance; assess the possibility of using real-time data to forecast ridership and improve service quality

Safety - BRT's effect on safety perceptions from the pedestrian's point of view

Fare collection - Fare collection options, fare structure, station design, infrastructure, system costs and available funds, technology, and other related issues

Signal priority - Signal priority refers to giving special treatment to transit vehicles at signalized intersections; e.g. signal timing and phasing optimization

Real-time information - How to keep passengers updated with information on the BRT system?

Station security - Passengers' security while they are waiting for the bus or arriving at a station

Appendix B. **Issue Prioritization Matrix and Code Table**

The following coding system was used to fill in the prioritization matrix.

Code Table	
3	High Priority
2	Medium Priority
1	Low Priority

Rank each issue on a scale of 1-3 for each criteria, 3 as high priority whereas 1 as low.

		Strategic Fit			Economic Impact			Feasibility			
	Projects & Initiatives	Cost efficiency	Feasibility/Ease of implementation	Probability of quick results	Economic Impact	Community impact	Environmental impact	Potential savings in the future	Service quality (reliability and efficiency)	Improvement potential for defect reduction	Total
category	Weighting	15%	15%	5%	20%	20%	5%	10%	5%	5%	100%
Design and Branding	Corridor integration	2	3	1	3	3	1	1	3	1	2.35
	Park and Ride	2	1	1	2	2	1	1	1	1	1.55
	Taxis	1	1	1	1	1	1	1	1	1	1
	Parking regulation	1	2	1	2	2	2	1	2	1	1.65
	Congestion charging and road pricing:	3	2	1	3	3	2	2	1	1	2.4
	Day restrictions by license plate number or vehicle occupancy (HOV)	1	1	1	1	1	1	2	1	2	1.15
	Station Infrastructure	3	2	1	3	3	1	1	2	1	2.3
	Dedicated running ways (busways)	3	2	1	2	3	1	2	2	1	2.2
	Quality of streetscape	2	1	1	3	3	1	2	2	1	2.1
Economic developement	Analyze potential by-products	1	1	1	1	1	2	2	2	1	1.2
	Assessment of investment oppourtunities around stations and corridor	2	2	1	3	3	1	1	1	1	2.1
	Impact on automobile use	1	1	1	2	2	2	1	1	1	1.45
	Transfer center outside downtown	2	3	2	2	3	1	1	2	1	2.15
	Transit-oriented development	2	2	1	3	3	1	1	1	1	2.1
Land Development	Density (population/housing)	1	1	1	2	2	1	1	1	1	1.4
	Increase in property value/tax	2	1	1	3	3	2	1	1	1	2
	Integration with land use policies	2	2	2	3	3	2	1	1	1	2.2
	Parking configuration	2	2	1	1	1	1	2	2	1	1.45
Marketing	Brand Id, Contextual Design	3	2	3	3	3	1	1	2	1	2.4
	Attracting More Choice Riders	1	2	1	2	2	1	1	2	1	1.6
	Travel Blending	3	2	1	3	3	1	2	2	1	2.4
Community Impact	Public Perception	1	2	1	1	3	1	1	1	1	1.55
	Public Engagement	1	2	2	2	3	1	1	1	1	1.8
	Reducing Road Suplpy	3	1	1	2	1	3	1	1	1	1.6
Financing	Private Participation	3	2	1	2	2	1	2	2	1	2
	Financing Alternatives	3	1	1	2	2	1	1	1	1	1.7
	System sustainability	3	1	1	3	3	1	1	1	1	2.1
Operations	Travel Time	1	1	1	2	2	1	1	2	1	1.45
	Mode Connections at Transit Stations	2	2	1	2	2	1	1	1	1	1.7
	Quality of Service	2	1	2	1	3	1	1	2	1	1.65
	Ridership Forecast	3	2	1	3	3	1	1	2	1	2.3
	Safety	1	1	1	1	3	1	1	3	1	1.5
	Fare Collection	2	2	1	1	3	1	1	3	1	1.8
	Signal Priority	3	1	1	2	2	1	2	1	1	1.8
	Real-time information	3	2	3	3	3	1	2	2	1	2.5
	Station Security	1	1	1	1	3	1	1	3	1	1.5

Appendix C. **Calculating the Optimum Distance Between Stations (Hook, 2007)**

Box 8.4: Calculating the optimum distance between stations

Optimising the distances between stops is done by minimising the generalised cost of travel for the walking distances to the stations and the travel speed of the passengers passing along the corridor.

For purposes of this example, it will be assumed that passengers walk a maximum of one-half of the distance between stations (D), and on average each passenger will walk one-quarter of this distance. Thus, walking time for boarding and alighting passengers is proportional to station distance. On the other hand, passengers in vehicles incur an additional delay for each stop, so the delay is inversely proportional to D. The calculation for determining the optimum distance between stations is as follows:

$$Dopt_x = [g1 * (C_x + g2 * Cmax) / Pk_x]^{0.5}$$

Where:

$Dopt_x$ = Optimum distance between stops in a particular area x
C_x = Peak hour bi-directional demand (crossing volume/hour) on point x
Cmax = Peak hour uni-directional maximum demand of lines that stop on stations x
Pk_x = Bi-directional density of passengers boarding and alighting near point x
g2 = A constant that reflects travel cost constants divided by walking cost constants
g1 = 4 * (Cst / Csw) * Vw * Tob
- Cst = the value of walking time (US$ / walking time)
- Csw = the value of time for transit passengers (US$ / transit system time)
- Vw = walking speed (km hour)
- Tob = Dwell time lost at each station (excluding boarding and alighting time)

For this example, the following assumptions are made:

Cst / Csw = 0.5 (*i.e.*, people value transit time twice as much as walking time)
Vw = 4 kph
Tob = 30 seconds = 1/120 hours
G2 = 0.4
C_x = 7,000 passengers per hour
Cmax = 9,000 passengers per hour
Pk_x = 2,500 passengers / kph

Based on these assumptions:

g1 = 4*0.5*4/120 = 0.067 km

$Dopt_x = [\, 0.067 * (7{,}000 + 0.4 * 9{,}000) / 2{,}500 \,]^{0.5}$
= 0.533 km = 533 metres

Thus, the optimum distance between the stations in area x is 533 metres. This example assumed that passengers will value time on the transit vehicle more than walking time. This preference is not always the case, especially in areas with a high-quality walking environment.

Appendix D. **Fare Collection System Elements Costs**

On-Board Payment

	Unit	Capital Cost Range per Unit	
		Low	High
Electronic registering farebox	Farebox	$5,000	$6,000
Electronic registering farebox (with smart card reader)	Farebox	$6,000	$8,000
Validating farebox (includes magnetic card processing unit)	Farebox	$12,000	$13,000
Validating farebox (with smart card reader)	Farebox	$13,000	$14,000
Stand-alone smart card processing unit	Vehicle	$1,500	$2,000
Integrated farebox smart card module	Module	$500	$1,000
Bus operator control unit	Vehicle	$1,500	$2,000
Magnetic farecard processing unit (upgrade)	Unit	$4,000	$6,000
On-board probe equipment	Vehicle	$500	$1,500
Garage probe equipment	Garage	$2,500	$3,500

Table 27. Estimates of capital costs (per unit) for on-board payment elements (Hinebaugh & Díaz, 2009).

	Operating Cost Range	
	Low	High
Spare parts (% of equipment cost)	10%	15%
Support services (% of equip. cost, for training, documentation, revenue testing & warranties)	10%	15%
Installation (% of equipment cost)	3%	10%
Nonrecurring engineering & software cost (% of equipment cost)	15%	30%
Contingency (% of equipment cost/operating cost)	10%	15%
Equipment maintenance costs (% of equipment cost)	5%	7%
Software licenses/ststem support (% of systems/software cost)	10%	20%
Revenue handling costs (% of annual cash revenue)	3%	10%
Clearinghouse (% of annual AFC revenue, for card distribution, revenue allocation, etc) (depends on nature of regional fare program, if any)	3%	6%

Table 28. Estimated operating and maintenance costs for fare collection (2006 US $)[11] (Hinebaugh & Díaz, 2009)

Proof-of-Payment (POP)

	Unit	Capital Cost Range per Unit	
		Low	High
Ticket vending machine (TVM)	Unit	$25,000	$60,000
TVM ipgrade – smart card processing	Unit	$5,000	$7,500
Stand-alone validator	Unit	$2,000	$5,000
Hand-held validator	Unit	$1,500	$4,000
Station hardware/software	Station	$10,000	$25,000
Garage hardware/software	Garage	$10,000	$50,000
Central hardware/software	System	$75,000	$300,000

Table 29. Estimates of capital costs (per unit) for POP elements (Hinebaugh & Díaz, 2009).

[11] Cost information from recent system procurements, vendor estimates and general industry experience.

Appendix E. **Ridership Survey**

Interviewee Information:

Gender ☐F ☐M

Age ☐Under 25 ☐25-45 ☐45-65 ☐Above 65

Disabled ☐Yes ☐ No

***Occupation:** ____________________ ☐Prefer not to be disclosed

Do you have a car in Pittsburgh?

☐Yes ☐ No

Interviewer:____________________

Date:____________________

Time:____________________

Stop selected:____________________

(Inbound/ Outbound)

Question Sheet:

<u>Important note</u>: The survey is exclusively designed for the ridership experience along the Downtown-Uptown-Oakland corridor. Please remind the interviewee our purpose for the survey if the interviewee starts rambling on other subject matters. Interviewer can start addressing the interviewee by saying for example, "would you mind if I take up your five minutes? We are doing a survey for our school project at Carnegie Mellon University and we would like to know about your current ridership experience." Remain courteous at all times is required.

1. **How many times a week do you take buses from Downtown to Oakland or the reversed way?**

2. On a scale of satisfaction where 1 represents the least satisfied while 5 the most satisfied, what is your experience in terms of the following aspects:

Bus frequency: (how often does the bus come to your stop?)

□1-least satisfied □2 □3 □4 □5-Most satisfied

Bus capacity: (how crowded is the bus?)

□1-least satisfied □2 □3 □4 □5-Most satisfied

Service Speed: (how quickly do you get to your destination once you get on the bus?)

□1-least satisfied □2 □3 □4 □5-Most satisfied

Bus Cleanliness:

□1-least satisfied □2 □3 □4 □5-Most satisfied

Fare Collection: (how satisfied are you with paying the fare to board the bus?)

□1-least satisfied □2 □3 □4 □5-Most satisfied

Shelter Design:

□1-least satisfied □2 □3 □4 □5-Most satisfied

3. What attracts you to use public transit?

□Convenience □Eco-awareness □High gas price □ Don't have a car □ No need to park

□Reliability □Others, Please specify:____

____

____

4. What features of bus services are important to retain you as a customer?

□Frequency □Reliability □Fare Price □Bus cleanliness and comfort □Service Speed
□Distance to the bus stop □Bus design and station design

□Others, Please specify: ____

____

____

5. **How long does it generally take you to walk to the bus stop?**

6. **How many minutes of walking are acceptable for you?**

7. **What other comments do you have in terms of your ridership experience (from Downtown to Oakland and the reversed way)?**

8. **Are you aware of plans to improve transit operating between Downtown-Oakland-East end? Would you like to be kept informed of this effort? If Yes, please share your email address with us and we will get back to you about our research findings. Thanks!**

Email: ____

Appendix F. **Rider Survey Guide**

Heinz BRT Rider Survey Guide

Point Persons: Luna Timothy Carlos

Overview: The interview is prepared for Heinz-PAAC Bus Rapid Transit project to better understand current riders' behavior for the **Downtown-Uptown-Oakland transit corridor** in order to pave the way for future BRT development. It is estimated to take up to five to ten minutes for each interview. The interview is totally voluntary and will be conducted in an informal manner.

Approach: The project team will be in charge of the whole corridor from Downtown to Oakland. One stop in each district is selected to conduct the research. In order to avoid potential bias caused by different traffic hours, interviews will be conducted during rush hours from **7:00-10:00am; 3:00pm-7:00pm** and non-rush hours to make statistically significant conclusions.

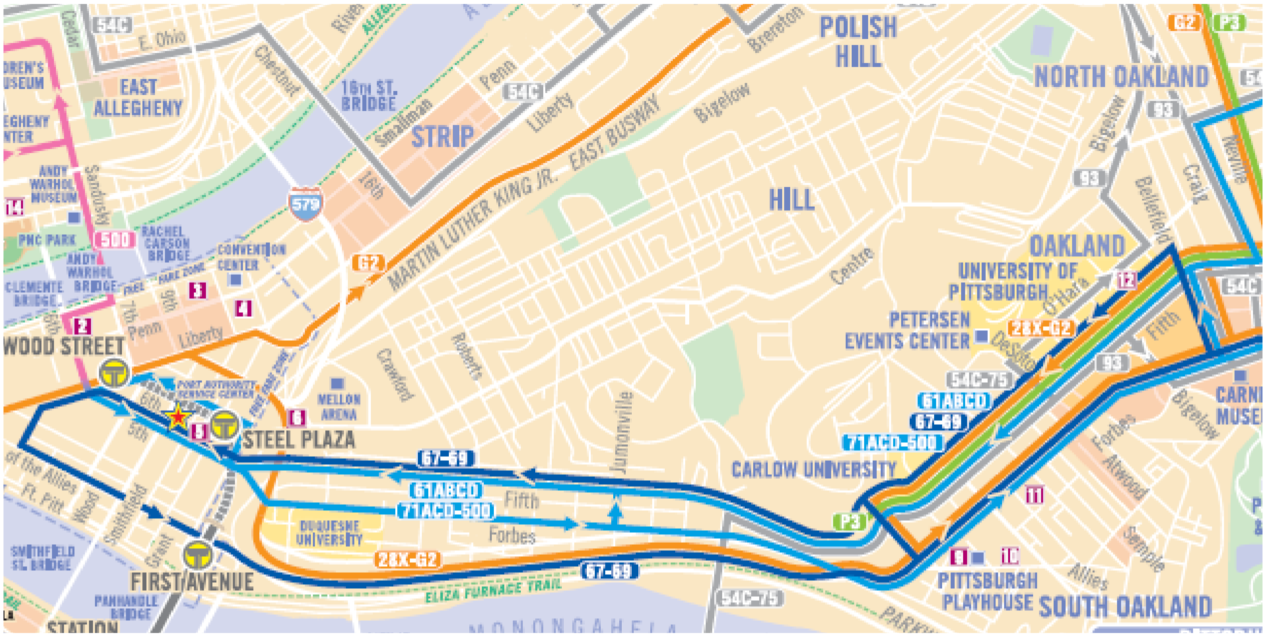
Stops and interviewees will be drawn in a random manner to guarantee trustworthy results. For instance, interviewer A is allowed to get off any stop within downtown during rush hours to conduct the interview and choose to get off at any other or even the same stop during non-rush hours to continue interviewing. Interviewing sample is drawn in a random method.

Instructions:

- **The interviewer should stay in the corridor at all times during interviews (as is shown in the map below).**

Map 1: Proposed BRT corridor, source: http://www.portauthority.org/paac/portals/0/BRT/BRTForum.pdf

Map 2: current bus routes along the proposed corridor; source: http://www.portauthority.org/paac/portals/0/BRT/BRTForum.pdf



- Each interviewer is requested to cover the three areas at two time sessions—rush hours and non-rush hours.

Survey Population: Each interviewer will interview 8 people during rush hours at each station (3 stations in total: 1 in downtown; 1 in Oakland and 1 in Uptown) and 5 people during non-rush hours at each station. **The number of people interviewed and workload is subjective to change but the interviewer needs to stay at the station for one hour to conduct as many interviews as he/she can.**

<u>**Individual task list**</u>

	Rush Hours 7:00-10:00am；3:00pm-7:00pm	**Non-Rush Hours 10:00am-3:00pm**
Downtown	**8**	**5**
Uptown	**8**	**5**
Oakland	**8**	**5**
Total	**24**	**15**

Interviewers can either choose to go out in the morning or during the afternoon. Work hours are approximately 6 hours:

Flight 1 schedule (interview in the morning):

7am-8am Oakland

8am-9am Hill

9am-10am Downtown

10am-11am Downtown (reverse direction)

11am-Noon Hill

Noon-1pm Oakland

Flight 2 schedule (interview in the afternoon):

Noon-1pm Oakland

1pm-2pm Hill

2pm-3pm Downtown

3pm-4pm Downtown (reverse direction)

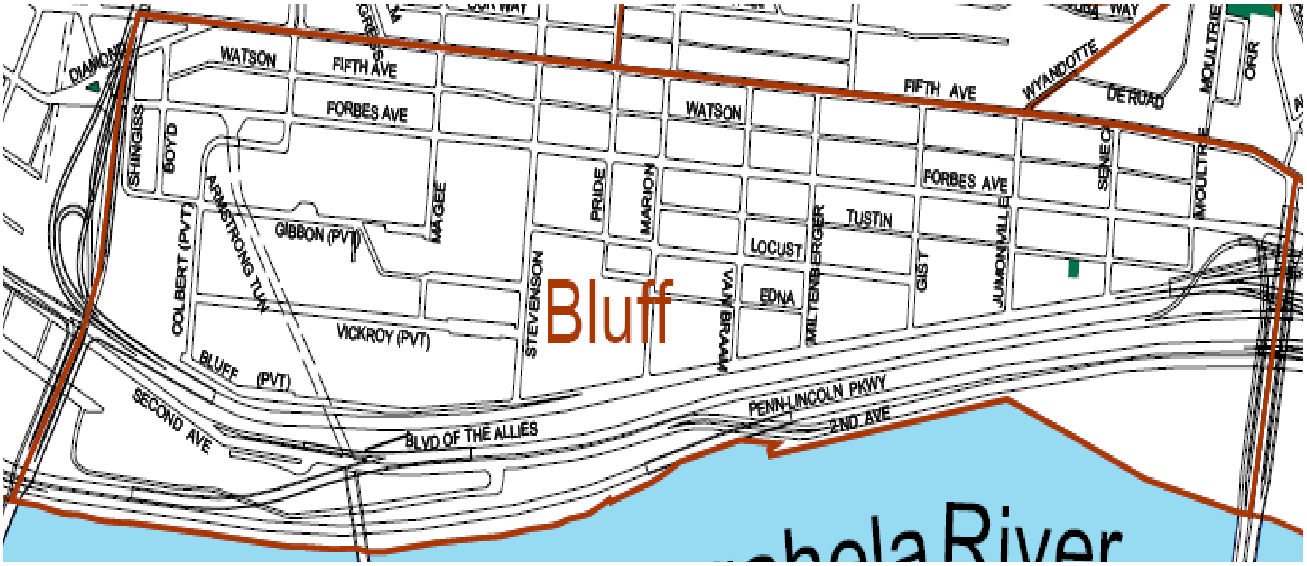
4pm-5pm Hill

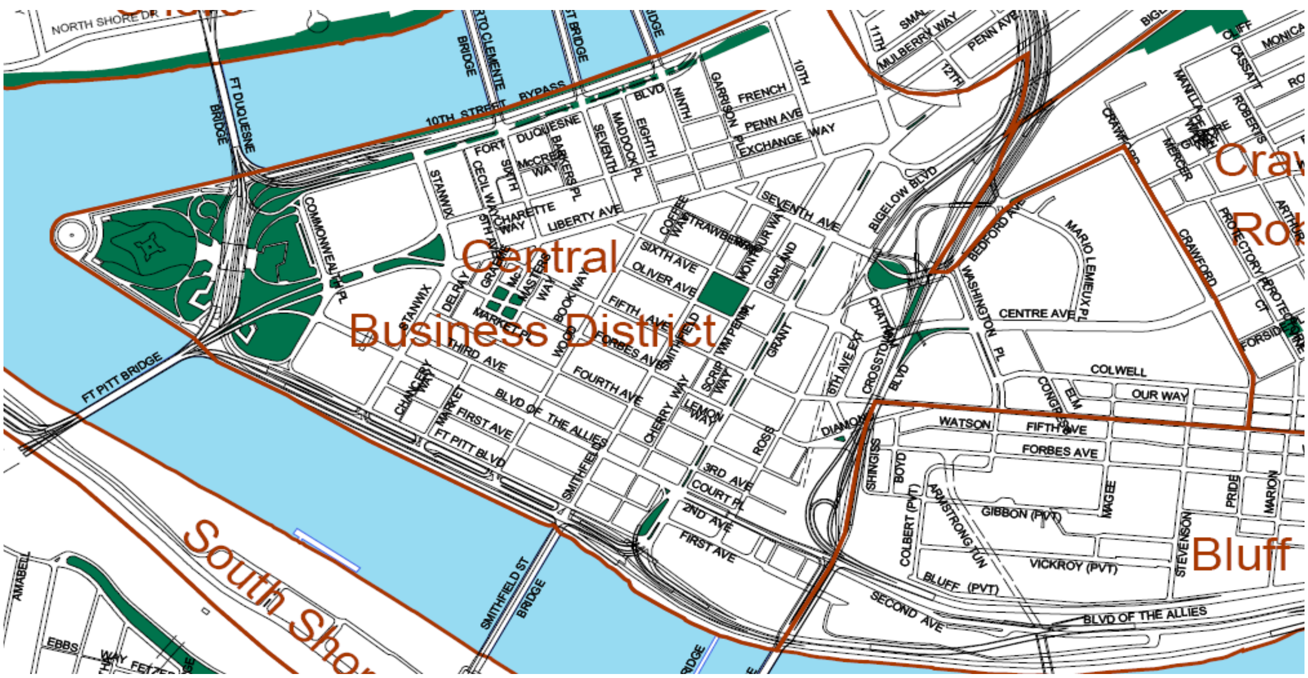
5pm-6pm Oakland

Intended Population Coun	Rush Hours **7:00-10:00am; 3:00pm-7:00pm**	Non-Rush Hours
Downtown	64	40
Uptown	64	40
Oakland	64	40
Total	192	120

Group Total: 311. Ideally, we can get close to 300 responses

- Miscellaneous: Below are the maps for Uptown and Downtown (map source: Department of City Planning website):





16. About the Center for Economic Development

For over 23 years, the Center for Economic Development (CED) at the H. John Heinz III College of Carnegie Mellon University has conducted applied research to improve the institutions, communities, and economy of the Pittsburgh region. In the fall of 2009, this mission was shared with the students of the College. These students now have new learning opportunities in policy and practice through the Center via the Fellows of the CED, all top leaders of some of the most influential and innovative institutions working in economic, community, and technology development in the region.

The Center would like to thank the Port Authority of Allegheny County (PAAC) for sponsoring the *Recommendations for Implementing Bus Rapid Transit in Pittsburgh's Oakland-Uptown-Downtown Transit Corridor* project. Special thanks go to CED Fellow Steve Bland, Chief Executive Officer of PAAC, Wendy Stern, Assistant General Manager of PAAC, David Wohlwill, Manager of Extended Range Planning at PAAC, and to the very active members of the project's advisory board. Special thanks also go to Christopher Paul of RAND Pittsburgh for advising the project, and to the very hard working team of students that conducted the research and completed this report.

The offices of the CED are located at:

HBH 230
5000 Forbes Ave
Pittsburgh, PA 15213
Phone: 412.268.9810
Fax: 412.268.9828
www.cmu.edu/ced
Carnegie Mellon University H. John Heinz III College of Public Policy and Management