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# Use Of Busways in Urban Areas

**A Thesis Presented for the Master of Science Degree**
**The University of Tennessee, Knoxville**

**Michael Harris Gallant**
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## DEDICATION

Dedicated to Dr Arun Chatterjee and Dr Frederick Wegmann for their encouragement, patience, and support over the years while studying at the University of Tennessee

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## ABSTRACT

This study reviews Busway technology, the highest form of Bus Rapid Transit, and its applications to improve mobility within urban areas. The purpose of this study is to identify the potential benefits of busways as an alternative to costly rail transit. Two case studies were performed for busways in current operation in Miami, FL and Pittsburgh, PA. This study will offer a comprehensive analysis of both busway systems and how they have positively affected important transit corridors in the aforementioned metropolitan areas. This study will also discuss the planning process, guidelines, and design criteria for busway development.

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# 1 INTRODUCTION

## 1.1 Background

There are many challenges today facing urban planners and engineers when attempting to address the increasingly complex transportation needs of metropolitan areas across the United States. As the population of cities continues to grow at a rapid pace, the existing transportation infrastructures of these cities become congested due to the increased number of vehicles on urban roadways. Many of these roadways were widened earlier, and these facilities again are reaching their expanded capacity. In many cases, it is becoming cost prohibitive and impractical to further widen or double-deck existing roadway facilities in urban areas resulting in the increasing of traffic congestion.

Historically, mass transit in the United States has played a moderate role in alleviating traffic congestion although it provides an alternative to the use of private automobiles. Mass transit has the ability to improve mobility within a metropolitan area by offering bus, rail and ferry services, and it can reduce the number of autos on clogged roadways -- freeways and bridges/tunnels. Unfortunately, for many cities, transit ridership remains low, and in some instances, has dropped over the years. As transit ridership continues to erode, private auto usage continues to increase, further complicating current traffic congestion problems in urban areas.

### 1.2 Problems with Traditional Bus Service and Light Rail Transit

Transit systems all across the United States have been exploring various ways to reverse this downward trend in transit ridership over the last several decades. Conventional bus systems offering traditional local/express services in mixed traffic have not been the answer. Conventional bus services typically do not have their own dedicated right-of-way (ROW), and so they are forced to intermix with regular traffic and are subject to the same traffic conditions. In recent years, several transit systems have invested in very costly rail systems, namely light rail transit (LRT), as an alternative to conventional bus systems. Unfortunately, after implementation some of these LRT systems are experiencing much lower ridership than originally projected. Examples of these cases include Baltimore MTA, Buffalo Metro Rail, San Jose VTA (National Transit Database website, FTA 2002 http://www.ntdprogram.com/). Though there are a few success stories such as the San Diego Trolley, Saint Louis Metrolink, and Portland MAX, the costs involved to develop and operate a new LRT system often outweigh the benefits. Further, in some cases, metropolitan areas are not seeing a significant decrease in traffic congestion in the corridors where the LRT lines serve. This has fueled considerable public debate with regard to the funding for future rail extensions or new rail startups since the general public, in most instances, must pay for a portion of these rail services, resulting in increased taxes. In fact, many cities have repeatedly rejected proposals for LRT (or other rail technologies) because of the fear that their tax dollars would be wastefully used on a new costly rail system that might not prove to be beneficial to the community as touted by rail proponents.

Another problem with LRT is that in some cases it is not truly a form of rapid transit such as heavy rail and commuter rail technologies. Consequently, LRT may not be viewed as an attractive alternative to automobile users since many commuters might not see a significant time saving using this particular mode. Most LRT systems in the U.S.A. today do not operate in their own ROW in downtown areas but rather intermix with local traffic. There are a few exceptions such as Saint Louis Metrolink, which operates in an old abandoned freight railroad tunnel under downtown Saint Louis which may explain why this particular LRT line is a phenomenal success, far exceeding original ridership estimates since it's inception in the mid-1990s.

### 1.3 BRT - Bus Rapid Transit as an Alternative

In recent years, the Federal Transit Administration (FTA) has been promoting an alternative option to costly rail systems-- Bus Rapid Transit (BRT). BRT is defined by FTA as a rapid mode of transportation that can combine the quality of rail transit and the flexibility of buses. The Transit Cooperative Research Program, Project A-23 (TCRP-A23) expands on this as follows: "BRT is a flexible, rubber-tired rapid transit mode that combines stations, vehicles, services, running way, and ITS elements into an integrated system with a strong positive image and identity. BRT applications are designed to be appropriate to the market they serve and their physical surroundings and can be incrementally implemented in a variety of environments. BRT is a permanently integrated system of facilities, services, and amenities that collectively improve the speed, reliability, and identity of bus transit. In many respects, BRT is rubber-tired light rail transit (LRT), but with greater operating flexibility and potentially lower capital and operating costs.” (Journal of Public Transportation, Volume. 5, No 2, page 2)

BRT is defined in a broad sense to include a variety of bus priority treatments that would be an improvement over conventional bus transit such as contra-flow lanes on arterial streets/freeways, reserved curb lanes, limited/skip-stop service, dedicated lanes on local streets without a separated ROW, use of freeway HOV lanes, etc. There are numerous examples of transit systems today using a variety of BRTs that are not busways with exclusive ROW. Los Angeles LACMTA has “The Rapid” which is a limited stop bus operation using curb lanes along one of the busiest thoroughfares in the country. Seattle Metro uses an exclusive underground bus tunnel (with stations) in its downtown region. WMATA buses in the Washington DC metro area and Houston MTA buses use peak-direction HOV lanes shared with other HOVs on a dedicated ROW in the median of freeways. LYNX in Orlando has “Lymmo” which is a downtown circulator that uses a dedicated bus lane on local streets and offers traffic signal priority to buses in the CBD. Similarly, Portland’s Tri-Met employs traffic signal priority but uses two parallel bus-only streets in the downtown area. All of these are forms of bus rapid transit as defined by the Federal Transit Administration though they may not be truly “rapid” in nature.

### 1.4 Busways

One form of BRT which several U.S. transit systems are developing is “busways”. A busway may be defined as a roadway used only by bus vehicles. A busway may or may not have exclusive R-O-W. A busway contains the same elements as defined for BRT and more. It should be noted that busways are the highest type of BRT and not all BRTs are busways. When considering developing a busway, planners should investigate all mode choices available for the specific transit corridor being examined. When rail transit is a potential option, there should be clear justification for proposing a busway (or any other form of bus rapid transit) over rail. The potential benefits for busway must be weighted against those benefits of rail transit. One of the great benefits of busway development is the significantly less capital investment involved when compared to development of a rail system (e.g., the lack of requirement for constructing a special facility to accommodate and maintain railcars). A few metropolitan areas that plan on using some form of rapid transit considered this benefit as one of the prevailing factors for selecting bus over rail. But the advantages of busway development should be more than just considering the cheaper costs. According to a recent Transportation Cooperative Research Program (TCRP) Report, here are some of the principal advantages for choosing the bus option.

- The ability to alter design standards as volumes increase over various segments of a route in accordance with capacity needs (i.e., much greater "staging" or incremental development capability);
- Relatively low capital costs for infrastructure (i.e., no need for track, electrification, and other fixed plant);
- The potential for higher and more flexible types and frequencies of service over different route segments (i.e., capacity need not be constant over the entire route);

- The flexibility to combine feeder (i.e., collector and distribution on local streets) and line-haul services without the need for a physical transfer between vehicles;
- Opportunities to extend service into low-density areas without the need for additional dedicated running ways;
- The capability of being used by a variety of vehicle sizes and types;
- Simpler procurement practices for both construction and vehicles;
- Shorter implantation periods;
- The ability to start construction on key sections first, such as segments that provide congestion relief or are the easiest to build, and still provide integrated service for an entire corridor;
- A variety of competitive vehicle suppliers and less need for conformity in vehicle procurement;
- Less expensive vehicles, even when accounting for capacity and service life differences (TCRP Report #90- BRT: Volume 2- Implementation Guidelines)

Conversely, there are some technical advantages of rail transit over bus transit. Here are some of the advantages as described in the same TCRP report.

- Rail transit has the ability to run high-capacity trains in high-volume corridors;
- Potentially less labor-intensive operation, depending on passenger volumes;
- Greater potential capacity;
- Better levels of service at higher volumes;
- A more positive image on the part of developers and customers;

(TCRP Report #90- BRT: Volume 2- Implementation Guidelines)

Ultimately, transit planners who promote the bus option must clearly identify the numerous benefits offered with busways to the community and all agencies concerned. Though it may initially be a challenge to sell busway development as the best option for a metropolitan area, educating the public that busways can not only be more cost efficient but also be quickly constructed, environmentally friendly, and can promote urban land use. Other potential benefits include reasonable operating and maintenance costs, significant travel time savings as well as high capacities and performance.

This thesis will provide a comprehensive analysis of bus rapid transit focusing on busways with regard to their planning concepts and applications as well as design guidelines. Further, case studies of two busway services in current operation will be performed and reported. The case studies will focus on fully operational busways located in Miami and Pittsburgh.

# 2 HISTORY OF BUSWAYS AND BUS RAPID TRANSIT

## 2.1 Busway Concept is not New

One of the first true busways in this country went into full operation in 1977 in Pittsburgh, PA. But this was not the first busway ever considered. In fact, the busway concept goes back to 1937 when the city of Chicago explored ideas of converting rapid rail transit lines to bus operation via superhighways. The plans were never fully developed due to the lack of capital, but this encouraged other metropolitan areas and transit companies to consider an alternative to the more costly rail option. (Journal of Public Transportation, Vol. 5, No. 2, 2002)

In 1959, the city of Saint Louis considered a circuitous busway (in the clockwise direction) around the downtown area offering better access to several large employment centers in the CBD. Unfortunately, the St. Louis busway plan suffered the same fate as the Chicago busway plan due to the lack of funding. Similarly, Milwaukee developed a transitway plan in the late 1960s which included an east-west busway, but in 1970 this plan was abandoned because of financial constraints. (Journal of Public Transportation, Vol. 5, No. 2, 2002)

In 1969, the state of Virginia constructed the first segment of an exclusive busway called the Shirley Busway which arguably, the first busway built in the United States to divert express buses from congested lanes along Interstate 95 in the Washington, DC, metropolitan area. In 1971, the state had completed all segments of this busway, which ran between Springfield and Arlington, VA along 10 miles of the I-95 corridor. This facility did not have any stations, but rather offered a direct link with bus-only egress/entry ramps along its length. This busway uses the median of I-95. After a few years of operation as a busway, the state of Virginia opted to allow other types of passenger vehicles with three or more occupants to use the Shirley Busway. This was the demise of an all-exclusive roadway for buses in northern Virginia in favor of High Occupancy Vehicle (HOV) lanes. (Shirley Highway Busway/HOV System website, http://www.roadstothefuture.com/Shirley_Busway.html)

Other cities have considered exclusive bus roadways in the past, but there was always a stronger push for rail transit to alleviate problems along congested travel corridors. Historically, bus transit has not been looked upon favorably by local politicians and the general public, primarily because buses always have had an image problem. Buses have been linked to contributing to the road congestion problems in urban areas hence not offering a true transportation alternative to the automobile. Other negative issues surrounding bus transit are the use of antiquated vehicles, poor on-time performance, not enough express/limited stop service, air pollution, and noise. Because of some of these issues, several cities in the 1980s and 1990s opted for the more expensive Light Rail Transit (LRT) alternative. These cities include Baltimore, Buffalo, Dallas, Denver, Hudson-Bergen County (NJ), Portland, Sacramento, St Louis, Salt Lake City, San Diego, and San Jose.  As of spring of 2004, Houston, Minneapolis, and Phoenix also broke ground for brand new LRT operations.

## 2.2 Busways around the World

On the international landscape, busways are currently more popular in several other countries than in the United States. As of 2004, there are many fully operational busway systems in cities around the world such as Adeilade (Australia), Amsterdam (The Netherlands), Bogota (Colombia), Brisbane (Australia), Curitiba (Brazil), Essen (England), Jakarta (Indonesia),  Leeds (England), Ottawa (Canada), Runcorn (England), and Sao Paulo (Brazil). Bangkok (Thailand) is one of several international cities today looking into busways as a less expensive alternative to rail transit.

## 2.3 Recent Busways in USA

Not all U.S. cities have discarded the busway or BRT concept.  Today, there are three metropolitan areas that are currently running busway-type operations.  These are Los Angeles, Miami and Pittsburgh. Los Angeles and Pittsburgh are unique in that they also operate LRT systems.  It is important to note that although Miami names it's bus only transitway the Miami South Busway, it is not 100% exclusive ROW.  Hartford, CT, will be the fourth U.S. city to have a busway which is currently under construction and expected to be fully operational by January 2007.  This brand new 9.4 mile busway in Hartford will use an exclusive ROW-- an active and inactive railroad ROW-- from downtown Hartford to the suburban community of New Britain in the southwest section of the metropolitan area. Hartford is also performing busway feasibility studies for two other heavily used transit corridors in the region since rail transit has proven to be cost-prohibitive for that metro area (New Britain-Hartford Rapid Transit website, http://www.ctrapidtransit.com). Lane Transit District in Eugene, Oregon is planning a BRT network (to be named EmX- Emerald Express) in which segments of a few of these new routes will have exclusive ROW (Lane Transit District website, http://www.ltd.org)

# 3 AVAILABLE GUIDELINES FOR BUSWAY AND BRT APPLICATIONS IN URBAN AREAS

This chapter deals with the planning and design of busways and bus rapid transit including planning concepts, warrants and guidelines for design as suggested by the Transportation Cooperative Research Program and Federal Transit Administration. The reference used is the Transportation Cooperative Research Program, Report #90-BRT: Volume 2- Implementation Guidelines. The discussion is organized in three groups -- planning, warrants, and design. The primary goal, when investigating the applications of a busway, should be to increase peak-period person-capacity as well as provide a fast and efficient form of transit. A busway should penetrate high-density residential areas, serve the Central Business District, and provide convenient distribution to major downtown activities. Also, a busway should be of economic design, offering lower per-mile capital cost when compared to rail transit which is critical because bus transit usually has higher operating costs than rail. The following sections address these and other issues related to busway development.

## 3.1 Planning Considerations

This presents guidelines for the basic planning process, when and where bus rapid transit and more specifically busways, should be considered and identifies some planning principles and objectives. When planning for a busway, it should be included in the overall master transportation plan for a metropolitan area. Before a busway can be developed, an extensive transportation planning process must be undertaken considering all of possible alternatives of modes (e.g., LRT, busway, etc.) to meet the mobility needs for a specific corridor. Planning for busway development requires analysis of the potential level of demand, benefits, cost, and impacts.

Public input plays a key role when it comes to transportation planning. One of the key issues which may adversely impact the early stage of the planning process of busway development is an overall negative perception of bus transit by the public as well as some transit planners. Historically, bus service has been perceived as being of lower quality than rail service. Another issue regarding public perception of bus transit is that buses are viewed as being less environmentally friendly than rail. A busway could also be perceived as not having the same degree of permanence as that of rail since a busway facility does not need rails or any other form of fixed guideway. These and other issues must be adequately addressed when pitching the busway concept to the general public, city planners, and professionals within the transit industry.

It is important to seek local, regional and state cooperation in the planning, development and implementation of a busway. Other major disciplines to be represented in the planning process include traffic engineering, urban planning, safety, and security. There should be an open dialogue between all concerned agencies during the entire planning process.

One of the key issues when considering busway development is finding the most suitable corridor for the transitway in conjunction with available rights-of-way. For example, the rights-of-way of an abandoned railroad may be easy to procure but the location of this ROW may not have the potential of capturing the transit market it is intended to serve. The railroad ROW may be located in a corridor which does not facilitate easy access for transit users, e.g. very little or no available space for a parking facility next to busway station. The same could be said for the development of a busway in a freeway median. The location of a busway in the middle of a freeway may not be easily accessible to many potential transit riders since it may not allow for convenient and safe pedestrian access. The busway should be located in the vicinity of an existing major transit corridor where it could potentially attract the most ridership. It should also offer convenience and safety for pedestrian access.

There must be a realistic assessment of the travel demand, benefits, costs, and impact. The transportation needs must be clearly identified for the transit corridor being considered for improvement. The objective is to quantitatively analyze a transit corridor to determine if it meets the criteria for potential busway development. The following factors should be considered:

1. intensity and growth prospects and patterns of the urbanized area
2. existing and potential future demand for public transportation
3. expansion of the urbanized area
4. street width continuity, capacity, and congestion
5. opportunities for off-street running ways

6. locations of major employment centers and residential developments in relation to potential BRT routes
7. community attitudes -- community willingness to support public transportation can foster transit-oriented development
8. community resources

(TCRP Report #90- BRT: Volume 2- Implementation Guidelines)

After these factors have been adequately addressed, there must then be a determination of what type of treatment, if any, best meets the needs of the transit corridor. In order to perform this, several key questions must be asked. How many buses and bus passengers are currently using the transit corridor during daily and peak periods? What are the projected future transit needs, and are the numbers significant enough to warrant the building of a busway? What are the general traffic flows in this corridor? What are current auto and bus travel speeds? Where are the major points of road congestion? If a busway is developed, will there be a significant travel time savings and reduction in person delay? Also to be addressed are issues concerning roads and rights-of-way that could be used, ways to accommodate buses through the CBD, and needed changes in the use of road space and traffic controls, if applicable.

It is also imperative to consider how busway development reflects regional planning objectives as well as how it relates to and promotes future growth and contributes to redevelopment. It must also be easy to use and provide a strong sense of permanence and identity in order for it to be a viable transportation alternative.

When preparing to present plans for development of a buway, the following factors should be clearly identified:

- Vehicle requirements;
- Horizontal and vertical alignments;
- Geometric design features of the facility such as cross-sections, points of entry/egress, and CBD distribution;
- Station locations and typical designs that show platforms, shelters and structures, passenger amenities, pedestrian access, bus transfer arrangements and parking;
- Fare collection approach, equipment, and facilities;
- Traffic controls and ITS applications;
- Bus operating plans including routing, service span, types and frequencies;
- Provisions for maintenance and enforcement;
- A staging plan;
- Refined cost estimates;
- Opportunities for transit-oriented development near stations

(TCRP Report #90- BRT: Volume 2- Implementation Guidelines)

The busway plan should be developed as an integrated system that has the same characteristics of rail transit- emphasis on major markets, improve speed and reliability and influence transit-oriented development.

### 3.2 Warrants

According to suggested FTA and TCRP guidelines, rapid transit of any type work best in urban areas that have the following characteristics (1) high employment and population density, (2) an intensively developed downtown area with limited street capacity and high all-day parking costs, (3) a long-term reliance on public transport, (4) highway capacity limitations on approaches to the city center and (5) major physical barriers that limit road access to the central business district and channels bus flows. The guidelines go on to suggest that three conditions should be met in order for bus rapid transit to be considered (1) the proposed location is a large city with a strong CBD, an urbanized area or an activity center with dense patterns that facilitate transit use; (2) there are current total passenger flows that might support high service frequencies that are characteristic of rapid transit, and (3) there is sufficient presence of buses where bus lanes or busways are being considered. (TCRP Report #90- BRT: Volume 2- Implementation Guidelines)

Previous case studies performed by the FTA had shown that the need for any form of rapid transit is generally dependent upon the size of the urban area, the concentration of population and activities in key transit corridors and the strength of the CBD. Those case studies, based on cities in Canada and the United States, have shown that most bus rapid transit systems are found in cities that have more than 750,000 people and downtown employment exceeds 75,000 people. See Table 3.1 for more details regarding ideal conditions for the consideration of rapid transit. The possible exceptions to this would be

**Table 3.1** Ideal Conditions for Rapid Transit Development- Design Year

| PRIMARY DETERMINANTS | RAIL | RAIL OR BUS | BUS (MINIMUM) |
|---|---|---|---|
| Urban Area Population | 2,000,000 | 1,000,000 | 750,000 |
| Central City Population | 700,000 | 500,000 | 400,000 |
| Central City population density, in people/sq mile | 14,000 | 10,000 | 5,000 |
| High-density corridor development | Extensive and clearly defined | Limited bus defined | Limited but defined |
| CBD Function | Regional | Regional or Sub-regional | Regional or Sub-regional |
| CBD floor space (sq ft) | 50,000,000 | 25,000,000 | 20,000,000 |
| CBD employment | 100,000 | 70,000 | 50,000 |
| Daily CBD destinations/sq mi | 300,000 | 150,000 | 100,000 |
| Daily CBD destinations per corridor | 70,000 | 40,000 | 30,000 |
| Peak-hour cordon person movements leaving CBD (four quadrants) | 75,000-100,000 | 50,000-70,000 | 35,000 |

Source: Center City Transportation Project: Urban Transportation Concepts, 1970 smaller cities which have unique factors that may be favorable to BRT, to include busways. Some of those factors may be major physical or topographical limitations as well as large employment centers or other special activity centers like major medical facilities and universities. The availability of inexpensive rights-of-ways and rapid urban growth may be other factors which may warrant the development of bus rapid transit. See Table 3.2 for details regarding the summary of warrants for busway development for three different alignments; special right-of-way, freeway median, and railroad right-of-way.

In order for a busway or any other form of BRT to be attractive, one of the key factors for its success is the frequency and span of service. It is recommended that bus service frequencies on a busway should be 8 to 10 minutes during peak hours and 12 to 15 minutes during off-peak hours. The span of service should be at least 16 hours a day. According to the study, these frequencies should translate into daily ridership of at least 5,000 riders. When bus rapid transit operates on local streets with non-BRT bus routes, the combined daily ridership should be approximately 10,000. Converging routes that have overlapping service should operate at 2 to 4 minute headways during peak periods and every 5 to 6 minutes during off-peak.

**Table 3.2** Summary of Warrants for Busway Development

| | **Planning Period (years)** | **Express Bus Volume (design yr range in one-way peak-hour** | **Bus Passenger Volume (design yr range in one-way peak-hour** | **Desired Avg. Peak-hour bus time savings (min/bus)** | **Basic land-use parameters** | **Other relevant conditions** |
|---|---|---|---|---|---|---|
| Special right-of-way | 10-20 | 40-60 | 1,600-2,400 | 5 | Urban population, 750,000; CBD employment-50,000; floor space, 20 million sq ft | Stations required. Within CBD, bus speeds under 6 MPH; and/or CBD over 1 sq mile in area |
| Freeway median | 10-20 | 40-60 | 1,600-2,400 | 3 | | Freeway congested, ramp metering insufficient, contra-flow lane not feasible. Stations required |
| Railroad right-of-way | 10<br>10 | 20-30<br>40-60 | 800-1,200<br>1,600-2,400 | 3-5<br>2-3 | | Existing unused RR grade available. Stations required |

Source: National Cooperative Highway Research Program: Bus Use of Highways Planning and Design Guidelines, 1975

## 3.3 Design Guidelines

There are two important components of busway or BRT design, running ways and busway stations/facilities. The running ways for a busway having exclusive right-of-way should allow for rapid and reliable movement of buses and provide a clear sense of presence and permanence. Ideally, the access controlled roadway should offer an operating environment where buses do not have interference from other vehicular traffic as well as provide superior transit service when compared to traditional bus operations that operate on local streets intermixing with other traffic. Busway stations should be convenient, comfortable, safe, and accessible to passengers with disabilities. These facilities should have a strong sense of identity to the community in which it serves as well as a sense of permanence.

## 3.4 Running Ways

There are three basic service components regarding running ways – CBD distribution, line haul and neighborhood collection. The CBD distribution should allow buses to penetrate local streets in close proximity to major employment centers within the downtown area. Line haul routing should provide fast access leaving the CBD to outlying commercial and residential communities with minimum or no interference from other traffic. Neighborhood collection should allow for easy access to transit within suburban communities. The objective is to offer transit users a one-seat ride from origin to destination on a full access controlled roadway without the need for physically transferring to other transit vehicles. For the purposes of this thesis, running way classification of Class I-Uninterrupted Flow-Full Control of Access will be discussed and recommended although there will be discussion of Class II-Partial Control of Access. See Table 3.3 for details regarding classification of running ways.

Pittsburgh East-MLK Busway is classified as a Class I running way because it is a fully grade-separated busway. Miami South Busway is classified as Class II as it is an at-grade busway and offers only partial control of access because the roadway facility has many intersecting roads which cross the transitway.

**Table 3.3** Running Ways Classified by Extent of Access Control

| **Class** | **Access Control** | **Facility Type** |
|---|---|---|
| I | Uninterrupted Flow- Full Control of Access | Bus Tunnel<br>Grade-Separated Busway<br>Reserved Freeway Lanes |
| II | Partial Control of Access | At-Grade Busway |
| III | Physically Separated Lanes within Street Rights-of-Way | Arterial Median Busway, Bus Streets |
| IV | Exclusive / Semi-Exclusive Lanes | Concurrent and Contra Flow Bus Lanes |
| V | Mixed Traffic Oeprations | |

Source: TCRP Report #90-BRT-Volume 2 – Implementation Guidelines

According to TCRP based upon FTA suggested guidelines, here are the guidelines which should influence location and design of running ways with regard to busways or BRT:

- Running ways should serve major travel markets and they should penetrate these markets whenever possible
- Running ways generally should be radial, connecting the city center with outlying residential and commercial areas
- BRT is best achieved by providing exclusive grade separated rights-of-way to serve major markets
- Effective downtown passenger distribution factilities are essential in providing direct BRT service to downtown trip origins and destinations
- BRT running ways should follow streets that are relatively free flowing whenever possible
- Special running ways (busways, bus lanes, and queue bypasses) should be provided
- Preferential treatment for buses may be provided around specific bottlenecks or along an entire route
- Running ways should maximize the person flow along a roadway with minimum net total person-delay over time
- An exclusive bus lane should carry significantly more people than an adjoining general traffic lane used during the the peak travel periods

- Buses should be able to enter and leave running ways safely and conveniently
- Running ways should provide a strong sense of identify for BRT
- Adequate signing, marking and traffic signal controls are essential
- Bus lanes and queue bypasses may be provided along both one-way and two-way streets
- Running way designs should be consistent with established national, state and local standards
- Running way designs may allow possible future conversion to rail transit without disrupting BRT operations
- Running ways can be shared by BRT and LRT when they are designed to accommodate both transit types in terms of cross section, curves, grades and vertical clearance

(TCRP Report #90- BRT-Volume 2, Implementation Guidelines)

When considering the type of running way for busway design, costs may be a major factor in the decision making process. In fact, it was costs that forced the hands of Miami MDTA to decide that the South Busway would be an at-grade semi-access controlled busway versus a fully grade-separated busway. According to the FTA, the costs involved for a fully grade-separated busway facility are as follows:

Cost (not including ROW)

- Aerial Transitway - $12-30 million per lane mile
- Below-grade Transitway - $60-105 million per lane mile

- Additional Lanes: $2.5-3 million per lane mile (within existing roadway profile); $6.5-10.12 million per additional lane mile

The costs for an at-grade busway are approximately $6.5-10.2 million per lane mile. This figure does not include the cost of acquiring right-of-way. (Project No. FTA-VA-26-7222-2004.1, Characteristics of Bus Rapid Transit for Decision-Making, August 2004)

The following table offered by the Transportation Research Board-Natioinal Research Council provides some general guidelines for running way design for fully-grade separated busway and at-grade busways with intersections. See Table 3.4 "Suggested Busway Design Criteria" for more details regarding specific design criteria.

### 3.5 Busway and BRT Stations

Busway and BRT station design is an important feature of any BRT system. The stations must have a unique identity that differs from stops used by conventional bus operations. The station design must integrate with the local character of the corridor served and be easily recognizable to transit users. The station design must demonstrate unique characteristics that identify with speed and reliability. This is very important because the premise is to offer a superior product which differentiates itself from traditional bus services. Ideally, busways and BRT are developed to not only accommodate existing transit users in a corridor but also attract new customers.

**Table 3.4** Suggested Busway Design Criteria

| ITEM | FULLY GRADE SEPARATED | AT-GRADE |
|---|---|---|
| Design speed (mph) | | |
| Desirable | 70 | 50 |
| Minimum | 50 | 30 |
| Lane width (ft) | | |
| With paved shoulders | 12 | 11-12 |
| Without paved shoulders | 13 | 13 |
| Paved shoulder width (ft) | 8-10 | 6-8 |
| Total paved width-normal flow (ft) | 26-44 | 24-40 |
| Minimum viaduct width (ft) | 28 | 28 |
| Minimum tunnel width (ft) | 31 | 31 |
| Minimum vertical clearance (ft) | | |
| Desirable | 14.5-18 | 14.5 |
| Absolute minimum | | 12.5 |
| Minimum latitude dist. To fixed obstructions (ft) | | |
| Left | 3.5 | 2 |
| Right | 6 | 3 |
| Maximum super elevation (ft/ft) | .08 | .08 |
| Min. radius of horizontal curves (ft) | | |
| 70 mph | 1600 | 1600 |
| 60 mph | 1150 | 1150 |
| 50 mph | 750 | 750 |
| 40 mph | 450 | 450 |
| 30 mph | 250 | 250 |
| Absolute min. radius (ft) | | |
| Convertible to conventional rail | 250 | 250 |
| Convertible to LRT | 100 | 100 |
| Non-convertible | 30 | 30 |
| Maximum gradients (%) | | |
| Desirable | | |
| Convertible to rail | 3-4 | 3-4 |
| Other | 5 | 6 |
| Ramps, up | 6 | 7 |
| Ramps, down | 7 | 8 |
| Absolute | | |
| Main Line | 8 | 8 |
| Ramps | 10 | 10 |
| Ramps | | |
| Design speed (mph) | 30-35 | 15-25 |
| Lane width w/shoulders (ft) | 12 | 12 |
| Lane width w/o shoulders (ft) | 14 | 13 |
| Paved shoulder width (ft) | 8 | 8 |
| Total paved width (ft) | 14-22 | 13-20 |

Source: National Cooperative Hwy Research Program Report 155-Bus Use of Highways

Busway or BRT stations may be simple or sophisticated in design. The more features a station offers, the greater the potential to attract new riders. Some BRT systems have basic transit stops which may offer nothing more than a bus shelter. This is common with those systems which run simple limited-stop services. Enhanced stops may include a more elaborate bus shelter with lighting and offer basic amenities like benches, pay phones and trash cans. Two examples of BRT systems with enhanced stops would be LACMTA "The Rapid" in Los Angeles, CA and PAT South Busway in Pittsburgh, PA. A designated station may have platforms for level boarding and deboarding as well as a full range of amenities for passengers such as printed transit information and perhaps retail services. PAT East-MLK Busway in Pittsburgh, PA has designated stations along its transitway. A transit center or intermodal terminal is a more elaborate facility with numerous types of enhanced services such as a customer service desk. Such larger facilities could accommodate numerous bus routes, rail transit and intercity bus and rail. The costs for BRT stops will vary according to number of features and amenities offered. The most basic stop with only a shelter may cost from $15,000 to $20,000 per shelter. The most advanced transit center may run upwards of $5 million $20 million for the facility. (Project No. FTA-VA-26-7222-2004.1, Characteristics of Bus Rapid Transit for Decision-Making, August 2004)

Busway stations should be adequately spaced apart in order to achieve high operating speeds as well as minimize travel times. This is one of the primary advantages of BRT over traditional bus services and this should be exploited whenever possible. Depending upon arrival mode of transit users will depend on busway station distances. For those stations which are closer to the urban center, and where pedestrian access is more prevalent, it is suggested that station spacing should be between .25 and .33 miles apart. If the primary arrival mode is by transferring from another bus, .5 to 1.0 miles is recommended. For transit users who drive an automobile to a park and ride lot near a busway station, 2.0 miles is suggested.

The following is a detail of busway station features which will vary according the needs of the transit corridor and costs. Sources used are TCRP Report #90- BRT-Volume 2, Implementation Guidelines and Project No. FTA-VA-26-7222-2004.1, Characteristics of Bus Rapid Transit for Decision-Making.

Platform height is determined by height of the curb at the leading edge of the platform. There are three basic platform height options: standard curb, raised curb and level platform. Standard curbs have a vertical height of approximately 6 inches, raised curbs have 9-10 inches and level platforms with 14 inches. Level platforms are most ideal as they offer ease of boarding and alighting standard high floor transit vehicles. For busway systems using low floor buses, a standard curb would be sufficient.

Platform length with a single berth typically has 60 feet in length when conventional 40 foot buses are used. Busway station platforms can be 300 feet or longer if there is a need to accommodate multiple articulated buses. Penn Station on the East-MLK Busway in Pittsburgh, PA has a busway platform length over 300 feet.

A busway station should be designed to offer passing capability for express buses or when there is a frequent level of service in which buses may form long queues at stations during peak periods. Buses can pass stations by either having a passing lane or a lane which offers bus pull-outs.

Station access is another important factor which determines pedestrian accessibility and/or linkages to a nearby park and ride facility. Pedestrians should be able to access busway stations by sidewalks and pedestrian bridges, whenever possible. There should be a pathway by pedestrian bridge or another type of path for easy access to area park and ride facilities. It is important that the busway station has a safe design so to not encourage pedestrians from crossing the active transitway.

A busway station should also provide a secure environment by offering adequate lighting as well as easily identifiable emergency phones. Stations should be illuminated well in order to avoid any dark areas on station platforms. Closed-circuit television monitoring and/or police surveillance on foot patrol may be ideal if not too cost-prohibitive.

# 4 CASE STUDIES – PITTSBURGH, PA and MIAMI, FL

## 4.1 PITTSBURGH, PA

Pittsburgh, Pennsylvania is the first city in the United States to have a fully operational busway network. With a population of 1,400,000 in the metropolitan area, Pittsburgh currently has three busways operating along 19 miles of dedicated roadway, serving a few of the heaviest transit corridors in the region. The transit authority has plans to expand the busway network by providing busways along other important transit corridors which are currently served by only traditional local/express bus service.

### 4.1.1 Port Authority of Allegheny County (PAT)

The Port Authority of Allegheny County (PAT) is the primary agency operating mass transit service for the metro Pittsburgh area, which includes most of Allegheny County as well as portions of neighboring Armstrong, Beaver, Washington and Westmoreland Counties. With a service area of over 730 square miles, PAT operates 1000 buses (standard, articulated, and over-the-road motor coaches), 83 light rail vehicles, 2 incline cars and over 450 paratransit vehicles. PAT operates the Monongahela Incline, a private organization operates the 2 cars running on the Duquesne Incline. Systemwide average weekday ridership (for all modes) is 230,000. Weekend ridership is 108,000 for Saturdays and 63,000 for Sundays. Annual ridership for 2003 was approximately 68 million. (Port Authority of Allegheny County General Statistics website, http://www.portauthority.org)

Before the creation of the Port Authority of Allegheny County, there was a variety of transit services operated by numerous private bus and rail companies. In the spring of 1964, PAT took over most of these bus and rail operations to promote a more cohesive transportation network in the metropolitan Pittsburgh area. In the mid-1970s, PAT began exploring ways to improve the service for commuters traveling between the central business district and the suburbs in the southern region of the metropolitan area. In 1977, PAT opened its very first access controlled bus roadway, called the South Busway. Before the development of Pittsburgh's first busway, traditional bus service operated primarily on local surface streets and thereby was subjected to the same traffic conditions as other vehicles. To ease the gridlock problems between suburbs to the south and the central business district, the South Busway seemed to be an attractive alternative. The South Busway was followed by the East Busway and then the West Busway.

### 4.1.2 South Busway

The first phase of the busway network included a dedicated bus roadway with connection to a railroad tunnel through Mount Washington. The railroad tunnel, which was used by the old streetcar network, was modified to accommodate rubber-tired vehicles as well as maintain the trackage for joint use with rail transit. Both buses and light rail operate in tandem through the Mount Washington tunnel as well as along the busway for the first few stations. No local vehicular traffic is authorized to use of tunnel, except for emergency vehicles. This makes the South Busway unique because the other two busways in the network do not have rail operations along any portion of the roadways.

PAT transit buses exit the central business district using the Smithfield Street Bridge over the Monongahela River to Station Square LRT station, then proceeding through Mount Washington Tunnel and continuing to the South Busway onto suburban destinations. Sixteen PAT bus routes use the South Busway to serve residential areas such as Baldwin Township, Bethel Park, Brentwood, Knoxville, and Mount Oliver. Not all buses traveling via Mt Washington Tunnel use the South Busway. A private suburban operator, Mid-Mon Valley Transit Authority (MMVTA), also utilizes the Mount Washington tunnel and South Busway to reach the more outlying suburbs of Donora, Charleroi, and Spears in Washington County.

The South Busway has a total of 11 stations operating along 4.3 miles of roadway. Many of these stations are basic stops for boarding/alighting without having typical busway station features found in the rest of the network. All South Busway stations have side platforms. The busway has one lane per direction with several stations accommodating both bus and rail vehicles. Bus lane width is 12 feet wide. The South Busway is not exclusive ROW on all portions of the transitway. There are segments of the busway which have intersecting streets which cross the busway facility.

There are a total of 552 weekday bus trips with an approximate ridership of 11,000. The construction cost of the South Busway was $27 million for 4.3 miles of length. (Port Authority of Allegheny County website, http://www.portauthority.org)

### 4.1.3 East Busway (aka Martin Luther King, Jr. Busway)

The next busway built in Pittsburgh after the South Busway was the East Busway (now renamed Martin Luther King, Jr. East Busway), which opened in early 1983. This busway was constructed along the abandoned Pennsylvania Railroad right of way serving the busiest transit corridor in metropolitan Pittsburgh. Two tracks were removed for busway construction. A total of 36 bus routes use this busway, reaching the most densely populated areas of Pittsburgh where transit dependent ridership is greatest.

The original premise for the East Busway was to construct it so that later it could possibly be converted to light rail transit operations, contingent upon demand. Since ridership levels have far exceeded original estimates, plans are still in place for eventual conversion to light rail when funds become available.

Because of supportive local policies regarding land use in the eastern region of the city, the East Busway has proven to be a big success. After the opening of the East Busway, there has been a lot of new development near and around busway stations. Numerous shopping centers have sprung up as well as new commercial office buildings and apartment complexes. The busway allows easy continuous access to these newly developed centers without requiring transit users to transfer between different bus routes. As a result of all of this new development, the East Busway has been able to enjoy significant ridership gains over the years because this busway is not only used for commuter trips but also other types of transit trips.

The East Busway facility begins at Penn Station in the western section of downtown Pittsburgh and operates to the east through many of the large commercial and residential areas of East Liberty, Homewood, Wilkinsburg and Swissvale. The East Busway has a total of nine stations and operates along 9.1 miles of access controlled roadway for buses exclusively. 6.8 miles opened in 1983, another 2.3 miles opened in summer 2003. All East Busway stations have side platforms. The busway has one 12 foot lane per direction with a center passing lane at stations for limited-stop/express bus routes. The construction cost of the busway (without extension) was $115 million (with extension, an added $68 million for the 9.1 miles of length). There are a total of 973 bus trips with an average weekday ridership of nearly 30,000. Several of the busway stations have commuter park and ride lots adjacent to stations. (Port Authority of Allegheny County website, http://www.portauthority.org)

### 4.1.4 West Busway

The most recent busway built in Pittsburgh is the West Busway, which opened, in late 2000. This busway primarily serves the less densely populated suburban communities of western Pittsburgh. One of the greatest features of this busway is having the new faster link between downtown Pittsburgh and Pittsburgh International Airport. A bus trip to the airport from downtown now takes only 40-minutes, causing stiff competition with taxi services which offer similar trip times. Before the opening of the West Busway, there was sporadic transit service from the airport to the central business district. Today, PAT bus route “28X-Airport Flyer” offers frequent (and rapid) service between the airport and downtown Pittsburgh with continuing local service to business, hospital, and university districts in Oakland. In fact, it is route 28X, which made the West Busway a success, having the highest ridership of any other route along this busway. Also serving the West Busway are routes “100-West Busway-All Stops” and “33X-West Busway Downtown-All Stops”. Route 100 runs weekdays only whereas route 33X runs weekday peak periods and weekends. PAT bus route 28X travels most of the West Busway and then connects with I-279 Parkway West Expressway which leads to airport. Bus routes 100 and 33X operate along the entire length of the the busway between Carnegie and Sheraden Stations.

The Port Authority of Allegheny County anticipates that the new West Busway will experience significant ridership gains in the future because the busway alignment runs through several areas of metropolitan Pittsburgh which are slated for new development as a result of local policies in support of mixed land use for commercial development. In fact, it was part of the planning process for the West Busway to be located in a corridor which could promote future growth. The busway stations were strategically placed at locations along the transitway where there is the greatest potential of future commercial and residential development (Interview- Richard Feder, AICP, PAT, Mar. 2003)

The West Busway begins near West Carson Street along the Ohio River, opposite downtown Pittsburgh, travels through the Berry Street Tunnel and terminates near the community of Carnegie. Part of the busway uses existing (and abandoned) Conrail railroad rights of way. The busway has a total of six stations along 5 miles of exclusive roadway for buses and there is one lane per direction of travel. The construction cost of this facility was $258 million for the 5 miles of length. There are a total of 391 bus trips per weekday with an average ridership level of just over 9,500. The West Busway also hosts commuter park and ride lots adjacent to most of its busway stations (Port Authority of Allegheny County website, http://www.portauthority.org). See Table 4.1 "General Statistics of Busways in Pittsburgh" for summary of details for three busways in Pittsburgh, PA.

**Table 4.1** General Statistics of Busways in Pittsburgh, PA

| | **South Busway** | **East Busway (MLK)** | **West Busway** |
|---|---|---|---|
| **Year opened** | 1977 | 1983 | 2000 |
| **Construction cost (millions)** | $27 | $115 (first segment) | $258 |
| | | $68 (extension) | |
| **Length of facility (miles)** | 4.3 | 6.8 | 5 |
| **# of stations/stops** | 11 | 9 | 6 |
| **# of bus routes** | 16 | 36 | 11 |
| **Weekday trips** | 552 | 973 | 391 |
| **Average weekday ridership** | 11,000 | 30,000 | 9,500 |

### 4.1.5 Future Outlook for Rapid Transit in Pittsburgh

As mentioned previously, PAT is evaluating other potential transit corridors to build more busway type facilities to improve the mobility of buses from the CBD to outlying communities and suburbs. However, recent problems with cuts in funding at the state level has forced PAT to consider reducing existing levels of transit service. There are no new plans for expanding the busway network with the exception of those plans that already have dedicated funding. In the meantime, PAT is still performing various transportation studies, exploring a variety of transportation options for the metropolitan area. Some of these studies include other forms of rapid transit. In the Airport Multimodal Corridor Major Investment Study, there is serious consideration for LRT (versus bus transit) to better serve the communities to the west of Pittsburgh. The North Shore Connection study focuses on the continuation of LRT services via subway tunnels under the Allegheny River for improved access to this growing region which hosts large sporting facilities as well as numerous redeveloped areas.

## 4.2 MIAMI, FL

Like many large metropolitan areas in the United States, Miami, FL has been exploring various ways of improving the movement of people throughout the metro area. Miami, FL is the 16$^{th}$ largest metropolitan area in the U.S. with a population of just under two million inhabitants. The Miami metro area has historically been plagued with severe traffic problems due to the continued surge in population growth. Major roadways as well as the numerous causeways crossing the Intracoastal Waterway to Miami Beach operate at capacity. Local downtown Miami streets also have become heavily congested due to a dramatic increase of businesses and commercial development. There are not enough existing freeways to adequately serve all of these regions of Dade County and it is nearly impossible to build more roadways because of the limitation of available space. Transportation planners in South Florida have examined many ways of easing the daily traffic congestion problem in metropolitan Miami and have realized that the best option for improving mobility is to invest more in mass transit.

### 4.2.1 Miami-Dade Transit Authority (MDTA)

The Miami-Dade Transit Authority (MDTA) is the primary operator of public transit services in the Miami area, which includes all of Dade County as well as the beach communities to the east and the southernmost portion of Broward County to the north. The MDTA has a service area of over 350 square miles. The transit system operates 830 buses (standard, articulated, and minibuses), 136 heavy rail vehicles (Metrorail), 29 fully-automated people-mover vehicles (Metromover), and nearly 200 paratransit vehicles. Systemwide average daily weekday ridership for all modes is approximately 350,000. Average weekend ridership is 200,000 for Saturdays and 155,000 for Sundays. Total annual riderhsip (which includes total boardings for paratransit ambulatory and non-ambulatory services) for FY 2003 was approximately 87 million. It is important to note that the total annual transit ridership in Miami has been steadily increasing over the last decade. (MDTA Facts at a Glance; MDTA System Performance Summary; National Transit Database)

The MDTA currently operates transit services 24 hours a day, seven days a week. The transit system operates fixed route services on 92 local/express/limited-stop bus routes, one rapid rail line (Metrorail) and three downtown circulator (Metromover) routes which operate on an elevated guideway. There are eleven local bus routes, three dedicated "night owl" bus routes and paratransit services that operate 24 hours a day.

After the removal of the last streetcar lines in the fall of 1940, the only transit service available for several decades was traditional bus. Under the old MTA, the route structure was not set up to offer much limited-stop or express service and so buses were slow, overcrowded and inefficient. More people opted to use their private vehicles as an alternative to undependable bus transit. Consequently, ridership levels plummeted to all-time lows during this period (Motor Coach Age-Miami, Nov 1971). After the formation of the MDTA, the transit authority explored various ways to attract people back to mass transit. The only way to do this was to offer a product that is far superior to transit services that were offered in the past. Commuters needed to have an attractive alternative that was more than traditional bus service.

### 4.2.2 Birth of Rapid Transit in Miami

In 1984, the MDTA opened it's very first rapid rail line called Metrorail. Two years later, the MDTA made another improvement by opening Metromover, the downtown circulator built to improve mobility within the CBD. The Metromover was also designed to offer a free connection for Metrorail passengers who need access to parts of the downtown area in which Metrorail does not serve. Metromover is a "people mover" system with vehicles of 60 passenger capacity and it operates in an automated manner. Metrorail operates along an elevated 22.4-mile heavy rail line from the northern section of Dade County (Hialeah), through downtown Miami and onto the south county region of Dadeland. Like many other transit systems despite high hopes of adding or extending existing rail service, the MDTA was financially unable to build more rail lines. The problem with this situation is that the South Dade County area has been developing in leaps and bounds and current Metrorail service is not able to adequately serve these growing communities because its current southern terminus does not extend to this region. The MDTA originally had the idea of extending the existing rail line beyond the Dadeland-South station along US Route 1. However, due to financial constraints, it was unable to find adequate funding for future construction. As a consequence, the MDTA had to become more industrious in finding alternative ways of providing a less costly but efficient rapid transit service to connect Metrorail to these densely populated communities. Historically, only local bus lines served this region via congested local streets. These local buses are subjected to the same traffic conditions as all other vehicles on the road hence, and thus there is no real time saving advantage for commuters. The MDTA wanted to find a way to offer bus service from these south Dade County communities to the closest Metrorail station by bypassing congested roadways. The MDTA's answer to this complex problem was the development of a bus-only controlled access roadway called the South Busway.

### 4.2.3 Introduction of the South Busway

The South Busway is a semi-access controlled at-grade roadway which operates along the old Florida East Coast (FEC) railroad right-of-way. The Florida Department of Transportation and Federal Transit Administration deemed it cost prohibitive to develop an elevated roadway for buses in this corridor. Because of the existing unique roadway configuration in this corridor, it was impossible to construct the busway to avoid cross roads intersecting at-grade with the transitway. The busway is located directly parallel to a major national highway, Hwy US 1 (Dixie Highway) to the east. Most sections of the South Busway are only 100 feet from Dixie Highway, the most heavily traveled corridor in Dade County. Because of the close proximity to this busy thoroughfare, there are many intersecting roads that cross the alignment. There are no overpasses to avoid conflict with the transitway so traffic signals are located at each of these intersecting roads. Currently, traffic signal pre-emption (using loop detectors) is disabled for safety reasons due to numerous crashes between buses and cars which resulted in three deaths thus far. Traffic signal operation on the busway is coordinated with traffic signals on Hwy US 1. When Hwy US 1 has a "green" light, all westbound turning traffic has a "red" turn signal. During this phase, any bus on the busway will come to a complete stop as it approaches the intersecting road. If the light is "green" for Hwy US 1, then the light for the bus at the intersection on the busway will turn from “red” to “green”. The bus would then proceed slowly (15 mph) through the intersection. If there is a “red” light on Hwy US 1, all busway traffic must come to a complete stop and wait until the light for the highway cycles back to “green”. Because transit buses operating along the transitway have to stop at not only busway stations/stops but all traffic signals as well if the light is red, this impedes the performance of the busway since transit vehicles are frequently stopping at locations other than stations. Bus travel times have now increased by 8-10 minutes as a result of the frequent stopping at traffic lights along the transitway. The South Busway is not truly rapid in nature though, it is an improvement over traditional local bus service. However, the MDTA is currently investigating the issue and may have a remedy soon by reintroducing traffic signal pre-emption to improve bus travel times along the South Busway (Interview- Joe Peres, MDTA, Feb 2006).

### 4.2.4 South Busway - Phases I and II

The MDTA opened the first 8.2 mile segment (Phase I) of the South Busway in early 1997. This initial segment is from the Metrorail Dadeland-South terminus to SW 200 Street in Cutler Ridge. Next, Phase II includes two segments, a 5-mile segment extending to SW 264 Street in Naranja and a 6.5-mile segment to it’s terminus at SW 344 Street in Florida City. The 5-mile long first segment of Phase II became operational in 2004. The second segment of Phase II should be completed in late 2005. Thus far, there are a total of 22 stations along 13.2 miles of busway. Upon completion of the entire

South Busway, there will be a total of 30 stations along the transitway with a total length of 19.8 miles.

The cost for the first 8.2 miles of the busway was $21 million plus $17 million for the purchase of the Florida East Coast Railroad right-of-way (for the entire length of the transitway). It is estimated that the total cost for the entire 19.8 mile long busway from Dadeland to Florida City will be approximately $43 million. The busway alignment is 100 feet wide with two 12-foot lanes – one for each direction. At each busway station, there are passing lanes to allow for express busses to pass during peak periods. Every station could support a maximum of three standard length buses per direction. Busway stations do not contain ITS elements or enclosed waiting areas but many have open shelters, benches, posted maps/route frequency tables and public phones. As of this writing, many busway stations have been severely damaged by the affects of Hurricane Wilma. The hurricane had torn the plastic coverings off shelter canopies as well as swept away posted bus route frequency tables and maps. The transit agency plans to refurbish the affected busway stations sometime in the near future.

### 4.2.5 South Busway - Travel Times, Frequencies and Routes

Current bus travel times from the Dadeland-South Metrorail station to SW 200 Street/Cutler Ridge busway station is 25 minutes. Travel times from Dadeland-South to SW 264 Street station is approximately 40 minutes. The total travel time to the final busway station at Florida City is expected to be just less than 60 minutes (significantly less than local bus service which could take up to 2.5 hours with transfers). The MDTA has plans to improve these bus travel times by reducing dwell times at busway stations and reintroducing traffic signal pre-emption at intersections.

The South Busway is a roadway exclusively for buses with the exception of emergency vehicles. The busway could also be used as an evacuation route in the event of a natural disaster or other emergency. Nine MDTA bus routes currently have service on at least some portion the South Busway but only the Busway Local (#31), Busway Flyer (#34) and Busway Max (#38) operate on most of the facility. Refer to figures in Appendix for specific details on routing. "Busway Max" is the only route that operates 24-hours a day on the South Busway. Service frequencies of routes operating on the busway vary by time of day and day of week. On average, bus frequencies during weekday peak periods are 3-10 minutes. Headways for overnight owl service are 60 minutes. For more details regarding frequency of service along the South Busway, refer to Table 4.2 "Bus Frequency Table for Miami South Busway."

For all routes combined, there are approximately 12,500 boardings each weekday and 13,600 for both Saturday and Sunday, totaling to just over 75,000 riders per week, far exceeding projected ridership estimates. Ridership along the South Busway continues to grow each month as it gains in popularity amongst South Dade County commuters.

**Table 4.2** Bus Frequency Table for Miami South Busway

| | WEEKDAYS | | | | | SATURDAYS | | | | | SUNDAYS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Route** | am pk | midday | pm pk | nights | | am pk | midday | pm pk | nights | | | midday | pm pk | nights |
| **1** | 20 | 40 | 20 | 60 | | 40 | 40 | 40 | 60 | | 60 | 60 | 60 | 60 |
| **31** | 15 | 30 | 15 | 35 | | 30 | 30 | 30 | 35 | | 30 | 30 | 30 | 35 |
| **34** | 18 | - | 18 | - | | - | - | - | - | | - | - | - | - |
| **35** | 30 | 30 | 30 | 60 | | 30 | 30 | 30 | 60 | | 30 | 30 | 30 | - |
| **38** | 15 | 30 | 10 | 30 | | 20 | 20 | 20 | 30 | | 20 | 20 | 20 | 30 |
| **52** | 30 | 30 | 30 | 60 | | 30 | 30 | 30 | 60 | | 30 | 30 | 30 | 60 |
| **65** | 30 | - | 30 | - | | - | - | - | - | | - | - | - | - |
| **252** | 15 | 30 | 15 | 30 | | 30 | 30 | 30 | - | | 30 | 30 | 30 | - |
| **287** | 24 | - | 24 | - | | - | - | - | - | | - | - | - | - |

Service frequencies are approximate
AM peak denotes morning inbound trips
PM peak denotes afternoon outbound trips
Route 38 perates 24 hours per day, 7 days per week
Data derived from individual MDTA bus schedules

### 4.2.6 Future Outlook for Rapid Transit in Miami

It should be pointed out that in addition to the South Busway, there are many other exciting prospects for Miami's future in terms of mass transit improvements, which include plans for the development of additional Metrorail lines as well as re-introducing electric streetcars in the downtown area. Several transit corridors are currently being evaluated for best mode choice (bus, heavy rail, light rail, and/or streetcar) that will meet the needs for the region. The most important corridor needing immediate attention is Flagler Street, which has the most heavily used bus route in the entire MDTA system. Typical monthly ridership on bus routes 11 (local) and 51 ("Max" limited stop) is over 500,000 yet only traditional bus service is available in this corridor today.

A more complex situation arises with improving access from downtown Miami to Miami Beach. A large waterway --the Atlantic Intracoastal -- separates the two cities and presents an interesting challenge for transportation planners who would want to improve existing transit services to this region. The MDTA has been considering light rail as an option to be constructed in the median of the McArthur Causeway, but there are numerous opponents who do not want the disruption of vehicular traffic on the cities' most heavily used causeway. Some form of bus rapid transit (for example, limited-stop service) may be a better alternative for Miami Beach as it is much easier and faster to design and implement.

Table 4.3 represents the busway service hours for both Miami and Pittburgh systems. Table 4.4 illustrates a comparison chart of the Miami busway and the most heavily used busway in Pittsburgh, East MLK, Jr. Busway. Table 4.4 offers an overall summary of the differences between both busway systems with regards to operations, service frequencies, fare collection method, roadway characteristics, vehicle types used, and busway station features.

**Table 4.3** Busway Service Hours for Miami and Pittsburgh

| | **Weekdays*** | **Saturdays*** | **Sundays*** |
|---|---|---|---|
| | | | |
| **Miami South Busway** | 24 hours | 24 hours | 24 hours |
| **Pittsburgh East-MLK Busway** | 5:00am-12:45am | 5:15am-12:45am | 5:15am-12:45am |
| **Pittsburgh West Busway** | 5:00am-12:10am | 5:00am-12:10am | 5:00am-12:10am |
| **Pittsburgh South Busway (bus)** | 5:00am-1:00am | 6:00am-1:00am | 6:00am-1:00am |
| **Pittsburgh South Busway (rail)** | 4:30am-1:00am | 5:00am-1:20am | 5:15am-1:05am |
| **These are approximate service hours* | | | |

Data source: Published schedules from PAT-Pittsburgh and MDTA-Miami

**Table 4.4** Busway Characteristics: Pittsburgh-East Busway vs. Miami-South Busway

| | **PITTSBURGH-EAST MLK BUSWAY** | **MIAMI-SOUTH BUSWAY** |
|---|---|---|
| **Busway length (miles)** | 9.1 | 13.2 |
| **Total number of stations** | 9 | 22 |
| **Max operating speed (mph)** | 55 | 45 |
| **Avg operating speeds (mph)** | 30 (All stops/Local) | 13 (All Stops/Local) |
| | 40 (Express) | 18 (Express) |
| **Avg weekday ridership (2004)** | 30,000 | 12,500 |
| **Number of bus routes** | 36 | 9 |
| **Span of Service (hrs)** | 20 | 24 |
| **Avg Headways-Peak (min)** | 2 to 8 | 3 to 10 |
| **Off-Peak Base Headway (min)** | 15 | 10 |
| **Fare Structure** | Flat (on busway - 1 zone) | Flat |
| **Fare Media** | cash, swipe card | cash, swipe card, token |
| **Fare collection method** | pay as board (inbound) | pay as board |
| | pay as exit (outbound) | |
| **Off vehicle fare collection** | no | no |
| ***Roadway Characteristics*** | | |
| **- exclusive ROW** | full access controlled | semi-access controlled |
| **- at grade intersections** | no | yes |
| **- traffic signal priorities** | no | yes |
| **- passing capabilities** | yes (passing lanes) | yes (bus pullouts) |
| **- lane width (ft)** | 12 | 12 |
| **- busway station platform location** | side | side |
| ***Vehicle Type*** | | |
| **- over-the-road coaches** | yes | no |
| **- articulated** | yes | no (new artics arrive 2007) |
| **- standard** | yes | yes |
| **- minibuses** | no | yes |
| **- fuel propulsion** | CNG, diesel | CNG, diesel |
| **- low floor buses** | yes | yes |
| ***Busway Stations*** | | |
| **- length (number of buses)** | 3 (minimum) | 3 |
| **- enclosed shelters** | limited | no |
| **- ITS** | limited | no |
| **- platform height** | standard curb | standard curb |
| **- availability of printed sched./maps** | limited | no |
| **- availability of seating** | yes | limited |

# 5 SUGGESTED GUIDELINES FOR BUSWAY APPLICATIONS

After reviewing the established guidelines for busway and BRT applications according to the Federal Transit Administration, Transportation Cooperative Research Program, and National Cooperative Highway Research Program, I am in agreement with much of the criteria for determining whether a busway or BRT development is warranted. I also agree with suggested design guidelines. I have analyzed the official data and concur with a significant portion of the findings. I have also performed case studies of two busway systems in operation today including site visits to both transitway facilities and find that the two systems are in concert with much of the official guidelines offered by the FTA.

One possible problem which I detect from evaluating the established data, is that these guidelines are quite dated and perhaps not entirely applicable today as they were twenty to thirty years ago. In particular, I question the data used to determine minimum criteria for rapid transit development according to Table 3.1, Ideal Conditions for Rapid Transit Development- Design Year from the report, Center City Transportation Project: Urban Transportation Concepts, 1970. It is suggested that the minimum requirements for consideration of rapid transit for urban areas is a population of 2 million (for rail), 1 million (for rail or bus) and 750,000 (for bus). I am not in total agreement with these threshold values for the following reason- when this data were established in the early 1970's, car ownership in the USA was not as significant as it was 30+ years ago and transit usage was substantially higher. Although transit usage has been steadily increasing during the past decade, car ownership has also increased, dramatically. As a consequence of having so many new car owners, there are many more car-oriented trips today and a lot less trips on public transportation. This has lead to significant traffic congestion in cities all across the country. In spite of the known dangers of air pollution contributed by automobiles in many of our medium to large metropolitan areas, car usage continues to rise. As a result, many urban roadways are at or near capacity and there are very few options left for increasing this capacity. In consideration of these factors, I propose that some of the minimum requirements for rapid transit development be relaxed. If transit planners of medium-sized urban areas (with a population under 750,000) are to use the established data provided by the government, some planners may believe that their metro area does not meet minimum requirements for potential rapid transit development. This may prove detrimental to an urban area that is looking for alternative transportation options like rapid transit to help alleviate major traffic congestion problems. I propose that the urban area population criteria for bus rapid transit be reduced from 750,000 to 500,000. There are numerous urban areas around the country with a population of under 750,000 that could benefit from some form of rapid transit to help reduce major traffic congestion.

There is another minimum requirement on Table 3.1 that deserves being reviewed. The minimum threshold for consideration of rapid transit depends on CBD employment of 100,000 (for rail), 70,000 (for rail or bus) and 50,000 (for bus). The term "CBD employment" and associated numbers are too restrictive and may not reflect the true employment landscape for a particular urban area. There may be concentrated employment centers located in suburban locations, far from the downtown area. Not all commuter trips today are CBD-oriented as many businesses in recent years have relocated away from the traditional urban core.  This has had a substantial affect on transit ridership in many communities as a significant number of commuter trips are in effect reverse-commute trips. Although the CBD is typically the magnet for much of the employment in many urban areas it is not the only location. The “CBD employment” criteria many no longer be a meaningful gauge to measure ideal conditions for rapid transit development. This term may need to be more inclusive of all substantial employment centers in an urban area. Consider this, several transit agencies around the USA have already begun to realize the decentralization of employment in the downtown area and have responded by creating transportation centers or transit hubs in non-CBD locations (e.g. Houston Metro and Dallas DART in Texas). Some transit agencies have even gone so far to adjust their transit timetables to reflect that peak-hour direction may actually be both directions on particular transit routes (e.g. Chicago METRA suburban railroad timetables).

# 6 CONCLUSIONS AND RECOMMENDATIONS

Upon completion of my research for this thesis, I am convinced that busways and BRTs can be viable forms of rapid transit in the same manner as rail transit is. A BRT can offer the same attributes as those of rail transit but at potentially lower capital and operating costs. This is a plausible alternative for any metropolitan area that wants to improve passenger mobility but may not be able to afford the price tag for an expensive rail system. A BRT can be of high performance and quality as well as offer a sense of permanence which may aid in attracting new riders to mass transit. If designed properly and having considerably improved operating speeds and reliability, a BRT could potentially rival traditional LRT services. A busway with exclusive R-O-W can offer similar quality of service as that of a subway/heavy rail because of its 100% exclusive ROW, as evidenced with the East-MLK Busway in Pittsburgh, PA. Several aspects of operating BRT are examined with reference to the two case studies.

## 6.1 Right-of-Way

When comparing the two BRT systems studied for this thesis, I would consider Pittsburgh's busways superior to the busway in Miami for several reasons. Both busways are built on old railroad right-of-ways but the design and operation of each are very different. One of the greatest differences between the two is that Pittsburgh's East-MLK Busway, probably the closest to a "true" busway in USA, has an exclusive right-of-way for the entire roadway length whereas the Miami's South Busway has at-grade intersections and is subjected to significant cross-traffic at many of these intersections. There are no traffic intersections or traffic signals along the East-MLK Busway in Pittsburgh, and busway stations are spaced from ½ to 2 miles apart so buses are capable of reaching high operating speeds. This is not the case for the South Busway in Miami because buses operating along the route are frequently influenced by traffic signals at the intersections. It should be pointed out that the MDTA installed traffic signal priority systems for buses at many intersections but discontinued the practice because of frequent crashes between buses and cars at these intersections (see next paragraph below). The frequent stops at traffic lights impede bus operating speed which increases bus travel times and thus adversely affects the quality of service. As a consequence, the MDTA will need to resort to potentially costly options for a remedy for this problem. As of this writing, the problem has not been resolved though it is understood that the management and planners are aware of the issue and are currently exploring a few options.

### 6.2 Land Use

After the arrival of the East-MLK, Jr. Busway in Pittsburgh, PA in 1983, the transit corridor in the eastern section of Pittsburgh has undergone resurgence. The East Busway has affected land use patterns in this region because of its convenient connections to concentrations of employment centers, shopping areas, and numerous residential complexes. As a result of the convenience of the East Busway and supportive land use policies that promote mixed use development, this transit corridor has enjoyed lots of new activity around busway stations. The East Busway has also experienced significant gains in ridership. The East Busway is a good example of how public transportation can promote future land use patterns. Conversely, the South Busway in Miami, FL is located in a transit corridor where there is not much development today although it does offer continuous connection between some activity centers like a nearby shopping mall and some commercial development. The MDTA chose this alignment because it was easy and inexpensive to acquire an old abandoned railroad right-of-way. However this alignment is located in a region where there are not many attractions and future development around some busway stations may be hampered because of poor access.

### 6.3 Safety

Another issue with having an at-grade busway facility with intersecting roads is the problem with safety. The South Busway in Miami has been plagued with many accidents involving buses and cars at several intersections along the transitway. There is adequate signage and traffic signals in place identifying the busway but automobile drivers frequently elect to ignore such warnings and enter the intersections without care. This has resulted in numerous collisions between buses and cars causing many serious injuries and even death. It may be noted that the same phenomenon currently affects the brand new LACMTA Orange Line Busway in the San Fernando Valley in Los Angeles, CA. The immediate remedy offered by the MDTA (and LACMTA in Los Angeles) was to enforce a new policy for bus operators to reduce speeds when crossing intersections. But this is only a temporary solution and does not truly address the issue of bus-car conflicts.

Unfortunately, it appears that the MDTA did not anticipate this potential problem during the planning stages of the South Busway. One possible solution, which I would suggest, is to redefine the busway facility and consider it like a railroad by installing railroad crossing gates at each of the busway crossings. This could have a positive impact by potentially reducing the number of crashes at these crossings. The one downside to this would be the high costs of installing railroad crossing gates. The upside could be that liability costs would be reduced for the MDTA and safety at busway crossings could be restored.

PAT busways in Pittsburgh are not immune to safety concerns either as there is the continual problem of alighting passengers who cross the travel lanes of the busway to reach busway station platforms on the other side. This is a potentially serious problem identified at certain stations along the very active East-MLK Busway. Though, there does not seem to be a large number of incidents reported involving pedestrians and buses on Pittsburgh busways, I have personally witnessed this potentially dangerous situation of passengers weaving and dodging between moving buses to reach the opposite platform. I have reported this to the administration at PAT headquarters. A possible remedy for this situation is to have pedestrian bridges available at both ends of the busway platforms, or have one pedestrian bridge located at the center connecting platforms on each side. Also, a continuous dividing barrier (such as a jersey barrier) should be constructed in the center of the roadway, separating bus direction of travel. However, if a barrier is built, an additional bypass lane would be needed for each direction.

## 6.4 Vehicles

It is important that a transit agency assigns appropriately sized vehicles for use on busways, particularly during off-peak hours when there is less frequent service and a reduction in the number of routes serving the busway. Though there may be significantly less ridership during off-peak times, it is still important to use appropriate vehicles to accommodate potentially high passenger loads. PAT in Pittsburgh appears to have a good handle on this as they assign articulated buses throughout the week on the EBA (East Busway All-Stop) major route serving East-MLK Busway. Conversely, the MDTA in Miami does not assign right type of vehicles, and I have identified a problem which could be easily remedied. I would suggest that the Miami MDTA discontinue the practice of using minibuses on the very popular Route “31-Busway Local” during off-peak periods. Minibuses, by design, have very limited seating and standing room and hence should not be used on a major bus route in a large city. There have been numerous times when minibuses used on Route 31 have been filled with heavy loads because bus headways during late evening hours are 30 minutes. If the base headway during late hours is to remain 30 minutes along the busway then it would be best to use, at minimum, standard 40-foot transit coaches. If the use of smaller buses is the preferred vehicle choice, then service frequencies must be adjusted, that is increased, to better serve the bus riding public. When using minibuses, it is be strongly recommended to increase frequencies from 30 minutes to perhaps 15 or 20 minutes though, this would increase labor costs for the transit agency as more bus drivers would be needed to operate the additional number of vehicles. Increasing the number of minibuses perhaps is unfeasible as the MDTA, like most other transit agencies around the country, are wrangling with ways to reduce labor costs rather than increase them. As an example, the CTA (Chicago Transit Authority) recently faced budget concerns and implemented a reduced service plan. The CTA re-examined their rapid rail system. As a cost-cutting measure, the CTA had decided to increase the number of cars per train while at the same time reducing the number of trains in operation. Though not immediately popular with transit users in Chicago, this small fix had helped the CTA reduce some of their labor costs. It also helped in increasing capacity on transit vehicles by dispersing passengers onto longer trains. Similarly, I believe the MDTA could benefit from the CTA example by using larger buses keeping the same frequencies, while addressing the capacity needs of passengers who use Route 31 on the increasingly popular South Busway.

### 6.5 Fare Collection

An important feature of busways should be the simplicity and expediency of fare collection so passengers can board and alight quickly hence reducing dwell times of buses at busway stations. PAT in Pittsburgh has had a long standing policy of requiring passengers to pay as you board transit vehicles when traveling inbound but pay as you exit as you travel outbound. The boarding process when leaving the CBD is very quick as articulated buses using the busway have all three doors available for boarding. But the alighting process is delayed when reaching stops outside of downtown because all passengers are required to exit through the front door (back doors remain locked until the bus reaches the route terminus). This dramatically increases delay as a large group of alighting riders wait in the aisle as each passenger pays their fare at the farebox before disembarking. The inbound-travel fare collection process in Pittsburgh is like that of Miami and most other U.S. transit systems, pay as you board. I propose that both the MDTA and PAT take a look at the fare payment procedures of other transit agencies like LACMTA (LRT and Red Line Subway) in Los Angeles, CA and Tri-Met (LRT) in Portland, OR. These two systems use an "honor system" for their rapid transit lines in which riders use pre-paid passes/tickets instead of paying fares on transit vehicles hence, speeding up the boarding and de-boarding process. Fare inspectors who would randomly board vehicles to verify that passengers have their proof of payment can monitor fare enforcement.

# REFEERENCES

## REFERENCES

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MIAMI-DATE TRANSIT AUTHORITY, MDTA website http://www.miamidade.gov/transit/

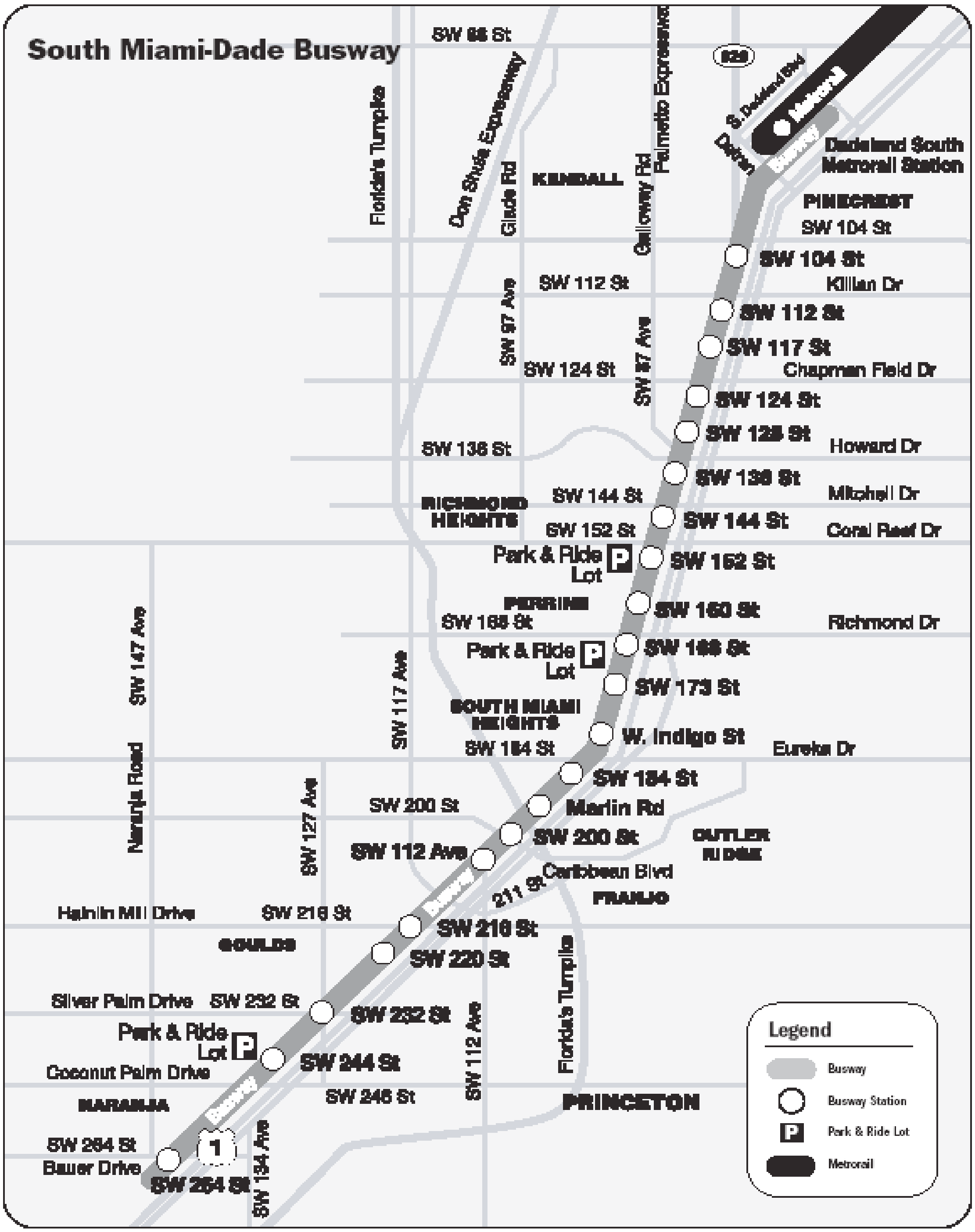

## PERSONAL INTERVIEWS


JOSE PERES, MDTA Road Supervisor, Metro-Dade Transit Authority, Miami, FL (Interviewed: Oct 2005, Feb 2006)

RICHARD FEDER, AICP, Port Authority of Allegheny County, Pittsburgh, PA (Interviewed: Mar 2003)

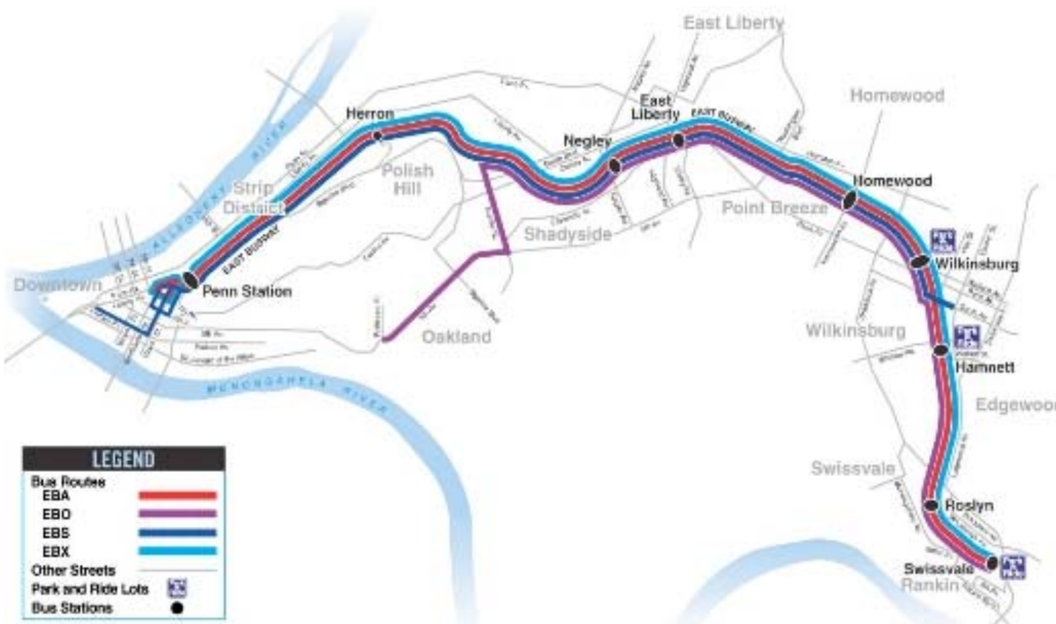
# APPENDIX

South Miami Busway Map-2005



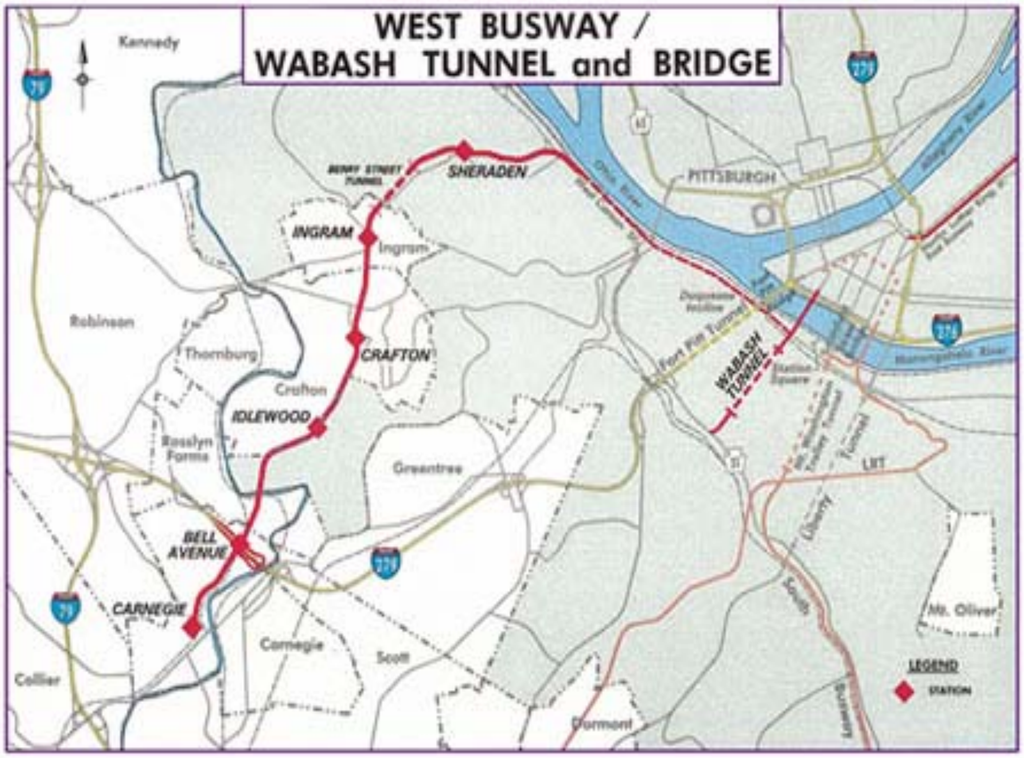

Courtesy of MDTA website, used by permission

East-MLK, Jr. Busway in Pittsburgh, PA-2005




Courtesy of PAT website, used by permission

West Busway in Pittsburgh, PA - 2006




Courtesy of PAT website, used with permission

# VITA

Michael Harris Gallant was born in New York City, NY and was raised in Southern California, New York City metro area, and Miami Beach, FL. He attended high school at Central High School in Valley Stream, NY and graduated from Springfield Gardens High School in New York. He attended college at Cerro Coso Community College while in the Air Force at Edwards AFB in California, Antelope Valley College in Lancaster, CA and the University of Tennessee in Knoxville, TN. He graduated with a Bachelors of Science in Mechanical engineering at the University of Tennessee in May of 1997 and a Masters of Science in Civil Engineering with an emphasis in transportation engineering in May of 2006. He has served in the United States Air Force for five years and attended college thereafter. He currently works for the Office of Information Technology at the University of Tennessee and is pursuing an engineering position in the public transportation industry with later aspirations to work for the federal government handling national transportation issues and public policy.