SR-836 Express Bus Service Study

Draft Report
Prepared for the

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EXECUTIVE SUMMARY

The Dolphin Expressway (SR-836) in Miami-Dade County, managed by the Miami-Dade Expressway Authority (MDX), is one of the most critical corridors providing east-west mobility to Miami-Dade County. Currently, the SR-836 corridor and most of the other freeways and arterials in the vicinity are operating at undesirable levels of service during the peak hours. In addition, planned major construction activities are expected to create additional operational issues. To address the existing and forecasted operational problems, MDX has identified and tested possible capital improvement projects to enhance mobility along SR-836.

Consistent with the SR-836 improvement effort, the purpose of this project is to investigate the feasibility of a bus transit system on SR-836. Potential supporting components to increase the ridership and improve the performance of this bus service are as follows:

- Transit-Oriented Developments (TODs)
- Park-and-ride facilities
- Intelligent Transportation Systems (ITS)
- Operating bus-on-shoulders
- Feeder buses

This project investigated the feasibility of a bus system on SR-836 in Miami-Dade County. The project explored the potential attributes needed for such a bus system, along with the abovementioned supporting components.

Bus System

An express bus service is recommended for operation on SR-836. The preferred attributes of this service are the following:

1) Simple route layout
2) Frequent service
3) Less frequent stops
4) Color-coded buses and stops
5) Transit signal priority
6) High-capacity buses
7) Feeder network
8) Real-time transit information
9) Low-floor vehicles
A number of alignments and parameters were modeled in this study for the proposed bus system to identify the alignments that produced both the highest revenue to cost ratio and high ridership. Based on this modeling effort, two investigated alternative alignments appear to produce the best results for ridership and revenue to cost ratios. These two alternatives connect the Florida International University (FIU) Modesto A. Maidique Campus (FIU’s main campus) with downtown Miami. The modeling effort indicates that park-and-ride and feeder buses were not beneficial. This may be due to the insensitivity of the forecasting model to these strategies. This issue needs to be revisited in the design stage of the project.

Among the investigated alternatives, two alternatives are found to be more effective based on ridership and revenue to cost ratio. These two alternatives are Alternative 2A and Alternative 3A. Alternative 2A alignment is from FIU to downtown stopping at the FIU Engineering Center and the MIC. Alternative 3A is from FIU to downtown stopping at the FIU Engineering Center, Dolphin Mall, NW 87 Ave., Merchandise Center, the MIC, and the Medical Center of the University of Miami (MCUM). The modeling results of this study, shown in the Table below, indicate that the revenue to cost ratio for Alternative 2A is 0.33 with the assumption of 50% average fare (the average fare collected is 50% of the full fare due to fare discounts, evasion, and equipment failure) and 0.50 with 75% average fare. A percentage of the full fare is considered to account for discounted and free fares (e.g., students, seniors, courtesy passes, etc.), farebox problems, and other issues associated with the fare collection. For Alternative 3A, the results below show that the revenue to cost ratio is slightly higher with 0.36 with 50% average fare assumption and 0.54 with 75% average fare. It is expected that ITS will increase these values by 10% based on previous studies. As reported in the TOD section of this document, a ridership increase of up to 40% may be expected, also based on previous studies. Assuming that the TODs will be financed outside this project, the revenue to cost ratio can increase to 0.82 with alternative 3A if both ITS and TODs are implemented. As described in the modeling section, no benefits could be quantified for the feeder bus system. In addition, the impacts of the bus-on-shoulder are not accounted for in the revenue to cost calculations. It is expected that these two components will further increase the ridership and the revenue over cost. Finally, better enforcement and payment mechanism to reduce fare evasion will increase the revenue/cost ratio (as stated earlier, the average fare is assumed to be 50-75% of the full fare).

This report identifies and discusses issues critical to the success of the bus system, including funding mechanisms, decision regarding operational responsibilities, coordination among stake holder agencies, fare settings and enforcement, selecting a final alignment in the design stage, providing feeder bus service, providing park and ride facilities, utilizing environmentally friendly vehicles, traveler comfort, and the need for a marketing campaign.
### Modeling Results for Alternative 2A vs. Alternative 3A

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<tbody>
<tr>
<td>Alternative 2A (from FIU to downtown with stops at the engineering center and the MIC)</td>
<td>Base (No ITS and 50% average fare)</td>
<td>4,066</td>
<td>8</td>
<td>$4,777</td>
<td>$14,477</td>
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<td>$5,255</td>
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<tr>
<td></td>
<td>ITS with 75% average fare</td>
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<td></td>
<td>$7,883</td>
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<td>0.54</td>
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<tr>
<td>Alternative 3A (FIU to downtown with stops at the engineering center, Dolphin Mall, NW 87th Avenue the MIC, and UM hospital)</td>
<td>Base (No ITS and 50% average fare)</td>
<td>5,909</td>
<td>11</td>
<td>$6,943</td>
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<td></td>
<td>ITS with 50% average fare</td>
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<td>$7,637</td>
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<td></td>
<td>ITS with 75% average fare</td>
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<td>$11,456</td>
<td>$19,463</td>
<td>0.59</td>
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**Intelligent Transportation Systems**

Intelligent Transportation Systems (ITS) will be an important component of the proposed bus system. These will include transit vehicle tracking, transit operation management, transit
passenger and electronic fare collection management, transit security, transit maintenance, passenger counters, and transit traveler information.

Another important component of this deployment is multimodal management and information coordination. Dynamic message signs on SR-836, and potentially on arterial streets, should be used to deliver highway and transit information to travelers. In addition, some of these signs could communicate park-and-ride space availability to prospective users. Other ITS devices could also be utilized for this purpose, including electronic displays and signs, 511, websites, and potentially personalized information using hand held devices and in-vehicle equipments.

The deployment could also include advanced modeling and analysis of traffic in real-time based on transportation system measurements to optimize the performance of the system. Signal controls will have to be updated to accommodate the change in traffic patterns due to the park-and-ride facilities and the future TODs. In addition, bus priority could be considered to reduce trip travel times and to increase overall on-time performance.

**Bus-on-Shoulder**

This study recommends utilizing congestion by-pass (queue-jumper) utilizing shoulder for the SR-836 bus system. This operation should allow buses to bypass traffic queues during congested conditions. However, the study identified a number of issues to consider with such implementation that should be addressed, including the loss of shoulder functionality, conflict with on and off ramps, need for bus operator training, need for additional shoulder construction and maintenance, potential shoulder-widening conflict with the planned construction activities on SR-836, need for adequate signage and pavement markings, and need for a marketing program.

ITS technologies could also be used to support the operation of buses-on-shoulders. This could include communicating the presence of disabled vehicles or emergency/enforcement vehicles on the shoulder. Such information could be communicated using infrastructure based devices, such as lane control signs or pavement lights with changing colors, to indicate this to the driver. In addition, driver-assist technologies such as vehicle-merging assistance and lane-departure warning systems could help to increase safety, considering the narrowness of shoulders and the need for buses to frequently merge into traffic.

**Park-and-Ride**

Park and ride facilities can be implemented in the short-term, while others should be considered for longer-terms of implementation. In the short-term, at minimum, park-and-ride stops at west Miami-Dade and the Miami Intermodal Center (MIC) should be explored. Additional locations such as the Florida International University Engineering Center (FIU EC); the interchange of NW 87th Avenue and the Dolphin Expressway; and the intersection of NW 107th Avenue and NW 12th Street could also be explored. MDT is already planning park-and-ride facilities as part of their east-west corridor plan. The park-and-ride facilities should be designed to maximize
traveler’s convenience, ensure security, and provide information to travelers. Over time, it is possible that some park-and-ride locations may evolve to fully-developed TODs.

Next Steps

In this study, an express bus system is proposed. While this is part of the planning phase of the project, the design and implementation phases still need further investigation. Below are some of areas that require more in-depth exploration:

- **Transit Demand.** One of the areas that need to be investigated in greater detail is the potential demand for this service and the optimum hours of operations to improve the outputs obtained by the modeling calculations. For instance, the service could be provided only during the peak hours to reduce the operational costs. As transit ridership demand may increase with time, providing additional hours of service could be evaluated in the future. A survey of potential transit customers can be taken to assist with this task.

- **TODs.** There is also the possibility of further exploring the TOD concepts in coordination with local and regional agencies. Although this may be expected to occur at some point in the future, the groundwork to prepare for future implementation still needs to be conducted. The TOD concept outlined in this study has not been fully investigated in terms of its impacts, particularly as it applies to South Florida.

- **ITS.** The use of ITS technologies for highway and transit and the integration of ITS as applied to these two modes also needs to be explored further. The coordination, implementation, and utilization of highway ITS and transit ITS is critical to the success of this project. The availability of travel information can help travelers on SR 836 decide whether to continue using the highway or switch to transit. With this information, potential riders are given the ability to make an informed choice about their mode of travel. In addition, providing real-time information can enhance the travel experience for both drivers and transit riders.

- **Bus-on-shoulders.** The condition of pavement, geometry, signage, markings, and other control devices needs to be assessed to ensure the safety and effectiveness of buses using shoulders.

- **Preference survey.** Finally, a preference survey needs to be conducted to assess the public attitudes toward park-and-rides, TODs, express buses, feeder buses, and the use of ITS technologies.
1. INTRODUCTION

1.1 Background
The Dolphin Expressway (SR-836) in Miami-Dade County, managed by the Miami-Dade Expressway Authority (MDX), is one of the most critical corridors providing east-west mobility to Miami-Dade County. Currently, the SR-836 corridor and most of the other freeways and arterials in the vicinity are operating at undesirable levels of service during the peak hours. In addition, major construction activities have created additional operational issues. To address the existing and forecasted operational problems, MDX has identified and tested possible capital improvement projects to enhance mobility along SR 8361.

Consistent with MDX effort, the purpose of this project is to investigate the feasibility of a bus transit system on the Dolphin Expressway in Miami-Dade County. The project explores the potential attributes needed for such a bus system. The proposed system could be supported by other components to help increase ridership and improve performance efficiency. These components could be introduced in a gradual manner, since some of them may not be feasible to implement in the short term. It is anticipated that the bus transit system will be supported by five potential components, as follows:

1) Transit-Oriented Developments (TODs): TODs are moderate- to high-density developments located within an easy walk of a major transit stop. These areas generally have a mix of residential, employment, and shopping opportunities designed for pedestrians. By bringing potential riders closer to transit facilities, TODs are expected to increase transit ridership. Such developments, however, are not considered possible in the short-term (by 2012), and should thus be investigated for future implementation. If implemented, one such TOD could be located adjacent to the Blue and Gold Parking Garages on Florida International University’s (FIU) Modesto A. Maidique Campus (FIU’s main campus). Another TOD could be considered near the Miami Intermodal Center (MIC). The TODs are to be designed in an innovative manner to maximize the attraction of residents and visitors to these facilities. Such facilities will include a pedestrian-friendly environment, traffic calming, parking, and mixed-use development.

2) Park-and-ride facilities: While some of these facilities can be implemented in the short-term, others should be considered for longer-terms of implementation. In the short-term, at minimum, park-and-ride stops at west Miami-Dade and the MIC should be explored. Additional locations such as the Florida International University Engineering Center (FIU EC); the interchange of NW 87th Avenue and the Dolphin Expressway; and the intersection of NW 107th Avenue and NW 12th Street are also candidates. MDT is already planning park-and-ride facilities as part of their east-west corridor plan, as discussed later in this document. The park and ride facilities should be designed to maximize traveler’s convenience, ensure vehicle security, and provide information to

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travelers. Over time, it is possible that some park and ride locations may evolve to fully developed TODs.

3) Intelligent Transportation Systems (ITS): ITS provide advanced technologies and strategies to support the integrated operations of highways, transit, and parking facilities and maximize the efficiency and attractiveness of the system.

4) Operational strategies to improve the system performance: This could include, for example, operating the proposed bus system on SR-836 shoulders.

5) A feeder bus system that increases traveler convenience and potentially the ridership.

1.2 Project Vision
This section presents an overview of a bus system for potential implementation on SR-836. Some of the elements of this system could be considered for short-term implementations, while long- or medium-term implementations are more suitable for those subject to time constraints.

For the investigated bus system to work, it must be able to attract choice riders in addition to people who have no other transportation alternative. Choice riders are those who own cars and could drive to the airport, work, or other destinations without using public transportation. Special buses, TODs, ITS, park-and-ride facilities, feeder buses, and innovative operational strategies (e.g., bus-on-shoulders) can be used in combination to attract such choice customers who will travel by car unless the alternative modes are more convenient, reliable, attractive, safe, cost-competitive, and comfortable.

One important aspect of the proposed system is to use bus services that mimic rail services in terms of quality and reliability. This should include, where possible, roadway reconfiguration, amenities, a signal priority system, and planning and engineering. Maps, shelters, and electronic fare collection equipment must also be placed at the stations for the convenience of passengers.

Ideally, the associated major bus stops should offer more amenities than a regular bus stop to increase the attractiveness of the transit system. Some of these stop facilities should be near or physically connected to pedestrian-oriented parking structures. The bus stops also need to be designed for maximum accessibility and comfort. To achieve this, bus stops could have shelters with travel information displays, ticketing, and other items to maximize the traveler’s satisfaction. These stops would also provide a comfortable and safe environment for passengers waiting on buses. Moreover, free Wi-Fi, comfortable seating, and nearby stores and shops could provide services for utilizing their waiting times productively.

The schedules of transit must be such that potential customers would find them convenient to use and easy to remember. The vehicle design should allow passengers to easily get on and off the bus. For example, low-floor buses could be considered or bus stations designed to provide for a floor height equal to the bus floor height. Additionally, the system could include other features to improve access, such as double doors on one or both sides of the vehicle.
Cost is one of several critical factors in deciding the success or failure of a bus system. The combined cost of parking and the bus ticket must not exceed the values accepted by travelers. To this end, a marketing campaign can help increase prospective riders’ awareness of the potential monetary and time-savings provided by the system.

To attract choice riders and motorists to the proposed system, the following components are also important:

- Exterior and interior bus vehicle design should be superior to regular buses;
- Accurate and timely travel information should be provided on a pre-trip basis, at the stations, on-board the bus, and using handheld mobile devices;
- There should be reliable and efficient service between stations;
- Travelers should have the ability to make good and enjoyable use of time during intermodal stops;
- Urban centers with pedestrian-oriented streets, open spaces, and corridors could help attract travelers. The centers should be accessible by using different modes; and
- Park-and-ride components, feeder buses, and advanced operational strategies could be used to support an efficient system.

The bus service provided must be attractive for potential FIU faculty, staff, and/or students living in Broward and Palm Beach Counties who can head south on the Tri-Rail to the MIC and then west to FIU on the proposed system.

### 1.3 Project Mission

The goal of this project is to investigate the feasibility of a bus system on SR-836 that is attractive to choice travelers. The specific objectives are as follows:

- Identify the attributes of the bus service to be deployed as part of the investigated system;
- Investigate the impacts of potential alignment alternatives and other factors on the bus ridership using demand forecast modeling;
- Identify ITS technologies and strategies to support management agencies and travelers;
- Identify potential TOD concepts for future implementation;
- Identify operational strategies to support efficient bus operations such as buses on shoulders, transit bus priority, and feeder buses; and
- Identify implementation and operation issues to be addressed for successful implementation.

### 1.4 Project Stakeholders

The investigated implementation is expected to serve the needs of the following potential user groups:
1) Travelers to and from west Miami-Dade, Miami International Airport (MIA), the Miami Intermodal Center (MIC), and downtown Miami, in addition to riders of the Tri-Rail and Metrorail. Depending on the selected alignment, it can also serve riders/travelers from other areas.

2) Public agencies including Miami-Dade Expressway Authority (MDX), Florida Department of Transportation (FDOT), Miami-Dade Transit (MDT), Metropolitan Planning Organization (MPO), Miami-Dade County Public Works, MIA, South Florida Regional Transportation Authority (SFRTA), FIU, Miami-Dade County Traffic Division, and potentially local municipalities.

3) Motorists who use the Dolphin Expressway and potential transit-riders.

4) Private sector companies that may be interested in the bus system and/or its supporting components.
2. BUS SYSTEM

This section discusses the bus systems proposed for implementation on SR-836 and their respective attributes. Other supporting systems are discussed in the subsequent sections of this document.

2.1 Bus System Types

To assist with the project investigation of potential bus systems for implementation, a literature review of the national and international experience related to advanced bus systems has been conducted in this study. The literature review begins by identifying suitable transit technologies and modes required for a sustainable and efficient transit service. The following transit modes are included in this review: bus rapid transit (BRT) service, limited-stop bus service, and express bus service. Elements key to the success of these services are then presented for potential applicability to the MDX project.

Urban centers around the world are showing an increased interest in Bus Rapid Transit (BRT) service as a viable transportation option. BRT is a relatively new concept and it is being considered as a potentially cost-effective solution. This concept has either already been applied or is being considered for implementation in South Florida. The Miami-Dade Busway is an example of a BRT solution, and other BRT applications are being investigated for implementation by MDT.

The objectives of BRT include improving bus service frequency and reliability, reducing travel time, making the system easy to use, providing better passenger comfort, and improving bus transit image. Although there are some variations, the ideal attributes of a fully implemented BRT System include the following items:

- Simple route layout
- Frequent service
- Headway-based schedules
- Less frequent stops
- Level boarding and alighting
- Color-coded buses and stations
- Bus signal priority
- Exclusive lanes
• High-capacity buses
• Multiple door boarding and alighting
• Off-vehicle fare payment
• Feeder network
• Coordinated land use planning

Table 2-1 provides a comparison of national BRT implementations. Appendix A presents further information about national and international examples of BRT systems.

A **limited-stop bus service** operates on a route similar to local bus routes, but making stops only at selected locations, such as major intersections, landmarks, or at transfer points to connecting bus routes. Limited stop bus services can be viewed as a form of BRT with no dedicated lanes. In some cases, they can be used as precursor to BRT systems since more BRT attributes can be added at a later time. In heavily congested traffic conditions, however, limited stop bus services may not always achieve speeds faster than those of regular buses. Examples of limited stop bus services include Route 51 in Miami-Dade County, the Breeze in Broward County, the New York City Transit’s Limited-Stop Services, and Route 467 of the Societe de transport de Montreal in Canada. Appendix A presents national and international examples of the implementations of limited stop bus services. Appendix A.2 presents examples of existing limited stop bus services.

An **express bus service** is a transit service in which vehicles stop only at widely spaced stops, often at the beginning and end of a route. These routes can parallel local service, but are intended to serve fewer stops/stations in order to reduce travel time between two commuter points. Express buses usually provide service from the suburbs or surrounding cities to the downtown areas and are being introduced by MDT in Miami-Dade County. Examples include the Flyer bus service from MIA to Miami Beach, the Kendall Cruiser (on Kendall Drive), and the I-95 Express on I-95. Appendix A.3 presents national and international examples of express bus services.
## Table 2-1: Comparative Data on National BRT Corridors and Characteristics

<table>
<thead>
<tr>
<th>City</th>
<th>BRT Corridor</th>
<th>Length (mi)</th>
<th>Transit Priority Treatments</th>
<th>Pre-BRT Boardings</th>
<th>Post-BRT Boarding</th>
<th>Travel Time Savings</th>
<th>Travel Connections</th>
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<tbody>
<tr>
<td>Boston</td>
<td>Silverline (Phase I &amp; II)</td>
<td>3.30</td>
<td>TSP and dedicated lane</td>
<td>7627</td>
<td>14,943 (98% increase)</td>
<td>0.25</td>
<td>Local bus and rail</td>
</tr>
<tr>
<td>Las Vegas</td>
<td>MAX</td>
<td>7.50</td>
<td>TSP and mostly Dedicated lane</td>
<td>7,300 per weekday</td>
<td>9,800 / weekday (25% increase)</td>
<td>35% average</td>
<td>Local bus</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>Orange Line</td>
<td>14.00</td>
<td>TSP and Exclusive Busway</td>
<td>N/A</td>
<td>22,000 Weekday Boardings</td>
<td>N/A</td>
<td>Local and regional bus, local rail</td>
</tr>
<tr>
<td>Cleveland</td>
<td>Silverline</td>
<td>7.07</td>
<td>TSP and Exclusive Busway</td>
<td>20,000 per weekday (projected)</td>
<td>30,000 per weekday</td>
<td>26% (projected)</td>
<td>Local bus and rail</td>
</tr>
<tr>
<td>Kansas City</td>
<td>MAX</td>
<td>8.00</td>
<td>TSP and dedicated lane in AM</td>
<td>3,500** (43% increase)</td>
<td>5,000** (43% increase)</td>
<td>20%</td>
<td>Local bus</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>Metro Rapid Ventura</td>
<td>16.40</td>
<td>TSP only</td>
<td>20,400 weekday boardings</td>
<td>45% increase</td>
<td>28%</td>
<td>Local bus and rail</td>
</tr>
<tr>
<td>Eugene, OR</td>
<td>Emx Franklin</td>
<td>4.00</td>
<td>TSP and dedicated lane</td>
<td>2,667</td>
<td>4,530 (70% increase)</td>
<td>30%</td>
<td>Local bus</td>
</tr>
<tr>
<td>Everett, WA</td>
<td>Swift SR 99</td>
<td>16.70</td>
<td>TSP and dedicated lane</td>
<td>4,300 daily boardings</td>
<td>6,600 daily boardings * (53% increase)</td>
<td>30% (projected)</td>
<td>Local and regional bus, Amtrak, and commuter rail</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>1.196th Avenue Edmonds ferry to SR 9</td>
<td>12.90</td>
<td>TSP only</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local bus and regional bus, Amtrak, and commuter rail</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>1a. 196th from Ferry to Lynnwood TC/ Convention Center</td>
<td>5.70</td>
<td>TSP only</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local and regional bus, ferry, Amtrak, and commuter rail</td>
</tr>
</tbody>
</table>

(Continued on next page)
<table>
<thead>
<tr>
<th>City</th>
<th>BRT Corridor</th>
<th>Length (mi)</th>
<th>Transit Priority Treatments</th>
<th>Pre-BRT Boardings</th>
<th>Post-BRT Boarding</th>
<th>Travel Time Savings</th>
<th>Travel Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snohomish County, WA</td>
<td>2, Airport Rd/128th/132nd</td>
<td>10.10</td>
<td>Use of HOV lane</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local bus</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>3, 164th SR 99 to Mill Creek</td>
<td>3.70</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local and regional bus</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>4, SR 9 UW Bothell Campus to Arlington</td>
<td>33.00</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Regional bus</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>5, SR 527 Downtown Bothell to Everett Mall</td>
<td>13.00</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Regional bus</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>6, SR 529 Everett Station to Smokey point at 172nd</td>
<td>12.70</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local and regional bus, Amtrak, and commuter rail</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>6a, SR 529 Everett Station to Marysville (State and 88th St, NE)</td>
<td>7.30</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local and regional bus, Amtrak, and commuter rail</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>7, U.S. 2 Lake Steven Transit Center to Everett Station</td>
<td>6.20</td>
<td>Westbound HOV lane in AM peak</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Local and regional bus, Amtrak, and commuter rail</td>
</tr>
<tr>
<td>Snohomish County, WA</td>
<td>8, Mukilteo Speedway Ferry Dock to SR 99</td>
<td>6.10</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Regional bus, Ferry, and Commuter rail</td>
</tr>
</tbody>
</table>

(Source: BRT Planning, ITDP, 2007)
2.2 Desirable Bus System Attributes

Based on the review of the above mentioned systems, this study identified the main attributes that transit agencies consider for improving bus service frequency and reliability, reducing travel time, making the system easy to use, providing better passenger comfort, and improving bus transit image. These desirable attributes are listed as follows:

1) Simple route layout
2) Frequent service (15 minutes during peak times)
3) Headway-based schedules
4) Less frequent stops (assume three to five stops per trip)
5) Level boarding and alighting (transit stop entry area elevated to match the vehicle floor height or use of low-floor vehicles)
6) Color-coded buses and stations (branding of vehicles and stops): One of the key attributes reported by many agencies was system branding to make the system both easy to recognize and use. Stations, stops, and vehicles need to be painted with distinctive colors that differentiate them from all other bus routes in the system. MDT has recognized the importance of branding and has implemented this strategy on its BRT and express bus services.
7) Bus signal priority (buses are given priority at traffic signals to improve reliability and reduce travel times)
8) Exclusive lanes (to reduce travel times and increase travel time reliability)
9) Higher capacity buses (use of vehicles with higher passenger capacity when needed)
10) Multiple door boarding and alighting (double doors on one side of bus or double doors on both sides of bus to separate areas for boarding or alighting passengers)
11) Off-vehicle fare payment (ticket payment before boarding the bus)
12) Feeder network (feeder buses provide passengers with connection services to their destinations or other transport systems)
13) Coordinating with land use planning (to promote walking and transit usage)
14) Real-time information (use ITS technology to provide information to travelers, including next bus arrival)
15) Low-floor vehicles (to allow for faster passenger boarding and alighting)
16) Marketing and communications campaigns: Such campaigns proved helpful to demonstrate basic objectives for the introduction of new systems designed to reduce passenger travel times, increase service reliability, improve fleet and station appearance, and improve service effectiveness.
17) Intelligent Transportation Systems (ITS), which more and more agencies are utilizing to assist with operations and provide quality service to passengers.

2.3 Candidate Bus System Attributes for SR-836

The previous section discussed the attributes of a successful bus system. From the list of 17 potential attributes identified in that section, 10 were selected for use with the proposed express bus on SR-836, in the short-term. The remaining attributes may be explored in future studies, but were not considered in the short-term, as they may require more time to implement and thus would not be feasible for operation by 2012. The desirable attributes are as follows:
1) Simple route layout: A simple route will be easy to understand, easy to remember, and will help reduce travel times for people traveling along SR-836. Furthermore, since the proposed express bus system will follow the same simple alignment in a consistent manner, the system will generate a confidence similar to that provided by fixed guideway modes.

2) Frequent service during peak hours: To ensure that the forecasted demand is served efficiently and to increase system attractiveness, a frequent service during the peak hours is proposed (15-minute headways).

3) Less frequent stops: This will ensure that the delays at stops are minimized and that the travel times will be reduced. As travel time is an important element to attracting riders, having an optimal numbers of stops is critical for the success of the proposed system. Having too many will increase travel times, whereas having too few will fail to capture the needed ridership. Thus, a balance between these two factors should be achieved.

4) Color-coded buses and stops: This ensures that buses operating on SR-836 have a unique identity and can be easily recognized and identified as an express and faster transit service. Color-coded buses and stops can provide a higher level of visibility that will differentiate this service from the regular bus service. For instance, MDT created special branding for the Kendall Cruiser and I-95 Express buses. Similarly, special branding can be designed to distinguish the SR-836 express bus, which has proven an effective marketing tool to attract new riders.

5) Transit signal priority (TSP): Transit signal priority modifies the normal traffic signal timing to facilitate the movement of transit vehicles. By providing priority to buses at signalized intersections, the overall delay and travel times are reduced and reliability increased. Depending on the alignment selected for this project, TSP at selected signalized intersections should be considered to improve travel times.

6) High-capacity buses: The use of buses that can carry a larger number of passengers can help to reduce the need for more buses, in particular, during peak time. Bus options vary in terms of size, design, propulsion system, internal configuration, etc. Bus aesthetic is also important for reinforcing the presence and identity of the system. Depending on the ridership forecast for this project, regular buses, articulated buses, or a combination of both will be considered.

7) Feeder bus: The bus system on SR-836 could benefit from connecting to feeder buses or other transit systems. Travelers may need to transfer in order to complete their trip from origin to destination and vice-versa. These transfers occur at stops and stations that can
make use of the existing transit service, in the short-term. A feeder bus system can also provide connectivity to residential areas.

8) Real-time information on bus arrivals: This information reduces the anxiety of not knowing when the bus will arrive and helps passengers to make more efficient use of their wait. This attribute is therefore highly recommended for the Express Bus system. The use of technology to provide this type of information can also help to bolster the image of the system as progressive and innovative.

9) Low-floor vehicles: Having a low-floor vehicle allows for faster boarding and alighting. This can help to reduce the dwell-time, as well as the overall travel times, at bus stops and stations. Since low-floor buses improve travel times, this is another attribute that will be attractive to riders of the proposed Express Bus system.

10) ITS: As will be described later in the document, ITS deployment is an essential part of the proposed bus system. MDT has already implemented several ITS technologies and is in the process of implementing other technologies for use in the near future. Similar technologies will need to be implemented on the proposed system for optimal operations. The integration between highway and transit ITS deployment is also recommended.

Bus-on-shoulder is an additional attribute that can help to reduce travel times, which is expected to attract more travelers to the proposed bus system. This operation will be discussed in more detail later in the document.

MDX is a strong supporter of technologies that can reduce the impact to the environment. The new bus system will provide an opportunity to showcase this commitment and will provide an example for sustainable transportation in South Florida, as discussed later in this chapter.

2.4 Proposed System Summary
The proposed bus system is expected to be an express bus service with some additional attributes to make the system more attractive to potential riders. Table 2-2 compares the characteristics of the proposed system to the characteristics of other systems reviewed in the literature.
Table 2-2: Proposed System Characteristics Compared to Typical Systems

<table>
<thead>
<tr>
<th>Characteristics / Type of Service</th>
<th>Proposed System</th>
<th>Typical BRT</th>
<th>Express</th>
<th>Limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Route Layout</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Frequent Service</td>
<td>Peak Hours</td>
<td>Y</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Headway-based Schedules</td>
<td>N</td>
<td>Y</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Less Frequent Stops</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Level Boarding and Alighting</td>
<td>N</td>
<td>Y</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Color-coded Buses and Stations</td>
<td>Y</td>
<td>Y</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Bus Signal Priority</td>
<td>Y</td>
<td>Y</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Exclusive Lanes</td>
<td>Partial (potentially shoulder)</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>High Capacity Buses</td>
<td>Peak Hours</td>
<td>Y</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Multiple Door Boarding and Alighting</td>
<td>N</td>
<td>Y</td>
<td>Varies</td>
<td>Y</td>
</tr>
<tr>
<td>Off-vehicle Fare Payment</td>
<td>N</td>
<td>Y</td>
<td>On-board</td>
<td>On-board</td>
</tr>
<tr>
<td>Feeder Network</td>
<td>Y</td>
<td>Y</td>
<td>Varies</td>
<td>N/A</td>
</tr>
<tr>
<td>Coordinating Land Use Planning</td>
<td>N</td>
<td>Y</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TOD's</td>
<td>N</td>
<td>No</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Professionally Trained Operators</td>
<td>Y</td>
<td>Varies</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Special Vehicle Design</td>
<td>Y</td>
<td>Varies</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>ITS Technology</td>
<td>Y</td>
<td>Y</td>
<td>Varies</td>
<td>Varies</td>
</tr>
</tbody>
</table>

2.5 Issues Associated with the Bus System

Discussed below are some of the issues that need to be considered during the planning, implementation, and operation of the proposed bus system.

2.5.1 Funding and Costs

An important aspect of the proposed system is the capital cost required to purchase the buses, associated facilities, and equipment. In addition, operations and maintenance costs will also have to be accounted for.

A number of items contribute to the recurrent operations and maintenance costs. These may include the following: labor for operators, labor for supervision and management, labor for customer service/marketing, fuel/energy (vehicles and facilities), marketing materials/public information, contracted services, maintenance and repair costs, and routine cleaning and inspection. The estimation of the capital and operating costs will be presented in the revenue and cost section of this document.
Potential funding sources could include grants and/or bonds from local, state, or federal agencies. In addition, revenue is expected to be generated from the farebox, advertising, and associated fees from future TODs. In the absence of local funds allocated to this service, other sources can be considered. Below is a list of potential Federal and State programs:

- **FDOT Transit Funding Programs**
  - Transit Corridor Program
  - Public Transit Service Development Program
  - Commuter Assistance Program
  - Park-and-Ride Program
  - New Starts Transit Program
  - Intermodal Development Program
  - Transportation Regional Incentive Program

- **Federal Funding Programs**
  - New Starts Program
  - Small Starts and Very Small Starts Program
  - Bus and Bus-Related Facilities Program
  - Job Access and Reverse Commuter Program
  - Flexible Funding Programs

The draft of the MDT Transit Development Plan for fiscal years 2011 to 2020 states that the agency has applied for a JARC (Job Access and Reverse Commute) grant in the amount of $500,000 to be used for the SR-836 Express Bus.

### 2.5.2 Operation Responsibilities

Operation is an important component of the proposed system. Thus, the question of who is going to operate the system will have to be answered in the early stages of the planning and design of the system. The proposed system could be operated by MDT or a private service provider, but both of these options present advantages and disadvantages.

Although the option of a private service provider could be a viable alternative, there are a number of disadvantages associated with this option. Operating a service separately in a region like Miami-Dade may not produce the same quality of transit service provided by the existing transit agencies that have extensive resources and have established a framework for bus operations. In addition, having a private provider operating this service will introduce another level of complexity to coordination and inter-agency communications. Advanced technologies of the type proposed in this study require expertise and resources that may not be easily provided by the private sector. Furthermore, there is a need for skilled personnel such as bus operators, supervisors, and mechanics. These employees must be supported by administrative and technical staff such as managers, IT personnel, planners, administrators, marketing specialist, etc. to efficiently administer and deliver a high-quality bus system. Fortunately, MDT has already developed the expertise required in these areas.
Finally, a bus system will require supporting facilities such as stations and stops, maintenance facilities, and operating facilities. Additional components such as spare parts, administrative vehicles, maintenance equipment, fueling systems, and information technology systems are also required. MDT already has these facilities and the necessary infrastructure needed to support the proposed bus system. In the case of a turnkey operation provided by a third party provider, the cost may be lower. However, there is no guarantees that the same level of service will be provided. This needs to be investigated in the design stage of the system.

### 2.5.3 Agency Coordination

For both short-term and long-term implementations of the bus system proposed in this document, agency coordination will be required. As such, there will be a need for close coordination with MDT in particular. MDT already has plans for implementing an east-west transit system on SR-836 and the associated park-and-ride facilities, which are programmed in the regional plan. Therefore, it is logical to closely coordinate the proposed implementation with MDT.

Additional park-and-ride facilities and future TODs will result in a change to traffic patterns on the street network, which is already congested during peak periods of the day. There may be a need to conduct impact studies to determine the effects of the new traffic developments in accordance with the policies and regulations of the County and its affected municipalities. In addition, the change in pattern will potentially require updates to the signal-timing plans which may need to be administered by the Miami-Dade County Public Works Department. Bus priority has also been considered as a potential measure to improve travel times and on-time performance of buses in Miami-Dade County. MDT is already working with the County Public Works Department to evaluate real-world deployment of this strategy along main corridors such as Kendall Drive. As the proposed SR 836 service will pass through congested arterial streets, such a strategy may be beneficial and thus consideration should be given to include it as part of the deployment.

The proposed TODs in the long-term and park-and-ride in the short-term, if implemented within FIU, will require additional coordination. This includes the approval of such facilities as part of the FIU Master Plan in coordination with the responsible departments at FIU. In addition, all future TODs should comply with the regulations, policies, and plans of the county, municipalities, and jurisdictions impacted. Considerable coordination with these entities will be required.

### 2.5.4 Park-and-Rides

A park-and-ride facility is a parking lot (or garage) used by transit riders to park their vehicles during mass transit trips. These facilities are located along a major transit line and can have, in addition to park-and-ride garages or lots, kiss-and-ride areas for transit users who are dropped-off in the morning and picked-up in the afternoon; bus bays immediately adjacent to the parking
area; pedestrian facilities (e.g. sidewalks, lighting, etc.); and bicycle facilities (e.g. bike racks, lockers, etc.).

A number of studies have been conducted and plans developed to implement park-and-ride facilities within Miami-Dade County by various agencies, such as MDT, FDOT, Tri-Rail, and some cities. A comprehensive plan was recently developed by the MPO\(^2\). The plan takes the existing facilities, planned facilities, and new facilities into consideration.

Currently, there are 30 park-and-ride facilities in Miami-Dade County for Tri-rail, Metro-rail, the US-1 busway, and express/special Metrobus services. None of these facilities are in the vicinity of the potential bus alignments considered in this study. However, there are programmed park-and-ride facilities that have high priority and are expected to be included in a near term or five-to ten-year plan, including the MIC and the park-and-ride facility on Dolphin Station/Doral (NW 12th Street/ NW 107th Avenue) with 189 spaces. Table 2-3 and Figure 2-1 below show the planned and programmed park-and-ride facilities.

The MPO park-and-ride study recommended short-, near-, and mid-term implementation for park-and-ride facilities based on the following criteria:

- Existing or expected route ridership
- Existing or expected parking demand
- Site accessibility for transit vehicles
- Site accessibility for park-and-ride patrons
- Potential implementation mechanism
- Location permitting ease
- Land cost
- Construction cost

In the vicinity of the proposed alignments, the park-and-rides identified in the MPO study for the short-term are the SW 8th Street/147th Avenue and the Dolphin Station/Doral (NW 12th Street/107th Avenue). This study recommends that these two locations, in addition to potential locations at FIU and the MIC, are considered to support the proposed express bus system.

A number of issues are associated with park-and-ride implementation, including safety, management, multimodal access, security, comfort levels, and so on. Lessons learned from the national and local standards should be considered in the design, implementation, and operation of these facilities.

<table>
<thead>
<tr>
<th>Location</th>
<th>Planned</th>
<th>Programmed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. 117 (Honaker Bridge)</td>
<td>200</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>U.S. 117 (5th Street)</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Central Avenue Park (1st Ave. to 5th St.)</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Athletic Park</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Western Blvd. (100 to 500 St.) (Liberty)</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>College Road</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>1st Street</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Broadwater Ave.</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Main St. (1st Ave. to 5th St.)</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>1st Avenue</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Broadwater Ave. (1st Ave. to 5th St.)</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>College Rd. (1st Ave. to 5th St.)</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>U.S. 117 (100 to 500 St.) (Collierville Blvd.)</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Robertsville Rd.</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Broadwater Ave. (1st Ave. to 5th St.)</td>
<td>50</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

*Note: All improvements planned for 2023-2025.*
2.5.5 Fares

An important consideration of the bus system is the fares charged to potential express bus customers. Different fare options include free fares, fares currently used for similar systems, and the fare to be charged when transferring to other systems. Each of these options has its respective advantages and disadvantages. To promote consistency in the region, this service can be modeled after the I-95 Express which charges $2.35 per directional trip. Furthermore, the technology that will be used for fare collection is a key element to the system’s success. This study will recommend electronic fare payment, as discussed further in the ITS section of this document.
2.5.6 Alignments

A number of alignments could be proposed for the service investigated. Such alignments and associated stops are investigated in the modeling section of this document. The final selection of the alignment should be made based on a number of factors, including ridership, revenue/cost ratio, directness, speed, travel times, availability of park-and-rides, agency coordination results, and so on. It should also be mentioned that MDT has a programmed bus service with a preferred alignment. The final alignment for the bus service of this study should be coordinated with the programmed MDT bus service. Below is the alignment provided by MDT. The plan shows that it is programmed for 2014 and it is also listed in the MDT Draft Transit Development Plan.

The modeling section of this document addresses the bus service from west Miami-Dade to the MIC and downtown, and compares the resulting ridership with different alternatives. In the future, consideration may be given to extending the service to Miami Beach, if in fact that service is found to be beneficial.

2.5.7 Feeder Bus Service

Feeder bus service has the potential to increase ridership, however, it will also increase the total cost of the project. The modeling section of this document investigates the resulting change in ridership due to such a bus service. It is also expected that smaller vehicles will be used for this service. In general, the costs of such buses can range between $80,000 to $150,000, depending on the size and specifications.
Feeder buses have the advantage of providing service to both main bus stations and park-and-rides. To be successful, the operating areas of these services will have to take the population density near the surrounding bus stations into account. Initial operating areas were identified for the purpose of the modeling in this study. However, this will have to be revisited in the detailed planning and design stage of the bus system.

It should be mentioned that Tri-Rail is currently operating shuttle services to and from their stations. Lessons learned from these services would be very useful to the implementation of the SR-836 bus system.

Coordination between the proposed bus service and the supporting feeder buses will be needed to ensure that there is a minimum waiting time.

### 2.5.8 Environmentally-Friendly Vehicles

The express buses should be environmentally friendly in accordance with the MDX and regional goals of reducing the impact of transportation on the environment. There are currently significant advances in technologies such as electric, hybrid-electric, hydrogen, and compressed natural gas, leading a trend towards green and sustainable passenger vehicles of the future. Applying such technologies in mass transit vehicles will redefine and create a new generation of efficient and eco-friendly buses.

A hybrid vehicle utilizes both a fuel engine to move transmission and an electric motor powered by a rechargeable battery. At lower velocities, the electric engine is optimal and requires no fuel to power the vehicle. At higher velocities, the engine switches to the regular fuel engine which functions best under these conditions. A purely electric vehicle, however, has only an electric motor powered by rechargeable batteries to move the transmission.

The main advantage of hybrid-electric vehicles is that they have improved fuel efficiency compared to regular fuel-powered vehicles when driving in the city. This efficiency can result in a significant reduction of greenhouse gas emissions. Hybrid Electric Buses are available in a wide range of bus sizes and are technically feasible for transit service in the United States. MDT is using a Diesel-Hybrid Bus for its express services. Such buses are candidates for this implementation. Figure 2-2 below depicts the buses used in the Kendall Cruiser express service.

Another alternative is the hydrogen fuel cell vehicle. There are two ways in which hydrogen has been used to improve the efficiency of vehicles. Hydrogen alone can be used as a fuel instead of gasoline to perform the combustion in an engine. Not only that, but the hydrogen fuel cell is also used as a mechanism that turns the chemical reaction between oxygen and hydrogen into electrical energy to power a vehicle. In this case, the engine is no longer necessary and the fuel cell can directly power the motor controlling the transmission.

Fuel cell technology is very promising for various reasons. Firstly, hydrogen as a fuel source is unlimited, thus refueling is rapid and low-cost. Secondly, the only emission from hydrogen as
fuel is warm air and water. Lastly, the energy conversion efficiency of fuel cells is decent, but has potential to be further enhanced as well. Hydrogen fuel cell technology, however, is fairly young and its production costs are presently expensive. Additionally, maintenance and repair costs can also be elevated due to the lack of hydrogen fuel cell specialists in the market.

Figure 2-2: Express Bus Vehicles Used by MDT
2.5.9 Comfortable Traveler Experience

Demand models of the type employed in this study use travel time and cost as the sole factors in calculating the ridership of the buses. In reality, other variables such as safety, security, and comfort are also important travel decision factors. The vehicles should be comfortable and safe as well as provide attractive services to travelers, such as internet access and traveler information systems.

The recommended comfortable ride experience should be extended to bus stops, stations, and park-and-ride facilities. In this respect, comfortable settings and amenities, such as the opportunity to purchase refreshments, need also be considered. Moreover, services like internet access and next-bus arrival information should be made available to drivers.

Ideally, the associated major bus stops should offer more amenities than a regular bus stop to increase the attractiveness of the transit system. Some of these stop facilities should be near or physically connected to pedestrian-oriented parking structures. The bus stops also need to be designed for maximum accessibility and comfort. To achieve this, bus stops could allow for shelters with travel information displays, ticketing, and other items to maximize the traveler’s satisfaction. These stops would aim to provide a comfortable and safe environment for passengers waiting on buses. Moreover, free Wi-Fi, comfortable seating, and nearby stores and shops would encourage passengers to find productive ways of utilizing their waiting times.

2.5.10 Marketing

At the initial stage of development, marketing can be crucial to the success of this project. Early opportunities for promoting this service need to be identified and a market strategy subsequently developed. The expected challenges to the proposed express bus service are as follows:

- **Getting people to realize that this is a new and different experience**: The public at large needs to have an understanding of the uniqueness of this project. To do this, we must create proprietary names for the system, the actual vehicles, and the total experience that the rider will have. These names will help to differentiate the entire project from other transportation experiences, and will set the tone for marketing efforts as we move forward. It will also help separate the express bus system from regular bus service.

- **Getting people to want to use the system**: This can begin with identifying what can be appealing to riders. It is important to understand the project from a customer’s point of view. People also need to feel secure, be interested, and be entertained. Therefore, providing solutions that satisfy customers’ needs and requirements are key to the success of this project.
• **Creating an experience where the rider feels comfortable and well cared for while they walk, ride, and wait:** In order to create a positive overall experience for the user of the SR-836 Express Bus, the transit operator must go beyond having a system that is convenient, economical, and efficient—the system also needs to be attractive to people. Future TODs can enhance riders’ experience by providing additional services; for example, by creating environments that are linked to TODs and open spaces such as public squares. This can be especially attractive for choice riders. The figure below shows an example of a public square.

The marketing campaign to promote the new service can be accomplished by in-house staff or by a marketing company. This can also be combined with an advertising campaign such as placing ads on buses, stops, and stations to generate additional revenue.

![Figure 2-3: A Public Square in Palma de Mallorca](image)

### 2.5.11 Parking Structure

Another issue is the structural integrity of the parking garages, at FIU for example, if they are to be incorporated into the TODs or park-and-rides in the future. However, as mentioned earlier in the document, this consideration has to be addressed in coordination with the responsible
departments at FIU and the FIU Master Plan. From a structural point of view, the garages need to be assessed to determine their integrity, specifically regarding the capability to expand and accommodate additional capacity.

The FIU Blue and Gold parking structures are located at the Modesto A. Maidique Campus. Their locations are ideal for implementing the TOD concept. Figure 2-4 illustrates the location of the two parking structures. There is no apparent structural problem with these parking structures, but the parking layout, traffic flow, and ramp design need to be further investigated. Some of the parking spaces may be converted into offices and retailers as part of future TODs, which will impact the building code requirement for minimum design live load. Appendix B provides additional information on a potential TOD implementation at FIU.
3. TRANSIT ORIENTED DEVELOPMENTS (TODS)

TODs are one of the elements that can be considered for future implementation with the proposed system to increase the overall effectiveness of service. As stated previously, TODs for at least two locations, in the vicinity of FIU and the MIC, should be considered. However, this implementation is not feasible for short-term implementations (by the year 2012) since it requires extensive planning, coordination, design, and construction efforts. This section presents background information about TOD and how it could be implemented to increase the ridership of the bus system.

3.1 TOD Background

There is general agreement in the public transit community that TODs will significantly improve pedestrian and bicycle access to transit. Expected outcomes by the establishment of TODs include encouraging transit ridership and reducing automotive trips. Advocates for TODs and public transit frequently suggest that transit and TODs are also important to the economy (Bailey, 2007; BBPA, 2007; Clower et al., 2007; and BBPA, 2008).

With TODs, people move through dense, mixed-use developments within a 1/2- to 1/4-mile walking distance from a train station or transit stop (Gruen 1964, Pushkarev, and Zupan, 1975; Seneviratne, 1985; Calthorpe, 1993; and O'Sullivan and Morroll, 1997). Empirical evidence of people’s willingness to walk may be found in the literature (Gladstone Associates, 1974; Pushkarev and Zupan, 1977; RPA, 1997; Sherrett, 1979; PDPWA, 1982; MTA, 1988; SCTA, 1989; OMT, 1992; NJ Transit, 1994; PBSJ, 1996; Bossard, 2002; Zhao et al., 2003; Cervero et al., 2004; and Dittmar and Ohland, 2004).

In a previous study by Zacharias, it is mentioned that a 1/4-mile walking radius is too conservative; studies of pedestrian behavior in walking environments of a higher-quality indicate that, in an environment of wide sidewalks, convenient subways, street transit, and appealing architecture, streetscaping, and parks, people will walk farther distances. Similar studies conducted by Zacharias in San Francisco showed that office workers walked an average of 1,998 feet (0.38 miles) during lunch time (see Zacharias, J., “Reconsidering the impacts of enclosed shopping centers: a study of pedestrian behavior around and within a festival market in Montreal.” Journal of Landscape and Urban Planning 26:149-160 (1993); and Zacharias, J., “Spatial behavior and urban design in downtown San Francisco,” Paper presented at the International Conference: Spatial Analysis and Environmental Behavior, Eindhoven, The Netherlands, Nov. 29th to Dec. 1st (1995); and Zacharias, J., “The non-motorized core of Tianjin, International Journal of Sustainable Transportation,” 1, 231-248 (2007)).

TODs require transit systems that can efficiently transport people to and from the TOD and thereby allow for a better quality of life without complete dependence upon the car for mobility.
and survival. TODs greatly reduce the need for driving and the burning of fossil fuels. Within a TOD, buildings are located along the street. There are fewer private and more public spaces. A TOD includes small blocks, narrow streets, wider sidewalks, street trees, and lights. Also, TODs typically have lower parking ratios, shared parking, parking behind buildings, and on-street parallel parking. TODs also tend to generate higher property values and revenue for the public and private sector.

A traditional TOD is a moderate- to high-density development, located within an easy walk of a major transit stop. These areas generally have a mix of residential, employment, and shopping opportunities designed for pedestrians, as shown in Figure 3-1. TODs can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use.

![Figure 3-1: Street Corner of a TOD Provided by Sacramento Regional Transit District](image)

### 3.2 Proposed TOD Concept

TODs are more than just density; they represent a building and landscape design that helps to orient travelers toward transit use. Many TOD advocates, however, assume incorrectly that density and pedestrian improvements applied to typical urban or suburban communities will be sufficient to provide the benefits claimed. There are many other factors that contribute to the success of TODs in attracting transit ridership.

In the U.S., roadways and parking lots remain a dominate feature of urban development and few efforts exist to create car-free centers or pedestrian corridors that would encourage pedestrians to congregate in large numbers and walk farther than typical distances (beyond a 1/4- to 1/2-mile). What is clear from the literature and from common experience is that most American streets lack acceptable walking environments for pedestrians, and therefore, people walk shorter distances. As such, where better and safer walking areas exist, people walk farther. What remains to be seen is the actual willingness of people in South Florida to walk long distances, although evidence from past research in other parts of the world that suggests that this could be expected.
Historically in urban and suburban areas of the U.S., a 1/4 to 1/2-mile was traditionally assumed as a reasonable walking limit. Such walking range represents ample opportunity for retail and cultural activities to blossom over a relatively large urbanized area of a quarter-square mile to one-square mile.

An ideal TOD environment, as envisioned in this study, would include large scale walking environments and plazas for significant pedestrian activity. Examples of such environments can be found in many European cities. Many variations exist as to size and shape of these TOD developments. Streets or other corridors suitable for large scale walking or gathering tend to be wide and sufficiently long to link multiple small and major destinations. Figure 3-2 shows examples of such environments outside the U.S.

Figure 3-2: Public Square in Old Quebec, Canada and Outdoor Shops in Budapest, Hungary

A proposed TOD, similar to what could be considered in the future for this project, is depicted below in Figure 3-3. This TOD has the following components:

- Passenger rail service providing long distance area transportation
- Transit service providing access to areas surrounding the TOD
- Parking
- Office use
- Hotel use
- Residential use
- Ground floor retail use
3.3 Expected TODs Benefits

It is anticipated that the TODs will become desirable destinations and will generate sufficient traffic to support an express bus system. These TODs will provide benefits in terms of a number of performance measures. Transportation engineering literature indicates the potential benefits of traditional TODs, as documented below:

- TOD can provide mobility choices
- TOD can increase public safety
- TOD can increase transit ridership by 20% to 40%
- TOD can reduce the rate of increase in vehicle miles traveled
- TOD can help to conserve resource lands and open space (they consume less land than low-density, auto-oriented development)
- TOD can play a role in economic development

3.4 Implementation Issues

One of the issues with TOD implementation, however, is the identification of potential locations. One potential location is FIU’s campus, shown in Figures 3-4 and 3-5. FIU’s Modesto A. Maidique Campus has grown rapidly in the last 20 years and although there is substantial under-used land left (as the aerial photograph shows), there is also an increasing need to develop a
detailed strategy that implements the general policy goals adopted in the FIU Master Plan. These strategies must take full advantage of the opportunities provided by the existing facilities and transportation systems, and coordinate effectively with the neighboring municipality of Sweetwater to the north, and adjoining areas across NW 107th Avenue to the east.

Figure 3-4: Existing Conditions between the Blue and Gold Parking Garages at Florida International University on Maidique Campus
Another potential location is the vicinity of the Miami Intermodal Center (MIC). The MIC is still under construction at the present writing of this report, although the first phase has been completed. The overall master plan for the MIC project anticipates enhanced rail facilities, including a future high-speed rail stop, and a terminal and concourse building that would link and organize all the modes of transportation which converge on the site. Miami-Dade County’s land use policies encourage transit-oriented development at locations where major investments in transportation facilities have taken place.

The current plan also anticipates private mixed-use development on parcels that are in close proximity to the transportation facilities. The MIC is located in unincorporated Miami-Dade County. It has a future land use designation of Terminal and is targeted as a Metropolitan Urban Center. This last designation mandates pedestrian access and TOD design features in the vicinity of transit stops.

There are a number of challenges for implementing a TOD, as follows:

- The TOD design should consider multimode access, including transit, pedestrian, and bicycles. Previous experience shows that many existing TODs do not account for this consideration.
- Community and agency coordination is needed to optimally plan, design, and implement TODs.
- Land use/zoning policies should be considered.
• There is a potential risk of failure at high cost if not well-planned and designed.
• Private and public financing is difficult to obtain.
4. BUS ON SHOULDERS

4.1 National Experience
In some cities in the U.S. and Canada, buses are allowed to drive on the shoulder. This is usually referred to as “bus-only shoulder lane.” However, instead of having full operations of buses on the shoulders, a potential cost-effective application is to allow buses to use shoulders as shoulder-bypass lanes or queue jumpers-only in order to bypass congestion at a traffic bottleneck. The bus use of shoulders as a continuous lane or bypass lane has been implemented in Maryland, Minnesota, Virginia, Washington, British Columbia, Ohio, California, and Ontario. An excellent review of these implementations and the lessons learned can be found in a report by the Transit Cooperative Research Program (TCRP). Operating bus-on-shoulder has been increasingly considered to improve the travel time and travel time reliability of buses, thus potentially increasing overall bus ridership. This strategy is very attractive and cost-effective. Nevertheless, there are a number of issues to consider regarding implementation, as listed below:

- Shoulders are intended to provide support for enforcement and incident management activities, including the accommodation of disabled vehicles and incident management response vehicles, emergency vehicle access, highway maintenance staging, and use by the Florida Highway Patrol (FHP) during enforcement activities. Bus operations should be designed in recognition of these high-priority functionalities.
- The segment under consideration includes several interchanges, such as the SR-836/SR-826 interchange. The potential conflicts at the on-and off-ramps need to be addressed and the geometric design of these ramps checked to determine if there is any sight-distance issue with the bus implementation, particularly for merging on-ramp traffic.
- There will be a need for bus-driver training to ensure safe and efficient operations.
- There may be some safety concerns, including the speed differential between the travel lane and bus on shoulder, and also with the loss of the safety buffer that the shoulder provides.
- There will be an extra need to ensure that the shoulder is clear from debris at all times. To achieve this, additional costs of maintenance may be needed to keep the shoulders free from debris and to maintain the shoulder pavement.
- The construction activities planned for SR-836 will have to be considered when implementing the bus operation on shoulder.
- Many highway shoulders are 10-feet wide or less. When examining the SR-836 segment of this project, it was determined that 2.7 miles has a right shoulder width of equal or less than 8 ft., 6.7 miles has a 10-ft. shoulder, and 1.1 miles has a 12-ft. shoulder. This was based on the analysis of the FDOT RCI database. The buses themselves are nearly 10-ft. wide, including mirrors. The minimum shoulder width for bus operation is set to 12 ft. in Cincinnati and 10 ft. in Minneapolis (except along barriers where the standard is 11.5 ft.).
- Shoulders may not be able to support high volumes of bus traffic since buses are very heavy vehicles. However, this will not be a problem for the SR-836 implementation since the volume of the bus traffic is expected to be low. In addition, it is recommended that the operation will be a bypass operation and thus occur for only short time periods.
• Drainage side slopes and catch basins sometimes also need modification to provide comfortable bus rides. These should be examined for the SR-836 sections to determine if any modifications are needed.
• The potential benefits of using in-vehicle driver assistance technologies on buses that use the shoulder lanes should be considered. Such technologies should make it easier and safer for bus drivers to operate on narrow shoulder lanes. Potential applications can include merging assist, as well as the lane-keeping assist, technologies. These technologies will be further addressed in the ITS section of this document.
• Adequate signage and pavement markings must be provided for safe operations.
• One of the complaints of bus drivers in the pilot study on SR-874/SR-878 discussed in the next section was that the pavement slope between the roadway and the shoulder transition felt uncomfortable. Changes in the height and slope of the pavement transition area may reduce the instability caused when vehicles move to the shoulder.
• If rumble strips are to be used, they should be positioned in the center of the shoulders so buses can operate while straddling the strips.
• A marketing program is needed to educate motorists about the program, and an enforcement program is under development.

The TCRP study report mentioned earlier concluded that with proper operating rules and upgrades to shoulder facilities, the use of shoulders for buses is expected to be a successful and cost-effective solution. The shoulder bypass lanes implementation alternative is expected to require minimal shoulder upgrade cost and can provide significant benefits. Such implementations, for example in Minnesota and New Jersey, as reported in the TCRP report, have required a minimal level of additional signing and no special pavement markings. Signs are periodically placed along a shoulder designating it for “Authorized Buses Only.” These signs were placed approximately a quarter- to half-mile apart along the freeway shoulders. Warning signs that alert drivers to “Watch for Buses on Shoulders” are also provided along on-ramps before the merge with shoulder and freeway traffic. Small yellow advisory signs are posted along the shoulder at places where the shoulder narrows. In Cincinnati, the buses run along the shoulder of I-71 using the left shoulder so as not to affect off-ramps and on-ramps. “Bus-on-shoulder” signs are installed every quarter-mile.

In the Minnesota’s queue jumper implementation, bus drivers use the shoulders only when general purpose lane travel speeds drop below 35 mph. Buses travel only 15 mph faster than mainline traffic, up to a maximum of 35 mph. If a disabled vehicle blocks the shoulder lane, or the highway patrol has pulled a vehicle over in the shoulder lane, the transit vehicle merges into the general bus lane to bypass the obstruction. Bus drivers are also trained to yield to automobiles, particularly at on-ramps.

In Cincinnati, the shoulder lane is used when traffic slows below 30 mph and buses will not be allowed to travel more than 15 mph above the speed of highway traffic. Only buses and emergency vehicles will be permitted to use the shoulder, and buses will yield to emergency vehicles.
With regard to the benefits of these implementations, even when the bypass segment is relatively short, it has been found that the traveler perception of travel time savings is high. National experience indicates time savings with the freeway shoulder lane use in the range of 5 to 15 minutes for the average trip depending on the level of congestion. An average of 7 minutes is saved on most trips during peak travel periods. The customer perception of the time-savings, however, is much higher. Travelers view the use of the shoulders not only as saving time, but also as a way to minimize the stress resulting from sitting in traffic congestion. Also, the perception of trip reliability is much higher with the use of freeway shoulders.

### 4.2 Miami-Dade Experience

The Miami–Dade MPO completed a Special Use Lane Study for the region in 2005 that addressed transit use of shoulder bypass lanes. This study evaluates the condition of the shoulders along the freeway system as a bypass lane for allowing transit bus use in cases of traffic congestion. Recommendations were given regarding a core system that would consist of buses using shoulders on the Homestead Extension of Florida’s Turnpike, SR-826 (Palmetto Expressway), SR-836 (Dolphin Expressway), I-75, and I-95

An Interlocal Agreement was executed between the Miami Dade County Transit (MDT) and the Florida Department of Transportation (FDOT) Tallahassee Office for establishing a Pilot Project for by-pass bus-on-shoulders in 2006 for three years. MDT entered into agreements with FDOT and the Miami-Dade Expressway Authority (MDX) to allow transit buses along the shoulders of the expressways under their jurisdictions in March 2006. A Pilot Project was created along SR-874 (Don Shula Expressway) and SR-878 (Snapper Creek Expressway) based on three existing MDT Kendall Area Transit (KAT) routes.

An evaluation of the Pilot project mentioned above concluded the following:

- There were no traffic accidents involving bus-on-shoulders vehicles according to the Florida Highway Patrol, MDT, and MDX operations staff.
- Field surveys show no adverse wear on the highway shoulders, drainage culverts, or other roadway features due to the demonstration project.
- The service did gain new riders over 2006. However, cuts in MDT service in 2007 adversely impacted bus ridership. This ridership changed in accord with MDT bus service changes.
- Riders are very pleased with the service and judge the project favorably.
- Riders estimate greater time-savings than they actually receive.

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• Substantial increase was reported in on-time performance from MDT, compared to service prior to the experiment.

Bus driver’s complaints include that the shoulder is not wide enough for smooth operation; the travel-lane/shoulder pavement edge transition creates a less than ideal ride; and other motorists are a problem as buses merge to and from the shoulder.

The evaluation study recommended the consideration of park-and-ride facilities to support the three evaluated routes mentioned above. The MPO study also recommended additional express bus routes on the region expressways. If the shoulder bus service is to be implemented on SR-836, a new agreement with FDOT and MDT will be required.

4.3 Bus-on-Shoulder Cost

The evaluation study of the SR-874/SR-878 pilot project mentioned above reported that the cost to implement the project was low—about $15,000 needed special traffic signs. MDT also incurred costs for in-house driver training. The SR-874 and SR-878 shoulder pavement was examined before the implementation and it was determined that there was no need to upgrade the pavement on SR-874/878, as the existing shoulder pavement design was adequate for the buses. Such analysis would have to be performed on SR-836 to determine if the pavement required an upgrade or not.

It should be recognized, however, that the shoulder width used for the SR-874 and SR-878 implementations is the same as the existing width (10 ft.). While bus drivers reported that they would like wider shoulders, the evaluation study reported that widening the shoulder is estimated to cost over $500,000. In a more complex environment like the SR-836 corridor, it is expected that the cost will be much higher. In addition, as reported earlier, the shoulder width is determined to be less than 10 ft. for parts of the SR-836 corridor. Consideration should be given to have 11- to 12-ft. wide shoulders, and at least 11.5 ft. where buses operate next to barriers. The SR-836 sections will be under construction in the near future and opportunities to incorporate the wider shoulder requirements should be explored. The figures below depict MDT buses using shoulders on the SR 874/878 facilities.
National experience indicates that the cost of the required improvements depends on specific conditions. When a highway shoulder is being considered for bus-only shoulder use, existing shoulder conditions need to be evaluated to determine what additional modifications are needed. Costs also vary depending on whether the shoulder conversion is an independent project or is included as part of a larger construction project. The Minnesota DOT uses construction cost of $100,000 per mile as an average cost for upgrading shoulder lanes, including the rebuilding of drainage grates and paving at a 3- to 5-inch asphalt depth. More detailed numbers based on national experience are listed below:

- When only signing and striping improvements are required, the average cost for a freeway section improvement is expected to be from $2,000 to $3,000 per mile.
- When minor shoulder repairs and catch basin adjustments are needed, and signing and striping improvements are also required, the estimated cost for this work is $6,000 per mile, plus signing and striping costs.
- If pavement depth is insufficient, the estimated cost for adding depth is $15,000 per mile, assuming a 2-inch asphalt overlay.
• If the roadway is not being overlaid, the bituminous shoulder must be removed and the granular base adjusted. The estimated cost for this work is between $35,000 and $45,000, plus signing and striping costs.

• If the shoulder width is inadequate, widening and depth replacement are required. Signing and striping improvements are also required. The estimated cost for this work is between $45,000 and $70,000 per mile, plus signing and striping costs.
5. INTELLIGENT TRANSPORTATION SYSTEM (ITS)

This section discusses ITS deployments to support the bus system project described in the previous sections. An assessment was done of the ITS deployment needed for the proposed deployment and a framework was developed for this deployment. It is important to note that the framework was developed as a future “long term” of the ITS deployments necessary for the project. Some of these deployments are not directly applicable to the immediate MDX project. However, when planning ITS deployments, it is important to recognize this big picture, long-term view in order to realize synergies between the deployments, to allow more effective and efficient use of the resources, and to support better information and coordination between agencies. This section first presents a brief introduction of the potential deployments identified in the ITS framework that was developed in this study utilizing the national ITS architecture (NITSA) and statewide ITS architecture (SITSA). This section then focuses in greater detail on a subset of the ITS deployments that is applicable, or has the potential to be applicable, to the immediate MDX project.

5.1 Summary of ITS Framework

This section presents a framework for the ITS that have the potential to be deployed in support of the project. However, as discussed above, only a subset of these concepts is applicable to the MDX project, and will be discussed in greater detail in the following subsections of this report.

**Advanced Public Transit Systems:** Public transportation will be an important component of the deployment. ITS will play an important role in supporting transit system operations, including transit vehicle tracking, transit operation management, transit passenger and fare management, transit security, transit maintenance, and transit traveler information.

**Multimodal Traveler Information Systems:** It is recommended that the implementation be supported by an advanced traveler information system that provides integrated information about highway congestion, transit, incident, travel time, parking, and potential services and facilities available at the TODs.

**Multimodal Management Systems:** This will include information sharing and coordination of transit, freeway, and surface street management activities.

**Congestion Pricing and Managed Lanes:** Congestion pricing either by itself or combined with managed lanes can be implemented to encourage carpooling and possibly induce shifts in mode or time. These implementations can also generate revenue since a toll is charged to a specific group of vehicles. Although congestion pricing and/or managed lanes may be beneficial to the bus deployment, the decision to implement them will have to be made by the MDX based on many technical and institutional factors that are beyond the scope of this study.
**Dynamic Message Signs (DMS):** As will be described later in this document, a DMS implementation plan was developed for the MDX facilities and a few connecting arterials. With the bus project proposed in this study, the DMS deployments can be used to support additional requirements, including the provision of multimodal information regarding recommended mode shift to transit during incident conditions and park-and-ride information.

**Traffic Detection and Probe Surveillance:** Currently, true-presence microwave detectors are implemented at 1/3-mile intervals on MDX facilities. In the future, additional detection capabilities will be needed on arterial streets in the vicinity of the TODs for the monitoring of these facilities and to ensure optimal signal control. Accurate and reliable travel time estimation on arterials will be an important component of ITS deployments in Miami-Dade County. This will most likely require probe surveillance based on vehicle re-identification or tracking.

**Signal Control Strategies:** Signal-control strategies will be needed to provide optimized control in consideration of travelers attracted to the TOD and park-and-ride facilities.

**Incident Management:** FDOT District 6 and MDX provides a strong incident management program for Miami-Dade County freeways. These programs are among the most successful and effective ITS deployments. Consideration should be given to extending these services as needed to arterial streets. However, the benefits and costs of such an extension should be carefully studied.

**Parking Management and Information Systems:** The parking management and information systems will have to be implemented on the individual garage facility level and on an area-wide level. In individual facilities, these systems will guide motorists to empty spaces or garage levels that have empty spaces. In larger areas with multiple facilities, the systems will guide the motorists to the nearest available parking garage that meets their requirements. In addition, an electronic payment system, and an associated access control and enforcement system, will be needed.

**Ride Sharing:** This service provides static or dynamic ride-sharing/ride-matching services to travelers. The service could allow near-advance or real-time ride-sharing reservations to be made on the phone, the web, interactive kiosks, or other equipment. This service will also have to be coordinated with South Florida Commuter Services. Commuter Services currently provide traveler information services including a 24-hour call center, corporate carpool and vanpool programs, tri-county transit information, on-site rideshare promotions and displays, computerized rideshare matching, and an Emergency Ride Home program. Commuter Services work jointly with employers to set up transportation and parking programs, and provide confidential employee commute analysis and training.

**Electronic Toll Collection (ETC):** ETC using the Sunpass system is one of the most successful ITS implementations. The proposed bus system should be equipped with Sunpass Tags.
**Integrated Fare Collection System:** Various services within the proposed bus system will include financial payments. These services include electronic toll collection, transit fare, parking fare, car-sharing fare, and even payment for services at the ATODs. Consideration should be given to the integration of at least some of these electronic fare payment systems (including MDT Smart cards and SunPass transponders). While, it is recognized that it may not be feasible to integrate the payments of all of these services, it may be possible, for example, to integrate some of these services.

**Construction and Maintenance Support:** During the construction and maintenance of the facilities associated with the proposed project, there will be a need to manage traffic in areas of the roadway where maintenance, construction, and utility work activities are underway. In addition, there will be an optimal scheduling of these activities to minimize impact on traffic. Information about these activities and their impact will need to be disseminated to centers or traveler information systems that can utilize such information as part of their operations.

**Infrastructure Monitoring:** This will include monitoring the condition of pavement, bridges, tunnels, associated hardware, and other transportation-related infrastructure using both fixed and vehicle-based infrastructure monitoring sensors.

**Pedestrian and Bicycle Operations and Safety:** This service will ensure that all pedestrians and bicycles are able to safely and efficiently cross the street, including those visually challenged, physically challenged, and the elderly.

**ITS Data Archives:** Data collected from different sources will have to be archived in an integrated data warehouse. Data mining features are also included in this marketing package in addition to the basic query and reporting user access features.

**Real-Time System Analysis and Optimization:** This will include the modeling and analysis of traffic in real-time based on data collected in real-time to optimize the performance of the transportation system.

As mentioned earlier in this section, a subset of the above ITS components are directly applicable to the MDX project. These components are discussed below.

### 5.2 Dynamic Message Signs

MDX ITS deployment on SR-836 is in the process of including dynamic message signs (DMS). The MDX traffic management center has delivered information to SR 836 drivers using highway advisory radio. The traveler information is also disseminated using the statewide advanced traveler information system (ATIS) that includes 511 traveler information phone and web services, as discussed in the next section. Realizing the importance of DMS in delivering traveler information, MDX is currently in the process of installing DMS on SR-112, SR-836, SR-874, SR-878 and SR-924. The DMS deployment will be used to display real-time information to
motorists on the roadway; incident information; travel time estimates; lane blockages; major construction and maintenance activities; evacuation route information; toll operations messages; public safety awareness campaigns; AMBER alerts; Law Enforcement Officer (LEO) alerts; and Silver alerts. The MDX DMS will also be used to display real-time information about other agency roadways that are connected to MDX facilities including I-75, I-95, I-195, I-395, SR-826, US-1, and the Homestead Extension of Florida’s Turnpike (HEFT).

A report prepared for MDX by HNTB entitled “Dynamic Message Sign Implementation Study” proposed DMS locations for MDX facilities upstream of traffic bottlenecks and in advance of major decision points like ramps and major interchanges. A limited number of arterial DMS are to be located on arteries adjacent to freeways, providing traffic information which allows motorists the opportunity to adjust their commute before entering the freeway. All newly deployed MDX DMS will be integrated with the MDX TMC using the existing MDX Gigabit Ethernet fiber optic communications system.

The number of recommended DMS along SR-836 in the DMS implementation plan mentioned above is six freeway DMS in addition to two arterial DMS on NW 137th Avenue at the SR-836 starting point. The recommended DMS locations for SR-836 are presented in Figure 5-1. It was stated that the locations listed in the DMS Implementation Study are conceptual and that the final location and quantity of the DMS will be determined by the Design-Build team and submitted to MDX for approval. The DMS implementation study estimated the cost of one freeway DMS to be $274,150 and that of arterial DMS to be $164,150. These costs include the sign, structure, and all associated equipment, cabling, and construction.

Examination of Figure 5-1 indicates that particularly freeway DMS 1, 4, 6, and arterial DMS 8 could be useful in delivering multimodal-related messages to drivers to affect mode shifts, particularly in incident conditions. Additional DMS will be needed on LeJeune Road, NW 107th Avenue, and other arteries in the vicinity of the TOD facilities. In addition, coordination with the FDOT and the Florida Turnpike Enterprise will be needed to support delivering multimodal messages on SR-826, I-95, and the Florida Turnpike, in case of severe incidents on SR-836. It should be mentioned that FIU is currently conducting a project for the FDOT central office research center to examine multimodal information sharing and the coordination of the management of these systems. The results of the multimodal information sharing research will be useful to this project.
Figure 5-1: Proposed SR-836 DMS Location Layout in the MDX DMS Implementation Plan
The proposed DMS deployment can be used to encourage a shift in mode to the provided bus service, in case of incidents on MDX and other surrounding facilities. Motorists on SR-836, the approaching freeways, and the approaching arterials would receive messages informing them of incident conditions and directing them, when appropriate, to use the bus service. In its basic form, this can be accomplished by developing rules to display stored DMS messages, which would be stored in the SunGuide traffic management center DMS message database, to be activated under various incident locations and conditions. As with other messages, the MDX operator will have the opportunity to override the automatically generated messages.

In a more advanced implementation, the travel time expected using the bus service and passenger cars can also be displayed to allow drivers to make informed decisions regarding a switch in their mode of travel. With this implementation, the central system would include an intelligent decision support system to estimate the travel times when using the passenger car and transit modes and to recommend mode shifts in real-time. Such an advanced implementation, however, requires resolving a number of issues, as discussed below.

The travel time estimation for highway and transit should be accurate and reliable to gain the trust of the motorists. In addition, the transit travel time should include the transit waiting time and the time required to travel on both the arterial and freeway segments of the transit trip. As mentioned above, the DMS system is currently managed from the MDX TMC using the SunGuide software. This software allows the estimation of freeway travel time using a simple method that is based on speed measurements by point traffic detectors located at one-third-mile intervals on the corridor. Research at FIU indicates that this method works well in uncongested conditions, but the accuracy is significantly reduced in congested conditions and in traffic incident conditions. A new travel time estimation algorithm has been proposed for this purpose.

In addition, there is no ability to estimate the transit travel time using the SunGuide software. Thus, either the SunGuide software will need to be modified to estimate transit travel time or it will need an application that is interfaced with the SunGuide software, which will need to be developed to accommodate this additional functionality. The sharing of information from the SunGuide software and the MDT transit management system will also be required. In an effort to enhance arterial travel time estimation, a probe surveillance market package could be implemented that uses automatic vehicle location and/or vehicle identification technologies, such as Bluetooth or Sunpass readers, to measure the travel time of passenger cars and transit vehicles.

The proposed project will include parking facilities and eventually TODs. An advanced parking management system that provides parking information will be needed as well. This system will also utilize arterial street DMS to deliver parking availability and direction messages to motorists.
5.3 Advanced Traveler Information System (ATIS)

The DMS deployment described in the previous section can be considered as a traffic management subsystem, rather than a traveler information subsystem, since its main purpose is to manage traffic. In fact, the national ITS architecture classifies DMS as traffic management devices. Additional technologies are needed to disseminate information to travelers that will allow them to improve their trip route, mode, and time technologies. The express bus system will provide a unique opportunity to have an integrated multimodal, multi-facility traveler information system that allows travelers to make informed decisions in selecting their trip routes, times, and modes, and that will potentially provide advice regarding the optimal decisions.

Three ATIS market packages were selected for the South Florida region in the statewide ITS architecture development effort. The three selected market packages are basic broadcast information (broadcasted to all travelers), interactive traveler information (information provided based on travelers requests), and optimal route recommendations offered by information service providers. The recommended route information could also potentially include trip mode recommendations.

Currently, the 511 traveler information phone service and web service are the main ATIS components to deliver traveler information in Southeast Florida. Within this region of Florida, telephone and web services started delivering information to travelers as a 10-digit number in May 2001, and began utilizing the 511 number in July 2002. These services were managed by a private sector information service provider (Smart Route Systems) in contract with the FDOT. However, in mid 2009, all state 511 traveler information phone and web services were combined in one statewide system referred to as the Florida Statewide 511 System.

The system provides bilingual (English and Spanish) real-time traffic information, including travel times, congestion, construction, lane closures, severe weather, and emergency evacuation information on all Florida interstate highways, toll roads, and other major roadways. The service is managed by a private sector contractor and is available 24 hours a day via phone with Interactive Voice Response (IVR) by dialing 511, or on the Web at www.FL511.com. The 511 system receives ITS data and video through center-to-center communications with Florida TMCs. Information from transit and airport agencies is available from the 511 phone and web systems through links/transfers to the transit agency information system.

The transit information system includes information on trip planning, fare and schedule information, and service alerts, but does not include real-time estimated bus arrival. In addition, because arterial streets generally do not have travel time detection technologies, no travel time information is reported for them. The incident information on these arteries is generally obtained through police reports and calls to the TMC.
A number of opportunities exist to expand the ATIS capabilities in the region to better support multimodal traveler information, as described below:

- At various locations in the future TOD facilities (and potentially park-and-ride facilities), ATIS displays and/or interactive ATIS kiosks should be installed to provide highway and transit information. A good example of ATIS displays is the system installed at the Florida Turnpike Enterprise rest plaza. This system displays alert messages and video from CCTV cameras on the Florida Turnpike. A variety of information can be delivered such as travel time from the TOD facility to major destinations using the highway and transit modes, expected next bus arrival, video images from critical locations of the corridor, and any toll information.

- At bus stops, DMS displaying the estimated arrival times of next buses need to be installed. Miami-Dade is currently providing information for the arrival of the next Metrorail vehicle, but not other types of transit vehicles. However, it is expected that the new automatic vehicle location (AVL) of the metro bus system will include and allow the dissemination of next bus arrival information.

As discussed earlier in this section, the current statewide ATIS system does include detailed transit and arterial travel time information. However, the statewide ATIS system is flexible in that it allows each region to manage the traveler information content being reported on the 511 system. An investigation can be made into the possibility of expanding the 511 phone and web services to include special features for the freeway, arterial, and transit facilities associated with the proposed bus system. Such modifications would allow the traveler to specify an origin and a destination and receive estimated travel time for the highway and transit modes. Such implementation, however, will require the integration of transit real-time data with the ATIS system and additional detectors and video cameras on local arteries in the vicinity of the TODs and park-and-rides. This may not be within the scope of the current MDX bus project.

The implemented ATIS could also potentially support other useful ITS applications such as parking management and information systems, and ride-sharing.

Additional delivery methods will be possible in the future including those integrated with handheld devices and in-vehicle devices. The current developments in the IntelliDrive program should provide inputs to these potential implementations.

### 5.4 Advanced Public Transportation System (APTS)

ITS will play a prominent role in supporting the proposed transit system operations, including transit vehicle tracking, transit operation management, transit passenger and fare management, transit security, transit maintenance, and transit traveler information.
Many of the APTS mentioned above have already been deployed by the Miami-Dade Transit. Realizing the importance of ITS, MDT has made ITS implementation a strong focus. As such, an MDT Information Technology and ITS Strategic Plan was developed in 2004.

ITS-specific initiatives that were proposed in the MDT ITS Strategic Plan include:

1) On-Board Bus Infrastructure and Replacement
2) Automated Passenger Counting
3) Customer Information Network
4) Real-Time Information
5) Bus Traffic Control Management
6) E-commerce
7) Fare Collection
8) Paratransit
9) Safety and Security
10) Traffic Signal Prioritization (TSP)
11) Scheduling Enhancements and Planning Tools
12) Workforce Management
13) Core Data Management
14) Decision Support Tool

MDT has deployed Automatic Passenger Counters (APCs) and an Automated Fare Collection System on 100% of its fleet. A Scheduling Enhancements and Planning Tools project was completed as well. In addition, a Request for Proposals (RFP) will be issued to replace the MDT’s current CAD/AVL system (Computer-Aided Dispatch and Automatic Vehicle Location System) with a new state-of-the-art system. Currently, information is provided about the arrival of the next Metrorail vehicle using DMS installed at the Metrorail stations. No such technologies have been implemented for other types of transit vehicles, although this may be expected in the near future. Traffic Signal Priority (TSP) deployments are also being considered on a case by case basis and are being tested on Kendall Drive.

As indicated above, MDT has already implemented or is planning to implement ITS technologies for its fleet. These technologies should also be implemented on the proposed bus fleet. The following are specific additional recommendations for the MDX bus project.

There will be a need for additional coordination and information sharing between transit and highway operations to provide an integrated management of the system and deliver real-time multimodal information to travelers. The ultimate goal would be to have automated center-to-center connections between transit management and highway management. An alternative would be to build an external application that interfaces with the traffic management and transit systems, processes the data, and produces and disseminates information critical to the operation
and management of the system. This latter alternative is currently being explored by the FIU research team as part of an FDOT research center project.

In addition to installing ITS technologies on the fixed-route transit vehicles, similar technologies will be needed for the feeder bus network, if such a network is included in the design. This network will require optimization both off-line at the planning level and on-line, in real-time, at the operations level.

It is anticipated that portions of the bus trips between origins and destinations will be on signalized arterial streets. Preferential treatment of transit vehicles on these arteries would improve the bus operations and encourage increased ridership. These preferential treatments can be justified by the fact that a bus carries significantly more passengers than a passenger car. Thus, treatments that favor buses are expected to reduce the total person-hours of travel and encourage mode shifts to transit. Preferential treatment of transit vehicles includes bus lanes, queue jumpers, and transit signal control priority (TSP). TSP can be implemented in a variety of approaches such as passive priority, early green (red truncation), green extension, actuated transit phase, phase insertion, phase rotation, and adaptive/real-time control. A queue jumper is a bus with preferential treatment that combines a short stretch of a special lane with a TSP to allow buses to bypass waiting queues of traffic. These buses are given an early green signal, enabling them to “cut” in front of otherwise lengthy queues (see Figure 5-2). Bus lanes are lanes provided exclusively for the use of buses and are not anticipated to be used for this project in the near-term. Bus priority is currently being tested on Kendall Drive in Miami-Dade County and should be considered for the MDX bus operations.

Figure 5-2: Example Configuration of a Queue Jumper
5.5 Signal Control Systems

Optimized signal control will be needed on alternative routes and for the connections between the TOD, park-and-ride, and the limited access facilities. Miami-Dade County will finalize the transfer of the signal to the county to a state-of-the-art signal control system in the near future. The proposed implementations in this study will require the involvement of the County in further updating their signals to ensure optimal operations. The optimized operation of the signal control system is essential to express bus implementation because this is expected to significantly impact traffic patterns in the vicinity of the associated facilities. This will require significant retiming of the signals to accommodate the new patterns. In addition, the multi-facility operation of the system will require a close integration between expressway and arterial operations to ensure optimal operations of the connections between different facilities and optimal operations of the diversion route signals to accommodate diverted traffic during incident conditions.

The signal control will need to be enhanced at various locations at and around the TODs to optimize and facilitate pedestrian movements and transit vehicle operations including the potential for bus priority. Appropriate advanced pedestrian and bicycle detection technologies to ensure crossing safety can be included to support this function.

5.6 Support of Bus-on-Shoulder

This study recommends utilizing bus-on-shoulder (queue jumper) for the SR-836 bus system. This operation should allow bus to bypass traffic queues during congested conditions. However, the study identified a number of issues to consider with the implementation, including loss of shoulder functionality, conflict with on- and off-ramps, need for bus operator training, need for additional shoulder construction and maintenance, potential shoulder widening conflict with the planned construction activities on SR-836, need for adequate signage and pavement markings, and need for a marketing program.

ITS technologies could also be used to support bus-on-shoulders and operations. This could include communicating the presence of disabled vehicles or emergency/enforcement vehicles on the shoulder. Such information could be communicated using infrastructure based devices, such as lane-control signs or pavement lights with changing colors, to indicate this to the driver. In addition, driver-assist technologies such as vehicle-merging assistance and lane-departure warning systems could help to increase safety, considering the narrowness of shoulders and the need for buses to frequently merge into traffic.

5.7 Data and Performance Measurements
MDX and FDOT Districts have used devices such as traffic detectors and closed circuit television cameras (CCTV) to collect traffic parameters for operational purposes. The MDX and all FDOT districts utilize the SunGuide system as the central software in their TMCs. The SunGuide system maintains operational databases for use in report generation. Below is a description of two archived files that are produced by the SunGuide software.

1) Incident Archives: For each SunGuide incident record, the stored information includes incident timestamps (detection, notification, arrivals, and departures), incident ID, responding agencies, event details, chronology of the event, and environmental information. The detection timestamp is the time when an incident is reported to the TMC and input to the SunGuide system. The notification timestamps refer to the time when responding agencies are notified and are recorded per notified responding agency. The arrival and departure timestamps are also per responding agencies and refer to the time when responding agencies arrive and depart from the incident site.

2) Detector Data Archives: the traffic condition data are stored in Traffic Sensor System (TSS) text flat files, with each file including data for all the detection stations for a 24-hour day. The TSS file contains one record for each lane of each detection station for every 20-second polling interval. Each TSS data record includes the following information: timestamp, detection station name, lane number, speed, occupancy, and raw count.

In addition, the Statewide Transportation Engineering Warehouse for Archived Regional Data (STEWARD) has been developed as a proof of concept prototype for the collection and use of ITS data in Florida. The development of this prototype has demonstrated that data from traffic management centers around Florida can be centrally archived in a practical manner and that a variety of useful reports and other products can be produced. STEWARD archives data in a database that supports the generation of reports and queries. The current effort has concentrated on archiving point traffic detector data and travel time estimates.

The STEWARD database contains summaries of traffic volumes, speeds, and occupancies collected from point traffic detectors. These detectors are located every 0.3 to 0.5 mile on the equipped corridors in Florida. The stored data can be aggregated by 5-, 15-, and 60-minute periods, as requested by the user. Reports can be generated by each detector, detection station, and system-wide. The travel times in the archive are those estimated by the TMC software in Florida (the SunGuide software) based on data collected from the point traffic detectors. STEWARD includes a quality assessment procedure to identify bad or suspicious data as well.

Transit agencies, including MDT, have also archived their operational ITS data. Furthermore, a transit agency data warehouse referred to as ADAMS has been developed as a proof of concept for the warehousing of ITS transit data in Florida.

Recent research efforts conducted by FIU for the FDOT has developed decision support and performance measurement tools that can be used to support the operations of traffic management.
centers in Florida. These included assessing and improving incident impacts, incident management performance, benefit-cost analysis, travel time estimation quality, and transit system performance. The use of such tools and further integration of highway, transit, and toll data will allow for better planning, optimization, and management of the system. The integration of databases from different sources will also facilitate the development of more powerful tools to optimize system implementations and operations.

5.8 Costs of ITS Deployments

It is very difficult to estimate the costs of the ITS deployments proposed to support the Express Bus/TOD deployment in an accurate manner unless at least a concept design for the ITS deployment is available. However, this section presents an order of magnitude cost estimates for the potential ITS deployments at the planning level. More detailed and accurate cost estimates will be possible when the concept design becomes available.

1) Dynamic message signs: Additional DMS deployment will be needed to support further diversion to the express bus system. As stated earlier in this report, the DMS implementation study estimated the cost of one freeway DMS to be $274,150 and that of arterial DMS to be $164,150. These costs include the sign, structure, and all associated equipment, cabling, and construction. Assuming that there will be a need for one additional freeway DMS and four additional arterial DMS to support diversion to the express bus system during incidents, the cost of the DMS deployment will be close to $1 million. The operation and maintenance (O&M) cost can be assumed to be $20,000 per freeway sign and $12,000 per arterial sign, based on previous surveys. The DMS life cycle was estimated to be 10 years for the DMS and 20 years for the structures in the Florida-specific parameter project. It should be recognized that, depending on the design, there may be a need for more arterial DMS. However, there may be opportunities to utilize hybrid static/dynamic signs. In addition, there may be opportunity to use Highway Advisory radios combined with static signs with flashing beacons. The cost of one HAR is estimated to be $65,000 with an O&M cost of about $5,000. Overall, it is estimated that the cost of the additional DMS deployment, possibly supplemented by static/hybrid signs and HAR deployments, will be between $1 million and $1.4 million.

2) Traveler Information Systems: As discussed earlier in this document, additional ATIS deployment could include ATIS kiosks/monitor displays at the Express Bus facilities, next bus arrival signs, and extension of the ATIS delivery through phone, web, and other hand-held and in-vehicle devices, to produce a multimodal, multi-dissemination channel system. With regards to ATIS Kiosks/ displays and their integration with the central system, it is estimated that this will cost $25,000 per location. Next bus arrival signs are estimated to cost from $25,000 to $30,000 per location. Assuming four to six of these technologies (displays and next bus signs) are utilized, the cost of deployment is estimated to be between $250,000 and $350,000. With regard to the expansion of ATIS
to a multimodal, multi-dissemination channel system, investigation of a public-private sector mechanism is one option with which to achieve this end.

3) **Advanced Public Transportation Systems**: As mentioned earlier, MDT is already installing APTS technologies on their fleets. Overall, it is estimated that the cost of AVL, passenger counter, electronic fare payment, mobile data terminal, security system, and an on-board information system will cost about $50,000 per bus. Integration of highway and transit software and support of optimal operations based on the collected data will include software module development and testing that is estimated to be $1 million. Bus priority cost is estimated at $6,000 to $10,000 per intersection, with an additional $2,500 per bus for on-bus equipment. Queue jumpers will require additional costs in order to modify the intersection geometry.

4) **Signal Control Systems**: As stated above, Miami-Dade County is in the process of upgrading the current signal system in the County to a state-of-the-art system. The additional modifications required to produce optimal operations for the newly generated patterns of general traffic, transit, and pedestrians are estimated to cost $15,000 per intersection with $4,000 O&M cost per year. If an adaptive signal control is selected the additional cost is estimated to be $40,000 to 50,000 per intersection, with $5,000 to $7,000 O&M per intersection per year. The above costs do not include those required to modify the geometry to accommodate the newly generated patterns.

5) **Data Management and Performance Measurements**: It is anticipated that additional costs will be required to develop and integrate tools for data management, performance measurements, and decision support tools. The cost is estimated to be between $500,000 and $1 million.

5.9 **Benefits of ITS Deployments**

Below are high-level estimates of ITS benefits. These estimates will be revised in future tasks of the express bus system planning and design, based on more detailed analysis:

1) **Dynamic message signs and ATIS**: The main DMS/HAR and ATIS benefits will be to induce diversion to alternative routes and to the express bus system in case of lane blockage incidents. Recent analysis by FIU that utilized FDOT District 6 detector data from the SR-826 east-west corridor indicates that the diversion rates in case of incidents vary between 0% and 40% of traffic depending on incident conditions and traffic conditions during incidents. The introduction of the express bus system as a viable alternative option, combined with additional deployment and enhanced DMS and ATIS, is expected to increase travel diversion rates.

2) **Advanced Public Transportation Systems**: Based on our review of the literature, APTS strategies can result in 5% to 20% improvement in on-time performance. In addition, various strategies will result in a 5% to 10% increase in transit ridership. Bus priority is estimated to improve the travel time of buses by 10% to 12%. The reduction in bus delay per intersection can range from 15% to 30% depending on the red time that the bus gets, which is a function of the congestion level in the system for the period under
investigation. For cross street transit, the delay at individual intersections increases by 6% each time transit vehicles pass through during the peak periods, and by 0% during the off-peak periods.

3) **Signal Control Systems**: Past studies indicate that signal control system benefits range from 5% to 7% reduction in delays for simple frequent retiming of the traffic signals, and from 5% to 12% reduction in delays for adaptive control. However, the benefits for the express bus system are estimated to be significantly higher, at least for the initial deployment, since it will result in shifting traffic patterns that may cause significant mobility and safety problems if the signal control is not modified to accommodate these changes.

4) **Data Management and Performance Measurements**: It is anticipated that the use of decision support and optimization tools to integrate the operations of freeway, signalized arterial, transit, and toll facilities will allow for better planning, optimization, and management of the express bus system. This is expected to result in significant improvements in mobility, safety, and the revenue generation of all facilities and modes of travel.
6. PRELIMINARY MODELING OF TRANSIT RIDERSHIP

This section summarizes a preliminary modeling effort to assess the ridership potential of the proposed bus system, as described in the previous sections. It should be mentioned that, in 2009, HNTB conducted a feasibility study of an express bus service that would utilize primarily the SR-836 and connect the western area of Miami-Dade County with downtown. This HNTB study is highly relevant to this project in terms of its purposes, service areas, alignment, and operating parameters. In this section, the HNTB study results are summarized first, followed by a description of the analysis conducted in this study to estimate potential ridership for the proposed bus system.

6.1 Previous HNTB Study Results

HNTB completed an analysis of an express bus service along SR-836 for MDX in 2009. The SERPM 6.5 2005 time-of-day model was used in the analysis, with the SR-836 extension to NW 137th Avenue coded into the 2005 model.

Proposed Transit Routes
The two alternative routes considered in the HNTB study are shown in Figure 6-1. The proposed routes were assumed to operate on the general purpose lanes of SR-836.

![Route 1](image1)

![Route 2](image2)

Figure 6-1: Route 1 and Route 2 Proposed by HNTB
Route 1 had four stops: the southeast corner of SW 137th Avenue and SW 8th Street, MIC, the Health District, and the downtown Miami-Dade Transit (MDT) station adjacent to the Government Center Metrorail Station. Route 2 had eight stops: FIU main campus, Dolphin Mall, International Mall, Mall of Americas, Miami Merchandise Mart, MIC, the Health District, and the downtown MDT station adjacent to the Government Center Metrorail and Metromover Stations.

Model Assumptions
The headways for both routes were assumed to be 15 minutes for peak, off-peak, and midday periods. The transit fare was assumed free for both routes in the model.

Route 1 had park-and-ride facilities located at SW 137th Avenue/SW 8th Street and at the MIC, while Route 2 had six park-and-ride lots.

Table 6-1 shows the 2005 travel time and ridership results for Route 1. For Route 1 eastbound, the peak period travel time is 75.42 minutes and off-peak travel time is 46.34 minutes. For westbound, the peak period travel time is 50.05 minutes and off-peak travel time is 45.43 minutes. **Route 1 has a daily ridership of 2,549 passengers.** Peak period ridership is 1,149 passengers.

Table 6-1: 2005 Modeled Travel Time and Ridership for Route 1

<table>
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<th>Direction</th>
<th>Distance (Miles)</th>
<th>Travel Time (Minutes)</th>
<th>Ridership</th>
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<tr>
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</table>

Route 2 data was recreated in the 2005 SERPM based on the alignment and model parameters from the HNTB report since previous model input was not available. Due possibly to some minor differences between the coding of the original network and that attempted by FIU, the model results were slightly different. Route 2 has a daily ridership of 3,889 passengers, with 2,641 passengers traveling in the eastbound direction and 1,248 passengers in the westbound direction, as shown in Table 6-2.

Table 6-2: 2005 Modeled Travel Time and Ridership for Route 2

<table>
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<th>Direction</th>
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<td>23.84</td>
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6.2 Modeling of the Proposed Bus System

Since the objective of this study is to determine the short-term ridership, the SERPM 6.5 (Southeast Regional Planning Model) 2005 time-of-day model was used. The model was only modified to reflect the proposed bus system and the associated implementations, as described below.

6.2.1 Proposed Transit Route

Three alignments were modeled in this study, each with variations of parameters, as follows:

- The first alignment is the same as HNTB Route 1 alignment (see Figure 6-2). The original HNTB model assumed a transit speed that is the default in SERPM, which is lower than highway speed to account for regular operations of buses. However, since the proposed bus is an express bus service on the freeway, the bus speed is expected to be close to that of automobile speed of the freeway section. Thus, additional runs were made with bus speed equal to 100% freeway speed. Furthermore, as stated in the bus-on-shoulder section, this implementation will result in actual and perceived reduction in travel time during congested conditions. On average, it was reported that the bus travel time is lowered by 7 minutes due to the bus-on-shoulder. Thus, sensitivity analysis was conducted with additional runs made that involve higher speeds of buses compared to automobiles (110% and 120% of freeway automobile speeds).
- Route 2 (see Figure 6-2) is similar to Route 1 but with the service starting from FIU instead of NW 137th Avenue and with a stop at the Engineering Center of FIU.
- Route 3 is similar to Route 2 but with additional stops at the programmed NW 12th Street Park-and-Ride, NW 87th Avenue, the Merchandise Center, MIC, University of Miami Hospital, and downtown.

Variations of the above alignments that were also modeled include the following:

- Stopping routes at MIC instead of downtown
- Including the MIC Metrorail connector in the model
- Including feeder buses
- Variations in park-and-ride implementations
- Free service versus $2.35 transit fare
Figure 6-2: The Three Routes Considered in This Study
The headway for the proposed route was assumed to be 15 minutes for peak and off-peak periods, as assumed in the HNTB study. Sensitivity analysis on this headway can be conducted in the design stage of the project.

6.2.2 Model Results

Table 6-3 presents the model results for the proposed Route 1 with different parameters and assumptions. The results for Route 1 from the HNTB study are also listed in Table 6-3.

<table>
<thead>
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<th>Off Peak</th>
<th>Daily</th>
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<td>TT (Min)</td>
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<td>WB</td>
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<tr>
<td>Route 1 with 110% speed</td>
<td>EB</td>
<td>51.91</td>
<td>1692</td>
<td>26.47</td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>29.84</td>
<td>512</td>
<td>25.95</td>
</tr>
<tr>
<td>Route 1 with Fare and 110% speed</td>
<td>EB</td>
<td>52.39</td>
<td>1294</td>
<td>26.47</td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>29.9</td>
<td>504</td>
<td>25.95</td>
</tr>
<tr>
<td>Route 1 with 120% speed</td>
<td>EB</td>
<td>51.98</td>
<td>1420</td>
<td>24.33</td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>27.39</td>
<td>581</td>
<td>23.76</td>
</tr>
<tr>
<td>Route 1 with Fare and 120% speed</td>
<td>EB</td>
<td>47.98</td>
<td>1414</td>
<td>24.33</td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>27.36</td>
<td>526</td>
<td>23.76</td>
</tr>
<tr>
<td>Route 1 with 100% speed, with MIC-MR Connection</td>
<td>EB</td>
<td>51.98</td>
<td>1420</td>
<td>24.33</td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>27.39</td>
<td>193</td>
<td>23.76</td>
</tr>
</tbody>
</table>

Note: TT means travel time and its unit is minutes; Dir. means the direction of the listed routes.

Based on Table 6-3, the following can be stated:

- Increasing bus operation speed improves the estimated ridership from 2,549 to 4,098 passengers per day as a result of the change in the calculated travel time.
- Additional increase in speed due to the operation on shoulder can further increase the ridership during the peak time, as indicated by examining the results with 10% and 20% travel speed increase. However, it should be understood that the values in this table (the 10% and 20% assumptions) are not claimed to reflect the actual increase in speed or ridership due to bus-on-shoulder operations. They are merely reported to show the
sensitivity of these variables to speed increases by giving preferential treatments for the
buses versus automobiles.

- Charging $2.35 fare instead of free service results in reducing the ridership from 4,098 to
3,283 passengers per day, with 100% speed assumption.
- Including the MIC Metrorail connection in the model increases the passenger ridership
from 4,098 to 4,575 passengers per day.

In order to test the impact of the bus feeders, other alternatives were modeled with bus feeders at
stops for FIU, Dolphin Mall (DM), NW 87th Avenue, and the Medical Center of the University
of Miami (MCUM), as shown in Figure 6-3. Different park-and-ride assumptions were also
tested. Table 6-4 shows the tested alternatives. The modeled results of those alternatives are
shown in Table 6-5.

Table 6-4: Different Alternatives for Route 1, Route 2, and Route 3 with a Fare of $2.35

<table>
<thead>
<tr>
<th>Name</th>
<th>Route</th>
<th>Variation of parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>137 AVE – SR-836 – MIC – DT</td>
<td>Park-and-ride at 137th AVE and MIC</td>
</tr>
<tr>
<td>1B</td>
<td>137 AVE – SR-836 – MIC</td>
<td>Park-and-ride at 137th AVE and MIC</td>
</tr>
<tr>
<td>2B</td>
<td>FIU EC – SR-836 – MIC</td>
<td>Park-and-ride at FIU and MIC</td>
</tr>
<tr>
<td>3C</td>
<td>FIU-EC – DM – 87 AVE – MC – MIC – MCUM – DT</td>
<td>Park-and-ride at FIU, Dolphin Mall, and MIC, and bus feeders for FIU, 87th AVE, Medical Center, and Downtown</td>
</tr>
</tbody>
</table>

The potential bus feeder alignment for the bus stops can be illustrated in the following figure.
The results from the analysis are shown in Table 6-5. Based on these results, the following can be concluded:

- The alternatives that extend to downtown (1A, 2A, 3A, and 3C) have the highest daily ridership among all the alternatives and significantly more than those stopping at the MIC. However, the travel times are higher for these alternatives.
- Alternative 3, which involves more stops than the other alternatives, also has higher ridership than alternatives 1 and 2; however, it has higher travel times as well.
- By comparing the daily ridership between Alternatives 3A, 3C, and 3D, it can be observed that including park-and-ride facilities and adding bus feeders do not significantly increase the bus route ridership according to the model. This, however, may be due to the low sensitivity of the demand model, and additional investigation is needed to determine the impacts of these factors in the future.

As discussed in the ITS and TOD sections, these two components are expected to increase the ridership from about 10% and 20% to 40%, respectively. Furthermore, the bus-on-shoulder operation is expected to reduce the travel time and the perceived travel time. Thus, this operation is expected to further increase the ridership. The effects of the ITS, TOD and bus-on-shoulder are not reflected in the demand model results.
Table 6-5: Impacts of Alternatives on the Proposed Transit Travel Time and Ridership with 100% Speed and $2.35 Fare

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Dir</th>
<th>Peak TT(Min)</th>
<th>Peak Ridership</th>
<th>Off Peak TT(Min)</th>
<th>Off Peak Ridership</th>
<th>Daily TT(Min)</th>
<th>Daily Ridership</th>
<th>Total Ridership</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>EB</td>
<td>62.38</td>
<td>1032</td>
<td>29.16</td>
<td>2107</td>
<td>3139</td>
<td>3683</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>32.91</td>
<td>164</td>
<td>28.53</td>
<td>380</td>
<td>544</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>EB</td>
<td>39.51</td>
<td>450</td>
<td>18.24</td>
<td>466</td>
<td>916</td>
<td>994</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>20.88</td>
<td>15</td>
<td>18.59</td>
<td>63</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>EB</td>
<td>52.26</td>
<td>931</td>
<td>28.48</td>
<td>1931</td>
<td>2862</td>
<td>4066</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>32.86</td>
<td>375</td>
<td>28.49</td>
<td>829</td>
<td>1204</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>EB</td>
<td>34.39</td>
<td>229</td>
<td>17.56</td>
<td>269</td>
<td>498</td>
<td>1033</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>WB</td>
<td>20.85</td>
<td>151</td>
<td>18.55</td>
<td>384</td>
<td>535</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3A</td>
<td>EB</td>
<td>74.22</td>
<td>946</td>
<td>36.58</td>
<td>2337</td>
<td>3283</td>
<td>5909</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>46.69</td>
<td>770</td>
<td>35.12</td>
<td>1856</td>
<td>2626</td>
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<td></td>
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</tr>
<tr>
<td>3B</td>
<td>EB</td>
<td>56.87</td>
<td>294</td>
<td>25.66</td>
<td>693</td>
<td>987</td>
<td>2595</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>34.72</td>
<td>468</td>
<td>25.18</td>
<td>1140</td>
<td>1608</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3C</td>
<td>EB</td>
<td>74.22</td>
<td>978</td>
<td>36.58</td>
<td>2510</td>
<td>3488</td>
<td>6186</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>46.69</td>
<td>767</td>
<td>35.12</td>
<td>1931</td>
<td>2698</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>EB</td>
<td>74.22</td>
<td>947</td>
<td>36.58</td>
<td>2338</td>
<td>3285</td>
<td>5910</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB</td>
<td>46.69</td>
<td>769</td>
<td>35.12</td>
<td>1856</td>
<td>2625</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. OPERATING REVENUES AND COST ESTIMATES

This section includes an estimate of the capital, operations, and maintenance costs of the proposed bus system and associated supporting systems.

7.1 Bus Capital and Operation Costs

As mentioned earlier, environmentally-friendly “green” vehicles such as Hybrid-Electric and Diesel-Electric buses are suitable for the proposed express bus service. Another alternative can be using the CNG (Compressed Natural Gas) buses. The costs of these vehicles vary in price, depending on whether they are articulated or regular buses, and/or if these buses include particular features. MDT is currently using Diesel-Electric Hybrid buses for its express service. For instance, the price of the MDT Kendall Cruiser (articulated bus) is approximately $900,000. The cost of a similar regular bus is about $600,000. These buses meet the characteristics identified for buses that can be used in this project.

A previous HNTB SR-836 express bus study estimated the capital cost of a hybrid bus to be around $500,000. This bus is equipped with advanced design, hybrid/electric or other clean fuels, comfortable seating, and WI-FI.

In this study, additional investigation was conducted of different types of buses, with costs varying from about $300,000 to slightly above $1 million. However, it appears that the buses that meet the project specifications will range in price between $600,000 and $900,000, depending on whether articulated or regular buses are used.

Two sources were used to estimate the operation and maintenance costs of the buses.

- Based on the National Transit Database and local and national providers, HNTB estimated the operation cost of buses, including storage, maintenance, supervision, and supplies, to be between $59 and $165 per revenue hour. $150 was selected for the SR-836 in the HNTB study.
- MDT also suggested using $98 per revenue hour as a rule of thumb for planning purposes.
- Another source is the Bus-on-Shoulders Service Evaluation Report prepared by Parsons for Miami-Dade MPO (2009), which reported the MDT Metrobus operating costs to be about $105 per hour.
- In this study, the overall operation and maintenance costs were estimated to be $150 per hour.
7.2 Feeder Capital and Operation Costs

Feeder buses can increase the attractiveness of the express bus service. This feature can provide potential riders with an alternative to riding or walking to the park-and-ride lots. As this service will be accomplished by smaller vehicles that can provide services to the park-and-ride, the costs will range between $80,000 to $150,000, depending on the size and specifications.

The cost of the operations of feeder buses is expected to be lower than the regular bus service. The current cost per hour of operations for the shuttles servicing the Tri-Rail station is $55. For feeder buses, the cost of $55 per hour will also be used. This was based on the rates under contract with SFRTA (Tri-Rail) to operate shuttle bus service.

7.3 Revenue to Cost Ratio Analysis

A revenue to cost ratio analysis was conducted for two potential alternatives, based on the results of the modeling discussed in Section 6. These alternatives are as follows:

- Alternative 2A: This alternative is estimated by the model to result in a daily ridership of 4,066 passengers per day, with an average travel time in the peak period of 52.3 minutes for the eastbound direction and 32.9 minutes for the westbound direction. During the off-peak, the travel times were approximately 28.5 minutes in both directions.

- Alternative 3A: This alternative is estimated in the modeling step to result in a daily ridership of 5,909 passengers per day, with an average travel time in the peak period of 74.22 minutes for the eastbound direction and 46.7 minutes for the westbound direction. During the off-peak, the travel times were approximately 36 minutes in both directions.

The weekday revenue was calculated in this study by multiplying the daily ridership produced by the traffic demand model by an average fare value. This average fare value was calculated as a percentage of the full fare to account for fare evasion, discounts, equipment failure, etc. Sensitivity analysis was conducted by assuming two different percentages, 50% and 75%, respectively.

The cycle time for each bus was calculated by using the travel times for each peak period of the day and a 10% layover/recovery time at the end of the line. The number of buses was calculated by dividing the cycle time during the peak periods by the headway (15 minutes in this study).

The total number of operating hours in a day was calculated as the sum of all the travel times of all round trips. The daily operation cost was calculated by multiplying this number by $100 per hour. The capital cost of the buses was annualized, assuming an interest rate of 7% and a bus-life of 10 years. This annualized capital cost was divided by 255 (the number of weekdays in a year)
to produce a daily value that is added to the daily operational cost, resulting in the total cost of the bus system. These results are shown in Table 7-1.

The results in Table 7-1 below show that the revenue to cost ratio for Alternative 2A is 0.33 with 50% average fare assumption and 0.50 with 75% average fare. For Alternative 3A, the results below show that the revenue to cost ratio is slightly higher with 0.36 with 50% average fare assumption and 0.54 with 75% average fare.

It is expected that ITS will increase these values by 10%. As reported in the TOD section of this document, a ridership increase of up to 40% may be expected. Assuming that the TODs will be financed outside this project, the revenue over cost ratio can increase to 0.82 with alternative 3A if both ITS and TODs are implemented. As described in the modeling section no benefits could be quantified for the feeder bus system. In addition, the impacts of the bus-on-shoulder are not accounted for in the revenue to cost calculations presented in this section. It is expected that these two components will further increase the ridership and revenue to cost ratio. Finally, better enforcement and payment mechanism to reduce fare evasion will increase the revenue/cost ratio (as stated earlier, the average fare is assumed to be 50-75% of the full fare).
Table 7-1: Alternative 2A vs. Alternative 3A

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 2A</td>
<td>Base (No ITS and 50% average fare)</td>
<td>4,066</td>
<td>8</td>
<td>$4,777</td>
<td>$14,477</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>No ITS and 75% average fare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITS with 50% average fare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITS with 75% average fare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 3A</td>
<td>Base (No ITS and 50% average fare)</td>
<td>5,909</td>
<td>11</td>
<td>$6,943</td>
<td>$19,463</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>No ITS and 75% average fare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITS with 50% average fare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITS with 75% average fare</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
8. SUMMARY AND RECOMMENDATIONS

This project investigated the feasibility of a bus transit system on the Dolphin Expressway in Miami-Dade County and the potential attributes needed for such a bus system. Supporting components of the proposed bus system were also investigated to help increase the ridership and improve the system performance. These components include park-and-ride facilities, operations on shoulders, Intelligent Transportation Systems (ITS), and feeder buses. In addition, a variation of the TOD concept was discussed as a potential future component. This section presents recommendations for the implementation and operation of the bus system and its supporting components.

Bus System

An express bus is recommended for operation on SR-836. The preferred attributes of this service are listed as follows:

1) Simple route layout
2) Frequent service
3) Less frequent stops
4) Color-coded buses and stops
5) Transit signal priority
6) High-capacity buses
7) Feeder network
8) Real-time transit information
9) Low-floor vehicles
10) Buses-on-shoulders

A number of alignments and parameters were modeled in this study for the proposed bus system to identify the alignments that produced both the highest revenue to cost ratio and high ridership. Based on this modeling effort, two alternative alignments appear to produce the best results for ridership and revenue to cost ratios. These two alternatives connect the FIU Modesto A. Maidique Campus (FIU’s main campus) with downtown Miami. The modeling effort indicates that park-and-ride is beneficial; however, it also showed that feeder buses were not found to produce benefits (an issue which needs to be revisited in the design stage of the project).

The estimated ridership for Alternatives 2A and 3A range from 4,066 to 5,909 and the revenue to cost ratio range from 0.33 to 0.59 depending on the specific alternative and the assumptions used in the analysis as detailed in this report. It is expected that using ITS ridership can increase by 10%. Similarly, TODs can be expected to increase ridership up to 40%. In addition, the impacts of the bus-on-shoulders can further increase the bus ridership and the revenue over cost ratio.
Finally, better enforcement and payment mechanism to reduce fare evasion will increase the revenue/cost ratio (as stated earlier, the average fare is assumed to be 50-75% of the full fare).

This report identifies and discusses issues critical to the success of the bus system including funding mechanisms, decision regarding operational responsibilities, coordination among stakeholder agencies, fare settings and enforcement, selecting a final alignment in the design stage, providing feeder bus service, providing park and ride facilities, utilizing environmentally friendly vehicles, traveler comfort, and the need for a marketing campaign.

**Intelligent Transportation Systems**

Advanced Public Transportation Systems (APTS) will be an important component of the bus system. These will include transit vehicle tracking, transit operation management, transit passenger and electronic fare collection management, transit security, transit maintenance, passenger counters, and transit traveler information.

Another important component of this deployment should be multimodal management and information coordination. Dynamic message signs on SR-836 and potentially on arterial streets should be used to deliver transit and highway messages to travelers. In addition, some of these signs could communicate park and ride space availability to potential users. Other ATIS devices could be used for this purpose including electronic displays and signs, 511, websites, and potentially personalized information using hand held devices and vehicles.

The deployment could also include advanced modeling and analysis of traffic in real-time based on transportation system measurements to optimize the performance of the system. Signal controls will have to be updated to accommodate the change in traffic patterns due to the park and ride facilities and the future TODs. In addition, bus priority could be considered to reduce travel times and to increase on-time performance.

**Bus-on-Shoulder**

This study recommends utilizing congestion by-pass (or queue jumper) bus-on-shoulder operation for the SR-836 bus system. This operation should allow bus congestion bypass (queue jumper) during congested conditions. However, the study identified a number of issues to consider with the implementation as including lost of shoulder functionality, conflict with on and off ramps, need for bus operator training, need for additional shoulder construction and maintenance, shoulder widening potential conflict with the planned construction activities on SR 836, need for adequate signage and pavement markings, and need for a marketing program.

ITS technologies could also be used to support bus-on-shoulders and operations. This could include communicating the presence of disabled vehicles or emergency/enforcement vehicles on the shoulder. Such information could be communicated using infrastructure based devices, such as lane-control signs or pavement lights with changing colors, to indicate this to the driver. In addition, driver-assist technologies such as vehicle-merging assistance and lane-departure
warning systems could help to increase safety, considering the narrowness of shoulders and the need for buses to frequently merge into traffic.

**Park-and-Ride**

Park and ride facilities can be implemented in the short-term, while others should be considered for longer-term implementations. In the short-term, at a minimum, park-and ride-stops at west Miami-Dade and the MIC (Miami Intermodal Center) should be explored. Additional locations such as the Florida International University Engineering Center (FIU EC); the interchange of NW 87th Avenue and the Dolphin Expressway; and the intersection of NW 107th Avenue and NW 12th Street are also candidates. MDT is already planning park-and-ride facilities as part of their east-west corridor plan. The park-and-ride facilities should be designed to maximize traveler’s convenience, ensure vehicle security, and provide information to travelers. Over time, it is possible that some park and ride locations may evolve to fully-developed TODs.

**Future Considerations**

In this study, an express bus system was proposed. While this is part of the planning phase of the project, there is still a need for further investigation into the following design and implementation areas:

- **Transit Demand.** One of the areas that need to be investigated in greater detail is the potential demand for this service and the optimum hours of operations to improve the outputs obtained by the modeling calculations. For instance, the service could be provided during only the peak hours to reduce the operational costs. As transit ridership may increase with time, providing additional hours of service could be evaluated as a means to satisfying this demand. A survey of potential transit customers can be taken to assist with this task.

- **TODs.** There is also the possibility of further exploring the TOD concepts in coordination with local and regional agencies. Although this may be expected to occur at some point in the future, the groundwork to prepare for implementation still needs to be conducted. The TOD concept outlined in this study has not been fully investigated in terms of its impacts, particularly as it applies to South Florida. Also, it is recommended that potential funding mechanisms for TODs at FIU and the MIC are explored. This could include the involvement of private and/or public agencies.

- **ITS.** The use of ITS technologies for highway and transit and the integration of ITS as applied to these two modes also needs to be explored further. The coordination, implementation, and utilization of highway ITS and transit ITS is critical to the success of this project. The availability of travel information can help travelers on SR 836 decide whether to continue using the highway or switch to transit. With this information, potential riders are given the ability to make an informed choice about their mode of travel.
travel. In addition, providing real-time information can enhance the travel experience for both drivers and transit riders.

- Bus-on-shoulders. The condition of pavement, geometry, signage, markings, and other control devices needs to be assessed to ensure the safety and effectiveness of buses using shoulders.
- Preference survey. Finally, a preference survey needs to be conducted to assess the public attitudes toward park-and-rides, TODs, express buses, feeder buses, and the use of ITS technologies.

Next Steps

A potential next step of this project is to further develop and implement a multimodal, multi-facility Traffic Management and Traveler Information System. This would include integrating data from multiple sources. FIU is conducting a research for the FDOT research center on this topic. It is recommended that this research is extended and implemented to address the specific problems and issues to the SR 836 MDX facility, particularly considering the significant impact of the planned construction activities on the corridor.

MDX TMC receives a significant amount of traffic and incident data that are used mainly for planning and operational purposes. There are opportunities for further use of these data to improve the performance of the MDX facilities and management activities. FIU has developed decision support tools that utilize ITS data in an efficient and effective way. It is recommended that these tools are extended to meet MDX requirements. Additional tools can be developed and implemented for MDX operations. These decision support tools are expected to utilize advanced analytical techniques and visualization to support various MDX operation and planning processes.

With the implementation of MDX DMS system, it is recommended that an examination is done of the DMS messaging strategies. Again these messages should be based on detailed analysis of ITS data and system performance under different conditions. Opportunities for other methods to disseminate traveler information including the emerging mobile communication technologies should also be explored.
REFERENCES


APPENDIX A
A.1 Bus Rapid Transit Case Studies

Community Transit

Community Transit (CT) provides bus service within Washington State’s Snohomish County and south to Seattle. It is now implementing its first bus rapid transit (BRT) line. This 16.7-mile line is part of the new BRT program called Swift. Running along SR-99 in south Snohomish County, it will extend from Everett Station in the north (a major multi-modal transportation hub with commuter rail, Amtrak, and local bus connections) to Aurora Village in the south (a regional shopping center and transit center), and provide connections to King County Metro buses and to Seattle.

This is Washington’s first true implementation of BRT and it incorporates the following elements:

1) Off-board fare collection
2) Near-level boarding
3) Stations that provide real-time next bus arrival information
4) Frequent headways
5) BRT vehicles with triple doors and low floors

Even in the early stages of the SR-99 BRT line, CT received frequent inquiries about where the next BRT line was going to be and several communities within the county were lobbying for consideration. This interest represented a dramatic change from previous years when many jurisdictions considered transit as a necessary nuisance. This new shift in attitude towards BRT has helped to create more comfortable communities, and has stimulated great interest in Snohomish County.

Categorizing Evaluation Criteria

CT staff members prepared an initial list of criteria and overall goals for the Swift BRT. This included a review of the Federal Transit Administration (FTA) New Starts/Small Starts criteria and a review of literature documenting the characteristics of successful BRT systems. Based on staff input at Community Transit, the criteria included those factors that supported BRT travel demand (population and employment density, activity centers, zoning support, and existing transit ridership) and those that supported BRT choice (transit signal priority, travel time savings, and connectivity to other modes).

Las Vegas MAX

The Regional Transit Commission (RTC) of Southern Nevada started operating the Metropolitan Area Express (MAX) on June 30, 2004. The 7.5-mile line is currently providing service between the Downtown Transportation Center (DTC) and North Las Vegas (see Figure A-1). The features of the MAX system include a dedicated transit lane, optical guidance system, low-floor vehicles, in-vehicle bicycle racks, enhanced passenger stations, multiple entry boardings,
traffic signal priority, automated passenger counters, off-board fare collection, and a CAD/AVL system. The Las Vegas MAX BRT system uses Civis vehicles that are manufactured by Irisbus in France. Civis vehicles are distinctive for being capable of using an optical tracking system to guide each vehicle along painted paths on the roadway. This allows the vehicle to function as a tram.

Alignment

The MAX system was developed with 22 stations spaced approximately 3/4 miles apart along Main Street/Las Vegas Boulevard. Along the alignment, there are ten intersections equipped with Traffic Signal Priority (TSP) for the BRT system and it includes one queue jumper. This provides priority treatment for the MAX vehicles that operate on congested traffic along Las Vegas Boulevard North.

Stations

The MAX stations are fully ADA compliant. They are approximately 220-ft. long with platforms 65-by-10 ft. with 17 inch curbs to allow for level boardings. A sidewalk at the rear of the station keeps the vehicle boarding and alighting access area clear of through pedestrians, a design that reduces station dwell times. Each station also has indirect ground and panel lighting to illuminate the station at night.
The edge of the platform has a tactile surface to alert visually impaired passengers of their proximity to the edge of the platform. Although the height of the vehicle floor is within a small tolerance of the curb height, RTC decided it would also equip the MAX vehicles with ramps to facilitate boardings. The capital cost of each station was approximately $175,000.

Vehicles

The Civis vehicle, manufactured by Irisbus in France, is an articulated bus with an optical guidance system and dual diesel-electric propulsion system that mimics a rail vehicle. The dimensions of the vehicle are 61 ft. in length, 102 inches in width, and 134 inches in height. The vehicle can carry up to 120 passengers and has four doors on the right: two in front of the articulated joint and two behind. The bicycle rack is located inside at the rear of the vehicle. Because the maximum speed of the vehicle at full load is 45 miles per hour, the Civis vehicle is not suited to freeway operation.

In order to address federal and state compliance requirements and operating conditions unique to Southern Nevada, RTC required modification to the basic Civis vehicle. For instance, the air conditioning had to meet specifications based on the Las Vegas Pulldown Test. This requires that a vehicle reduce the interior temperature from 120° to 73° in 30 minutes. In addition, RTC requested a waiver for local street operation, since the axle weights were close to 29,500 pounds and the maximum allowed in Nevada is 25,000. The cost of MAX vehicle is approximately $1 million. Table 10 shows a summary of the costs.

Intelligent Transportation systems

The MAX BRT system uses several Intelligent Transportation Systems (ITS) to assist with transit operations and provide quality service to passengers. The ITS technologies include Traffic Signal Priority (TSP) along Las Vegas Boulevard North, Optical Guidance System (OGS), Automated Passenger Counters (APCs), and a CAD/AVL system.
Table A-1: Summary of MAX Project Costs

<table>
<thead>
<tr>
<th>Project Element</th>
<th>Total cost</th>
<th>% of total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Civis Vehicle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle &amp; systems (10 total) - Irisbus</td>
<td>$11,960,386</td>
<td>58.90</td>
</tr>
<tr>
<td>Vehicle Mfg Inspection - TRC/Semaly</td>
<td>$340,760</td>
<td>1.70</td>
</tr>
<tr>
<td><strong>Passenger Shelters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Services -Stanley consultants</td>
<td>$1,150,966</td>
<td>5.70</td>
</tr>
<tr>
<td>Construction bid (west coast contractors)</td>
<td>$4,152,259</td>
<td>20.50</td>
</tr>
<tr>
<td>Guidance markings</td>
<td>$55,532</td>
<td>0.30</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$15,530</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Dynamic Message Signs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger Information Displays</td>
<td>——</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Ticket Vending Machines</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production &amp; Installation</td>
<td>$1,900,000</td>
<td>9.40</td>
</tr>
<tr>
<td>Fare Collection Design</td>
<td>$200,000</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Radio Communications/AVL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio/AVL/APC Installation</td>
<td>$298,810</td>
<td>1.50</td>
</tr>
<tr>
<td><strong>Transit Signal Priority</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation Strategy &amp; Analysis</td>
<td>$26,026</td>
<td>0.10</td>
</tr>
<tr>
<td>Traffic Signal Equipment</td>
<td>$120,000</td>
<td>0.60</td>
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<tr>
<td>Vehicle Emitters</td>
<td>$10,945</td>
<td>0.10</td>
</tr>
<tr>
<td>Signal Controller Software Mods</td>
<td>——</td>
<td>0.00</td>
</tr>
<tr>
<td>Data Collection &amp; Mgmt-Econolit/Trafficwerks</td>
<td>$59,200 $20,290,414</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$20,290,414</td>
<td></td>
</tr>
</tbody>
</table>

(Source: Las Vegas Metropolitan Area Express (MAX) BRT Demonstration Project Evaluation, 2005)

Los Angeles, California

After visiting the internationally recognized BRT system in Curitiba, Brazil, the Los Angeles County Metropolitan Transportation Authority (MTA) Board of Directors authorized a study to determine the potential for successful implementation of a BRT system in their city. The feasibility study recommended that MTA partner with the City of Los Angeles to conduct a demonstration project along two to three major arteries with strong transit patronage. The feasibility study evaluated the key attributes of Curitiba’s BRT program and determined that only six were appropriate for the initial phase of the MTA Metro Rapid Transit Program: Simple Route Layout, Frequent Service, Headway-Based Schedules, Less Frequent Stops, Level Boarding and Alighting, and Color-Coded Buses and Stations. The study also recommended that the MTA demonstration should include bus signal priority treatment that was not operational in Curitiba.

The attributes were selected to help MTA achieve its goal of improving operating speed, service quality, ridership, and customer satisfaction. The Metro Rapid Transit is a BRT system that started as a demonstration program operating on two major arteries in Los Angeles: the 26-mile Wilshire/Whittier Boulevard corridor and the 16-mile Ventura Boulevard corridor. These
corridors were selected due to high passenger demand in both an urban and suburban environment. The primary goal of the system was to increase operating speeds along these two corridors. Operating speed is usually low due to extensive vehicle dwell times (nearly 50% of total operating time with approximately 20% waiting at traffic signals and 25% passenger boardings and alightings).

To achieve this, the MTA introduced bus signal priority, level boarding/alighting with low-floor buses, headway rather than timetable schedules, fewer stops, far-side stops/stations and active operations management in the field and from the Bus Operations Control Center. Real-time passenger information signs at selected shelters are also provided to inform passengers of the estimated next bus arrival times. Headway based service measures the evenness of vehicle spacing rather than the time a vehicle reaches a specific geographic point.

A marketing and communications campaign was included to demonstrate basic objectives of the BRT system. These include reducing passenger travel times, increasing service reliability, improving fleet and station appearance, and enhancing service effectiveness.

Vehicles

Level boardings and alightings were also viewed as a key attribute of the Metro Rapid Transit Program and considered critical to enhancing bus speed through a decrease in what MTA estimated to be 25% of total operating time spent by boarding and alighting passengers. The Metro Rapid Transit Program operates with NABI 40-foot low-floor buses that run on compressed natural gas (CNG) and are distinguished from local buses by special red and white colorations. The vehicles are equipped with bus priority transponders, automatic vehicle location, and automatic passenger counters.

Service Schedule and Frequency

Envisioning a high-frequency service (an approximately 3-minute peak on the Wilshire/Whittier route and a 10-minute peak on the Ventura route), MTA chose to implement a headway-based service rather than a time-point-based service. For high-frequency service, headway-based scheduling is preferred due to its ability to reduce vehicle bunching and provide adequate capacity.

Service Identity and Design

Other key attributes of the Metro Rapid Transit Program were chosen in an effort to make the system very simple to use and easily recognizable. A conscious effort to brand the Metro Rapid Transit Program including its vehicles, amenities, and route design was undertaken. First, all Metro Rapid Transit vehicles have identically painted red exteriors that differentiate them from all other MTA routes. Exterior advertising is prohibited to simplify design and make the vehicles more identifiable.
The Metro Rapid Transit stops also have a unique design. The red color scheme is carried over to the stops and amenities, and they are not co-located with stops for other MTA bus services. Instead, the Metro Rapid Transit stops are typically placed at the far side of the intersection while local routes are located on the near side. This arrangement facilitates transfer opportunities by clearly distinguishing between various services.

One important advantage of Metro Rapid Transit is that its service is similar to rail in terms of quality, but it requires a significantly lower capital investment. For example, the capital cost for the Wilshire/Whittier line was approximately $10 million per mile including vehicles, roadway reconfiguration, amenities, signal priority system, and planning and engineering. Annual operating expenses average approximately $500,000 per mile.

Rouen, France

Rouen is geographically located 155 miles from Paris, London, and Brussels. Its population density is about 3,500 per square mile, with slightly more than 100,000 people living in the downtown area. Transports en Common de L’Agglomération Rouennasse (TEAR) provides public transport in the city of Rouen. 143 standard buses, 53 articulated buses, 28 light-rail vehicles, and 8 minibuses run on the streets of Rouen. Nearly 3.2 miles of the total 298 bus route miles are on priority rights-of-way.

The current operating Optically Guided Bus was adopted when TEAR dropped the idea of implementing Light-Rail Transit (LRT) due to the increase in the LRT’s costs over budget. TEAR adopted Civis buses with optical scanning capabilities which could carry 3,000 to 4,000 passengers per hour per direction, considerably more than the capacity of a regular bus. The optical guidance system was opted for over LRT because the vehicle path may be modified, which reduces roadway wear.

The first line is 8.7 miles in length and has 31 stations, the second line is 7.6 miles with 30 stations, and the third line is a stretch of 12.3 miles. In the central area, all three lines follow a common alignment. An articulated Agora bus is 17.8 meters long with 40 seats available, while an articulated Irisbus Civis is 18.6 meters long with 41 seats. The Civis buses are propelled by electric motors mounted on the wheels and a diesel engine that runs an alternator which produces the needed electricity. These Civis buses have Global Positioning Satellite (GPS) equipment to track their location.

Maps, shelters, and fare collection equipment are placed at the stations for the convenience of passengers. One thousand free parking places for bus users are provided at the Pole D’Echanges where three bus routes converge. Fare collection is at stations or on board vehicles. A magnetic reader is available at the entrance of each bus. The buses have priority at the intersections, with signal priority provided via radio signal from the vehicle to the traffic light. Vehicles are also equipped with remote control units to change traffic signals manually when the communication fails.
Bogota, Colombia

Bogota, the capital of Colombia, has an urban population of more than 5 million. A multi-billion dollar capital improvement program provided 877 parks, 117 miles of road pavement, the introduction of sewage treatment to 417 neighborhoods, and the construction or refurbishment of 72 schools and libraries. The TransMilenio BRT system was included in this remarkable transformation.

TransMilenio began operations in December of 2000 as a public/private system designed to be operated by private contractors under government oversight. The TransMilenio BRT system is composed of four components: specialized infrastructure, efficient operations, advanced ticketing, and a new institution for system planning, development, and control. Infrastructure, planning, and control components are funded by public institutions while operations and ticketing are contracted out to private companies.

Exclusive dual lanes in each direction were designed for trunk line service, with roads for feeder buses, stations, and complementary facilities comprising the system’s infrastructure. 24 miles of dual median bus lanes and 59 stations were included in the system. 40- to 180-meter-long stations are located at the median and are spaced at an average distance of 500 meters. Pedestrian sidewalks, plazas, and overpasses are included in the system, as well as bus maintenance and parking facilities. Stations are closed facilities and doors open when buses arrive.

Red-colored Volvo and Mercedes articulated buses with two sets of double doors and two single doors on the left side of bus (for use at island stations) have a capacity of up to 160 passengers. Standard green-colored buses with 80-passenger capacity are used as feeder buses. TransMilenio operates express and local services to maximize service supply.

System operations are carried out by private companies with strict conditions set forth through concession contracts. Concessions are provided related to route kilometers served by each operator. Private concerns control the production and distribution of smart cards and the acquisition and installation of turnstiles. Validation of systems, passenger information, and money-handling are included in ticketing. These too are privately operated. Money from the card sales is deposited in a trust fund to pay the operators according to the rules set forth in the concession contracts.

A control center is operated by TransMilenio to allow service and passenger access supervision. Buses are equipped with a GPS system and a processing unit to report their position every six seconds. The control center receives turnstile information, including the number of passengers entering and exiting the system.

System speeds average 26 km per hour (16.2 miles per hour) overall. Available records indicate a 93% reduction in fatalities from traffic accidents, a 40% drop in air pollutants, and a 32% decline in travel time for users after five months of operation. The TransMilenio system runs
without any subsidy from public agencies. Private operators receive the increase in revenue during increased demand and are required to absorb the risk during cost increases.

**Adelaide, Australia**

The 6.2-meter-wide, 12-kilometer-long O-Bahn Guided Busway of Adelaide links downtown Adelaide with northeastern suburbs. Metropolitan Adelaide has a population of 1.1 million, with an urban area 80 kilometers long and 15 kilometers wide. The Passenger Transport Board administers public transport, including guided bus, tram, and suburban rail service, and is mainly operated by TransAdelaide. The O-Bahn Busway was selected over LRT (which has previously been preferred by the public) due to its significantly lower initial cost and reduced need for passenger interchange.

The O-Bahn system contains automatic track guidance for buses that were developed in Germany. This O-Bahn concept enables a standard service bus to be steered both manually and automatically in track-guided operation. Guide rollers are fixed to rigid arms that are in turn connected to the front axle of the bus and can interact with a raised concrete curb to automatically guide the vehicle, freeing the bus driver from steering. The track consists of precast-concrete elements, and concrete crossbeams are supported by board piles to provide long-term stability. L-shaped concrete slabs atop the crossbeams form the guidance surfaces. Track alignment was designed for speeds up to 100 kilometers per hour (62.1 miles per hour) except at stations and exits. There are 11 bridges over water, 1 over a road, 14 roads over bridges, and 8 footpath bridges.

The stations were built to protect pedestrian areas and walkways and have an ample guideway width to permit bicycle access and storage parking. About 50 articulated and 40 rigid Mercedes-Benz buses were initially operated on the guideway, and MAN articulated buses were also available for operation. The buses are fitted with up-rated diesel engines of 240 hp in rigid buses and 280 hp in articulated buses to achieve the speed specified on the track. Antilock brake systems and high-intensity driving lights are added to each bus to achieve operational speeds of 100 km/h. In the event of damage to the front tires, the wheels are equipped with a metal inner tire, which prevents full deflation.

To avoid collision of a disabled bus with other vehicles, the operator of the disabled bus switches on a highly visible hazard light, and the Traffic Control Center is then informed by an alarm sound on all work channels of the radio network. Special maintenance and recovery vehicles equipped with guide wheels and capable of traveling in both directions on the track are used for bus recovery and track maintenance.

O-Bahn ridership approximates 2.5 million passengers annually and about 30,000 per day. The Busway was reported to generate a 24% increase in patronage from new riders; parking at stations, however, is limited to several hundred spaces. Travel times for trips between downtown Adelaide and the suburbs were reduced from approximately 40 minutes to 25 minutes.
A.2 Limited Bus Stop Implementation Examples

New York City

Some 25 of the 200 local bus routes in New York City operated by New York City Transit have a limited-stop component; 14 of these operate only during peak hours. Buses stop at about 0.5-mile intervals, usually at major intersections, institutions, or places of high activity. Limited-stop routes serve transportation hubs or other high traffic generators. Limited-stop service reflects the following factors:

1) Uses wider roads for operations
2) Operates on roadways with progressive traffic signal timing
3) Spacing between stops should be approximately 0.5 miles
4) Operates at a distance from rail rapid transit or commuter lines
5) Route should be at least 5 miles in length
6) Maximum of 10-minute headways

New York City Transit uses conventional and articulated buses for limited-stop service. Limited-stop routes have an average length of 8.3 miles and these buses save almost one minute per mile. Time savings approach those that might be attained by bus rapid transit service, in which there is faster boarding and alighting and traffic priorities are provided along the bus route. Table A-2 shows some operating characteristics of New York’s limited-stop service.
Table A-2: New York City Local and Limited-stop Bus Speeds

<table>
<thead>
<tr>
<th></th>
<th>Manhattan</th>
<th>Brx</th>
<th>Brooklyn</th>
<th>Queens</th>
<th>Staten Island</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td># of routes</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>General Route type</td>
<td>Grid</td>
<td>Grid</td>
<td>Grid</td>
<td>Feeder</td>
<td>Feeder</td>
<td></td>
</tr>
<tr>
<td>Miles</td>
<td>9.9</td>
<td>7.6</td>
<td>8.4</td>
<td>6.6</td>
<td>8.5</td>
<td>8.3</td>
</tr>
<tr>
<td>Local bus speed mph</td>
<td>8</td>
<td>10.2</td>
<td>8.5</td>
<td>12.4</td>
<td>14.2</td>
<td>10.7</td>
</tr>
<tr>
<td>Limited-stop bus speed mph</td>
<td>8</td>
<td>10.2</td>
<td>8.5</td>
<td>12.4</td>
<td>14.2</td>
<td>10.7</td>
</tr>
<tr>
<td>Local bus time (min)</td>
<td>97.1</td>
<td>55.6</td>
<td>68.9</td>
<td>38.3</td>
<td>41.2</td>
<td>54</td>
</tr>
<tr>
<td>Limited-stop bus time (min)</td>
<td>76.1</td>
<td>44.7</td>
<td>59.1</td>
<td>32.1</td>
<td>36.6</td>
<td>47</td>
</tr>
</tbody>
</table>


Montreal, Canada

Societe de transport de Montreal (STM) is a transit agency that provides services on the Island of Montreal, Quebec in Canada. In March 2009, STM began limited-stop bus service (Route 467 Express Saint-Michel) that runs parallel to the existing Route 67 Saint-Michel, a heavily used bus route east of the CBD. Table 12 provides the physical characteristics of Route 67 and Route 467.

Table A-3: Physical Characteristics of Routes 67 and 467

<table>
<thead>
<tr>
<th></th>
<th>Route 67 regular</th>
<th>Route 467 express</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northbound</td>
<td>Southbound</td>
</tr>
<tr>
<td>Length (Km)</td>
<td>9.16</td>
<td>9.96</td>
</tr>
<tr>
<td>Traffic Signals</td>
<td>40</td>
<td>43</td>
</tr>
<tr>
<td>Number of Stops</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>Average stop spacing (meters)</td>
<td>241</td>
<td>255</td>
</tr>
<tr>
<td>Length (Km)</td>
<td>8.38</td>
<td>8.89</td>
</tr>
<tr>
<td>Traffic Signals</td>
<td>36</td>
<td>40</td>
</tr>
<tr>
<td>Number of Stops</td>
<td>36</td>
<td>17</td>
</tr>
</tbody>
</table>

Route 467 operates between 6:00 to 19:00 with a maximum headway of 10 minutes. A before-and-after study was carried out by a research team to evaluate the limited-stop bus service provided by STM. Table 13 provides the performance statistics of the Routes 67 and 467. Note that while ridership on Route 67 slightly decreased, the combined statistics for Routes 67 and 467 significantly increased after the introduction of Route 467.
Table A-4: Performance Statistics for Route 67 (before/after Starting Route 467) and Route 467

<table>
<thead>
<tr>
<th>Variable</th>
<th>67 NB before</th>
<th>67 SB before</th>
<th>67 NB after</th>
<th>67 SB after</th>
<th>467 NB</th>
<th>467 SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run time (sec)</td>
<td>2061</td>
<td>2102</td>
<td>2025</td>
<td>2071</td>
<td>1852</td>
<td>1869</td>
</tr>
<tr>
<td>Passenger Activity</td>
<td>166</td>
<td>177</td>
<td>136</td>
<td>145</td>
<td>128</td>
<td>133</td>
</tr>
<tr>
<td>Maximum Load</td>
<td>46</td>
<td>44</td>
<td>38</td>
<td>36</td>
<td>41</td>
<td>38</td>
</tr>
<tr>
<td>Actual stops</td>
<td>28</td>
<td>30</td>
<td>28</td>
<td>29</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Scheduled stops</td>
<td>35</td>
<td>37</td>
<td>35</td>
<td>37</td>
<td>13</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>67 before</th>
<th>67+467 after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run time (sec)</td>
<td>4163</td>
<td>7817</td>
</tr>
<tr>
<td>Passenger Activity</td>
<td>343</td>
<td>542</td>
</tr>
<tr>
<td>Maximum Load</td>
<td>90</td>
<td>153</td>
</tr>
<tr>
<td>Actual stops</td>
<td>58</td>
<td>84</td>
</tr>
<tr>
<td>Scheduled stops</td>
<td>72</td>
<td>100</td>
</tr>
</tbody>
</table>

A.3 Express Bus Implementation Examples

Toronto

The Toronto Transit Commission (TTC) currently operates 22 express bus services. These can be broadly categorized into three service types:

*Local-Express Bus Services:* usually consist of an express branch that operates on a regular TTC route, often in the peak-periods, from Monday to Friday only. The express buses typically serve all local stops at the outer end of the route, and then serve limited stops only as they get closer to the subway station. These services are implemented when there are overall passenger benefits to reassigning the existing buses on the route to express bus operation on a no-net cost basis.

*Rocket Routes:* These are limited-stop express routes that generally link two major transit destinations. They typically have peak-period service and some off-peak service. These services involve additional costs, which must be covered by attracting new riders to the system.

*Downtown Express Routes:* These are routes that operate directly to the downtown in the morning peak-period and from downtown in the afternoon peak-period. They provide an alternative to travel on the Yonge Subway or parallel local bus and streetcar routes. Premium fares are charged for travel on these routes.

Express services improve the customer experience by reducing travel time and making transit a more attractive travel option than other modes of travelling. The local express service reduces operating costs on long routes because fewer buses, overall, are required to provide the necessary capacity, compared to operating all the buses in slower local service. The Rocket Routes and downtown express routes generally require an overall increase in operating costs. The provision
of a direct no-transfer and fast service to link major destinations means that the Rocket Routes provide substantial benefits to customers, and attract new customers to the TTC because of the reduced travel time.

**Singapore**

Singapore Bus Service (SBS) and Trans-Island Bus Services have recently introduced express bus services that reduce commuting times. There are 10 express bus services, including a special express bus service called the Rapid Bus Service (RBS), which are aimed at providing faster and smoother travel, as well as more direct routes. These express services operate with limited stops along the route and enjoy uninterrupted travel on expressways as part of the journey.

The one-way route length of the journey is about 30 km with a scheduled trip time of 74 minutes. The RBS only stops at high-demand bus stops along its route through the two residential regions. It then bypasses the rest of the areas using the Bukit Timah Expressway and Pan-Island Expressway to reach the fringe of the CBD area. At the fringe of the CBD area, the RBS again stops only at selected high demand stops before reaching the CBD area. The RBS terminates at the Shenton Way within the CBD area before turning back in the opposite direction, almost along the same route, for the return journey.

The RBS only stops at 50% of the bus stops along its route. Many stops are near MRT stations in the northern residential regions, as well as at the fringe of the CBD and also within the CBD area. These express bus services are designed to serve the high-demand bus stops and bypass the low-demand bus stops. Express bus services can only be found within 1 km (0.6 miles) of the catchment area instead of the 400 meters (1/4 mile) in normal bus services. Buses are fitted with transponders to give them priority as the buses approach certain signalized intersections. This gives them a better (less interrupted) flow through intersection traffic. The RBS buses are able to travel at a higher average operating speed of 25 km/h (15.5 m/h) and thus allow for shorter journey times with scheduled mean headways of about 10 minutes during the commuter peak periods and about 13 minutes during the off-peak periods.

The RBS incorporates many beneficial features of a rail-based system and is able to provide a new platform for service innovations and creative value. It also charges a lower fare than the rail system. Some of the value added includes the installation of route maps with bus stop locations onboard the RBS buses, as well as at the bus stops. BRT buses are also given a distinctive service number to distinguish them from the other regular and express services.

During the commuter peak periods, RBS users perceived that the waiting time for the buses was longer than the expected waiting time of 5 to 6 minutes based on random arrivals. This is expected as passengers tend to overestimate their waiting time given the tendency to remember occasions of longer waiting and forget occasions of shorter waiting. It was also found that regular users were more time sensitive concerning their waiting time and were less patient than
the non-regular users, when compared to the perceived waiting time between regular and non-regular users.
APPENDIX B
Potential TOD Implementation at FIU

Figures B-1 and B-2 show diagrams of the potential TOD location and general layout at FIU’s Modesto A. Maidique Campus (FIU’s main campus). The proposed TOD is centered on and adjacent to the Blue and Gold Garage, which like all existing buildings, is shown in black in Figure B-2. Green hatching indicates a proposed car-free plaza and pedestrian corridors, while black hatching points to the proposed buildings. Blue dots mark future parking garages. The red dot is the proposed location of transit and bus service. In addition, the future grid of traffic-calmed streets is shown with dashed lines.

![Figure B-1: Aerial of Blue and Gold Parking Garage with TOD Location Circled](image)

In Figure B-2, the proposed TOD location is shown with an orange circle.

TOD concepts are applicable to existing locations within FIU’s main campus. These facilities would enhance pedestrian activity and create high-quality public spaces at key centers of campus life. Further refinements of these concepts are possible and should be investigated in the future.

Figure B-3 shows conceptualizations for buildings, with additional mixed-use pedestrian-oriented parking structures that frame the plaza, mixed-mode streets, and pedestrian corridors. Existing buildings and new parking structures are shown in gray, with proposed mixed-use and liner buildings shown in blue. A proposed TOD on the Maidique Campus at and adjacent to the
Blue and Gold Garages will be carefully designed to enhance the function and appearance of existing buildings. The proposed bus system could enter FIU via Snapper Creek Road, SE 117th Avenue, and the SW 17th Street/SW 108th Avenue corridor. It would have a stop at the FIU Community Stadium and at the Blue Parking Garage or the new parking structures east of the Herbert and Nicole Wertheim Performing Arts Center.

Figure B-2: Initial Suggestions for TOD Improvements

Figure B-3: Design Development at FIU’s Maidique Campus