TRANSIT CONTRAFLOW FEASIBILITY STUDY FINAL REPORT

Prepared For: Miami-Dade MPO

Prepared By: Kimley-Horn and Associates, Inc.

June 2002

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INTRODUCTION

The objective of the *Transit Contraflow Feasibility Study* is to evaluate the practicability of establishing contraflow bus operations in Miami-Dade County. A contraflow bus lane is one example of a bus priority treatment. These treatments address traffic congestion by maximizing the person-carrying capacity of a roadway or corridor. The primary concept behind bus priority treatments is to provide buses savings in travel time and more predictable travel times. Bus priority treatments are often used in corridors that are either at or near vehicle capacity, and where the physical and financial feasibility of widening the roadway is limited.

The South Miami-Dade Busway, which is an 8.5 mile facility that is reserved for buses and emergency vehicles between the Dadeland South Metrorail Station and the Cutler Ridge neighborhood at SW 112th Avenue, is an example of an existing bus priority treatment in Miami-Dade County. Busways are roads designed, built and operated exclusively for buses. Past bus priority efforts in Miami-Dade County included a reversible bus lane on NW 7th Avenue and a contraflow bus lane on U.S. 1.

Arterial bus lanes, which may be reserved for the exclusive use of buses, are a common form of bus priority treatment and represent a minimum cost approach to increasing road-use efficiency, improving bus service, and enhancing the bus transit image. Corridor treatments offer excellent potential for enhancing urban mobility and altering modal choice patterns. In particular, bus lanes may provide some of the following benefits:

- Reduce bus travel times
- Improve bus service reliability and schedule adherence
- Improve passenger safety
- Increase bus service “visibility” or route identity
- Reduce bus operating costs

Improved on-schedule operation may make it possible to provide additional bus service without more vehicles or cost.

Arterial bus lanes may (1) be located either along outside street curbs or along street medians and (2) operate either with (concurrent flow) or counter (contraflow) to automobile traffic flow.

Curb bus lanes in the normal direction of flow are the most common bus lane treatment and are found in more than 20 cities in the United States and Canada. However, curb bus lanes are often difficult to enforce and may produce only marginal benefits to bus flow because of conflicts with right-turning vehicles.

Median bus lanes are best suited for express bus service because they require provisions for stops and pedestrian refuge in the median area. Median bus lanes also require left turns to be either prohibited or controlled to minimize interference with buses.

Contraflow bus lanes enable buses to operate opposite to the normal flow of traffic. The separation from other traffic flows reduces conflicts with other vehicles. Contraflow lanes are most commonly employed along one-way streets where they can create favorable routes for buses by allowing them to bypass congestion associated with a central business district (CBD) or bottleneck. Along two-way streets, contraflow lanes may provide an exclusive lane for buses traveling in the peak direction by removing an underutilized lane from service in the off-peak direction. However, contraflow lanes may complicate service and access to adjacent properties and may also create conflicts with left-turning traffic.

Contraflow lanes may be able to provide significant increases in person capacity at significantly lower costs in comparison to conventional widening considerations. Therefore, congested corridors in Miami-Dade County will be evaluated in this study to determine if contraflow bus lanes are feasible. If corridors are identified where contraflow operations are practical, an outreach program will be conducted to solicit the concerns of affected businesses and residents. A plan will then be developed for establishing contraflow services in these corridors taking into consideration the concerns of the community. As such, the composition of this project has been organized into the following tasks:

- Literature Research
- Evaluation of Potential Contraflow Corridors
- Feasibility of Implementing Transit Contraflow
- Public Involvement/Corridor Outreach Effort

LITERATURE RESEARCH

This section of the report represents the findings of the literature research conducted as a prelude to assessing the feasibility of establishing contraflow bus operations in Miami-Dade County. Past Miami-Dade bus priority treatments on NW 7th Avenue and U.S. 1 are described. Also discussed is Miami-Dade County's past evaluation of reversible flow operations along Flagler Street. Bus and high occupancy vehicle (HOV) contraflow operations in North America are examined, and advantages and disadvantages associated with these applications are summarized. The findings of the literature research provide the foundation necessary to proceed to the next project task, which is the review and evaluation of potential transit contraflow corridors.

Past Miami-Dade County Bus Priority Efforts

During the 1970s bus priority demonstration projects were implemented in two corridors in Miami-Dade County. The NW 7th Avenue demonstration project served a corridor extending from downtown Miami north to the Golden Glades Interchange area. The U.S. 1 demonstration project served a corridor extending from I-95 south of downtown Miami to Sunset Drive. These projects were discontinued with the opening of the I-95 HOV lanes and the Metrorail system. A discussion of the history of these demonstration projects follows.

NW 7th Avenue Express Bus (Orange Streaker) Priority System

A three and a half year demonstration project was established in Miami in 1973 to develop more efficient people moving capabilities in the I-95/NW 7th Avenue corridor. The project was divided into two phases. The first phase involved the implementation and evaluation of bus priority techniques on NW 7th Avenue and the second phase involved the implementation and evaluation of HOV lanes on I-95. A parking lot was constructed in the Golden Glades Interchange area and was designated the Golden Glades Park-n-Ride Facility. The primary service provided during Phase I was express bus service between the Golden Glades Park-n-Ride Facility and major service areas in and around downtown Miami. The express bus system was advertised as the "Orange Streaker" system. Phase I was evaluated while the HOV lanes were being constructed on I-95.

Three bus priority techniques were tested in Phase I of the project:

1. Reversible Exclusive Bus Lane - There were three distinct typical sections of the reversible exclusive bus lane along NW 7th Avenue between the Golden Glades Park-n-Ride Facility and NW 5th Street near downtown Miami. A description of these three sections follows:

   - Golden Glades to NW 119th Street (2.665 miles) - This section of NW 7th Avenue was a six-lane divided arterial. The lane adjacent to the median was reserved for buses 24-hours a day in the southbound direction. No reserved lane was provided for buses in the northbound direction in this section.

   - NW 119th Street to NW 79th Street (2.534 miles) – This section of NW 7th Avenue consisted of seven lanes with no raised median. The center lane functioned as a reversible bus lane during peak periods and as a two-way left-turn lane during off-peak periods. Left-turns were prohibited at midblock locations during the peak period operations. At signalized intersections left-turn bays were provided next to the bus lane and left-turn vehicles were allowed to cross the bus lane only during a protected left-turn phase.

   - NW 79th Street to NW 5th Street (4.774 miles) – This section of NW 7th Avenue provided five lanes with no raised median. The center lane operated as a reversible bus lane during peak periods and as a two-way left-turn lane during off-peak periods. Left-turns were prohibited during the peak period reversible lane operations.

2. Bus Preemption of Traffic Signals - Each of the 35 signalized intersections along NW 7th Avenue was provided with the capability of preemption of traffic signal control by the Orange Streaker buses. The preemption system consisted of optical transmitters installed on the buses, optical receivers installed at each signalized intersection, and phase selector units installed in each controller cabinet. The preemption system was eventually extended past NW 7th Avenue into the route service areas and 49 additional intersections were equipped with detector units.

3. Traffic Signal Progression System - The traffic signals on NW 7th Avenue from NW 151st Street to NW 5th Street were coordinated and operated in a progression mode to favor traffic

traveling in the peak direction. Theoretically, a bus in the exclusive bus lane could stay within a progression band and travel the length of NW 7th Avenue without stopping.

The priority treatments for buses on NW 7th Avenue were examined in a study that consisted of five stages. During Stage 0 the before conditions were established. During Stage 1 the buses operated in mixed mode with the automobile traffic but were equipped with signal preemption capabilities. In Stage 2 the buses were provided an exclusive lane along with the signal preemption capability. In Stage 3 the buses operated in a reserved lane in a coordinated system with the progression designed to favor the buses, but without signal preemption capabilities. During Stage 4 the buses operated in a reserved lane with traffic signal progression and preemption capability to allow the buses to preempt any signals that did not fall in the progression band.

Some conclusions that were drawn from the study in terms of the effect of the bus priority system on bus travel times and schedule variability include:

- Each of the bus priority techniques was successful in reducing bus travel times in the corridor.
- The combination of bus preemption and a reversible exclusive bus lane (Phase 2) produced the lowest bus travel times of all the schemes that were tested.
- The potential benefits of the bus priority operations were best realized in areas where a high degree of motorist compliance with restrictive traffic regulations, such as no left-turns, was not essential.
- The substitution of signal progression for preemption resulted in a relatively small increase in travel time for the buses and was more favorable for the general-purpose automobile traffic.
- Schedule adherence was improved with a coordinated signal operation combined with an exclusive bus lane. Signal preemption by the buses tended to produce a lower degree of schedule adherence in comparison to the coordinated signal operation. The study attributed this incongruous result to the greater flexibility the signal preemption system allowed bus drivers in selecting travel speeds.

One of the major factors in the success of a reserved lane for buses is the extent to which non-priority vehicles violate the reserved lane. Violators can impede the flow of buses and present safety hazards. In the early stages of the project observations indicated that violation of the reserved lane and left-turn violations were of sufficient magnitude to impede the progress of the express buses. In general, the violations decreased during the course of the project and those drivers that continued to violate were more careful about delaying the buses.

The "Orange Streaker" experienced a general increase in ridership in the first thirteen months of service. After the initial period of growth, ridership leveled off at 1,450 passengers per day. An average of 26 bus trips was needed to provide the express bus service during each peak period.

The following conclusions were drawn regarding the effect of the NW 7th Avenue bus priority system on the traffic operations and passenger movement in the corridor:

- The bus priority systems did not adversely affect and the better signal progression actually improved the travel times of automobiles in the corridor.
- The use of traffic signal progression provided a greater benefit to automobile traffic than bus preemption of traffic signals.
- There was not any evidence of an increase in the accident rate for automobiles.
- The initiation of the exclusive reversible bus lane resulted in an increase in bus accidents.
- The bus accident rate was significantly higher in the portions of NW 7th Avenue where there was no physical median.
- During the peak periods the Orange Streaker bus system moved between 13 to 25 percent of the total passengers in the corridor in only 1 to 2 percent of the vehicles. The express bus system achieved a modal split of 8.6 percent of the potential trips.

In summary, the priority bus treatments in the NW 7th Avenue corridor were found to reduce the travel times for both buses and automobiles. Automobile accident rates were unaffected but the provision of an exclusive bus lane resulted in an increase in the number of bus accidents, especially at the start-up of the reversible lane operations. However, with the completion of the I-95 HOV lanes in 1976 the express buses began operating on I-95.

U.S. 1 Express Bus (Blue Dash) Priority System

A contraflow bus lane was provided along U.S. 1 for a period of time during the 1970s as part of the express bus system that was advertised as the "Blue Dash." A contraflow bus lane was created in the northbound direction feeding into downtown Miami during the morning peak period and in the southbound direction for outbound traffic during the evening peak period. The treatment extended 5.5 miles from SW 72nd Street (Sunset Drive) to I-95.

The setup of the contraflow lane required manually positioning cones to mark the lane and overhead traffic devices were also utilized to identify the contraflow lane. During peak periods two general purpose traffic lanes operated in both directions on U.S. 1. In the peak direction of travel the inside lane next to the median was reserved for HOVs while the inside lane in the off-peak direction was converted to a contraflow lane for buses. Buses did not make any stops within the contraflow lane and they traveled in the contraflow lane from end to end. The contraflow operations were abandoned during the 1970s and buses then traveled in the concurrent flow HOV lanes until these lanes were also discontinued before the opening of Metrorail in the 1980s.

At the beginning of the project the number of peak-period bus trips in the corridor was increased from 10 to 84. The contraflow bus induced over 1,700 more riders per day to use transit. The new corridor transit ridership level was over five times the level that existed prior to the project. Nearly two-thirds of all patrons has driven to work by themselves before the project, and overall 77 percent had used automobiles for their trips prior to the project. The income ranges of the riders were much higher than the county average for bus riders, demonstrating that the "Blue Dash" system attracted "choice" riders.

The "Blue Dash" contraflow lanes improved travel times for transit riders by ten to sixteen minutes. The project enables the corridor to carry 2,400 more persons in 350 fewer vehicles per day. The improved person carrying capacity was reflected in substantial savings of approximately 1,000 person-hours per day in user travel times. However, Miami-Dade Transit (MDT) staff recalls several disadvantages associated with the contraflow lanes including:

- The manpower effort and expense associated with setting up and removing the safety posts that marked the lane.
- That left-turns were prohibited on U.S. 1 when the contraflow lane was in operation.

- A large police presence involving the coordination of several departments was required to discourage lane and turn violations.
- The contraflow lane often appeared empty because of the low volume of buses that utilized it.
- There were pedestrian safety issues associated with the buses operating against the expected flow of the traffic stream.

Flagler Street Reversible Flow Study

During the early 1990s Miami-Dade Metropolitan Planning Organization (MPO) and Florida Department of Transportation (FDOT) staff jointly evaluated the possible introduction of reversible or unbalanced flow on numerous arterials throughout the urban area. The evaluation resulted in the selection of West Flagler Street corridor between approximately West 27th Avenue and the Palmetto Expressway as a primary candidate for a more detailed planning evaluation.

Reversible flow could be instituted on West Flagler Street at a relatively low capital cost without any significant pavement widening. Capital funding needs would be associated with traffic signal controller and signal head display modifications at existing signalized intersections, the installation of overhead lane use control signals throughout the corridor, traffic control signing and pavement marking changes along the route, and a program of public information announcements. The introduction of reversible flow operations could be accomplished by converting the existing center two-way left-turn lane to another lane devoted to through traffic movements in the predominant direction of peak period traffic flow. However, this improvement would require prohibiting left-turn movements during periods of reversible flow.

The study determined that, with current demands, congestion levels, and operating characteristics along the corridor, reversible flow operations would result in an overall net negative benefit when considering impacts to both directions of travel, safety, access to adjacent residential neighborhoods, and bus operations. The major shortcoming found in not selecting the Flagler Street corridor for further project development activities was the lack of a significant directional imbalance in the peak period travel demand.

Bus Contraflow Lanes on Arterials

Arterial street contraflow lanes can be an effective approach for moving buses through a congested area such as a downtown or major activity center. This technique most often uses a lane along a one-way arterial street for buses-only operating in the opposite direction of travel. Contraflow lanes can provide benefits to bus transit operations by increasing the speeds of the buses and enhancing travel time reliability. Routes may be consolidated onto the bus contraflow lane to simplify operations and provide a focal point for passengers.

Currently, most facilities of this type in North America operate in downtown areas. Examples of contraflow bus arterial lanes include applications in Pittsburgh, San Francisco, Minneapolis, Los Angeles, San Juan and Montreal. Additionally, contraflow bus lanes were briefly implemented and then removed in Chicago during the 1980s. A discussion of the arterial contraflow bus lane operations in these cities follows.

Pittsburgh Contraflow Bus Lanes

The Port Authority of Allegheny County, also known as the Port Authority Transit (PAT), provides a network of transportation services to persons traveling within a 730 square mile area, including the City of Pittsburgh. They are the largest providers of mass transit services in western Pennsylvania. Bus contraflow lanes and exclusive busways have long been part of PAT's transit system.

Two types of bus contraflow lanes are found in Pittsburgh: downtown bus loops that operate along a set of one-way pairs (Wood Street and Smithfield Street) and a corridor application along 5th Avenue. The contraflow lanes on all these facilities are in operation 24-hours a day, seven days a week. PAT believes that contraflow operation during limited periods would create confusion that could lead to safety issues. The contraflow bus lane operates in the curb lane on all of these facilities.

The bus contraflow lanes within the downtown loop have been in operation for a number of years. These lanes originated after the removal of the downtown trolley system. The Wood Street contraflow bus lane extends approximately 1/3 mile from Fort Pitt Boulevard to 4th Avenue. The Smithfield Street contraflow bus lane stretches beyond the downtown loop and extends approximately 1 mile from Liberty Avenue to the Boulevard of the Allies. Along both facilities there is one general-purpose traffic lane and on-street parking in the direction opposing the contraflow bus operation during off-peak periods. During peak periods on-street parking is prohibited resulting in two general-purpose traffic lanes.

Approximately 550 buses daily and 60 buses during the peak hour use the downtown loop portion of the bus contraflow lanes, consisting of the Wood Street contraflow lane and the portion of the Smithfield Street contraflow lane between 6th Avenue and the Boulevard of the Allies. Over 30,000 passengers per day are carried on buses that utilize these facilities. The portion of the bus contraflow lane on Smithfield Street between Liberty Avenue and 6th Avenue is utilized by approximately 320 buses per day and 40 buses during the peak hour and this lane serves approximately 18,000 daily riders.

The 5th Avenue contraflow bus lane has been in operation since the 1970s. It serves a busy corridor connecting the downtown to the University of Pittsburgh. The width of 5th Avenue varies so that the number of general-purpose lanes opposing the contraflow lanes fluctuates from two to four. Over 400 buses per day utilize the 5th Avenue contraflow lane and these buses carry approximately 35,700 daily passengers.

According to PAT, the primary benefit associated with the contraflow lanes is schedule adherence. Safety measures have been implemented along 5th Avenue because of occasional pedestrian incidents. These measures include a 15-mile per hour (mph) speed limit for the contraflow lane, mid-block stops, and a railing along the curb to prevent pedestrians from crossing in front of buses. Openings in the railing are provided only at street corners and bus stops. Interestingly, there have not been any safety problems in the downtown area despite heavier concentrations of pedestrians and it has not been necessary to implement any special safety measures along the Wood Street and Smithfield Street contraflow lanes.

San Francisco, Sansome Street Contraflow Transit Lane

The City of San Francisco has a significant downtown employment of about 280,000. In 1984 it was estimated that about 55% of the downtown workforce commuted by public transportation. Congestion was exacerbated by the 1989 Loma Prieta Earthquake, which removed the Embarcadero Freeway from service adding about 100,000 vehicles to downtown streets. The increased automobile congestion also led to deterioration in public transportation services. In particular, the reliability of three transit routes (the #12, #15 and #42 Lines) that were operating on two southbound one-way streets (Montgomery and Battery Streets) was seriously affected by the recurrent congestion. Delays of up to 50 minutes on weekday afternoons were common. This led to the inception of the Sansome Street Contraflow Project during 1997.

Several potential alternatives were considered to reduce delay including installing concurrent flow bus lanes on Montgomery and Battery Streets. This option was ruled out because it would exacerbate congestion by eliminating a lane for the existing peak direction general-purpose traffic during the afternoon peak hour. The City then considered the option of changing a parallel one-way northbound street (Sansome Street) into a two-way street for southbound transit service. An extensive traffic study was conducted including the collection of turning movement counts, level of service analysis, and parking surveys along Sansome Street. The study demonstrated that it would be feasible to convert one of the northbound lanes to a southbound bus lane along the section between Washington and Bush Streets. The biggest obstacle was how to deal with loading zones on the west side of Sansome Street. The elimination of all loading zones was rejected because of the high demand in the downtown area. This led to a compromise to permit commercial vehicles to also use the contraflow lanes. The compromise allowed buses to bypass most of the congestion on Montgomery and Battery Streets and retained freight loading access for all businesses on both sides of Sansome Street.

The public participation strategy for the Sansome Street Contraflow Project consisted of two primary objectives: (1) make sure the public understands the need for the project and (2) be sensitive and responsive to the public's concerns. The City first engaged in an outreach program to identify and solve most problems before having them expressed at a public hearing. A joint project memo/fact sheet was delivered to every business and building manager along Sansome Street with a brief project description to make sure the scope and impacts of the project were well understood. By the time of the public hearing, the project had support from downtown merchant associations and businesses. A second public information campaign began one month before the opening of the southbound bus contraflow lane. The Department of Parking and Traffic (DPT) installed warning signs on Sansome Street facing northbound traffic to (1) inform motorists about the new southbound lane and (2) provide the opening date.

The implementation of the project required signal modifications from a one-way to a two-way street at five intersections, re-striping the street, and installing new signs to restrict southbound traffic in the contraflow lane to buses and commercial vehicles. The total cost of the project was $120,000. Contraflow operations are in effect 24-hours a day. According to staff, this type of operation is less confusing and discourages violation.

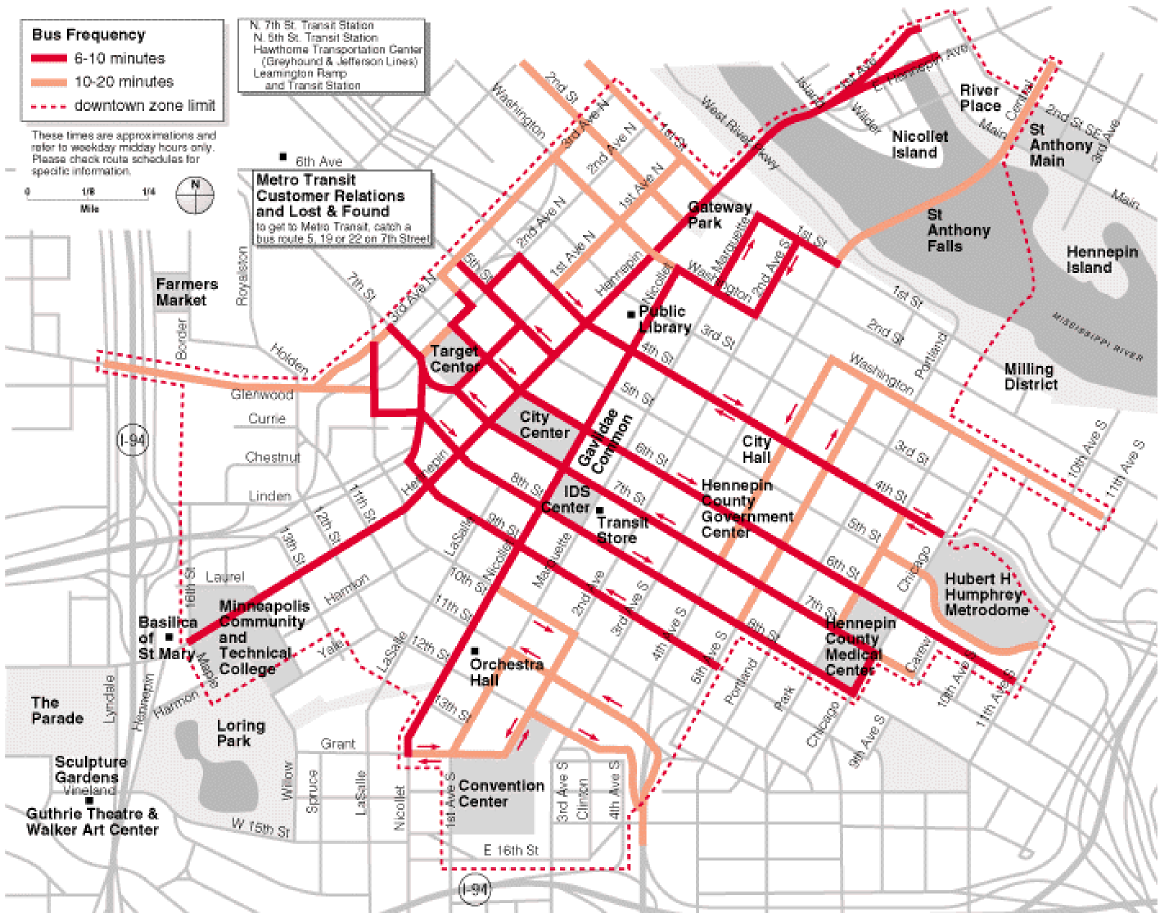
A before and after study was conducted to evaluate the effectiveness of the project. The study demonstrated that standard deviations of travel time, which is indicative of service reliability, were reduced during all time periods with the most significant changes occurring during the PM peak period. The maximum travel time for Bus Line #15 was reduced from approximately 42 minutes to about 15 minutes. The maximum travel time for Bus Lines #12 and #42 was reduced from approximately 56 minutes to 23 minutes.

This project resolved bus delays along 1,612 feet of Montgomery and Battery Streets in downtown San Francisco. Other bus priority projects are being implemented as part of a larger comprehensive plan to improve transit service in the downtown area including a "queue jump" project. Based upon the success of the Sansome Street contraflow lane, the City will consider contraflow operations as a possible solution at other locations.

Minneapolis Downtown Contraflow Bus Lanes

Several bus-only lanes are in operation in downtown Minneapolis including a bus/pedestrian mall (Nicollet Mall) and reverse flow (contraflow) bus lanes on Marquette, Second and Hennepin Avenues. The contraflow bus lanes on Marquette and Second Avenues were implemented in the 1970s to improve the flow of buses through the downtown and reduce conflicts between buses and general-purpose traffic. The contraflow lanes were initially implemented as temporary facilities and when the test proved successful, the lanes were made permanent. The contraflow bus lane on Hennepin Avenue was first implemented as a temporary facility in 1980 and made permanent several years later.

The contraflow bus lanes extend a distance of approximately twelve blocks along Marquette, Second and Hennepin Avenues. These streets previously functioned as one-way streets. The typical cross section of these streets now consists of a contraflow bus lane that is eleven feet wide and three general-purpose lanes ranging in width from ten feet to twelve feet. All three contraflow lanes are restricted to buses only during the peak periods, but provide limited access for taxis and delivery trucks during off-peak periods. Each facility accommodates between 100 and 120 buses during the peak hours. Pedestrian and vehicle safety concerns were addressed through the use of signs, special signals, and general education programs.



Downtown Minneapolis Bus System

Los Angeles, Spring Street Contraflow Bus Lane

A contraflow bus lane has been in operation on Spring Street in downtown Los Angeles since 1974. The Spring Street contraflow bus lane was developed to support the opening of the San Bernardino Busway, alleviate congestion, improve the flow of buses through the downtown, and provide travel time savings to transit users. The lane is 1.5 miles long extending from Olympic Boulevard on the south to Macy Street on the north. Before implementation of the project, Spring

Street was a four-lane one-way street serving southbound traffic. The eastern lane was converted into a thirteen-foot lane bus-only lane operating in the northbound direction. Traffic lanes were re-striped, new signage and additional bus stops were added, and buses were rerouted from parallel streets to take advantage of the contraflow lane. A number of improvements were made to the facility in 1979 to address operational problems including (1) widening portions of the contraflow lane to between 21 to 26 feet to allow passing room for buses, (2) separating local and express bus stops, and (3) revising signal timing.

Spring Street Contraflow Bus Lane – Los Angeles

Implementation of the Spring Street contraflow bus lane increased the speed and reduced the travel time of both express and local buses traveling through downtown Los Angeles. Approximately 270 buses utilize the contraflow lane during the afternoon peak hour and about 140 buses utilize the facility during the morning peak.

Some adverse impacts have resulted from the Spring Street contraflow bus lane operations. There is a high rate of pedestrian accidents including several fatalities associated with pedestrians not expecting a bus to be traveling in the opposite direction along a one-way street. A second adverse impact associated with the contraflow operations has been the isolation of the east side of Spring Street. The contraflow lane prevents on-street parking and loading activity along the curb. As a result, several long time businesses have closed over the years and redevelopment has lagged in comparison to the west side of Spring Street. There has been some consideration to remove the contraflow lane to allow the east side of Spring Street to redevelop.

The City of Los Angeles considered implementing a contraflow lane along Hill Street similar to the Spring Street operation. However, the local business community protested against the proposal because of the loss of on-street parking and loading. Hill Street was eventually converted to a two-way off-center street to minimize these impacts. Only buses and local access general-purpose traffic is permitted in the new direction of travel.

San Juan, Puerto Rico, Contraflow Lanes

There are several examples of contraflow bus lanes in San Juan, Puerto Rico. Contraflow bus operations are found on four roadway segments with a total of approximately eleven miles of contraflow lanes. Additionally, there is one exclusive bus lane that runs concurrent to the traffic flow. The contraflow bus lanes have been in operation for a number of years and were first implemented in the 1970s. Although bus service occurs roughly between 5:00 AM to 10:00 PM, the contraflow operations are in effect 24-hours a day, seven days a week. In all instances the contraflow lane is located in the curb lane next to the sidewalk.

One of main bus priority routes is along Ponce De Leon Avenue. This route provides eastbound service using an exclusive contraflow lane. Ponce De Leon Avenue is a three-lane one-way arterial that runs in the westbound direction. Fernandez Juncos Avenue is another main contraflow route, where priority bus passenger service is provided using a westbound contraflow exclusive bus lane. Fernandez Juncos Avenue – another contraflow corridor – is also a three-lane one-way arterial. In addition to the contraflow bus lane routes, there is an exclusive bus lane that runs concurrent with the general-purpose traffic on Munoz Rivera Avenue. None of these routes have signal preemption capabilities for the buses.

The primary benefits associated with San Juan's contraflow bus lanes are travel time savings and schedule adherence. For the most part, buses utilizing the lanes are fully loaded during the morning and evening peak hours. There are no significant operational problems associated with the lanes and pedestrian safety is not a major issue. One operational disadvantage occurs when buses are forced to wait behind other buses that are loading within the contraflow lane, as they do not have the ability to pass because there is only one lane allocated to the contraflow operations.

Montreal Contraflow Bus Lanes

The Montreal metropolitan region has over three million inhabitants. Transit is of great value to the public and the region is served by three independent transit carriers that are coordinated by a regional agency, the Agence metropolitaine de transport (AMT). The Societe de transport de la communaute urbaine de Montreal (STCUM) is the largest of the three transit carriers. STCUM operates 1,626 buses and 759 Metrorail (subway) cars. STCUM's system carried almost 340 million passengers in 1994. The system features a number of priority measures for buses including the "R Bus" routes that use either reserved or contraflow lanes. Montreal has contraflow bus lanes on Pie IX Boulevard and the Champlain Bridge and a reversible bus lane on the Viau Bridge.

Pie IX Boulevard is an example of contraflow operations on a two-way arterial street. Pie IX Boulevard is a six-lane divided arterial roadway. The contraflow lane is provided adjacent to the median in the southbound direction during the morning peak period (6:00-10:00 AM) and in the northbound direction during the evening peak period (3:00-7:00 PM). The Pie IX Boulevard contraflow operation extends approximately 4.5 miles from Amos Street to Pierre-de-Coubertin Street at the Pie IX Metro station.

Traffic cones are set up near street crossings to mark the Pie IX Boulevard contraflow lanes and left-turns are prohibited during its hours of operation. Approximately 90 buses daily utilize the Pie IX Boulevard contraflow lane carrying over 6,000 passengers. Studies indicate that approximately nine percent of these passengers are new transit customers. The contraflow lane provides the buses a fourteen minute travel time savings. The biggest problem associated with the Pie IX Boulevard contraflow lane occurs when the lane is forced to close because of snow.

Pie IX Boulevard Contraflow Bus Lane – Montreal

The Champlain Bridge contraflow bus lane extends approximately eight miles from Taschereau Boulevard to the Wellington Exit. The contraflow lane is provided against the median curb on this six-lane divided highway. The lane operates in the southbound direction during the morning peak period (5:30-9:30 AM) and in the northbound direction during the evening peak period (3:00-6:15 PM). Traffic cones are utilized to mark the lane and left turns are prohibited. Approximately 700 buses utilize the Champlain Bridge contraflow lanes daily carrying over 32,000 passengers. The contraflow operations provide a sixteen minute savings in travel time for the buses.

Champlain Bridge Contraflow Bus Lane - Montreal

The Viau Bridge bus lane is an example of a reversible bus lane, which extends approximately three miles from Proulx Street to Gouin Boulevard. Two general-purpose traffic lanes are provided in the northbound and southbound directions and a reversible bus lane is provided in the median, which is raised six inches higher than the general-purpose lanes. The reversible lane operates in the southbound direction from 6:00 to 11:00 AM and in the northbound direction from 1:00 to 11:00 PM. Approximately 465 buses use the Viau Bridge reversible lane daily carrying 11,000 passengers. The operations result in a three-minute savings in travel time.

Chicago Downtown Contraflow Bus Lanes

Contraflow bus lanes were installed on four downtown streets in Chicago in the early 1980s but were later removed because of safety issues primarily related to perceived pedestrian hazards. Chicago had previously experimented with a concurrent flow bus lane on Washington Street but this service was discontinued in the 1970s because of (1) difficulties in keeping this lane free of general purpose traffic, (2) severe congestion on the remaining travel lanes, and (3) safety hazards associated with midstreet passenger loading islands. The contraflow bus lanes were installed as a part of a federally mandated air quality improvement program and sought to increase bus patronage by improving east-west bus service across the central business district. The primary objectives of the contraflow bus lanes were to decrease bus travel times and improve bus schedule regularity.

The bus lanes were implemented in two pairs which provided east-west service across the downtown and served the commuter rail stations. Contraflow bus lanes were installed on Adams Street and Jackson Boulevard in 1980 and on Washington and Madison Streets in 1981. The contraflow lanes on Adams Street, Jackson Boulevard and Washington Street extended from Michigan Avenue west to Jefferson Street (.87 miles) and the contraflow lane on Madison Street extended from Michigan Avenue west to Desplaines Street (.91 miles). The south bus lane pair (Adams Street and Jackson Boulevard) consolidated nine bus routes onto the two streets and the north bus lane pair (Washington and Madison Streets) consolidated seven routes onto the two streets. This consolidation removed almost all buses from other east-west downtown streets. All four contraflow bus lane streets were formerly one-way streets and only transit vehicles were allowed to operate in the opposite direction. The bus lanes on all four streets were eleven feet wide and separated from the other traffic lanes by two foot wide pavement markings.

The operation of the contraflow bus lanes gave rise to public concerns over safety and congestion. However, a before/after traffic accident study demonstrated that after an initial jump in bus-pedestrian accidents, there was a decline to an accident rate only slightly higher than before the contraflow bus lanes were installed. A before/after study was also performed to measure the effect on travel speeds of the general-purpose traffic. There was a significant decrease in travel speeds immediately after the lanes were installed that was primarily attributed to the following factors:

- The impact of delays made by turning vehicles was exacerbated by the bus lane occupying one lane for exclusive bus use. Only two lanes remained for general-purpose traffic including left-turning vehicles that now faced opposing traffic.
- Buses flowing in the general-purpose lanes inhibited the flow of traffic since these lanes had been narrowed to 9 feet to accommodate the contraflow operations.
- Double parking by delivery vehicles formerly blocked only one of three general-purpose travel lanes. After the installation of the contraflow bus lane a double-parked delivery vehicle blocked one of the only two general-purpose travel lanes.
- There was widespread roadway narrowing in the downtown area to accommodate construction and utility repair at the same time the contraflow operations were initiated.

A Traffic Management Task Force was created to address some of these problems and the results of their efforts (which included such measures as peak hour turn restrictions) led to an increase in general-purpose travel speeds to near the travel speeds that existed before implementation of the contraflow lanes.
The implementation of the contraflow bus lanes had a positive impact on bus operations across the central business district (CBD). There was a 22 percent decrease in the amount of time it took a bus to cross the CBD in the evening rush period and the reliability of service also improved. The combination of decreased downtown travel time and improved reliability allowed the same level of service to be provided with five fewer buses yielding a savings of about $400,000 in annual operation costs. In terms of patronage, these benefits were realized by 55,000 daily passengers who traveled in the contraflow lanes and over 200,000 passengers in the outlying area that rode routes that used the downtown contraflow lanes. Approximately 15,500 passengers traveled in the contraflow bus lanes during the morning peak period and approximately 16,750 passengers during the evening peak period.

On November 26, 1984, a prominent businessman was killed when a bus traveling in a contraflow lane struck him. This was the second pedestrian killed since the lanes were opened. The Chicago City Council ordered that the lanes be removed as quickly as possible. The contraflow lanes were replaced by concurrent flow lanes during 1985 and 1986. The stated opinion of the City engineering staff was that the contraflow bus lanes were operating efficiently and should be maintained and that errant pedestrian behavior contributed to the bus-pedestrian accidents.

Contraflow Lanes on Limited Access Facilities

Express bus routes in many cities utilize limited access facilities. These routes often provide service in the peak direction only, at a premium fare. Some of the tactics used to speed expressway bus service include bus-only or (HOV) lanes. There are many different design alternatives for these types of facilities including contraflow lanes, which are used to take advantage of imbalances in directional flows by time of day. Contraflow lanes on limited access facilities typically have a physical divider that separates the lane from the opposing flow. A new technology is the use of movable concrete barriers by a special truck (Zipper Machine).

Examples of these "zipper " lanes are found in Boston, Dallas, and Honolulu. A discussion of existing expressway contraflow lane operations in North America follows.

New Jersey Route 495 Exclusive Bus Lane (XBL)

The New Jersey Route 495 exclusive bus lane (XBL) became the first contraflow bus lane on an expressway in the United States when it was implemented in 1970. The far-left lane of the westbound travel lanes of Route 495 is converted to the XBL during the morning peak period to serve eastbound buses destined for Manhattan. The XBL is 2.5 miles long and connects the New Jersey Turnpike (I-95) and the Lincoln Tunnel, which is one of three vehicular facilities that connect New Jersey with Manhattan. The success of the XBL has led to similar operations on the approaches to the Queens Midtown Tunnel and the Brooklyn Battery Tunnel.

The XBL operates during weekday mornings from 6:15 AM to 10:00 AM. The lane setup includes positioning over 575 traffic delineators to mark the lane and checking overhead traffic devices to ensure that the lanes are properly identified. Access to the XBL is limited to buses with a seating capacity of sixteen or more passengers and all empty buses are prohibited from using the XBL. Buses using the XBL are equipped with E-Zpass, which allows the buses to flow unimpeded through the toll plaza at the approach to the Lincoln Tunnel.

Experience indicates that the operating capacity of the XBL is about 725 buses per hour. Each day, approximately 1,700 buses carrying more than 60,000 passengers use the XBL saving from 10 to 25 minutes of travel time. It is estimated that the XBL keeps 10,000 cars off the road each day and thus eases congestion and improves air quality.

Boston Southeast Expressway (I-93) Contraflow HOV Facility

The Southeast Expressway (I-93) is a principal eight-lane highway linking Boston with communities to the southeast of the city. The facility is the second most heavily traveled roadway in New England accommodating approximately 200,000 vehicles each weekday. In November 1995, a new six-mile contraflow HOV facility that uses movable barrier technology opened between Furnace Brook Parkway and Savin Hill. The I-93 project took less than three years to design, install, and become fully operational. The project cost about 80 percent less than it would have cost to build twelve miles of additional lanes.

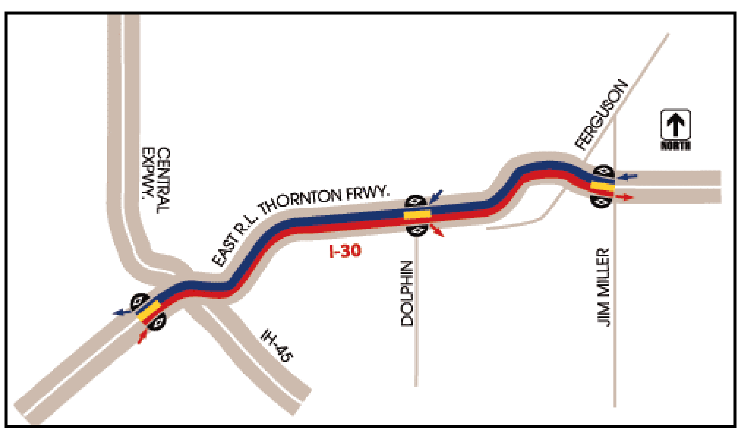
Twice a day, transfer machines move a concrete barrier to create an additional lane in the peak direction of traffic. Use of the I-93 Contraflow HOV lane is limited to three-plus carpools, vanpools, and transit vehicles. Reports indicate a ten to fifteen minute travel time savings for users of the lane.

I-93 Contraflow HOV Lane – Boston

East R.L. Thornton Freeway Contraflow HOV Facility, Dallas, Texas

The East R.L. Thornton (I-30) Contraflow HOV lane opened in Dallas in September 1991. The facility was extended from 3.3 miles to 5.2 miles in February 1996. This contraflow lane reserves the inside freeway lane in the off-peak direction for use by carpools, vanpools, and buses. The lane operates from 6:00 to 9:00 AM in the inbound direction and from 4:00 to 7:00 PM in the outbound direction. The movable barrier contraflow lane is 20 feet wide.

In 1997 the contraflow lane served an average of 15,500 person trips per day. During the AM peak hour 4,157 person trips per hour utilized the contraflow lane and approximately 28 percent of these were passengers on Dallas Area Rapid Transit (DART) buses. The HOV lane is carrying nearly double the typical person carrying capacity of a freeway lane. On average, bus travel speeds have improved from 21 mph before the contraflow lane to operating speeds of 56 mph.



Limits of I-30 Contraflow Operations - Dallas

H-1 Zipper Lane, Honolulu, Hawaii

The H-1 Zipper Lane began operation in 1999. This facility is an approximately 4.5 mile contraflow lane that is created by a Zipper Machine that moves a string of connected movable barriers. The corridor created by the moveable barriers provides a traffic lane and shoulder area where HOV vehicles can pull over without interfering with traffic in the contraflow lane.

H-1 Zipper Lane - Honolulu

The objective of the Zipper Lane is to alleviate morning traffic congestion on the H-1 Freeway between Manager's Drive Overpass and the Pearl Harbor Interchange. When the contraflow lane is in use one lane from the outbound (westbound) direction, which is underutilized during the morning peak, is made available to the Honolulu bound HOVs. The Zipper Lane is reserved for buses, vanpools, and carpools with three or more occupants. It operates each weekday morning from 5:30 to 9:00 AM. Travel time studies indicate that vehicles that enter the Zipper Lane at its first entrance near Manager's Drive Overpass reduce their travel time by approximately 25 minutes.

Summary of Findings of Literature Research

This section of the *Transit Contraflow Feasibility Study* examined past Miami-Dade County bus priority treatments and contraflow operations in North America. The objective of this task was to identify the advantages and disadvantages of establishing contraflow facilities in Miami-Dade County. A summary of pros and cons is presented next.

The primary advantages associated with bus priority treatments and contraflow operations include:

1. <u>Reduction in Bus Travel Times</u> - Contraflow bus lanes often provide significant travel time savings for transit vehicles.
2. <u>Transit Schedule Adherence</u> - Reliability of travel time improves with contraflow operations. The enhanced schedule adherence provided by contraflow operations is often considered its greatest asset.
3. <u>Increased Person Moving Capacity</u> - Buses provide great potential for increasing corridor capacity by moving more people in fewer vehicles.
4. <u>Consolidation of Routes</u> - Transit routes may be consolidated onto streets providing bus priority treatments to simplify operations and provide a focal point for passengers. However, consideration should be taken not to overload the facility.
5. <u>Reduction in Automobile Delay</u> - Large-scale modal shifts from automobile to transit may result in less delay for remaining automobile traffic.
6. <u>Operational Cost Savings</u> - Reduced travel time and improved reliability may result in reduced round-trip travel time which may allow the same level of service to be provided in fewer buses.
7. <u>Capital Cost Savings</u> - Improvements that utilize excess capacity in the off-peak direction can be implemented for significantly less than it would cost to construct additional lanes.

The primary negative aspects associated with bus priority treatments and contraflow operations include:

1. <u>Pedestrian Safety</u> - There is often a high rate of bus/pedestrian accidents which result from pedestrians stepping in front of buses that are traveling against the flow. The situation is exacerbated because contraflow lanes are often adjacent to the curb and may be narrow to

take advantage of existing right-of-way. This restricts the bus driver's ability to avoid incidents. However, measures may be employed to improve safety such as installing a railing along the curb to prevent pedestrians from crossing in front of buses, as was done in Pittsburgh.

2. Bus Accidents - The initiation of transit contraflow operations may result in an increase in bus/automobile accidents until drivers become familiar with the scheme.
3. Violations - Even when a bus lane has a high throughput measured in persons per hour the lane may appear underutilized. This perception may result in violations without the presence of strict law enforcement. Violations may also lead to bus/automobile accidents.
4. On-Street Parking and Loading - Curbside lanes may preclude on-street parking and loading activities. This may negatively impact existing businesses and slow down redevelopment efforts.
5. Bus Loading Delays - The provision of a single lane for contraflow operations may result in delays if buses stopped for loading activities cannot be passed by other buses. The Spring Street contraflow lane in Los Angeles was widened at locations to allow passing room for buses to address this operational problem.
6. Automobile Delays - Taking a lane away from general-purpose traffic may result in increased delays for automobiles in the corridor. Contraflow operations along streets that were formerly one-way may also result in more complicated operations and increased delay at signalized intersections. Traffic delays may be minimized through traffic control measures such as turn restrictions.

In summary, contraflow bus lanes may provide reductions in travel time for buses and improved schedule adherence. Designs that accommodate commercial deliveries, permit stopped buses to be passed, and are self-enforcing, are most useful. Contraflow bus lanes may provide the biggest benefit to bus passengers in corridors that are severely congested in the peak direction of travel or along short segments to bypass delay associated with a CBD or bottleneck.

The findings of the literature research have provided the foundation necessary to proceed to the next project task, which is the review and evaluation of potential transit contraflow corridors. A set of qualifications and standards (physical and operational) will be developed for the implementation of transit contraflow services and potential corridors where transit contraflow service could be implemented will be evaluated.

EVALUATION OF POTENTIAL CONTRAFLOW CORRIDORS

Based on the information collected in the literature research, a set of minimum standards was developed for implementing transit contraflow services. A fatal flaw analysis was selected as the initial "Tier 1 Screening" process. The corridors emerging from this analysis were then carried forward through a more detailed evaluation or "Tier II Screening."

Potential Transit Contraflow Corridors

A list of candidate corridors in Miami-Dade County, where transit contraflow operations could potentially be implemented, was developed for assessment in this study. The initial requirement for consideration as a candidate corridor was the presence of Miami-Dade Transit (MDT) bus service. A review of Miami-Dade County's transit map illustrates that MDT provides bus service in most of the primary transportation corridors in the County. However, a limited number of bus routes utilize many of these corridors. MDT staff assisted in identifying the corridors that have the highest levels of bus service. These corridors were considered the best candidates for contraflow operations and worthy of further evaluation. As a starting point, broad limits were defined for the candidate corridors with the intention of narrowing down to more specific limits during the evaluation process. The list of candidate corridors for transit contraflow operations follows:

- Biscayne Boulevard – NE 14th Street to Aventura Mall
- Brickell Avenue – Biscayne Boulevard Way to Rickenbacker Causeway
- Collins Avenue – 17th Street to 192nd Street Causeway
- Flagler Street – Miami River to SW 107th Avenue
- Kendall Drive – SW 157th Avenue to U.S. 1
- LeJeune Road – U.S. 1 to NW 36th Street
- MacArthur Causeway – Biscayne Boulevard to Washington Avenue
- Washington Avenue – 5th Street to 17th Street
- 17th Street – Dade Boulevard to Collins Avenue
- NW/NE 167th/163rd Street – Golden Glades to Collins Avenue
- NW 7th Avenue – NW 5th Street to Golden Glades
- NW/SW 27th Avenue – U.S. 1 to NW 211th Street

- NW 135th Street/Opa Locka Boulevard – Opa Locka Tri-Rail Station to Biscayne Boulevard
- Coral Gables Central Business District – Andalusia Avenue/Aragon Avenue from LeJeune Road to Douglas Road
- Hialeah Central Business District – Palm Avenue/East 1st Avenue from Okeechobee Road to NW 74th Street
- Miami Central Business District – SW/SE 1st Street / NW/NE 1st Street from SW/NW 2nd Avenue to Biscayne Boulevard

Tier I Screening

A fatal flaw analysis was selected as the initial screening process for the candidate transit contraflow corridors. This approach identifies a few key elements, called fatal flaws, which may eliminate a corridor from further analysis. A first level evaluation or "Tier I Screening" was conducted based on these elements. The fatal flaws considered in the "Tier I Screening" process were the level of bus service and the number of lanes remaining to serve the opposing general-purpose traffic. The corridors emerging from this fatal flaw analysis were then carried forward through a more detailed evaluation or "Tier II Screening."

Tier I Evaluation Criteria

The number of buses or bus passengers can provide an indication of a need for bus priority treatment. A minimum threshold must be considered to ensure that a reserved bus lane does not look under-utilized, thus creating an "empty lane syndrome." If a reserved bus lane appears under-utilized, pressure may be exerted to open the lane to general-purpose traffic. According to National Cooperative Highway Research Program (NCHRP) Report 155, *Bus Use of Highways Planning and Design Guidelines*, for short contraflow segments, such as bypassing a bottleneck, there should be a minimum of 20 to 30 buses per hour or 800 to 1,200 peak hour bus passengers. For extended contraflow segments, such as corridor treatments, there should be a minimum of 40 to 60 buses per hour or 1,600 to 2,400 peak hour bus passengers. Therefore, for purposes of the "Tier I Screening" analysis, corridors were required to have a minimum of 20 directional buses per hour to merit further evaluation.

In order to minimize costs associated with construction and right-of-way acquisition, roadway widening was not considered an option with this project. Contraflow bus lanes would be developed solely through the conversion of a general-purpose traffic lane. Therefore, the screening process considered the impact of a lane conversion on traffic flow and congestion levels in the remaining general-purpose lanes. The criterion developed to evaluate the conversion of a general-purpose traffic lane to contraflow bus operations was the minimum number of lanes remaining to serve the opposing general-purpose traffic. For the purpose of the "Tier I Screening" analysis, the project's study advisory committee recommended that that two-way streets should provide at least five lanes and one-way streets should provide at least three lanes for further consideration as a potential contraflow corridor. This criterion assures that at least two lanes remain to serve the general-purpose traffic traveling opposite the contraflow lane.

Tier I Data Collection

The number of directional buses per hour was determined by first identifying the bus routes within the candidate corridors. Route schedules were then examined to obtain headways, which were utilized to estimate the number of peak hour buses per route. The directional buses per hour were calculated by summing the number of buses per hour for each route within the candidate corridors.

The number of through traffic lanes in the candidate corridors was obtained from a review of aerial photography.

Results of Tier I Corridor Screening

Results of the "Tier I Screening" are presented in Table 1. The fatal flaw analysis resulted in the elimination of all but the following segments of five candidate corridors:

- Biscayne Boulevard – NE 14th Street to NE 36th Street
- Collins Avenue – 26th Street to 63rd Street; 73rd Street to Haulover Bridge; Sunny Isles Causeway to 192nd Street Causeway
- 17th Street – Dade Boulevard to Washington Avenue

TABLE 1
MIAMI-DADE TRANSIT CONTRAFLOW FEASIBILITY STUDY
"TIER I" CORRIDOR SCREENING (FATAL FLAW ANALYSIS)

Corridor	Limits	Level of Bus Service		Physical Constraints		Advances to "Tier II" Screening?
		Buses Per hour	Satisfies Criteria? (1)	Number of Lanes	Satisfies Criteria? (2)	
Biscayne Boulevard	NE 14th Street to Aventura Mall	20	Yes	6LD/5LU	Yes	**Yes**
Brickell Avenue	Biscayne Boulevard Way to Rickenbacker Causeway	20	Yes	4LD	No	No
Collins Avenue	17th Street to 192nd Street Causeway	32	Yes	6LD/3LOW (5)	Yes	**Yes**
Flagler Street	Miami River to SW 107th Avenue	10	No	5LU/3LOW	Yes	No
Kendall Drive	SW 157th Avenue to U.S. 1	10	No	6LD	Yes	No
LeJeune Road	U.S. 1 to NW 36th Street	10	No	6LD/5LU	Yes	No
MacArthur Causeway	Biscayne Boulevard Way to Washington Avenue	15	No	6LD	Yes	No
Washington Avenue	5th Street to 17th Street	20 (3)	Yes	4LD	No	No
17th Street (Miami Beach)	Dade Boulevard to Collins Avenue	37 (3)	Yes	5LU (6)	Yes	**Yes**
NW/NE 167th/163rd Street	Golden Glades to Collins Avenue	23	Yes	6LD	Yes	**Yes**
NW 7th Avenue	Flagler Street to Golden Glades	18 (4)	No	6LD/5LU	Yes	No
NW/SW 27th Avenue	U.S. 1 to NW 211th Street	10	No	6LD/5LU (7)	Yes	No
NW 135th Street/Opa Locka Boulevard	Opa Locka Tri-Rail Station to Biscayne Boulevard	2	No	5LU/3LOW	Yes	No
Coral Gables Central Business District Analusia Avenue/Aragon Avenue	LeJeune Road to Douglas Road	13	No	3LOW/2LU	Yes	No
Hialeah Central Business District Palm Avenue/East 1st Avenue	Okeechobee Boulevard to NW 74th Street	15	No	3LOW	Yes	No
Miami Central Business District SW/SE 1st Street and NW/NE 1st Street	SW/NW 2nd Avenue to Biscayne Boulevard	75	Yes	3LOW	Yes	**Yes**

Notes:
(1) Minimum of 20 directional buses per hour are required to satisfy the level of bus service criterion.
(2) Minimum of five lanes are required for two-way streets and three lanes are required for one-way streets to satisfy the physical constraints criterion.
(3) Buses per hour includes the "Electrowave" shuttle local circulator service.
(4) Buses per hour includes express bus routes that presently utilize I-95.
(5) Collins Avenue segment from 17th Street to 26th Street is 4LU. Collins Avenue segment from 63rd Street to 73rd Street is 2LOW. Collins Avenue segment from Haulover Bridge to the Sunny Isles Causeway is 4LD.
(6) 17th Street segment from Washington Avenue to Collins Avenue is 3LU.
(7) NW 27th Avenue segment from S.R. 112 to NW 103rd Street is 4LD.

- NW/NE 167th/163rd Street – NW 2nd Avenue to NE 15th Avenue
- Miami Central Business District – SW/SE 1st Street / NW/NE 1st Street from SW/NW 2nd Avenue to Biscayne Boulevard

The "minimum number of lanes" criterion narrowed the limits of two candidate contraflow corridors, Collins Avenue and 17th Street, by requiring at least two lanes to serve the opposing general purpose traffic. The segments of Collins Avenue from 17th Street to 26th Street, 63rd Street to 73rd Street, and the Haulover Bridge to the Sunny Isles Causeway are eliminated from further consideration because of this constraint. The segment of 17th Street from Washington Avenue to Collins Avenue also does not provide the required number of lanes.

The "minimum number of buses" criterion narrowed the limits of the Biscayne Boulevard, NW/NE 167th/163rd Street, and 17th Street corridors by requiring at least 20 directional buses per hour. The segments of Biscayne Boulevard from NE 36th Street to the Aventura Mall, NE 163rd Street from NE 15th Avenue to Collins Avenue, and 17th Street from Dade Boulevard to Alton Road are eliminated because of this criterion.

At the request of the Miami-Dade MPO, one additional candidate corridor – which also came very close to satisfying the "Tier I Screening" criteria – was also advanced beyond the "Tier I Screening." This corridors is defined as follows:

- NW 7th Avenue – Golden Glades to NW 5th Street

This corridor satisfies the "minimum number of lanes" criterion and comes very close to satisfying the "minimum number of buses" criterion. In fact, this corridors would satisfy the "minimum number of buses" criterion with only marginal increases in bus service.

Tier II Screening

The six candidate corridors that emerged from the "Tier I Screening" were evaluated in more detail in a "Tier II Screening" process. The purpose of the "Tier II Screening" was to identify the candidate corridors that offer the most potential for transit contraflow operations. The corridors emerging from the "Tier II Screening" will be assessed in detail for feasibility of implementing transit contraflow operations.

Tier II Evaluation Criteria

The "Tier II Screening" considered several additional evaluation criteria beyond the level of bus service and the number of lanes remaining to serve the opposing general-purpose traffic. Evaluation criteria that were considered in the "Tier II Screening" include:

- Physical Constraints – The ability to implement an arterial bus contraflow lane may be influenced by physical factors including roadway and intersection geometry, lane widths, presence of on-street parking, the ability to widen within the existing right-of-way, and the location of transition areas and access points.
- Operations/Intersection Control – The contraflow bus lane should represent a logical and operable segment. Factors influencing the operation of a contraflow lane may include setting up traffic separators, providing separate traffic signal heads, adjusting signal timing, or implementing turn restrictions.
- Level of Congestion – The level of congestion on an arterial street may help to identify the need for a bus priority treatment. Level of service should be considered on a both a link and intersection basis in potential contraflow corridors.
- Person Throughput – A criterion for a contraflow bus lane may be to increase the person carrying capacity of a corridor or facility. To meet this criterion the contraflow bus lane should move more people than the general-purpose lane it replaces.
- Links or System Connectivity – The presence of bus priority treatment in an intersecting corridor may indicate the need for bus priority treatment to provide a link to a major activity center or bus terminal.

Several additional criteria including driveway access and curb use, bicycle/pedestrian safety, and enforcement were also considered. However, it was determined that transit contraflow operations would have a negative impact on these criteria in all of the candidate corridors.

Tier II Data Collection

A thorough field review was performed and a number of photographs were logged for the six candidate corridors. The primary purpose of the field review was to identify disqualifying measures among the "Tier II Screening" evaluation criteria that may preclude establishing transit contraflow operations in the corridors. Physical constraints, operations/intersection constraints, and driveway access and curb use adverse to transit contraflow operations were noted during the field review.

Traffic volumes were obtained from the Florida Department of Transportation and the Miami-Dade County Public Works Department to identify the level of congestion in the study corridors. Based upon the existing traffic volumes and the previously identified levels of bus service, it was possible to approximate the impact of contraflow operations on the corridor's person throughput. Finally, the corridors were assessed for links or connections to bus priority treatments, major activity centers, or bus terminals.

Results of Tier II Corridor Screening

A qualitative assessment of the six candidate corridors was performed utilizing the "Tier II Screening" evaluation criteria. The corridors were assessed to determine if they possess conditions favorable or adverse for establishing transit contraflow operations and disqualifying criteria were identified that eliminated corridors from further consideration. Results of the "Tier II Screening" are presented in Table 2 and summarized for the individual corridors below.

Biscayne Boulevard

The segment of Biscayne Boulevard between NE 14th Street and NE 36th Street possesses several conditions conducive to transit contraflow operations. The entire segment consists of a five-lane cross section, presenting favorable physical factors and a logical operable segment. The segment has a heavy directional flow during the peak periods, with traffic flowing predominantly southbound during the AM and northbound during the PM. The segment also connects to the Omni Bus Terminal. Therefore, this segment of Biscayne Boulevard is a viable candidate for transit contraflow operations.

Northbound Biscayne Boulevard – PM Peak

TABLE 2
MIAMI-DADE TRANSIT CONTRAFLOW FEASIBILITY STUDY
"TIER II" CORRIDOR SCREENING

Corridor	Limits	Physical Constraints	Operations / Intersection Control	Level of Congestion	Person Throughput	Links or System Connectivity	Overall Feasibility
Biscayne Boulevard	NE 14th Street to NE 36th Street	+	+	+	+	+	+
Collins Avenue	26th Street to 63rd Street	-	X	-	-	-	-
	73rd Street to Haulover Bridge	-	X	-	-	-	-
	Sunny Isles Causeway to 192nd Street Causeway	+	+	-	X	-	-
17th Street	Alton Road to Washington Avenue	X	-	+	-	-	-
NW/NE 167th/163rd Street	NW 2nd Avenue to NE 15th Avenue	+	+	+	-	+	+*
NW 7th Avenue	NW 5th Street to Golden Glades	X	+	+	+	+	-
Miami Central Business District							
SW/SE 1st Street and NW/NE 1st Street	SW/NW 2nd Avenue to Biscayne Boulevard	X	X	+	+	+	-

Notes:
+ = Condition favorable for establishing transit contraflow operations.
- = Condition adverse for establishing transit contraflow operations.
X = Disqualifying criteria that eliminates corridor from further evaluation.
+ = Candidate for alternative bus priority treatment.*

Collins Avenue

Implementation of transit contraflow operations on Collins Avenue between 26th Street and 63rd Street is not favorable because this segment transitions between a three-lane one-way pair (with Indian Creek Boulevard) and a six-lane divided arterial at 26th Street, 44th Street, and south of 63rd Street. Accordingly, this segment does not represent a logical operable contraflow segment because of the need for multiple transition areas. This segment also does not compare favorably to other evaluation criteria, such as the presence of on-street parking and loading zones, level of congestion and links or system connectivity. Because the corridor is not heavily congested, the benefits to person throughput would also be minimal. Therefore, this corridor is not a viable candidate for transit contraflow operations.

Curb Lane Loading Zone – Collins Avenue at 44th Street

The segment of Collins Avenue between 73rd Street and the Haulover Bridge also is not conducive to transit contraflow operations because this corridor transitions from a three-lane one-way pair (with Harding Avenue) to a six-lane divided arterial north of 96th Street. Collins Avenue narrows to a four-lane divided arterial south of the Haulover Bridge. The need for multiple transition areas is not conducive to transit contraflow operations and this segment also lacks logical transition points. This segment also does not compare favorably to the other evaluation criteria including the presence of on-street

On-Street Parking – Collins Avenue at 73rd Street

parking and loading zones, level of congestion, person throughput, and links or system connectivity. Therefore, this corridor is not a viable candidate for transit contraflow operations. The entire segment of Collins Avenue between the Sunny Isles Causeway and the 192nd Street Causeway is six-lane divided, thus presenting favorable physical factors and a logical operable segment. However, this segment does not compare favorably to the other evaluation criteria. A low level of bus service minimizes the benefit to person throughput. This segment is not heavily congested and lacks link or system connectivity. Therefore, this corridor is not a viable candidate for transit contraflow operations.

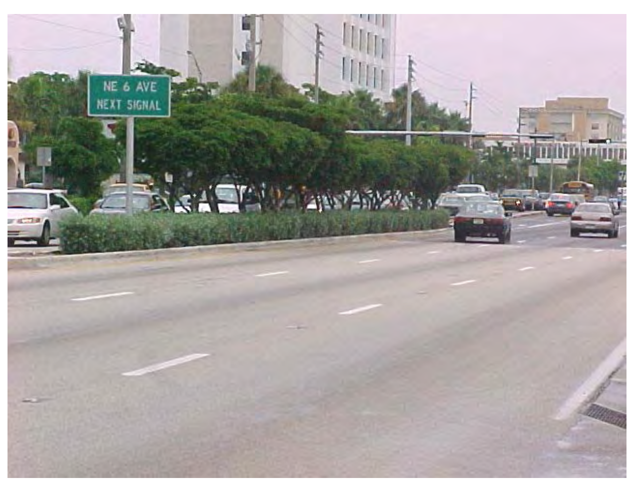
17th Street (Miami Beach)

The segment of 17th Street from Alton Road to Washington Avenue is a five-lane cross section, which can be conducive to transit contraflow operations. However, this segment is physically constrained by narrow lanes. This segment also lacks clear transition points for the contraflow operations. Additionally, this segment would not provide links or system connectivity. Finally, reserving a lane for transit contraflow operations would have an adverse impact on person throughput because of the heavy congestion at intersections along this corridor. Therefore, this corridor is not a viable candidate for transit contraflow operations.

Narrow Travel Lanes along 17th Street

NE 167th/163rd Street

The segment of NE 167th/163rd Street between NW 2nd Avenue and NE 15th Avenue is six-lanes divided, which may be conducive to transit contraflow operations. This segment also represents



NE 167th Street at NE 6th Avenue

a logical operating segment, providing a connection between the Golden Glades Park-and-Ride Lot and the 163rd Street Mall Bus Terminal. However, this segment is heavily congested in both directions during the peak hours. Without a significant increase in bus service, person throughput would be negatively impacted by transit contraflow operations because of the congestion. On the other hand, this segment may be a viable candidate for alternative bus priority treatments such as queue-jumpers or other signal preemption techniques.

NW 7th Avenue

Bus priority treatments were previously provided during the 1970s on the segment of NW 7th Avenue between NW 5th Street and the Golden Glades Park-and-Ride Lot. However, when the I-95 HOV lanes were completed, express bus service was diverted to I-95 and the bus priority treatments were discontinued. Although its existing level of bus service is not significant enough to warrant transit contraflow operations, the NW 7th corridor was evaluated because of increasing congestion in the I-95 HOV lanes. Therefore, the evaluation assumed that the express bus service would be diverted back to NW 7th Avenue.

The segment of NW 7th Avenue from NW 5th Street to the Golden Glades Park-and-Ride Lot is a logical operating segment that connects a modal transfer point (Golden Glades) and a major activity center (Downtown Miami). The corridor could also provide positive impacts on person throughput by serving the heavily utilized express bus routes. However, a portion of NW 7th Avenue has been improved since the 1970s with a raised median, and median improvements are programmed for the remainder of this segment. The raised median replaces the two-way left-turn lane that served as a reversible bus lane during the 1970s and negates the ability to implement a transit contraflow lane in this corridor.

Construction of Raised Median along NW 7th Avenue

SW/SE 1st Street and NW/NE 1st Street

The segments of SW/SE 1st Street and NW/NE 1st Street between SW/NW 2nd Street and Biscayne Boulevard have the highest levels of bus service of the candidate corridors. The corridors also provide a connection to the Downtown Bus Terminal. However, these segments are physically constrained by narrow travel lanes and NE 1st Street is further narrowed by the support columns for the Metromover. Additionally, with the high level of pedestrian activity in these corridors transit contraflow operations would adversely affect safety. Therefore, these corridors are not viable candidates for transit contraflow operations.

Metromover Column along NE 1st Street

Summary of Evaluation of Potential Contraflow Corridors

Two candidate corridors emerged from the "Tier I" and "Tier II" screening processes as viable candidates for bus priority treatment. These corridors are:

- Biscayne Boulevard from NE 14th Street to NE 36th Street
- NW/NE 167th/163rd Street from NW 2nd Avenue to NE 15th Avenue

These corridors will be assessed in detail for the feasibility of implementing bus priority treatment. The assessment will not limit the alternatives for transit improvements to contraflow operations. Results of the "Literature Research" and the "Review and Evaluation of Potential Contraflow Corridors" has demonstrated that restricting the possible improvements to transit contraflow operations may be too narrow. Alternative operational improvements may offer more benefit to transit operations. Therefore, the detailed assessment will consider a wide range of bus priority treatments aimed at improving transit service in these corridors.

FEASIBILITY OF IMPLEMENTING TRANSIT CONTRAFLOW

Based on a two tier screening process of transit corridors in Miami-Dade County, two corridors were selected as the best candidates for bus priority treatment: Biscayne Boulevard from NE 14th Street to NE 36th Street and NW/NE 167th/163rd Street from NW 2nd Avenue to NE 15th Avenue. These two corridors were examined in detail to determine the feasibility of implementing contraflow operations. The feasibility assessment considered benefits to transit service, impacts to traffic flow, affects on parking and curb use, required improvements, and costs.

Applicability of Contraflow Bus Lanes

Contraflow bus lanes enable buses to operate opposite to the normal traffic flow. The most common application of contraflow bus lanes is on one-way streets, where the contraflow bus lanes function as a special application of unbalanced traffic flow for bus operations. On two-way streets, successful application of contraflow bus lanes is contingent on a high directional imbalance in traffic volumes.

According to National Cooperative Highway Research Program (NCHRP) Report 155, *Bus Use of Highways Planning and Design Guidelines*, the following general conditions are desirable for the application of contraflow bus lanes on arterial streets:

1. Peak period congestion exists in the corridor to be served by the contraflow lane.
2. At least 40 to 60 buses carrying 1,600 to 2,400 people utilize the contraflow lane during the peak hour. Where contraflow lanes are in effect all day, at least 400 buses should use the lanes. Bus flow rates should approach 60 buses per hour during the heaviest 20-minute period. For short contraflow segments, such as bypassing a bottleneck, there should be a minimum of 20 to 30 buses per hour or 800 to 1,200 peak hour bus passengers. From the standpoint of enforceability, contraflow bus lanes work best when there generally is a bus in view.
3. The contraflow bus lane does not reduce peak hour, peak direction traffic capacity, except where such reductions are an integral part of regional transportation policy objectives.
4. At least two lanes remain for traffic in the opposite direction.

5. Curb parking and loading is prohibited during hours that the contraflow bus lanes are in effect. Provision for necessary access to abutting properties must be worked out in advance to the satisfaction of property owners.

Other factors of consideration include the length of the contraflow bus lanes and the required improvements and costs associated with implementing contraflow operations. The optimal length of contraflow bus lanes depends on bus routing patterns and street geometry. In particular, locations where streets join or change direction may provide logical terminal points for contraflow operations. In terms of required improvements, contraflow bus lanes may necessitate pavement markings, signage, traffic signal modifications, and lane use control signals.

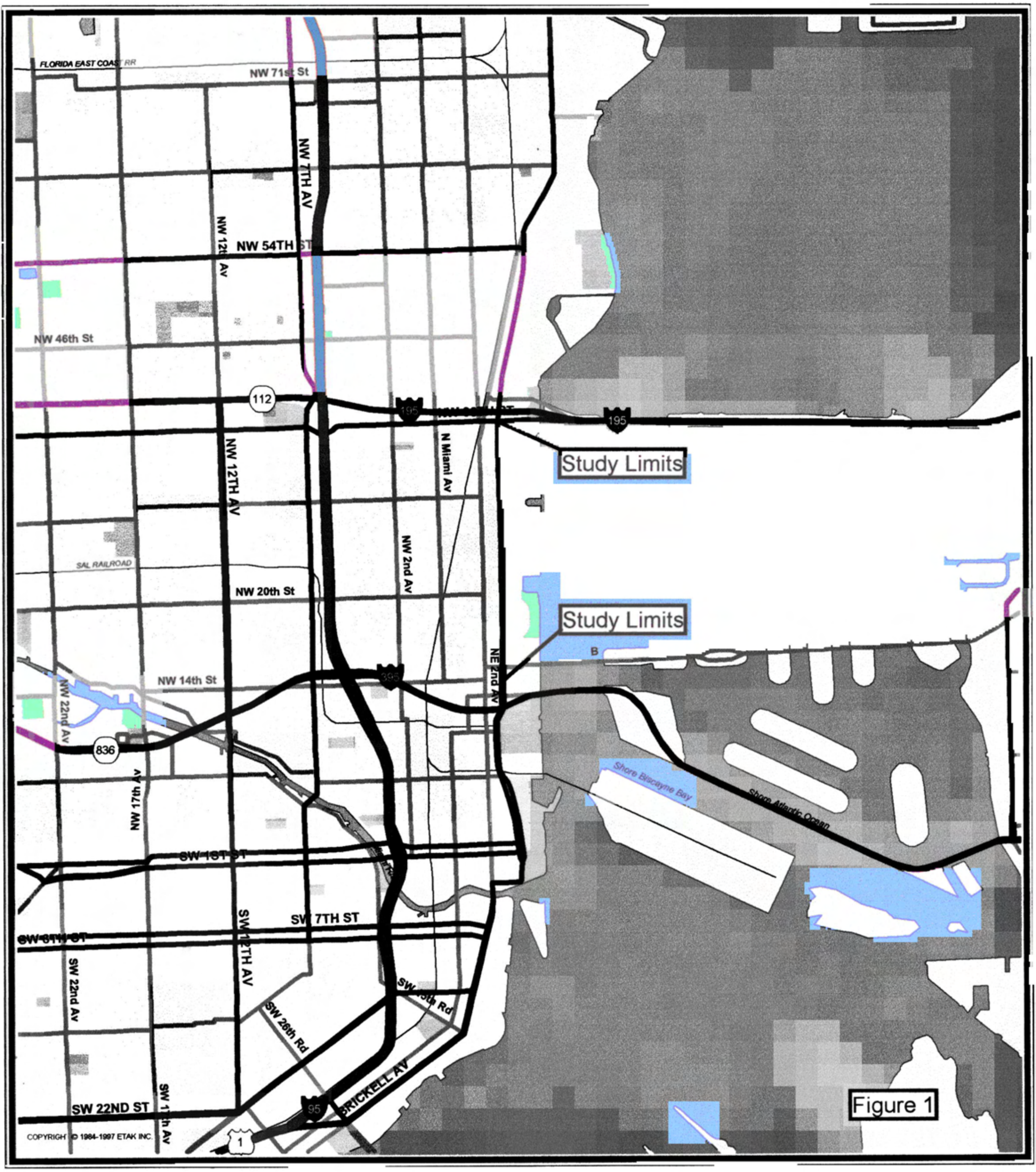
Based on the criteria discussed above, the feasibility of implementing contraflow bus operations on Biscayne Boulevard and NW/NE 167th/163rd Street was evaluated.

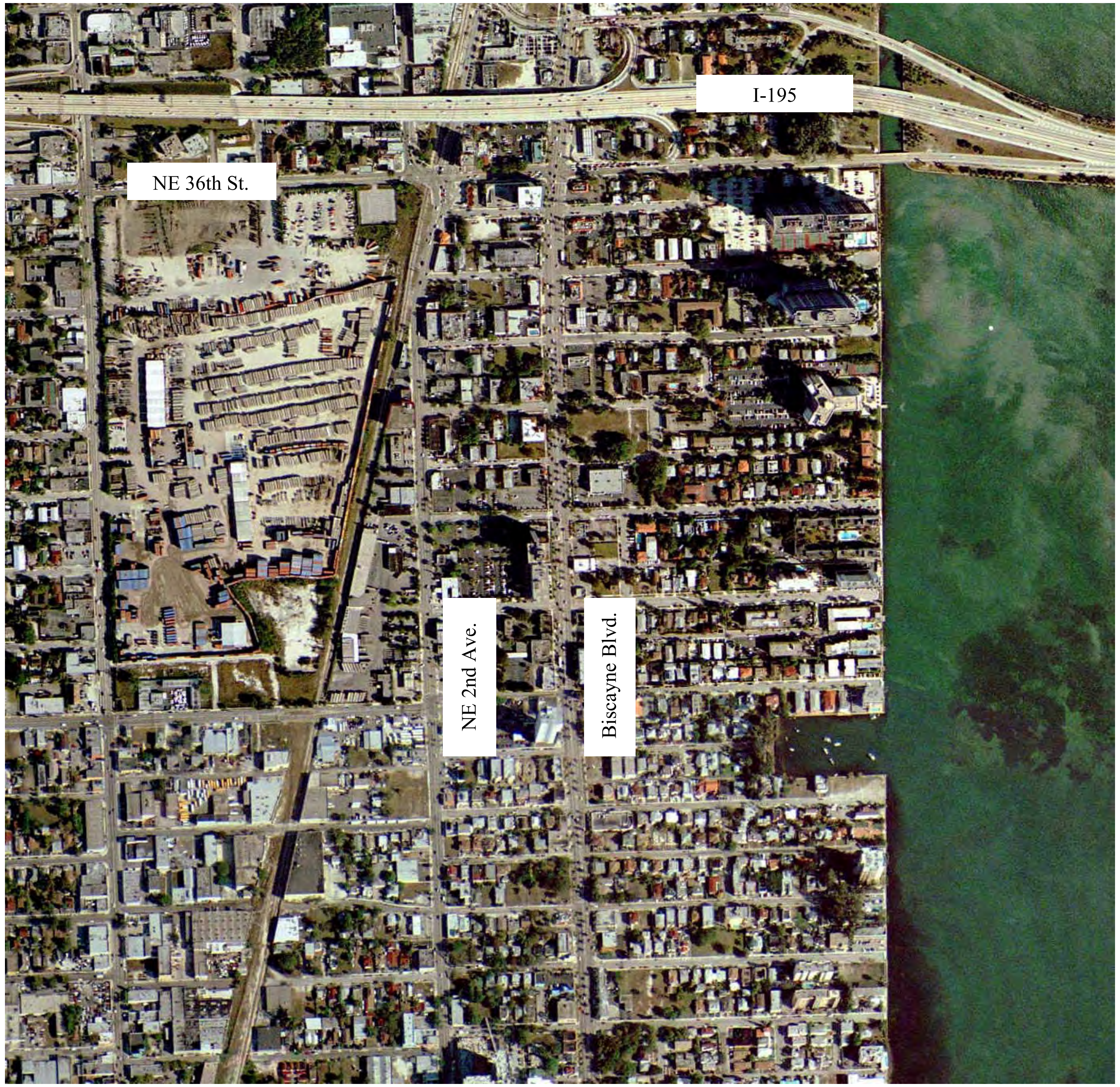
Assessment of Contraflow Bus Operations on Biscayne Boulevard

Figure 1 shows the general location of the segment of Biscayne Boulevard that was assessed for contraflow bus operations. For the entire length (approximately 1.5 miles) between NE 14th Street and NE 36th Street, Biscayne Boulevard is a five-lane section providing two lanes of through traffic in each direction plus a center two-way left-turn lane. Figure 2 presents an aerial view of the corridor. This section of Biscayne Boulevard approaches the Miami Central Business District (CBD) and provides a connection to the Omni Bus Terminal. Because of the proximity to the CBD, a number of Metrobus routes converge on Biscayne Boulevard and nearby parallel streets.

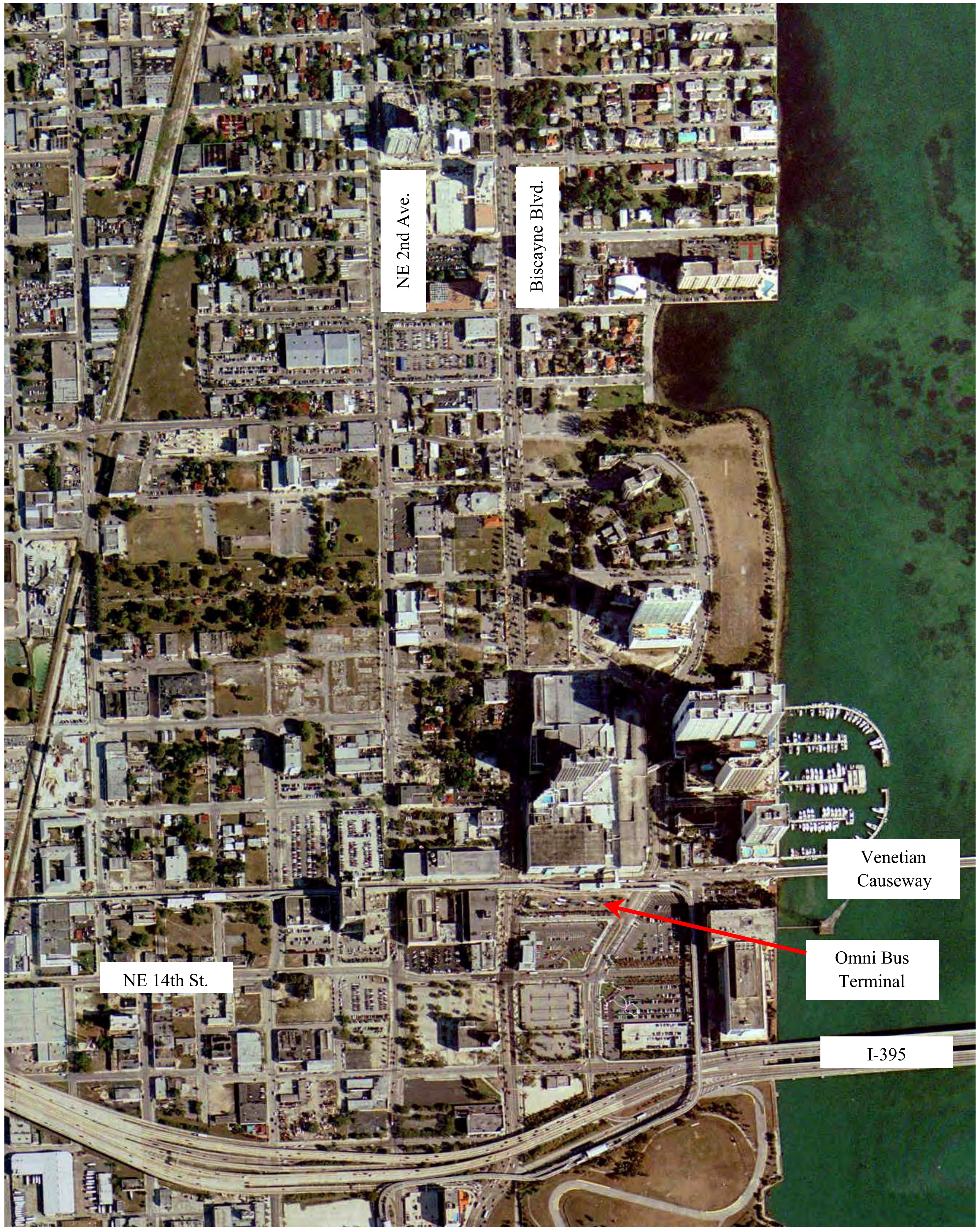
The geometry of Biscayne Boulevard is not conducive to contraflow operations. Contraflow bus lanes are generally found on one-way streets. Contraflow bus lanes may be implemented along two-way streets, such as in Montreal or along U.S. 1 in Miami-Dade County during the 1970s. However, the application of contraflow bus lanes on two-way streets has been along a raised median, which can serve as a refuge for passenger loading. In order to provide stops along Biscayne Boulevard, the outside curb lane in the opposite direction of travel would have to be designated as the contraflow lane and a customized bus would be needed that permitted passenger

Biscayne Boulevard Study Corridor Location Map





BISCAYNE BLVD - NORTHERN SECTION



BISCAYNE BLVD - SOUTHERN SECTION

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Aerial View of Biscayne Boulevard Corridor

NORTH

Figure 2

boardings and alightings on either side of the vehicle. Additionally, to minimize potential conflicts turn restrictions would be required to prevent vehicles from crossing the contraflow lane. Because of these factors, contraflow operations are not feasible for Biscayne Boulevard.

Alternative bus priority treatments may be appropriate for Biscayne Boulevard. In particular, the geometry of Biscayne Boulevard is conducive to a reversible bus lane similar to the operations along NW 7th Avenue during the 1970s. Two potential variations of a reversible bus lane could be implemented on Biscayne Boulevard:

- Alternative 1 - The center two-way left-turn lane would function as a reversible bus lane during peak periods. Left-turns would be prohibited during the peak period operations. Figure 3a illustrates this concept.
- Alternative 2 - The two-way left-turn lane would shift over one lane to the left to provide two general purpose lanes in the peak direction, an exclusive bus lane in the peak direction, a two-way left-turn lane, and one general purpose lane in the off-peak direction. Left-turns would be restricted at midblock locations. At signalized locations left-turning vehicles would be allowed to cross the bus lane only during a protected left-turn phase. Figure 3b illustrates this concept.

According to the guidelines outlined in NCHRP Report 155, *Bus Use of Highways Planning and Design Guidelines*, Alternative 2 should not be carried forward because it does not provide at least two lanes for traffic in the off-peak direction. A significant directional imbalance (approximately 65%/35%) in traffic flow exists on Biscayne Boulevard during the peak periods. However, two lanes are required to provide adequate capacity for the off-peak direction because traffic volumes in the off-peak direction exceed 1,000 vehicles during the peak hour. Therefore, the remainder of the analysis of Biscayne Boulevard is limited to Alternative 1.

Benefits to Transit Service

The existing bus routes in the vicinity of the Biscayne Boulevard corridor are shown in Figure 4. Seven Metrobus routes travel on Biscayne Boulevard within the study limits: Routes 3, 16, 32, 36, 62, 95X, T, and Biscayne Max. Another two Metrobus routes travel on NE 2nd Avenue north of NE 17th Terrace and along the NE 1st Avenue/NE 2nd Avenue one-way pair south of NE 17th Terrace: Routes 9 and 10. Because NE 2nd Avenue is approximately 500 feet west of Biscayne

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Biscayne Boulevard Reversible Lane Concepts

Alternative 1

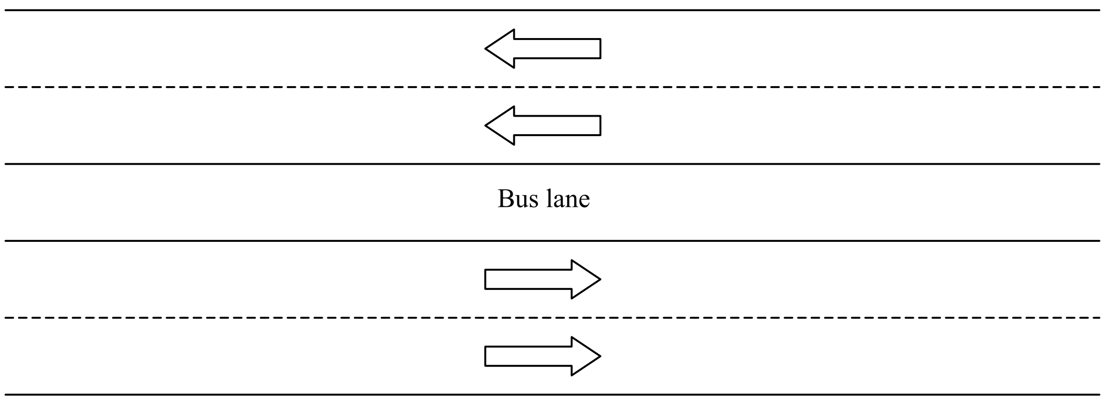


Figure 3a

Alternative 2

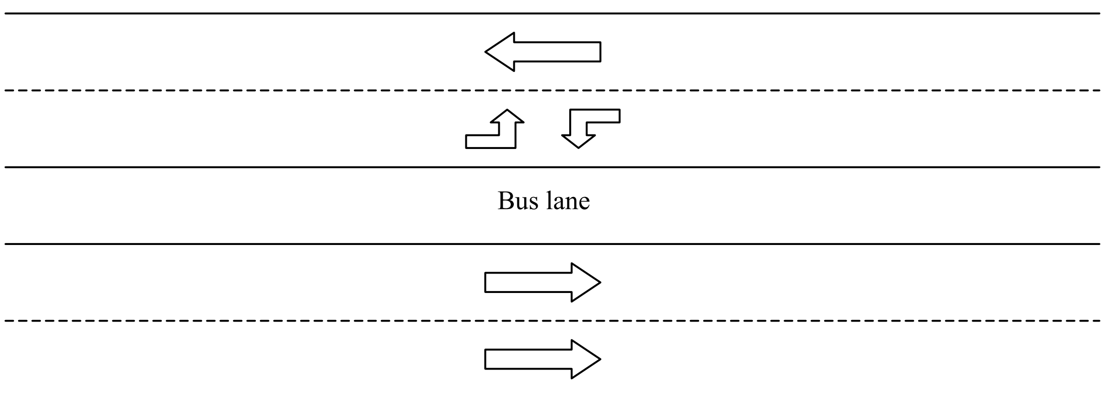


Figure 3b

Legend

ROUTE_NAME

- 10
- 16
- 3
- 32
- 36
- 62
- 9
- 95X
- BMAX
- T
- Streets

Miami-Dade Transit Contraflow Feasibility Study

Biscayne Blvd. Corridor Metrobus Routes

Kimley-Horn and Associates, Inc.

Figure 4

Boulevard, Routes 9 and 10 could potentially be relocated to Biscayne Boulevard between NE 14th Street and NE 36th Street without major inconvenience to riders. However, Miami-Dade Transit (MDT) staff has expressed reluctance to relocate any routes and remove service from any corridors.

The number of peak hour, peak direction buses traveling in the study corridor was calculated for comparison to the guidelines outlined in NCHRP Report 155, *Bus Use of Highways Planning and Design Guidelines*, which specify at least 40 to 60 buses carrying 1,600 to 2,400 people should utilize a contraflow bus lane. Table 3 summarizes the peak hour bus service and ridership in the Biscayne Boulevard corridor. The peak hour ridership was estimated by multiplying the number of buses per route by the average passengers per revenue hour for the route, based on information obtained from MDT *Ridership Technical Reports*.

Table 3: Biscayne Boulevard Peak Hour Bus Service and Ridership

Metrobus Route	Peak-Hour, Peak Direction Buses	Peak-Hour, Peak Direction Passengers
3	3	140
16	3	140
36	4	150
62	3	130
T	3	90
Biscayne Max	4	180
95X	0	0
Total	**20**	**730**

Sources: Miami-Dade Transit 2001 Transit Development Program
Miami-Dade Transit Ridership Technical Report – February 2001

The benefits of transit service on Biscayne Boulevard are significant. The 20 buses operating in the peak traffic direction carry approximately 730 passengers during the AM and PM peak hours. Transit ridership accounts for a significant amount of the total person throughput in the corridor. However, implementing a reversible bus lane on Biscayne Boulevard is not yet warranted based on the number of buses and ridership. Even if Metrobus Routes 9 and 10 were relocated from NE 2nd Avenue to Biscayne Boulevard, the level of bus service and ridership would not be significant enough to warrant implementing a reversible bus lane. To substantiate implementing a reversible bus lane on Biscayne Boulevard, the number of peak hour bus routes and ridership needs to be twice the existing level.

A disadvantage associated with a reversible bus lane on Biscayne Boulevard is that stops would not be possible within the segment because of a lack of refuge for passenger loading. MDT staff indicated that the elimination of stops along this corridor is not feasible. Therefore, a reversible bus lane would only benefit express routes that do not stop within the segment.

Impacts to Traffic Flow

Traffic volumes were obtained from the Florida Department of Transportation (FDOT) for two locations on Biscayne Boulevard within the study limits: north of NE 19th Street and north of NE 29th Street. The peak hour volumes at these locations are summarized in Table 4.

Table 4: Biscayne Boulevard Peak Hour Traffic Volumes

Location	Direction of Travel	AM Peak Volume (vph)	AM LOS	PM Peak Volume (vph)	PM LOS
North of NE 19th St.	SB	1,790	F	1,090	D
North of NE 19th St.	NB	830	D	1,730	E
North of NE 29th St.	SB	1,790	F	1,100	D
North of NE 29th St.	NB	890	D	2,170	F

Level of service (LOS) was calculated for Biscayne Boulevard based upon the maximum flow rates provided in the generalized service tables in FDOT's *1998 Level of Service Handbook*. Results of the level of service analysis demonstrate that Biscayne Boulevard operates at a poor level of service in the peak direction during the AM and PM peak periods. The level of service analysis demonstrates that peak period congestion exists in the corridor, which is one of the guidelines for establishing a contraflow lane outlined in NCHRP Report 155, *Bus Use of Highways Planning and Design Guidelines*.

The implementation of a reversible bus lane in the center lane of Biscayne Boulevard would require the elimination of left-turns in order to allow buses to use the center lane for through movement. Left-turns would also have to be prohibited during the changeover periods from balanced two-way flow to unbalanced reversible flow for buses. Some level of enforcement would be required to prevent violation of the left-turn restrictions; violators can impede the flow of buses and create safety hazards. The elimination of left-turns would also add travel circuitry for motorists that depart from Biscayne Boulevard at intermediate locations within the reversible flow segment. Until the number of buses utilizing the corridor increases substantially, the benefit in travel time savings and schedule reliability provided by a reversible bus lane is not likely to be significant enough to justify the impacts of eliminating left-turns, which would adversely affect access to adjacent neighborhoods and result in increased east-west cross traffic demands.

Affects on Parking and Curb Use

A reversible flow bus lane in the center of Biscayne Boulevard would not affect parking, loading, or curb access. However, access to adjacent properties would be adversely impacted by the elimination of bus stops and left-turn restrictions during periods of reversible flow.

Required Improvements

The implementation of a reversible flow bus lane in the center of Biscayne Boulevard would require reversible lane control signs, lane-use control signals, and pavement marking modifications.

The *Manual on Uniform Traffic Control Devices* (MUTCT 2000) specifies that a reversible lane control sign should be mounted over the center of the lane that is being reversed. Advance signs are required at boundaries of the reversible lane section, and transitions at the entry to and exit from the reversible lane section need to be signed.

Lane-use control signals are special overhead signals that permit or prohibit the use of specific lanes. These signals are most commonly used for reversible-lane control and are distinguished by placement of special signal faces over the lanes being controlled. Supplementary signs are used to explain the meaning and intent of the lane-use control signals.

The lane line pavement markings on each side of reversible lanes consist of two normal broken yellow lines to delineate the edges of a lane in which the direction of travel is reversed. Signs, lane-use control signals, or both are used to supplement reversible lane pavement markings.

Costs

Traffic signal modifications and lane-use control signals would comprise the largest component of capital costs for implementing reversible flow bus operations on Biscayne Boulevard. The proposed reversible lane segment contains ten signalized intersections. Lane-use control signals would need to be placed at mid-block locations located sufficiently far in advance of or beyond signalized intersections to prevent them from being misconstrued as traffic control signals. An order of magnitude cost estimate for required improvements on Biscayne Boulevard is $150,000.

Recommendation

A reversible flow bus lane on Biscayne Boulevard is not recommended for the following reasons:

- The number of buses and ridership is not significant enough to warrant implementing a reversible bus lane.
- Bus stops would not be possible within the reversible flow segment, because of a lack of refuge for passenger loading.
- Restricting left-turns during reversible flow operations would adversely affect access to adjacent neighborhoods and result in increased east-west cross traffic demands.

Bus priority treatments for mixed traffic flow are more appropriate for the Biscayne Boulevard corridor than an exclusive bus lane at this time. Bus enhancements or amenities that should be considered for the corridor include:

- Bus preemption of traffic signals
- Bus bays and turnouts
- Bus bulbs (sections of the sidewalk at bus stops that extend from the curb of a parking lane to the edge of the through lane)
- Improved bus stops with shelters

These improvements could provide immediate benefits to the large number of bus riders in the corridor and also attract additional riders. Bus preemption of traffic signals could provide both travel time savings and enhanced travel reliability. However, a detailed traffic operations study is needed to determine if the potential travel time savings for buses offset increased delays that may result for the general use traffic. As the number of bus routes and riders increase in the future, the feasibility of a dedicated bus lane should be reexamined.

An enhancement to bus stops such as shelters and benches could improve the transit user's overall experience. A field survey was conducted to assess the conditions of bus stops along the study corridor. The survey identified whether sidewalk connections, benches, and shelters are provided at the stops. Sidewalk connections are provided for all the stops along Biscayne Boulevard and benches and shelters at provided at many of the stops, as illustrated in the adjacent photograph. However, the installation of shelters could provide immediate benefits for bus patrons at several locations in the corridor by providing refuge from both the sun and frequent rain showers that are part of South Florida's climate. Locations presently lacking shelter include the bus stops in the vicinity of the following cross-streets along Biscayne Boulevard:

Bus Stop along Biscayne Boulevard

Southbound Biscayne Boulevard

- NE 35th Street
- NE 26th Street
- NE 22nd Street
- NE 20th Street

Northbound Biscayne Boulevard

- NE 14th Street
- NE 19th Street
- NE 21st Street
- NE 29th Street
- NE 35th Street

Shelters could be incorporated at these bus stops as part of a corridor enhancement project.

Assessment of Contraflow Bus Operations on NW/NE 167th/163rd Street

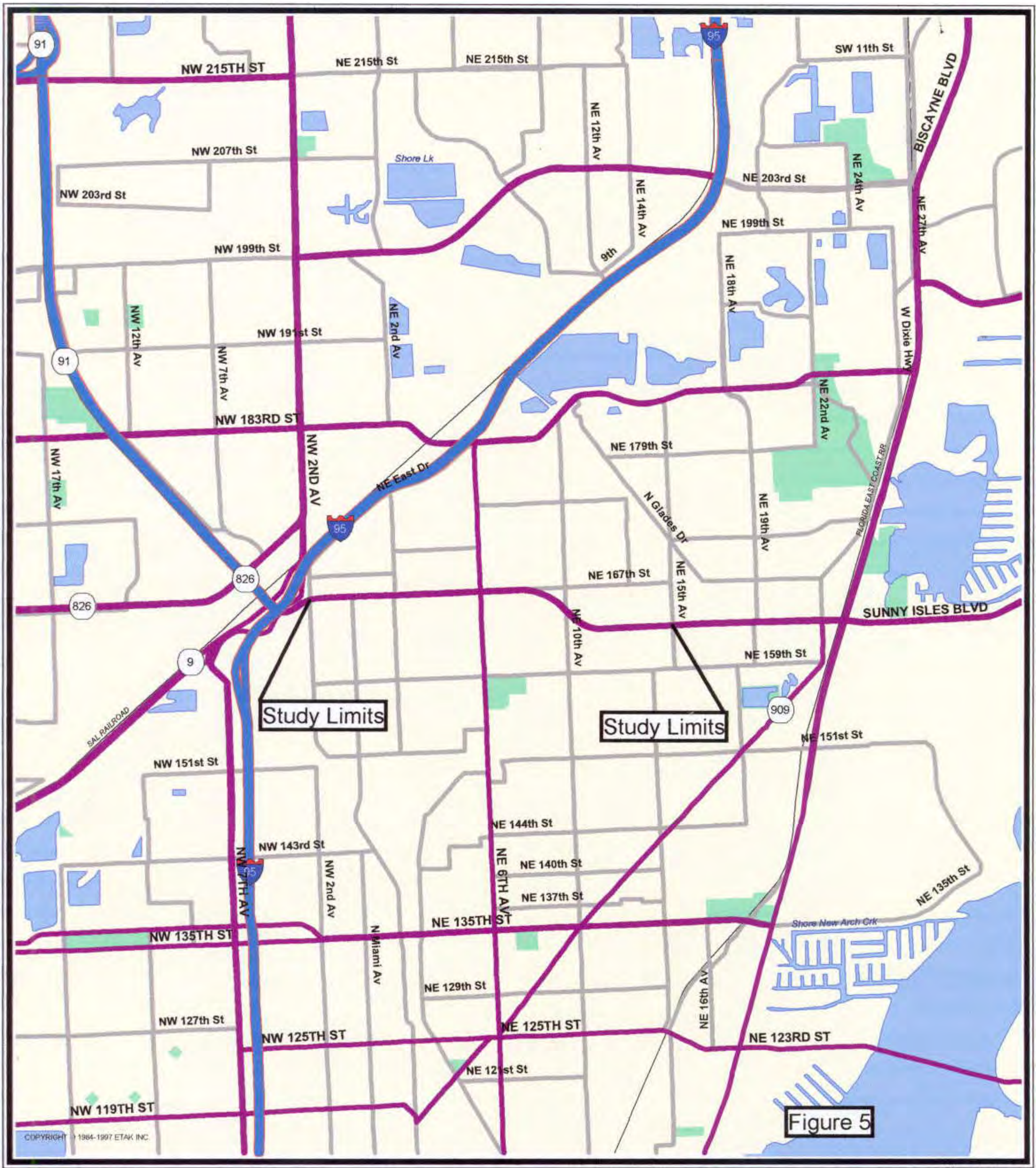
Figure 5 shows the general location of the segment of NW/NE 167th/163rd Street that was assessed for contraflow bus operations. For the entire length (approximately 2.1 miles) between NW 2nd Avenue and NE 15th Avenue, Biscayne Boulevard is a six-lane divided section. Figure 6 presents an aerial view of the corridor. This section of NW/NE 167th/163rd Street approaches the Golden Glades Park-and-Ride Lot and provides a connection to the 163rd Street Mall Bus Terminal. An intermodal center is planned to be integrated with the existing park-and-ride facilities at the Golden Glades. The Golden Glades Intermodal Terminal will serve the Tri-Rail station, Metrobus routes, Broward County Transit routes, taxis, and inter-city buses, and function as the North Miami-Dade transit hub.

The geometry of the NW/NE 167th/163rd Street corridor could be conducive to contraflow operations. Although contraflow bus lanes are generally found on one-way streets, contraflow bus lanes may be implemented along two-way streets with a raised median, such as along Pie IX Boulevard in Montreal or as along U.S. 1 in Miami-Dade County during the 1970s. To minimize potential conflicts left-turn restrictions would be required to prohibit vehicles from crossing the contraflow lane.

Because successful application of contraflow bus lanes is contingent on a high directional imbalance in traffic volumes, NW/NE 167th/163rd Street is not a viable corridor for contraflow operations. The directional distribution of traffic on NW/NE 167th/163rd Street is approximately 54%/46% during the peak periods. With the exception of the NE 163rd Street segment immediately adjacent to the 163rd Street Mall, less than 20 buses per hour travel in the corridor. Therefore, an exclusive bus lane is not warranted. However, bus priority treatments for mixed traffic flow may be appropriate for the NW/NE 167th/163rd Street Corridor. According to NCHRP Report 155, *Bus Use of Highways Planning and Design Guidelines*, mixed traffic bus priority treatments may be desirable where one or more of the following conditions apply:

1. There are less than 20 buses in the peak direction in the peak hour.
2. Allocating an exclusive lane for bus use would unduly reduce total corridor capacity.
3. Roadway widening is not feasible.

NW/NE 167th Street / NE 163rd Street Study Corridor Location Map



NE 167th / NE 163rd ST. - WESTERN SECTION

NE 167th / NE 163rd ST. - EASTERN SECTION

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STUDY

Aerial View of NW/NE 167th Street /
NE 163rd Street Corridor

NORTH

Figure 6

Because traffic signals represent a major source of delay for buses on arterial streets, significant time savings can be achieved by providing priority treatments for buses at signalized intersections. Bus priority treatments that may be considered for the NW/NE 167th/163rd Street corridor include signal queue jumps or bus preemption of traffic signals.

Signal queue jump lanes allow buses to move around the line of general traffic at a signal and travel through the intersection. One technique is to provide a separate signal head for the queue jump lane, which could be a left-turn lane. An advance green light is provided for the queue jump lane, while the opposing left-turn lane is held on red. This approach allows buses to move through the intersection and reenter the general traffic lanes in advance of other traffic. Figure 7 illustrates this concept.

Benefits to Transit Service

The existing bus routes in the vicinity of the Biscayne Boulevard corridor are shown in Figure 8. Seven Metrobus routes travel on NW/NE 167th/163rd Street for a significant distance within the study limits: Routes 2, 9, 22, 83, 95X, E, and V. Several additional Metrobus routes utilize NE 163rd Street to loop around the 163rd Street Mall Bus Terminal, but these routes travel within the corridor for only a few blocks.

The number of peak hour, peak direction buses traveling in the NW/NE 167th/163rd Street study corridor was calculated for comparison to the guidelines outlined in NCHRP Report 155, *Bus Use of Highways Planning and Design Guidelines*. Table 5 summarizes the peak hour bus service and ridership for routes that operate along a significant portion of the NW/NE 167th/163rd Street study corridor. The peak hour ridership was estimated by multiplying the number of buses per route by the average passengers per revenue hour for the route, based on information obtained from MDT *Ridership Technical Reports*.

Transit ridership accounts for a significant amount of the total person throughput in the corridor. The 13 buses operating in the peak traffic direction carry approximately 480 passengers during the AM and PM peak hours. Although the number of buses and ridership is not high enough to warrant an exclusive bus lane, enough buses and ridership exist to consider mixed traffic bus priority treatments.

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Bus Signal Queue Jump Concept

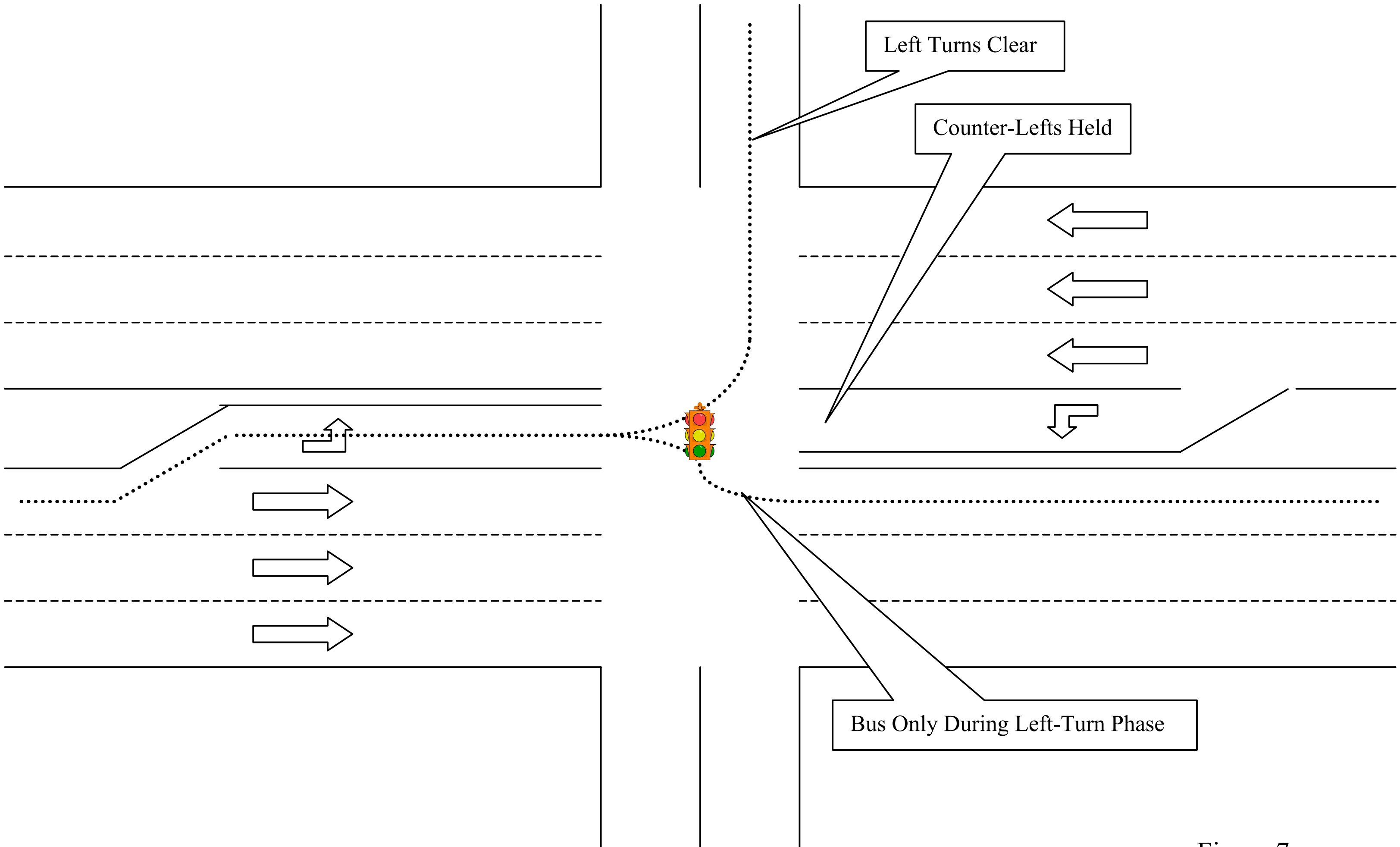
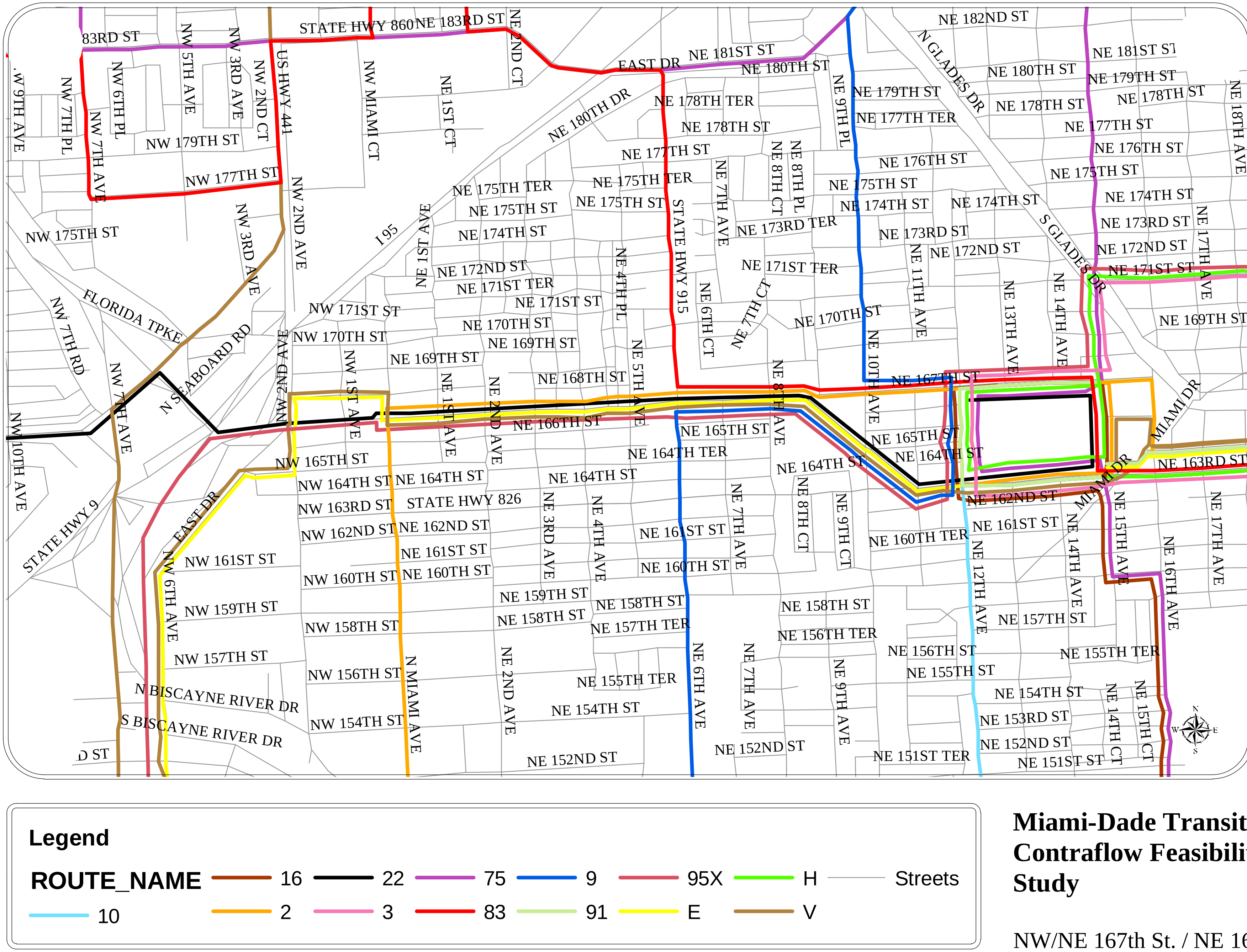


Figure 7



Miami-Dade Transit Contraflow Feasibility Study

NW/NE 167th St. / NE 163rd St. Corridor Metrobus Routes

Figure 8

Kimley-Horn and Associates, Inc.

Table 5: Biscayne Boulevard Peak Hour Bus Service and Ridership

Metrobus Route	Peak-Hour, Peak Direction Buses	Peak-Hour, Peak Direction Passengers
2	1	40
9	4	180
22	3	100
83	3	130
E	1	20
V	1	10
95X	0	0
Total	**13**	**480**

Sources: Miami-Dade Transit 2001 Transit Development Program
Miami-Dade Transit Ridership Technical Report – February 2001

Impacts to Traffic Flow

Traffic volumes were obtained from the *State Road 826 Corridor Study* for four locations on NW/NE 167th/163rd Street within the study limits: east of NW 2nd Avenue, east of NE 2nd Avenue, east of NE 6th Avenue, and east of NE 12th Avenue. The peak hour volumes at these locations are summarized in Table 6.

Table 6: NW/NE 167th/163rd Street Peak Hour Traffic Volumes

Location	Direction of Travel	AM Peak Volume (vph)	AM LOS	PM Peak Volume (vph)	PM LOS
East of NW 2nd Ave.	WB	2,490	E	3,500	F
East of NW 2nd Ave.	EB	2,950	F	2,780	F
East of NE 2nd Ave.	WB	2,000	D	2,760	F
East of NE 2nd Ave.	EB	2,320	E	2,480	E
East of NE 6th Ave.	WB	1,850	D	2,350	E
East of NE 6th Ave.	EB	2,250	D	2,215	D
East of NE 12th Ave.	WB	1,590	D	2,390	E
East of NE 12th Ave.	EB	1,970	D	1,960	D

The volumes presented in Table 6 demonstrate that volumes build toward the west end of the study corridor and there is not a heavy directional imbalance during the peak hours. Level of service (LOS) was calculated for NW/NE 167th/163rd Street based upon the maximum flow rates provided in the generalized service tables in FDOT's *1998 Level of Service Handbook*. Results of the level of service analysis demonstrate considerable congestion, especially toward the west end of the study corridor.

The implementation of signal queue jumps on NW/NE 167th/163rd Street would require modifying the signal timing at intersections where this concept is implemented. In particular, the left-turn lane for the off-peak direction would be held on red, while buses traveling in the peak direction moved through the intersection in advance of other traffic. A detailed operational study would be required to determine if the travel time savings provided to buses by these operations would be substantial enough to offset the increased delay that would be experienced by other movements at the intersection.

Affects on Curb Access

The implementation of signal queue jumps on NW/NE 167th/163rd Street would not affect curb access and there is no on-street parking or loading within the corridor. Access to adjacent properties within the corridor could be adversely impacted by signal timing modifications that reduce the amount of green time for cross street traffic and left-turns in the off-peak direction.

Required Improvements

The implementation of signal queue jumps on NW/NE 167th/163rd Street would require establishing signal preemption systems. The traffic signal preemption system would involve installing transmitters on the buses, receivers at the intersections under traffic signal control, and phase selector units in the controller cabinets.

Left-turn lanes would need to be extended to provide adequate storage to properly function as the queue jump lanes. Buses need to bypass the queue in the through lanes to access the queue jump. The extension of left-turn lanes to function as queue jump lanes could also necessitate closing median openings.

Costs

The capital costs for the signal queue jumps on NW/NE 167th/163rd Street would depend on (1) the number of intersections where the queue jumps are implemented and (2) the extent of median construction associated with extending left-turn lanes to function as the queue jump lanes. An order of magnitude cost estimate for the required improvements is approximately $25,000 per intersection or $125,000 for the corridor.

Recommendation

Bus priority treatments for mixed traffic flow such as signal queue jumps or bus preemption of traffic signals should be considered for the NW/NE 167th/163rd Street corridor. A significant amount of bus ridership already exists in the corridor. The number of bus routes operating along the corridor and bus ridership are likely to increase in the future with the redevelopment of the 163rd Street Mall, the development of the Golden Glades Intermodal Terminal, and the possible development of an intermodal center in the vicinity of NE 163rd Street and U.S. 1.

Because NW/NE 167th/163rd Street is heavily congested, the benefits provided by bus priority treatments need to be assessed against the impacts to general traffic. A detailed traffic operations study is needed to determine if the potential travel time savings for buses offset increased delays that may result for the general use traffic.

Summary of Feasibility of Implementing Transit Contraflow

Two corridors were examined in detail to determine the feasibility of implementing contraflow operations: Biscayne Boulevard from NE 14th Street to NE 36th Street and NW/NE 167th/163rd Street from NW 2nd Avenue to NE 15th Avenue. The feasibility assessment considered benefits to transit service, impacts to traffic flow, affects on parking and curb use, required improvements, and costs.

The geometry of Biscayne Boulevard is not conducive to contraflow operations. The outside curb lane in the opposite direction of travel would have to be designated as the contraflow lane in order to provide stops and a customized bus would be needed that permitted passenger boardings and alightings on either side of the vehicle.

A reversible bus lane could be implemented on Biscayne Boulevard. However, a reversible flow bus lane is not recommended because (1) the number of buses and ridership is not significant enough, (2) bus stops would not be possible within the reversible flow segment, and (3) restricting left-turns during reversible flow operations would adversely affect access to adjacent neighborhoods and result in increased east-west cross traffic demands. Therefore, bus priority treatments for mixed traffic flow, such as bus preemption of traffic signals, are more appropriate for the Biscayne Boulevard corridor at this time.

The geometry of NW/NE 167th/163rd Street corridor could be conducive to contraflow operations.

However, NW/NE 167th/163rd Street is not a viable corridor for contraflow operations because there is not a significant directional imbalance in traffic during the peak hours. Additionally, not enough buses utilize the corridor to warrant an exclusive bus lane. Bus priority treatments that may be considered for the NW/NE 167th/163rd Street corridor include signal queue jumps or bus preemption of traffic signals. A detailed traffic operations study is needed to determine if the potential travel time savings for buses provided by signal queue jumps offset increased delays that may result for the general use traffic.

Public Involvement/Corridor Outreach Effort

The public involvement/corridor outreach effort associated with establishing a contraflow bus lane should (1) provide information to make sure the public understands the purpose of the project and (2) be sensitive and responsive to the concerns of the community. The participation of neighborhood groups and businesses can help ensure that all potential issues are identified. Involving the community early in the planning process provides a sense of ownership in the project and ultimately leads to greater support for the project.

Early in the public involvement process information should be gathered on the opinions and attitudes of individuals and groups in the corridor where the contraflow lane will be established. Focus groups may be conducted with commuters, area residents, and the business community to obtain feedback on traffic congestion, access, transit improvements, and other issues. Surveys may also be used to identify community concerns. Key stakeholders, such as businesses along the corridor, should be interviewed to obtain their thoughts and concerns. The information acquired during this phase of public involvement should become an important component of the planning process and influence the choice and design of the facility.

Public meetings are the traditional mechanism for securing public input on transportation projects. Project staff formally present the issues, possible alternatives, the evaluation process, and eventually the recommended alternative. Brainstorming is one technique that permits the participants at a public meeting to voice their opinions on the advantages and disadvantages of proposed alternatives. Limitations of public meetings include (1) sparse attendance due to a lack of interest or the perception that public participation does not matter or (2) the project may be so controversial that the meeting disintegrates into a heated, unprofitable debate.

Various groups and stakeholders will be affected differently by the establishment of contraflow bus lanes. Commuters and users of public transit benefit from increased corridor throughput and improved travel time and schedule reliability for buses. However, other groups will be adversely impacted. For example, in Los Angeles there is a high rate of pedestrian accidents and businesses have closed and redevelopment has lagged along the Spring Street contraflow corridor, because the contraflow operations prevent on-street parking and loading activity along the curb. A challenge for the public involvement/corridor outreach program is to maximize involvement, participation, and input from each group and to identify the needs of each group.

A key to successfully establishing a contraflow bus lane is to emphasize the benefits to public transit, which most agree is a worthwhile goal, while remaining sensitive to the needs and concerns of residents and businesses along the corridor by obtaining their input during the development of the facility. In San Francisco, the City delivered a project memo/fact sheet to every business and building manager or owner along Sansome Street with a brief project description to make sure the scope and impacts of the Sansome Street contraflow project were well understood. Follow-up presentations were scheduled with downtown merchant associations to address their concerns and get their support, and the merchant associations agreed to inform their members of the project in their newsletters. Additional follow-up meetings were held to discuss specific concerns, such as parking loss or bus stop relocations in front of specific businesses. By the time of the project's public hearing, there was no major opposition to the project and the major merchant associations and businesses were in favor of the project.

Sansome Street Contraflow Lane –San Francisco

Providing information to motorists on new restrictions and encouraging commuters to take the bus are critical components of the implementing contraflow bus lanes. Activities that may form part of this effort include community outreach programs, newsletters, media advertisements, and ribbon cutting or opening ceremonies. The advertising and marketing program for introducing a contraflow bus lane should be initiated prior to the actual opening of the contraflow lane. A public information campaign was initiated one month before the opening of the Sansome Street contraflow transit lane in San Francisco. Warning signs were installed to inform motorists about the new contraflow lane and the opening date of the project was posted. Small cardboard signs were also installed on parking meters posts that provided (1) a brief description of the project, (2) the opening date, and (3) a contact name and telephone number. A week before the opening, a joint press release with a map of the area was issued to inform the public of the opening date and the local newspaper, the *San Francisco Chronicle*, wrote an article about the change.

Advertising and promotional activities should also be continued through the first months of a contraflow bus lane's operation. These programs can enhance the understanding of the project by the public and policy-makers and help ensure that commuters use the facility. Marketing efforts should also focus on the bus routes that the contraflow bus lane supports. Public involvement and marketing efforts may provide benefits in developing support not only for the current project, but also for future contraflow bus lane initiatives.

CONCLUSIONS

The objectives of this study were to evaluate the feasibility of establishing contraflow bus operations in Miami-Dade County and to select specific corridors for implementation. Contraflow bus lanes allow buses to operate opposite to the normal flow of traffic and are designed to take advantage of underutilized roadway capacity in the travel direction opposed to the peak period flow. Because contraflow bus lanes can provide significant increases in person capacity at substantially lower costs than roadway widening, congested corridors in Miami-Dade County were evaluated to determine if contraflow bus lanes are viable.

Pie IX Boulevard Contraflow Bus Lane - Montreal

Bus and high occupancy vehicle (HOV) contraflow operations in North America were examined to identify advantages and disadvantages associated with their application. A set of minimum standards for establishing contraflow bus operations in Miami-Dade County was developed based on information obtained in this literature research. According to the findings, few transportation corridors in Miami-Dade County have a high enough level of bus service to warrant implementing an exclusive bus lane, and the corridors which do have a high enough level of bus service are limited by other physical constraints that preclude the development of contraflow operations. Despite these shortcomings, two corridors were selected as the most viable candidates for contraflow or other bus priority treatments at this time:

- Biscayne Boulevard from NE 14th Street to NE 36th Street
- NW/NE 167th/163rd Street from NW 2nd Avenue to NE 15th Avenue

These two corridors were examined in detail to determine the feasibility of establishing contraflow operations. The feasibility assessment considered benefits to transit service, impacts to traffic flow, affects on parking and curb use, required improvements, and costs.

The geometry of Biscayne Boulevard is not conducive to contraflow operations, but the geometry of Biscayne Boulevard is favorable to a reversible bus lane similar to the operations along NW 7th Avenue during the 1970s. However, a reversible flow bus lane on Biscayne Boulevard is not recommended because (1) the number of buses and ridership is not significant enough to warrant an exclusive bus lane, (2) bus stops would not be possible within the reversible flow segment, and (3) turn restrictions during the reversible flow operations would adversely affect access to adjacent neighborhoods and businesses.

Existing Bus Stop with Amenities on Biscayne Boulevard

Bus enhancements or amenities that could be considered for the corridor include bus preemption of traffic signals, bus bays and turnouts, bus bulbs (sections of the sidewalk at bus stops that extend from the curb of a parking lane to the edge of the through lane), and improved bus stops with shelters and benches. A field review identified that sidewalk connections are provided for all the stops along Biscayne Boulevard and benches and shelters at provided at many of the stops. In particular, the installation of shelters at stops where they presently are not provided could supply immediate benefits to bus patrons at several locations in the corridor, by providing refuge from both the sun and the frequent rain showers that are part of the South Florida's climate.

The geometry of the NW/NE 167th/163rd Street corridor could be conducive to contraflow operations, but this corridor is not a viable corridor for contraflow operations because the directional imbalance in traffic volumes is not substantial during the peak periods. Additionally, there are not enough buses in the corridor to justify an exclusive bus lane. Because this corridor is heavily congested and traffic signals represent a major source of delay, bus priority treatments that may be considered include signal queue jumps or bus preemption of traffic signals. A detailed operations study is required to determine if the potential travel time savings for buses provided by signal queue jumps offsets increased delays that may result for general traffic.

In summary, the major thoroughfares and corridors in Miami-Dade County do not have a high enough level of bus service at this time to justify removing a travel lane from general traffic for the exclusive use of buses. Although bus routes could potentially be relocated to parallel corridors to achieve the required level of transit service, Miami-Dade Transit (MDT) staff has indicated that removing bus routes from any corridors in not practical because of inconvenience to riders that depend on the service. Until bus service in congested corridors in Miami-Dade County increases to a high enough level to warrant exclusive bus lanes, bus priority treatments for mixed flow traffic should be considered. Mixed traffic priority treatments are applicable for corridors where the following conditions apply:

- There are less than 20 buses in the peak direction in the peak hour.
- Allocating an exclusive lane for bus use would excessively reduce total corridor capacity for auto travel.
- Roadway widening is not feasible.

Examples of mixed traffic flow bus priority treatments that may be implemented in corridors such as Biscayne Boulevard and NW/NE 167th/163rd Street include traffic signal priorities (bus preemption, bus signal queue jumps), improved bus bays and turnouts, bus bulbs, and improved bus stops with shelters, benches, and other amenities. In the future, as the number of bus routes and ridership increases in specific corridors in Miami-Dade County, the feasibility of dedicated bus lanes could be reexamined.

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