CENTRAL BROWARD EAST-WEST TRANSIT STUDY

Microsimulation Alternatives Analysis Technical Memorandum

February 2013

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1.0 Introduction

Jacobs was retained by Florida's Department of Transportation, District Four, to perform an operational assessment of alternatives under consideration in the Central Broward East-West Transit (CBT) corridor.

This technical memorandum describes the approach, source data, assumptions, methodology, and results for a microsimulation analysis to assess the operational impacts and benefits of four pre-selected alternatives.

Each alternative considers different routes and transit technologies. Of the alternatives currently under consideration, the following four were selected for further evaluation:

- Alternative 1.1 – SR 7/Broward Boulevard
- Alternative 2.3 – Griffin Road with the One-way Loop
- Alternative 2.4 – Griffin Road using Nova Drive/Davie Road/Perimeter Road/4th Avenue
- Alternative 2.6 - Griffin Road using University Drive/Griffin Road to 17th Street

The pre-selected alternatives were chosen to provide the broadest level of evaluation among competing routes and transit technologies.

The operational analysis was performed using VISSIM 5.3 microsimulation software. AM and PM peak period base models were developed and calibrated to ensure the models reasonably reflect existing conditions and traffic behavior along the study corridors. A series of Build Alternative models were then created utilizing the calibrated peak period models as the baseline.

The following measures of effectiveness (MOEs) were computed from the model output to assess the impacts and benefits provided by each of the study alternatives:

- Percent difference of auto travel time, with and without premium transit service in place
- Percent difference between transit and auto travel times
- Total transit travel time between route termini
- Change in total intersection delay, with and without premium transit service in place

6.0 Conclusions

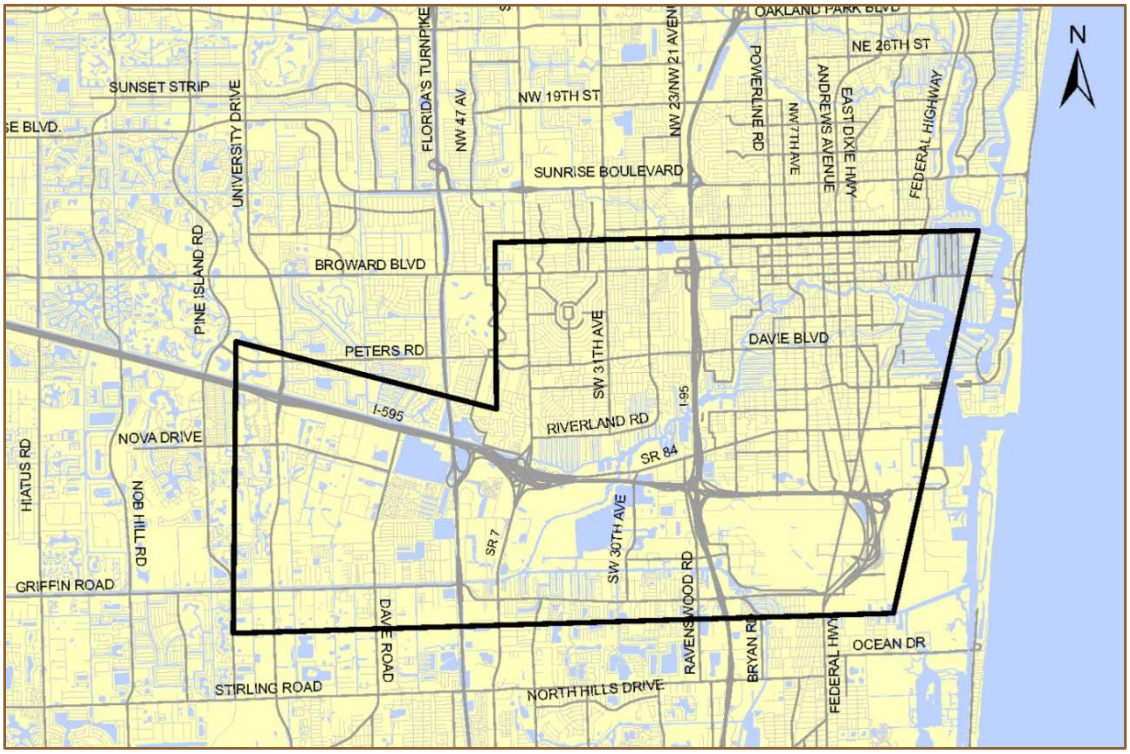
As previously mentioned, the Central Broward East-West corridor presents several challenges to microscopic simulation. Among others, it is heavily used for commute traffic, involves alternative transit options, and the immense scale of the network created unique difficulties. During the development of the Existing (Base) Model, the following challenges were encountered:

- The extent of the model itself (in size of the network and length of the simulation) required extensive running time, which slowed progress.
- I-595 was under construction at the time of model development; therefore reliable data could not be collected for use in the model calibration. Moreover, the changes being implemented on the I-595 mainline as part of the I-595 Express Design, Build, Finance, Operate and Maintain (D/B/F/O/M) project are expected to improve traffic conditions along I-595 with the implementation of reversible express toll lanes and other ramp, mainline and frontage road improvements. Consequently, it was decided not to model I-595. Moreover, since there are no transit stops along I-595; the impact to traffic operations on I-595 as a result of the proposed transit service will be negligible.
- Turning moving counts were not collected for the intersections of 2nd Street, Las Olas Boulevard, 6th Street, and 7th Street along Andrews Avenue. Therefore assumptions were made in order to balance volumes in this area.
- The short distance between several intersections within the model did not allow adequate time for drivers to follow routing decisions, causing unrealistic congestion as they attempted to change lanes. For these situations, routings had to be placed further downstream than the adjacent intersection.
- Turning movement counts at the I-95 ramps on Broward Boulevard were taken on the same day as the 2011 Mercedes-Benz Corporate Run. This created PM traffic volumes for the eastbound direction that were unusually high. To prevent excessive congestion the volumes were scaled down to match those taken previously at the intersection of Broward Boulevard and 24th Avenue.
- After the model had been created and calibrated using NEMA Standard Signal Control (SC) Emulator, it was requested to convert to all signal controllers to RBC standards. The conversion and recalibration of the model required an extensive amount of time.
- A FEC rail line crosses Broward Boulevard between NW 1st Avenue and NW 5th Avenue and Griffin Road west of US 1. Delay for the train crossing had to be simulated using a fixed time signal controller on a 20 minute (1,200 second) cycle length as this was the maximum allowed in VISSIM. To simulate the train crossing according to the FEC train schedule there should be approximately a 25 minute gap between trains in the AM and a 40 minute gap in the PM. These were reproduced accordingly in the simulation.
- A CSX/Tri-Rail line crosses Griffin Road just west of I-95. According to the CSX train schedule, there are no CSX trains traversing the study area during the AM and PM peak periods. However, Tri-Rail commuter train does provide service to the Fort Lauderdale Airport station located in the southwest quadrant of the Griffin Road/I-95 interchange during the peak periods. The northbound and southbound Tri-Rail train headways and departure times were coded in the model according to the South Florida Regional Transportation Authority (SFRTA) Tri-Rail schedule.

3.0 Base Model Development

As shown in Exhibit 1, the extent of the model study area includes approximately 27 miles of roadway from the west at University Drive to the east at the Fort Lauderdale-Hollywood International Airport and into downtown Fort Lauderdale.

Exhibit 1: Central Broward VISSIM Study Area

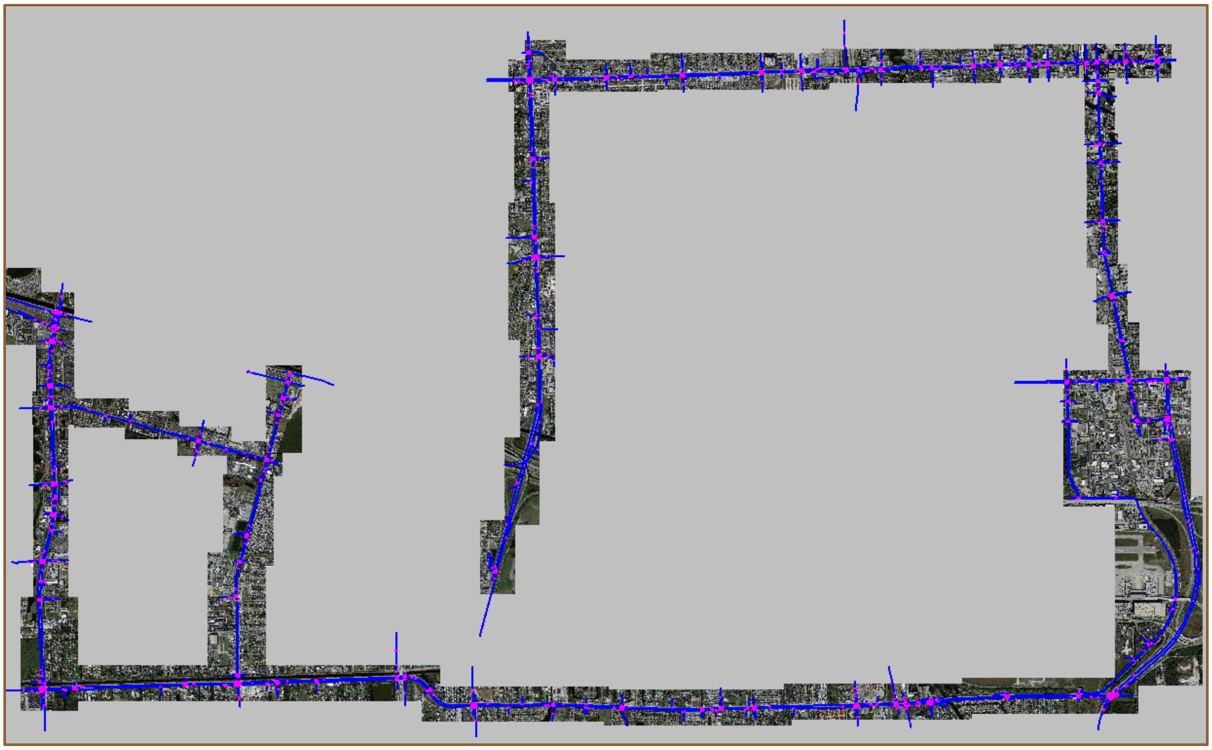


Since the purpose of this evaluation is to determine operational differences between the transit alternatives, the base model network only contains roadways east of the I-595/University Drive interchange where the routes and transit technologies differ. The transit route and station locations west of the I-595/University Drive interchange are similar among all four pre-selected alternatives, and this portion of the route will be served by premium bus for all alternatives.

Furthermore, since I-595 was under construction at the time of this modeling exercise, reliable data (i.e. traffic counts, travel time surveys, etc.) representative of typical traffic conditions could not be collected. The typical section of I-595 within the study limits is being significantly modified as part of the I-595 Express Design, Build, Finance, Operate, and Maintain (D/B/F/O/M) project to vastly improve traffic conditions along the I-595 corridor. The I-595 mainline improvements include the implementation of reversible toll lanes. Consequently, I-595 was not modeled since there are no transit stations along this freeway and the impact of the proposed transit service on traffic operations along I-595 is expected to be negligible.

The arterials and local roadways within the base model were coded using aerial photographs and topological information collected during field reviews (including but not limited to the number of lanes, length of turn bays, position of traffic signals, and posted speed limits). The model consists of 74 intersections, of which 69 are signalized. The limits of the VISSIM network are illustrated in Exhibit 2.

Exhibit 2: Central Broward VISSIM Network



For the demand side of the system, the vehicle inputs (traffic volumes) coded in the model were determined using balanced traffic count data. Micro-simulation models require a mathematically consistent volume set. As such, the turning movement counts collected in the field during the AM and PM peak periods between 2010 and 2012 were balanced along each corridor. Sink/source links were coded in the model to account for traffic generated on minor side streets and driveways.   Given the length of the transit route, an extended peak period was necessary to capture the transit service from the initial boarding station to the final alighting station. Therefore, two two-hour periods were analyzed; namely, from 7:00 AM to 9:00 AM during the morning peak and from 4:30 PM to 6:30 PM during the afternoon peak.

To start gathering information, the network should be filled with vehicles to avoid biasing the results; therefore, an additional period was included to account for the initial half hour prior to the actual simulation period (from 6:30 a.m. to 7:00 a.m.). In the same way, for the afternoon peak (4:30 p.m. to 6:30 p.m.), an additional half-hour period was included (from 4:00 p.m. to 4:30 p.m.).

VISSIM supports two different forms of input for the traffic demands: static (in which fixed vehicle inputs are assigned to entry links and routed throughout the network by means of static routing) and dynamic (in which the driver-vehicle unit must choose a route at the start of the trip at the origin parking lot). This model uses static assignment, which is useful when turning volumes are known and the model seeks to replicate existing conditions.

Specific details regarding the development of the base model can be found within the *Central Broward Transit - VISSIM Microsimulation Calibration Report* included in Appendix A.

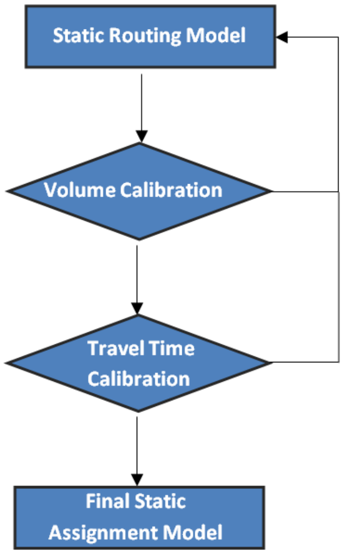
4.0 Base Model Calibration

This section provides a summary of the main elements and results of the calibration. Details pertaining to the calibration process, thresholds and results are thoroughly documented in **Appendix A** for further reference.

4.1 Calibration Process

Model calibration is the process undertaken to ensure that the model reasonably reproduces real-world traffic conditions. During the calibration process, model parameters affecting driving behavior such as car following, lane changing, headway, and driver distraction are tuned in order to replicate the values of both traffic volumes and travel times measured in the field. The base model was calibrated for both capacity and driver performance following the steps shown in Exhibit 3.

Exhibit 3: Calibration Process Flowchart



VISSIM provides a large number of output options, all of which can be tailored to the needs of the user[1]. For the purpose of this Study, the node evaluation and travel time output files were generated to calibrate the model. Data was collected every hour (3,600 seconds). In order to avoid biasing the results due to an initially empty network data collection started at 30 minutes (1,800 seconds) after the initiation of the simulation (seeding period) in both periods (AM and PM).

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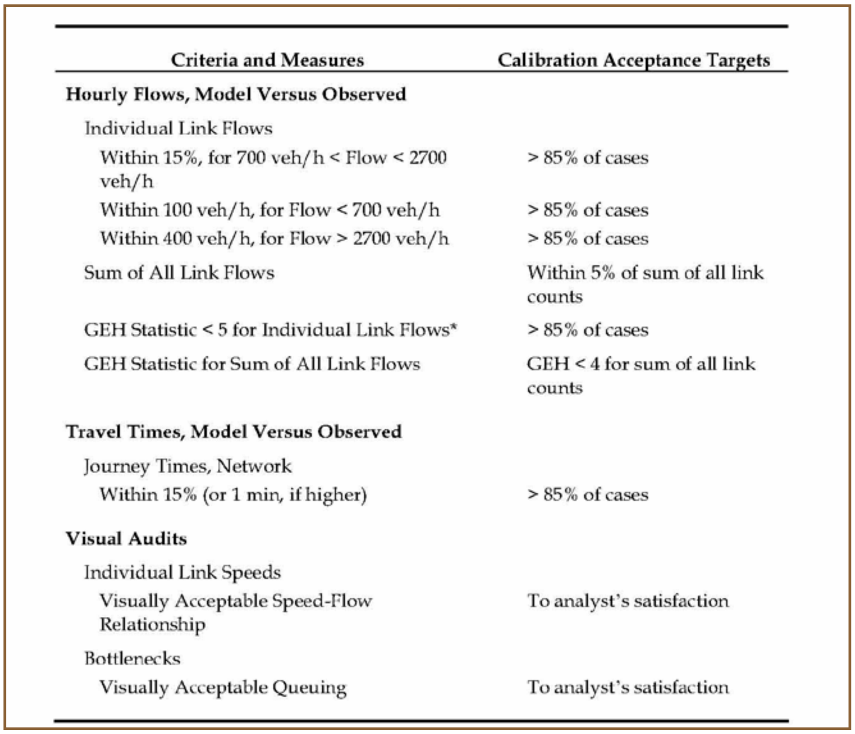
[1] VISSIM 5.10 User Manual © Planung Transport Verkehr (PTV) AG 2008.

Microsimulation models rely on random numbers to generate vehicles, select their destination and route, and determine their behavior as they move through the network. The results from individual runs can vary by 25 percent, and higher standard deviations may be expected for facilities operating at or near capacity[2]. In an effort to minimize the randomness inherent in stochastic models, the microsimulation models were run ten (10) times with different seeding values, and the results of each independent run were averaged to represent average predicted performance results. The average results were then compared to the respective field data in order to assure the proper calibration of the model.

4.2 Calibration Thresholds

The calibration targets utilized in the calibration effort were obtained from Traffic Analysis Toolbox Volume III –Guidelines for Applying Traffic Microsimulation Modeling Software; FHWA; Publication No. FHWA-HRT-04-040, 2003 and are summarized in Exhibit 4.

Exhibit 4: Calibration Targets



Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Within 400 veh/h, for Flow > 2700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	> 85% of cases
GEH Statistic for Sum of All Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey Times, Network	
Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Individual Link Speeds	
Visually Acceptable Speed-Flow Relationship	To analyst's satisfaction
Bottlenecks	
Visually Acceptable Queuing	To analyst's satisfaction

Most of the criteria included in Exhibit 4 are self explanatory, with the possible exception of the GEH Statistic. This measure is used in traffic modeling to compare two sets of traffic volumes (Observed and Modeled). This statistic is typically used to offset the discrepancies that occur when using only simple percentages, as traffic volumes vary over a wide range.

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[2] Traffic Analysis Toolbox Volume III –Guidelines for Applying Traffic Microsimulation Modeling Software; FHWA; Publication No. FHWA-HRT-04-040, 2003.

4.3 Calibration Results

The AM and PM peak periods presented different characteristics in directionality; therefore, they were calibrated separately. The results included in Appendix A correspond to ten (10) runs with different random seeds, which have been averaged.

As shown in Exhibits 5 and 6 for AM and PM peak periods, respectively, the volumes processed by the model were found to be well within the reasonable tolerance of the observed traffic volumes. Consistent with the calibration thresholds shown in Exhibit 4, more than 85% of the network links' flows have a GEH less than or equal to five (5); the sum of all link flows is within 5% of the sum of all link counts; and the link flows satisfied the modeled versus observed flow thresholds for more than 85% of the individual links.

Exhibit 5: AM Peak Period Volume Calibration Results

Percentage of Links by GEH (Criteria GEH ≤ 5)	
7:00-8:00	100%
8:00-9:00	100%

Sum Link Flows ±5%	
7:00-8:00	-1%
8:00-9:00	0%

Individual Link Flows			
Time	Flow<700 vph (± 100)	700<Flow<2700 vph (± 15%)	Flow<2700 vph (±400)
7:00-8:00	100%	100%	100%
8:00-9:00	100%	100%	100%

Exhibit 6: PM Peak Period Volume Calibration Results

Percentage of Links by GEH (Criteria GEH ≤ 5)	
4:30-5:30	100%
5:30-6:30	100%

Sum Link Flows ±5%	
4:30-5:30	1%
5:30-6:30	1%

Percentage of Individual Links Meeting Flow Thresholds			
Time	Flow<700 vph (± 100)	700<Flow<2700 vph (± 15%)	Flow<2700 vph (±400)
4:30-5:30	100%	100%	100%
5:30-6:30	100%	100%	100%

Furthermore, a model is reasonably calibrated when the modeled travel times are within 15% (or one minute if higher) of the average field collected travel time for 85% of the cases. The travel time results shown in Exhibit 7 indicate that both Existing AM and Existing PM model-generated travel times meet the calibration criteria for 100% of the cases.

Exhibit 7: AM and PM Peak Period Travel Times Calibration Results

Percentage of Travel Times within 15% (or one minute)	
7:00-9:00 a.m.	100%
4:30-6:30 p.m.	100%

Given the results presented above, the model is considered reasonably calibrated from a volume and travel time standpoint. The detailed travel time and volume calibration spreadsheets for the AM and PM peak periods are included in the *Central Broward Transit - VISSIM Microsimulation Calibration Report,* found in Appendix A. Visual observations of the model were also performed to ensure that it is reasonably replicating queues and speed-flow relationships within the network.

5.0 Transit Alternative Models

5.1 Alternatives

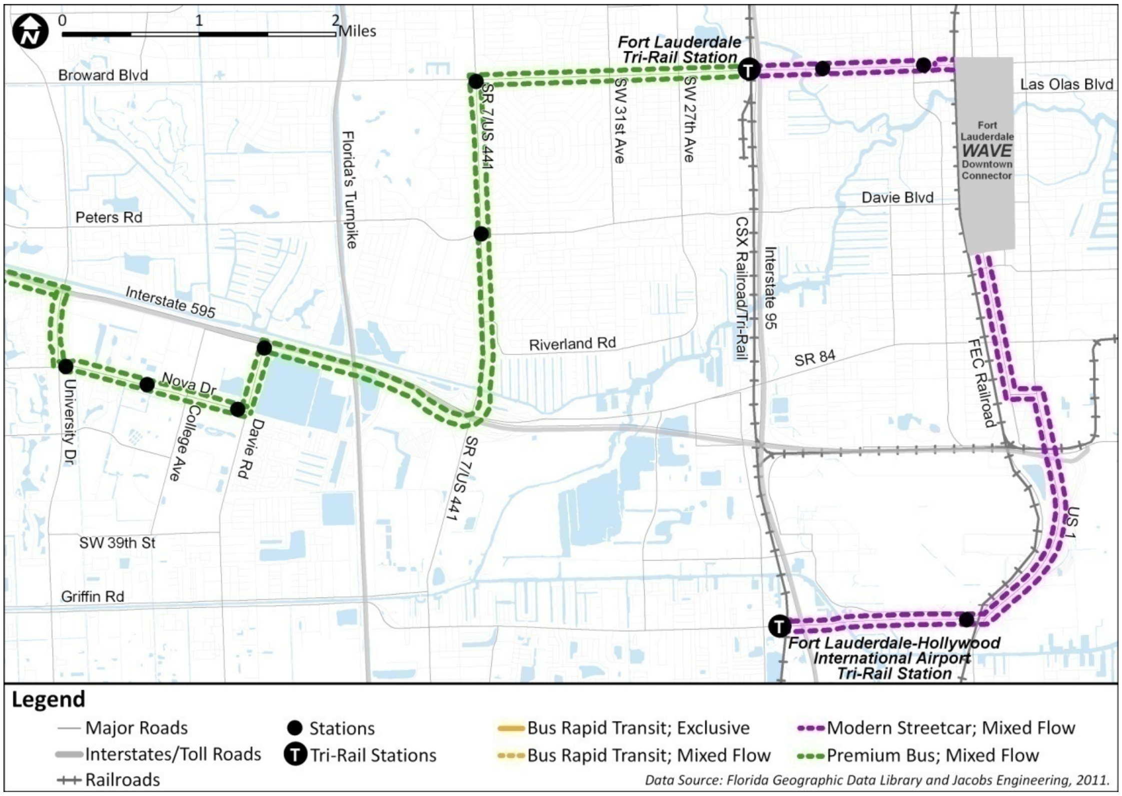
After an initial screening, the following four alternatives were selected as the Build Alternatives for the microsimulation operational analysis:

- Alternative 1.1 – SR 7/Broward Boulevard
- Alternative 2.3 – Griffin Road with the One-way Loop
- Alternative 2.4 – Griffin Road using Nova Drive/Davie Road/Perimeter Road/4th Avenue
- Alternative 2.6 – Griffin Road using University Drive/Griffin Road to 17th Street

Among others, the selection process considered the following aspects: service routes, transit technologies, operating conditions (i.e. exclusive lane or mixed flow traffic), recent input from local agencies, and potential impact to traffic operations.

The service routes, station locations, transit technologies, and operating conditions for each of the alternatives listed above are illustrated in Exhibits 8 through 11[3].

Exhibit 8: Alternative 1.1 - SR 7/Broward Boulevard



Data Source: Florida Geographic Data Library and Jacobs Engineering, 2011.

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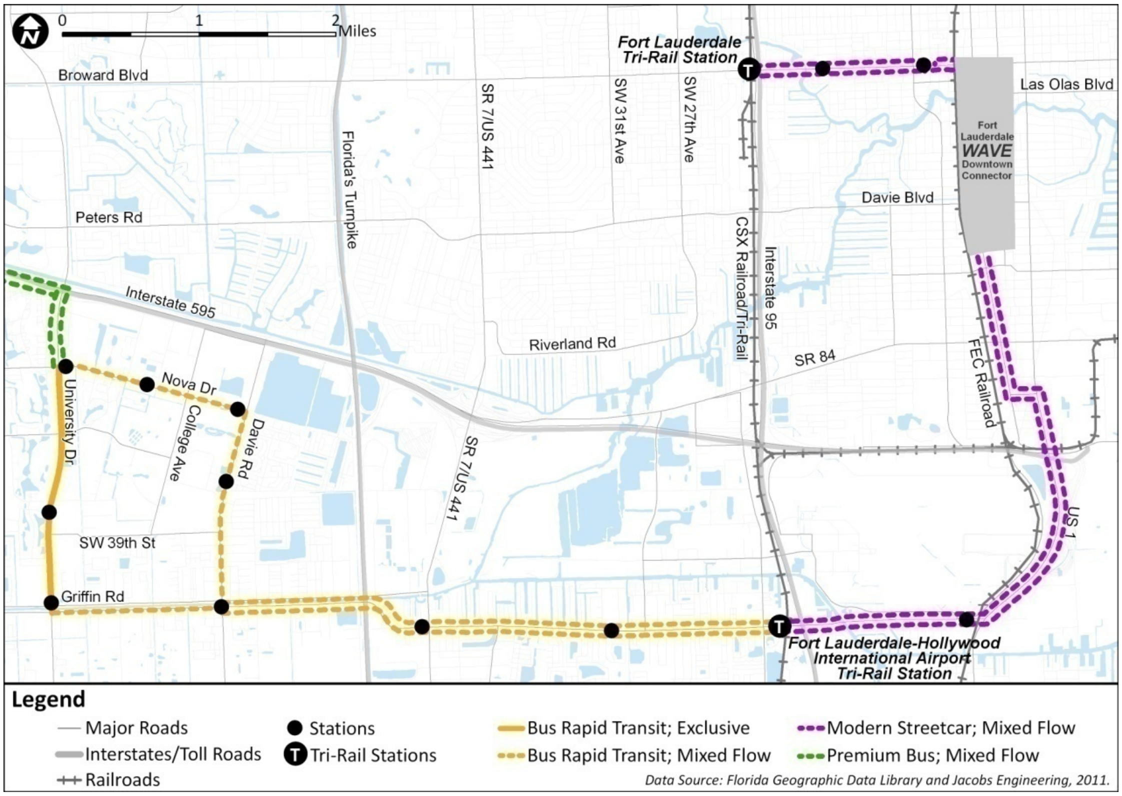
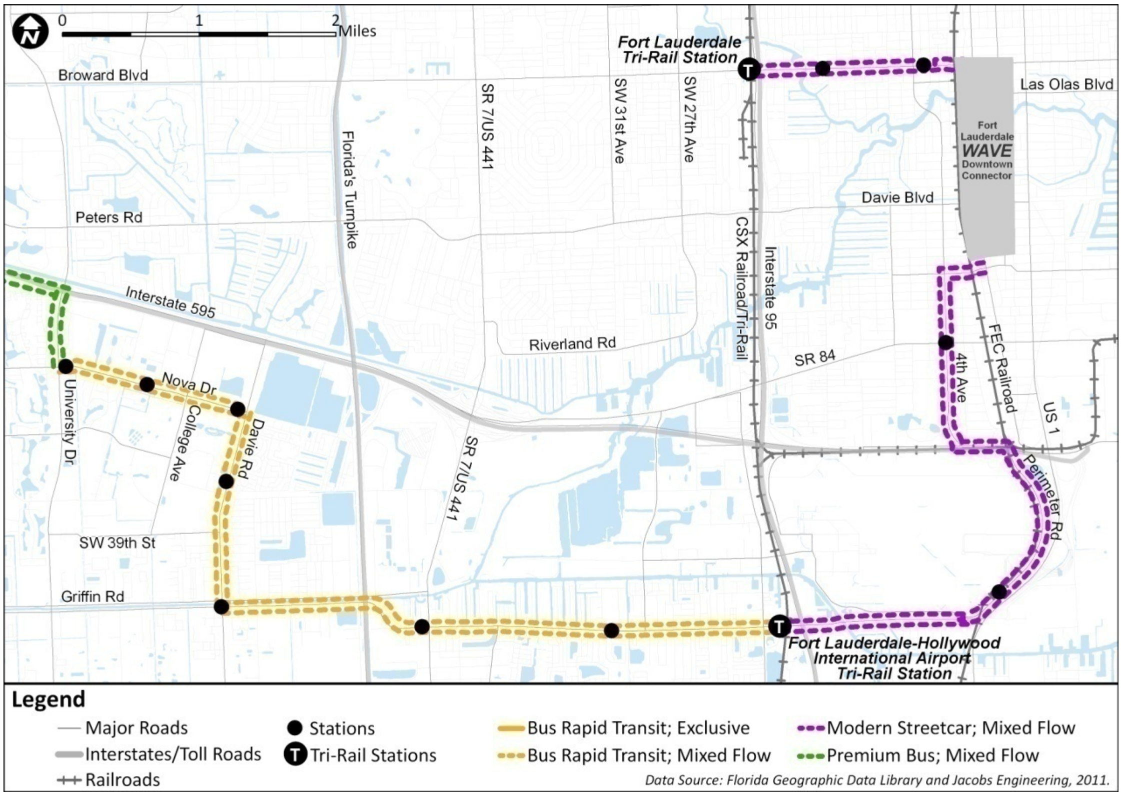
[3] Since the eastern section of the alignment is similar among all of the study alternatives, Exhibits 8-11 illustrate portions of the alignment with differing characteristics.

Exhibit 9: Alternative 2.3 - Griffin Road with the One-way Loop



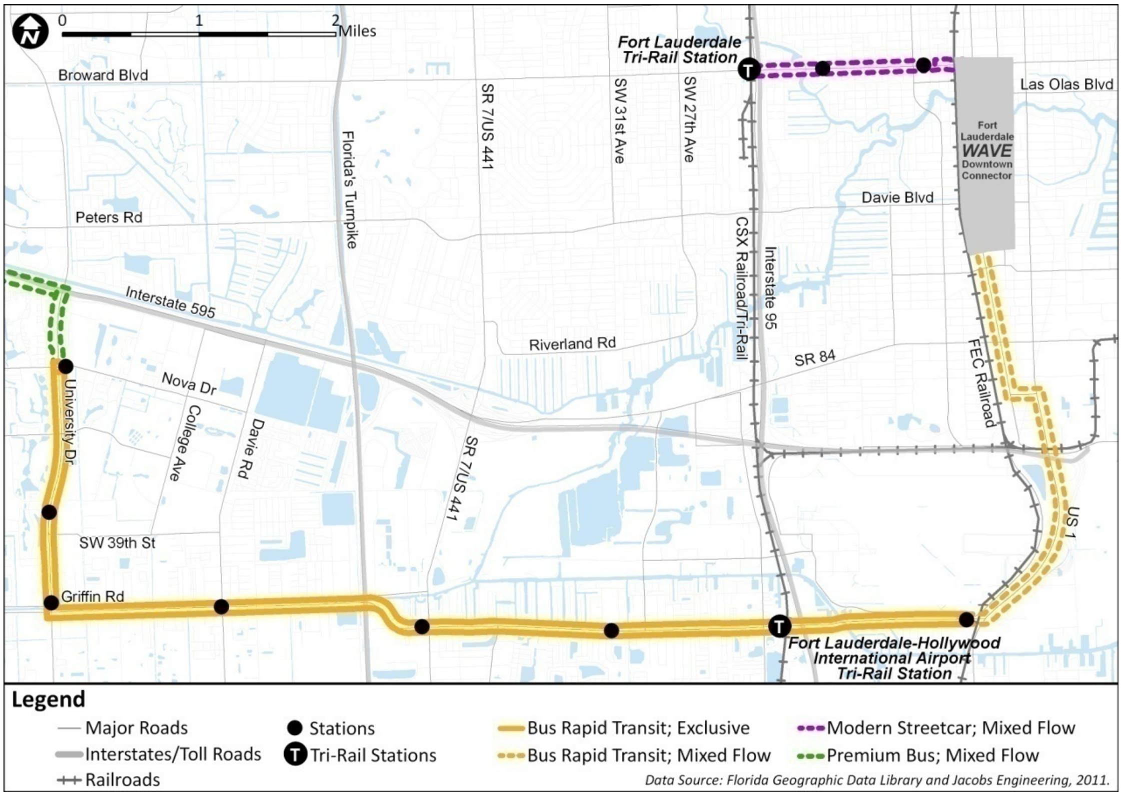
Data Source: Florida Geographic Data Library and Jacobs Engineering, 2011.

Exhibit 10: Alternative 2.4 - Griffin Road using Nova Drive/Davie Road/Perimeter Road/4th Avenue



Data Source: Florida Geographic Data Library and Jacobs Engineering, 2011.

Exhibit 11: Alternative 2.6 - University Drive/Griffin Road to 17th Street



Data Source: Florida Geographic Data Library and Jacobs Engineering, 2011.

The four pre-selected Build Alternatives have proposed alignments that begin at the Sawgrass Mills Mall/ BB&T Center (formerly the Bank Atlantic Center), to the west, then travel south to I-595 through the Sawgrass International Corporate Park. Once through the Sawgrass International Corporate Park, the alignments run east, following the I-595 corridor to University Drive. For each Build Alternative, this portion of the route will be served by premium bus. However as indicated in Section 3.0, since the transit route, stations, and technology are similar among the four study alternatives, the western portion of the study area is not modeled as part of this microsimulation analysis.

In the eastern portion of the study area, Build Alternatives 1.1, 2.3, and 2.6 will have the same alignment. From the Fort Lauderdale Tri-Rail Station to downtown Fort Lauderdale, the alignment is on Broward Boulevard. The alignment heads south on Andrews Avenue and Federal Highway/US 1. At Griffin Road the alignment turns west and travels to the Fort Lauderdale-Hollywood International Airport Tri-Rail Station. On the other hand, rather than traveling along Federal Highway, Alternative 2.4 runs adjacent to the Fort Lauderdale-Hollywood International Airport utilizing Perimeter Road and 4th Avenue. For this eastern portion of the corridor, the modern streetcar was the assumed technology for the Build Alternatives; with the exception of Alternative 2.6, in which bus rapid transit (BRT) was considered. Transit service within the eastern portion of the study area will operate in mixed traffic flow conditions, sharing the roadway with automobile traffic.

The alignments for all four alternatives connect to the Fort Lauderdale Wave Streetcar near the intersection of Broward Boulevard and Andrews Avenue. The Wave is a separate transit project which consists of a 2.7-mile streetcar system that will serve as a local circulator in downtown Fort Lauderdale. The Wave is anticipated to be fully operational in late 2015. Since the project is still in the project development phase, specifics regarding the Wave were not considered as part of this microsimulation analysis. For the purpose of this Study, the alignments were assumed to run along Andrews Avenue with no transit stops.

The Build Alternatives have different options in the middle section of the alignment between University Drive and I-95 as detailed below:

- Alternative 1.1 leaves the I-595 corridor, south on University Drive to Nova Drive where it turns east and travels to Davie Road. At Davie Road, the alignment turns north, re-enters the I-595 corridor and continues east to SR 7. At SR 7, the alignment travels north to Broward Boulevard then goes east continuing to the Fort Lauderdale Tri-Rail Station on Broward Boulevard, where it meets the eastern portion of the alignment. For this alignment, premium bus operating in mixed flow traffic was considered.
- Alternative 2.3 provides a one-way loop around the South Florida Education Center in Davie, Florida. The middle section of this alignment leaves the I-595 corridor, south on University Drive to Nova Drive. At Nova Drive the alignment turns east and continues to the intersection of Nova Drive and Davie Road where it then heads south on Davie Road past Broward College to Griffin Road. On Griffin Road the alignment continues east to the Fort Lauderdale-Hollywood International Airport Tri-Rail Station where it meets the eastern portion of the alignment. In the westbound direction, the alignment proceeds west along Griffin Road from the Fort Lauderdale-Hollywood International Airport Tri-Rail Station to University Drive where it then travels north to the I-595 corridor. Transit service within this section of the alignment was assumed to be BRT operating in mixed traffic flow conditions, with the exception of the segment along northbound University Drive, where the BRT is expected to travel within an exclusive lane along the east side of the roadway.
- Alternative 2.4 leaves the I-595 corridor at University Drive where it travels south to Nova Drive then turns east to Davie Road. At Davie Road the alignment turns south and travels to Griffin Road where it turns east. It then continues east to the Fort Lauderdale-Hollywood International Airport Tri-Rail Station where it meets the eastern portion of the alignment. For this alignment, BRT service was assumed to operate in mixed flow traffic conditions.
- Alternative 2.6 continues south from the I-595 corridor to Griffin Road, using University Drive. This alignment continues east on Griffin Road to the Fort Lauderdale-Hollywood International Airport Tri-Rail Station where it meets the eastern portion of the alignment. For this alignment, BRT was assumed to operate in an exclusive lane within the University Drive median and the outside lanes along Griffin Road. The outside lanes along Griffin Road will be converted from general purpose lanes to exclusive transit only lanes.

5.2 Build Model Development

A total of eight (8) VISSIM models were created to assess the Build Alternatives. A separate AM and PM peak period model was developed for each of the four pre-selected alternatives by incorporating the proposed transit improvements into the calibrated base models. Transit improvements were coded consistent with the transit network attributes shown in Exhibits 8 through 11.

In order to analyze transit service within VISSIM, the microsimulation model requires the following input data:

- Service route and schedule
- Stops or station locations and type (i.e. curbside stop, bus turnout, dwell times)
- Public transport vehicle type
- Operating characteristics (i.e. desired vehicle speed, mixed traffic flow, exclusive lane, TSP)

For the purpose of this analysis, all transit services were assumed to operate on ten minute peak period headways and all stations were assumed to be curbside stops. A bus turnout was only coded along Perimeter Road, which is a two-lane undivided roadway where traffic flow would be completely interrupted during passenger boarding and alighting. Vehicle dwell time at a transit stop is determined in VISSIM using either a dwell time distribution or a calculation based on the number of passengers alighting at the stop. Since peak-period passenger data was not available for this study, a dwell time distribution with a mean value of 30 seconds was assumed for all active transit stations.

Although VISSIM provides an array of transit vehicle types for use in modeling public transportation systems, the VISSIM library does not contain every vehicle type. When necessary, a compatible vehicle type was used for modeling purposes.

In order to facilitate the movement of transit vehicles through signalized intersections while minimizing the impact to cross-street traffic, TSP was incorporated into the build models. A TSP detector was placed immediately upstream of the each signalized intersection along the transit route.

TSP was implemented in this project as follows:

- Whenever a call from the transit vehicle is placed by passing over the detector, the remaining phases in the cycle use the minimum green time until the green for the transit vehicle phase is activated.
- After placing a call from the transit vehicle, the phase that is currently assigned green and has already passed the minimum green time will terminate and go to the next phase in the cycle.
- Whenever a call from the transit vehicle is placed while the transit phase is active, 30 seconds of extended green time is allotted to the phase to allow the transit vehicle to pass through the intersection.

6.0 Results of Microsimulation Analysis

The following measures of effectiveness (MOEs) were used to assess the impacts and benefits provided by each of the study alternatives:

- Network Performance Measures (total latent demand, total processed demand, total vehicle-miles traveled (VMT), total vehicle-hours traveled (VHT), average speed and average delay time per vehicle)
- Percent difference in auto travel time with and without premium transit service in place
- Percent difference between transit and auto travel times
- Total transit travel time between route termini
- Change in total intersection delay with and without premium transit service in place.

The network performance measures listed above were obtained from VISSIM using the model's network performance evaluation module. Within VISSIM, latent demand is defined as the number of vehicles unable to enter the network at the end of a simulation period; whereas processed demand consists of the total number of vehicles in the network and arrived vehicles at the end of the simulation.

VISSIM does not directly generate the remaining MOEs; therefore, the MOEs were computed using travel times and vehicle delays extracted from the models. For the purpose of this Study, automobile travel time refers to the average travel time experienced by trucks and cars, while transit travel time refers to the travel time for all public transport vehicle types (i.e. BRT, premium bus, and streetcar). Vehicle delays reported in this section include the total delay observed by all vehicle types (transit, cars, and trucks).

The analysis was conducted for the morning and afternoon two-hour peak periods from 7:00 to 9:00 a.m. and 4:30 to 6:30 p.m., respectively. Each peak period model was run for a total simulation time of 9,000 seconds. Data was collected every hour (every 3,600 seconds). In order to avoid biasing the results due to an initially empty network, in both periods (AM and PM), data collection started at 30 minutes (1,800 seconds) after the initiation of the simulation (seeding period).

As explained in Section 4.1, microsimulation models are stochastic in nature. Therefore, similar to the calibration phase, the microsimulation models were run ten times with different seeding values, and the results of each independent run were then averaged in an effort to minimize the randomness inherent in stochastic models. The average travel times and delays along the alignments were then compared to determine the impacts and benefits among the different alternatives.

The AM and PM peak period network performance measures for existing conditions and the Build Alternatives are summarized in Exhibits 12 and 13, respectively. From a network-wide standpoint the alternatives perform relatively similar to one another.   Slight variations are attributed to the differences among alternatives and the stochastic nature of the software for large networks. The results indicate that Alternative 2.6 processes slightly less vehicles due to the proposed conversion of one general purpose lane to a special use lane in both directions along Griffin Road.

Exhibit 12: AM Peak Period Network-wide Performance Measures

Measure of Effectiveness	Existing	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6
Latent demand (veh)	0	0	100	0	300
Processed Demand (veh)	122,100	122,100	122,000	122,100	121,800
Vehicle-miles traveled (VMT)	158,500	159,600	160,400	160,600	158,900
Vehicle-hours traveled (VHT)	7,300	7,600	7,600	7,600	7,700
Average speed (mph)	22	21	21	21	21
Average delay time (sec/veh)	100	109	109	108	112

Exhibit 13: PM Peak Period Network-wide Performance Measures

Measure of Effectiveness	Existing	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6
Latent demand (veh)	0	0	0	0	100
Processed Demand (veh)	144,300	144,300	144,300	144,300	144,200
Vehicle-miles traveled (VMT)	189,800	189,600	190,500	190,700	190,400
Vehicle-hours traveled (VHT)	9,000	9,700	9,800	9,700	9,800
Average speed (mph)	21	20	19	20	20
Average delay time (sec/veh)	111	127	129	127	129

Exhibit 14 shows the difference in auto travel time, with and without the proposed premium transit service in place under each Build Alternative. From an automobile standpoint, travel times are either slightly better or about the same during the AM peak period. Although travel times are higher during the PM peak period, the difference is generally less that 10 percent among all the alternatives, which is also within a range of expected error in stochastic simulations of such large networks.

Exhibit 14: Percent Difference in Auto Travel Time with Transit in Place

Time	Eastbound				Westbound			
	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6
7:00-8:00 a.m.	-1%	0%	3%	2%	-1%	-5%	2%	-4%
8:00-9:00 a.m.	0%	-4%	2%	-3%	0%	-3%	4%	-2%
4:30-5:30 p.m.	4%	9%	8%	1%	3%	5%	5%	5%
5:30-6:30 p.m.	1%	8%	5%	2%	5%	7%	7%	4%

- = reduction in travel time

+ = increase in travel time

Additionally, the baseline automobile travel time and total travel time for each alternative were compared to determine the travel time savings, if any, of utilizing transit in lieu of the automobile. In general, transit travel time was found to be longer than the baseline automobile travel time, primarily due to the added dwell time for passenger boarding and alighting at transit stops along the corridor. As shown in Exhibit 15, Alterative 2.6 provides the shortest transit travel time among all of the transit alternatives. The travel time benefit observed under Alternative 2.6 is most likely attributed to the fact that, of all the study alternatives, Alternative 2.6 is the only alternative that provides an exclusive lane for transit along more than half its route. The other alternatives travel in mixed traffic along most of the alignment.

Exhibit 15: Percent Difference Between Transit and Auto Travel Times

Time	Eastbound				Westbound			
	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6
7:00-8:00 a.m.	13%	9%	15%	7%	11%	9%	21%	6%
8:00-9:00 a.m.	16%	6%	13%	2%	10%	6%	18%	2%
4:30-5:30 p.m.	16%	20%	24%	5%	15%	13%	22%	5%
5:30-6:30 p.m.	13%	17%	19%	5%	16%	15%	23%	3%

-=shorter travel time on Transit

+=shorter travel time in Automobile

Total transit time between modeled route termini was also compared among the alternatives to determine which route provided the shortest travel time between I-595/University Drive and downtown Fort Lauderdale. It should be noted that the alternative routes are relatively similar in overall length. Moreover, as previously mentioned, the VISSIM model did not consider the western portion of the routes along the I-595 corridor, the Sawgrass Mills Mall, and Sawgrass International Corporate Center. (Nevertheless, since the routes and stops in these areas are the same for all alternatives, the additional transit travel time is irrelevant from a comparative point of view.)

The total transit travel time between modeled route termini is summarized in Exhibit 16. Similar to the results presented in Exhibit 15, Alternative 2.6 provides the fastest route, from a transit users standpoint, between I-595/University Drive and downtown Fort Lauderdale in the eastbound and westbound direction during both the AM and PM peak periods. Again, the improved travel times are most likely credited to the implementation of exclusive transit lanes along University Drive and Griffin Road.

Exhibits 15 and 16 also demonstrate that the remaining three alternatives (1.1, 2.3, and 2.4) perform relatively similar in terms of total transit travel time and difference in travel time when compared to automobile travel time.

Exhibit 16: Total Transit Travel Time between Route Termini

Time	Eastbound				Westbound			
	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6
7:00-8:00 a.m.	39	38	40	37	38	37	40	36
8:00-9:00 a.m.	42	41	43	40	43	39	42	37
4:30-5:30 p.m.	45	44	45	39	41	43	47	40
5:30-6:30 p.m.	42	41	42	38	39	43	47	38

Minutes between I-595/University Drive and downtown Fort Lauderdale

For further reference, Appendix B contains the average automobile and transit travel times by travel time segment for each peak hour.

The total intersection delay was also reviewed to understand the impact, if any; of implementing transit service and TSP on signalized intersections within the study area. The total delay at each intersection was computed from the average approach delay reported by VISSIM. Tables containing the total intersection delay at each signalized intersection are included in Appendix C. The average approach delay for the following intersections is also provided in Appendix C:

- SR 84 and University Drive,
- University Drive and Griffin Road,
- Griffin Rd and US 1,
- SR 84 and US 1,
- Andrews Avenue and Broward Boulevard,
- Broward Boulevard and SR 7,
- Broward Boulevard and I-95 ramps, and
- Griffin Road and I-95 ramps.

In general, the implementation of TSP within the study area network is not expected to have a significant effect on overall intersection delay. Although additional delay will occur on the cross-street approaches, it is not considerable enough to adversely impact the overall operation of the intersection to unacceptable conditions (delay > 80 seconds/vehicle[4]).

The majority of the signalized intersections within the study area network experienced a minimal increase in delay, if any. The increase in delay was typically 15 seconds or less and at most 23 seconds. Some intersections experienced a reduction in overall intersection delay with the implementation of TSP. As shown in Exhibit 17, an increase in delay of 15 seconds or less was reported at 97% or more of the intersections, and a reduction in delay was reported for around 25% of the signalized intersections.

Exhibit 17: Implications of Transit Signal Priority on Intersection Delay

	Increase in overall delay (greater than 15 sec.)				Reduction in overall delay			
Time	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6	Alt 1.1	Alt 2.3	Alt 2.4	Alt 2.6
7:00-8:00 a.m.	0%	0%	0%	1%	25%	16%	26%	20%
8:00-9:00 a.m.	3%	0%	0%	0%	22%	22%	22%	28%
4:30-5:30 p.m.	3%	3%	0%	3%	29%	32%	35%	35%
5:30-6:30 p.m.	0%	0%	0%	1%	25%	20%	22%	29%

Percent of signalized intersections within the study network.

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[4] According to HCM 2000 and HCM 2010, the LOS "E" maximum threshold for signalized intersections is 80 control delay sec/veh. Since control delay is a component of total delay, assuming a maximum delay threshold of 80 sec/veh with respect to total vehicle delay presents a conservative evaluation for the purpose of this study.

7.0 Conclusions and Recommendations

As indicated in the previous sections the following four alternatives were evaluated:

- Alternative 1.1 – SR 7/Broward Boulevard
- Alternative 2.3 – Griffin Road with the One-way Loop
- Alternative 2.4 – Griffin Road using Nova Drive/Davie Road/Perimeter Road/4th Avenue
- Alternative 2.6 - Griffin Road using University Drive/Griffin Road to 17th Street

The CBT corridor presents several challenges to microscopic simulation. It is heavily used for commute traffic and involves alternative transit options. Additionally, the immense scale of the network (in terms of the total number of intersections, lane miles, and length of simulation) created unique difficulties. For example, I-595 was under construction at the time of model development; therefore, reliable data could not be collected for use in the model calibration. Consequently, it was decided not to model I-595 since there are no transit stops along this freeway; therefore, the impact to traffic operations on I-595 as a result of the proposed transit service is expected to be negligible.

For the purposes of this Study, the following measures of effectiveness (MOEs) were computed from the VISSIM output to assess the impacts and benefits provided by each of the study alternatives:

- Network Performance Measures (total latent demand, total processed demand, total vehicle-miles traveled (VMT), total vehicle-hours traveled (VHT), average speed and average delay time per vehicle)
- Percent difference of auto travel time, with and without premium transit service in place
- Percent difference between transit and auto travel times
- Total transit travel time between route termini
- Change in total intersection delay, with and without premium transit service in place.

A review of the MOEs listed above produced the following findings:

- From an automobile standpoint, travel times along the respective transit route with transit alternatives in place are within 10% of the baseline travel time.
- Alternative 2.6 provides the greatest travel time benefit for transit users, and it is the shortest transit travel time between route termini.
- The remaining three alternatives (1.1, 2.3, and 2.4) perform relatively similar in terms of total transit travel time and difference in travel time when compared to automobile travel time.
- Although additional delay will occur on some of the cross-street approaches with the implementation of TSP, it is not considerable enough to adversely impact the overall operation of the intersection to reach unacceptable conditions.

In summary, although the previously conducted travel demand model analysis indicates that Alternative 2.6 is estimated to have the lowest ridership among the four-pre-selected alternatives, Alternative 2.6 provides the greatest overall travel time benefit and the fastest route between western and eastern Broward County.

Considering the findings of this Study, it is recommended that a cost-benefit analysis should be undertaken to determine if the cost of implementing Alternative 2.6 outweighs the perceived travel time benefits. The Federal Highway Administration's (FHWA) Surface Transportation Efficiency Analysis Model (STEAM) is one tool that could be used to perform a cost-benefit analysis involving multiple modes of transportation.

STEAM is an economic impact software that develops monetized impact estimates for multi-modal transportation alternatives. In addition to monetizing operational impacts, such as travel time, fuel consumption, and number of crashes, qualitative estimates of natural resource usage (energy consumption) and environmental impacts (vehicle emissions and global warming emissions) are also computed. Monetary benefits are assigned to each impact measure to develop an overall benefit for each alternative. Furthermore, STEAM is compatible with the use of SERPM (Southeast Florida Regional Planning Model), the preferred travel demand model being used for the Central Broward East-West Transit Study. STEAM uses input directly from the four-step travel demand modeling process for a detailed, system-wide analysis of alternative transportation investments.