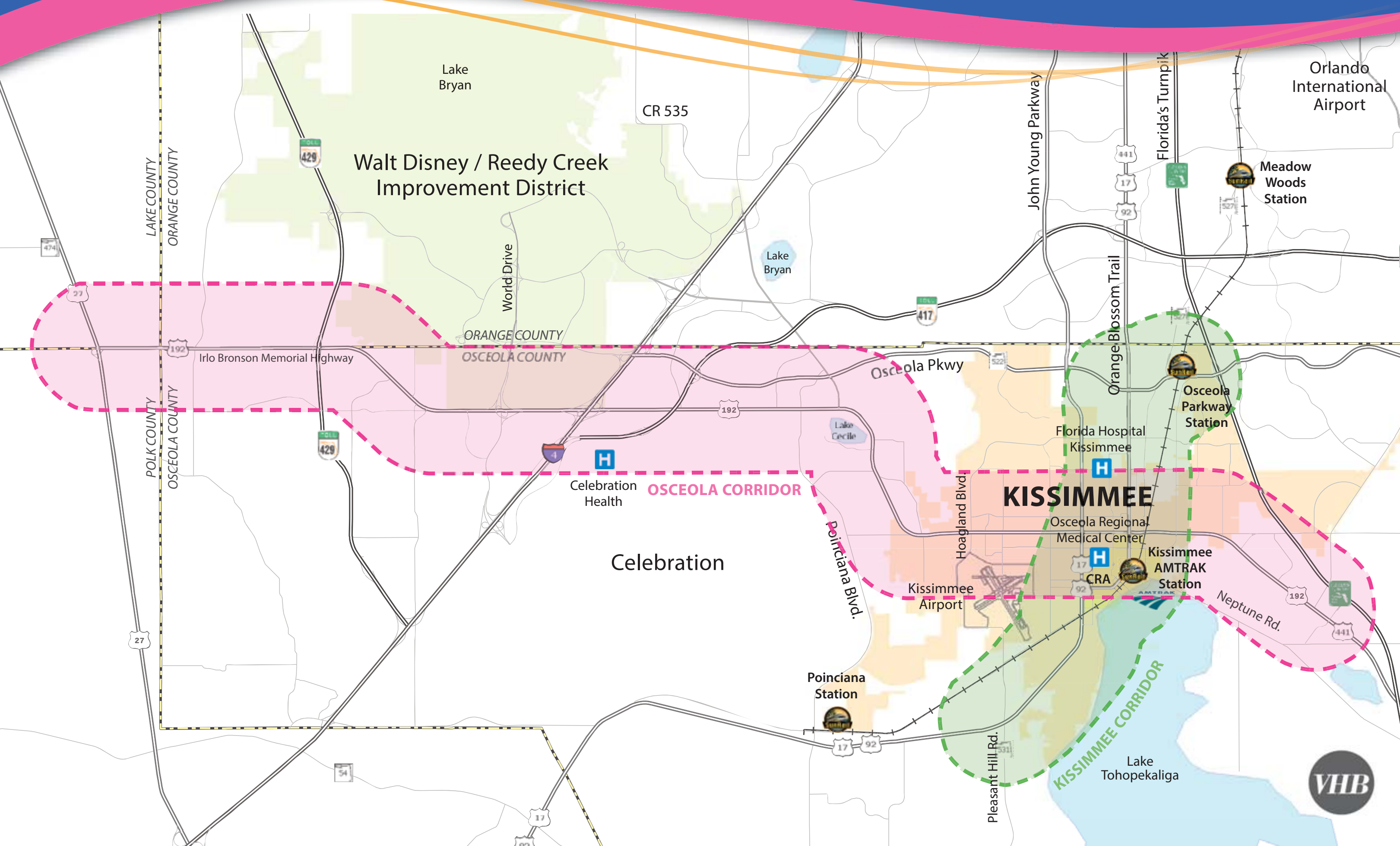
# US 192 Alternatives Analysis

## Appendix F: Basis of Engineering Report

October 2013

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# 1

# Introduction

## 1.1 Introduction and Background

This technical appendix summarizes the assumptions and criteria used for the conceptual engineering for the Short List of Alternatives (SLA). The five alternatives are as follows:

- No Build
- Enhanced Bus – Transit Signal Priority
- BRT Build Alternative 1 – Queue Jumps and Transit Signal Priority
- BRT Build Alternative 2 – Median busway from Celebration Place to Hoagland Boulevard
- BRT Build Alternative 3 – Median busway from Town Center Boulevard to Hoagland Boulevard

The conceptual engineering plans were used to develop quantities and associated construction costs. The plans were also used to identify right-of-way impacts, which were then used for estimating capital costs as well as potential environmental impacts. No conceptual engineering was completed for the No Build and Enhanced Bus alternatives, as major infrastructure improvements are not included for these alternatives.

Conceptual engineering was completed for the following elements:

- BRT stations (curbside and median)
- Typical queue jump
- Median busway

The remainder of the appendix summarizes each of these components.

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# 2

# Stations

## 2.1 Overview

The three BRT alternatives each include 19 stations to serve major destinations and intermodal transfer points within the Study Area. The station locations are the same for each alternative.

The layout for the BRT stations assumes an envelope of 80’x 12’ for the BRT station components. Included within this area are a shelter canopy, benches, lighting, mapping, fare collection equipment, secured bike parking, trash cans, and real-time bus location signage. The loading area for BRT vehicles is 100’ long to accommodate two vehicles (one regular bus, one articulated bus). The BRT station will include branding components such as a distinct name, logo, color scheme, shelter design and signage to distinguish it from the regular LYNX system. For the BRT service, all fares will be collected off-board (i.e., not on the bus) through ticket machines located at each station. Including off-board fare collection decreases the dwell time for buses at each location, as passengers can board and disembark more quickly.

While the station footprint size and components are the same for all three BRT alternatives, the location within the road right-of-way varies depending on the presence of a dedicated bus lane. Table F-1 summarizes the BRT station configurations associated with each alternative. An “offline” status indicates that the proposed station is located in a right-of-way that is separate from the roadway. Plan views of the station footprints are included in Appendix C.

**Table F-1: BRT Station Summary**

| Station | Parking Facility | Location within Road Right of Way | | |
|---|---|---|---|---|
| | | Build 1 | Build 2 | Build 3 |
| **Four Corners** | Shared | Offline | Offline | Offline |
| **Westside Blvd** | Shared | Curbside | Curbside | Median |
| **Vista del Lago Blvd** | None | Curbside | Curbside | Median |
| **Orange Lake Boulevard East** | Shared | Curbside | Curbside | Median |
| **Old Lake Wilson Road** | Shared | Curbside | Curbside | Median |
| **Walt Disney World** | None | Offline | Offline | Offline |

| Station | Parking Facility | Location within Road Right of Way | | |
|---|---|---|---|---|
| | | Build 1 | Build 2 | Build 3 |
| **Celebration Place** | Dedicated Lot | Offline | Offline | Offline |
| **Celebration Avenue** | None | Curbside | Median | Median |
| **Holiday Trail** | None | Curbside | Median | Median |
| **Poinciana Boulevard** | Shared | Curbside | Median | Median |
| **Lake Cecile** | None | Curbside | Median | Median |
| **Siesta Lago** | None | Curbside | Median | Median |
| **Old Vineland Road** | None | Curbside | Median | Median |
| **Armstrong Boulevard** | Shared | Curbside | Curbside | Curbside |
| **Emory Avenue** | None | Curbside | Curbside | Curbside |
| **Osceola Regional Medical Center** | None | Curbside | Curbside | Curbside |
| **Kissimmee Intermodal Facility** | Dedicated Lot | Offline | Offline | Offline |
| **Florida Hospital** | None | Curbside | Curbside | Curbside |
| **Osceola Parkway SunRail** | Dedicated Lot | Offline | Offline | Offline |

Note: The Kissimmee Intermodal Facility and Osceola Parkway SunRail stations would be constructed as part of SunRail, but would be used for this project as well.

### Parking Facilities

Each of the three BRT alternatives assumes shared parking will be available at certain stations where parking is available and where intersecting north-south streets provide connections to areas outside the immediate Study Area. The shared parking arrangements would be in conjunction with existing commercial development at the station (for example, a shopping center) and would allow for limited park and ride usage. These locations are identified in Table F-1.

A dedicated park and ride facility is proposed at the Celebration Place station at the southeast corner of US 192 and Celebration Place. This location is within the Celebration Development of Regional Impact (DRI) and would include parking for approximately 250 vehicles, with the ability to expand to 400. At this location, all routes (both BRT and local LYNX bus) would leave the US 192 corridor and the station would be within the park and ride lot. As part of the implementation of SunRail, park and ride lots are already proposed at the Kissimmee Intermodal Facility and Osceola Parkway stations

### Curbside Stations

Curbside BRT stations are proposed for locations where BRT service would operate in mixed traffic, as indicated in Table F-1. Figure F-1 shows the conceptual layout for the curbside BRT stations with queue jumps. All stations are located on the far side of the intersection, consistent with current LYNX practices. To facilitate safe pedestrian movement across US 192, all of the proposed station locations are at signalized intersections.

The curbside stations are designed with separate loading areas for local bus and BRT service. The layout for the curbside stations assumes an envelope of 80'x 12' for the BRT station components, as mentioned earlier. The local bus stop is located in advance of the curbside BRT station and includes a pullout. This pullout allows the BRT vehicle to pass local buses that may be stopped to pick up passengers. Having BRT and local bus stations together also allows for transfers between the routes. Local buses would stop at the BRT locations as well as at all other existing bus stop locations in the study area. A transition area is included to enable the BRT and local buses to merge back into the right lane of traffic. The entire length of the combined curbside local and BRT station, with transition area, is estimated at 500 feet.

### Median Stations

Median BRT stations are proposed for locations where BRT service would operate in a dedicated median bus lane, as indicated in Table F-1. Figure F-2 shows the conceptual layout for the median BRT stations. Stations would be located at signalized intersections on the far side of the intersection. A passing lane would be provided to allow local and express BRT routes to operate simultaneously. In the segment of roadway where the median bus lane is proposed, the local bus service would continue to operate to existing local bus stations along the outside curb. Similar to the curbside stations, the layout for the median stations assumes the same envelope and station components. To protect passengers from adjacent traffic, a barrier would be installed between the station waiting area and the travel lanes along US 192. The barrier would ensure that all access to the station is through the protected crosswalk and not mid-block.

### Offline Stations

Offline BRT stations are proposed major termini and transfer points within the system. For these locations, BRT routes would exit the adjacent roadway and stop within a dedicated parking lot or transfer facility. These stations are located at the following locations:

- Four Corners – WalMart shopping center, currently serves as terminus for Link 55
- Walt Disney World – location to be determined
- Celebration Place – proposed transfer center for BRT routes
- Kissimmee Intermodal Facility – SunRail and BRT/local bus transfer point
- Osceola Parkway SunRail Station – SunRail and BRT/local bus transfer point

With the exception of Walt Disney World, each offline station is proposed to contain a parking area (either shared or dedicated). The offline stations would serve both local and BRT services to facilitate transfers.

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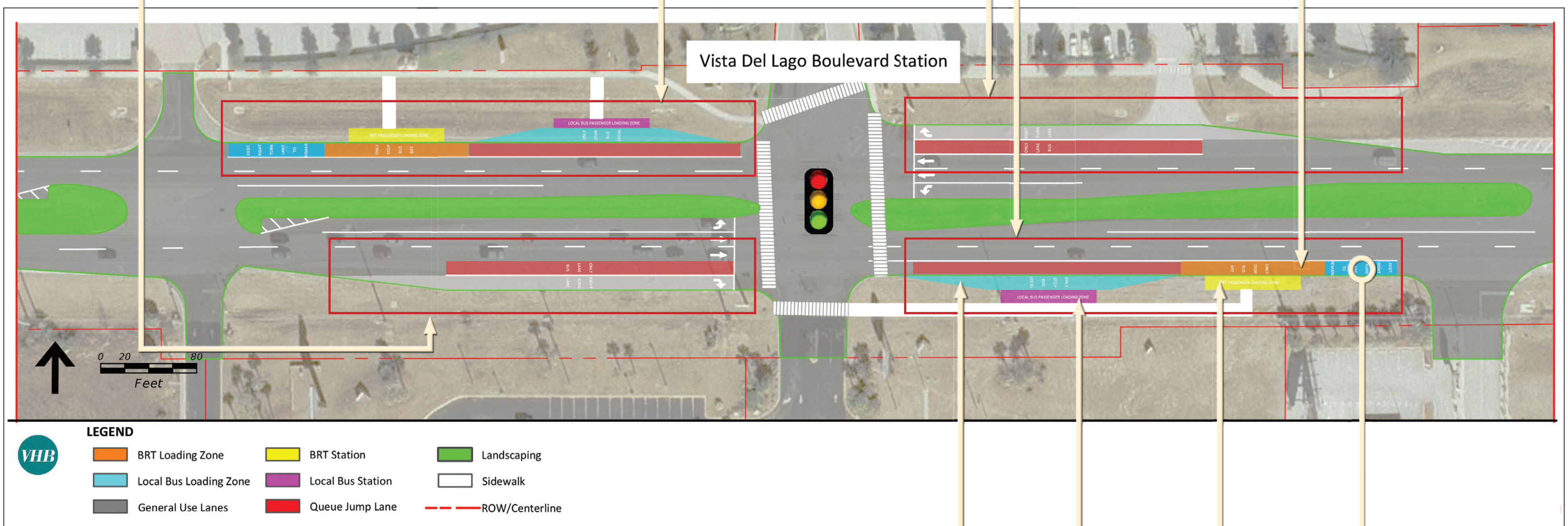
# Curb Running BRT & Queue Jumps

## How does it work?

At a "queue jump" before the signal, buses and BRT vehicles enter into the **bus only lane**. Right turners enter the **right turn lane** and other vehicles stay in the through lanes.

On the far end of the signal, buses and BRT vehicles enter another **bus only lane**. Local buses pull into **bus bays** to make stops. BRT vehicles access their stations at the **curb next to the BRT station.**

BRT vehicles stop here to pick up/drop off passengers.




Local buses pull into bus pull outs to pick up/drop off passengers, while allowing BRT vehicles to pass them to access the BRT Station.

Local Bus Stop

BRT Station

After exiting the station, buses and BRT vehicles re-enter through traffic transitioning back in the right lane.

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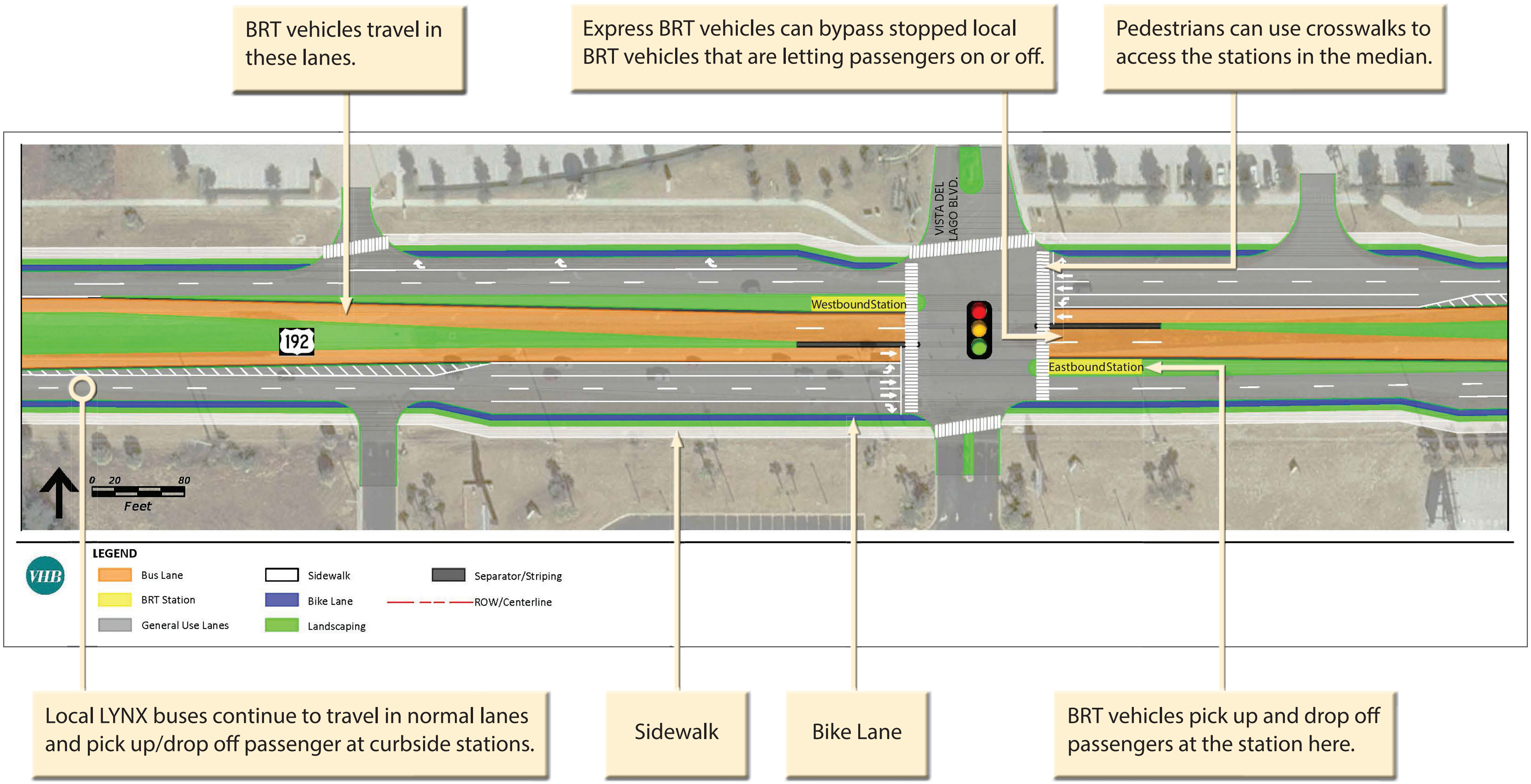
# Median Running BRT

## How does it work?



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# 3

# Queue Jumps

## 3.1 Overview

Queue jumps are included to provide opportunities for buses to bypass queued traffic at congested signalized intersections. They also provide a benefit to emergency vehicles as a way to bypass congested intersections. Queue jumps would allow the bus to bypass the queue at a light and proceed uninterrupted.

A more detailed definition of queue jumps and their application is included in the white paper included in this appendix.

## 3.2 Methodology and Design Considerations

Queue jumps are included for the following alternatives:

- BRT Build Alternative 1
- BRT Build Alternative 2
- BRT Build Alternative 3

Table F-2 summarizes the queue jump locations by alternative. Queue jumps are included only in areas where the BRT service operates curbside in mixed traffic. Queue jumps are not included in areas with a median busway, as they are not needed. No queue jumps are proposed for intersections with low to moderate congestion (Level of Service C or better). Due to right-of-way constraints along US 192/Vine Street and Central Avenue within Kissimmee, no queue jump lanes are proposed for the section of the BRT alignment from Hoagland Boulevard east to the Kissimmee Intermodal Facility.

The length of each queue jump lane was estimated based on the Year 2030 No Build traffic analysis. For each intersection, the queue jump length represents the $95^{th}$ percentile queue for through traffic. The use of longer queue jump lanes provides more certainty that buses will be able to access the lane prior to the beginning of the queue. For some locations, the $95^{th}$ percentile queue was projected to extend back to the upstream intersection. For these locations, the queue jump lane is assumed to form a continuous lane between intersections.

In most locations with a queue jump lane, a separate right turn lane exists. With the addition of the queue jump, the right turn lane would be moved to the outside, and it would also be extended to match the length of the queue jump lane. For queue jump locations where a right turn lane does not exist, both a queue jump lane and right turn lane would be added.

Table F-3 summarizes the length of each proposed queue jump along with the other recommended improvements.

## TABLE F-2 SUMMARY OF TRANSIT PRIORITY FEATURES BY ALTERNATIVE

| | Enhanced Bus (Transit Signal Priority Only) | | BRT Build 1: No Bus Lane; Curb Running | | | | BRT Build 2: Partial Bus Lane (Celebration Pl to Hoagland Blvd) | | | | | | BRT Build 3: Majority Bus Lane (Town Center Blvd to Hoagland Blvd) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Intersection* | *TSP* | | *TSP* | | *Queue Jump* | | *TSP* | | *Queue Jump* | | *Bus Lanes* | | *TSP* | | *Queue Jump* | | *Bus Lanes* | |
| | EB | WB | EB | WB | EB | WB | EB | WB | EB | WB | WB | EB | EB | WB | EB | WB | EB | WB |
| US 192 and Town Center Blvd | Yes | NO | Yes | NO | NO | NO | Yes | NO | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Avalon Rd/Westside Blvd | NO | NO | Yes | Yes | NO | NO | Yes | Yes | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Howard Johnson Ent/Vista Del Lago | NO | NO | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Orange Lake Blvd W | Yes | NO | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and SR 429 SB Ramps | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and SR 429 NB Ramps | Yes | Yes | Yes | Yes | NO | NO | Yes | Yes | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Orange Lake Blvd East | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Black Lake Rd | NO | NO | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Formosa Gardens Blvd | Yes | NO | Yes | NO | NO | NO | Yes | NO | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Entry Point Blvd/Sherberth Rd | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Old Lake Wilson Blvd | NO | NO | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Reedy Creek Blvd | NO | NO | NO | NO | Yes | Yes | NO | NO | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Griffin Rd | NO | Yes | NO | Yes | NO | NO | NO | Yes | NO | NO | NO | NO | NO | NO | NO | NO | Yes | Yes |
| US 192 and Celebration Pl/Parkway Blvd | NO | NO | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Arabian Nights Blvd | Yes | NO | Yes | NO | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Celebration Ave | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and International Dr | Yes | Yes | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Holiday Trail | NO | Yes | NO | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Seralago Blvd | NO | Yes | NO | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Polynesian Isles Blvd | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Poinciana Blvd | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and SR 535 | NO | Yes | Yes | Yes | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Super Target | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Seven Dwarfs Ln | Yes | NO | Yes | NO | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Siesta Lago Dr | Yes | NO | Yes | NO | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Bass Rd (Old Vineland) | NO | NO | Yes | Yes | NO | NO | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Hoagland Blvd | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes |
| US 192 and Armstrong Blvd | Yes | Yes | Yes | Yes | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO |
| US 192 and Dyer Blvd | Yes | NO | Yes | NO | NO | NO | Yes | NO | NO | NO | NO | NO | Yes | NO | NO | NO | NO | NO |
| US 192 and Orange Blvd | Yes | NO | Yes | NO | NO | NO | Yes | NO | NO | NO | NO | NO | Yes | NO | NO | NO | NO | NO |
| US 192 and Thacker Ave | NO | Yes | NO | Yes | NO | NO | NO | Yes | NO | NO | NO | NO | NO | Yes | NO | NO | NO | NO |
| US 192 and Emory Ave | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| US 192 and John Young Pkwy | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| US 192 and Central Ave | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| US 192 and Main St | Yes | Yes | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Central Ave and Oak | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Drury/Main/Neptine | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| US 441 and Carroll St | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NO | NO | Yes | Yes | Yes | Yes | NO | NO |
| US 441 and Donegan Ave | Yes | Yes | Yes | Yes | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO |
| US 441 and Columbia Ave | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Main St and Oak St | Yes | Yes | Yes | Yes | NO | NO | Yes | Yes | NO | NO | NO | NO | Yes | Yes | NO | NO | NO | NO |
| Main St/Broadway and Neptune Rd | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

Station locations are indicated in orange.

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## Table F-3: Summary of Queue Jump Locations and Additional Improvements (Curbside BRT Only)

| Intersection | Alternative | Eastbound | | Westbound | |
|---|---|---|---|---|---|
| | | Minimum queue jump length (ft) | Additional Improvement to Accommodate Queue Jump | Minimum queue jump length (ft) | Additional Improvements to Accommodate Queue Jump |
| US 192 and Howard Johnson Ent/ Vista Del Lago | Build 1 and 2 | 1166 | Extend RT lane | 1772 | Extend RT lane |
| US 192 and Orange Lake Blvd W | Build 1 and 2 | 408 | None | 1374 | Extend RT lane |
| US 192 and SR 429 SB Ramps | Build 1 and 2 | 420 | Extend RT lane | 100 | None |
| US 192 and Black Lake Rd | Build 1 and 2 | 627 | Construct New Bypass Lane | 714 | Construct New Bypass Lane |
| US 192 and Old Lake Wilson Blvd | Build 1 and 2 | 1132 | Extend RT lane | 1446 | Construct New Bypass Lane |
| US 192 and Reedy Creek Blvd | Build 1 and 2 | 1587 | Construct New Bypass Lane | 1269 | Construct New Bypass Lane |
| US 192 and Celebration Ave | Build 1 | 1021 | Create Continuous Lane | 545 | None |
| US 192 and Polynesian Isles Blvd | Build 1 | 905 | Extend RT lane | 753 | Extend RT lane |
| US 192 and Poinciana Blvd | Build 1 | 993 | Construct New Bypass Lane | 600 | Extend RT lane |
| US 192 and SR 535 | Build 1 | 686 | Construct New Bypass Lane | 510 | None |
| US 192 and Super Target | Build 1 | 768 | Construct New Bypass Lane | 906 | Extend RT lane |
| US 192 and Hoagland Blvd | Build 1 | 1531 | Construct New Bypass Lane | 1021 | None |

| Intersection | Alternative | Southbound | | Northbound | |
|---|---|---|---|---|---|
| | | Minimum queue jump length (ft) | Additional Improvements to Accommodate Queue Jump | Minimum queue jump length (ft) | Additional Improvements to Accommodate Queue Jump |
| US 441 and Carroll St | Build 1, 2 and 3 | 308 | None | 236 | None |

*Notes for Additional Improvements:*

*Extend RT lane – for these locations, the existing right turn lane would be lengthened to match the length of the queue jump.*

*Construct new bypass lane – for these intersections, a right turn lane does not currently exist. A new right turn lane would be constructed in addition to the new queue jump lane..*

*Create continuous lane – for these locations, the queue length approaches or exceeds the distance to the upstream signal. A continuous bus-only lane would be added that would extend back to the previous signalized intersection.*

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# 4
# Busway

## 4.1 Overview

Dedicated transit lanes are included for portions of BRT Build Alternatives 2 and 3 as a way to improve transit travel time and reliability. The lanes would be for BRT vehicles and emergency vehicles only. The limits for the busway are as follows:

- BRT Build Alternative 2 – Celebration Place to Hoagland Boulevard
- BRT Build Alternative 3 – Town Center Boulevard to Hoagland Boulevard

The remainder of this section covers the methodology and associated design considerations.

## 4.2 Busway Locations

The goals of this project focus on providing for a cost-effective transportation system that preserves and enhances the environment. Thus, potential busway locations were limited to areas with sufficient right-of-way for an additional lane. (An evaluation was completed for converting an existing lane from general use to transit-only, and is included in Appendix H. Based on this evaluation, conversion of an existing lane was not recommended as part of the alternatives for this study.) The following locations were determined infeasible for a new busway lane due to right-of-way constraints:

- US 192 from Hoagland Boulevard in Kissimmee east
- Central Avenue in Kissimmee
- US 441 (Main Street and Orange Blossom Trail) in Kissimmee

Based on this determination, busway considerations were limited to US 192 from Hoagland Boulevard west to Four Corners. This section of US 192 has a minimum right of way width of 200’, which allows for additional travel lanes to be constructed within the existing right of way.

For BRT Build Alternative 2, the busway was focused on areas with the highest level of future congestion. As identified through the Year 2030 No Build traffic analysis, these areas are between Celebration and Kissimmee; therefore, the busway is included from Celebration Place to Hoagland Boulevard.

For BRT Build Alternative 3, the busway was designed to serve as much of the corridor as possible after considering right of way constraints. Due to the existing interchange ramps at US 192 and US 27, the busway was not carried through to the Four Corners terminus. This was done to avoid interchange reconstruction costs for the new bus lanes on ramps and overpasses. Instead, the busway ends at the first signalized intersection east of US 27, which was identified as Town Center Boulevard. Therefore, the busway for Build Alternative 3 extends from Town Center Boulevard to Hoagland Boulevard.

## 4.3 Curb versus Median Busway Evaluation

For the busway limits, curb-running versus median-running busway options were evaluated and reviewed with members of the Steering Group. Built examples of both scenarios exist for BRT systems in the United States. For the US 192 corridor, however, a median-running busway was determined to be the preferred option for the BRT alternatives. A full list of evaluation factors and results is included in Tables F-4 and F-5. The primary advantages for a median busway were identified as follows:

- Avoids conflicts with driveways for adjacent properties
- Avoids busway conflicts between buses and right turning vehicles
- Allows for higher travel speeds for buses

However, the use of a median busway would require the closure of mid-block directional left turn openings not located at signalized intersections. The closure of these openings would limit conflict points between left turning traffic and through buses. Instead, left turning traffic and U-turns would only cross the busway at signalized intersections where the bus would then stop. At these locations, all left turn movements would be protected. BRT vehicles would move at the same time as the through traffic along US 192.

**Table F-4: Comparison of Curb versus Median Busway Options**

| Criteria | Curb Running | Median |
|---|---|---|
| **BRT Service:** Quality & efficiency of service through the corridor | Slowest and least reliable due to shared ROW with local service, curb cuts, right turns and mid-block left turns in/through the bus ROW. | Fastest and most reliable since service is located away from curb cuts and right turns. Lefts across busway are controlled/ channeled and signalized. |
| **Local Transit Service** | No impact to existing service. Local service shares ROW with BRT. | No impact to existing service. Disconnect between local and BRT service. |
| **Traffic Operations at Intersections** | Right turners and mid-block lefts crossing bus lane would be impacted. | Left turners at intersections and mid-block lefts would be impacted. |
| **Stations:** ease of construction | Stations on both sides of road: Easiest, lowest cost to build | Offset stations in median: slightly more difficult and expensive due to buffering |
| **Pedestrian Ease, Safety and Comfort** | Transit and non-transit pedestrians are familiar with curb transit configuration; must cross entire (and now two-lanes wider) highway cross section to reach land uses and BRT/bus stops in opposite direction. | Transit pedestrians would cross half of the highway to reach BRT stations. Local transit pedestrians and non-transit pedestrians would still need to cross entire highway but would have a mid-highway refuge. Visually narrows corridor, benefitting pedestrians. Jay-walkers would be prohibited from crossing the bus lane. |
| **Land Use:** integration & enhancement of existing/proposed communities and developments | Best for land uses. Maintains current conditions/connectivity between transit service and land use. | Medium for land uses---transit service is still visible from land uses on both sides and mid-highway location makes transit equally accessible to land uses from both sides. |
| **Construction:** ease of construction and impacts during construction | Construction on both sides of road. Existing lanes not impacted. Impacts land uses on both sides during construction. | Construction on both sides and median. Outer lanes built first, traffic shifted, then median busway constructed. Impacts land uses on both sides during construction. |

**Table F-5: Evaluation Summary for Curb versus Median Busway**

| Criteria | Curb Running | Median |
|---|---|---|
| BRT Service | ○ | ● |
| Local Transit Service | ● | ◑ |
| Traffic at Intersections | ◑ | ◑ |
| Stations | ● | ◑ |
| Pedestrian/Bicycle Ease, Safety and Comfort | ◔ | ◕ |
| Current Land Use | ● | ◑ |
| Future Land Use | ◑ | ● |
| Construction/Cost | ◕ | ◑ |

**KEY:**

● =Positive Performance
◑ =Neutral Performance (some positives, some negatives)
◔ =Mostly Negative Performance
◕ =Mostly Positive Performance
○ =Negative Performance

## 4.4 US 192 Median Busway Cross Section

Two cross section options were evaluated for the US 192 mid-block cross section incorporating median busways.

The first option would replace the existing median with a two-way busway that would include two landscaped dividers, one on either side of the busway to separate it from the general use lanes. The second option would maintain the existing median, with one busway lane constructed on either side of the median, separated from general use lanes by a 2' striped buffer. Figures F-3 and F-4 show the two mid-block cross section options. (The configuration of median BRT stations is the same for both options.)

The two options were compared based on constructability, potential costs, and maintenance of traffic. Table F-6 summarizes this comparison; a memo summarizing this evaluation is included within this appendix.

**Table F-6: Evaluation Summary for Mid-Block Busway Cross Sections**

| Description | Option 1 (Replace the Median) | Option 2 (Maintain the Median) | % Increase |
|---|---|---|---|
| Pavement Demolition Required (width in feet) | 66’ | None | 100% |
| Demolition of Existing Median (width in feet) | 22’ | None | 100% |
| Construction of Two New Landscape Buffers (width in feet) | 32’ | None | 100% |
| Modification to Existing Landscape Median (width in feet) | None | 22’ | 0% |
| New Pavement Construction (width in feet) | 94’ | 28’ | 350% |

This evaluation also found that the construction costs for first mid-block busway cross-section option (with two landscaped buffers) would exceed those for the second option (maintaining the existing median) by more than $10 million. Therefore, Option 2 was selected as the preferred mid-block busway cross section along US 192.

### Busway Design Assumptions

The conceptual engineering for the median busway was completed in accordance with the design standards in the FDOT Plans Preparation Manual. For the busway, the following general assumptions were made:

- 12’ lane width for busway lanes
- 2’ striped separator between busway and general use lanes
- Design speed of 50 mph for roadway geometric elements
- Incorporation of existing landscaped median, where possible
- Fencing or barrier landscaping along the median to prevent pedestrian crossings at unsignalized locations
- Mid-block directional left turns closed at unsignalized intersections (to prevent conflicts with vehicles crossing the busway)

### Other Cross Section Elements

In addition to the median busway, the recommended US 192 cross section contains pedestrian and bicycle facilities to allow for safe multimodal access along the corridor. The components of this section were reviewed with the Florida Department of Transportation and other Steering Group members, with refinements made to reflect agency input.

- General use lanes – 11’ lanes are assumed for general use travel lanes, consistent with existing conditions for most of the US 192 corridor.
- Bicycle facilities – a 5’ bike lane is included next to the general use travel lanes. This location is consistent with FDOT requirements that bicycle accommodations be provided on-street. For the majority of the US 192 busway area, a 5’ unmarked shoulder currently exists as a bicycle facility. At curbside stations, the bike lane would be between the general use lanes and the bus pulloff, so that buses can stop

adjacent to the curb. For areas with queue jumps, the bicycle lane would be located between the queue jump lane and the right turn lane.

- Pedestrian facilities – a 10' sidewalk is provided on both sides of the roadway, with a 5' landscape buffer between the sidewalk and bike lanes. This sidewalk width is consistent with existing conditions in the majority of the US 192 busway area.

## 4.5 Other Design Issues

In addition to the issues identified in the previous section, the following issues were also addressed as part of the conceptual engineering layout for the median busway along US 192.

### Bridges and Underpasses

The limits of the median busway contain several bridges over water bodies and roadway interchanges. These locations are listed below:

Bridges

- US 192 over Shingle Creek (BRT Build 2 and 3)
- US 192 over Bonnet Creek (BRT Build 2 and 3)
- US 192 over Reedy Creek (BRT Build 3)

Interchanges

- US 192 over Interstate 4 (BRT Build 3)
- US 192 under World Drive (BRT Build 3)
- US 192 under SR 429 (BRT Build 3)

Variations to the typical mid-block section occur within these areas (for example, a narrower median or a sidewalk width less than 10') in order to minimize costs for structural modifications. The recommended configuration for each location is shown in the plan sheets included in Appendix C.

### Transition Areas

For the locations where the BRT service changes from curb-running to median-running operations, transitions are proposed. All transitions occur at signalized intersections. For buses exiting the median busway, a separate bus-only phase would be included at these locations to allow buses to move from the inside to outside travel lanes. For buses entering the median busway, a transition lane begins in advance of the signalized intersection.

Transitions are proposed at the following locations:

- Town Center Boulevard (Alternative 3)
- Reedy Creek Boulevard (Alternative 3, for routes to/from Walt Disney World)
- Celebration Place (Alternatives 2 and 3)
- Hoagland Boulevard (Alternatives 2 and 3)

### West US 192 Widening

During the development of the Short List of Alternatives, the Florida Department of Transportation accelerated the construction schedule for the widening of US 192 between SR 429 and the Osceola /Lake County Line from four to six general use lanes. This project will be completed as a design/build, with construction expected to begin in 2014. Though this program was not identified in the adopted Work Program, the improvement is assumed to be in place for purposes of conceptual engineering.

# BRT Infrastructure Options:

*Queue Jumps/Queue Bypasses and Transit Signal Priority*

## 1.0 Introduction and Objective

One major component of the analysis for BRT service along US 192 is the progression of BRT vehicles within the roadway infrastructure. Two of the methods/tools that are proposed to move BRT vehicles through the US 192 corridor as efficiently as possible are queue jumps/queue bypasses and transit signal priority (TSP). TSP is an operational strategy that facilitates the movements of in-service BRT vehicles through signalized intersections. Queue jumps/queue bypasses provide a mechanism to allow BRT vehicles to bypass traffic queues at intersections.

The purpose of implementing these strategies is to reduce bus delay and enhance the reliability of the BRT service by maintaining BRT schedules while also minimizing impacts to the existing normal traffic operations. The objective of this document is to describe the components of each treatment and demonstrate the benefits and constraints of each.

## 2.0 Transit Signal Priority[1]

TSP along the mainline of a roadway is the process of altering the signal timing to give a priority or advantage to transit operations. TSP modifies the normal signal operation process to better accommodate transit vehicles ***within the coordinated operation of the signal system*** along a corridor. It should be noted that TSP is different from signal preemption, which interrupts normal signal operation to accommodate special events.

The usual TSP treatment is a relatively minor adjustment of phase split times at a traffic signal. The green phase serving the approaching bus may start sooner or stay green a little longer, so that the bus delay approaching the intersection

[1] TCRP Report 118: Bus Rapid Transit Practitioner's Guide

will be reduced or eliminated. The lengthened transit phase split time is recovered on the following signal cycle so that the corridor signal coordination timing plan can be maintained.

## Communicating with the Signal System

TSP systems can be manually implemented by the bus operator or automatically implemented using on-board technology. The latter is the preferred method because it eliminates the human factor requiring the operator to remember to activate the emitter.

The main types of automatic detection include:

- Optical detection can be used to transmit requests from buses to the traffic signal controller. Optical detection is widely used for emergency vehicle preemption;
- Inductive loop–based systems use an inductive loop embedded in the pavement and a transponder mounted on the underside of the transit vehicle to distinguish transit vehicles from other traffic;
- Detection systems based on global positioning system (GPS) technologies or radio frequency (RF) systems are also used.

## Prioritization Strategies

TSP strategies include passive, active, and real-time priority.

- **Passive strategies** attempt to accommodate buses through the use of pre-timed modifications to the signal system that occur whether or not a bus is present. Passive strategies can utilize bus operations data, such as bus travel times along street segments, to derive enhanced signal timing coordination plans.
- **Active strategies** adjust the signal timing after a bus is detected approaching the intersection. Depending on the capabilities of the signal control equipment and the presence of bus location or passenger loading detection equipment on board the bus, TSP may be either unconditional or conditional.
  - ***Unconditional strategies*** provide priority whenever a bus arrives.
  - **Conditional strategies** use AVL or passenger-counting equipment to decide whether to provide priority for a given bus based on if and by how much the bus is behind schedule and/or how many people are on board. These strategies also take into account how recently priority was given to another bus at the intersection. *Conditional priority is most commonly accepted as an initial TSP application in a corridor, assuming that buses would be issued priority only if they are behind schedule or have a certain number of persons on board the bus.*
- **Real-time** or **adaptive strategies** consider both bus and general traffic arrivals at an intersection or network of intersections. Such strategies require specialized equipment that is capable of optimizing signal timings in

the field to respond to current traffic conditions and bus locations. The green time can be advanced or extended within any signal cycle.

## Types of Signal Priority[2]

The four types of traffic signal priority are the following:

1. **Early Green** priority is granted when a bus is approaching a red signal. The red signal is shortened to provide a green signal sooner than normal.
2. **Green Extend** priority is granted when a bus is approaching a green signal that is about to change. The green signal is extended until the bus passes through the intersection.
3. **Free Hold** priority is used to hold a signal green until the bus passes through the intersection during non-coordinated (free) operation.
4. **Phase Call** brings up a selected transit phase that might not normally be activated. This option is typically used for queue jumper operation or a priority left-turn phase.

## Conditions of Application

TSP is typically applied when there is significant traffic congestion and, hence, bus delays along a roadway. Studies have found that TSP is most effective at signalized intersections operating under level of service (LOS) D and E conditions with a volume-to-capacity ratio (*v/c*) between 0.80 and 1.00. Under oversaturated traffic conditions (*v/c* greater than 1.00), long vehicle queues prevent buses from getting to the intersection soon enough to take advantage of TSP without disrupting general traffic operations.

A basic guideline is to apply TSP when there is an estimated reduction in bus delay with negligible change in general traffic delay. Given this condition, the net total person delay (on both buses and general traffic) should decrease with application of TSP at a particular intersection or along an extended corridor. Increases in general traffic delay associated with TSP have been shown to be negligible, ranging in most cases from 0.3% to 2.5%.

For TSP to be most effective, bus stops should be located on the far side of signalized intersections so that a bus activates the priority call and travels through the intersection and then makes a stop.

Prior to implementation of TSP within the US 192 Study corridor, the development of a Concept of Operations (ConOps) and Requirements Document will be required to define the components and plan of the TSP system. The requirements of this plan development are set-forth by US DOT.

[2] TCRP Report 90 – Bus Rapid Transit, Volume 2: Implementation Guidelines

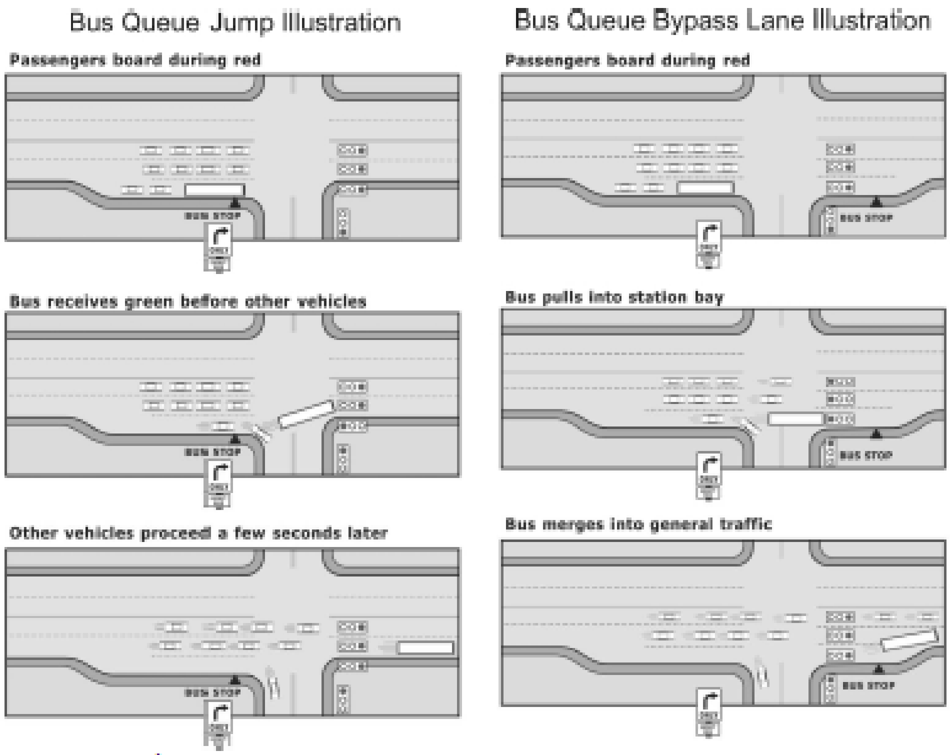
## 3.0 Queue Jumps/Queue Bypass Lanes[3]

BRT vehicles can bypass traffic queues at intersections through either the application of a "queue jump" or "bypass lane." With a **queue jump**, the bus would enter either a right-turn lane or a separate lane developed for buses only between the through and right-turn lane and then stop on the near side of the intersection. A separate, short bus signal phase would then be provided to allow the bus an early green to move into the through lane ahead of general traffic. Typically, green time from the parallel general traffic movement is reduced to accommodate the special bus signal phase, which typically is only 3 to 4 seconds. With a **queue bypass lane**, the bus would not have a separate signal phase but would continue through the intersection into a far-side stop before pulling back into general traffic. Queue bypasses require constant enforcement. Both types of bypass treatments are shown in Figure 1 below.

With a queue jump, the bus stop (if there is one at a particular intersection) needs to be on the near side, as the bus (if TSP is being used) would trigger a separate signal phase after it serves a stop. With a bypass lane, the stop should be on the far side, to reduce the conflict with right-turn traffic. With a queue jump, the typical type of bus detection is either a loop located in the pavement of a right-turn lane or separate bus lane on the near side of the intersection (just short of the stop bar or crosswalk) or video detection.

[3] TCRP 118/TCRP 90 Volume 2

**Figure 1**




Source: TCRP Report 118

## Traffic Signal Interaction

Sometimes TSP treatments are coupled with dedicated queue bypass lanes, to provide a special "buses only" or an "right turn only" signal (to clear right turners so that BRT vehicle may proceed); however, queue jumps or bypass lanes are generally applied as an alternative to mainline TSP.

Where TSP treatments are used, an actuated transit phase is triggered that only occurs when a bus is detected at the intersection for the queue jump phase. This special lead phase gives BRT vehicles trying to queue jump or utilize the bypass lanes an early green signal so they can go around general use traffic and then merge back into traffic.

## Geometry Needs

With either a queue jump or bypass lane treatment, a right-turn lane or separate lane for buses must be provided. A separate lane is essential where there are heavy right turns that move on special phases. This lane should be of sufficient length to allow the buses to bypass the general traffic queue at the intersection most of the time. On a roadway with existing shoulders, a queue jump or bypass lane treatment can be developed assuming the shoulder is of sufficient width (10 feet minimum) and pavement design to accommodate bus traffic.

Queue jump and bypass lane treatments are most effective ***where the bypass/right-turn lane is long enough to bypass the general traffic queue*** and/or ***the right-turn volume in the right-turn lane is relatively low***.

### Likely Impacts/Effectiveness

By allowing a bus to bypass general traffic queuing at a signalized intersection, bus travel time is reduced with improved service reliability. The extent of bus travel time savings will depend on the extent of general traffic queuing at a signalized intersection, the extent to which a bypass treatment can be developed to bypass the general traffic queue, and the magnitude of right-turn traffic if the queue bypass uses such a lane (and also whether or not free right turns are allowed from the right-turn lane).

Bus travel time savings are reduced if the right-turn lane traffic volume is heavy and there is limited opportunity for free rights or right turns on red. Application of bus queue jumps has been shown to produce 5% to 15% reductions in travel time for buses through intersections.

### Bus Gating

One other bus bypass option is gating. This technique involves stopping non-priority traffic short of the intersection while the priority traffic (buses) proceeds to the main stop line. As the signal turns green, the buses proceed ahead of non-priority traffic. A bus advance area before the main signalized intersection is used to store buses and give them entry into the main intersection *in advance* of queued traffic. A set of pre-signals holds general purpose traffic, allowing buses to advance around the general traffic queue.

## 3.0 Florida Examples

A sampling of Florida locations where these treatments are being used or are planned for implementation is included below.

### TSP

- Broward County
  - TSP at 50 intersection on Pines/Hollywood and Broward Boulevards.
  - Average time savings of 4 minutes during the AM peak period due to TSP – a 12% reduction in travel times. On-time performance improved from 66.7 to 75%.

    - During the PM peak travel time and signal delay were similar with and without TSP activated.
- HART MetroRapid (Tampa)
    - MetroRapid service planned to operate in mixed traffic.
    - Will use TSP to give buses longer green lights.
    - Also evaluating queue jumps along alignment.

## Queue Jumps

- SR 7 Queue Jump Demonstration Project
    - SR 7 (6-Lane divided) at Prospect Road (4-lane undivided)
    - Far side stop
    - Key bus routes running north/south (along SR 7)
    - Intersection already equipped withTSP software/hardware
    - Estimated cost of equipment (signalhead, ped signal heads, misc wiring, etc.) - $45,000.

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**Memorandum**

To: Lynx Team

Date: February 18, 2013

Project No.: 61694

From: Mark Bertoncini

Re: Lynx BRT Median Alternatives

**Purpose:** To develop relative cost differences between two (2) conceptual median running Bus Rapid Transit (BRT) guide way alternatives along US 192 between US 27 and Hoagland Boulevard. See Figure No. 1.

The project team has developed two (2) typical sections for constructing a median running BRT along the US 192 study corridor. The first alternative requires reconstruction of the existing median to provide a 28' guide way and 2-16' landscaped areas with a proposed curb to curb width of 126' consisting of the following:

- 6-11' Travel Lanes
- 2-14' Guide Ways (includes 4' separator)
- 2-16' Landscaped Buffer Areas

The second alternative maintains the existing median and utilizes the existing inside travel lane as the guide way and widens to the outside to accommodate the improvements. The proposed curb to curb width is 116' consisting of the following:

- 6-11' Travel Lanes
- 22' landscaped median
- 2-14' Guide Ways (includes 2-2' separators)

Both alternatives require widening to the outside of the existing pavement to maintain the existing 6-lane typical section for travel lanes. See Figure Nos. 2 and 3 for a graphical depiction of the two (2) alternative typical sections.

For the purpose of this analysis, two assumptions have been made as follows:

1. The section of US 192 between Hoagland Boulevard and Celebration Avenue was selected as a representative segment of the study corridor, approximately 5.6 miles;
2. The relative cost differences are based upon the improvements within the pavement area (curb to curb). Each alternative is assumed to have the same associated costs beyond the curb.

The existing typical section for this segment is 96’ in width (curb to curb), See Figure No. 4, and sits within a 200’ right-of-way and consists of the following:

- 6-11’ travel lanes
- 2-4’ Paved Shoulders
- 22’ Median

The study area has seven (7) proposed stops along the segment as follows:

1. Celebration Place (off-line station)
2. Celebration Avenue
3. Holiday Trail
4. Poinciana Boulevard
5. Lake Cecile Drive
6. Siesta Lago Drive
7. Old Vineland Road

The alignment for the two (2) proposed alternative typical sections were drawn graphically for the segment between Celebration Avenue and Holiday Trail, See Figure Nos. 5 and 6, in order to provide a visual aid to provide a better understanding of the proposed improvements.
Based on the above, following is a summary of the relative improvements needed:

Alternative No. 1 – Bus Way with Landscaped 16’ Medians
The existing median and 38’ of the existing pavement (19’ each side of the median) must be removed and reconstructed to construct the bus way. To accommodate the 3 thru traffic lanes, the pavement from the curb lane must be widened 19’. Theoretically, 14’ of the existing pavement structure will remain in place, which is unrealistic to try and salvage. Based on this, the entire cross section will need to be reconstructed.

Alternative No. 2 – Bus Way within Existing Median
This alternative will require the outside curb lane to be widened 14’ to accommodate the median bus way. The existing median and travel lanes will remain and not require reconstruction.
The following Table illustrates the required modifications to the roadway associated with each alternative typical section:

| **Description** | **Alt No. 1** | **Alt No. 2** | **% Increase** |
|---|---|---|---|
| Pavement Demolition Required | 66’ | None | 100% |
| Median Demolition | 22’ | None | 100% |
| New Landscape Median | 32’ | None | 100% |
| Modify Existing Landscape Median | None | 22’ | 0% |
| New Pavement Construction | 94’ | 28’ | 350% |

**Conclusion**

The additional work required to construct Alternative No. 1 over Alternative No. 2 will not only result in increased construction costs, construction time will be longer, traffic impacts will be greater due to more complex construction sequencing, and longer impacts to the retail/tourist community will occur.

When comparing relative construction costs between the alternatives, the curb to curb improvements for Alternative No. 1 could cost as much as 2.2 times Alternative No. 2 or upwards of $10M more over the 5.6 mile study section. When applied to the entire corridor length, the cost will be considerable more. We will evaluate that cost as we develop the alignment alternative throughout the project corridor.

It is therefore recommended Alternative No. 2 be the preferred alternative.

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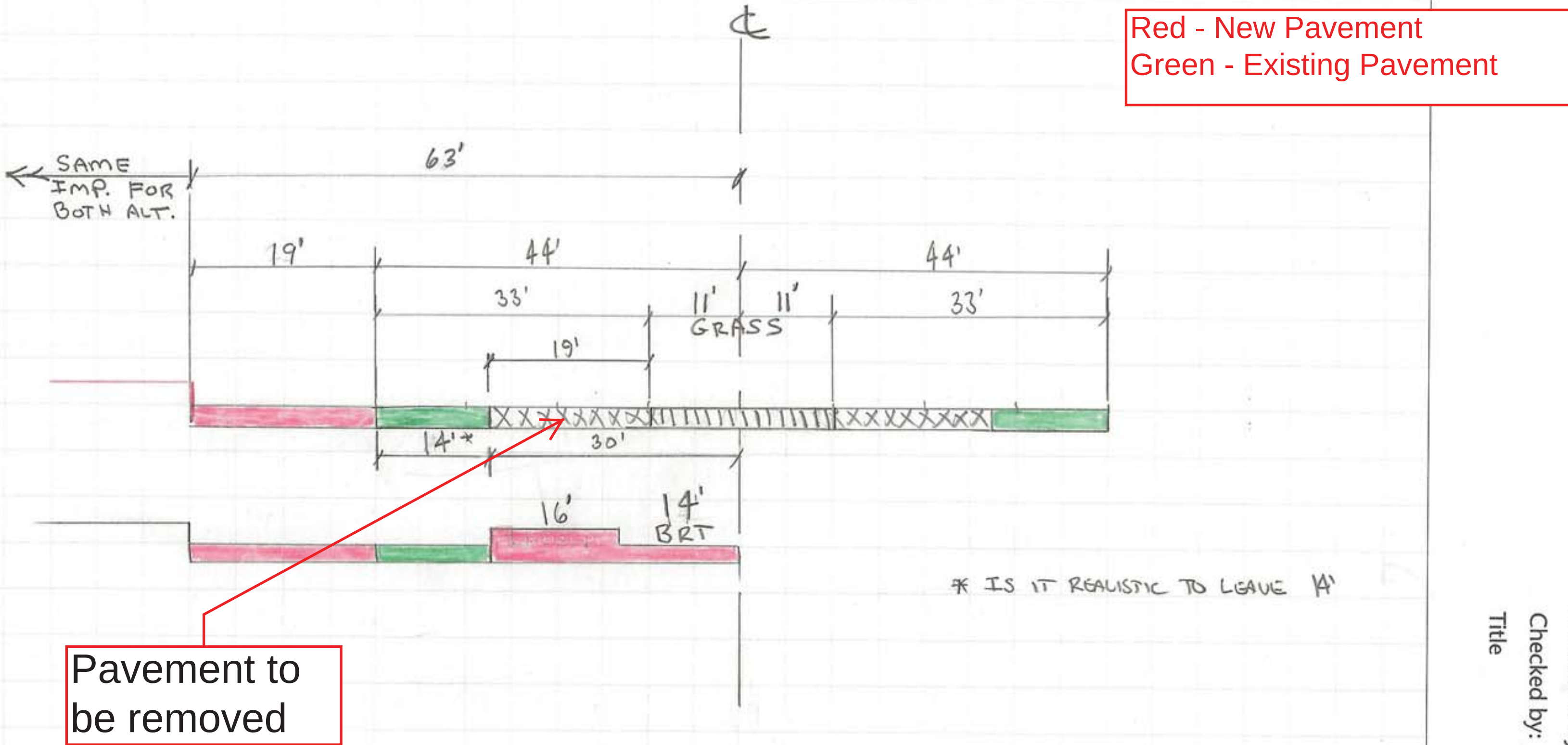


# CENTER BUSWAY ALT NO. 1

NEW PAVEMENT = 19+14 = 33'
NEW LANDSCAPE = 16'

COST / LF

| | | | | |
|---|---|---|---|---|
| PAVEMENT - (33' x 1) ÷ 9 SF/SY | = | 3.7 SY/LF | x $ 40/SY | = $ 148 |
| CURB - 2 LF | = | 2 LF/LF | x $ 25/LF | = $ 50 |
| LANDSCAPE - (16x1) ÷ 9 SF/SY | = | 1.8 SY/LF | x $ 10/SY | = $ 18 |
| | | | | $ 216/LF |
| | | | x 2 = | $432/LF |

**VHB** *Computations*

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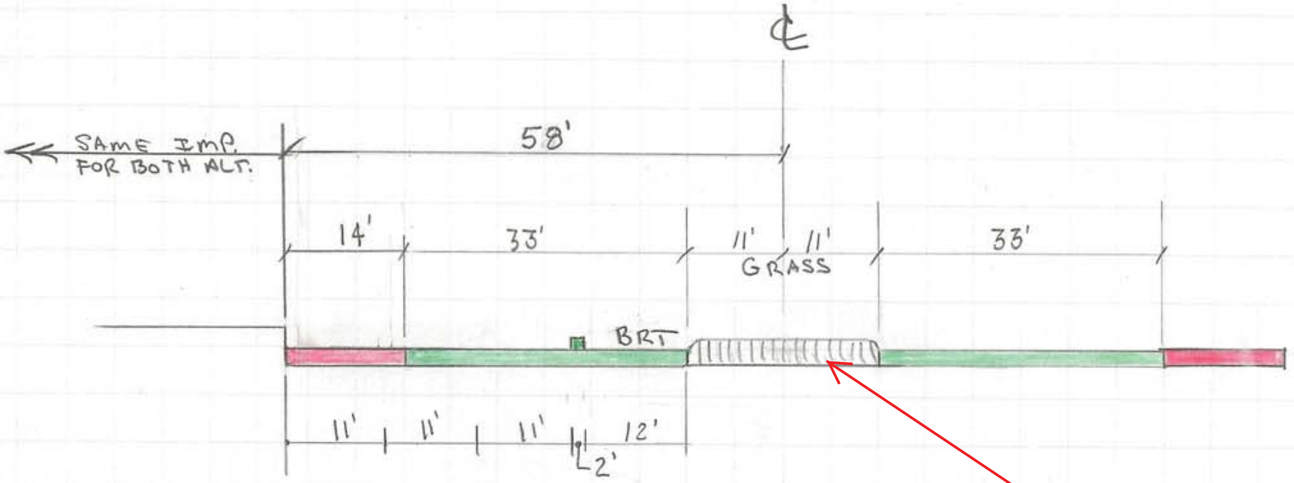


CENTER BUSWAY ALT NO. 2

NEW PAVEMENT = 14'
NEW SEPARATOR = 2'

COST /LF

PAVEMENT = $(14' \times 1) \div 9^{SF}/SY = 1.6\ ^{SY}/LF$ @ \$40/SY = \$64

SEPARATOR = $= 2\ ^{LF}/LF$ @ \$30LF = \$60

\$124/LF

X2 = \$248/LF

**VHB** *Computations*

Project: | Project #
Location: | Sheet of
Calculated by: | Date:
Checked by: | Date:
Title

ALT NO 1

11 miles x 5280' x $432 = $25.1M

ALT NO 2

11 miles x 5280 x $248 = $ 14.4M

Δ = $10.7M

COST REFLECTS DIFFERENCES IN PAVED AREAS, NOT ENTIRE IMPROVEMENT. ASSUME WORK BEYOND THE CURBLINE IS THE SAME FOR BOTH ALTERNATIVES.
I HAVE NOT LOOKED AT TRAFFIC IMPACTS AND MOT.