Development of Guidelines for Implementation of Freight and Transit Signal Priorities in Urban Corridors

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Project Information

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Stakeholders

- Florida Department of Transportation, Central Office, Public Transit Office
- Florida Department of Transportation, District 4, Freight and Multimodal Operations Office
- Broward Metropolitan Planning Organization
- City of Fort Lauderdale
Presentation Overview

• Introduction
  • Transit Signal Priority
  • Freight Signal Priority

• Literature Review

• Research Objectives

• Research Methodology

• Results
  • Developed Guidelines
  • Validation
  • Evaluation

• Conclusions
  • Key Takeaways
  • Recommendations

Source: https://daseuropeanautohaus.com
Introduction

- **Increase** in worldwide **freight** transport.
- Strongest expected growth is from **60%** in 2016 to **78%** in 2045 for **road transport**.
- Goods carried by **truck** is expected to grow **30%** between 2016 and 2045.
- More **passenger** vehicles and **inner-city transportation** models due to **urbanization**.
- The **rise** in the number of all types of vehicles will make the roads even **more congested**.

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**Source:** Bureau of Transportation Statistics, 2018
Introduction

Peak Period Congestion on High-Volume Truck Portions of the National Highway System

2012

2045

Source: Bureau of Transportation Statistics
Traffic Congestion in urban areas

More
• queuing,
• number of stops,
• travel times, and
• delays.

Less
• mobility,
• safety,
• reliability, and
• efficiency.

Solution ✓
Innovation of the on-street traffic controllers
Signalized intersections

Disruption caused by signals

Results in Traffic inefficiencies

Solution ✓
Intelligent Transportation Systems (ITS) technologies
Transit Signal Priority (TSP)

Source: https://www.regina.ca/
Introduction Cont.

Trucks worsen the traffic network

Due to:
- Slow Dynamics,
- Acceleration/deceleration time

- Only one stop of a truck could create a backward moving shockwave that is responsible for up to two-thirds of the total energy loss at the intersections.
- Trucks have significant impact on
  - Increasing congestion,
  - Mobility of transit and other vehicles,
  - Reliability and efficiency of freight operations, and
  - Increasing the fuel consumption and CO₂ emissions.

Therefore, it is beneficial to all network, if the number of stops for trucks would be reduced.

Source: https://www.washingtonpost.com/
Transit Signal Priority

- Technology to detect approaching transit vehicles.
- Alters signal timings to provide priority control to transit vehicles.
- Transit vehicles typically spend 15% of their trip time waiting at traffic signals.
- Reducing this delay by an average of 40% would reduce the travel time of a 60-minute round trip to 55 minutes.
- More people will be encouraged to use public transit thereby roadway level of service will be improved.

Freight Signal Priority

- Technology to detect approaching trucks.
- Alters signal timings to provide priority control to freight vehicles.
- Truck congestion wastes $28 billion in time and fuel annually.
- By providing green light to the approaching trucks:
  - Reduction in high fuel consumption and high emissions resulting from a stop and go of a truck.
  - Reduction in high pavement wear due to the braking of a heavy truck.
Selected Literature Review

- Garrow and Machemehl (1999) “Development and Evaluation of Transit Signal Priority Strategies” utilized micro-simulation to provide recommendations for TSP parameters. Based on the results, the study provided guidelines for green extension/red truncated values for the off-peak and peak periods based on the cross-street saturation level, as shown in tables below.

<table>
<thead>
<tr>
<th>Cross street Saturation Level</th>
<th>Recommended Green Extension/Red Truncation Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.25</td>
<td>Unbounded</td>
</tr>
<tr>
<td>0.25-0.35</td>
<td>20 Seconds</td>
</tr>
<tr>
<td>0.35-0.70</td>
<td>10 Seconds</td>
</tr>
</tbody>
</table>

The evaluation was based on:
- type of transit route,
- transit usage, and
- time of day
Selected Literature Review

- Chada and Newland (2002) “Effectiveness of Bus Signal Priority” conducted a study to examine the impact of TSP on traffic operations to develop a guideline on when TSP is beneficial to implement. They conducted a survey of transit professionals on the effectiveness of the TSP. They proposed a pre-implementation checklist to determine the suitability of TSP for a certain corridor as shown in the table below.

Pre-Implementation Checklist Point System (Chada and Newland, 2002)

<table>
<thead>
<tr>
<th>Pre-Implementation Checklist</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Express bus service?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Express bus service during off peak?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Far-side bus stops?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Highly saturated cross streets over 1.0 v/s ratio?</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Heavy volume intersections in the network?</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Many instances of two transit vehicles approaching one intersection?</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Do you have AVL technology installed?</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on the points gathered from the criteria above, the recommendations for TSP were provided below:

Recommendation Based on Point (Chada and Newland, 2002)

<table>
<thead>
<tr>
<th>Point Range</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No recommendation</td>
</tr>
<tr>
<td>1 – 2</td>
<td>Changes needed for priority</td>
</tr>
<tr>
<td>3</td>
<td>Somewhat recommended</td>
</tr>
<tr>
<td>4</td>
<td>Recommendation to pursue priority</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>Strongly recommended</td>
</tr>
</tbody>
</table>
Selected Literature Review

  - benefit estimation,
  - feasibility assessment,
  - cost and budget assessment, and
  - return on investment analysis.

They also provided the concept of operation, a detail guidelines of TSP planning, design, implementation, maintenance, and evaluation process.
Selected Literature Review


The methodology considered delay per person as the measure of effectiveness of the TSP.

Their methodology is shown in the figure.


The guidelines considered the
- bus operation performance (speed, frequency, ridership),
- geometric and traffic conditions (bus stop location, slack time), and
- impact of signal priority (v/c).
Selected Literature Review

Freight Signal Priority: There are very limited literature available related to the implementation guidelines.

- Sunkari et al. (2001) “Minimizing Truck Stops at High-Speed Rural Signalized Intersections”
  - Using loop detectors and a classifier to identify trucks approaching the intersection.
  - Minimizing number of stops, traffic delay, and pavement wear while improving safety.

  - Using video sensors to detect, identify trucks, in order to ensure the efficient and safe movement of freight.

  - Developing a multi-agent systems (MAS) based on freight signal priority algorithm aiming to reduce network-wide energy and emissions.

- Zhao, Y. et al. (2016) “A Traffic Light Signal Control System with Truck Priority”
  - Proposing a new truck priority system evaluated on signalized urban intersections for benefitting freight movements by the positive effects of green extension on the trucks’ movements.
Selected Literature Review

  o Evaluated the simultaneous implementation of the FSP and the TSP through real-world case study on a micro-simulation platform.

• WSDOT (2019) “Freight or Truck Signal Priority” provided the following considerations for when the FSP should be considered for the implementation on a corridor:
  1. A corridor is an important freight route that is used by a lot of trucks (Truck routes near ports, industrial areas, or distribution centers).
  2. The approach to a traffic signal is uphill where the time to accelerate from a red light is longer.
  3. The approach to a traffic signal is downhill and trucks may have to brake harder to stop in time for a red light.

In addition, the WSDOT (2019) document identified the following benefits from the implementation of FSP:

• improves safety,
• reduces congestion,
• reduces road maintenance, and
• reduces emissions.
Transit Signal Priority and/or Freight Signal Priority

TSP and FSP may not be effective for
- all traffic conditions,
- signal controls, and
- geometric conditions

Therefore

Thorough research and analysis are needed before implementing TSP and/or FSP

- Existing literature provides a guideline on how to implement either TSP or FSP.


Source: [https://moveaustralia.com/](https://moveaustralia.com/)
Research Objectives

Problem Statement:

- Due to the heavy mixed traffic congestion on multi-modal corridors and the importance of having a smooth transit and freight movements, the idea of implementing FSP and TSP simultaneously has developed to mitigate the congestion on certain multi-modal corridors.

The primary objectives of this research are:

- To develop guidelines for transportation agencies to identify corridors where FSP and/or TSP are feasible to be implemented.

- To evaluate the effectiveness of FSP and TSP in improving the performance of freight movements and public transportation at the same time.
Research Methodology

- Case Study Selection
- Data Collection
  - Freight Operation
  - Transit Operation
- Base Model Development
- Calibration/Validation
  - BlueTOAD
  - VISSIM
- Selection of Scenarios

- Evaluation of Results
  - Travel Time
  - Delay
  - Literature Gap Analysis
  - Guidelines’ Fundamental Factors
  - Mathematical Model
- Method Implementation
- Decision Trees’ Scenarios
- FSP & TSP Checklist
- Single Intersection

- Guidelines Development
- Validation of Guidelines
- Validation Scenarios
- Evaluation of Results
  - Base
  - FSP
  - TSP
  - FSP & TSP
- Intersection by Intersection
  - Travel Time
  - Delay
Current and proposed methodology was applied on Sunrise Boulevard, Fort Lauderdale, Broward County, Florida

- 4.2 miles corridor,
- 20 signalized intersections,
- 5 bus routes – 4 buses per hour per direction
- High truck volumes

Source: Florida Traffic Online - FDOT

Source: Google Map
Research Methodology Cont.

Data Collection

• Peak-hour Volumes – Morning Peak
• Traffic Counts
  • Turning Movements
  • Vehicle Classification
• Truck Characteristics & Dynamics
• Transit Data
**Microsimulation Model**

- **Vissim Version 11**
  - Update existing Microsimulation model
- **Calibration - Validation Process**
  - Bluetooth Data Travel Time data
- **Implementation of Priorities**
  - Detection System
  - Signal Timing Adjustments

![Simulation Network](image-url)
Research Methodology Cont. – Simulation Network

South East Florida, Sunrise Boulevard: NW 31st Avenue - N Federal Highway
### Scenarios

- Freight Signal Priority (FSP)
- Conditional FSP Type I
- Conditional FSP Type II
- Transit Signal Priority (TSP)
- FSP & TSP
- Conditional FSP Type I/ TSP
- Conditional FSP Type II/ TSP

#### FHWA Vehicle Classifications

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motorcycles 2 axes, 2 or 3 tires</td>
<td><img src="image1.png" alt="Motorcycle Image" /></td>
</tr>
<tr>
<td>2</td>
<td>Passenger Cars 2 axes, can have 1- or 2-axis trailers</td>
<td><img src="image2.png" alt="Passenger Car Image" /></td>
</tr>
<tr>
<td>3</td>
<td>Pickups, Panels, Vans 2 axes, 4-tire single units Can have 1 or 2 axle trailers</td>
<td><img src="image3.png" alt="Pickup Image" /></td>
</tr>
<tr>
<td>4</td>
<td>Buses 2 or 3 axes, full length</td>
<td><img src="image4.png" alt="Bus Image" /></td>
</tr>
<tr>
<td>5</td>
<td>Single Unit 2-Axle Trucks 2 axes, 6 tires (dual rear tires), single-unit</td>
<td><img src="image5.png" alt="Truck Image" /></td>
</tr>
<tr>
<td>6</td>
<td>Single Unit 3-Axle Trucks 3 axes, single unit</td>
<td><img src="image6.png" alt="Truck Image" /></td>
</tr>
<tr>
<td>7</td>
<td>Single Unit 4 or More-Axle Trucks 4 or more axes, single unit</td>
<td><img src="image7.png" alt="Truck Image" /></td>
</tr>
<tr>
<td>8</td>
<td>Single Trailer 3- or 4-Axle Trucks 3 or 4 axles, single trailer</td>
<td><img src="image8.png" alt="Trailer Image" /></td>
</tr>
<tr>
<td>9</td>
<td>Single Trailer 5-Axle Trucks 5 axles, single trailer</td>
<td><img src="image9.png" alt="Trailer Image" /></td>
</tr>
<tr>
<td>10</td>
<td>Single Trailer 6 or More-Axle Trucks 6 or more axles, single trailer</td>
<td><img src="image10.png" alt="Trailer Image" /></td>
</tr>
<tr>
<td>11</td>
<td>Multi-Trailer 5 or Less-Axle Trucks 5 or less axles, multiple trailers</td>
<td><img src="image11.png" alt="Trailer Image" /></td>
</tr>
<tr>
<td>12</td>
<td>Multi-Trailer 6-Axle Trucks 6 axles, multiple trailers</td>
<td><img src="image12.png" alt="Trailer Image" /></td>
</tr>
<tr>
<td>13</td>
<td>Multi-Trailer 7 or More-Axle Trucks 7 or more axles, multiple trailers</td>
<td><img src="image13.png" alt="Trailer Image" /></td>
</tr>
</tbody>
</table>

Source: Federal Highway Administration
Major Street Analysis: Sunrise Boulevard

Average Travel Time (s) for All Vehicles - EB & WB Directions

- Base Model
- FSP
- Cond. FSP Type I
- Cond. FSP Type II
- TSP
- FSP/TSP Cond. FSP Type I / TSP
- Cond. FSP Type II / TSP

Average Travel Time (s) for Freight Vehicles - EB & WB Directions

- Base Model
- FSP
- Cond. FSP Type I
- Cond. FSP Type II
- TSP
- FSP/TSP Cond. FSP Type I / TSP
- Cond. FSP Type II / TSP

Average Travel Time (s) for Transit Vehicles - EB & WB Directions

- Base Model
- FSP
- Cond. FSP Type I
- Cond. FSP Type II
- TSP
- FSP/TSP Cond. FSP Type I / TSP
- Cond. FSP Type II / TSP
According to the literature, developing the guidelines for the efficient implementation of FSP and TSP should be based on different factors such as:

- V/C ratio,
- Slack time,
- Cross street facility type,
- Bus Occupancy,
- Bus Delay,
- Peak hour bus passenger by direction,
- Bus stop location,
- Truck weight, and
- Truck’s commodity.

Source: https://nacto.org/
Mathematical Model

In order to estimate the dollar values of the travel time of passengers and trucks, and the occupancy of passenger cars and transit vehicles, this study utilized the values of travel time and occupancies estimated for Florida by Hadi et al. (2019).

\[ C_i = \sum_j d_j \times \beta_j \times O_j \]

Where:
- \( C \) is the total cost of delay for a specific signal configuration \( i \),
- \( d \) is the delay for vehicle type \( j \),
- \( \beta \) is the value of travel time for vehicle type \( j \),
- \( O \) is the occupancy for vehicle type \( j \).

Values of \( \beta \), and \( O \) are provided in the table, and \( d \) is calculated from the simulation output.

The benefit \( (B) \) of a specific signal configuration \( (i) \) is calculated by:

\[ B_i = C_i - C_{no\ priority} \]
Single Intersection

- A simple isolated signalized intersection has been considered randomly for the analysis of the guideline.
- The configuration of the intersection is consisting of three lanes in the east-west direction (Major direction) and two lanes in the north-south direction (Minor direction).

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Major Road</th>
<th>Minor Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/C</td>
<td>1.0, 0.8, 0.6, 0.5</td>
<td>1, 0.8, 0.6</td>
</tr>
<tr>
<td>Freight Percentage</td>
<td>5%, 10%, 20%</td>
<td>5%, 10%, 20%</td>
</tr>
<tr>
<td>Transit Frequency per hour</td>
<td>3, 6, 12</td>
<td>3, 6, 12</td>
</tr>
</tbody>
</table>
Various scenarios have been modeled and analyzed based on:

- Traffic volume,
- freight percentage,
- and transit frequency

The simulation was run for 10 different signal configurations:

- Major Road TSP,
- Major Road FSP,
- Major road TSP+FSP,
- Minor road TSP,
- Minor road FSP,
- Minor road TSP+FSP,
- Major+Minor road TSP,
- Major+Minor road FSP,
- Major+Minor road TSP+FSP,
- No signal Priority.

### TSP/FSP Checklist

<table>
<thead>
<tr>
<th>TSP</th>
<th>FSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
<td>3.</td>
</tr>
<tr>
<td>4.</td>
<td>4.</td>
</tr>
<tr>
<td>5.</td>
<td>5.</td>
</tr>
</tbody>
</table>

1. Express Bus Service
2. Bus stop location at Far side or midblock. If not, then planning to relocate the bus stop locations
3. Agencies want to reduce transit delay and increase the reliability.
4. Important truck route
5. Uphill/downhill
6. Safety issues
7. Environmental issue
8. Agencies want to reduce freight delay and increase the reliability.
Results

Developed Guidelines
Developed Guidelines

• The guidelines developed in this study are based on the results from simulation modeling that estimate the impacts of signal priority.

1. Different vehicle classes are modeled in the simulation.
2. Their performance is calibrated to estimate the impacts of TSP, FSP, and the combination of both.
3. The acceleration/deceleration characteristics of freight vehicles were modeled properly.
Validation

1. Check the slack time availability at each intersection (slack Time ≥ 5 seconds). ✓
   \[ Slack Time = Cycle Time - All Pedestrian Clearance Time + Minimum Left-turn Green Times \]

2. Determine the application of priority on
   - major road ✓
   - minor road
   - both

3. Check the applicability of FSP and TSP on the selected direction based on FSP/TSP checklist.

<table>
<thead>
<tr>
<th>FSP</th>
<th>Checklist</th>
<th>Satisfied/Unsatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Important truck route</td>
<td>Satisfied ✓</td>
</tr>
<tr>
<td></td>
<td>2. Uphill/downhill</td>
<td>Unsatisfied</td>
</tr>
<tr>
<td></td>
<td>3. Safety issues</td>
<td>Satisfied ✓</td>
</tr>
<tr>
<td></td>
<td>4. Environmental issue</td>
<td>Satisfied ✓</td>
</tr>
<tr>
<td></td>
<td>5. Agencies want to reduce freight delay and increase the reliability.</td>
<td>Satisfied ✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TSP</th>
<th>Checklist</th>
<th>Satisfied/Unsatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Express Bus Service</td>
<td>Satisfied ✓</td>
</tr>
<tr>
<td></td>
<td>2. Bus stop location at Far side or midblock. If not, then planning to relocate the bus stop locations</td>
<td>Satisfied ✓</td>
</tr>
<tr>
<td></td>
<td>3. Agencies want to reduce transit delay and increase the reliability</td>
<td>Satisfied ✓</td>
</tr>
</tbody>
</table>
Results

Validation

4. Preparation of detailed simulation with these three priority strategies:
   - TSP Only
   - FSP Only
   - TSP and FSP

   **Travel Time Cost ($) at Different Signal Configuration**

<table>
<thead>
<tr>
<th></th>
<th>Base</th>
<th>FSP</th>
<th>TSP</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Travel Time Cost ($)</td>
<td>35,777,878</td>
<td>33,406,778</td>
<td>33,879,792</td>
<td>33,642,748</td>
</tr>
<tr>
<td>Benefit (%)</td>
<td>-</td>
<td>6.63%</td>
<td>5.31%</td>
<td>5.97%</td>
</tr>
</tbody>
</table>

- FSP provides the highest benefit (6.63%)
- TSP and FSP could provide almost similar benefit (5.97%), while supporting these two modes of transportation.
- Thus, simultaneous implementation of FSP and TSP is the preferred alternative.
## Evaluation

### Major Street Travel Time Analysis

#### EB

<table>
<thead>
<tr>
<th>Segments</th>
<th>Base Car</th>
<th>Base Bus</th>
<th>HGV</th>
<th>FSP Car</th>
<th>FSP Bus</th>
<th>FSP HGV</th>
<th>TSP Car</th>
<th>TSP Bus</th>
<th>TSP HGV</th>
<th>FSP&amp;TSP Car</th>
<th>FSP&amp;TSP Bus</th>
<th>FSP&amp;TSP HGV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLK Jr Ave</td>
<td>272.90</td>
<td>319.75</td>
<td>243.57</td>
<td>195.99</td>
<td>255.11</td>
<td>162.57</td>
<td>274.74</td>
<td>312.09</td>
<td>246.46</td>
<td>179.37</td>
<td>256.17</td>
<td>144.88</td>
</tr>
<tr>
<td>NW 27 Ave</td>
<td>249.68</td>
<td>262.43</td>
<td>231.35</td>
<td>226.31</td>
<td>240.81</td>
<td>188.16</td>
<td>204.94</td>
<td>190.52</td>
<td>189.13</td>
<td>216.05</td>
<td>219.88</td>
<td>188.02</td>
</tr>
<tr>
<td>NW 24 Ave</td>
<td>233.05</td>
<td>195.87</td>
<td>223.44</td>
<td>170.38</td>
<td>137.61</td>
<td>162.57</td>
<td>198.31</td>
<td>110.46</td>
<td>190.95</td>
<td>157.19</td>
<td>118.48</td>
<td>147.83</td>
</tr>
<tr>
<td>I95</td>
<td>253.34</td>
<td>197.81</td>
<td>243.37</td>
<td>213.12</td>
<td>180.55</td>
<td>181.89</td>
<td>221.06</td>
<td>220.84</td>
<td>205.65</td>
<td>199.31</td>
<td>160.13</td>
<td>162.46</td>
</tr>
<tr>
<td>NW 16 Ave</td>
<td>178.71</td>
<td>140.19</td>
<td>177.49</td>
<td>139.84</td>
<td>155.07</td>
<td>142.41</td>
<td>171.45</td>
<td>146.12</td>
<td>154.38</td>
<td>140.02</td>
<td>137.28</td>
<td>147.63</td>
</tr>
<tr>
<td>NW 15 Ave</td>
<td>101.82</td>
<td>104.01</td>
<td>100.44</td>
<td>90.12</td>
<td>63.45</td>
<td>69.04</td>
<td>100.88</td>
<td>113.71</td>
<td>87.64</td>
<td>91.56</td>
<td>92.49</td>
<td>81.01</td>
</tr>
<tr>
<td>NW 9 Ave</td>
<td>187.53</td>
<td>194.12</td>
<td>153.05</td>
<td>135.99</td>
<td>117.80</td>
<td>85.57</td>
<td>182.49</td>
<td>133.01</td>
<td>169.29</td>
<td>126.50</td>
<td>109.43</td>
<td>104.47</td>
</tr>
<tr>
<td>NW 7 Ave</td>
<td>124.36</td>
<td>143.91</td>
<td>108.01</td>
<td>122.63</td>
<td>122.92</td>
<td>96.99</td>
<td>134.06</td>
<td>136.78</td>
<td>115.93</td>
<td>116.02</td>
<td>153.99</td>
<td>98.18</td>
</tr>
<tr>
<td>N Andrews Ave</td>
<td>90.02</td>
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# Results

## Evaluation

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Results

Major Street Analysis – Travel Time

Average Total Travel Time - EB

Average Total Travel Time - WB
Major Street Analysis – Average Delay

Average Delays (s) for All Vehicles - EB & WB Directions
Results

**Minor Street Analysis**

- In most of the study area:
  
  Unconditional priority (FSP & TSP) would result in the most significant delays for crossing street traffic compared with the base model.

  TSP scenario had the lowest travel times and delays since priorities were only established for transit vehicles with lower volumes than trucks and passenger vehicles.
Minor Street Analysis

- The box plot for the base model is smaller, meaning less variation in delays.
- The taller box plot of FSP & TSP priority means greater variation in the results.
- The box plot for the FSP and the TSP differs due to the number of vehicles that they provide priority for (buses versus trucks).
- The median of delay for TSP is less than that of FSP because of the differences in the volumes of vehicles.
Conclusions

Key Takeaways

1. Implementation of FSP and TSP presented a **positive effect** on the freight and transit movements in terms of **travel time** and the **delays**.

2. Scenario with **highest mobility** improvements was the combination of both FSP & TSP.

3. To implement a signal priority, the intersection should have **slack time more than 5 seconds**.

4. As expected, **minor street** usually experiences **higher delay** than the major street and providing priority in such direction **results a higher benefit**.

5. This study developed **separate guidelines** for various comprehensive conditions such as TSP and FSP implementation, TSP implementation, FSP implementation all for **Major Road** and the same cases for the **Minor Road**.

6. The Guideline established relates to those projects where **freight signal is considered**, and **freight delay** plays an important role in the analysis of corridor benefits.

7. This study has also found that **TSP and/or FSP** may **not be effective** for all traffic, signal control, and **geometric conditions**, thus in some cases the **simulation modeling** is of great importance.
Recommendations

• Identify the aspects of freight movements that have the greatest impact on the traffic network.

• Develop scenarios with different priority weights on FSP and TSP for evaluating their collaboration.

• Preparing priority based on the commodities of freight vehicles.

• Implementation of FSP and TSP strategies on the main arterials of a wider network for evaluating their impact.

• Deployment of FSP and TSP strategies in certain corridors based on the developed guidelines from this study. Deployment could consist of
  • Assessment of the feasibility of simultaneous implementation of Freight & Transit signal priority on the selected arterial network.
  • Deployment and application of FSP and/or TSP based on the results of same objective.
  • Evaluation of the effectiveness of the newly developed implementation.
Thank you for your attention!

Questions or Suggestions?

Taraneh Ardalan
Researcher
Freight Mobility Research Institute (FMRI)
Department of Civil, Environmental, and Geomatics Engineering

E-mail: tardalan2018@fau.edu