Improving Reliability and Efficiency on Urban Transportation Networks through Freight and Transit Signal Priority Strategies

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Freight transport holds a fundamental role on the economic system in the United States

- 8.9% of the Nation’s economic activity as measured by gross domestic product (GDP),
- 4% of total US labor force in freight transport,
- 63 tons of goods per American each year,
- 49.3 million tons - daily average freight movements,
- 52.5 billion dollars - freight value

Percentage of Freight Movements by Mode of Transport

Source: Bureau of Transportation Statistics (2017)
Peak Period Congestion on High-Volume Truck Portions of the National Highway System

2012

2045

Source: Bureau of Transportation Statistics
Major Flows by Truck to, from and within Florida

2012

2045

Source: Bureau of Transportation Statistics
Forecasting conditions at Florida until 2045

**Ton-Mile**

- **All Transport Modes**
- **Trucks**

**Value of Freight**

- **All Transport Modes**
- **Trucks**

*Source: Freight Analysis Framework Data*
• The presence of trucks around urban areas worsens problematic situations on the traffic network.
  ➢ Slow Dynamics.
  ➢ Additional time for acceleration/deceleration.
  ➢ Often stops due to signal heads.

• Trucks have significant impact on increasing congestion and affecting
  ➢ the transit and vehicle movements,
  ➢ the reliability and efficiency of freight operations.

Source: Federal Highway Administration
Objectives

• Prioritization of the freight and transit movements along an urban multimodal corridor.

• Simultaneous implementation of Freight & Transit Signal Priority
  ➢ improve freight mobility,
  ➢ provide good transit services,
  ➢ deteriorate the congested traffic conditions.
Methodology

Signal Priorities / Concept of Operations → Case Study → Data Collection

Priority Strategies / Scenarios → Calibration - Validation → Microsimulation Model

Results / Measures of Effectiveness

Y
N
• Intelligent Transportation Systems (ITS) components.
  ➢ unconditional preemption, (emergency vehicles, railroad crossing, drawbridge)
  ➢ transit signal priority (TSP),
  ➢ freight signal priority (FSP).

• **Transit Signal Priority** provides priority to transit vehicles by adjusting signal timing and phasing.

• **Freight Signal Priority** is the descendant of TSP, that uses similar technology with TSP to favor the movements of freight vehicles.
TSP & FSP strategy aims to

- increase travel time reliability for freight and transit vehicles,
- enhance safety at intersections, and
- provide environmental benefits.

Priority strategies

- Passive priority
- Active priority
- Priorities operating on real-time
Signal Priorities Cont.

**RED TRUNCATION**
Bus approaches red signal

**GREEN EXTENSION**
Bus approaches green signal

Signal controller detects bus; terminates side street green phase early

Signal controller detects bus; extends current green phase

Bus proceeds on green signal

Bus proceeds on extended green signal

Source: Smith, H. R et al., 2005
Concept of Operations

• Support the system engineering process.

• Accommodate different ➢ technology platforms,
  ➢ products,
  ➢ agency preferences.

• Accommodate multiple priority requests from different modes and fleets at the same.

• Priority based on ➢ vehicle mode,
  ➢ vehicle operation attributes,
  ➢ position,
  ➢ speed,
  ➢ traffic and weather conditions,
  ➢ local policies.
• Distributed Architecture
  ➢ Sensor Classification
  ➢ AVI/AVL Technology - Controller Cabinet
  ➢ Approaching Priority Vehicle
  ➢ Vehicle and Cabinet
  ➢ Vehicle and Cabinet Utilizing Connected Vehicle (CV) Technologies

• Central Architecture
  ➢ Fleet Management Center
  ➢ Fleet Management Center and TMC
  ➢ Extension of previous option with CV send information and priority level through cell communications to center
Sunrise Boulevard: NW 31st Avenue - N Federal Highway

Source: Florida Traffic Online & Google maps
Sunrise Boulevard at Fort Lauderdale, Broward County

- 4.2 miles corridor,
- 22 signalized intersections,
- 5 bus routes – 4 buses per hour per direction
- high truck volumes
- school zone area – speed limit 25mph
Data Collection

- Peak-hour Volumes
- Traffic Counts and Turning Movements
  - Vehicle Classification
- Truck Characteristics & Dynamics
- Transit Data

Source: Federal Highway Administration
Microsimulation Model

- PTV VISSIM microsimulation platform, Version 10
  - Update existing Microsimulation model

- Calibration - Validation process
  - Bluetooth Data Travel Time data

- Implementation of Priorities
  - Detection System
  - Signal Timing Adjustments

Source: Manual RBC – PTV VISSIM
**Scenarios**

- **Base Model:** Current traffic conditions – No Priority Strategy
- **Scenario I:** Freight Signal Priority – FSP
- **Scenario II:** Conditional Freight Signal Priority Type I
- **Scenario III:** Conditional Freight Signal Priority Type II
- **Scenario IV:** Transit Signal Priority
- **Scenario V:** Freight Signal Priority / Transit Signal Priority
- **Scenario VI:** Conditional Freight Signal Priority Type I / Transit Signal Priority
- **Scenario VII:** Conditional Freight Signal Priority Type II / Transit Signal Priority

*Source: Federal Highway Administration*
Results - Average Travel Time

Average Travel Time for All Vehicles - EB & WB Directions

Priority Strategies

Average Travel Time for Freight Vehicles - EB & WB Directions

Priority Strategies

Average Travel Time for Transit Vehicles - EB & WB Directions

Priority Strategies
## Results – Average Delay

### Average Delay for All Vehicles - EB & WB Directions

<table>
<thead>
<tr>
<th>Priority Strategies</th>
<th>Average Delay (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Model</td>
<td>400.00</td>
</tr>
<tr>
<td>FSP Cond.</td>
<td>300.00</td>
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<tr>
<td>Cond. FSP Type I</td>
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<tr>
<td>Cond. FSP Type II</td>
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</tr>
<tr>
<td>TSP FSP Cond.</td>
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<tr>
<td>Cond. FSP Type I / TSP</td>
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<tr>
<td>Cond. FSP Type II / TSP</td>
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### Average Delay for Freight Vehicles - EB & WB Directions

<table>
<thead>
<tr>
<th>Priority Strategies</th>
<th>Average Delay (s)</th>
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</thead>
<tbody>
<tr>
<td>Base Model</td>
<td>600.00</td>
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<tr>
<td>FSP Cond.</td>
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<tr>
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</tr>
<tr>
<td>Cond. FSP Type II</td>
<td>300.00</td>
</tr>
<tr>
<td>TSP FSP Cond.</td>
<td>700.00</td>
</tr>
<tr>
<td>Cond. FSP Type I / TSP</td>
<td>600.00</td>
</tr>
<tr>
<td>Cond. FSP Type II / TSP</td>
<td>500.00</td>
</tr>
</tbody>
</table>

### Average Delay for Transit Vehicles - EB & WB Directions

<table>
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<th>Priority Strategies</th>
<th>Average Delay (s)</th>
</tr>
</thead>
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<tr>
<td>FSP Cond.</td>
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<tr>
<td>Cond. FSP Type I</td>
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</tr>
<tr>
<td>Cond. FSP Type II</td>
<td>600.00</td>
</tr>
<tr>
<td>TSP FSP Cond.</td>
<td>1000.00</td>
</tr>
<tr>
<td>Cond. FSP Type I / TSP</td>
<td>900.00</td>
</tr>
<tr>
<td>Cond. FSP Type II / TSP</td>
<td>800.00</td>
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</tbody>
</table>

### Priority Strategies

- **Eastbound Direction**
- **Westbound Direction**
Results – Average Side Street Delay

Average Delay (s) on Side Streets - Unconditional Priorities

<table>
<thead>
<tr>
<th>Side Streets</th>
<th>Average Delay (s)</th>
<th>Base Model</th>
<th>FSP</th>
<th>TSP</th>
<th>FSP/TSP</th>
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</thead>
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<td>NW 31th Ave</td>
<td>0.00</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>50.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW 24th Ave</td>
<td>100.00</td>
<td>100.00</td>
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<td></td>
</tr>
<tr>
<td>I-95</td>
<td>150.00</td>
<td>150.00</td>
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<td></td>
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<tr>
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<td>NW 7th Ave</td>
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<td>Andrews Ave</td>
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<tr>
<td>NE 4th Ave</td>
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<tr>
<td>N Flager Dr</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>N Federal Hwy (West)</td>
<td>22;34</td>
<td>Base Model</td>
<td>FSP</td>
<td>TSP</td>
<td>FSP/TSP</td>
</tr>
<tr>
<td>NE 9th Ave</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>NE 10th Ave</td>
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<tr>
<td>NE 12th Ave</td>
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<tr>
<td>NE 15th Ave</td>
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<td></td>
</tr>
<tr>
<td>NE 16th Ter</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NE 17th Way</td>
<td></td>
<td></td>
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<tr>
<td>N Federal Hwy (East)</td>
<td>22;34</td>
<td>Base Model</td>
<td>FSP</td>
<td>TSP</td>
<td>FSP/TSP</td>
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<tr>
<td>NE 20th Ave</td>
<td></td>
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</tbody>
</table>
Average Green Time Duration (s) - Unconditional Priorities - EB Direction

- Signalized Intersections:
  - NW 31th Ave
  - NW 27th Ave
  - NW 24th Ave
  - I-95
  - NW 18th Ave
  - NW 15th Ave
  - NW 9th Ave
  - NW 7th Ave
  - Andrews Ave
  - NE 4th Ave
  - N Flager Dr
  - N Federal Hwy (West)
  - NE 9th Ave
  - NE 10th Ave
  - NE 12th Ave
  - NE 15th Ave
  - NE 16th Ter
  - NE 17th Way
  - NE 20th Ave
  - N Federal Hwy (East)

- Average Green Time Duration (s):

- Base Model
- FSP
- TSP
- FSP/TSP

- EB Direction

- Results – Average Green Time Duration
Results – Average Green Time Duration

Average Green Time Duration (s) - Conditional Priorities - EB Direction

Signalized Intersections:
- NW 31th Ave
- NW 27th Ave
- NW 24th Ave
- I-95
- NW 16th Ave
- NW 15th Ave
- NW 9th Ave
- NW 7th Ave
- Andrews Ave
- NE 4th Ave
- N Flager Dr
- N Federal Hwy (West)
- NE 9th Ave
- NE 10th Ave
- NE 12th Ave
- NE 15th Ave
- NE 16th Ter
- NE 17th Way
- N Federal Hwy (East)
- NE 20th Ave

Average Green Time (s)

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

Conditional Priorities and EB Direction

- Cond. FSP Type I
- Cond. FSP Type II
- Cond. FSP Type I / TSP
- Cond. FSP Type II / TSP
Results – Average Green Time Duration

Average Green Time Duration (s) - Unconditional Priorities - WB Direction

Signalized Intersections

- NW 31th Ave
- NW 27th Ave
- NW 24th Ave
- I-95
- NW 16th Ave
- NW 15th Ave
- NW 9th Ave
- NW 7th Ave
- Andrews Ave
- NE 4th Ave
- N Flager Dr
- N Federal Hwy (West)
- NE 9th Ave
- NE 10th Ave
- NE 12th Ave
- NE 15th Ave
- NE 16th Ter
- NE 17th Way
- N Federal Hwy (East)
- NE 20th Ave

Average Green Time (s)

Base Model - FSP - TSP - FSP/TSP

26/34
Results – Average Green Time Duration

Average Green Time Duration - Conditional Priorities - WB Direction

[Graph showing average green time duration for various signalized intersections and conditional priority models.]

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

Signalized Intersections:
- NW 31st Ave
- NW 27th Ave
- NW 24th Ave
- I-95
- NW 16th Ave
- NW 15th Ave
- NW 9th Ave
- NW 7th Ave
- Andrews Ave
- NE 4th Ave
- N Flager Dr
- N Federal Hwy (West)
- NE 9th Ave
- NE 10th Ave
- NE 12th Ave
- NE 15th Ave
- NE 16th Ave
- NE 17th Way
- N Federal Hwy (East)
- NE 20th Ave
Conclusions

- The evaluation of the FSP and TSP scenarios presented a positive effect on the freight and transit movements.
- The travel time and the delays were reduced significantly.
- The impact of the priority strategies on side street delays differs depending on the strategy applied (FSP & FSP/TSP presented the highest delays).
- Scenario with highest mobility improvements was the FSP/TSP.
- Scenario with significant mobility improvements and low impact on the side roads was the Conditional FSP Type I / TSP.
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.

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

- Develop and propose guidelines for the efficient implementation of FSP and TSP.
Thank you for your attention!

Questions?