FREIGHT MOBILITY RESEARCH INSTITUTE
College of Engineering and Computer Science
Florida Atlantic University

FMRI Webinar Lecture Series

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

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Project Information

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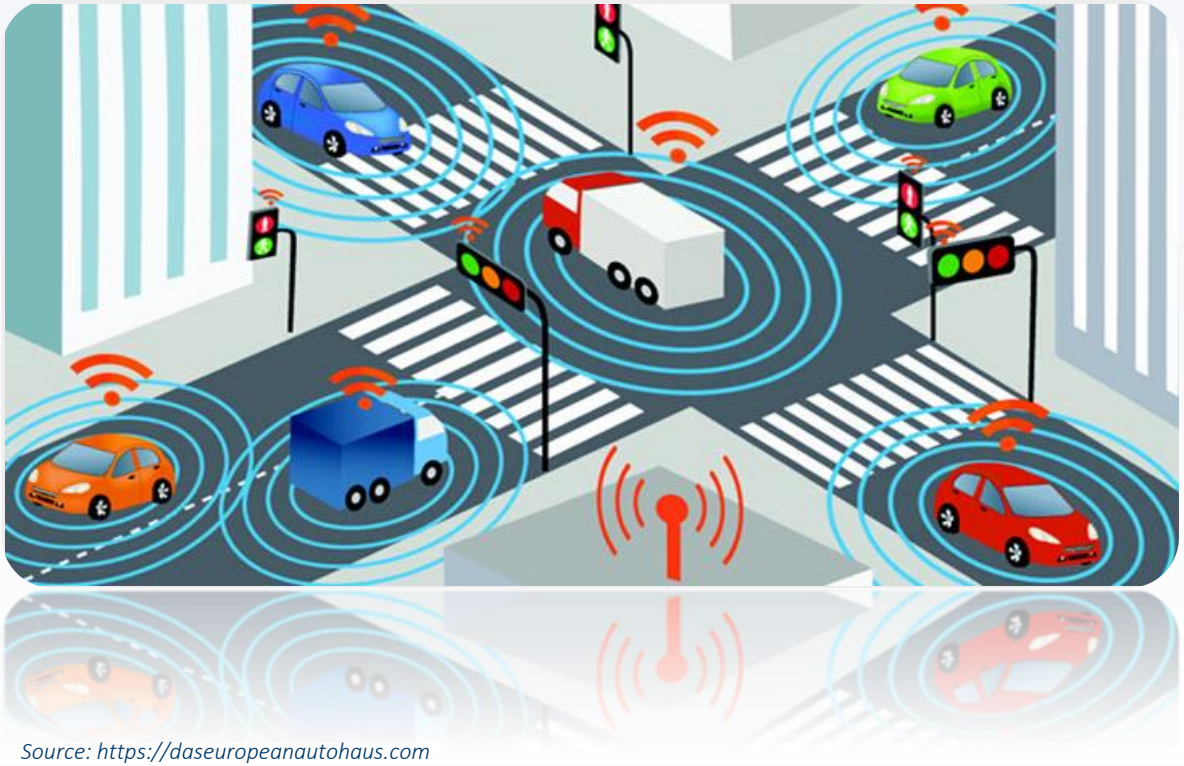
Stakeholders

- 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

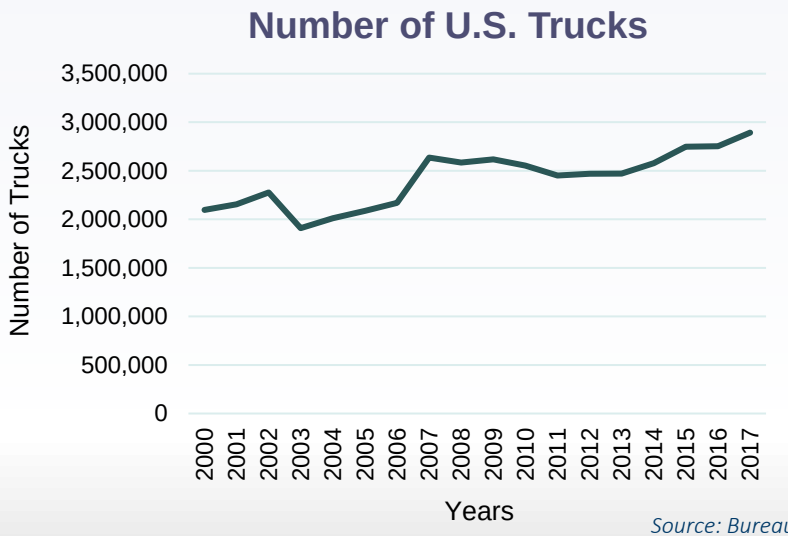
- Introduction
  - Transit Signal Priority
  - Freight Signal Priority
- Literature Review
- Research Objectives
- Research Methodology
- Results
  - Developed Guidelines
  - Validation
  - Evaluation
- Conclusions
  - Key Takeaways
  - Recommendations

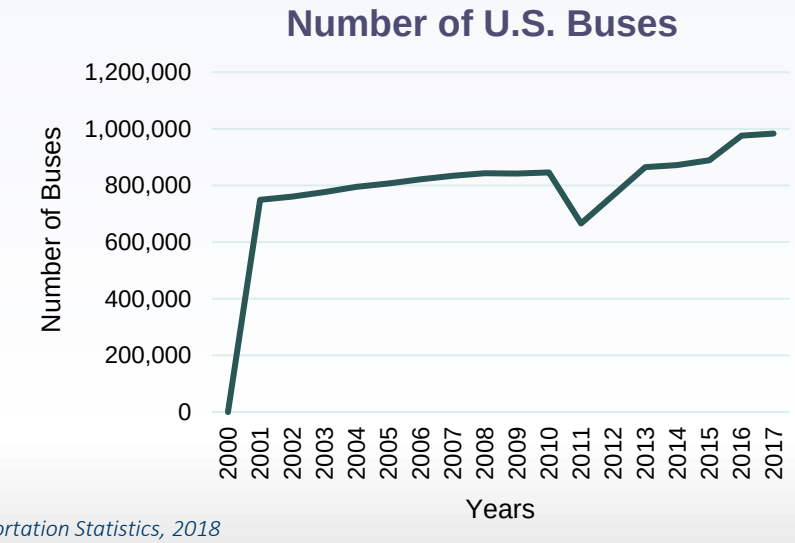


Source: https://daseuropeanautohaus.com

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**.



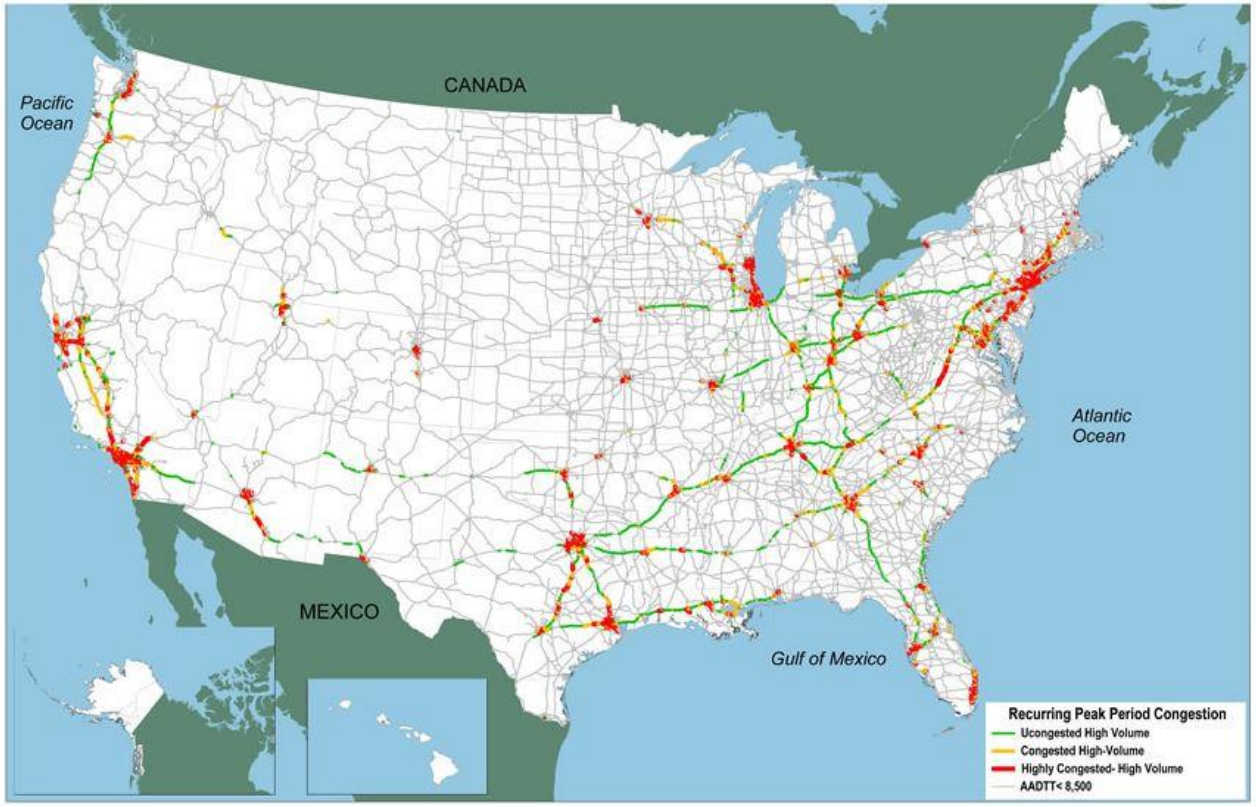


Source: Bureau of Transportation Statistics, 2018

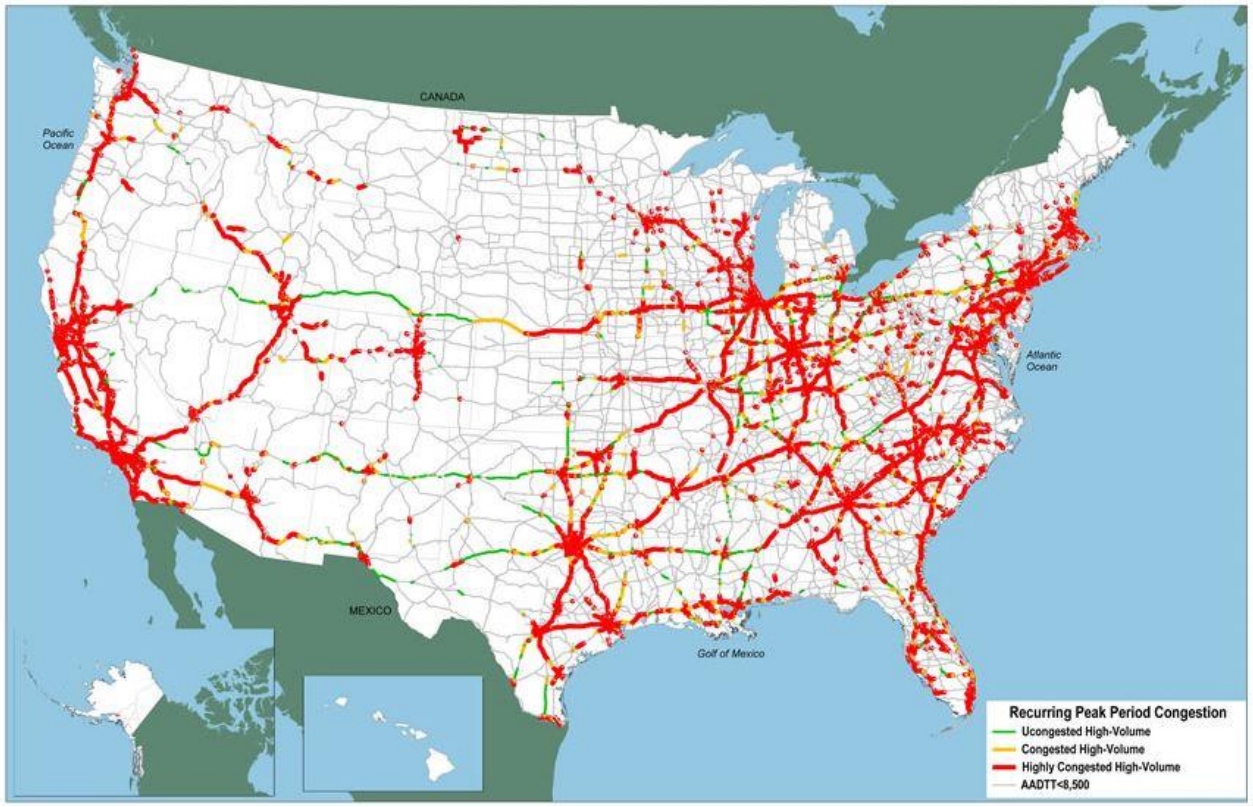
Introduction

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

2012



2045



Source: Bureau of Transportation Statistics

Introduction Cont.

Traffic Congestion
in urban areas

Results in

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

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

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

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)

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 **CO_2 emissions**.

Source: https://www.washingtonpost.com/

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

Introduction Cont.

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.

Guideline for Off-Peak Hour (Garrow and Machemehl, 1999)

Cross street Saturation Level	Recommended Green Extension/Red Truncation Length
<0.25	Unbounded
0.25-0.35	20 Seconds
0.35-0.70	10 Seconds

Guideline for Peak Hour (Garrow and Machemehl, 1999)

Cross Street Saturation	Green Extension = 10 seconds	Green Extension = 20 seconds
Saturation Level = 0.8	Minimal	Moderate
Saturation Level = 0.9	Moderate	Significant
Saturation Level = 1.0	Significant	Significant

** Minimal Impacts:* *Signal priority appropriate.*
**Moderate Impacts:* *Signal priority should be used with caution;*
** Significant Impacts:* *Signal priority should be avoided.*

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)

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

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

Recommendation Based on Point (Chada and Newland, 2002)

Point Range	Recommendation
0	No recommendation
1 – 2	Changes needed for priority
3	Somewhat recommended
4	Recommendation to pursue priority
> 4	Strongly recommended

Selected Literature Review

- Smith, H. R., Hemily, B., & Ivanovic, M. (2005). "*Transit Signal Priority (TSP): A Planning and Implementation Handbook*" developed a TSP planning and implementation handbook specifying the need for

  - 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

- Hu et al. (2014) "*Transit Signal Priority with Connected Vehicle Technology*" proposed a new TSP logic utilizing **connected vehicle technology**.

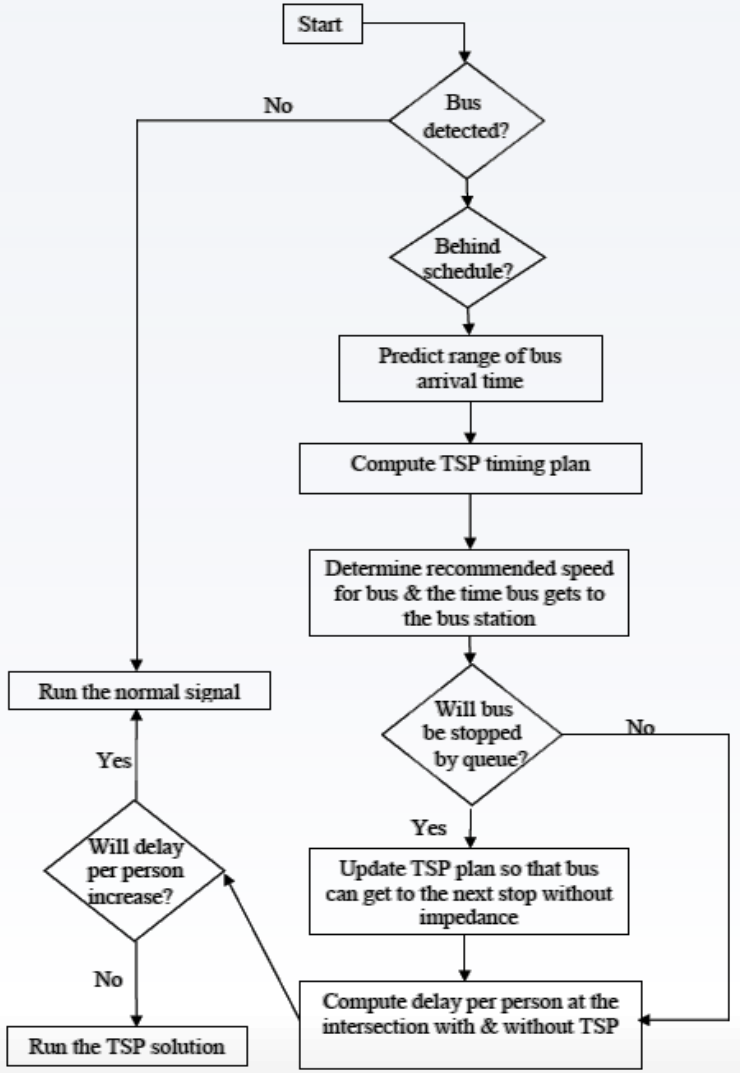
The methodology considered **delay per person** as the measure of effectiveness of the TSP.

Their methodology is shown in the figure.

- Kaisar et al. (2018) "*Guidance for Identifying Corridor Conditions that Warrant Deploying Signal Priority and Queue Jump*" developed guidelines for **TSP deployment** based on simulation results.

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.
- Saunier et al. (2009) "*A Prototype System for Truck Signal Priority (TkSP) Using Video Sensors*"
  - Using **video sensors** to detect, **identify trucks**, in order to ensure the **efficient** and **safe** movement of freight.
- Kari et al. (2014) "*Eco-friendly Freight Signal Priority Using Connected Vehicle Technology: A Multi-agent Systems Approach*"
  - 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

- Manta, S. (2019) "*Evaluation of Freight and Transit Signal Priority Strategies for Improving Transportation Operations in Urban Corridors*"
  - 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.

Selected Literature Review

Transit Signal Priority and/or Freight Signal Priority

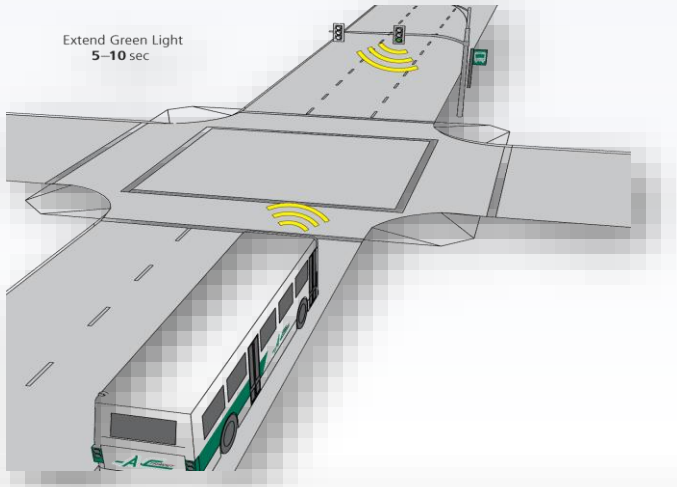
TSP and FSP
may not be effective for

- 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: http://www.actransit.org/

or

Source: https://imoveaustralia.com/

Research Objectives

Problem Statement:

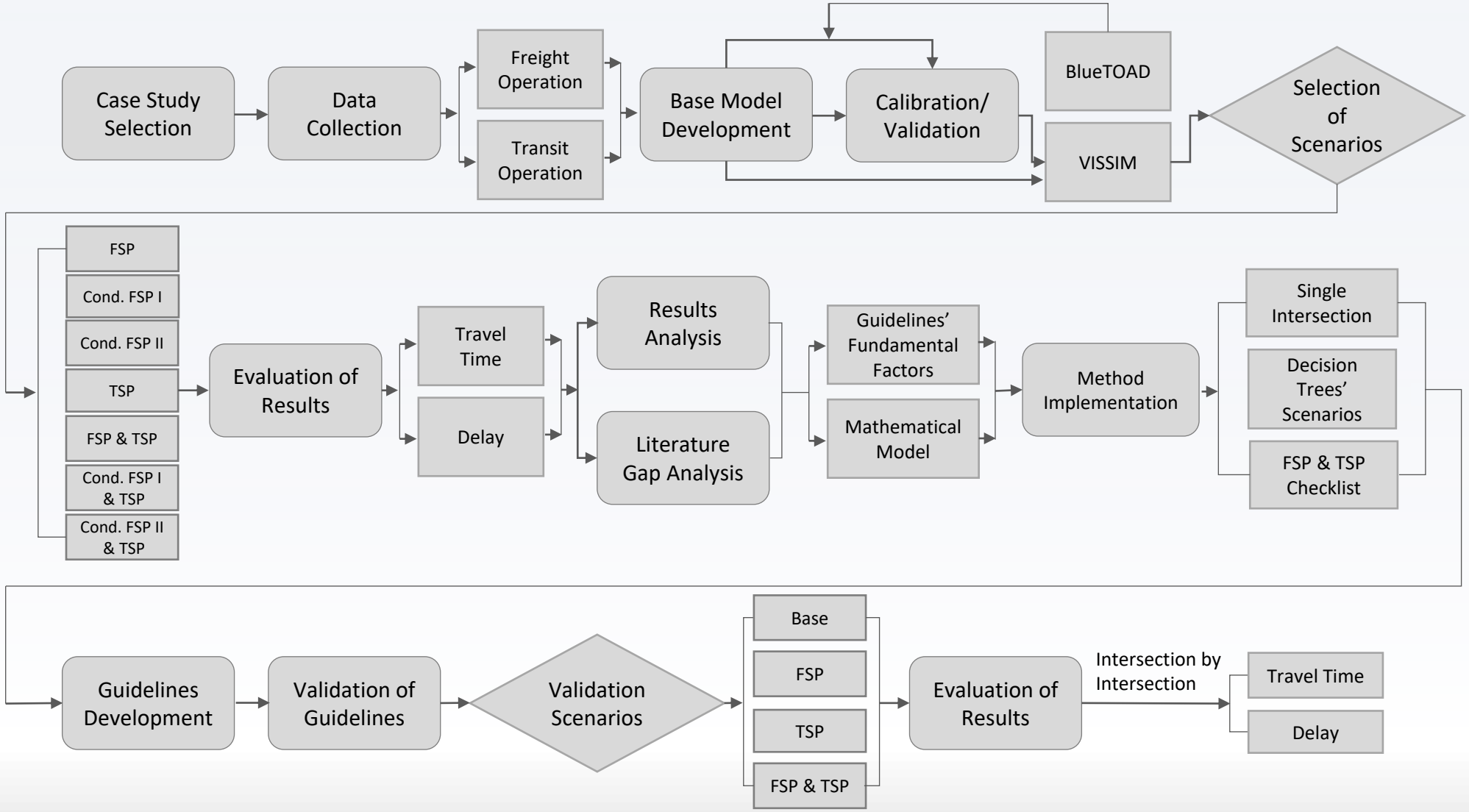
- Due to the **heavy mixed traffic** congestion on **multi-modal corridors** and the **importance of having a smooth transit and freight movements**, the idea of implementing FSP and TSP **simultaneously** has developed to mitigate the congestion on certain multi-modal corridors.

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.

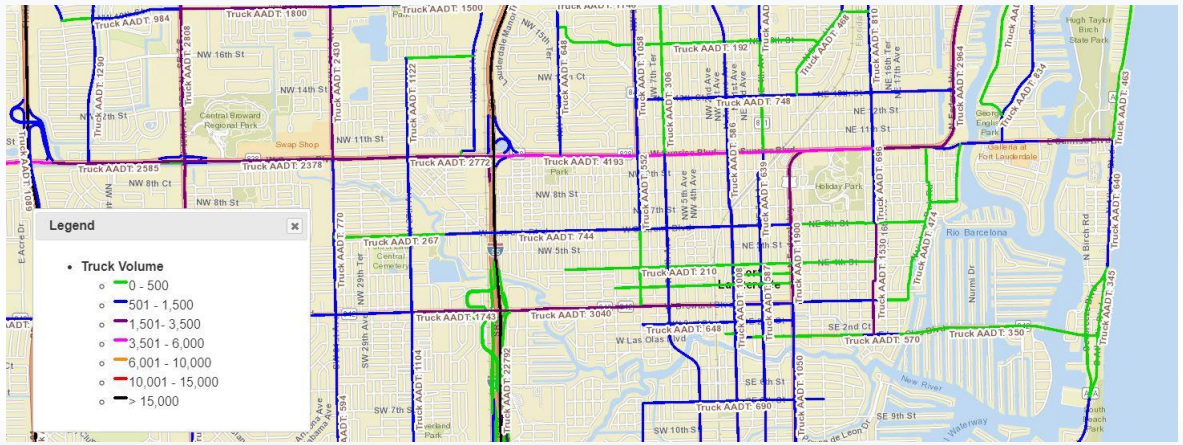
Research Methodology



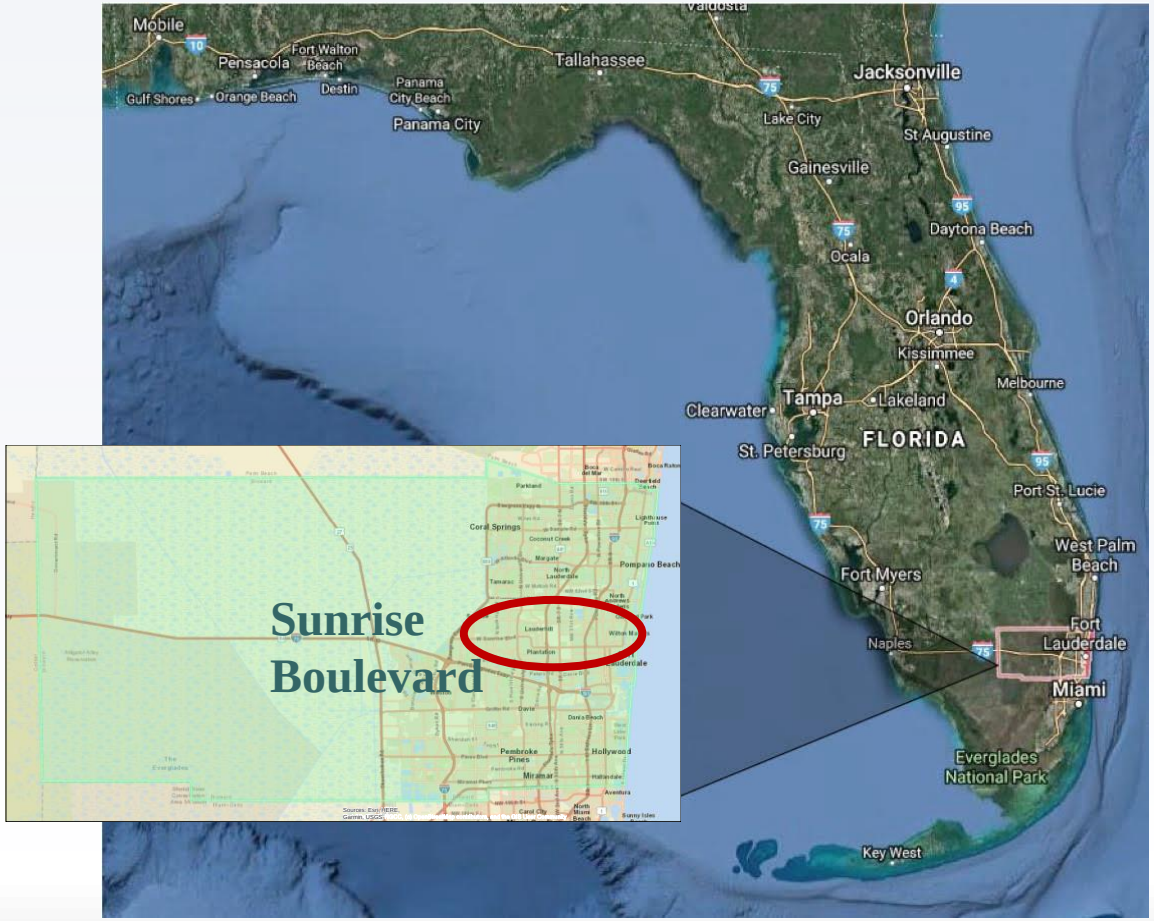
Research Methodology Cont. - Case Study

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

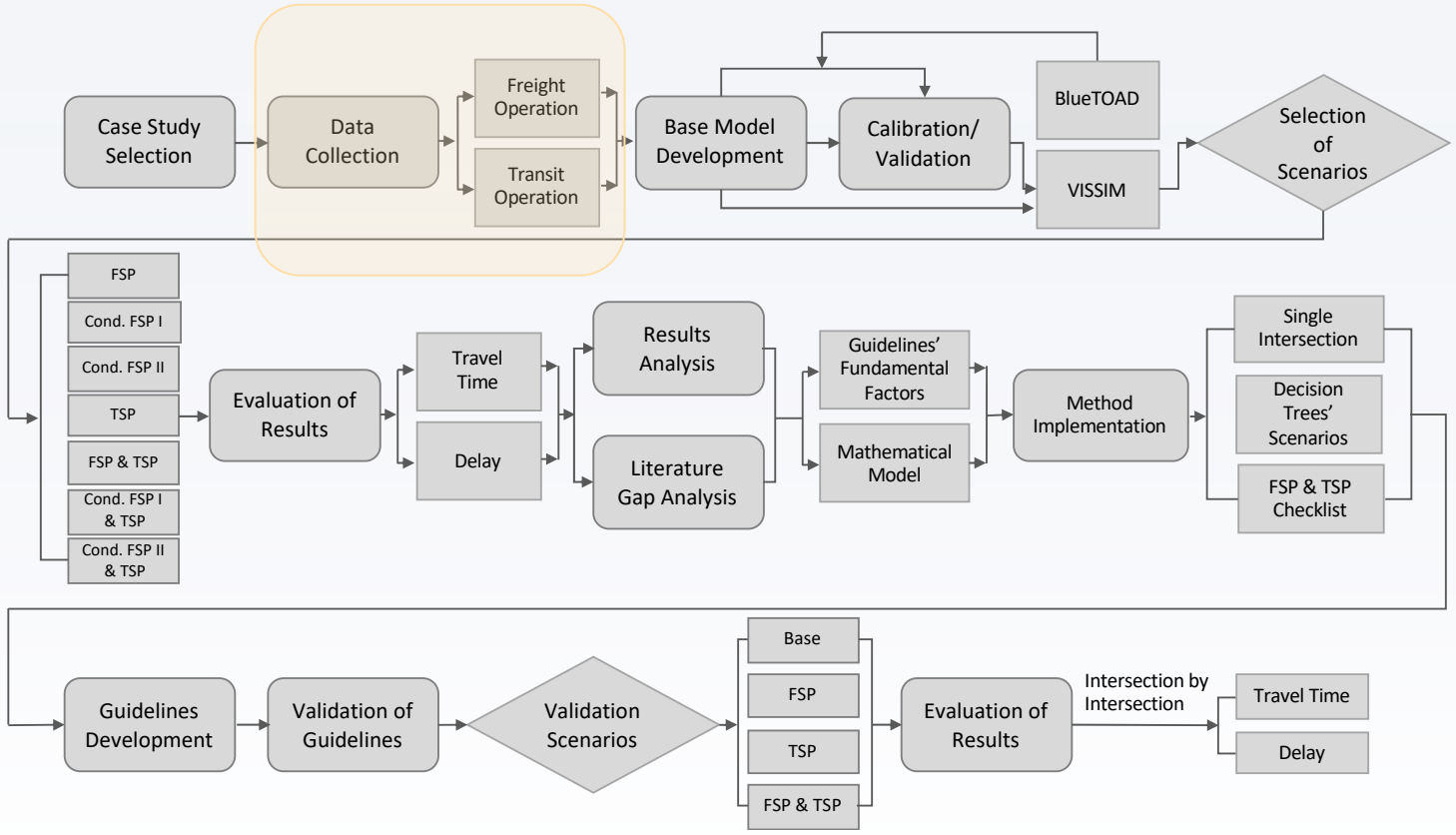


Source: Google Map

Research Methodology Cont.

Data Collection

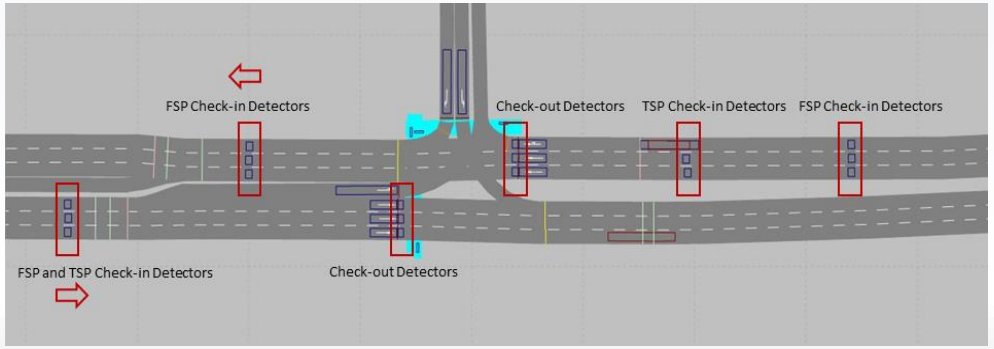
- Peak-hour Volumes – Morning Peak
- Traffic Counts
  - Turning Movements
  - Vehicle Classification
- Truck Characteristics & Dynamics
- Transit Data



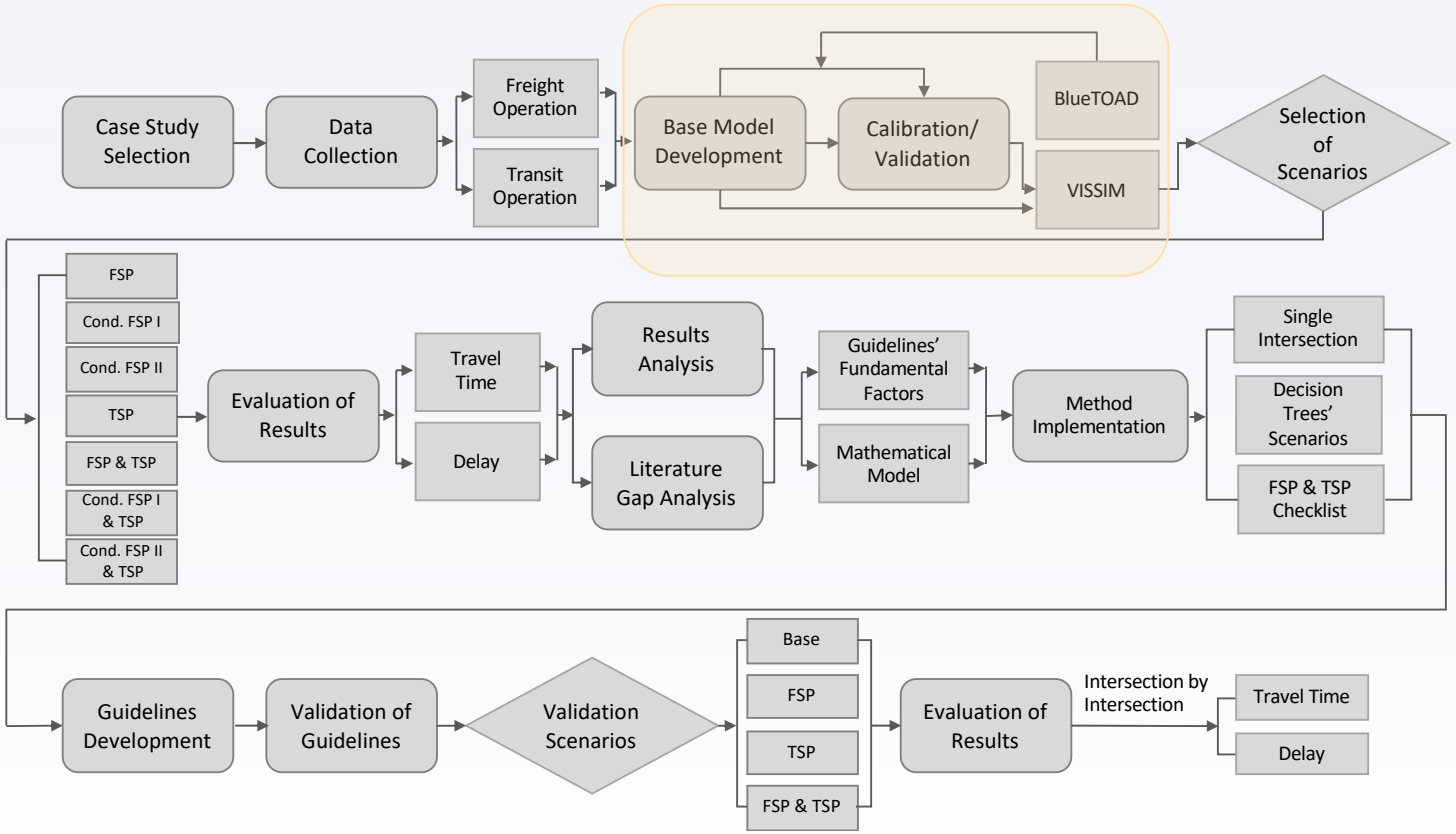
Research Methodology Cont.

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

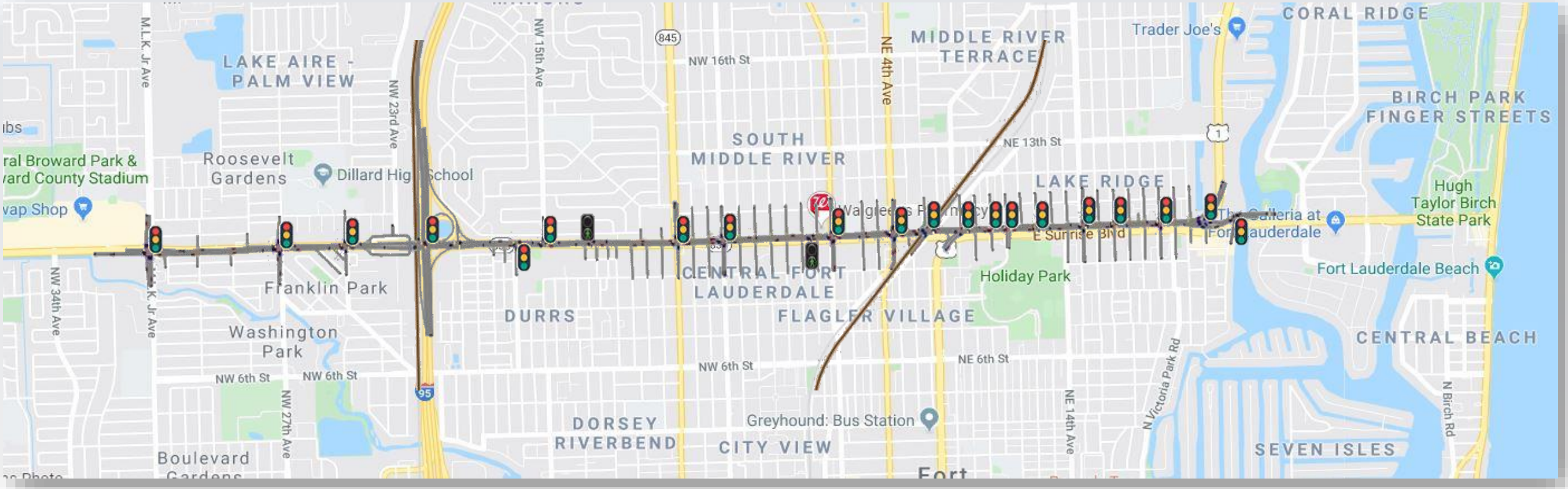


Simulation Network



Research Methodology Cont. – Simulation Network

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

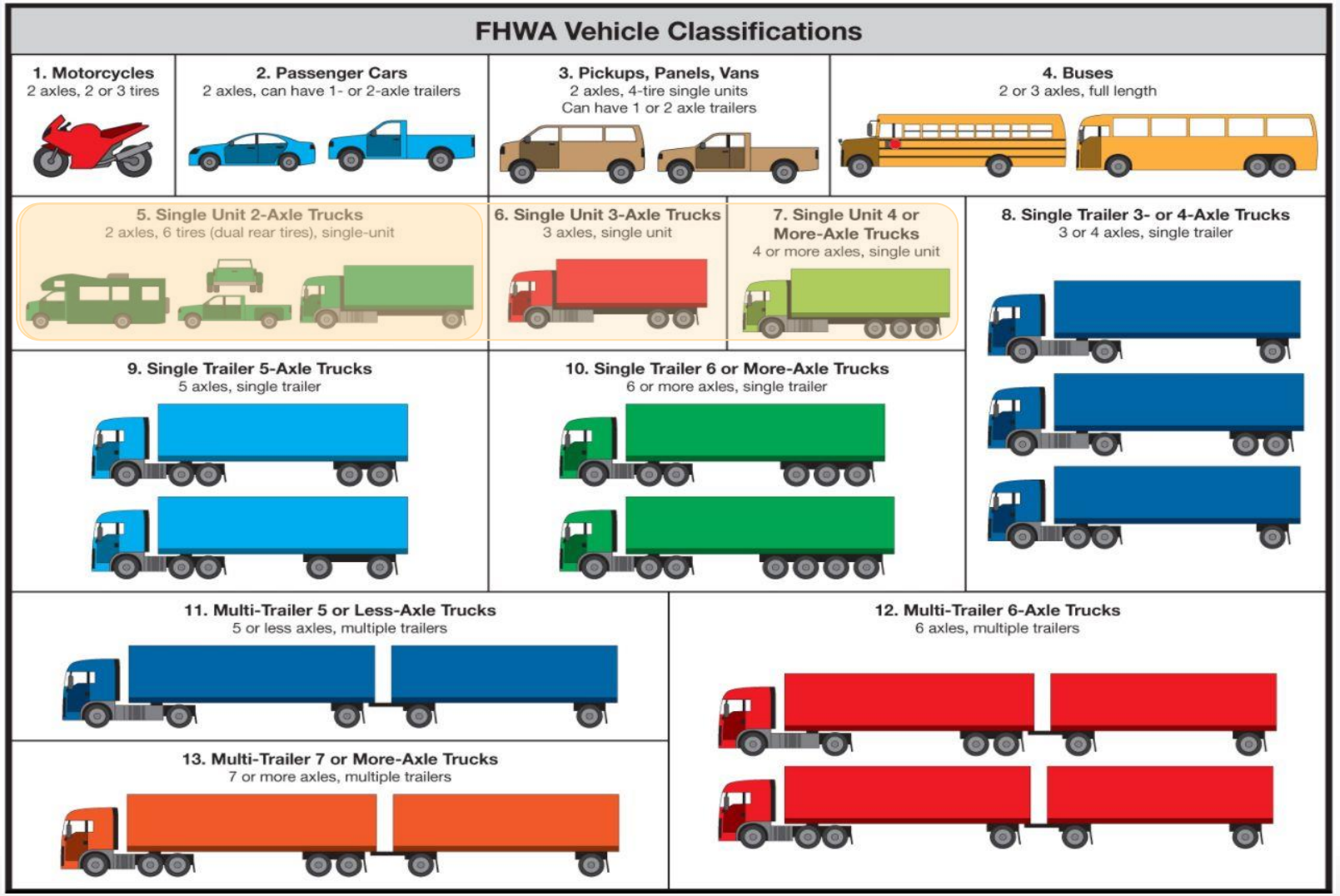


Simulation Network

Research Methodology Cont.

Scenarios

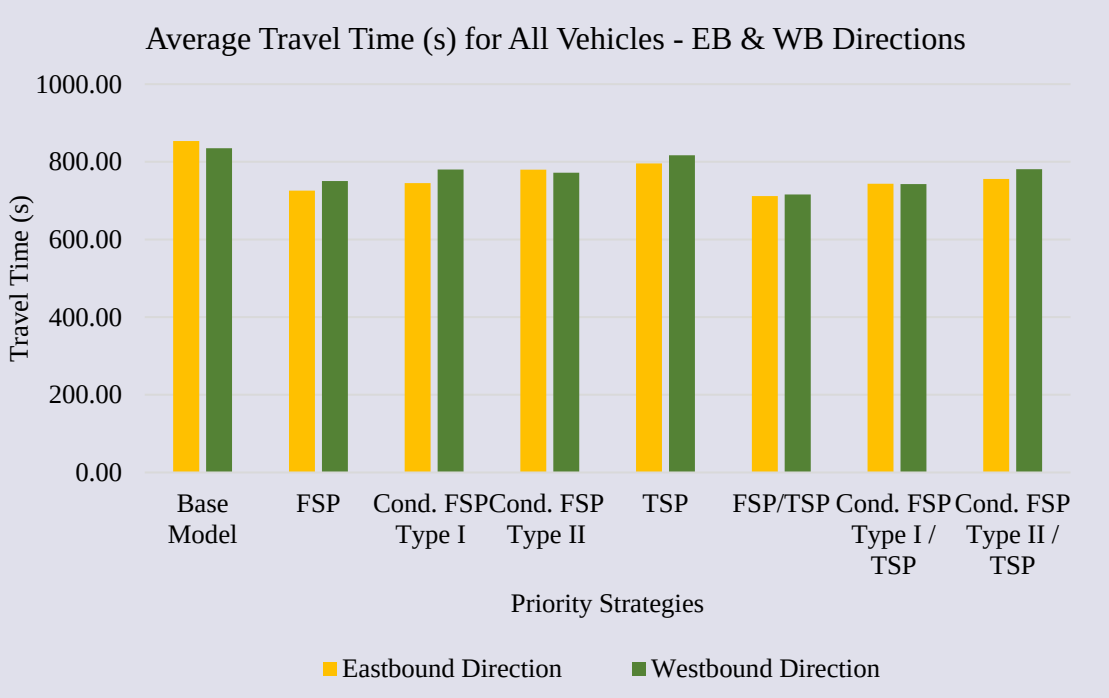
- Freight Signal Priority (FSP)
- Conditional FSP Type I
- Conditional FSP Type II
- Transit Signal Priority (TSP)
- FSP & TSP
- Conditional FSP Type I/ TSP
- Conditional FSP Type II/ TSP

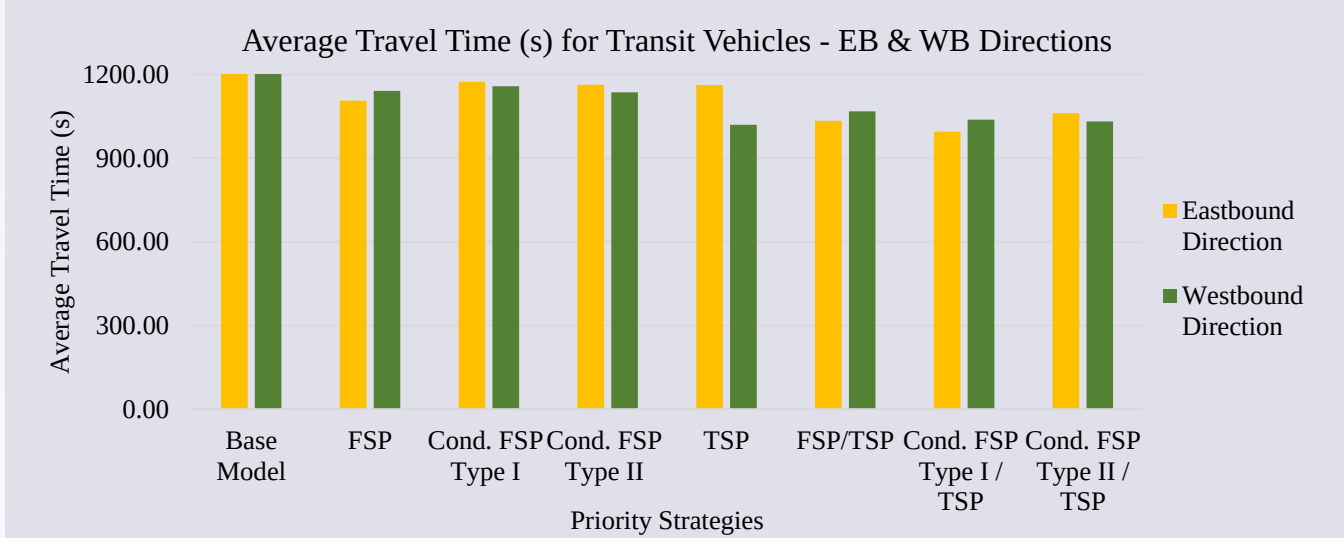


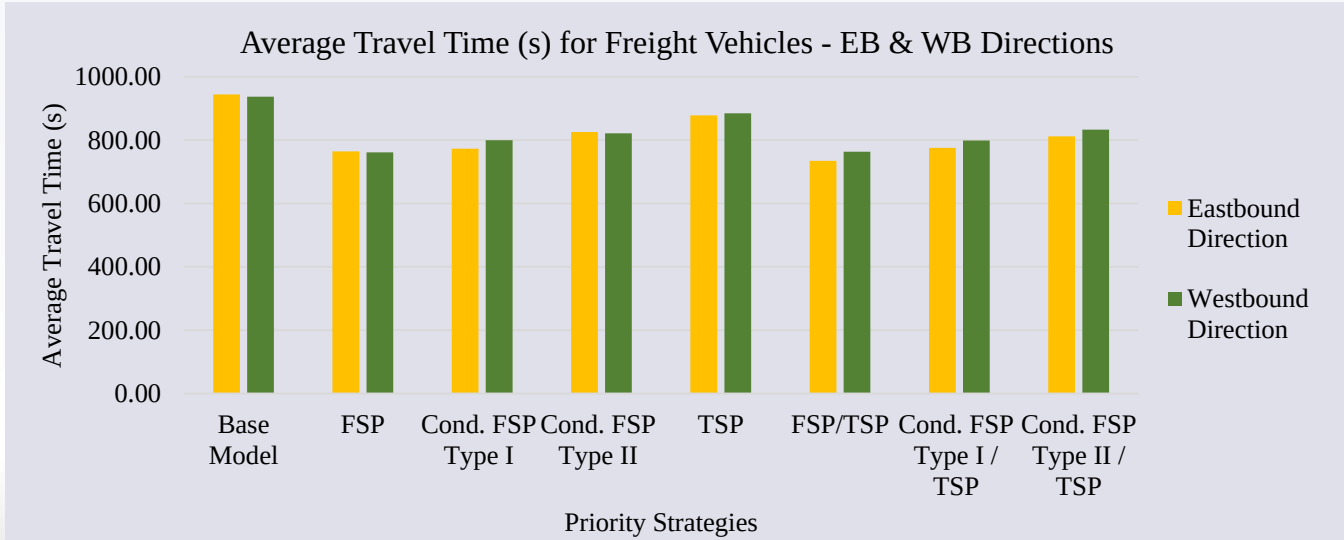
Source: Federal Highway Administration

Research Methodology Cont. - Results Analysis

Major Street Analysis: Sunrise Boulevard

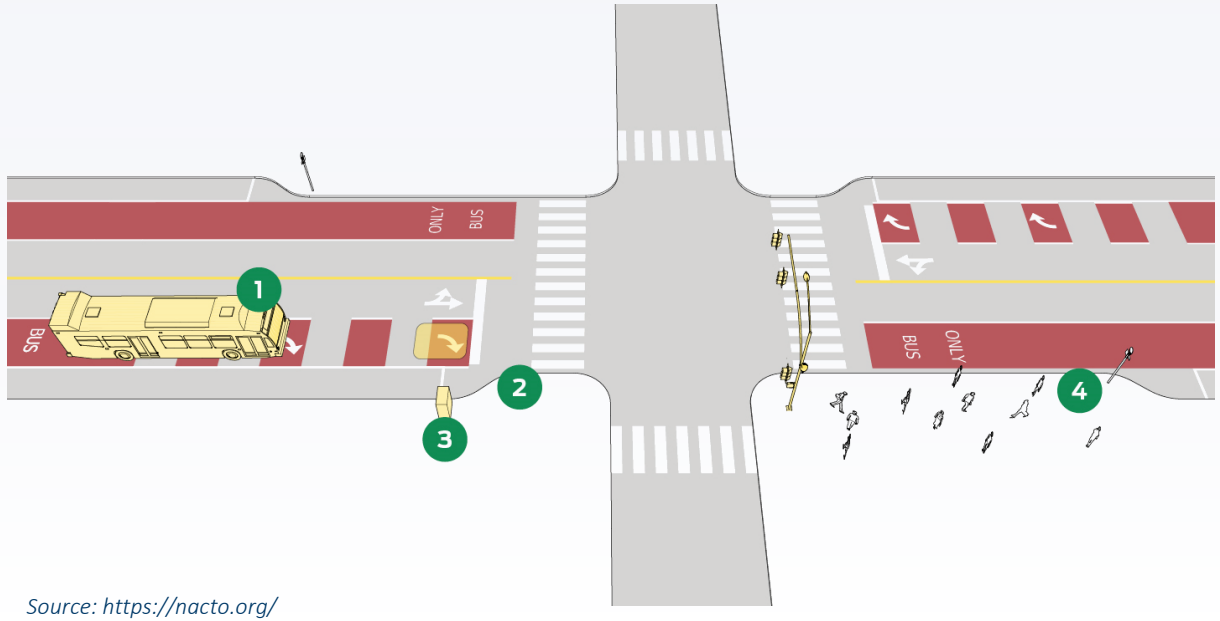






TSP/FSP Guidelines Factors

- 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).

$$C_i = \sum_j d_j * \beta_j * O_j$$

Where; C is the total cost of delay for a specific signal configuration i,

d is the delay for vehicle type j

β is the value of travel time for vehicle type j

O is the occupancy for vehicle type j

Value of Time and Occupancy

Parameters	Value ($)
Value of Time (Person) (β_{car}/β_{bus})	15
Value of Time (Freight) ($\beta_{freight}$)	80
Bus Occupancy (O_{bus})	50
Car Occupancy (O_{car})	1.2
Freight Occupancy ($O_{freight}$)	1.0

Values of β, 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:

$$B_i = C_i - C_{no\ priority}$$

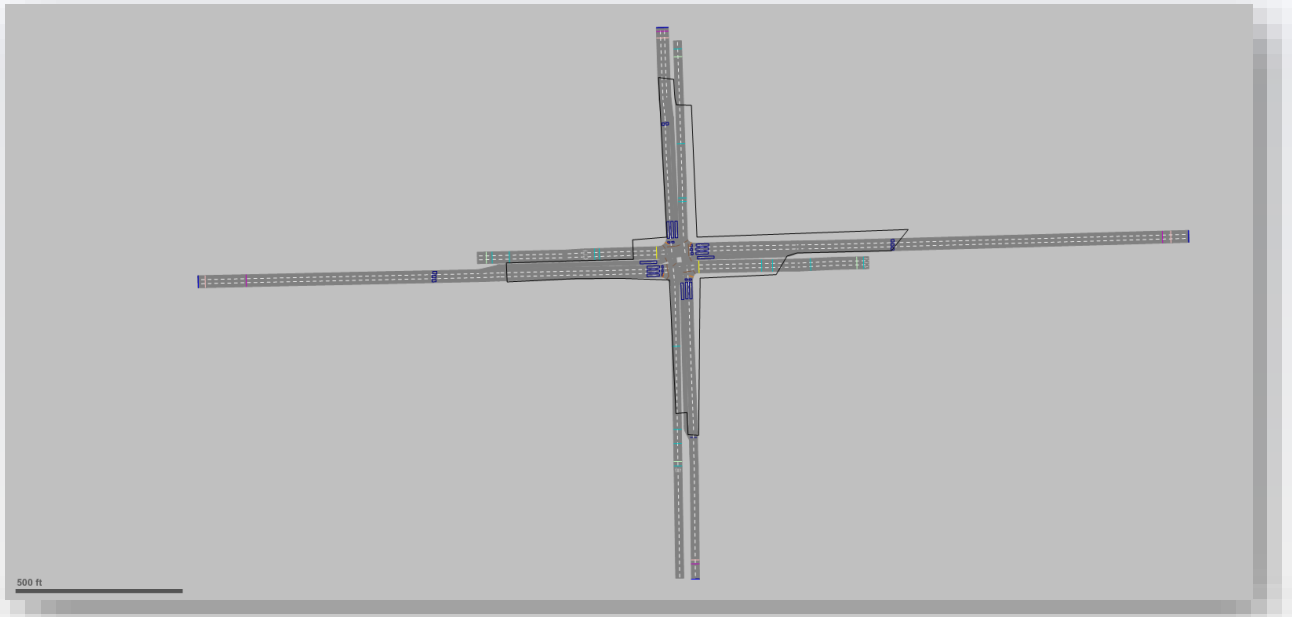
Research Methodology Cont.

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).

Utilized Simulation Parameters Set

Parameter Name	Major Road	Minor Road
V/C	1.0, 0.8, 0.6, 0.5	1, 0.8, 0.6
Freight Percentage	5%, 10%, 20%	5%, 10%, 20%
Transit Frequency per hour	3, 6, 12	3, 6, 12



Simulation Network

Research Methodology Cont.

Guidelines Development

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:

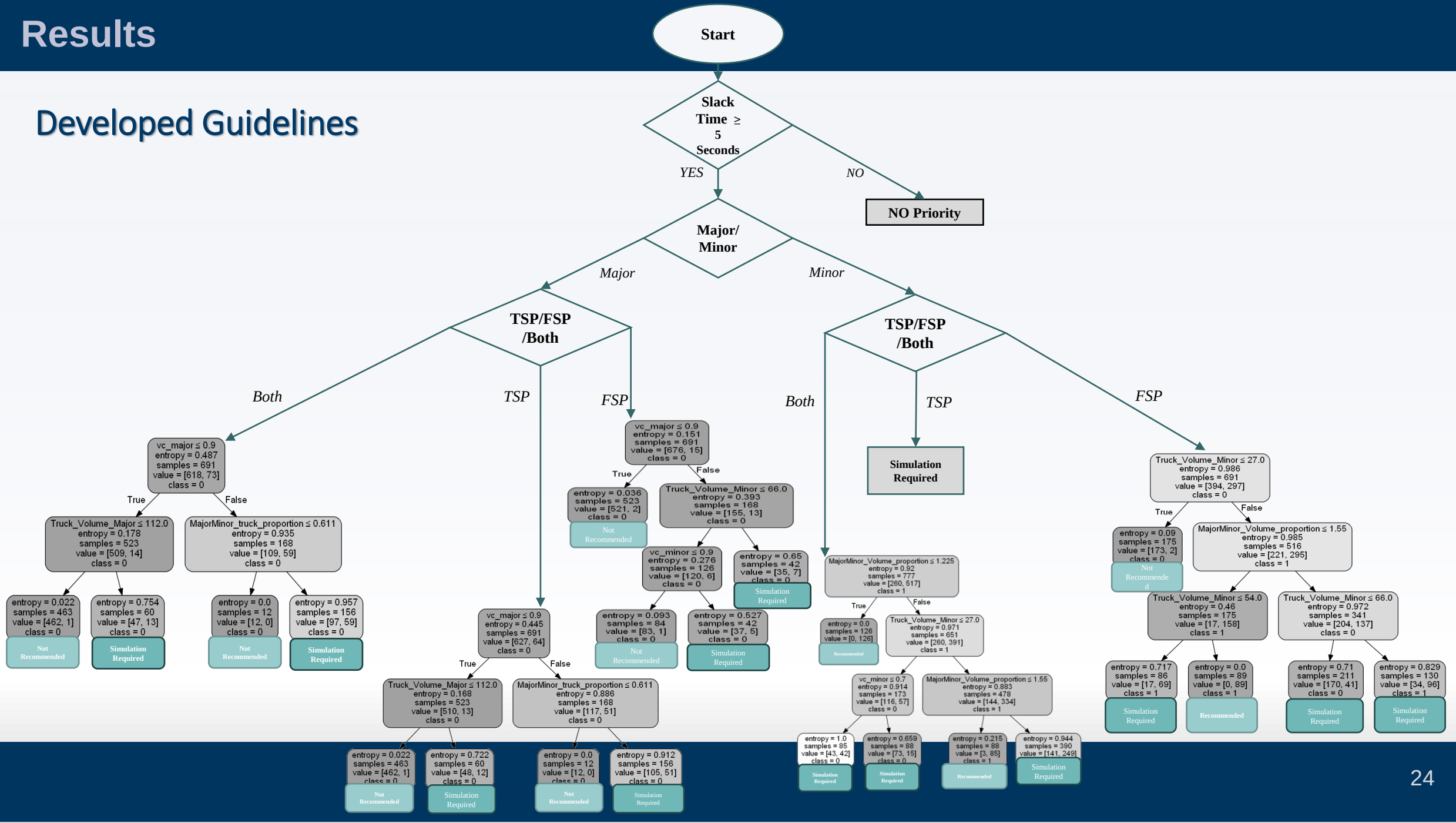
- Major Road TSP,
- Major Road FSP,
- Major road TSP+FSP,
- Minor road TSP,
- Minor road FSP,
- Minor road TSP+FSP,
- Major+Minor road TSP,
- Major+Minor road FSP,
- Major+Minor road TSP+FSP,
- No signal Priority.

TSP/FSP Checklist

TSP	FSP
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.	1. Important truck route 2. Uphill/downhill 3. Safety issues 4. Environmental issue 5. 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.

Results

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.

FSP	
Checklist	Satisfied/Unsatisfied
1. Important truck route	Satisfied ✓
2. Uphill/downhill	Unsatisfied
3. Safety issues	Satisfied ✓
4. Environmental issue	Satisfied ✓
5. Agencies want to reduce freight delay and increase the reliability.	Satisfied ✓

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

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

	Base	FSP	TSP	Both
Total Travel Time Cost ($)	35,777,878	33,406,778	33,879,792	33,642,748
Benefit (%)	-	6.63%	5.31%	5.97%

- 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.

Results

Evaluation

Major Street Travel Time Analysis
EB

Segments	Base			FSP			TSP			FSP&TSP		
EB	Car	Bus	HGV	Car	Bus	HGV	Car	Bus	HGV	Car	Bus	HGV
MLK.Jr Ave	272.90	319.75	243.57	195.99	255.11	162.57	274.74	312.09	246.46	179.37	256.17	144.88
NW 27 Ave	249.68	262.43	231.35	226.31	240.81	188.16	204.94	190.52	189.13	216.05	219.88	188.02
NW 24 Ave	233.05	195.87	223.44	170.38	137.61	162.57	198.31	110.46	190.95	157.19	118.48	147.83
I95	253.34	197.81	243.37	213.12	180.55	181.89	221.06	220.84	205.65	199.31	160.13	162.46
NW 16 Ave	178.71	140.19	177.49	139.84	155.07	142.41	171.45	146.12	154.38	140.02	137.28	147.63
NW 15 Ave	101.82	104.01	100.44	90.12	63.45	69.04	100.88	113.71	87.64	91.56	92.49	81.01
NW 9 Ave	187.53	194.12	153.05	135.99	117.80	85.57	182.49	133.01	169.29	126.50	109.43	104.47
NW 7 Ave	124.36	143.91	108.01	122.63	122.92	96.99	134.06	136.78	115.93	116.02	153.99	98.18
N Andrews Ave	90.02	166.96	74.83	87.22	106.87	61.29	153.70	144.16	139.43	132.37	152.48	103.81
NE 4 Ave	102.54	254.75	93.78	93.49	142.11	63.68	111.67	183.41	105.50	107.39	112.70	76.39
N Flagler Dr	78.10	51.05	56.87	93.04	85.28	58.96	114.85	63.14	74.19	97.82	76.44	76.17
NE 9 Ave	26.23	62.29	22.29	36.09	94.23	28.73	38.01	85.80	29.95	38.37	87.53	30.79
NE 20 Ave	45.23	59.67	40.87	45.61	43.75	32.58	42.47	30.13	30.92	49.79	42.65	30.23
N Federal Hwy(East)	105.14	139.74	93.68	121.08	188.87	82.72	105.45	154.28	87.58	114.19	160.48	68.49
N Federal Hwy (West)	106.33	89.66	78.94	90.23	113.92	54.75	91.66	127.47	54.89	91.78	86.20	64.16
NE 17 Way	52.99	121.23	53.12	92.47	143.30	78.00	54.34	124.41	56.22	88.29	139.56	98.10
NE 16th Terrace	41.44	101.17	31.50	38.14	96.76	28.53	35.14	82.24	24.81	38.76	93.22	30.36
NE 15 Ave	169.36	280.53	129.50	134.41	211.13	96.18	126.52	113.18	80.99	135.57	166.18	106.93
NE 12th Ave	43.78	111.65	39.98	39.61	110.83	27.92	57.51	130.03	47.98	44.67	123.91	35.78
NE 10 Ave	28.22	78.32	22.47	26.04	47.01	17.53	27.04	57.08	18.77	26.26	44.05	19.70
Total	2490.78	3075.12	2218.56	2191.81	2657.38	1720.09	2446.31	2658.86	2110.67	2191.29	2533.24	1815.37
Compared to Base	N/A	N/A	N/A	-12%	-13%	-22%	-1%	-13.5%	-4.8%	-12%	-17.6%	-18%

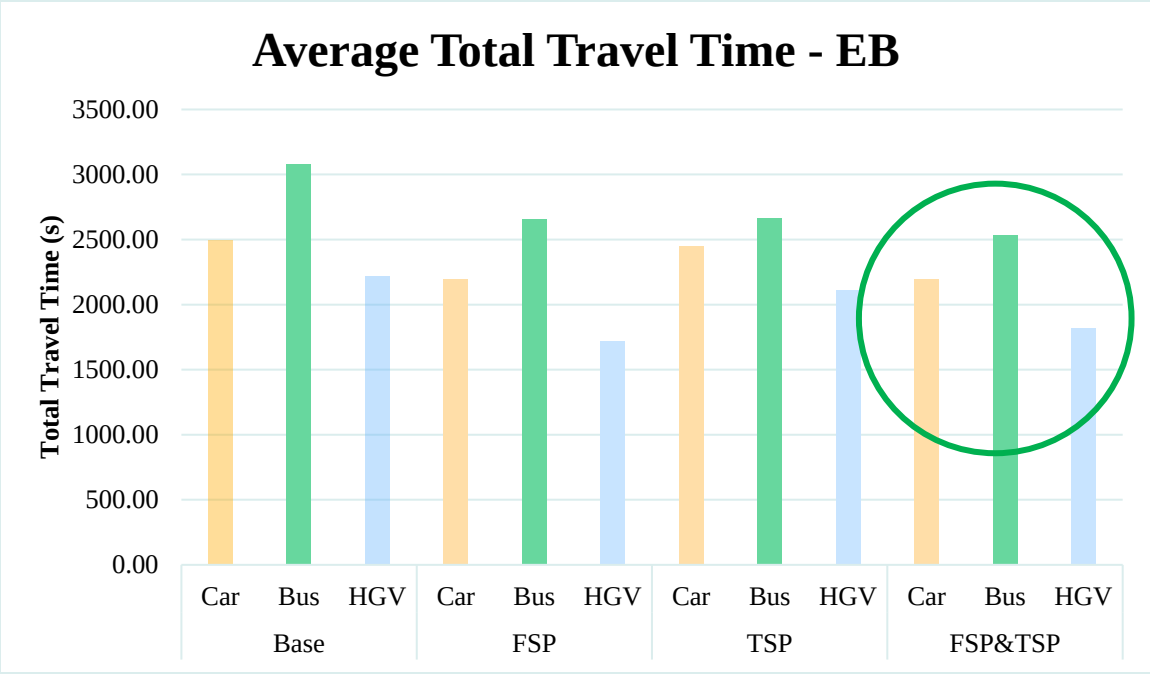
Results

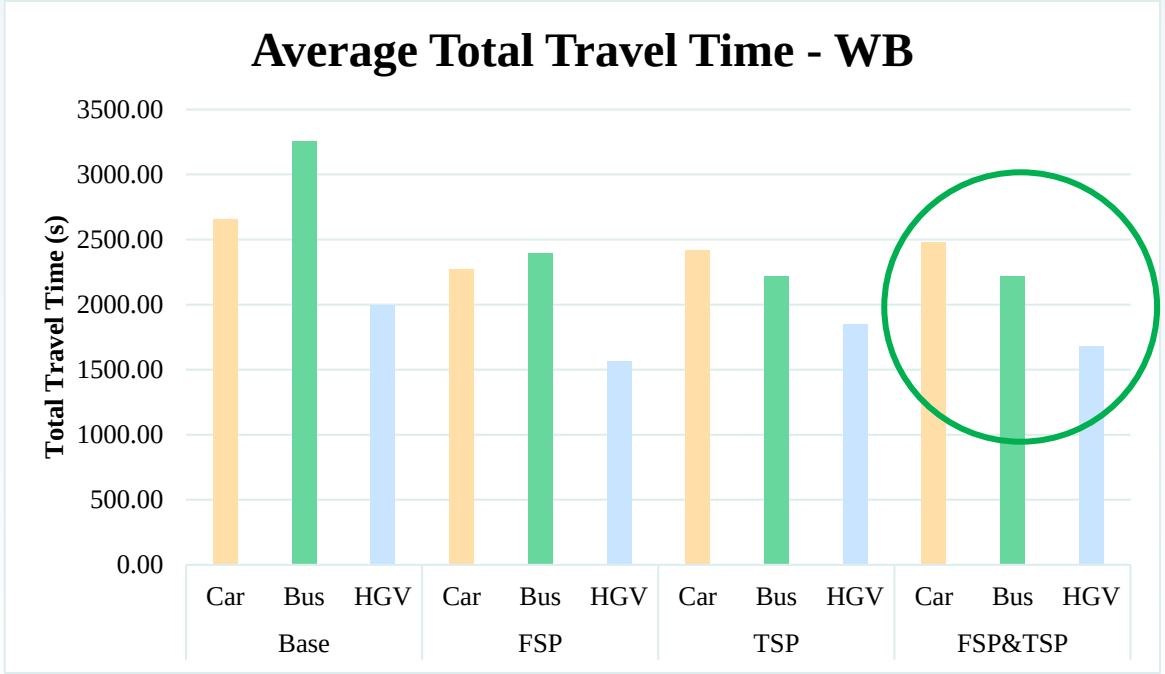
Evaluation

Major Street Travel Time Analysis
WB

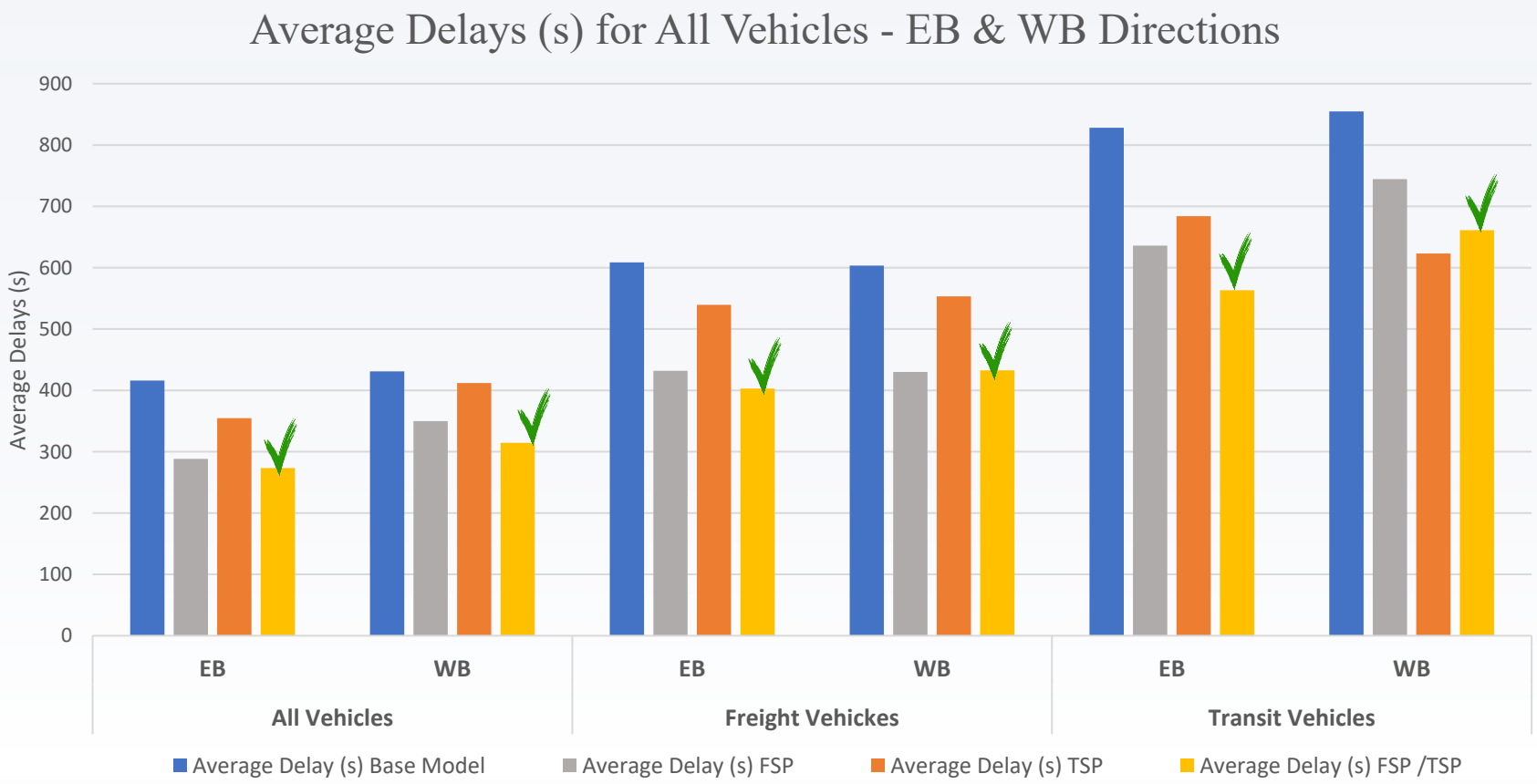
Segments	Base			FSP			TSP			FSP&TSP		
WB	Car	Bus	HGV	Car	Bus	HGV	Car	Bus	HGV	Car	Bus	HGV
MLK.Jr Ave	280.96	250.20	156.14	171.11	186.38	136.62	246.00	140.17	174.24	144.34	122.68	97.78
NW 27 Ave	221.86	320.80	196.94	191.68	196.12	151.83	185.28	178.01	165.59	180.49	163.68	155.63
NW 24 Ave	188.90	107.67	162.62	150.77	105.53	117.86	135.48	97.78	126.18	209.12	163.53	191.59
I95	202.83	164.73	146.68	251.86	145.76	169.34	148.16	138.06	93.54	264.83	137.18	155.35
NW 16 Ave	71.22	60.20	57.51	76.46	44.44	53.38	81.94	56.76	67.12	76.06	55.42	55.92
NW 15 Ave	134.00	158.07	120.96	81.51	125.52	74.99	109.29	154.04	97.17	91.15	114.65	79.11
NW 9 Ave	107.36	284.23	92.72	90.53	143.30	69.37	89.05	81.95	66.32	89.29	82.29	68.34
NW 7 Ave	121.77	107.99	88.48	75.65	61.76	46.24	117.30	89.70	83.35	111.06	70.40	77.94
N Andrews Ave	122.83	192.78	107.31	95.29	183.17	45.85	121.83	126.33	91.89	105.49	133.99	76.29
NE 4 Ave	203.20	254.09	128.25	156.55	110.02	82.61	182.89	94.92	96.34	150.86	86.21	58.07
N Flagler Dr	98.16	253.02	83.90	85.45	129.23	60.73	77.93	127.99	63.73	76.02	105.90	43.02
NE 9 Ave	49.25	49.80	42.12	32.32	40.46	29.21	45.22	47.46	44.38	38.60	46.41	33.14
NE 20 Ave	44.96	89.08	43.87	63.91	92.71	42.98	52.66	68.71	48.95	126.11	117.98	78.64
N Federal Hwy(East)	413.23	325.71	288.66	383.61	273.70	221.91	443.40	205.77	349.48	438.24	231.42	230.29
N Federal Hwy(West)	49.19	37.21	34.75	61.58	50.14	45.12	60.21	53.80	42.22	60.70	48.70	40.09
NE 17 Way	84.08	149.35	61.11	79.00	142.23	48.88	72.95	106.46	56.51	73.17	110.77	46.42
NE 16th Terrace	45.16	102.19	37.68	34.90	79.82	28.69	34.79	96.66	26.83	42.12	94.43	30.87
NE 15 Ave	156.91	230.33	92.95	141.03	202.58	104.26	158.32	225.54	103.42	153.94	222.92	123.16
NE 12th Ave	29.44	78.97	21.07	20.41	41.89	14.34	28.68	75.87	22.87	23.33	55.07	17.05
NE 10 Ave	30.90	41.79	26.89	25.70	37.00	23.35	25.27	51.01	26.03	26.43	54.62	21.63
Total	2656.21	3258.20	1990.60	2269.35	2391.76	1567.58	2416.65	2217.00	1846.16	2481.36	2218.25	1680.34
Compared to Base	N/A	N/A	N/A	-14.5%	-26%	-21%	-9%	-31.9%	-7.26	-6.5%	-31.9%	-15.6%

Major Street Analysis – Travel Time





Major Street Analysis – Average Delay



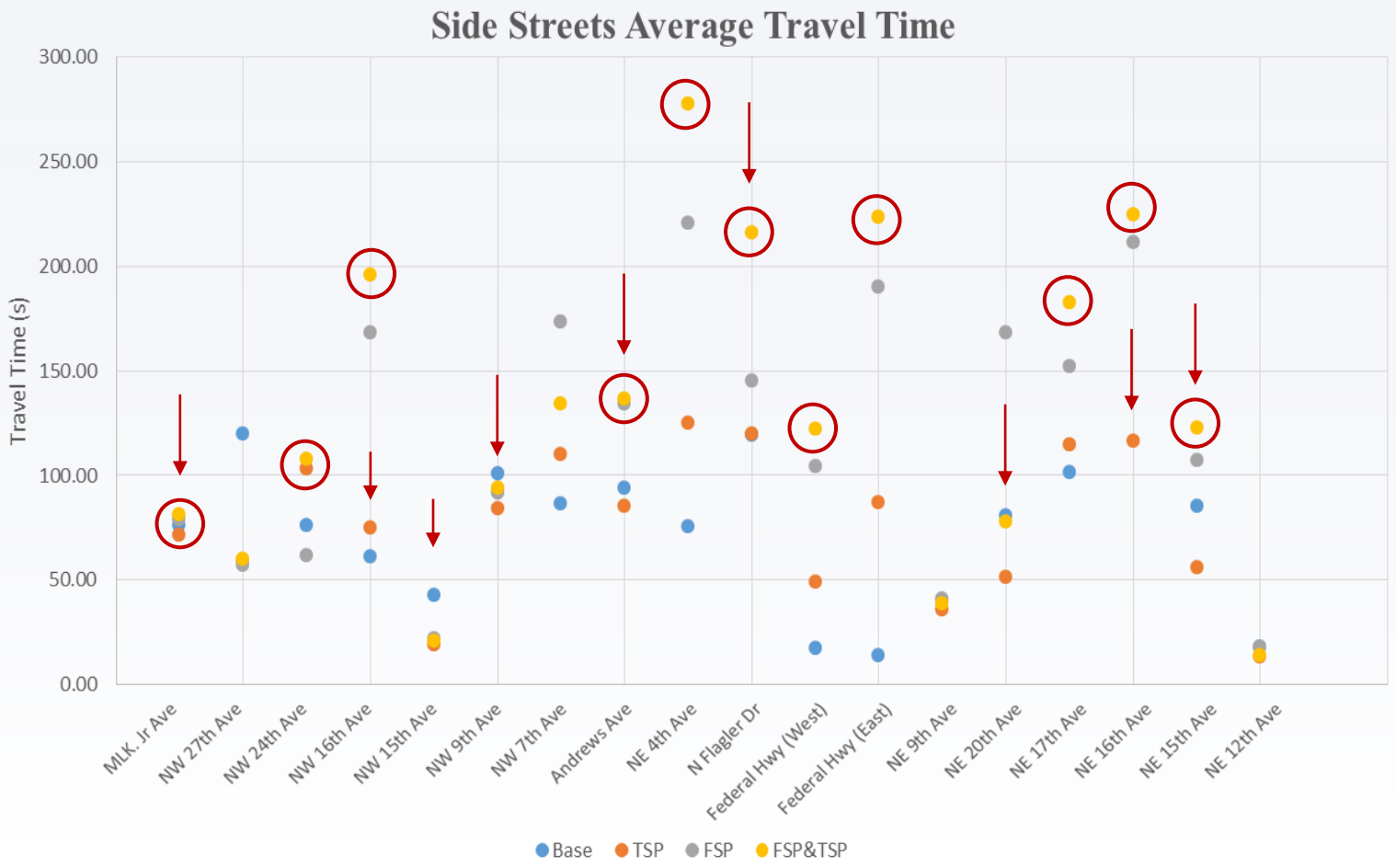
Results

Minor Street Analysis

- In most of the study area:

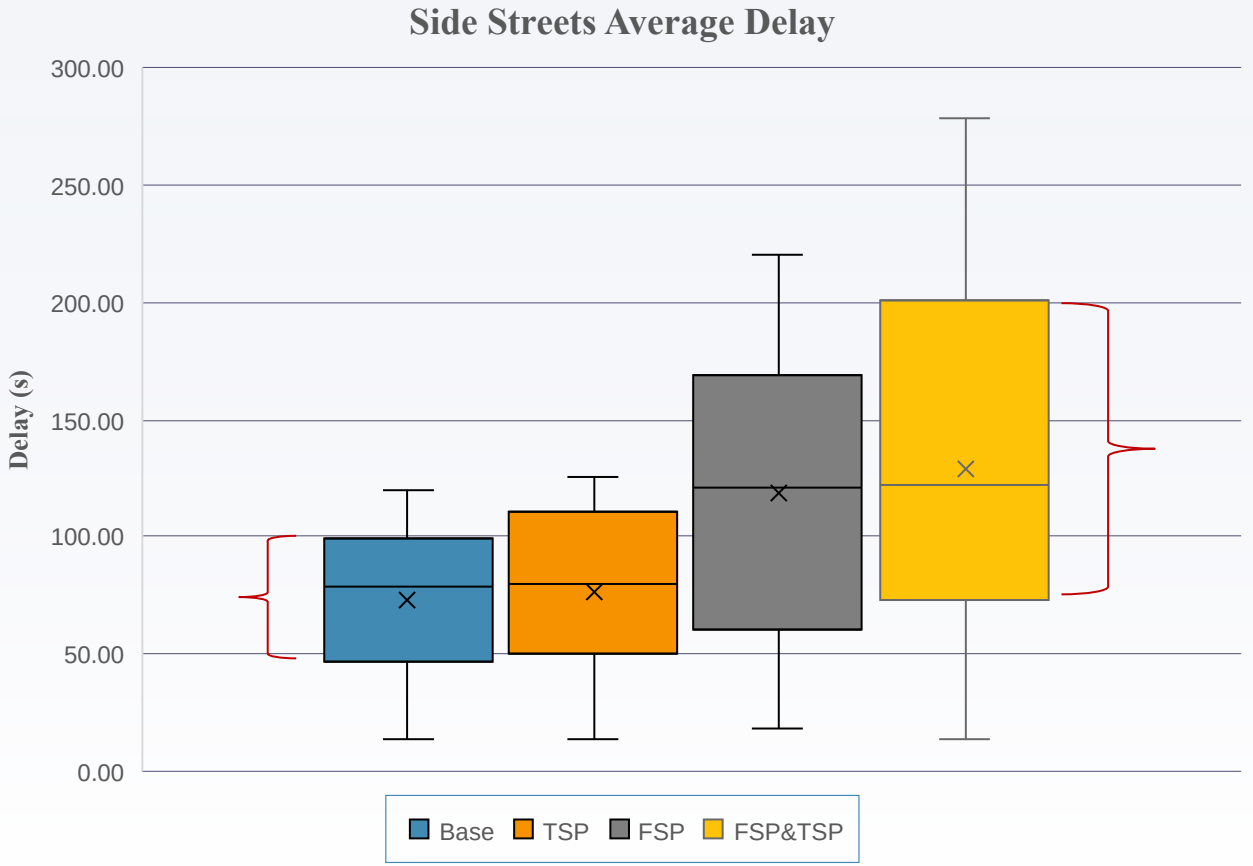
Unconditional priority (**FSP & TSP**) would result in the **most significant delays** for crossing street traffic compared with the base model.

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.

Conclusions

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.

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Thank you for your attention!

Questions or Suggestions?

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