

TRCLC 17-11

EVALUATION OF TRANSIT PRIORITY TREATMENTS IN TENNESSEE

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Introduction

❑ Transit Signal Priority (TSP)

- A strategy to Speed up Transit Vehicle Movement

❑ Benefits

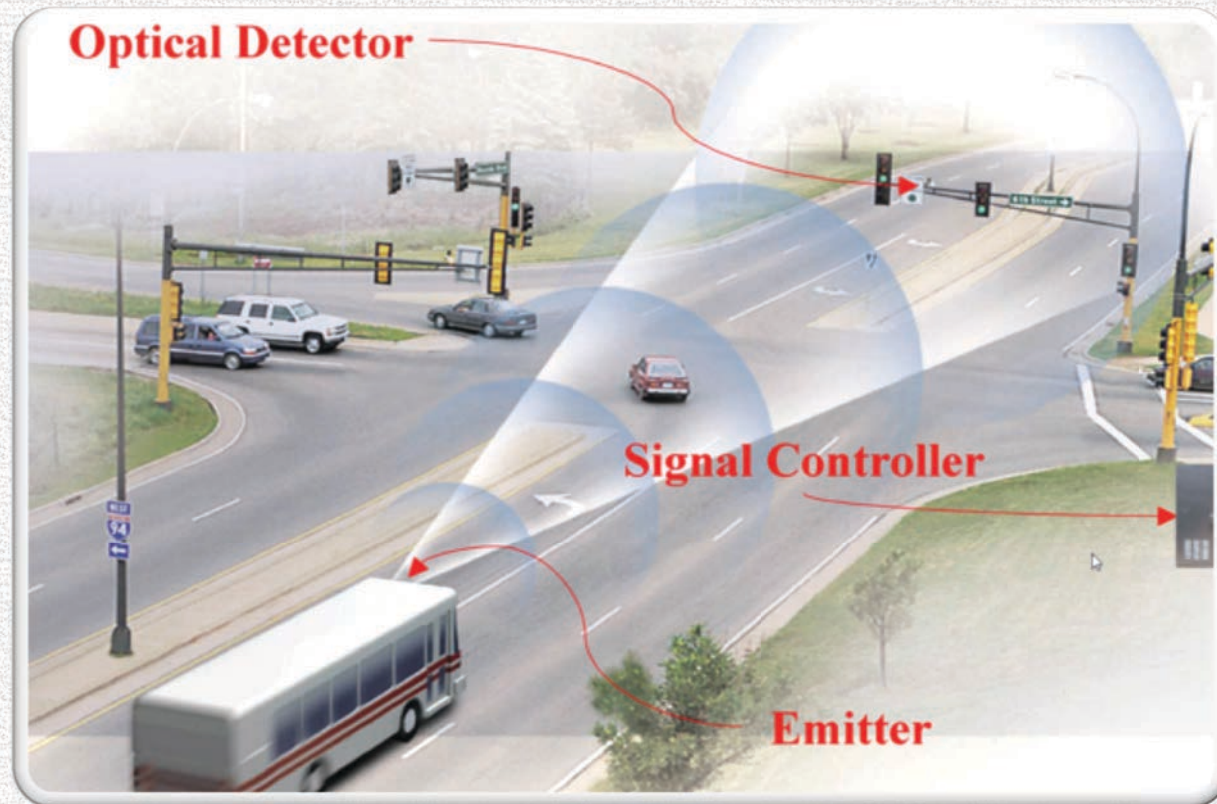
- Boost Transit Movement Without excessive Impact on other Road Users
- Reduce Bus Bunching
- Improve Transit (bus) Schedule Adherence
- Reduce High Auto Dependency
- Expand Mobility Choices
- Improve Transit ridership
- Reduce Energy consumption, green house Gases and other Pollutants



Principle of TSP Operation

□ Components

- Transit vehicle detection system
- Communication system
- Traffic signal control system



Why TSP in Nashville Corridors??

- ❑ Nashville is fast growing

- The population of the Nashville metro area grew by an average of 94 people a day from 2016 to July 2017

- ❑ High traffic congestion

- ❑ Poor bus serviceability

- ❑ Poor Schedule Adherence

- ❑ Transit unattractiveness

- According to David Hartgen only 1.5 to 2.5% of Nashville Residents use Transit



Study Corridor

- ❑ Section Gallatin Pike corridor
- ❑ 1.83 miles Long
- ❑ An arterial roadway
- ❑ two lanes in each direction
- ❑ Continuous shared left turn lane
- ❑ 9 signalised intersections
- ❑ 7 bus stops in each direction

Research Objectives

- ❑ Evaluate the impact of transit operation and TSP in Nashville with respect to;
 - Mainline and side street traffic operations
 - Bus schedule adherence in terms of late bus recovery.
 - control delay and Level of Service.
- ❑ To develop delay models for interrupted flow conditions to predict average delay per vehicle for a given flowrate and Queue Length.

Methodology

❑ Microsimulation Software Selection

➤ VISSIM

❑ Data collection

❑ Origin Destination (OD) Matrix Estimation and Validation

➤ Principle of Conservation Of Vehicles

❑ Base Model Development in VISSIM

➤ Isolated Intersection Based

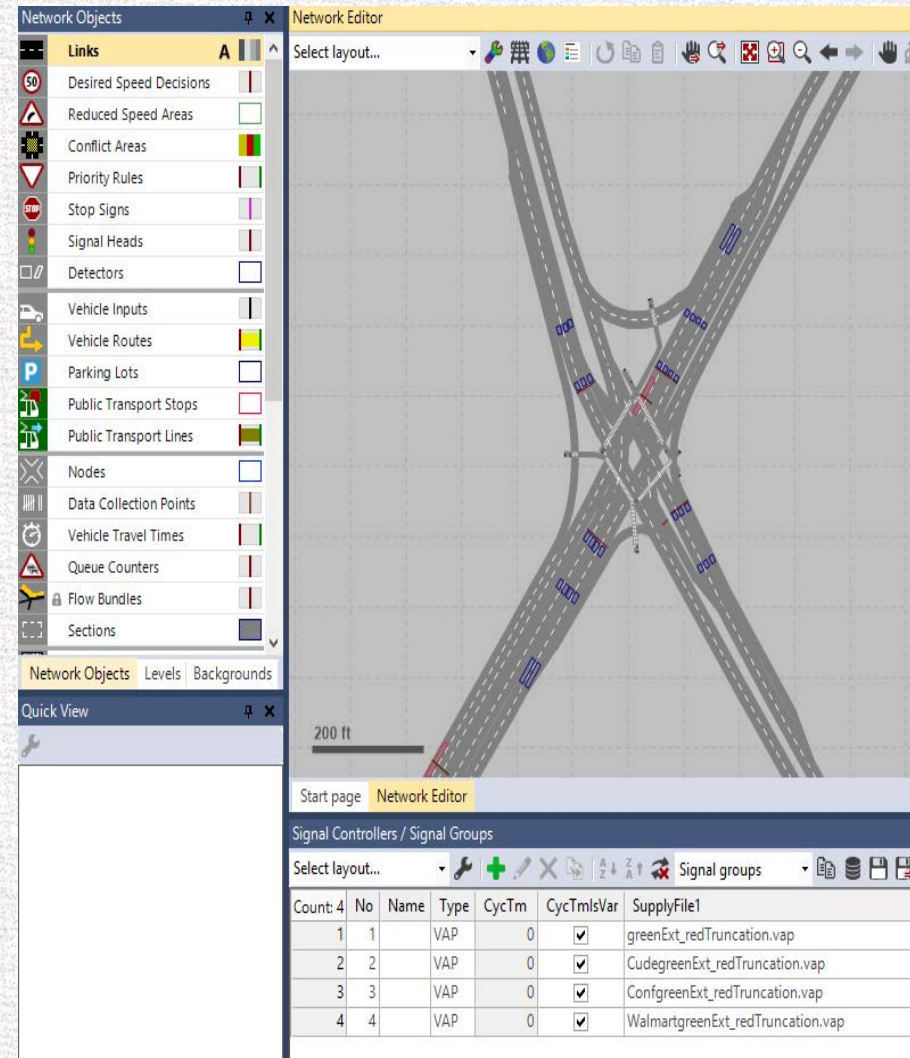
➤ Corridor Based

❑ Base Model Calibration and Validation

➤ Alternative Concept

➤ TSP

➤ VAP code: Green extension and Red truncation TSP strategies



Data Collection

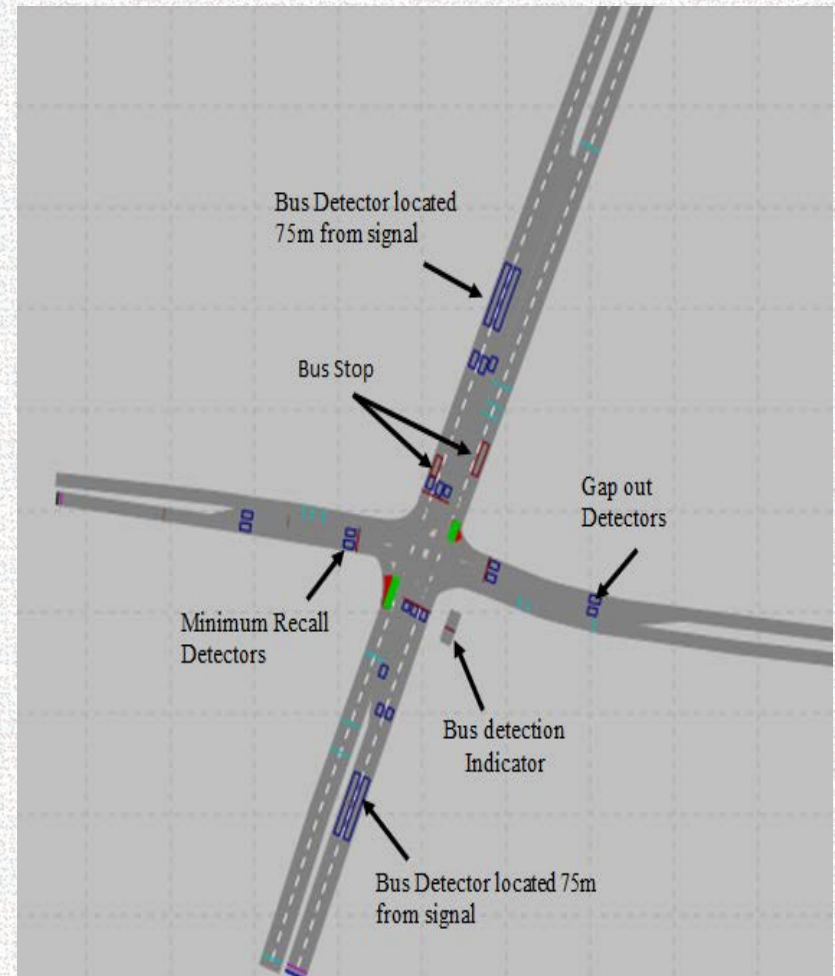
- ❑ Roadway Geometry
 - Intersection Layout
 - Lane Configuration
 - Bus Stop location and Types
- ❑ Traffic Data
 - Turning Movement Count(TMC)
 - General Traffic Travel Time
- ❑ Transit Data
 - Speed Profile
 - Bus travel Time
 - Boarding and Alighting Count
 - Ridership
 - Schedule Adherence
- ❑ Traffic Control Data
 - Signal Timing and Phasing Plans



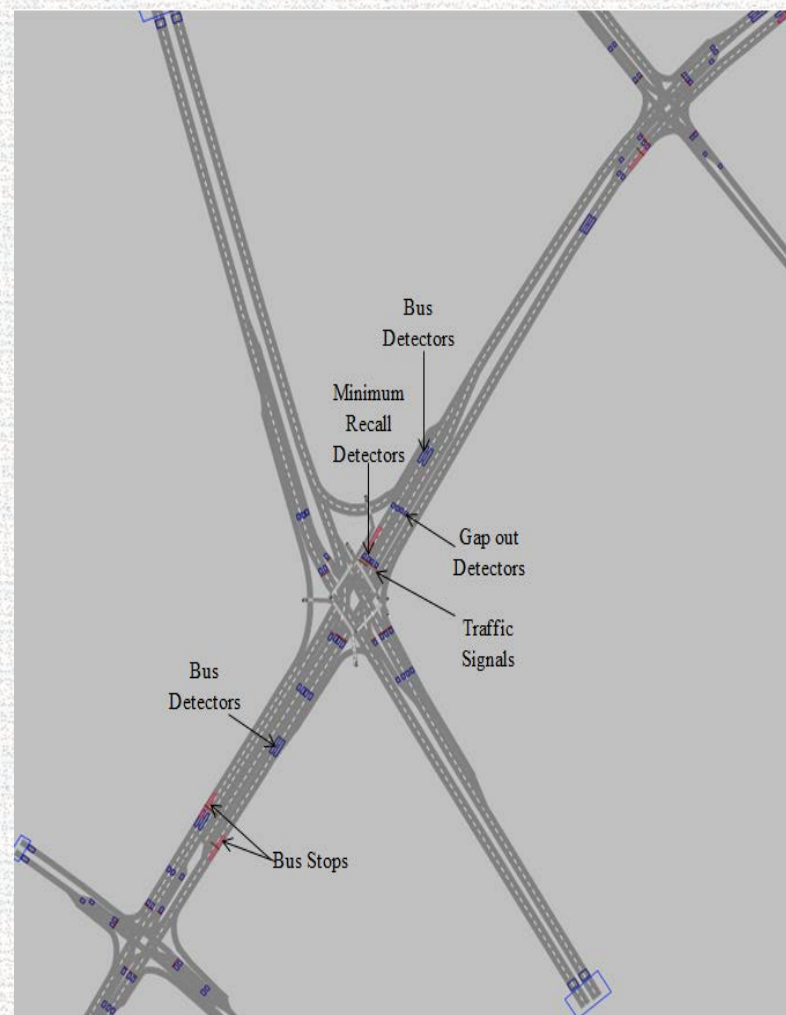
Base Model Development

- ❑ Corridor Geometry
- ❑ Connectors
- ❑ Urban Motorised Driving Behaviour
 - Wiedemann 74 car following Model
- ❑ Vehicle Composition
- ❑ Desired Speed Distribution
- ❑ Public Transportation Stops
- ❑ Public Transportation Line
 - Bus Dwell
 - boarding and alighting count
 - passenger flow characteristics
 - bus departure times
 - departure time offset
 - bus occupancy

Sample of Study Intersection alongside its Corresponding VISSIM Model



Section of Study Corridor alongside its Corresponding VISSIM Model



Dynamic Assignment In VISSIM

Network Objects

- Links
 - Desired Speed Decisions
 - Reduced Speed Areas
 - Conflict Areas
 - Priority Rules
 - Stop Signs
 - Signal Heads
- Detectors
- Vehicle Inputs
- Vehicle Routes
- Parking Lots
- Public Transport Stops
- Public Transport Lines
- Nodes
- Data Collection Points
- Vehicle Travel Times
- Queue Counters
- Flow Bundles
- Sections

Network Objects | Levels | Backgrounds

Quick View (Zones)

No	1
Name	North Alta Loma

Dynamic Assignment: Parameters

Files | Cost | Search | Choice | Convergence | Route guidance

☐ Use trip chain file

Trip chain file: ? .fkt

☒ Matrices

Count: 1	Matrix	VehComp
1	1: Gallatin	1: Gallatin

☐ Scale total volume to 100.00 %

Evaluation interval: 3900 s

Cost file: Gallatin Pike corridor.bew

Path file: Gallatin Pike corridor.weg

☒ Check edges

☒ Create archive files

☒ Store costs

☒ Store paths (and volumes)

Vehicle Classes:

- ☒ 10: Car
- ☒ 20: HGV
- ☒ 30: Bus
- ☐ 40: Tram
- ☐ 50: Pedestrian
- ☐ 60: Bike

OK Cancel

Zones / Parking Lots

Select layout... Parking lots

Count: 26	No	Name
1	1	North Alta Loma
2	2	North Arbys
3	3	North Rivergate
4	4	North Cude Ln
5	5	North Shepherd
6	6	North Town Hills

Quick View (Zones) | Smart Map

Signal Controllers / Signal Groups | Desired Speed Distributions / Data Points | Vehicle Com

Network Editor

Select layout...

Matrix Editor (Matrix '1: Gallatin')

		1	2	3	4	5	6	
	Name	North Alta Loma	North Arbys	North Rivergate	North Cude Ln	North Shepherd	North Town Hills	North C
	Sum	345.00	341.00	407.00	877.00	511.00	377.00	344.00
1	North Alta Loma	345.00	0.00	21.00	24.00	9.00	3.00	6.00
2	North Arbys	201.00	17.00	0.00	16.00	6.00	2.00	4.00
3	North Rivergate	839.00	32.00	44.00	0.00	46.00	14.00	29.00
4	North Cude Ln	383.00	6.00	8.00	23.00	0.00	10.00	21.00
5	North Shepherd	276.00	0.00	0.00	1.00	1.00	0.00	32.00
6	North Town Hills	209.00	1.00	1.00	4.00	4.00	5.00	0.00
7	North Conference Dr	471.00	9.00	13.00	36.00	38.00	41.00	21.00
8	North Burger King	70.00	1.00	1.00	3.00	3.00	3.00	2.00
9	North Liberty Ln	199.00	2.00	3.00	9.00	10.00	10.00	5.00
10	North North Side Dr	96.00	1.00	1.00	3.00	3.00	4.00	2.00
11	North Bob Frenley	68.00	1.00	1.00	2.00	3.00	3.00	1.00
12	North Walmart	93.00	1.00	1.00	4.00	4.00	4.00	2.00
13	South Alta Loma	229.00	87.00	12.00	14.00	5.00	2.00	3.00
14	South Arbys	163.00	11.00	56.00	10.00	4.00	1.00	2.00
15	South Rivergate	869.00	15.00	20.00	363.00	62.00	18.00	39.00
16	South Cude Ln	100.00	1.00	2.00	5.00	62.00	1.00	2.00
17	South Shepherd	144.00	3.00	4.00	12.00	13.00	54.00	3.00
18	South Town Hills	177.00	4.00	6.00	16.00	17.00	18.00	41.00
19	South Conference Dr	162.00	3.00	4.00	12.00	13.00	14.00	7.00
20	South Burger King	280.00	4.00	5.00	15.00	16.00	17.00	9.00
21	South Liberty Ln	167.00	3.00	4.00	10.00	11.00	12.00	6.00
22	South North Side Dr	102.00	1.00	2.00	5.00	5.00	6.00	3.00
23	South Bob Frenley	21.00	0.00	0.00	1.00	1.00	1.00	0.00
24	South Walmart	40.00	0.00	0.00	1.00	2.00	2.00	1.00
25	East Gallatin	1331.00	26.00	34.00	97.00	104.00	111.00	59.00

Start page | Network Editor

Matrices

Select layout...

Count: 1	No	Name	FromTime	ToTime
1	1	Gallatin	00:00:00	01:05:00

Signal Controllers / Signal Groups | Desired Speed Distributions / Data Points | Vehicle Compositions / Relative Flows | Public Transport Lines / Public Transport Line Stops | **Matrices** | Zones / Parking

Base Model Calibration and Validation

Corridor Model Calibration

□ OD Matrices Calibration

- checked for convergence
- 95% of travel time on all paths vary by less than 20% for at least 4 consecutive simulation runs

□ Speed Calibration

- Simulated and Observed Speed (PE < 5%)

□ Travel Time Validation

- Simulated and Observed Travel Time (PE < 5%)

PE=Percentage Error

Isolated Intersection Model Calibration

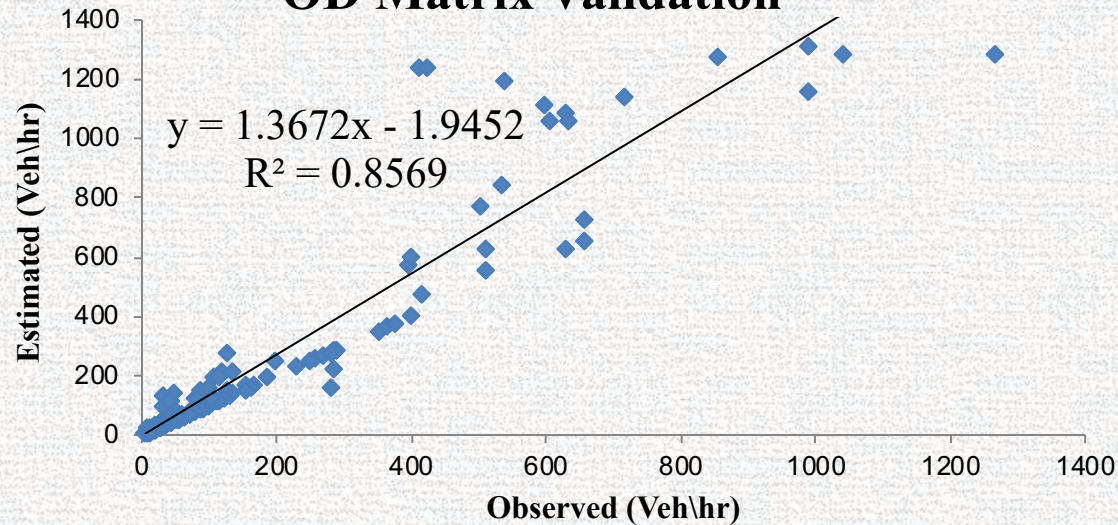
- Geofferey E. Havers (GEH) < 5

Adjust

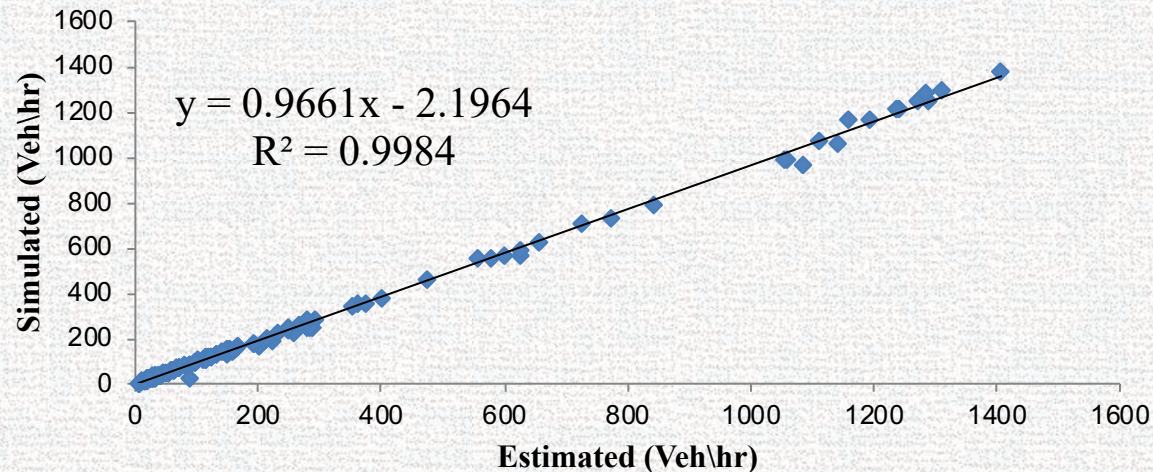
- Route choice assumptions,
- Vehicle composition,
- Driving behavior and
- Maximum and minimum look ahead distance
- Look back distance,
- Average standstill distance,
- Lane changing rule

OD Matrix Calibration and Validation Results

OD Matrix Validation



OD Matrix Calibration



TSP Signal Logic Implementation

❑ Passive Priority

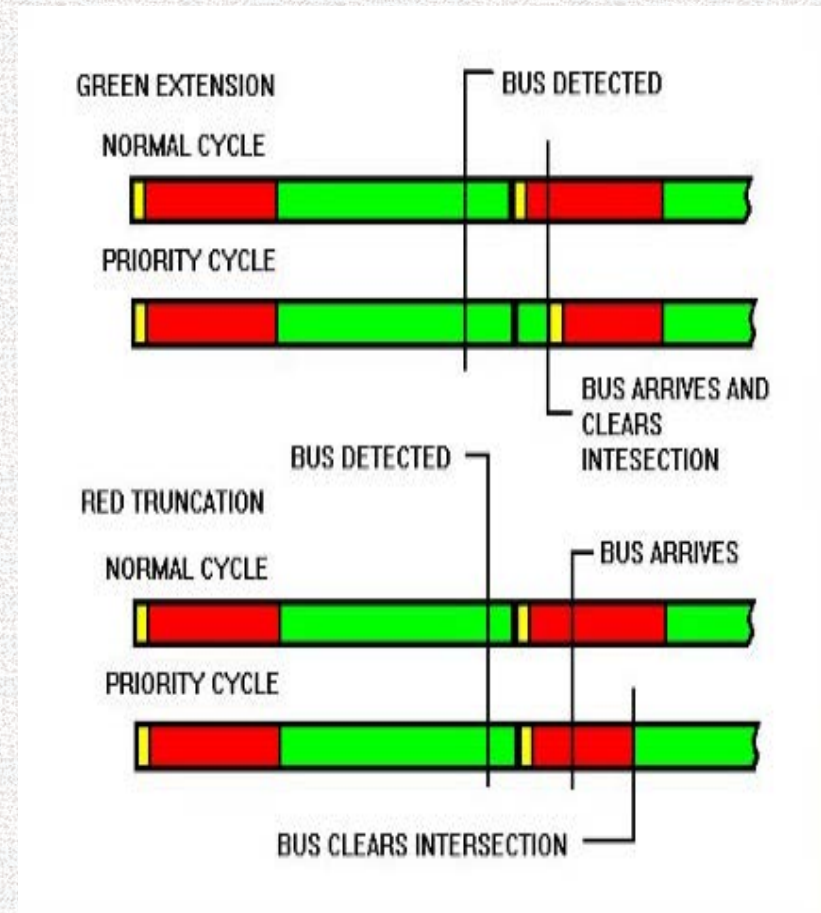
- It allocates more green time to approaches having higher bus flow than it would for others

❑ Active Priority

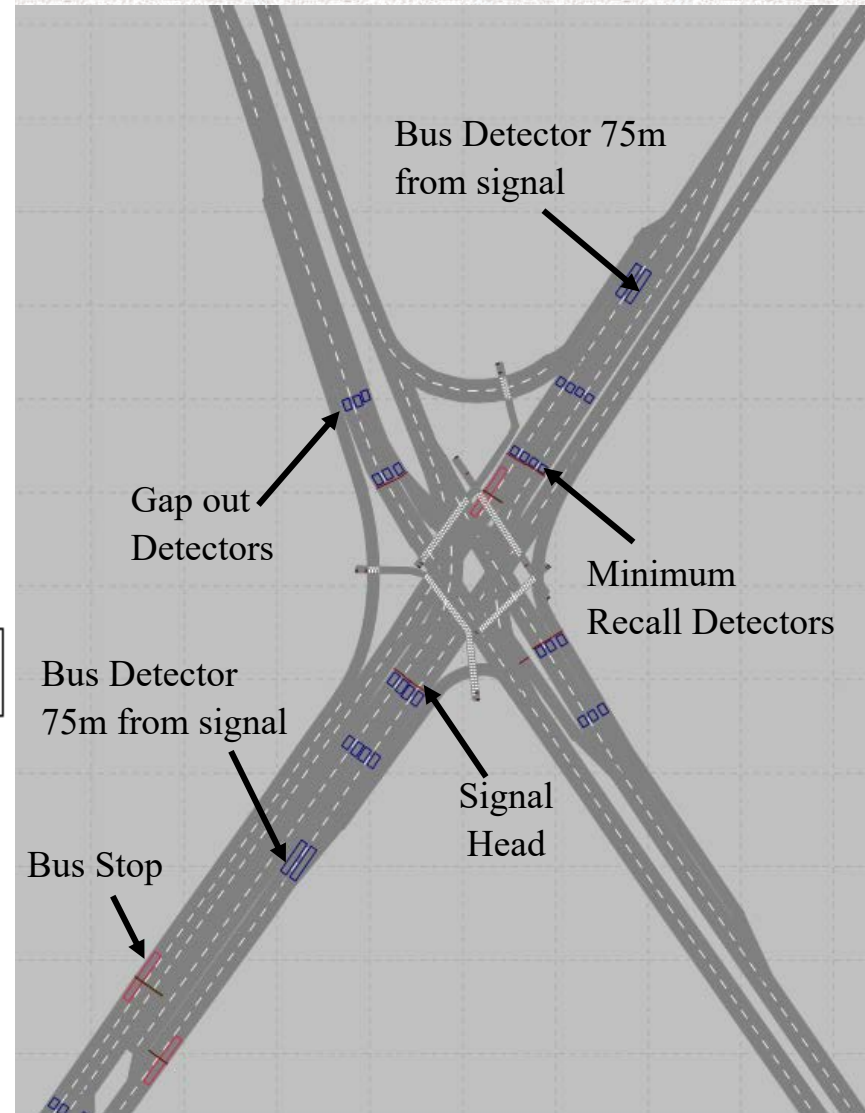
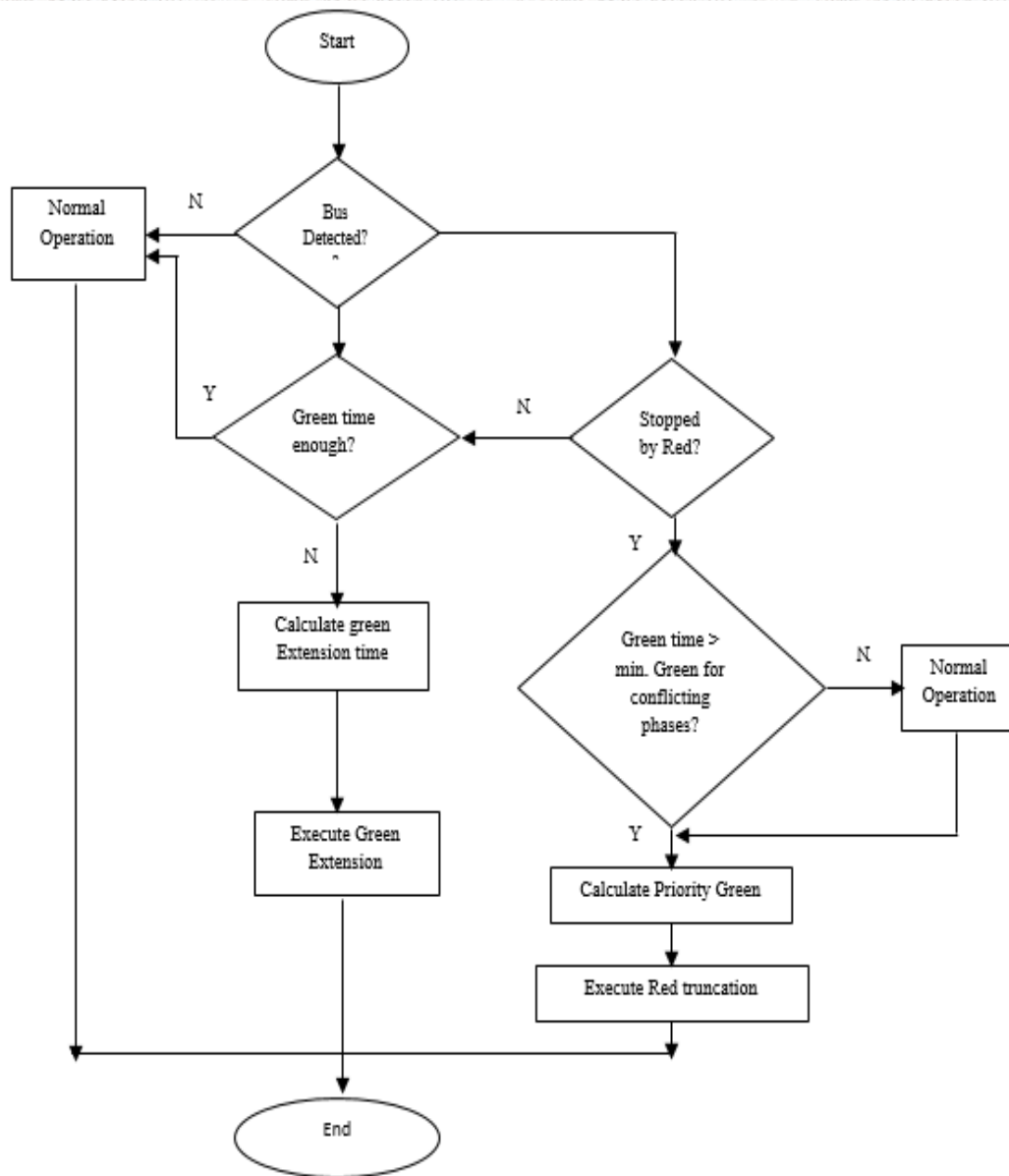
- Green Extension
- Red Truncation

❑ Vehicle Actuated Programing (VAP) Code

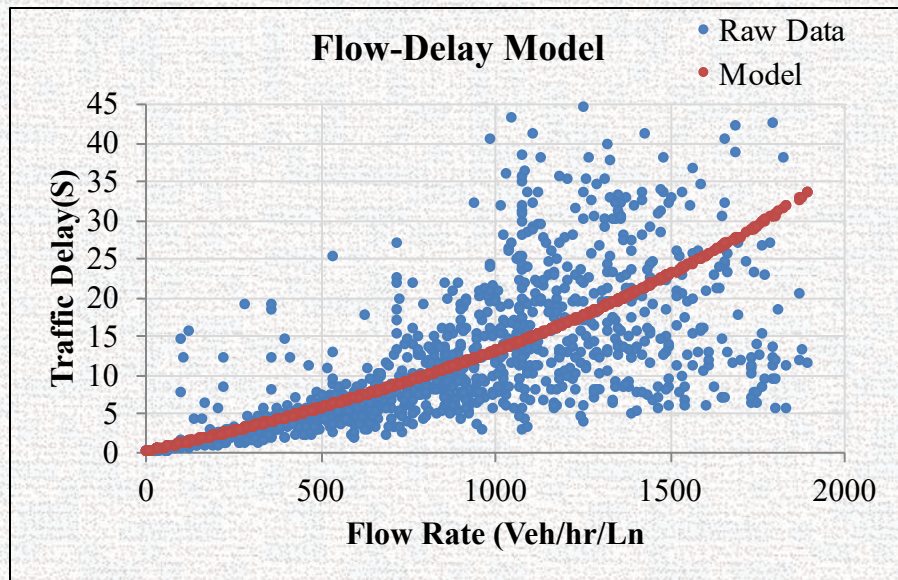
- Signal Timing and Phasing Plans



TSP Signal Logic Implementation in VAP Code



Delay Models

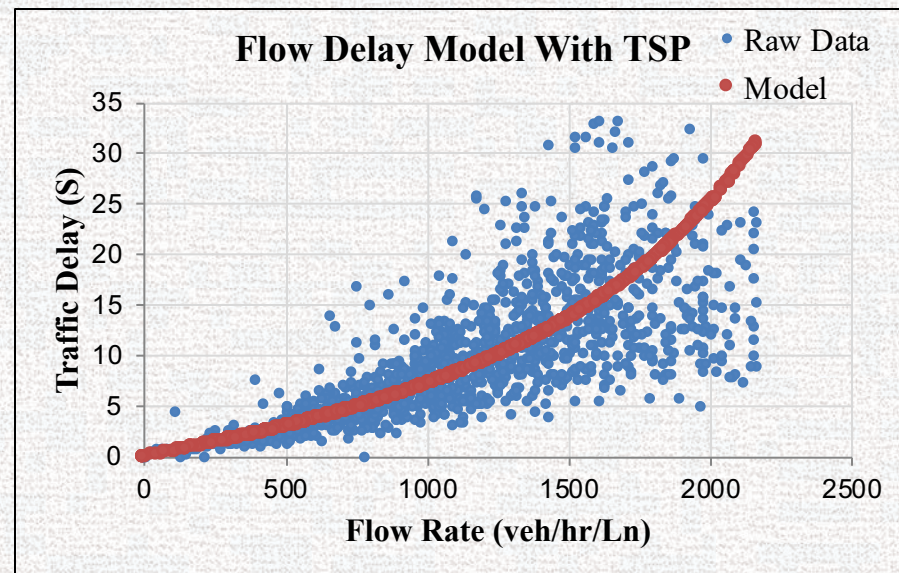


Model	α	β	R^2
No TSP	0.01	0.000228	0.979
TSP	0.00499	0.0003	0.928

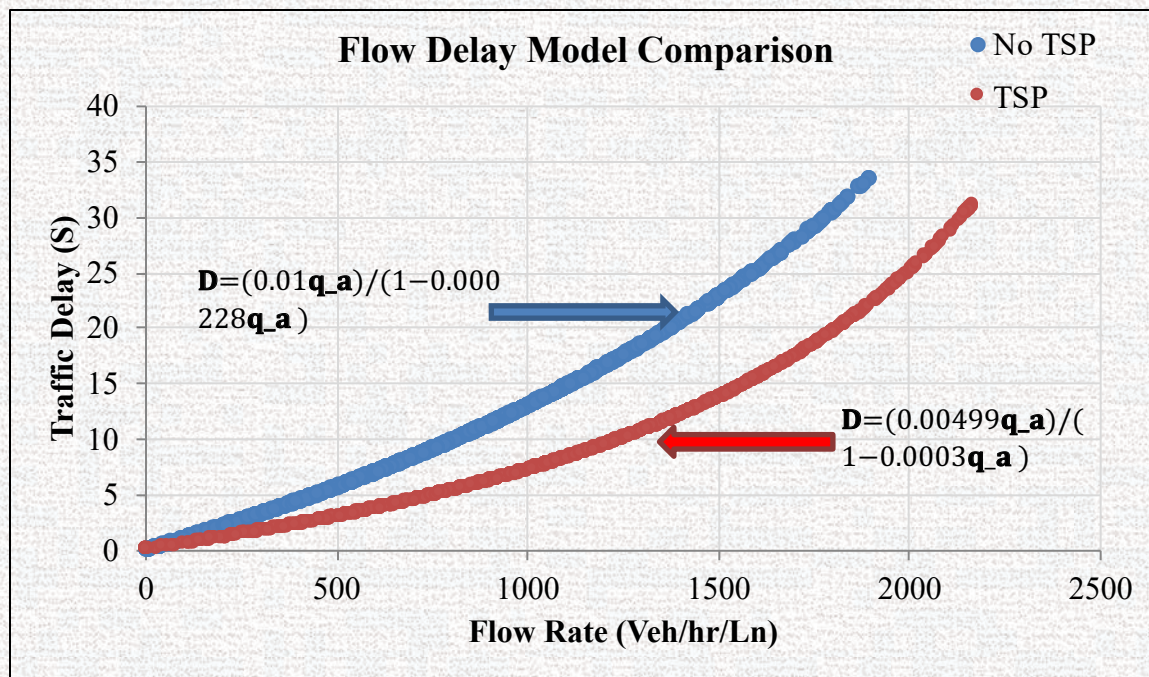
$$D = \frac{\alpha q_a}{1 - \beta q_a}$$

$$\alpha = \frac{1}{2} C [1 - g/C]^2$$

$$\beta = 1/s$$



FLOW Delay Model Comparison



❑ Maximum Flow Rate

➤ No TSP

■ 1896 veh/hr/ln of green

➤ TSP

■ 2163 veh/hr/ln of green

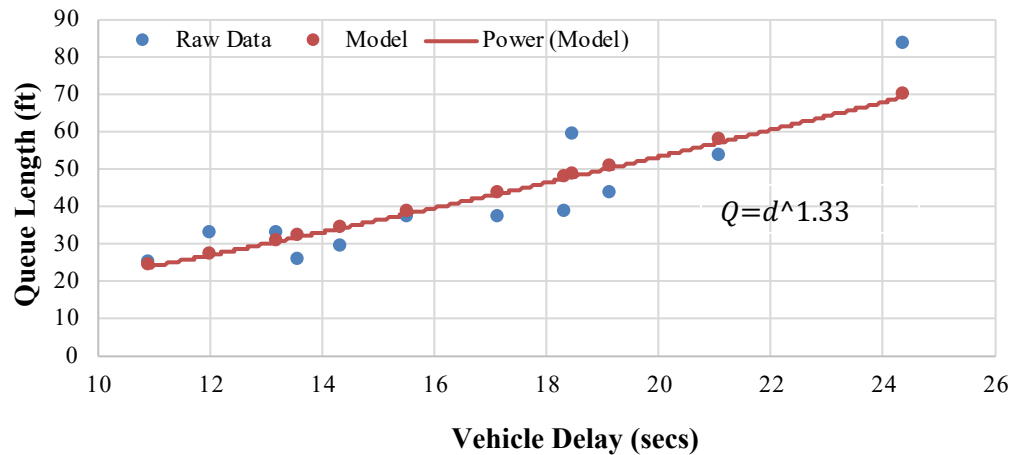
❑ TSP increased flow rate by 267 veh/hr/ln of green

❑ Delay Reduction

❑ Number of vehicles entering the link segment

Queue Delay Model

Queue Delay No TSP



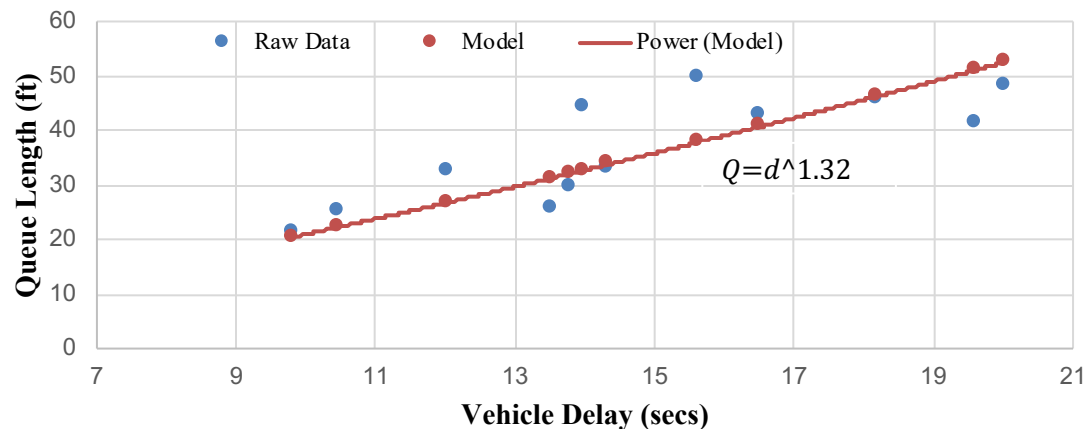
Scenario	Model	Coef.	Std. Err.	t	R^2
No TSP	α	1.33	0.017	79.72	0.974
TSP	α	1.32	0.018	72.11	0.972

❑ Max. Queue Length and Delay

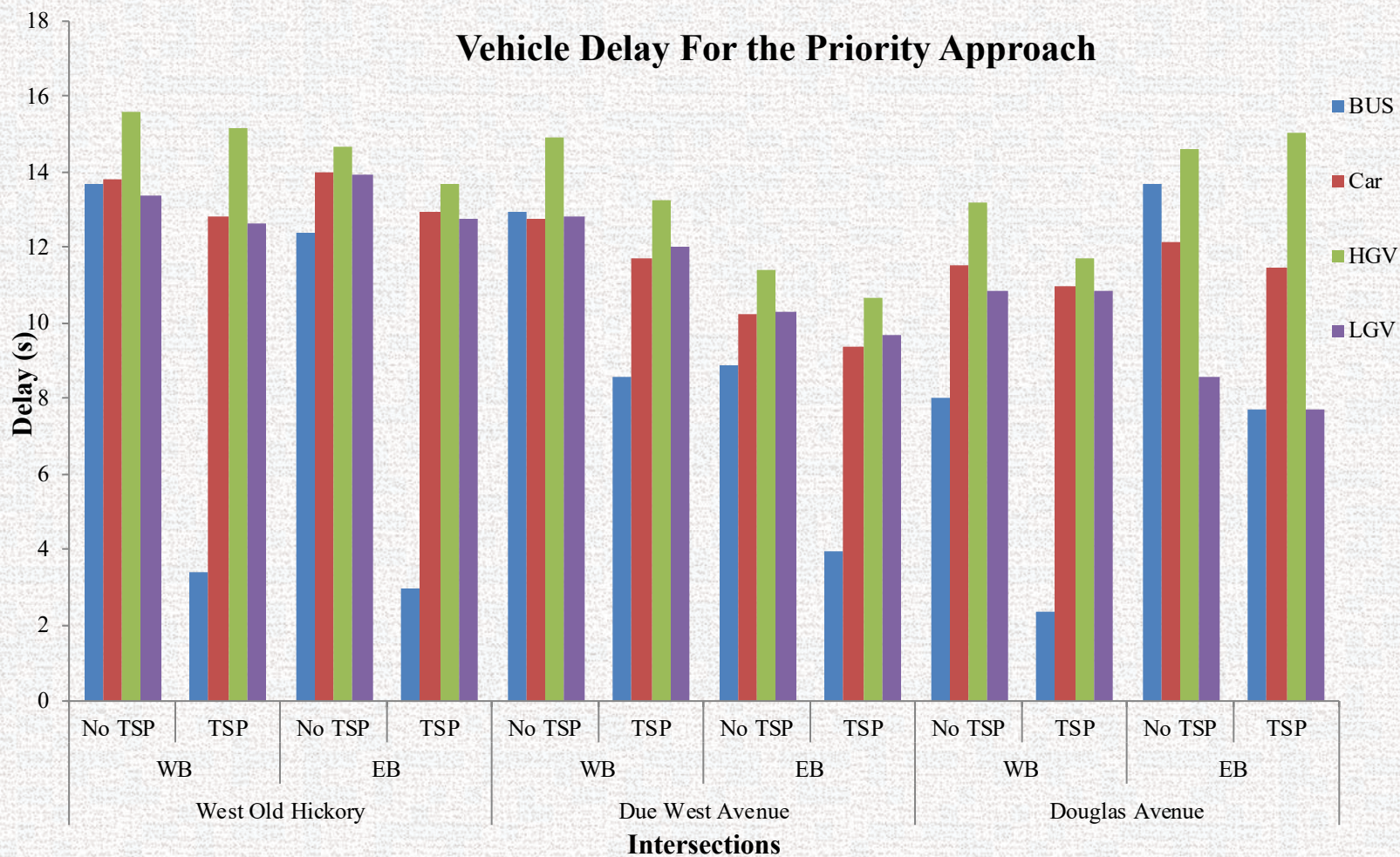
➤ No TSP (69-ft and 24s)

➤ TSP (53-ft and 20 sec)

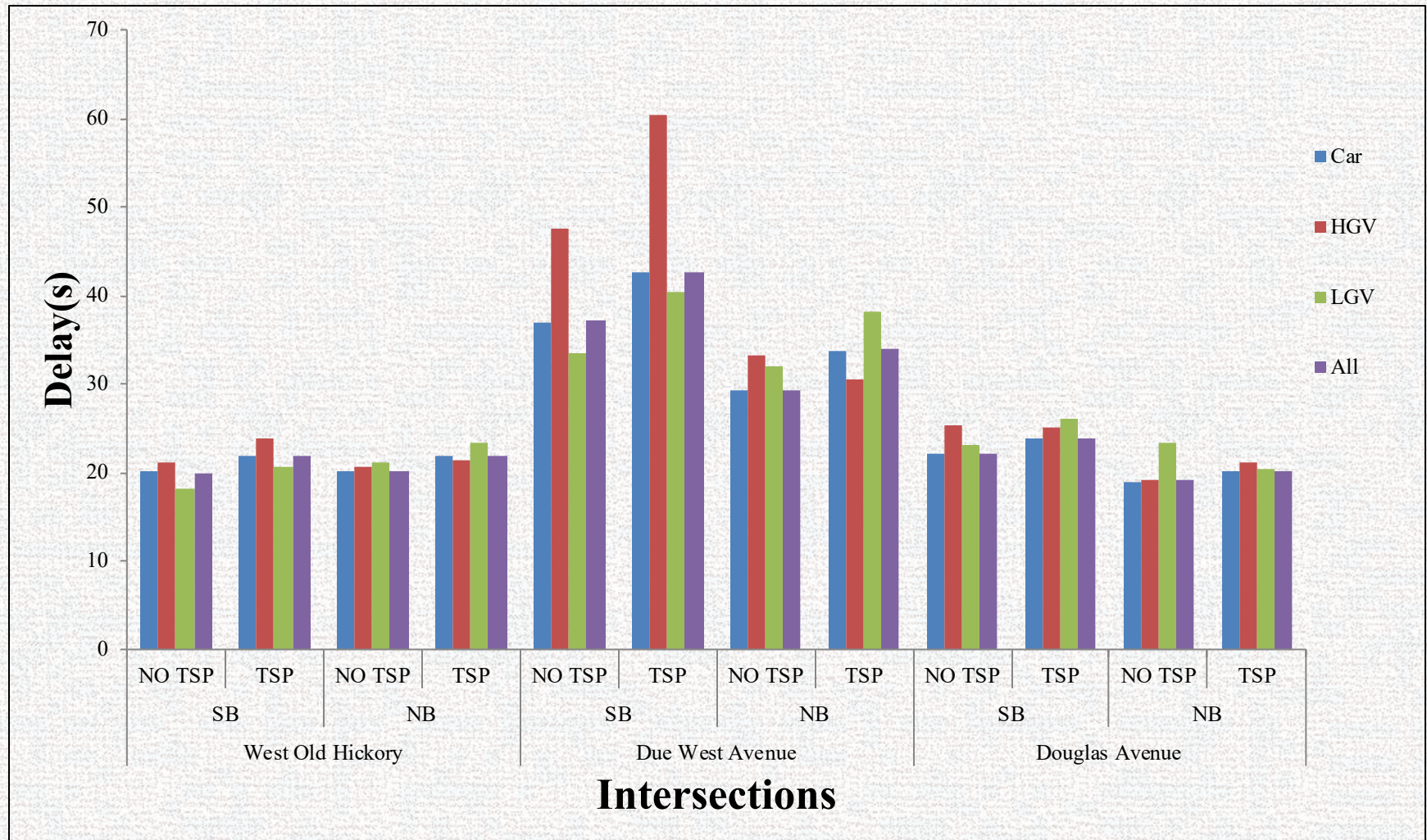
Queue Delay with TSP



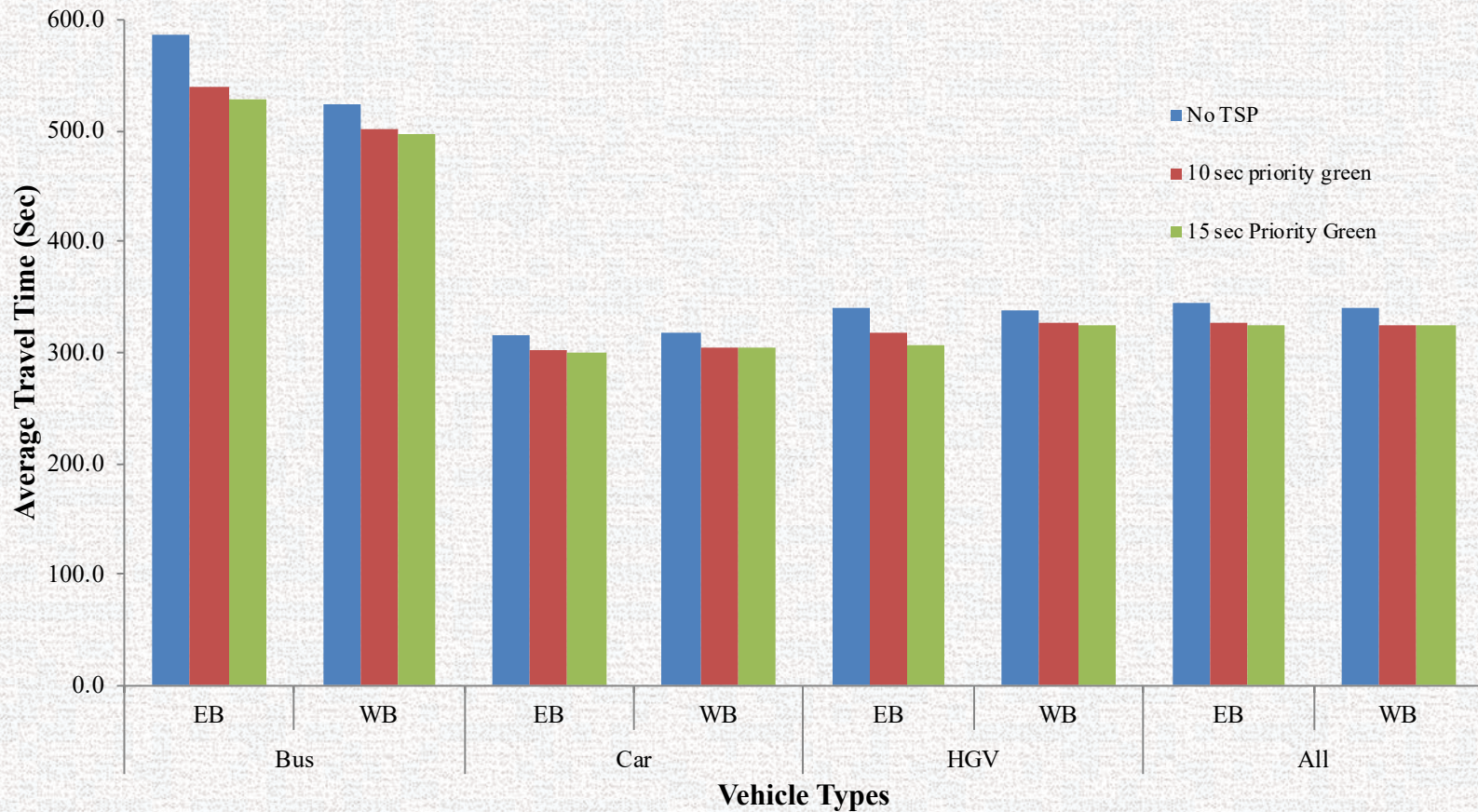
Isolated Intersection Based Main Line Delay Results



Isolated Intersection Based Crossing Delay Results

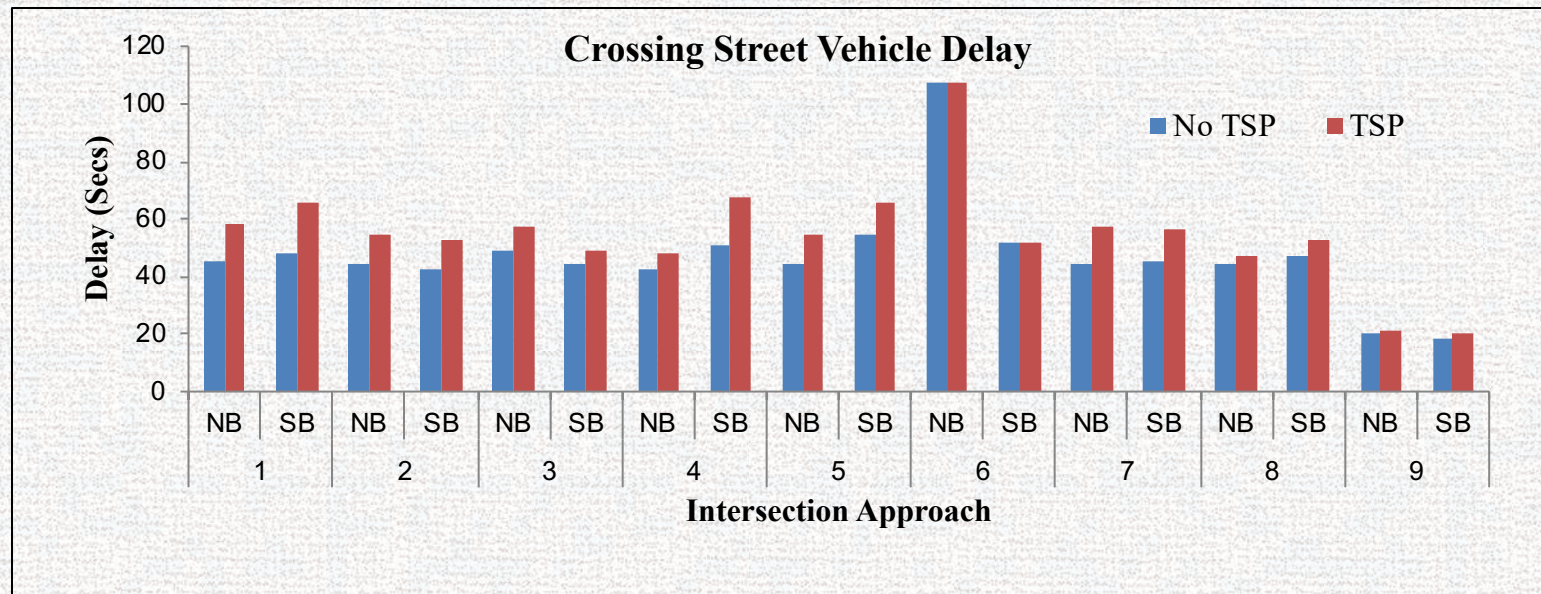
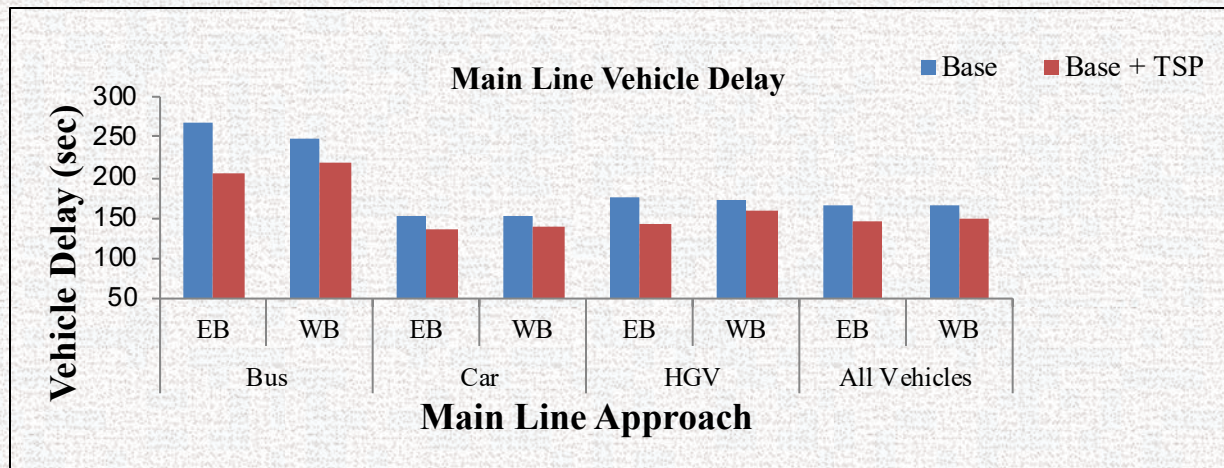


Corridor Based Main Line Travel Time Results

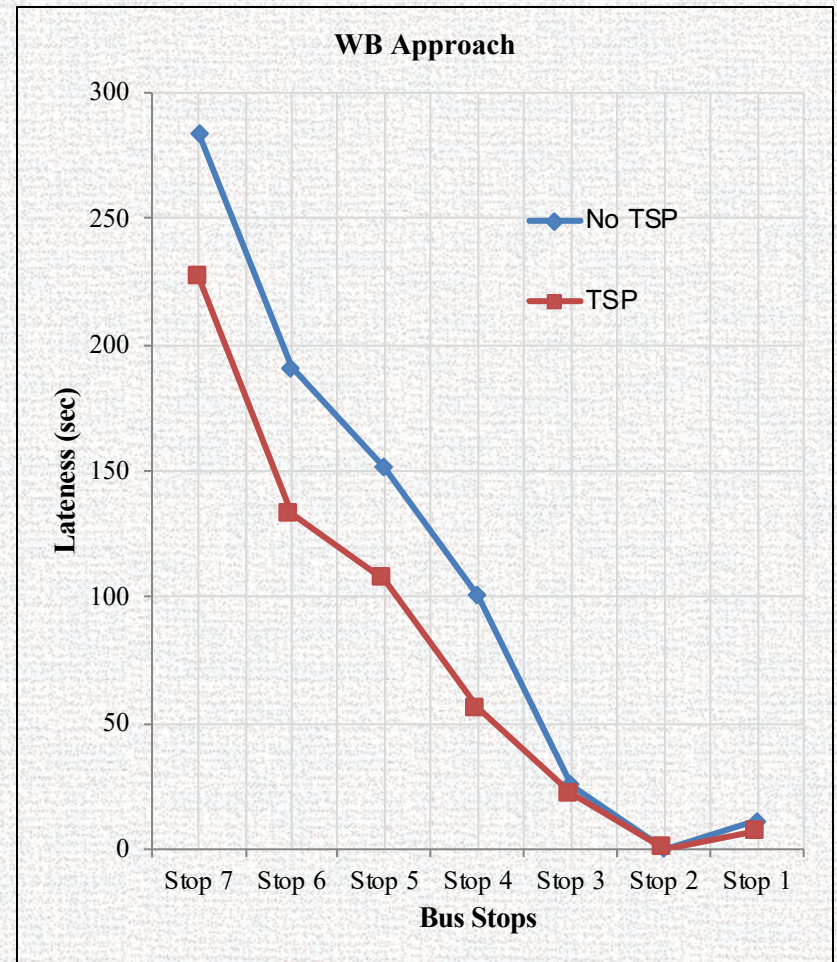
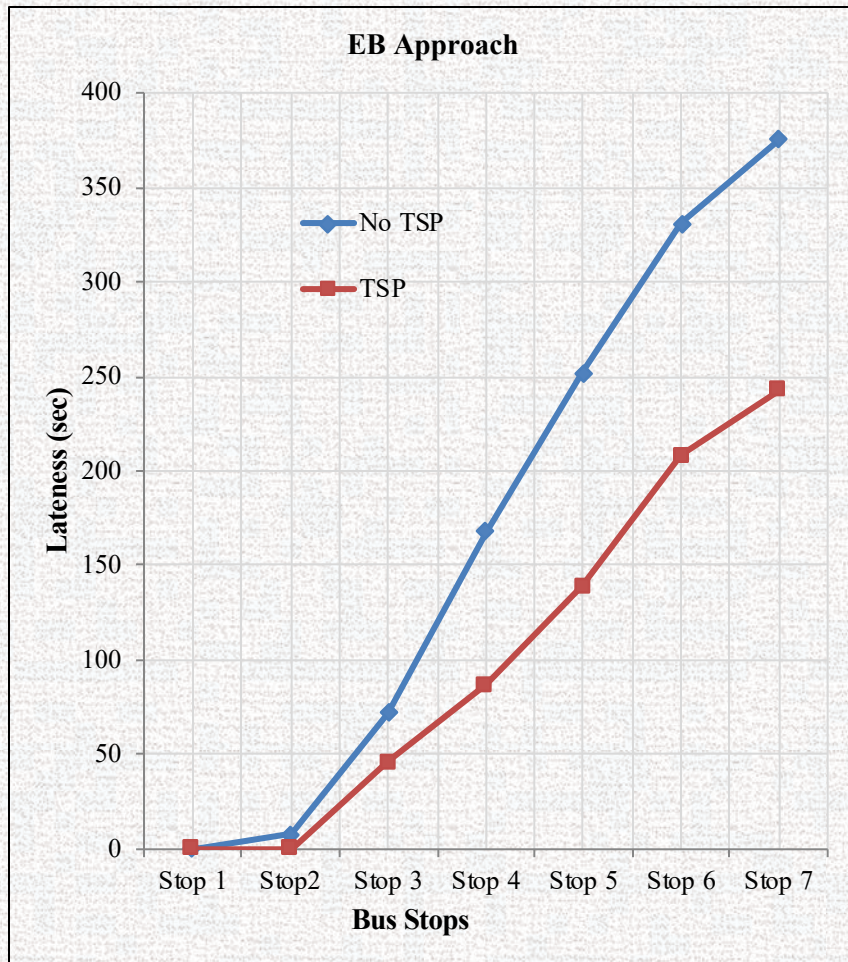


EB= Eastbound, WB= Westbound

Corridor Based Crossing Street Delay Results



Late Bus Recovery at Bus Stop Level



Impact of TSP on Level of Service

Isolated Intersection Based

Intersection	Field Signal Timing		LOS
	No TSP	TSP	
West Old Hickory	15.03	15.26	B
Due West Ave	14.71	14.95	B
Douglas Ave	14.78	14.71	B

Corridor Based

Intersection of Gallatin Pike and...	Intersection Delay & LOS					
	Base	LOS	Base + TSP	LOS	% Increase	% Reduction
Alta Loma	27.3	C	31.13	C	14.0	
Unnamed	21.47	C	21.51	C	0.2	
Rivergate	34.1	C	42.39	D	24.3	
Cude Lane	21.33	C	23.3	C	9.2	
Shepherd Hills	20.91	C	21.36	C	2.2	
Conference Dr	24.79	C	26.06	C	5.1	
Liberty	17.07	B	17.85	B	4.6	
North Side	17.67	B	18.45	B	4.4	
2284-2282 TN6	7.98	A	7.97	A		0.1

Conclusion

Corridor Based

- ❑ 5.1% to 10% Bus Travel time Reduction
- ❑ 4.3% to 7.3% Travel Time Reduction from Other Vehicles
- ❑ 11.4% to 22.9% Bus Delay Reduction
- ❑ 8.9% to 14.4% Delay Reduction for other Vehicles
- ❑ up to 15.9% Increase in Crossing Street Delay
- ❑ up to 25.21% to 43.1% Bus Lateness Recovery

Isolated Intersection Based

- ❑ 34% to 76% Bus Delay Reduction
- ❑ 3% to 9%, Delay Reduction For other Vehicles
- ❑ 0.1% to 18% Increase In Crossing street Delay