

2ISFO

**2ND INTERNATIONAL SYMPOSIUM
ON FREEWAY AND TOLLWAY OPERATIONS**

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Traffic Demand Dynamics during Urban Freeway Short-Term Lane Closures

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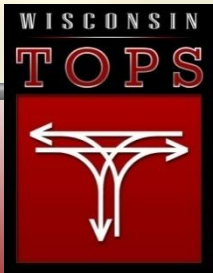
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Problem Statement

- With the aging highway infrastructures and increasing travel demand, the need for maintaining reliable and comfortable travel environments is becoming more important.
- However, the proliferation of the work zones is causing problems to daily commuters.
- Unlike the long-term work zones, the SLCs do not normally receive the same level of traffic control and management but their impact on daily commuters cannot be overlooked.
- Accurate traffic impact analysis is needed to help better allocate resources to mitigate the negative impacts.



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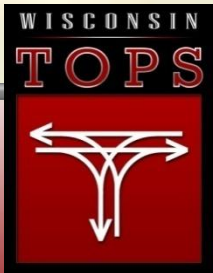
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Objectives

- Understand the dynamic nature of the driver route choice behavior during SLCs
- Identify the factors that help to explain and predict the route choice decisions
- Estimate the traffic pressure on (exiting) ramp terminals
- Estimate traffic impact on alternative (arterial) routes



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Definitions

- **Short-term lane closure (SLC)**

The closure, primarily maintenance activities, lasts between six to eight hours long, during daytime off peak. Lane restriction or partial closure is the main traffic control strategy. Closure approval lead time normally varies from 3 days to two weeks and traveler information may not be available.

- **V-SPOC Application Suite**

Web-based tools for analyzing traffic detector volume, speed, and occupancy data from the WisDOT Advanced Traffic Management System (ATMS) data archive for the years 1997-present.

- **Wisconsin Lane Closure System (LCS)**

The Wisconsin Lane Closure System (LCS) is a Web-based system for tracking closures and restrictions on Wisconsin state highways.



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Data Collection — Lane Closure Information

- Study scope
 - Time: January 2008-April 2008
 - Area: Wisconsin Southeast Freeway System (Milwaukee area)
 - Features: SLCs
- Data elements
 - closure configuration
 - duration and
 - Location, including road name, latitude and longitude.

- More than 5,500 closures have been logged since January 2008.

LANE CLOSURE SYSTEM Help | About | Contact Us | Exit WisLCS

Home | Search | Reports | Capacity | Calendar | Email | Preferences

Search

***Closure Status**

ALL

ALL SCHEDULED

ENTERED

PENDING

RETURNED

ALL ACCEPTED

ACCEPTED

RESCHEDULED (PENDING)

ALL FINAL

DELETED

CANCELED

COMPLETED

RESCHEDULED (FINAL)

***Closure Type**

ALL

CONSTRUCTION

BOTH

LOCAL PROGRAM

NOT LOCAL PROGRAM

MAINTENANCE

PERMIT

EMERGENCY

SPECIAL EVENT

***Region/County**

ALL

Hwy

Date Range From: 04/26/2009

Date Range To

Project ID

Closure ID

Above entries override ALL other search selections.

Order By: BEGIN DATE

Max Results: First 100

Search Reset

Expand | Printable | CSV | Capacity | Calendar (5227) MAINTENANCE | ACCEPTED

WAUKESHA: Soil Boring

ID	HWY	FACILITY	DESCRIPTION	DURATION	
1	I-43 NB	MAINLINE	Left Shoulder Closed at STH 164 (B-67-0118 BEGIN)	Daily/Nightly: 01/05/2009 - 01/06/2009 , 08:30 AM - 03:30 AM	ACCEPTED
2	I-43 NB	MAINLINE	Right Shoulder Closed at STH 164 (B-67-0118 BEGIN)	Daily/Nightly: 01/05/2009 - 01/06/2009 , 08:30 AM - 03:30 AM	ACCEPTED

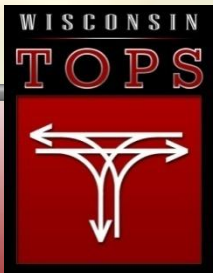
Modified Date: 01/02/2009 04:24 PM | Modified By: ehanson | Status: ACCEPTED | Applies To: ALL FACILITIES | Comment: INITIAL INSERT INTO DATABASE

Expand | Printable | CSV | Capacity | Calendar (5226) MAINTENANCE | ACCEPTED

WAUKESHA: Soil Boring

ID	HWY	FACILITY	DESCRIPTION	DURATION	
1	I-43 SB	MAINLINE	Left Shoulder Closed at STH 164 (B-67-0119 BEGIN)	Daily/Nightly: 01/05/2009 - 01/06/2009 , 08:30 AM - 03:30 PM	ACCEPTED
2	I-43 SB	MAINLINE	Right Shoulder Closed at STH 164 (B-67-0119 BEGIN)	Daily/Nightly: 01/05/2009 - 01/06/2009 , 08:30 AM - 03:30 PM	ACCEPTED

Modified Date: 01/02/2009 04:23 PM | Modified By: ehanson | Status: ACCEPTED | Applies To: ALL FACILITIES | Comment: INITIAL INSERT INTO DATABASE



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Data Collection—Volume, Speed and Occupancy

■ Data elements

- Detector locations
- historical detector volume, speed and occupancy.
 - Mainline detectors
 - Exit ramps
 - Entrance Ramps

- The dataset can be obtained in up to five(5) minute intervals.
- Data is updated daily and dates back to January, 1997.

Home > Web Applications > V-SPOC Help | About | Contact Us | Navigate: General Detector

General Detector Selections (SE Region)

Select Detectors

Corridor: I-43 NB Marquette Int to Silver Spring

Count Locations or Controllers: Count Locations: S-N MARQUETTE (906) (MAINLINE) (No Detectors)

Detector ID: [Add]

Listed Detectors:

Select Time Intervals

Start-Time (HH:M): 12 AM (00) : 00

End-Time (HH:M): 12 AM (24) : 00

Month: APR 2009

Calendar: + S M T W T F S

Grid: + 5 6 7 8 9 10 11

Grid: + 12 13 14 15 16 17 18

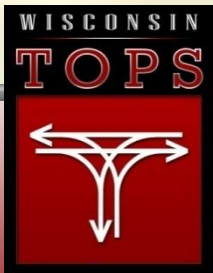
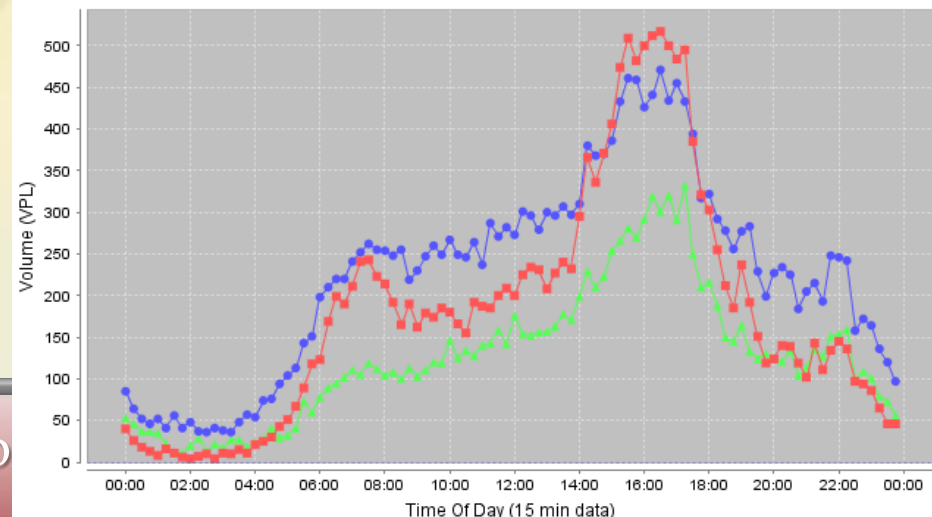
Grid: + 19 20 21 22 23 24 25

Grid: + 26 27 28 29 30

Preset Date Selections: Tues-Thurs Weekends

Buttons: Add All >>, Add, << Remove, << Remove All, Add, << Remove, << Remove All, Continue, Reset, Exit

Graph of Selected VSO Data



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Information Integration

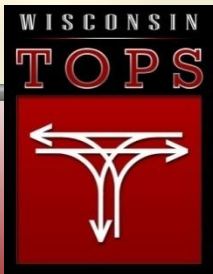
Lane closure Locations
retrieved from LCS

Detector locations
obtained from V-SPOC

Closure locations plotted
on a GIS map

Detector locations plotted
on a GIS map

Match closure and detector
locations and times

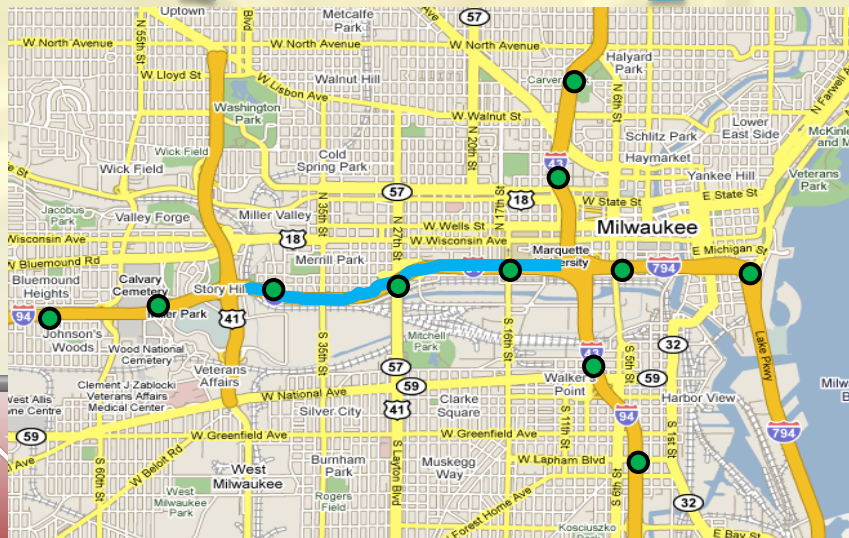
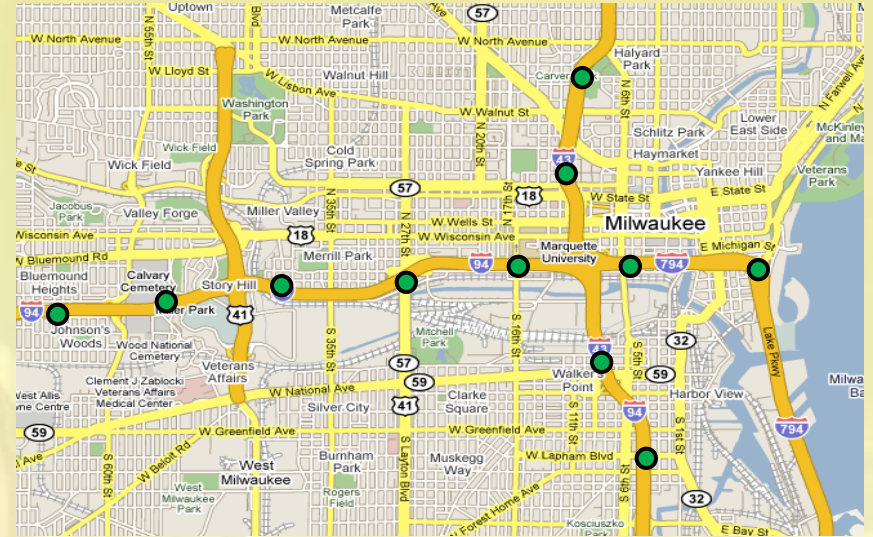
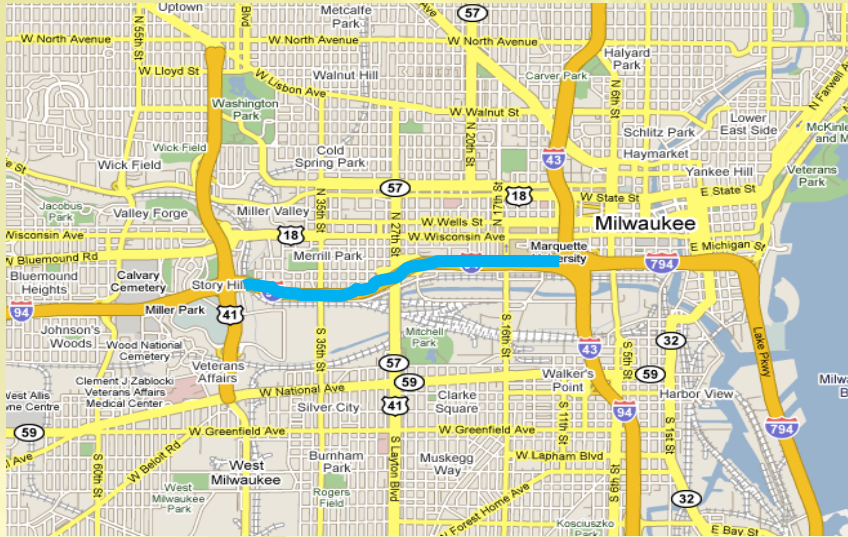


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Example



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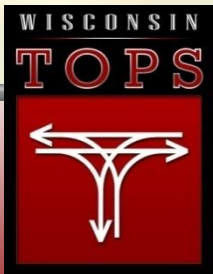
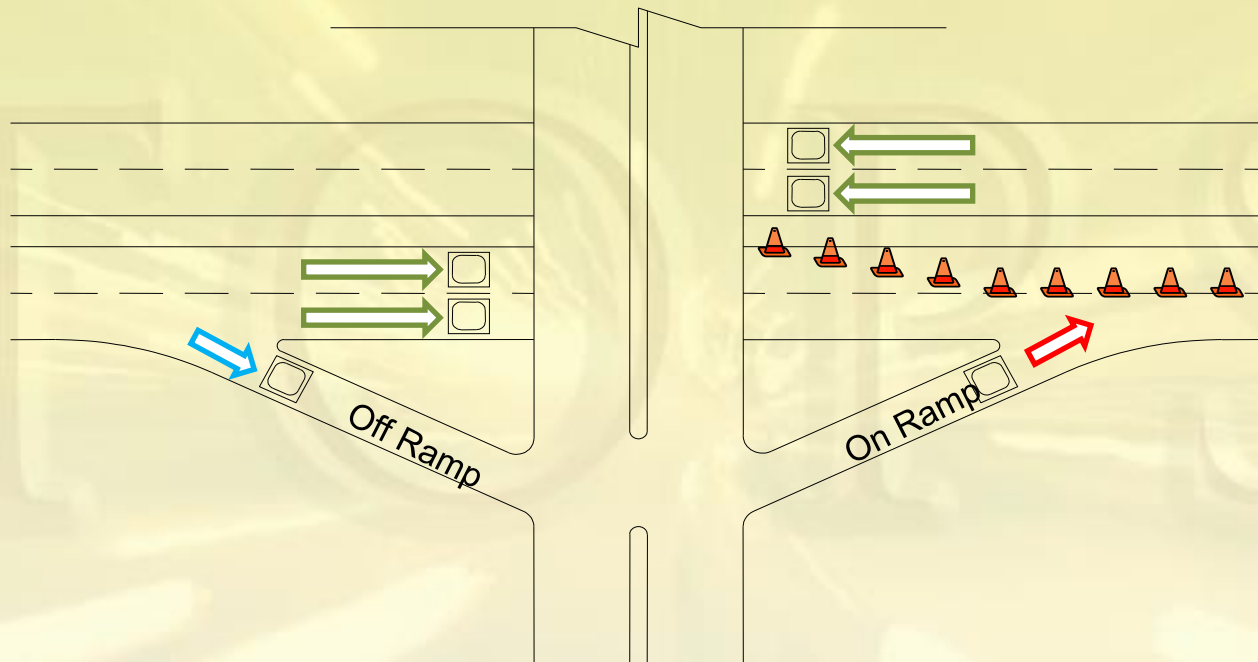
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Measurements Taken

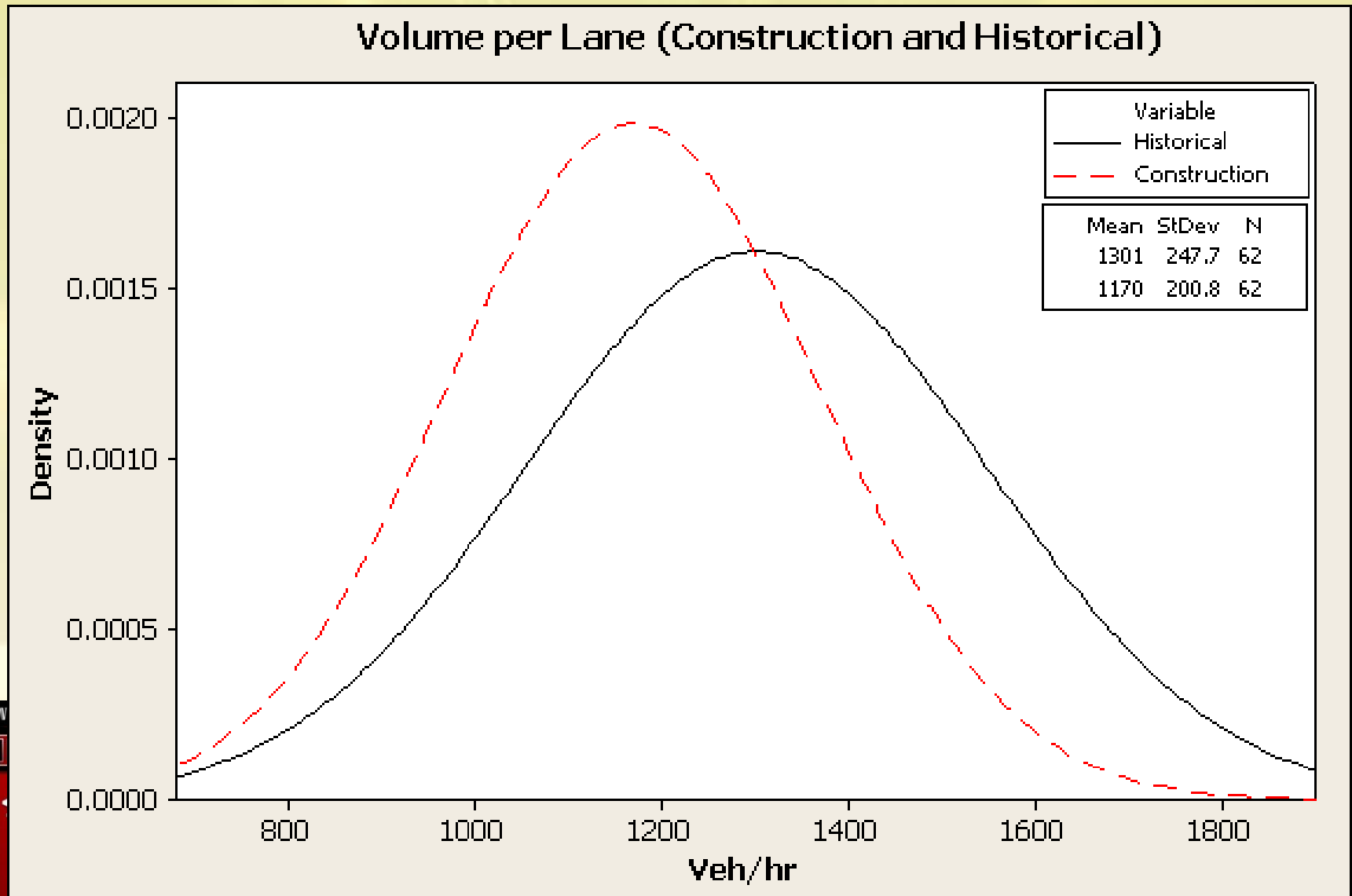


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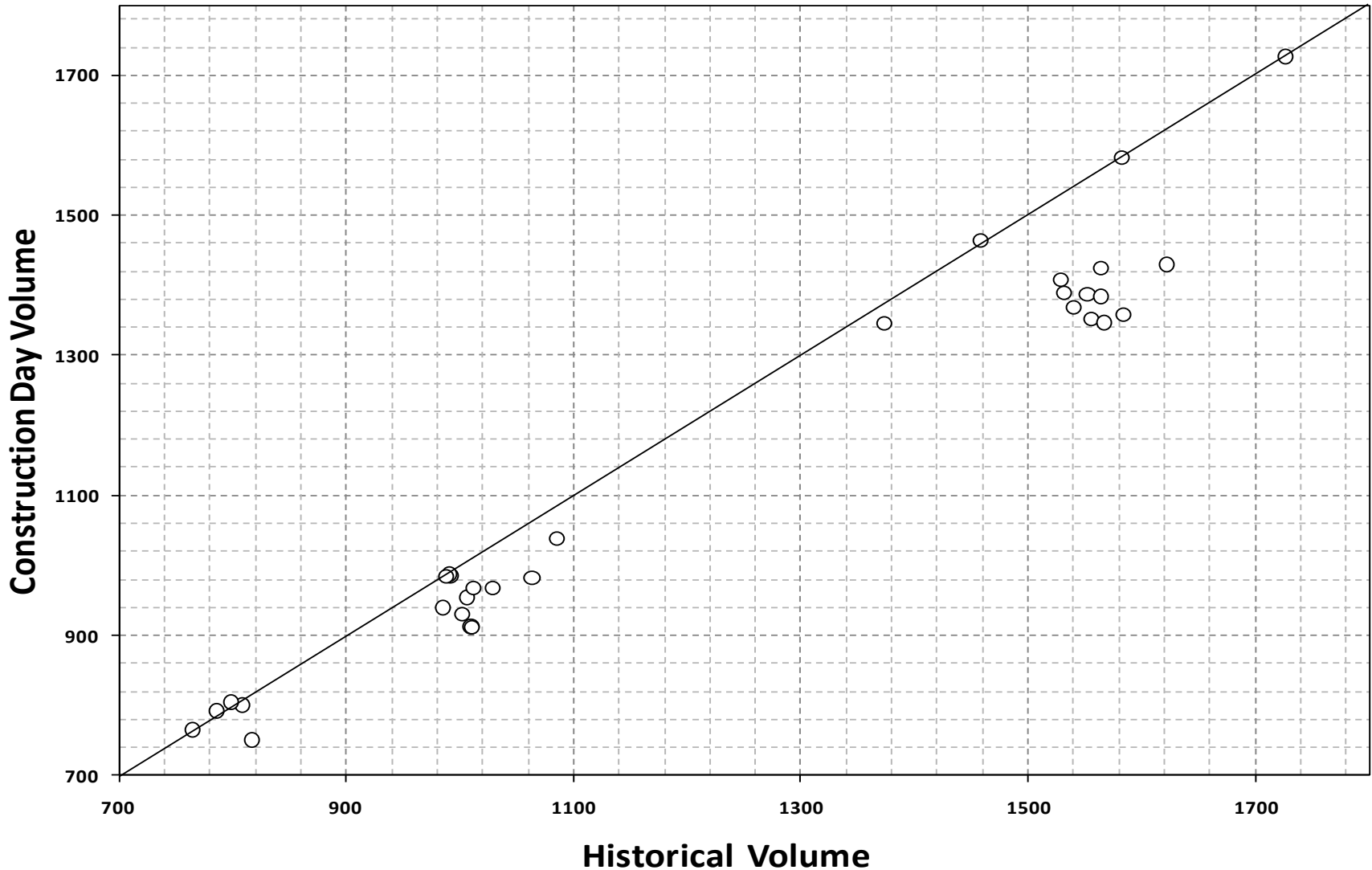


Range of Demand for Study



Demand Reduction at Closure

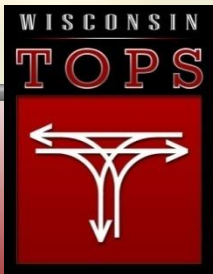
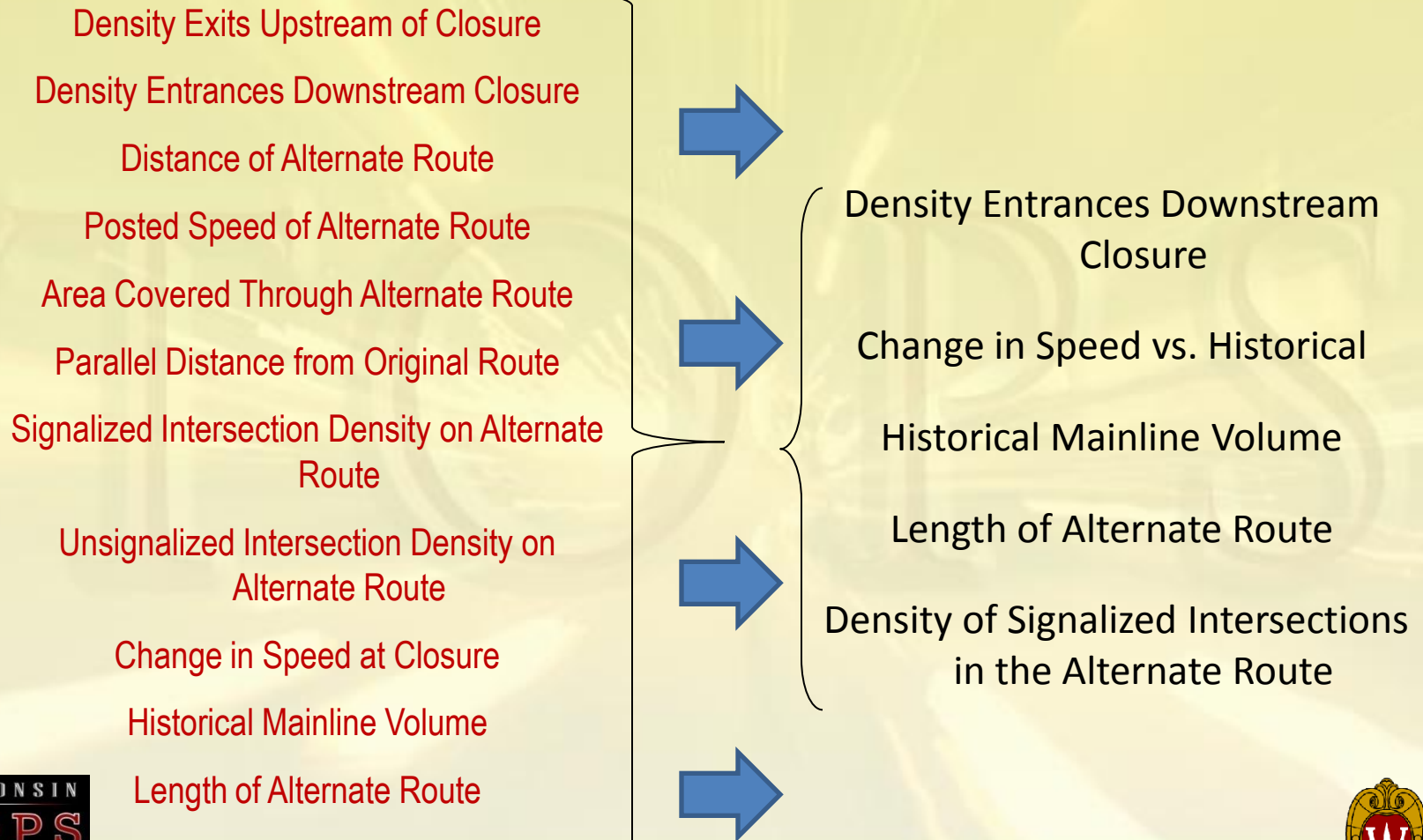
Construction Day Volume Vs. Historical Day Volume (Average per Lane)



Variable Summary

Variable	Min	Max	Average	Std. Dev.
Density Exits Upstream	0.367	2.174	1.026	0.342
Density Entrances Downstream	0.474	1.442	1.026	0.342
Alternate Route Length	2.100	3.700	2.630	0.645
Posted Speed Alternate Route	35.00	45.00	37.70	4.500
Area Covered by Alternate Route	40.00	755.0	334.5	216.0
Parallel Distance from Mainline	0.03	0.32	0.19	0.52
Signalized Intersection Density	0.811	4.879	3.793	2.325
Unsignalized Intersection Density	14.00	32.00	23.00	5.490
Change in Speed at Closure	-35.00	5.400	-22.00	13.00
Historical Mainline Volume	1,200	3,392	1,730	120.0

Data Reduction



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Gravity Model for Diverting Traffic

- Gravity Model 1

$$(\delta = P * A / f(\text{cost}) = \frac{(\beta_1 * S_r)^{\beta_2} * H_v}{L_A^2})$$

- Gravity Model 2

$$(\delta = P * A / f(\text{cost}) = \frac{(\beta_1 * S_r)^{\beta_2} * H_v}{\exp(L_A)})$$

Where,

δ = Number of Trips that are Diverted

P = trip production

A = trip attraction

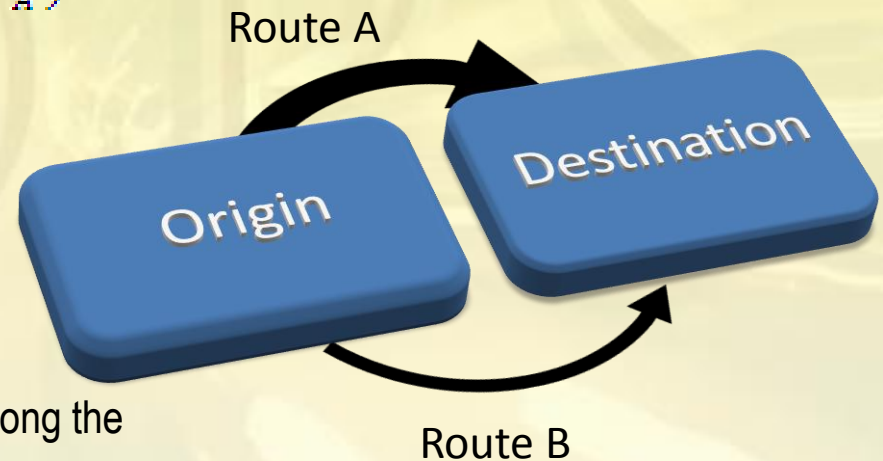
β_1 = Coefficient

β_2 = Coefficient

S_R = Density of Signalized Intersections along the alternative

H_V = Historical Main Volume

L_A = Length of Alternative Route (miles)



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Gravity Model Results

S_R = Density of Signalized Intersections (int/mile) H_V = Historical Main Volume (veh)

L_A = Length of Alternative Route (miles)

- Gravity Model 1 ($R^2 = 34\%$)**

$$(\delta = P * A / f(\text{cost})) = \frac{(\beta_1 * S_r)^{\beta_2} * H_v}{L_A^2}$$

	Estimate	Std. Error	t-value	Pr(> t)
Beta1	0.259	0.007344	35.271	<2.0 E-16
Beta2	3.027	0.477949	6.334	5.5 E-07

- Gravity Model 2 ($R^2 = 34\%$)**

$$(\delta = P * A / f(\text{cost})) = \frac{(\beta_1 * S_r)^{\beta_2} * H_v}{\exp(L_A)}$$



	Estimate	Std. Error	t-value	Pr(> t)
Beta1	0.327	0.01187	27.574	<2.0 E-16
Beta2	3.317	0.50286	6.596	2.7 E-07



Relative Mainline Demand Reduction

The following two linear models predict the relative mainline demand reduction during the SLC period.

$$\text{relative mainline demand reduction} = (\text{Diverting Traffic}) / (\text{Normal Traffic Demand})$$

Variable	Beta Coefficient	Standard Error	T-Value	P-Value (95%)
Intercept	0.030090	0.016460	1.83	0.073
Signalized Density	-0.031272	0.006399	-4.89	0.000
Delta Speed	0.0038573	0.000463	8.32	0.000

R² = 58.8%

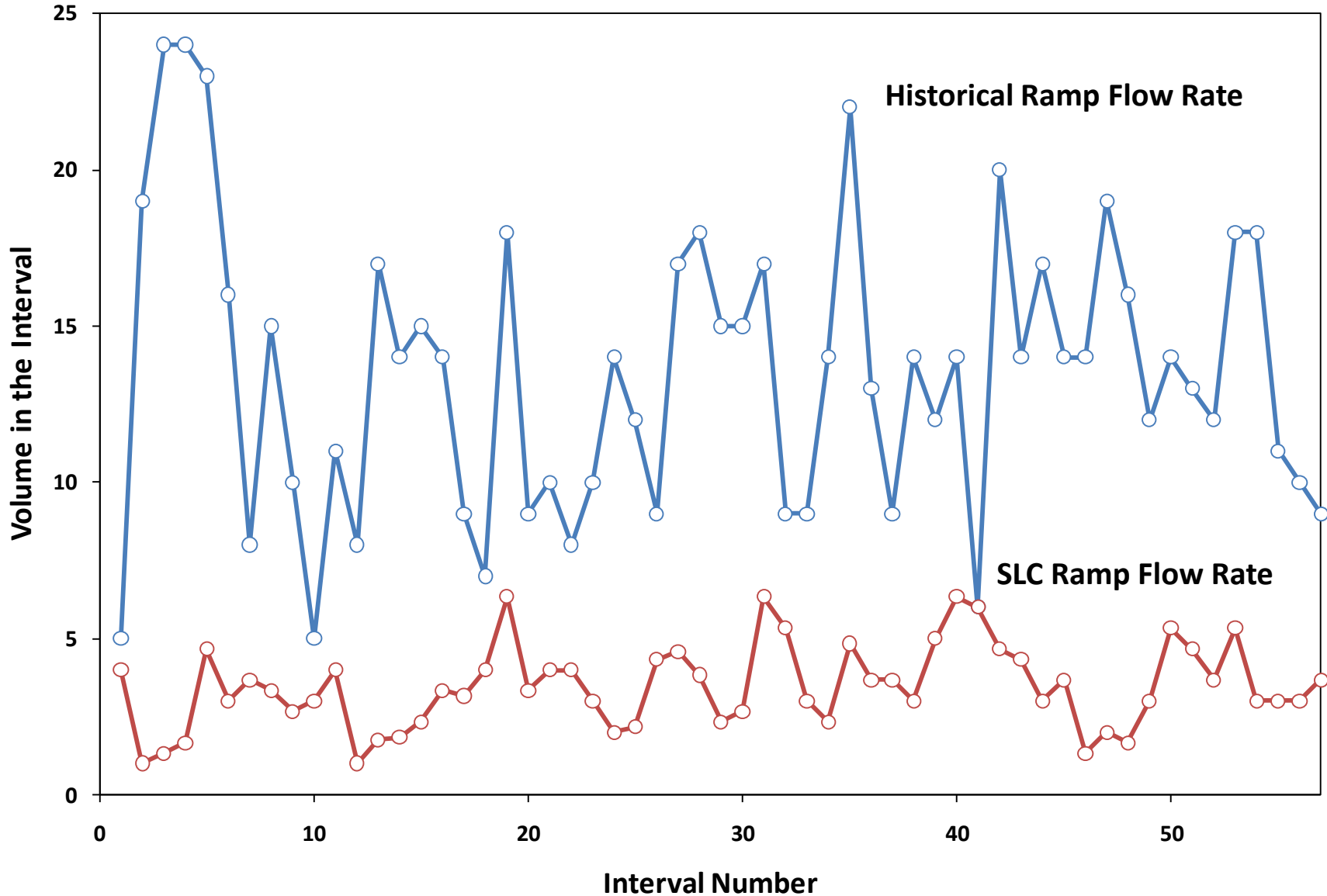
R² Adjusted = 57.4%

Variable	Beta Coefficient	Standard Error	T-Value	P-Value (95%)
Intercept	0.02399	0.01954	1.23	0.224
Density Downstream	-0.06542	0.18230	-3.59	0.000
Delta Speed	0.003857	0.000463	8.32	0.000

R² = 52.5%

R² Adjusted = 50.9%

Off Ramp Historical and Construction Volume



Off Ramp Demand Change

Model Description

Variable	Beta Coefficient	Standard Error	T-Value	P-Value (95%)
Intercept	-0.9662	0.3296	-2.93	0.005
Density Downstream	0.6052	0.3714	1.63	0.110
Delta Speed	-0.081473	0.009077	-8.98	0.000

$R^2 = 75.1\%$

R^2 Adjusted = 74.0%

Change in Off Ramp = -0.9662 + 0.6052 (Density Downstream) – 0.081473 (Delta Speed)



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Conclusions

- 13 lane closures were used in the study. Among them, 5 were deemed adequate for the analysis and studied further.
- The study designed a novel approach to integrating Wisconsin lane closure information with detector data to estimate the traffic impact on both ramp terminals and alternative routes.
- The results shows that off-ramp traffic increased during lane closure events.
- The results shows that up to 15% traffic will divert (natural diversion) during the lane closure events.
- Low density of signalized intersections along the alternative routes, high historical volume and short alternative route distance encourage diverting traffic.



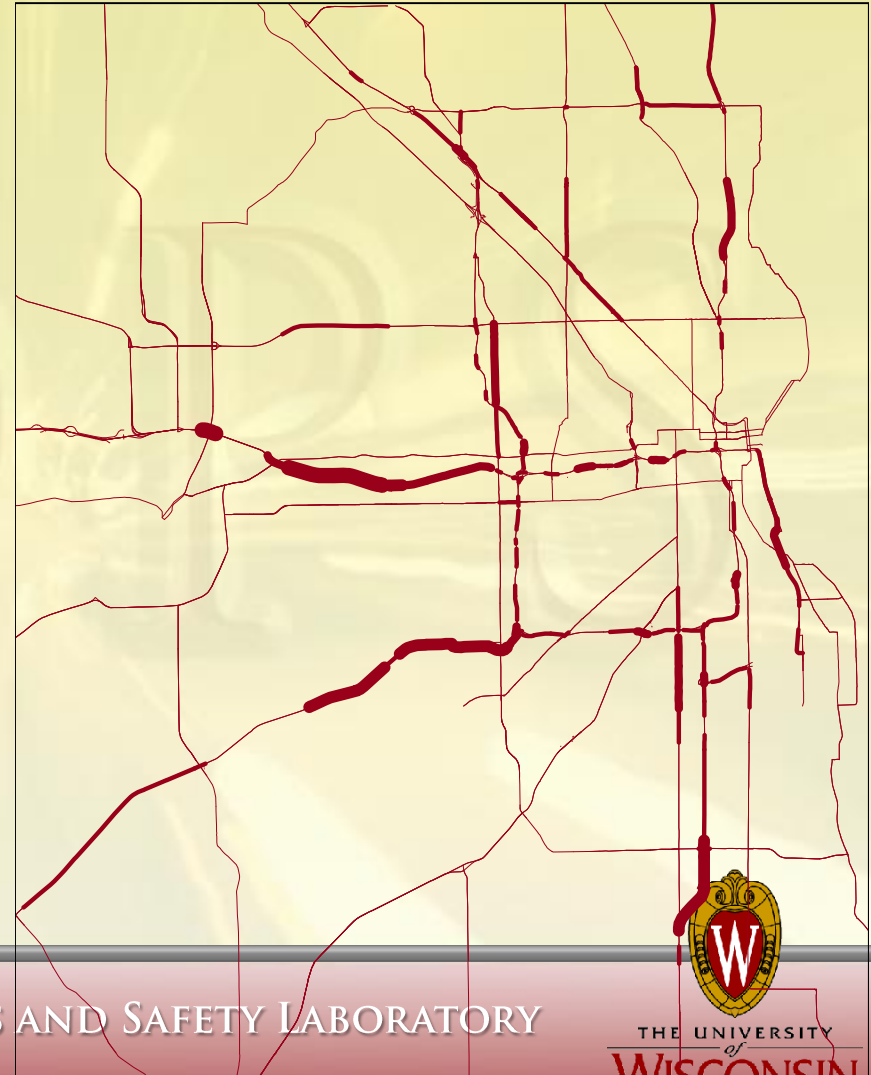
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Future Research

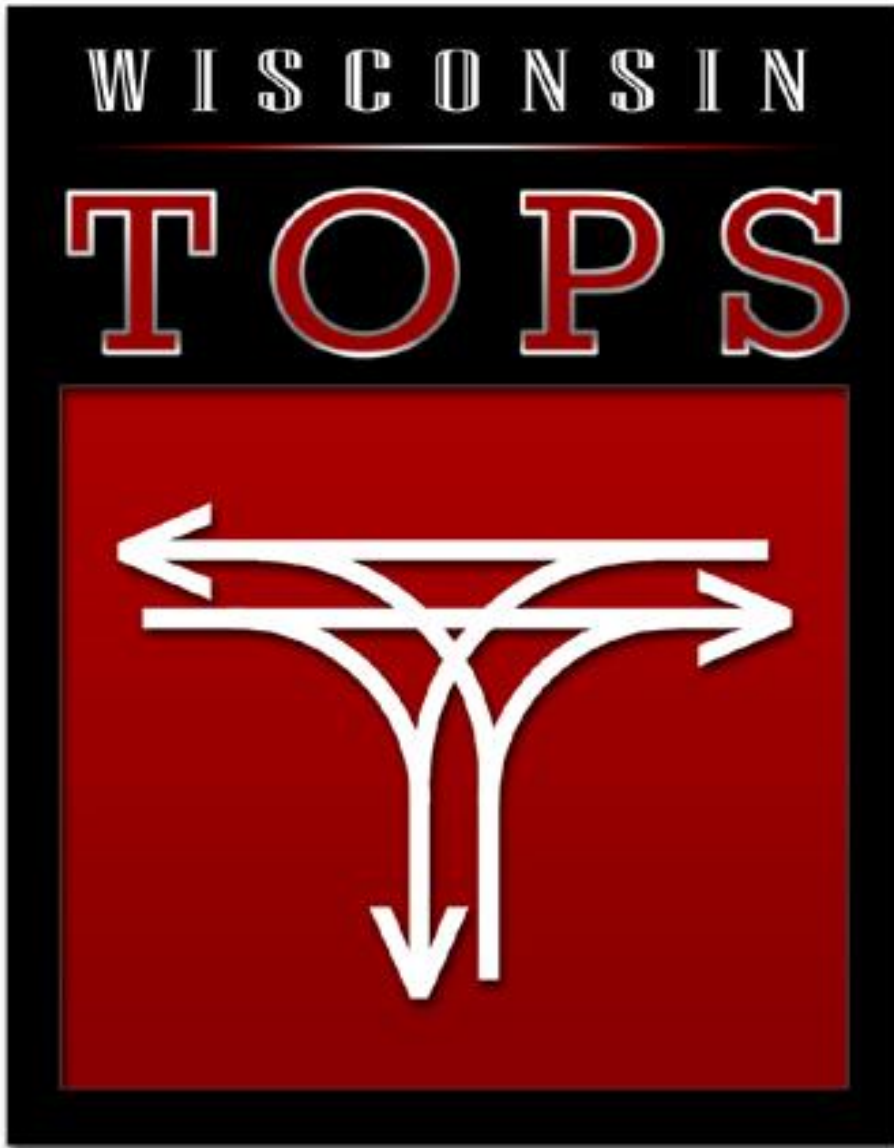
- Collect data for other corridors
- Develop corridor traffic impact index caused by SLCs
- Evaluate the application of ATIS in mitigating congestion by SLCs



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