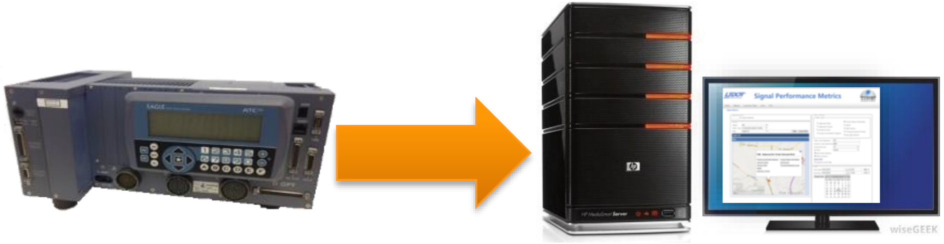
Automated Traffic Signal Performance Measures – The Fitbit® for Your Signal System

Date: April 27, 2017
Presented by: Susan Langdon

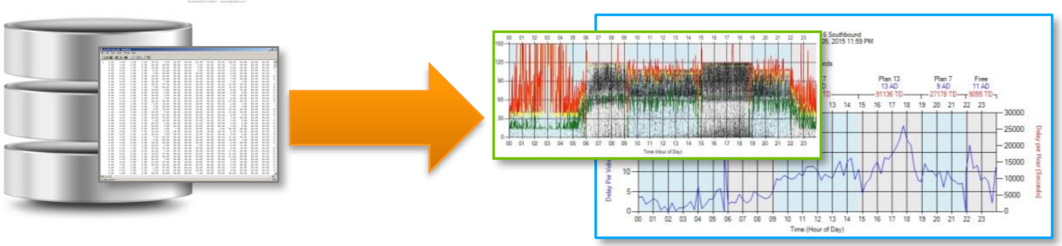
Opportunity

There are approximately 400,000 signalized intersections in the US ~ we need a systematic procedure for identifying operational problems … and fixing them using controller and probe data.

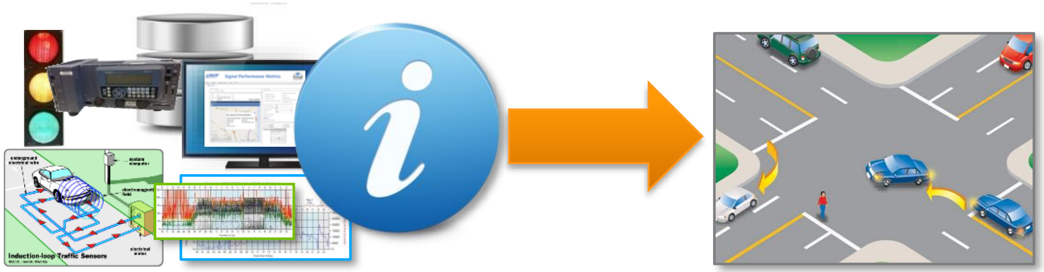
How to Improve the Situation?



How can we get useful data from the field?



How can we get useful information from the data?

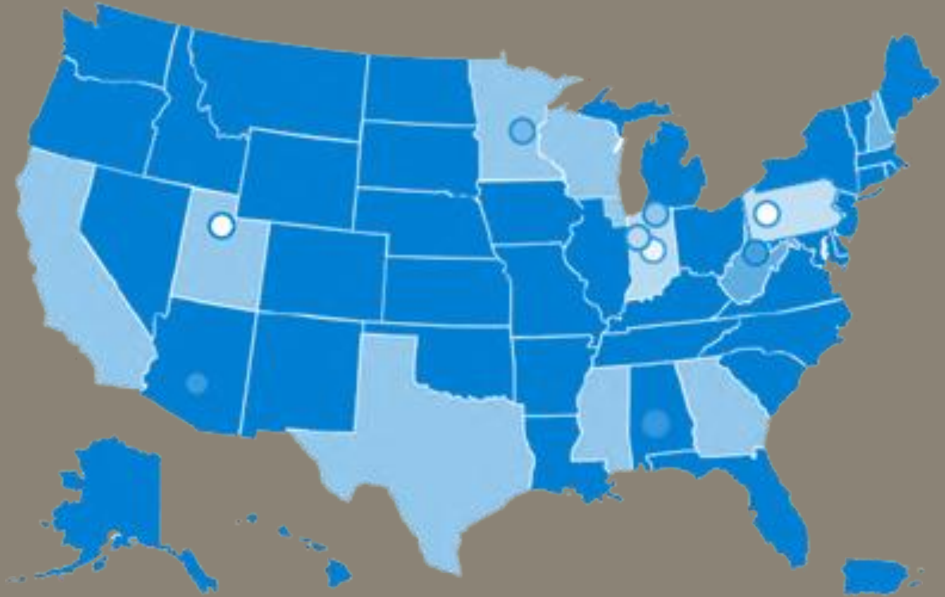


How can we leverage information to improve signal operations?

Pooled Fund Study

Participants:

- Wisconsin DOT
- ***Indiana DOT***
- Utah DOT
- City of Chicago
- Minnesota DOT
- California DOT
- New Hampshire DOT
- Texas DOT
- Mississippi DOT
- Georgia DOT
- Pennsylvania DOT
- USDOT

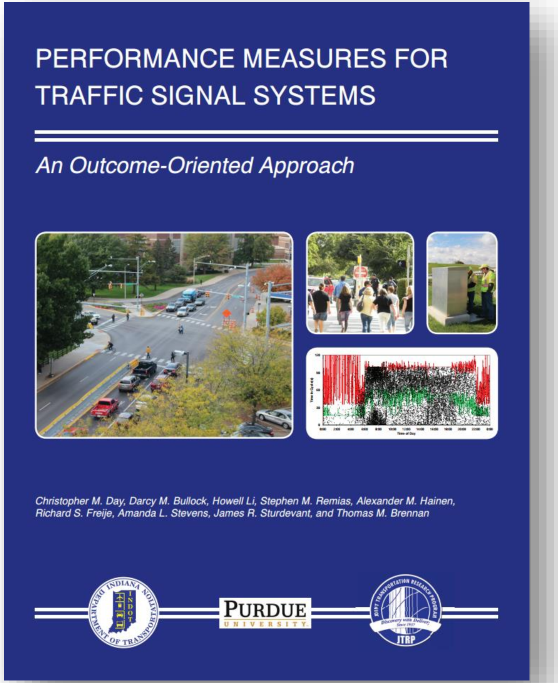


Stantec

Purdue University Research

Leader in research that has led to this ability along with partners

- Purdue, INDOT and controller manufacturers collaborate to develop data logging
- Purdue develops performance measures based on data
- UDOT develops software and website to utilize the data and performance measures



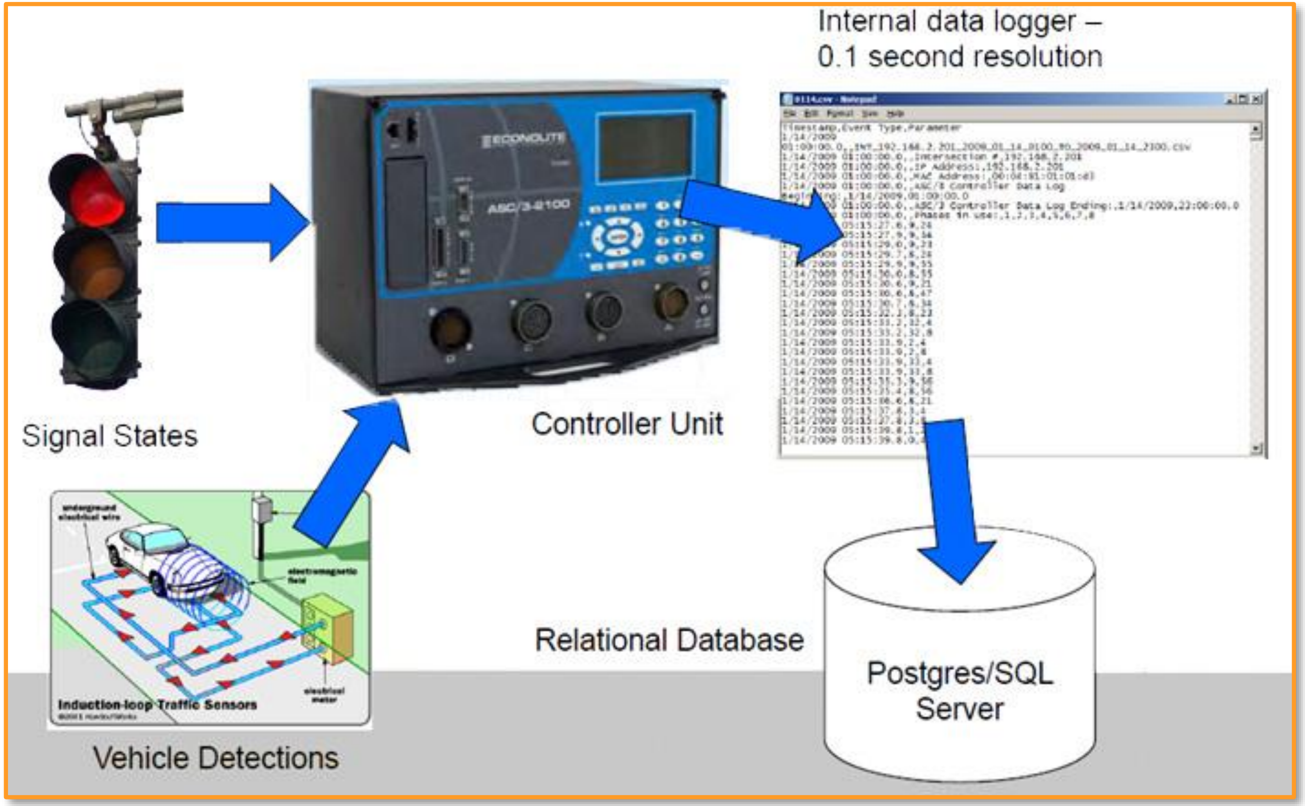
PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach

Christopher M. Day, Darcy M. Bullock, Howell Li, Stephen M. Remias, Alexander M. Hainen, Richard S. Freije, Amanda L. Stevens, James R. Sturdevant, and Thomas M. Brennan

PURDUE
UNIVERSITY

High-Resolution Event Data Concept



Internal data logger –
0.1 second resolution

Signal States

Controller Unit

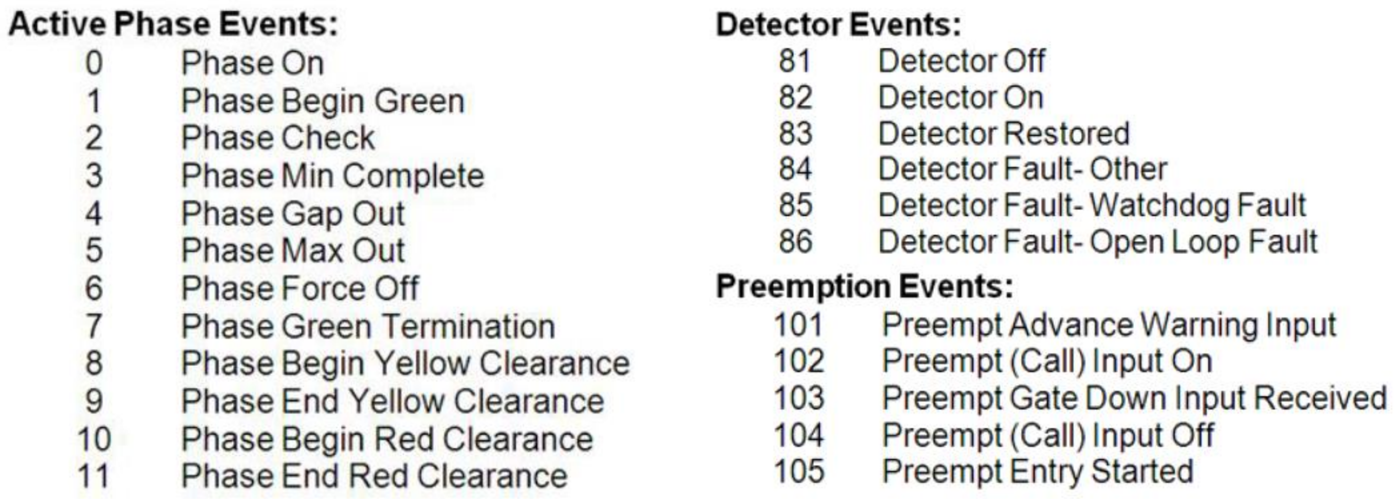
Vehicle Detections

Relational Database

Postgres/SQL
Server

Controller Enumerations

Event Code, Event Description, Parameter



Active Phase Events:

0	Phase On
1	Phase Begin Green
2	Phase Check
3	Phase Min Complete
4	Phase Gap Out
5	Phase Max Out
6	Phase Force Off
7	Phase Green Termination
8	Phase Begin Yellow Clearance
9	Phase End Yellow Clearance
10	Phase Begin Red Clearance
11	Phase End Red Clearance

Detector Events:

81	Detector Off
82	Detector On
83	Detector Restored
84	Detector Fault- Other
85	Detector Fault- Watchdog Fault
86	Detector Fault- Open Loop Fault

Preemption Events:

101	Preempt Advance Warning Input
102	Preempt (Call) Input On
103	Preempt Gate Down Input Received
104	Preempt (Call) Input Off
105	Preempt Entry Started

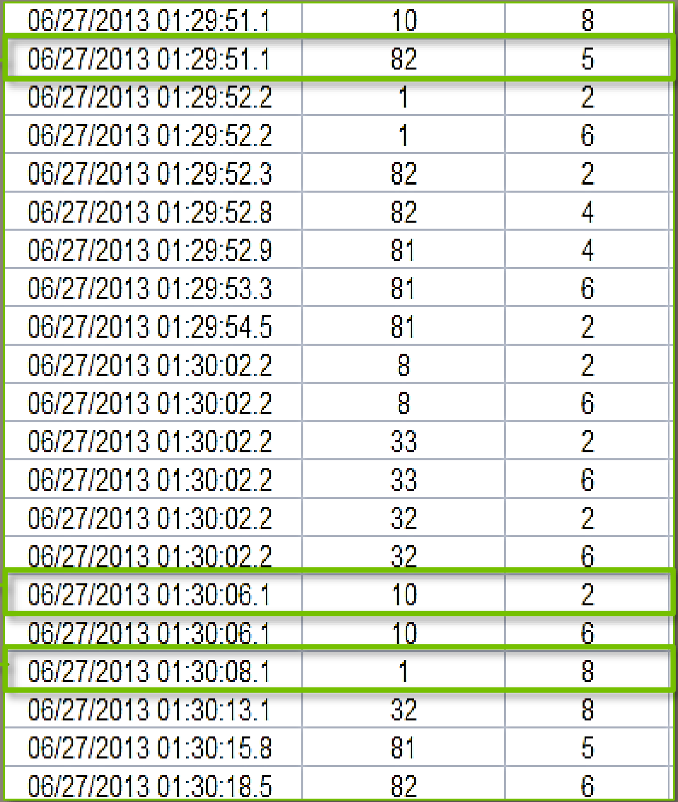
http://docs.lib.purdue.edu/jtrpdata/3/

High Resolution Data

Detector 5 ON

Phase 2 BEGIN RED

Phase 8 BEGIN GREEN



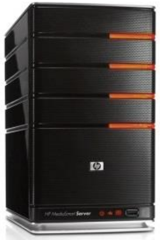
06/27/2013 01:29:51.1	10	8
06/27/2013 01:29:51.1	82	5
06/27/2013 01:29:52.2	1	2
06/27/2013 01:29:52.2	1	6
06/27/2013 01:29:52.3	82	2
06/27/2013 01:29:52.8	82	4
06/27/2013 01:29:52.9	81	4
06/27/2013 01:29:53.3	81	6
06/27/2013 01:29:54.5	81	2
06/27/2013 01:30:02.2	8	2
06/27/2013 01:30:02.2	8	6
06/27/2013 01:30:02.2	33	2
06/27/2013 01:30:02.2	33	6
06/27/2013 01:30:02.2	32	2
06/27/2013 01:30:02.2	32	6
06/27/2013 01:30:06.1	10	2
06/27/2013 01:30:06.1	10	6
06/27/2013 01:30:08.1	1	8
06/27/2013 01:30:13.1	32	8
06/27/2013 01:30:15.8	81	5
06/27/2013 01:30:18.5	82	6


HOW'S THE BIG DATA PROJECT COMING ALONG, HOSKINS?
© D.Fletcher for CloudTweaks.com

How Does It Work?

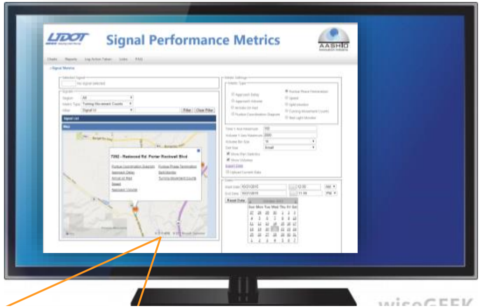
Controller with high-resolution data logging

Communication

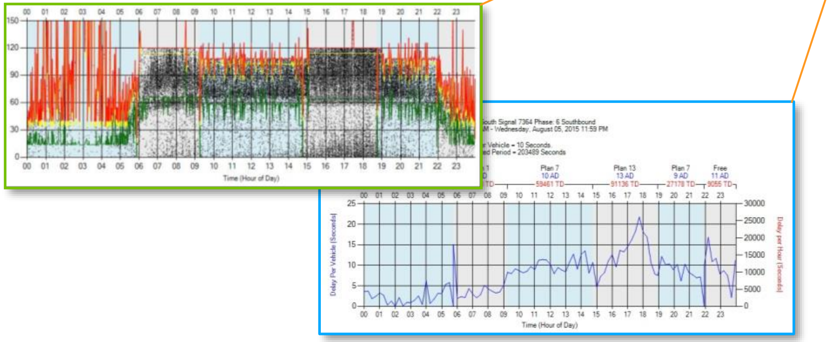


Server receives / stores data files

Query Data



Website software queries server data and displays as graphs



System Requirements

- High-resolution data logging controller
- Detection
- Communication
- Server
- Website

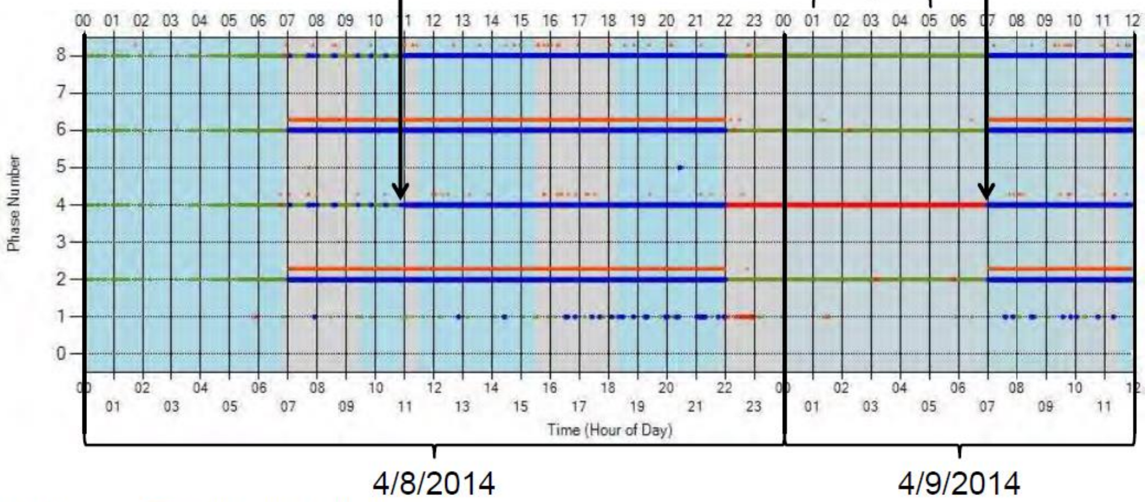
Does NOT require Central Traffic Management Software

Types of Performance Measures

- Purdue Phase Termination
- Split Monitor
- Purdue Coordination Diagram
- Approach Delay
- Purdue Split Failure
- Purdue Link Pivot
- Pedestrian Delay
- Preemption Details
- Turning Movement Count
- Approach Volume
- Arrivals on Red
- Approach Speed
- Yellow and Red Actuations

Phase Termination

- Phase 4 at 400 E & 800 N, 4/9/2014



Alert email sent

Phase 4 starts constant call

SPMs evaluated for % max outs

4/8/2014

4/9/2014

● Gap out

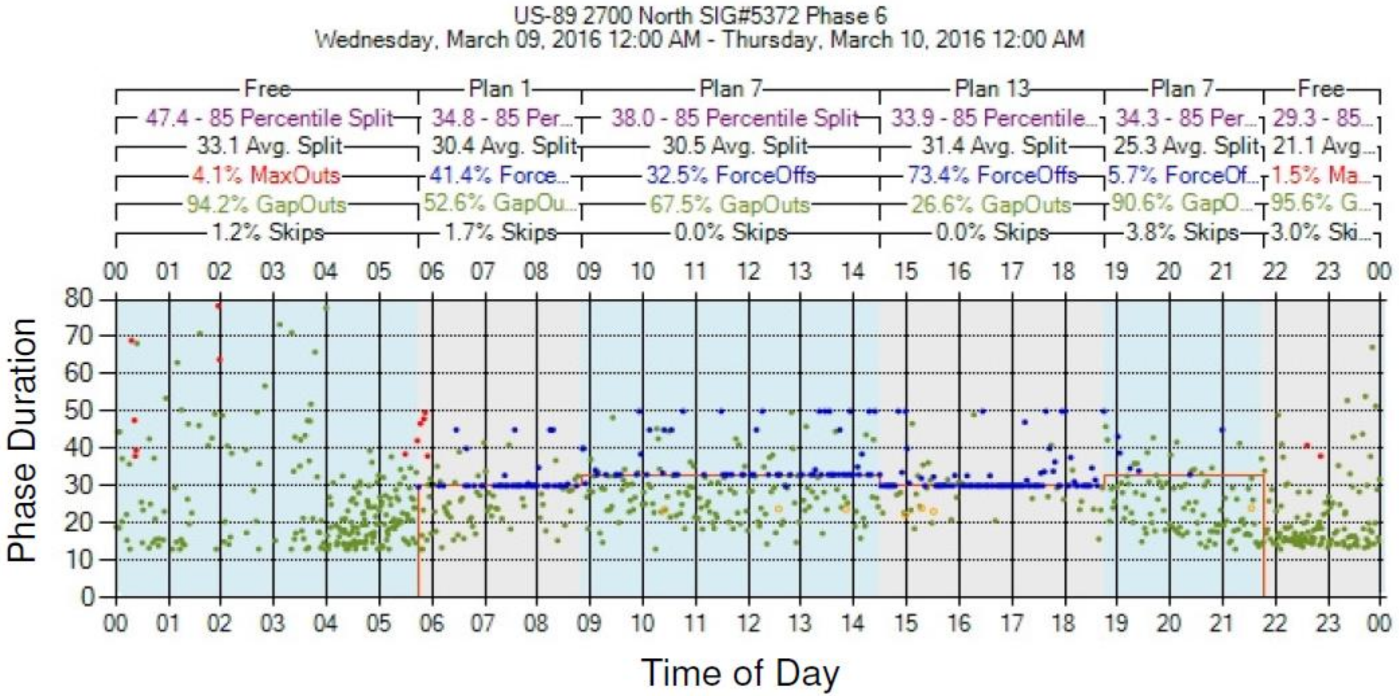
● Max out

● Force off

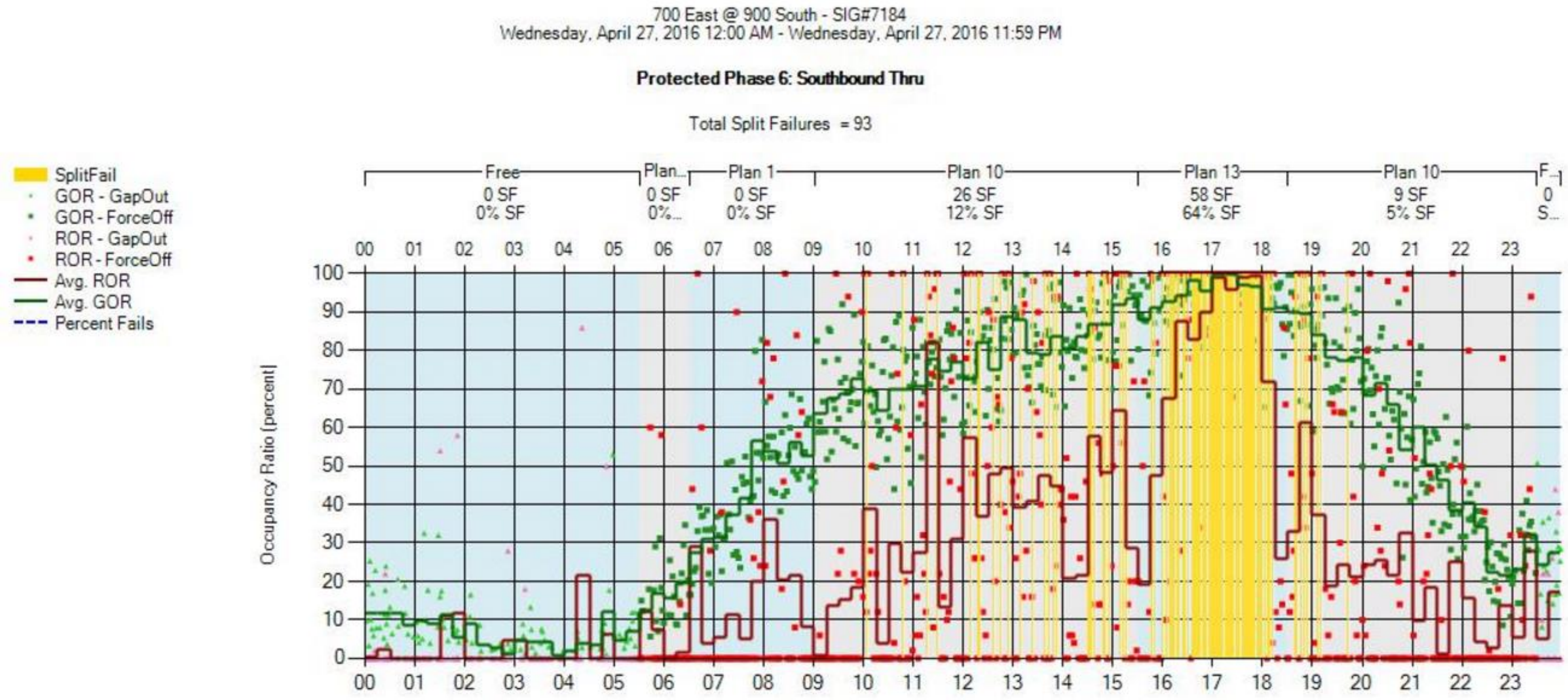
● Pedestrian activation (shown above phase line)

○ Skip

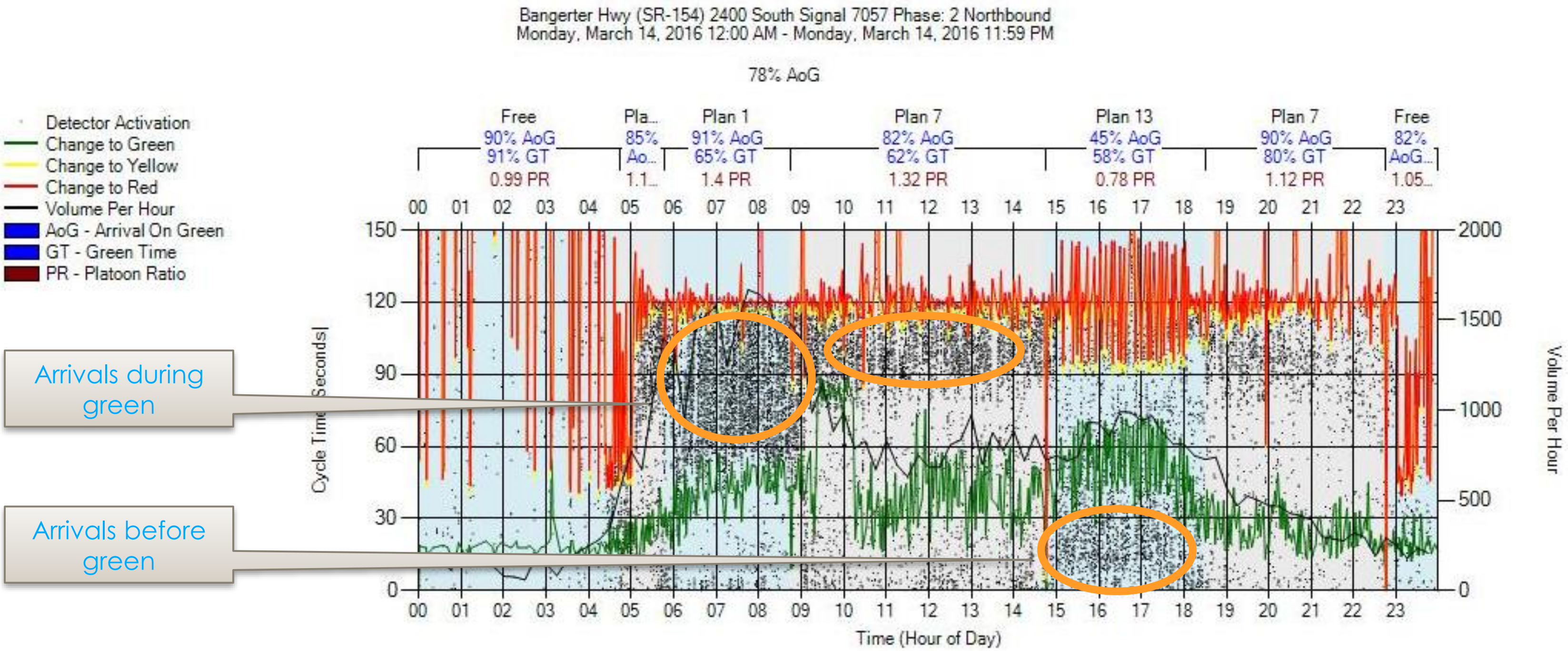
Split Monitor



Purdue Split Failure



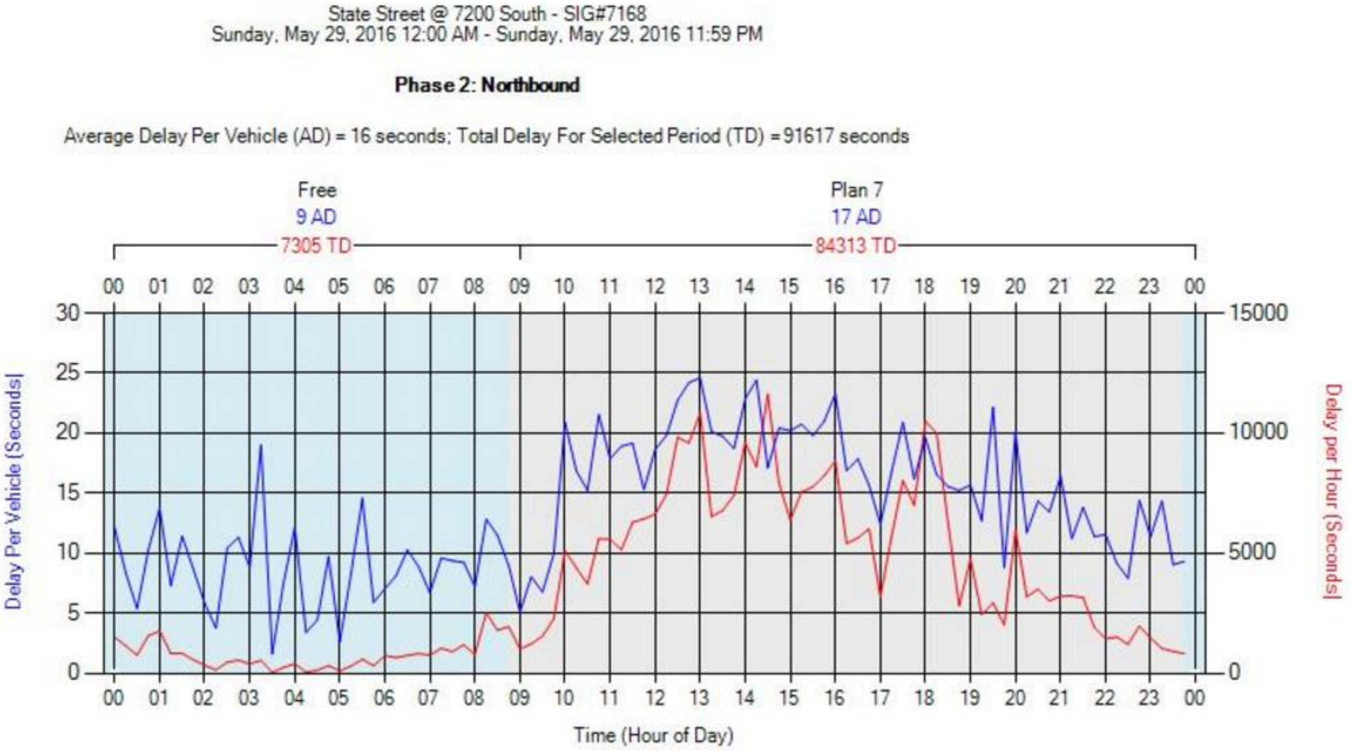
Purdue Coordination Diagram



Arrivals during green

Arrivals before green

Approach Delay



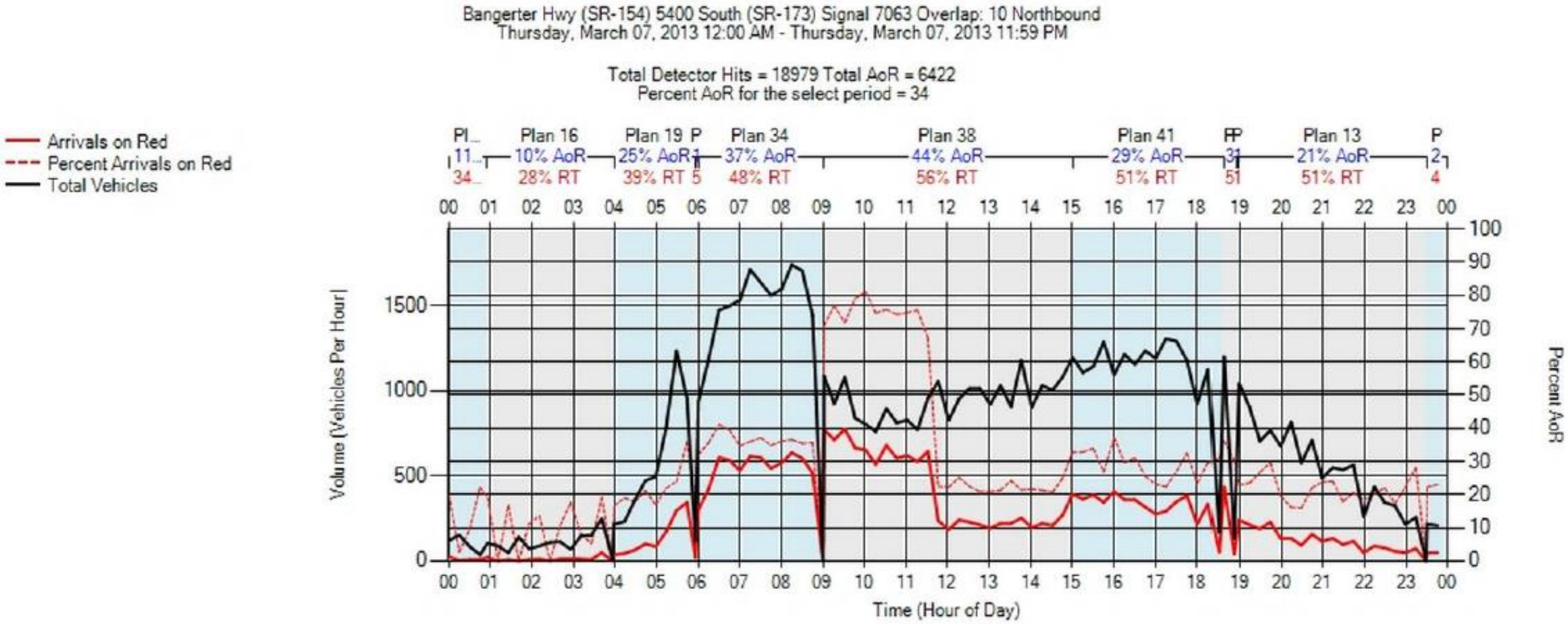
State Street @ 7200 South - SIG#7168
Sunday, May 29, 2016 12:00 AM - Sunday, May 29, 2016 11:59 PM

Phase 2: Northbound

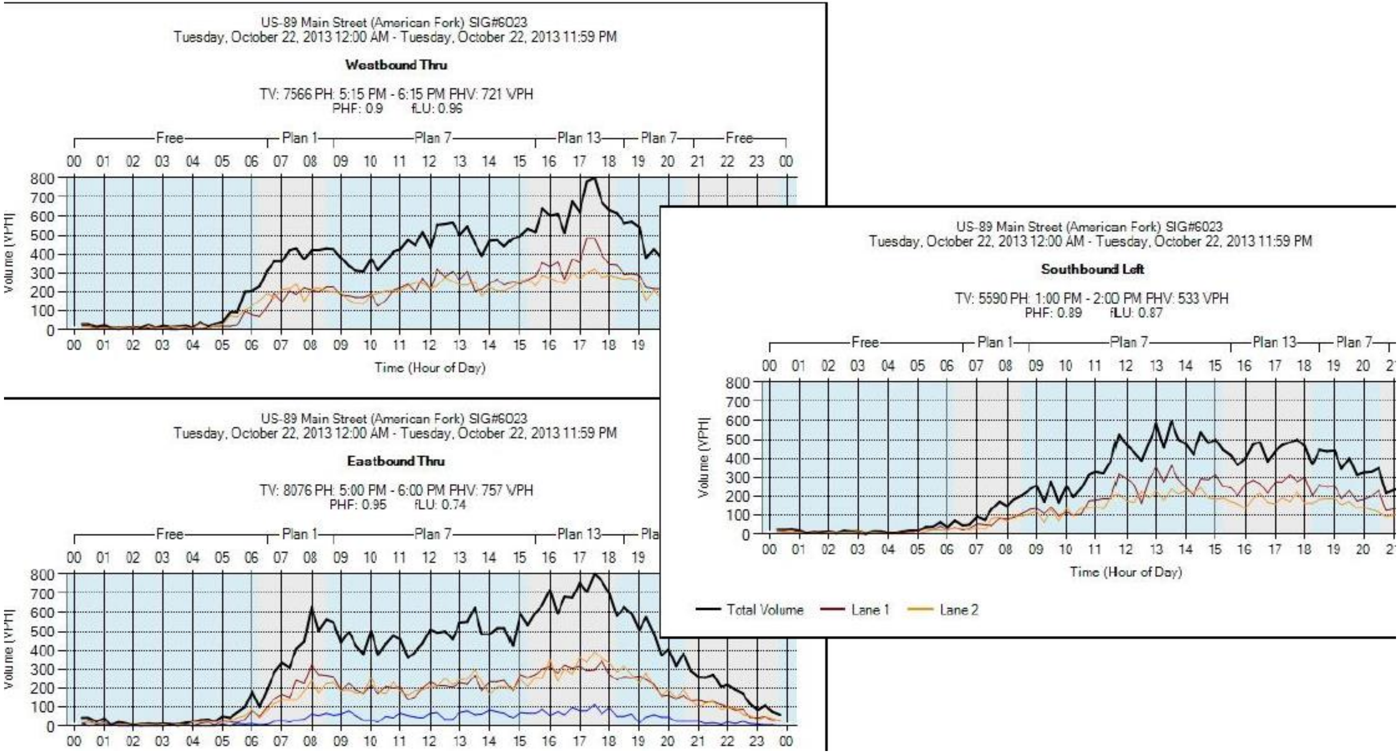
Average Delay Per Vehicle (AD) = 16 seconds; Total Delay For Selected Period (TD) = 91617 seconds

Simplified Approach Delay. Displays time between approach activation during the red phase and when the phase turns green.
Does NOT account for start up delay, deceleration, or queue length that exceeds the detection zone.

Arrivals on Red



Turning Movement Counts



US-89 Main Street (American Fork) SIG#6023
Tuesday, October 22, 2013 12:00 AM - Tuesday, October 22, 2013 11:59 PM

Westbound Thru

TV: 7566 PH: 5:15 PM - 6:15 PM PHV: 721 VPH
PHF: 0.9 fLU: 0.96

US-89 Main Street (American Fork) SIG#6023
Tuesday, October 22, 2013 12:00 AM - Tuesday, October 22, 2013 11:59 PM

Eastbound Thru

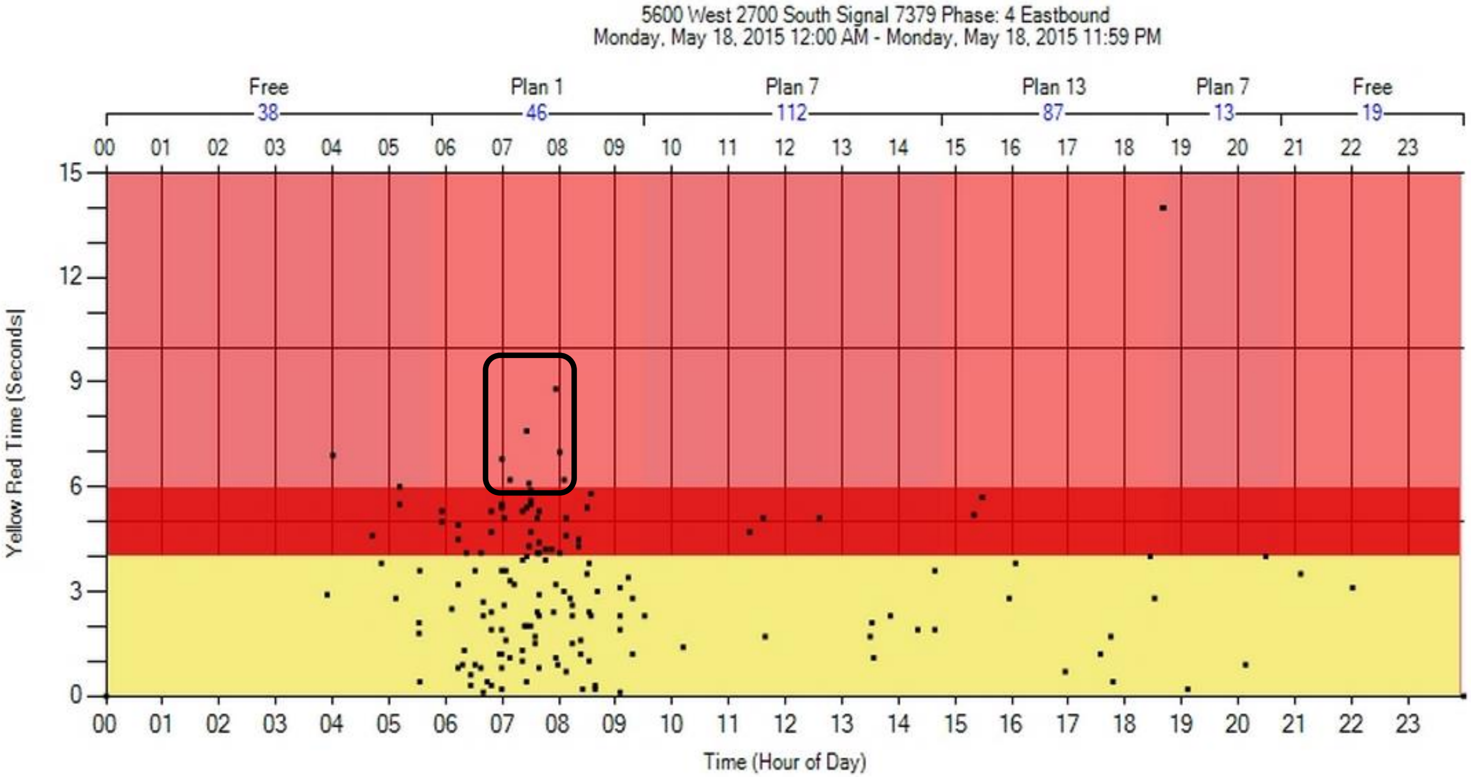
TV: 8076 PH: 5:00 PM - 6:00 PM PHV: 757 VPH
PHF: 0.95 fLU: 0.74

US-89 Main Street (American Fork) SIG#6023
Tuesday, October 22, 2013 12:00 AM - Tuesday, October 22, 2013 11:59 PM

Southbound Left

TV: 5590 PH: 1:00 PM - 2:00 PM PHV: 533 VPH
PHF: 0.89 fLU: 0.87

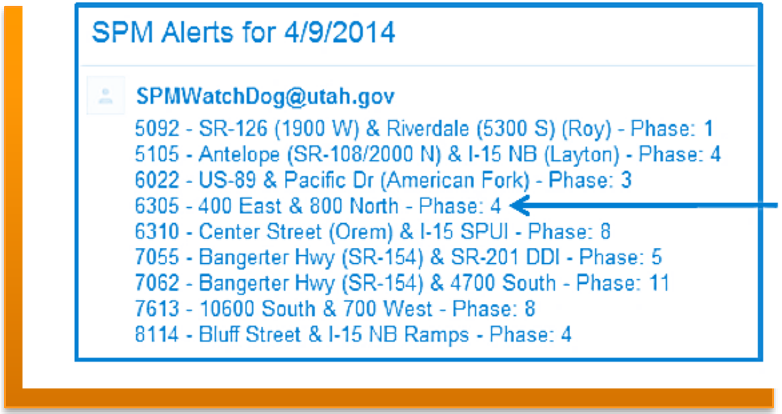
Red Light Monitoring



Stantec

Alerts

- Daily email at 7 am
- Uses Purdue Phase Termination chart data
- Flags phases with > 90% max-outs on each phase between 1 am and 5 am
- Compare to previous day's list; only phases with new flags are sent in email



SPM Alerts for 4/9/2014

SPMWatchDog@utah.gov

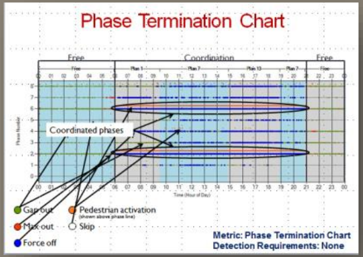
5092 - SR-126 (1900 W) & Riverdale (5300 S) (Roy) - Phase: 1
5105 - Antelope (SR-108/2000 N) & I-15 NB (Layton) - Phase: 4
6022 - US-89 & Pacific Dr (American Fork) - Phase: 3
6305 - 400 East & 800 North - Phase: 4
6310 - Center Street (Orem) & I-15 SPUI - Phase: 8
7055 - Bangerter Hwy (SR-154) & SR-201 DDI - Phase: 5
7062 - Bangerter Hwy (SR-154) & 4700 South - Phase: 11
7613 - 10600 South & 700 West - Phase: 8
8114 - Bluff Street & I-15 NB Ramps - Phase: 4

Example

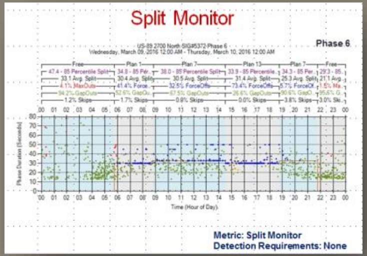
Engineers can now ***directly measure*** what previously could only ***estimate and model***

What can Automated Signal Performance Measures do for you?

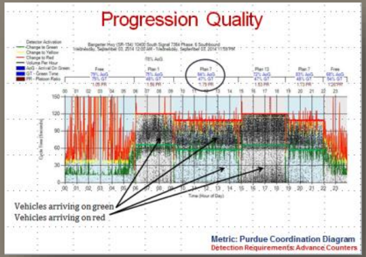
- Troubleshoot complaints and reduce wasted time for maintenance staff
- Identify problems more quickly – without waiting for the complaint call
- Operate & optimize system more efficiently
- Retime signals as needed, not on a schedule
- Communicate system performance to public & agency leaders
- Transition from reactive management to proactive signal management
- Truly ***MEASURE*** system performance



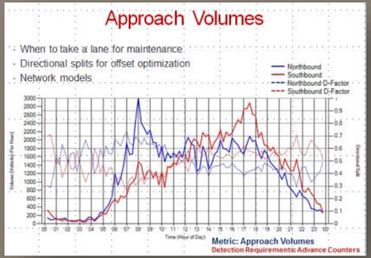
Metric: Phase Termination Chart
Detection Requirements: None



Metric: Split Monitor
Detection Requirements: None



Metric: Purdue Coordination Diagram
Detection Requirements: Advance Counters



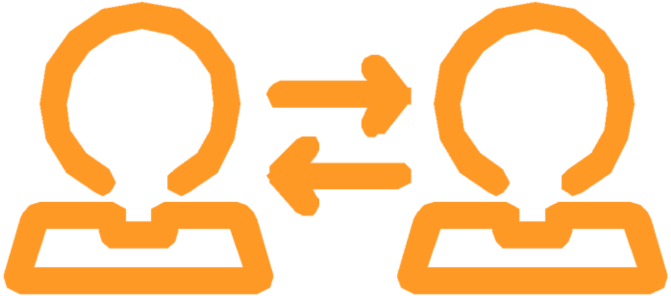
- When to take a lane for maintenance
- Directional splits for offset optimization
- Network models

Metric: Approach Volumes
Detection Requirements: Advance Counters

Future of Performance Measures?

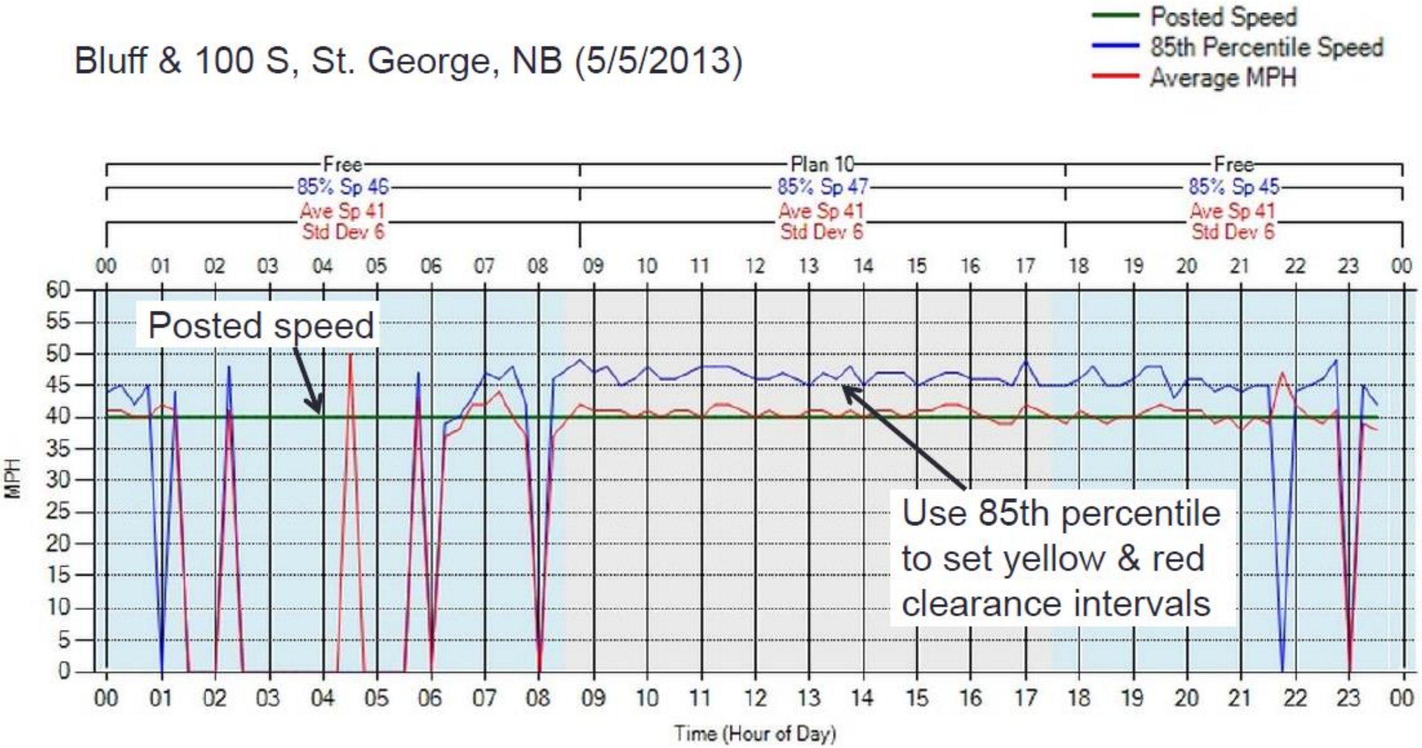
- UDOT software is available on the FHWA Open Source Application Development Portal (OSADP) http://www.itsforge.net
- GDOT provided documentation for installation and use of the UDOT software
- Every Day Counts-4 Regional Summits late Fall 2016 – ATSPMs major focus
    - https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/
- FAST Act funding – Advanced Transportation and Congestion Management Technologies Deployment http://www.fhwa.dot.gov/fastact/factsheets/advtranscongmgmtfs.cfm

Questions?



Susan Langdon, PE, PTOE
Susan.Langdon@stantec.com
Stantec – Richardson, TX
214.468.8200

Approach Speed

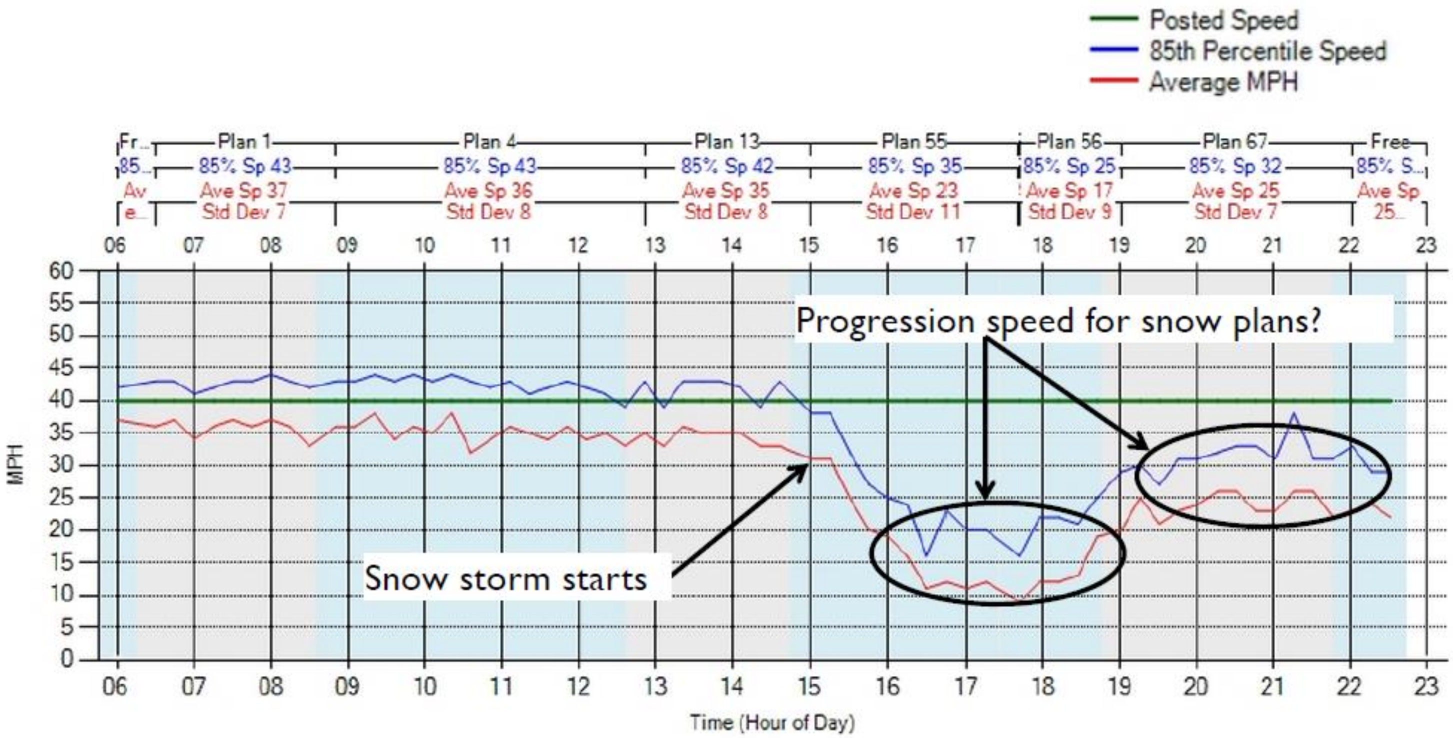


Bluff & 100 S, St. George, NB (5/5/2013)

Posted speed

Use 85th percentile to set yellow & red clearance intervals

Approach Speed

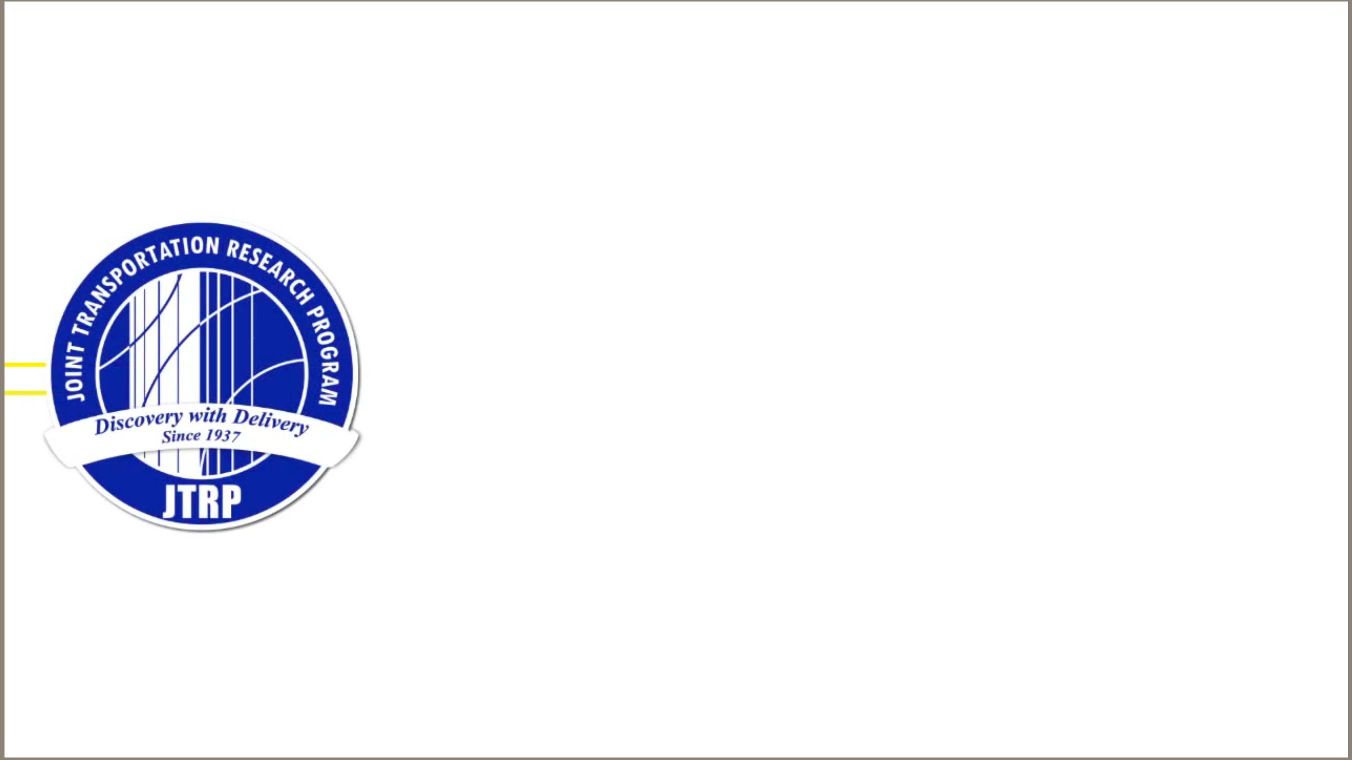


Progression speed for snow plans?

Snow storm starts

Offset Optimization Using Link Pivot Algorithm

https://www.youtube.com/watch?v=Yf1ZtDA8Edw



Executive Reports & Prioritizing

Are signal operations improving, staying same or declining? By how much?
How does agency most effectively priority resources and workload?

What are areas of most need?

Regional, corridor and intersection summaries available.

System Requirements

- Econolite cobalt – any version
- Econolite ASC3 – v2.50+ & OS 1.14.03+
- Econolite 2070 with 1C CPU Module V32.50+
- Intelight Maxtime V 1.7.0+
- Peek ATC Greenwave 03.05.0528+
- Trafficware 980ATCV 76.10+
- Siemens M50 Linux & M60 ATC (ecom v 3.5+, NTCIP V4.5+)
- McCain ATC Omni eX 1.6+

System Requirements
Detection

Any detection will work - loops, pucks, video, radar.

Speed metric requires radar detection.

System Requirements

Communication

Can be accomplished in many ways, including fiber optic cable, wireless radio, cable or telephone providers, cell modem, satellite, twisted wire pair, even site visit to manually download.

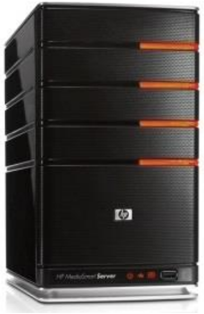
System Requirements

Operating Systems and Software

The software runs on Microsoft Windows Servers.

The database server is a Microsoft SQL 2008 or later; large systems will require Enterprise Edition.

System Requirements
Storage and Processing Requirements

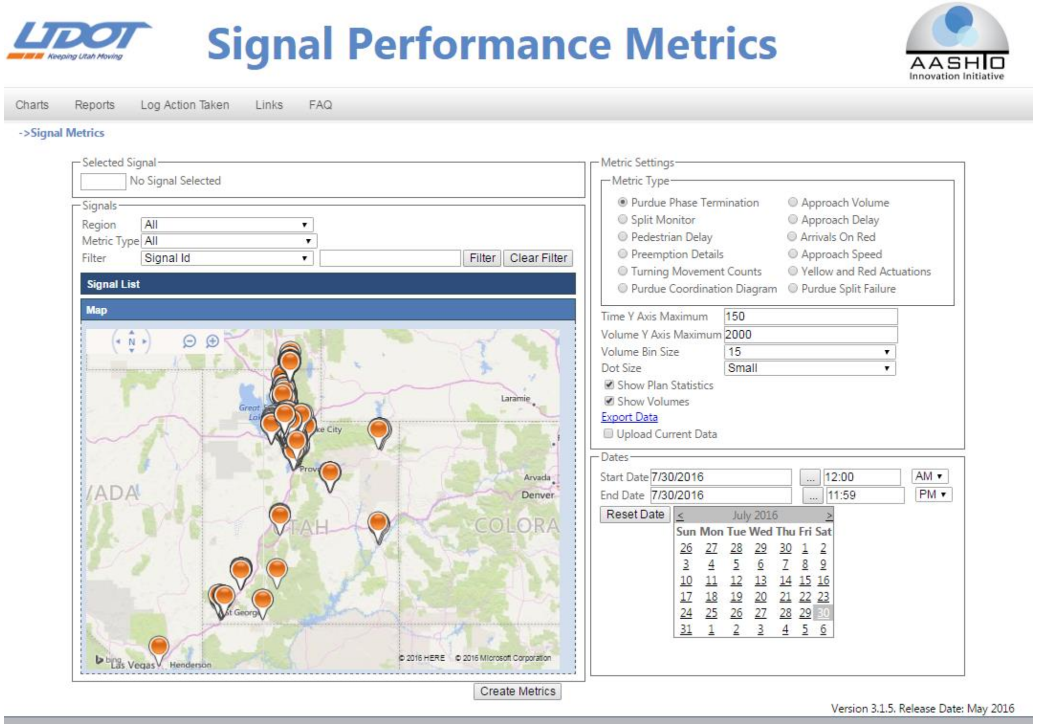


Detector data uses about 60% of the storage space, so the number of detectors attached to a controller will have a significant impact on the amount of storage space required.

Data storage will require approximately 12 MB per controller per day for 8 phase operation with detection on all approaches.

System Requirements

Website



Signal Performance Metrics

->Signal Metrics

Selected Signal

No Signal Selected

Signals

Region: All

Metric Type: All

Filter: Signal Id

Metric Settings

Metric Type

- ● Purdue Phase Termination
- ○ Split Monitor
- ○ Pedestrian Delay
- ○ Preemption Details
- ○ Turning Movement Counts
- ○ Purdue Coordination Diagram
- ○ Approach Volume
- ○ Approach Delay
- ○ Arrivals On Red
- ○ Approach Speed
- ○ Yellow and Red Actuations
- ○ Purdue Split Failure

Time Y Axis Maximum: 150

Volume Y Axis Maximum: 2000

Volume Bin Size: 15

Dot Size: Small

☑ Show Plan Statistics

☑ Show Volumes

Export Data

☐ Upload Current Data

Dates

Start Date: 7/30/2016 12:00 AM

End Date: 7/30/2016 11:59 PM

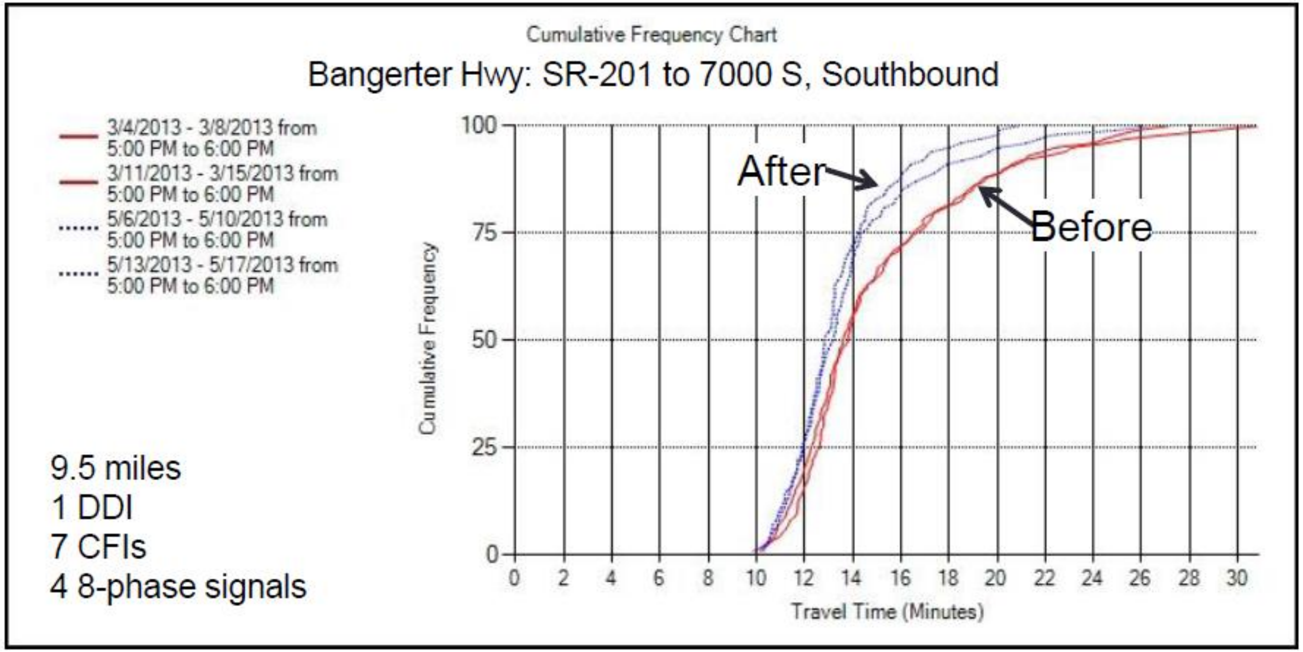
< July 2016 >

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

Version 3.1.5. Release Date: May 2016

http://udottraffic.utah.gov/signalperformancemetrics/

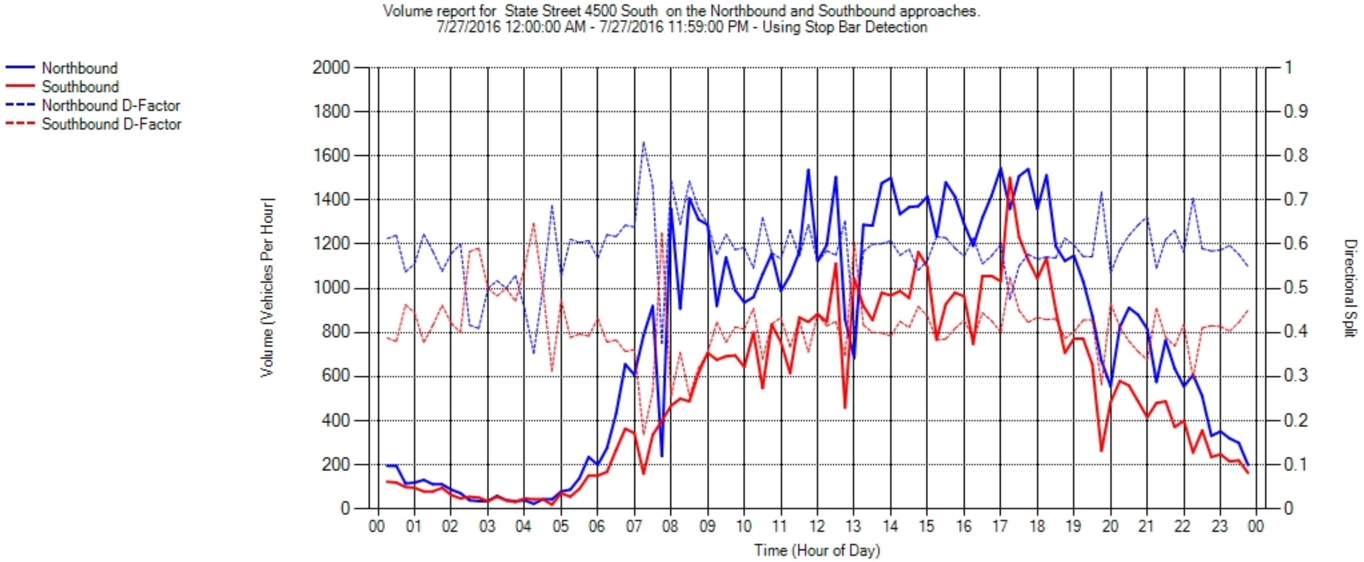
Purdue Travel Time



9.5 miles
1 DDI
7 CFIs
4 8-phase signals

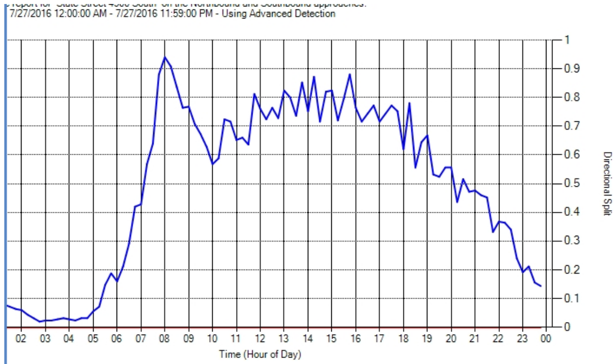
Approach Volumes

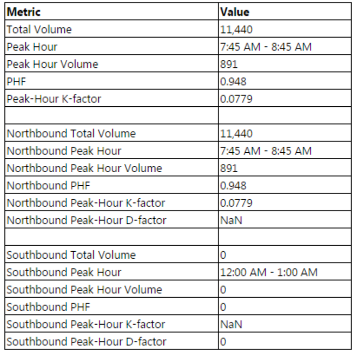
Stop Bar Detection



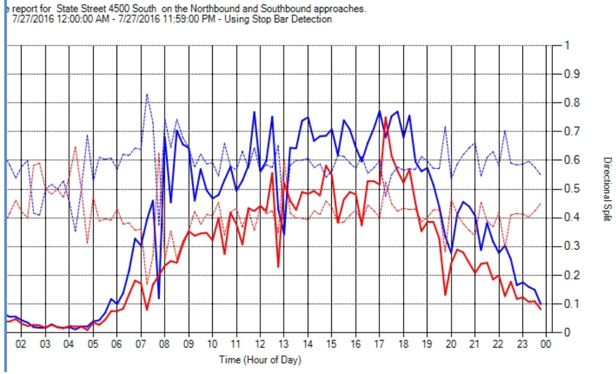
Approach Volumes

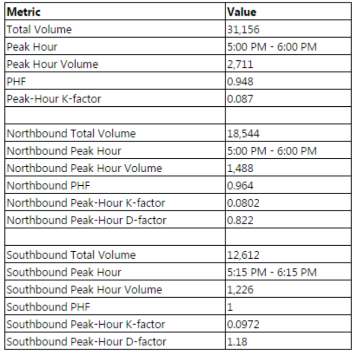
Stop Bar and Approach Detection





Metric	Value
Total Volume	11,440
Peak Hour	7:45 AM - 8:45 AM
Peak Hour Volume	891
PHF	0.948
Peak-Hour K-factor	0.0779
Northbound Total Volume	11,440
Northbound Peak Hour	7:45 AM - 8:45 AM
Northbound Peak Hour Volume	891
Northbound PHF	0.948
Northbound Peak-Hour K-factor	0.0779
Northbound Peak-Hour D-factor	NaN
Southbound Total Volume	0
Southbound Peak Hour	12:00 AM - 1:00 AM
Southbound Peak Hour Volume	0
Southbound PHF	0
Southbound Peak-Hour K-factor	NaN
Southbound Peak-Hour D-factor	0

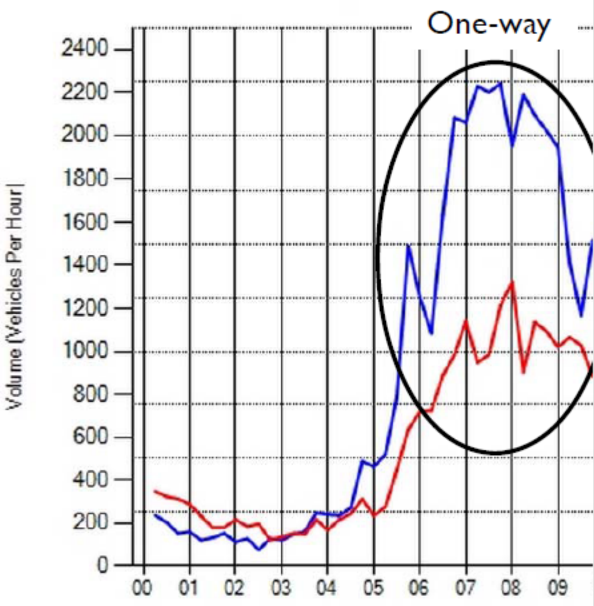


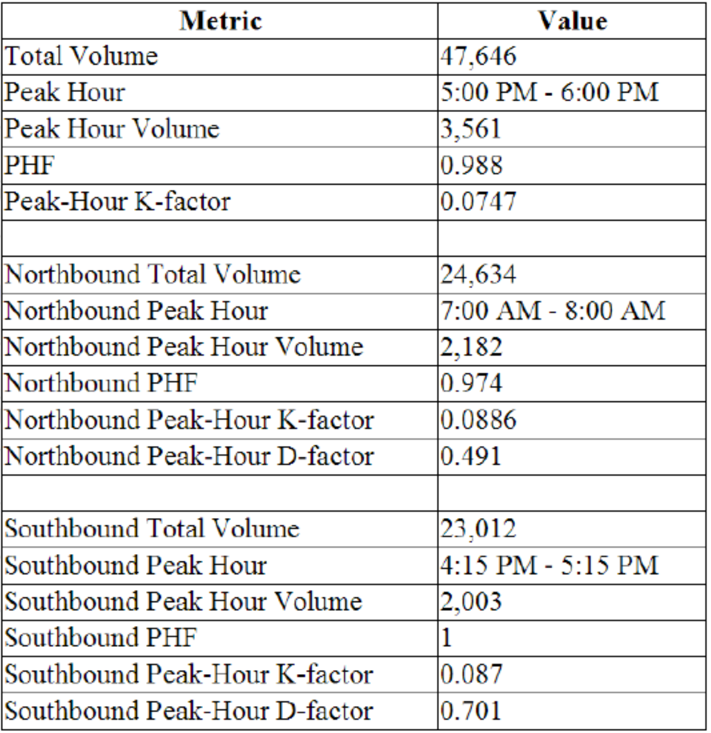


Metric	Value
Total Volume	31,156
Peak Hour	5:00 PM - 6:00 PM
Peak Hour Volume	2,711
PHF	0.948
Peak-Hour K-factor	0.087
Northbound Total Volume	18,544
Northbound Peak Hour	5:00 PM - 6:00 PM
Northbound Peak Hour Volume	1,488
Northbound PHF	0.964
Northbound Peak-Hour K-factor	0.0802
Northbound Peak-Hour D-factor	0.822
Southbound Total Volume	12,612
Southbound Peak Hour	5:15 PM - 6:15 PM
Southbound Peak Hour Volume	1,226
Southbound PHF	1
Southbound Peak-Hour K-factor	0.0972
Southbound Peak-Hour D-factor	1.18

Coordination: Progression Type

Metric: Approach Volume





Metric	Value
Total Volume	47,646
Peak Hour	5:00 PM - 6:00 PM
Peak Hour Volume	3,561
PHF	0.988
Peak-Hour K-factor	0.0747
Northbound Total Volume	24,634
Northbound Peak Hour	7:00 AM - 8:00 AM
Northbound Peak Hour Volume	2,182
Northbound PHF	0.974
Northbound Peak-Hour K-factor	0.0886
Northbound Peak-Hour D-factor	0.491
Southbound Total Volume	23,012
Southbound Peak Hour	4:15 PM - 5:15 PM
Southbound Peak Hour Volume	2,003
Southbound PHF	1
Southbound Peak-Hour K-factor	0.087
Southbound Peak-Hour D-factor	0.701

Link Pivot Algorithm

- Based on the validated prediction methodology, we devised a way to systematically adjust offsets to find an optimal solution…

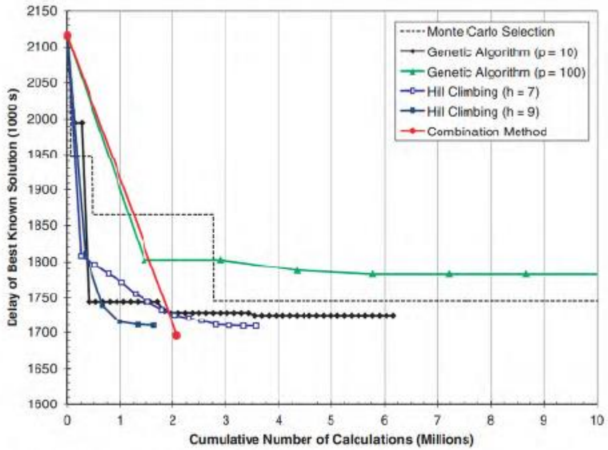


FIGURE 6 Performance of alternative methodologies for offset optimization.

Computational Efficiency of Alternative Algorithms for Arterial Offset Optimization

Christopher M. Day and Darcy M. Bullock

BACKGROUND

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