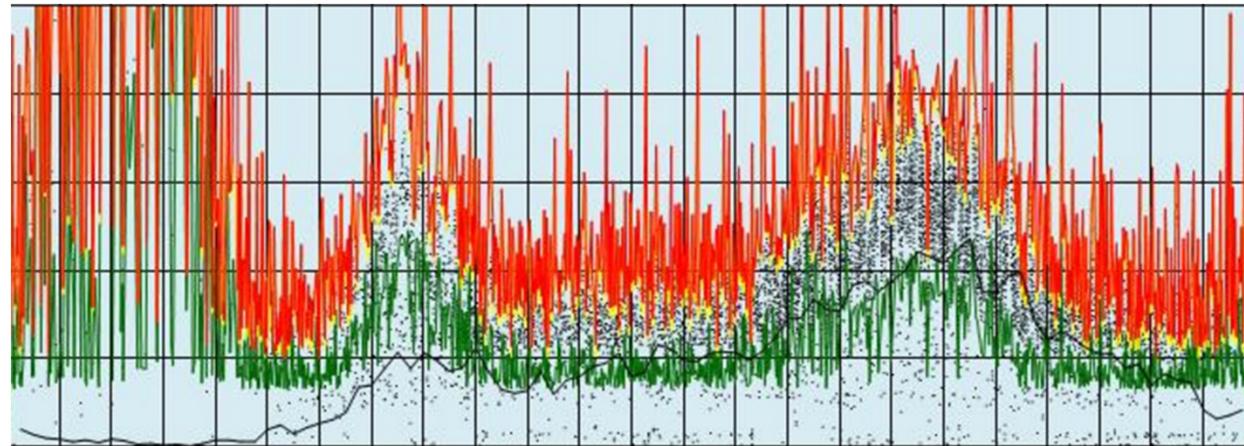


UDOT's Experience



Automated Traffic Signal Performance Measures

Mark Taylor

Traffic Signal Operations Engineer
Utah Department of Transportation
marktaylor@utah.gov

Brief Utah Update

- 2004 Traffic Signals in the State of Utah
 - 1189 owned and operated by UDOT (60%)
 - 815 owned and operated by cities /counties (40%)



- All cities share same ITS communications
 - 94% of UDOT signals connected
 - 78% of non-UDOT signals connected



- All cities in Utah & UDOT share same ATMS



Challenge from UDOT Executive Leaders (2011)

“What would it take for UDOT’s traffic signals to be world class?”

“What’s the trend – are signal operations improving, staying the same or getting worse?”

“What are our areas of most need?”

 **Quality
Improvement
Team**



QIT Recommendations (July 2011)

- Communications and detection maintained during projects
- Proactive signal maintenance
- **Real-time monitoring of system health and quality of operations**

UTAH DEPARTMENT OF TRANSPORTATION

WORLD CLASS
TRAFFIC SIGNAL MAINTENANCE
& OPERATIONS



QUALITY IMPROVEMENT TEAM
Final Report

July 2011



PURDUE
UNIVERSITY



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



POOLED FUND STUDY

INDIANAPOLIS

NOVEMBER 12, 2014



PERFORMANCE MEASURES FOR
TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach

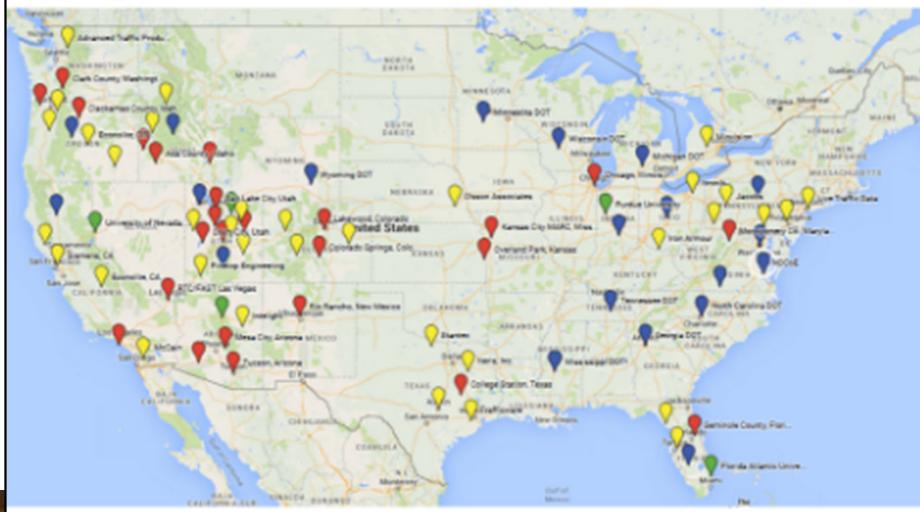


Christopher M. Day, Darcy M. Bullock, Howell Li, Stephen M. Romas, Alexander M. Hansen, Richard S. Freije, Amanda L. Stevens, James R. Shastevan, and Thomas M. Brinavan

 PURDUE


Signal Performance Measure Workshop

January 26–27, 2016



169 Representatives from 85 Different Organizations



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PRESENTATIONS FROM JANUARY 26-27, 2016



2016

Tuesday, January 26th

Traffic Signal Performance Measures Workshop

Darcy Bullock, Purdue University

TSM&O in Florida

Raj Ponnaluri, Florida Department of Transportation

Automated Traffic Signal Performance Measures, AASHTO Innovation Initiative 2013 Focus Technology

Rob Clayton, Utah Department of Transportation

Lessons Learned from ASCT and Systems Engineering

Eddie Curtis, Federal Highway Administration

Transportation Pooled Fund Program Recap

*Jim Sturdevant, Indiana Department of Transportation
Richard Denney, Federal Highway Administration*

Public/Private Partnerships: Expanding the Reach of Traffic Signals

Lynne Yocom, Utah Department of Transportation



Implementation of Automated Traffic Signal Performance Measures

By CHRISTOPHER M. DAY, PH.D., MARK TAYLOR, P.E., PTOE,
JAMIE MACKEY, P.E., PTOE, ROB CLAYTON, P.E., PTOE,
SHITAL K. PATEL, P.E., GANG XIE, P.E., HOWELL LI,
JAMES R. STURDEVANT, P.E., AND DARCY BULLOCK, P.E.

Over the last few decades traffic signal systems have evolved from rigid, fixed-time electromechanical systems to a distributed computing model with sophisticated detection and communication infrastructure. Although modern signal systems are relatively robust, operating continuously for years under all weather conditions, there is a tendency for operational inefficiencies to accumulate over time, as individual components such as detectors fail, or traffic conditions evolve beyond the parameters that the signal control was designed to accommodate. For a number of years, the engineering community has acknowledged opportunities for improvement, such as retiming or investing in new equipment.¹ However, historically, it has been very difficult to comprehensively evaluate changes in signal operations because the cost of data collection constrained the temporal and spatial extent of study.

www.ite.org August 2016 27

Day, Christopher M, M. Taylor, J. Mackey, R. Clayton, S. Patel, G. Xie, H. Li, J.R. Sturdevant, and D.M. Bullock, "Implementation of Automated Traffic Signal Performance Measures," *ITE Journal of Transportation*, pp. 26 – 34, August 2016.

ATSPM Basic Concept

Hi Def Data Logger
included in controller
firmware

Hi Def logs retrieved
every 10-60 minutes
from controller to server

Website to display
SPM's



(Or...Retrieve data logs
from controller manually
using Raspberry Pi)

A Central Signal System is NOT used or Needed!

Why Model what you can Measure?

System Requirements



High-resolution Controller with built in data logger using Indiana Enumerations

- Econolite Cobalt: Any Version
- Econolite ASC3 NEMA: V. 2.50+
- Econolite 2070 with 1C CPU Module: V. 32.50+
- Intelight Maxtime: V. 1.7.0+
- Peek ATC Greenwave 03.05.0528+
- Trafficware 980ATC V. 76.10+
- McCain ATC eX NEMA: V. ?
- Siemens M50 Linux & M60 ATC
 - ECOM V. 3.52+
 - NTCIP V. 4.53+

2070's don't work without 1C CPU



Data Logger records to the 1/10 second resolution

Objective: Vendor Neutrality



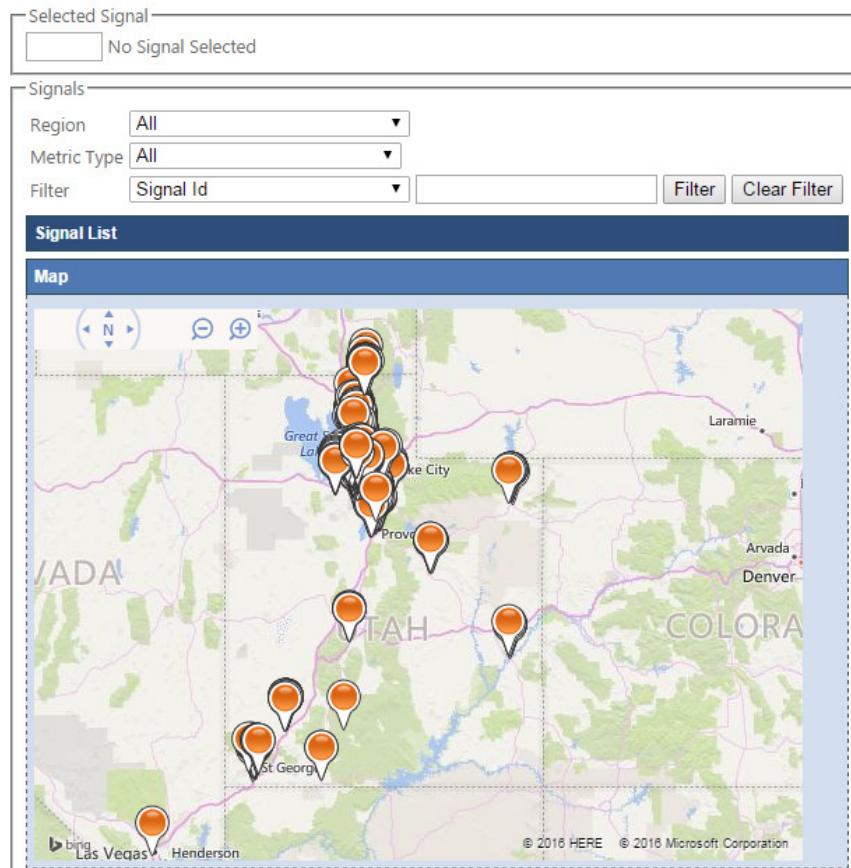


Signal Performance Metrics



Charts Reports Log Action Taken Links FAQ

->Signal Metrics



Metric Settings

Metric Type

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

8/11/2016

...

12:00

AM

End Date

8/11/2016

...

11:59

PM

[Reset Date](#)

August 2016						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	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	7	8	9	10

1694 traffic signals

[Create Metrics](#)

Version 3.1.5. Release Date: May 2016



Signal Performance Metrics



Charts Reports Links FAQ

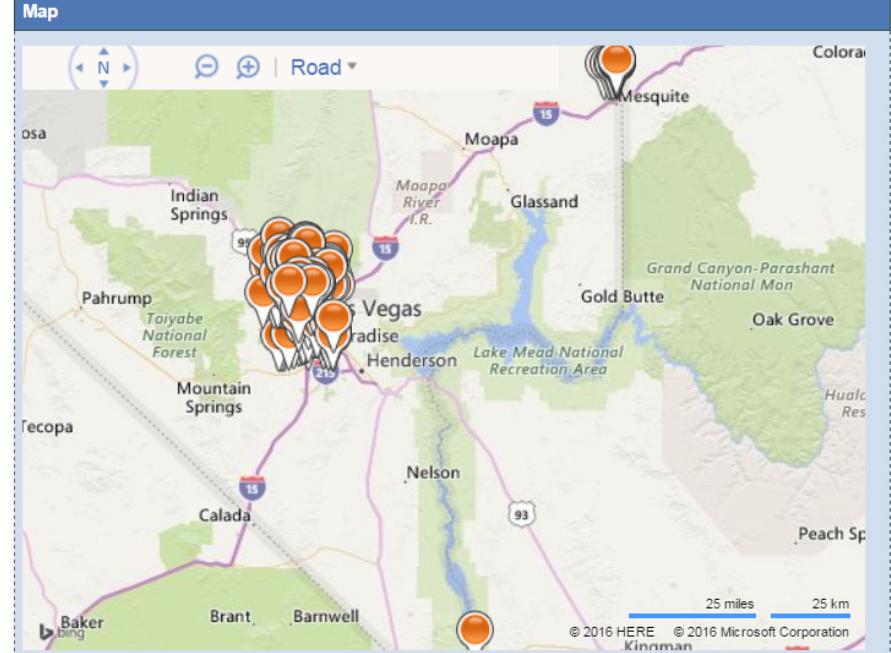
Signal
Time Space Diagram
Enter Chart Comments

Selected Signal
No Signal Selected

Signals
Region: All Metric Type: All
Filter: Signal Id Filter Clear Filter

Signal List

Map



Metric Settings

Metric Type

- Approach Delay
- Purdue Phase Termination
- Approach Volume
- Speed
- Arrivals On Red
- Split Monitor
- Purdue Coordination Diagram
- Turning Movement Counts
- Ped Button Push Diagram

Time Y Axis Maximum: 150
Volume Y Axis Maximum: 2000
Volume Bin Size: 15
Dot Size: Small

Show Plan Statistics
Show Volumes

Export Data

Dates

Start Date: 8/11/2016 End Date: 8/11/2016

Reset Date

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	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	7	8	9	10

286 traffic signals

Create Metrics



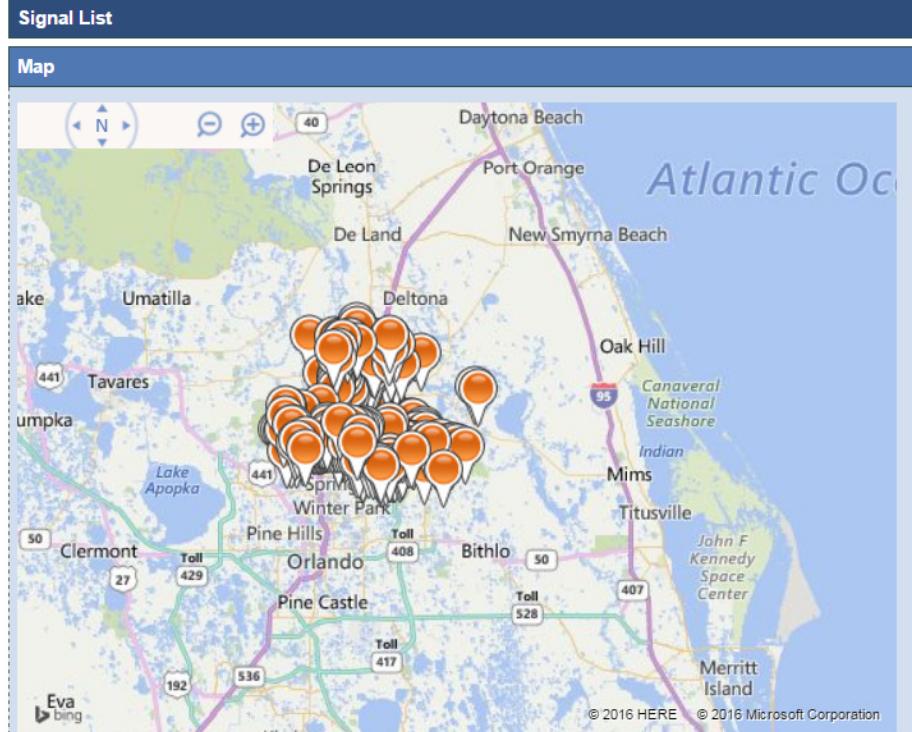
Signal Performance Metrics



->Signal Metrics

Selected Signal
 No Signal Selected

Signals
Region Metric Type
Filter



Create Metrics

Metric Settings

Metric Type

- Approach Delay
- Purdue Phase Termination
- Approach Volume
- Speed
- Arrivals On Red
- Split Monitor
- Purdue Coordination Diagram
- Turning Movement Counts

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 8/11/2016

12:00

AM ▾

End Date 8/11/2016

11:59

PM ▾

≤ August 2016 ≥

Sun Mon Tue Wed Thu Fri Sat

31	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	7	8	9	10



Signal Performance Metrics

->[Signal Metrics](#)

Selected Signal

No Signal Selected

Signals

Region: All

Metric Type: All

Filter: Signal Id

Signal List

Map

© 2016 HERE © 2016 Microsoft Corporation

Metric Settings

Metric Type

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

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: 8/11/2016 ... 12:00 AM

End Date: 8/11/2016 ... 11:59 PM

[Reset Date](#)

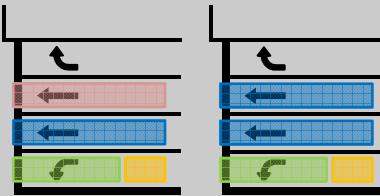
Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3
4	5	6	7	8	9	10

45 traffic signals

[Create Metrics](#)

Agencies using SPMs – Separate systems deployed (16 and growing)



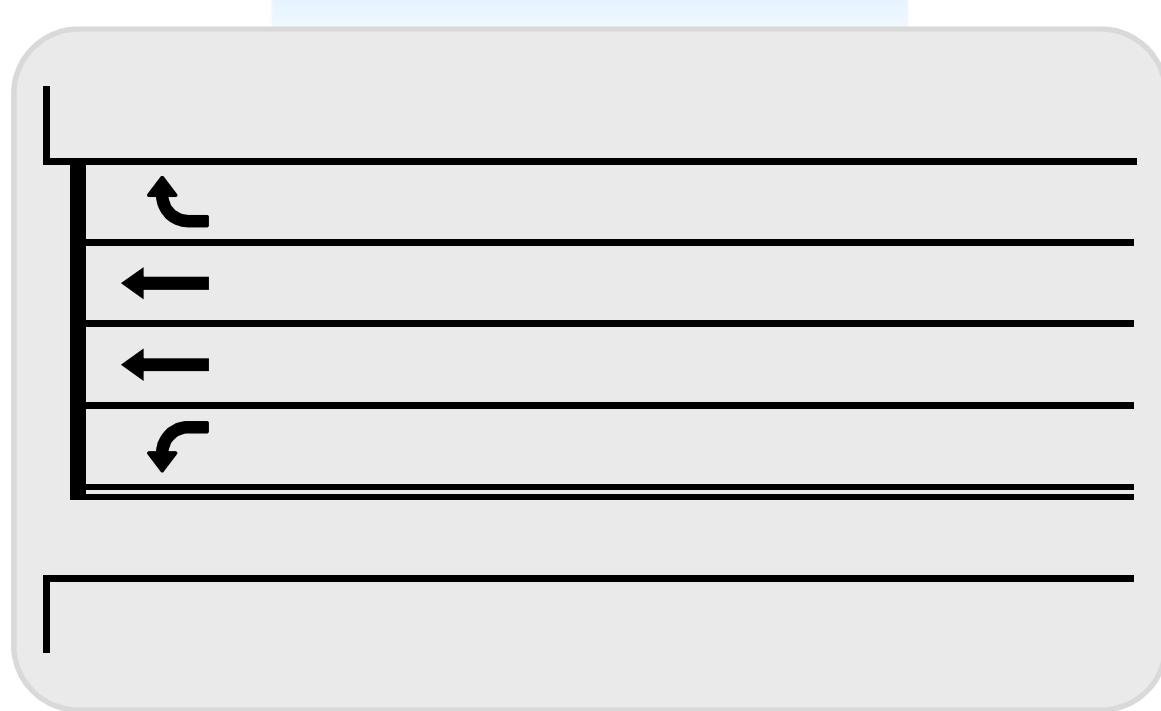
Detection	Metric
None	 Purdue Phase Termination Split Monitor Preemption Details Pedestrian Delay
Advanced Count	 Purdue Coordination Diagram Approach Volume Approach Speed (requires detection with speed service)
Lane-by-lane Presence Lane Group Presence	 Purdue Split Failure (Darcy will talk more about this)
Lane-by-lane Stopbar Count	 Turning Movement Counts

Detection

None

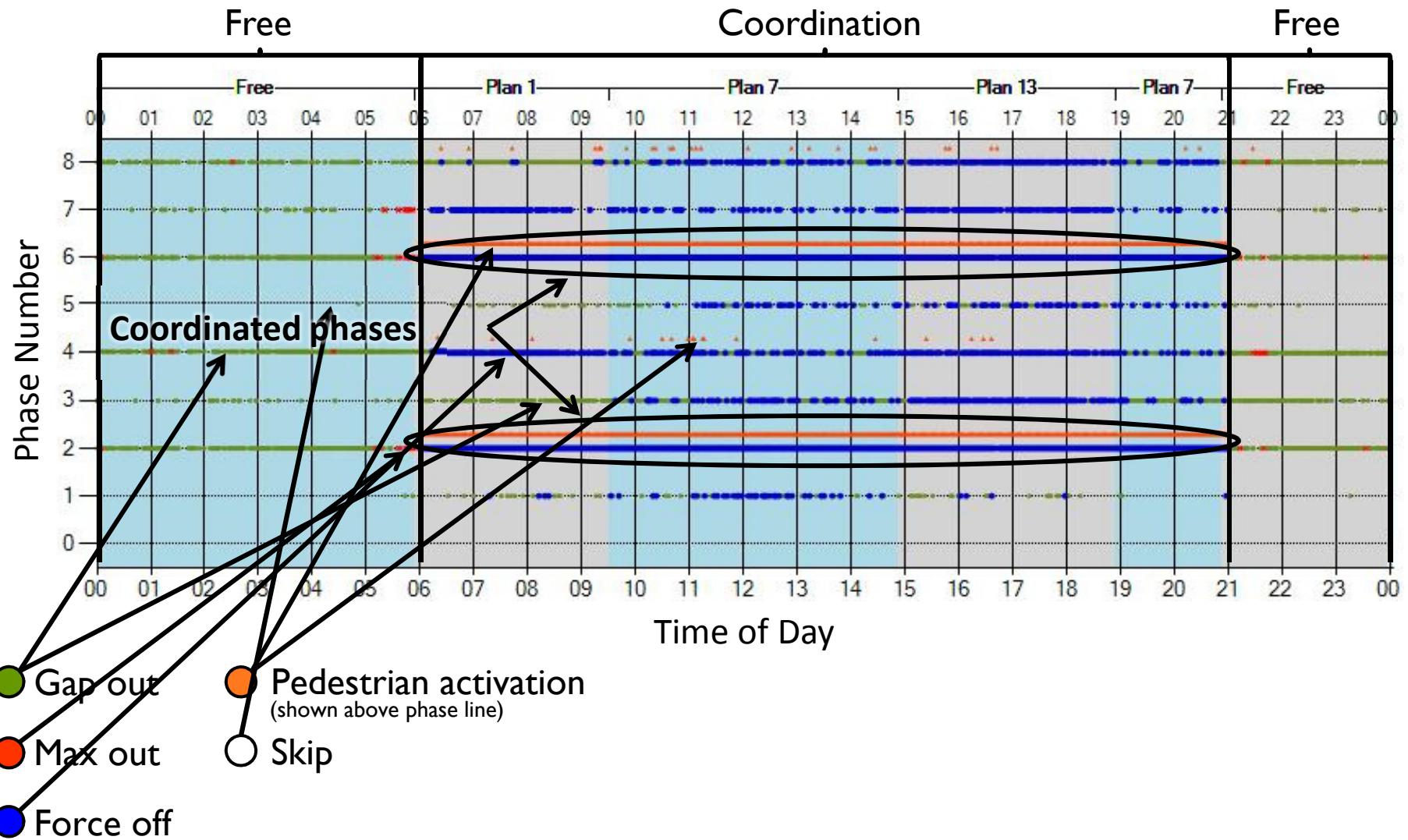
Available Metrics

- ❯ Purdue Phase Termination
- ❯ Split Monitor
- ❯ Pedestrian Delay
- ❯ Preemption Details



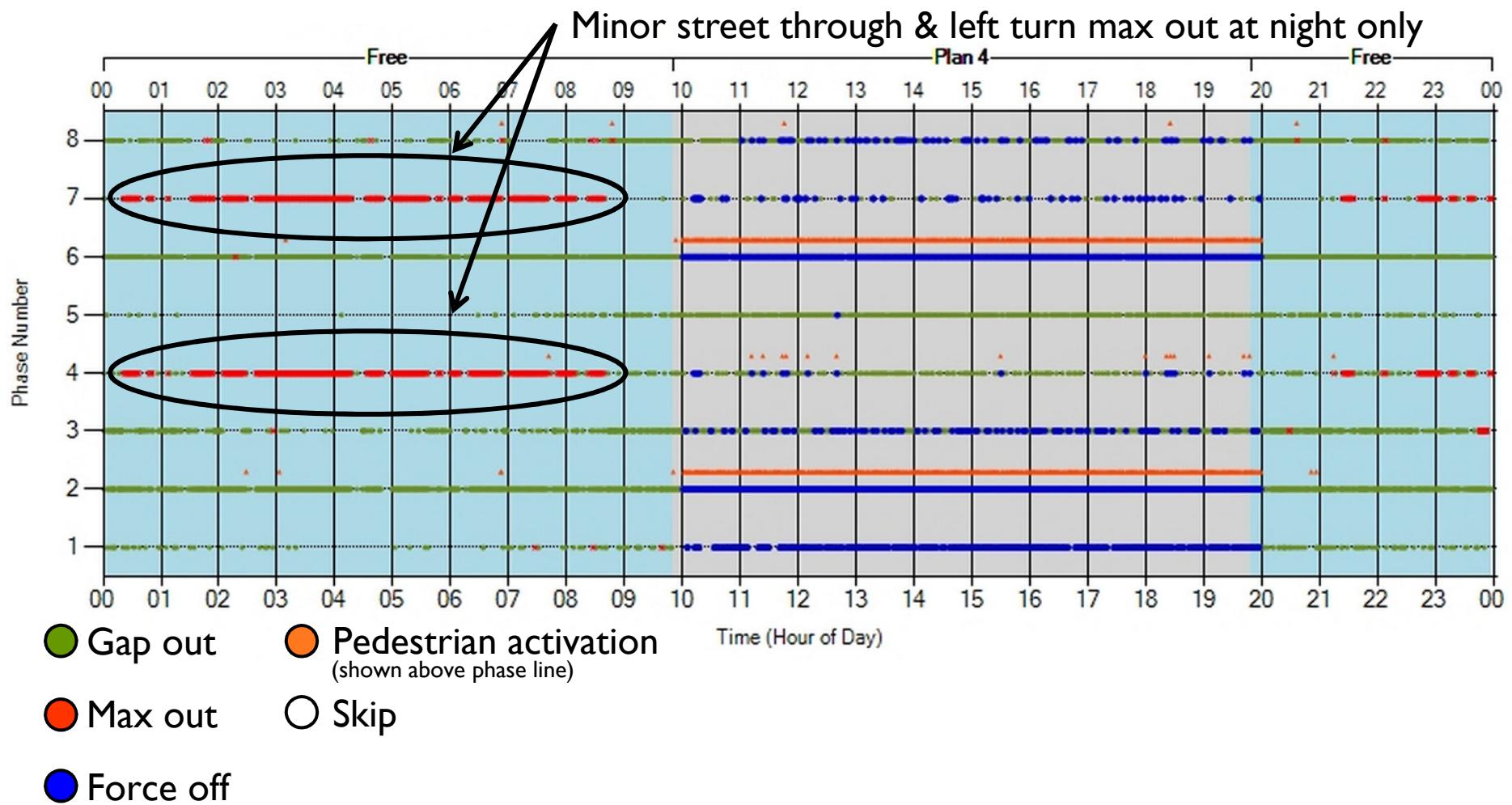
1694 traffic signals

Metric: Purdue Phase Termination



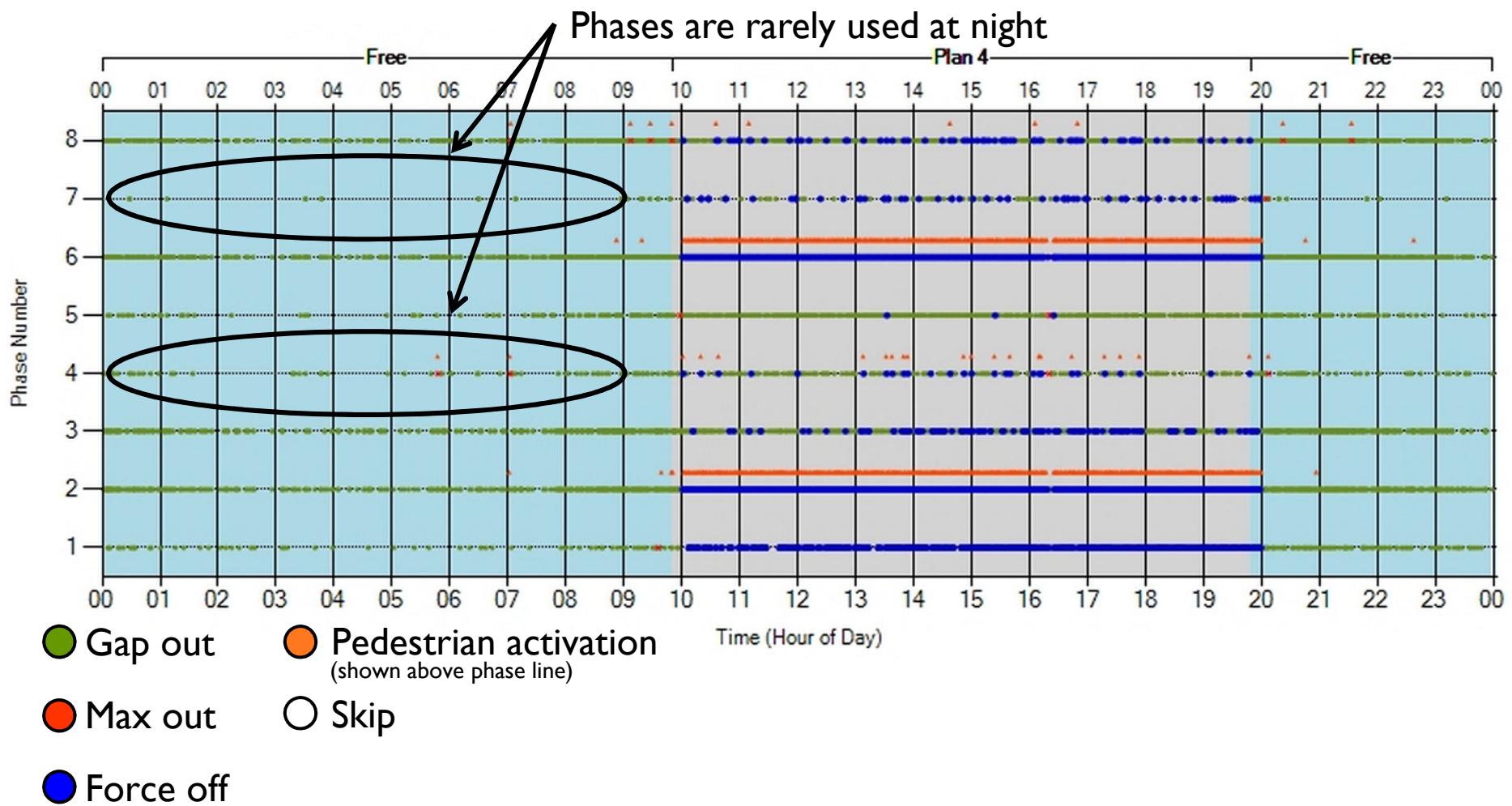
Nighttime detection problem

- ## ► BEFORE: Video detection not working at night

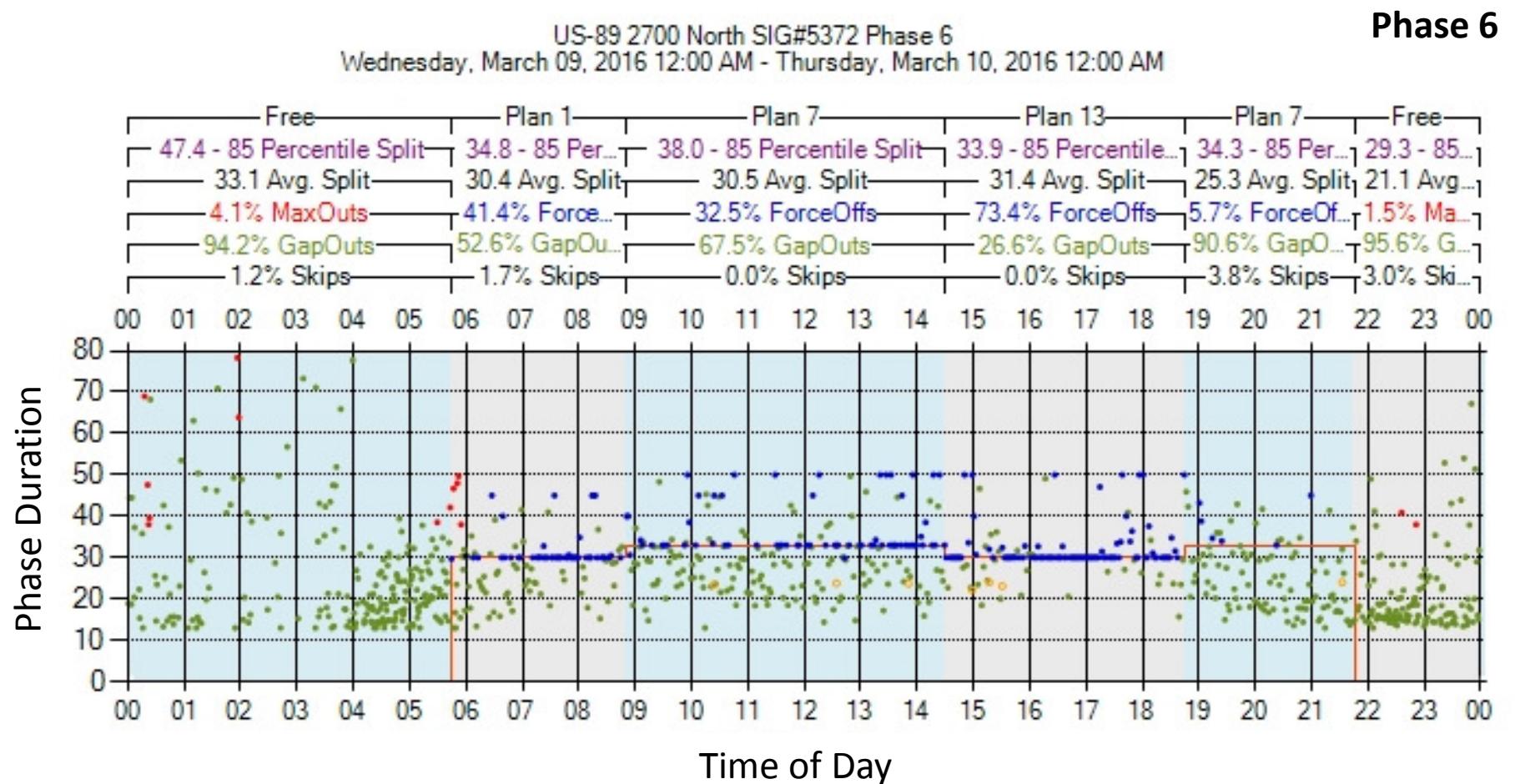


Nighttime detection problem – Fixed!

- ## ► AFTER: New detection technology installed



Metric: Split Monitor



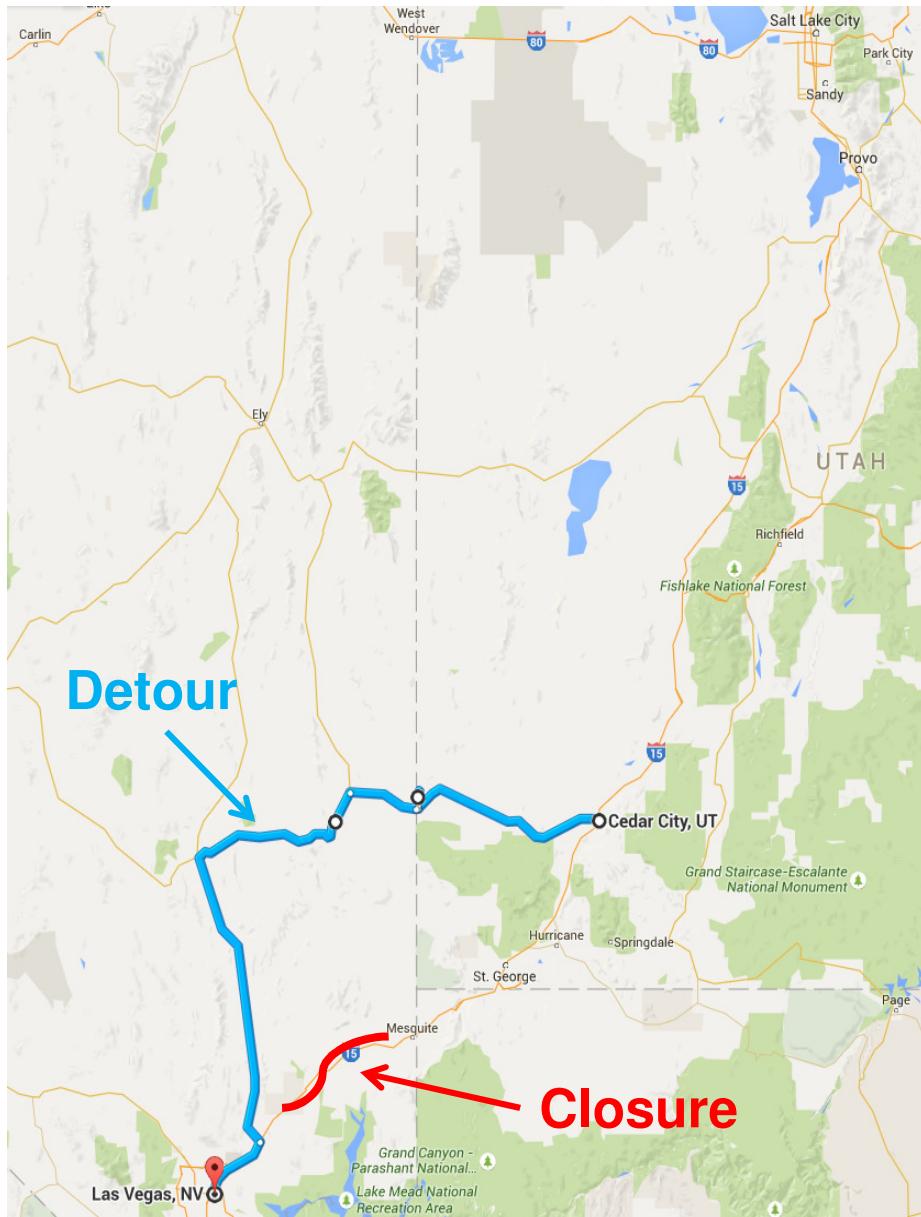
Freeway Closure Example using SPMs - Nevada



Heavy rain rips apart I-15 in Nevada, forces freeway closure

By Ken Ritter, Michelle Rindels, Associated Press | Posted Sep 9th, 2014 @ 7:44pm

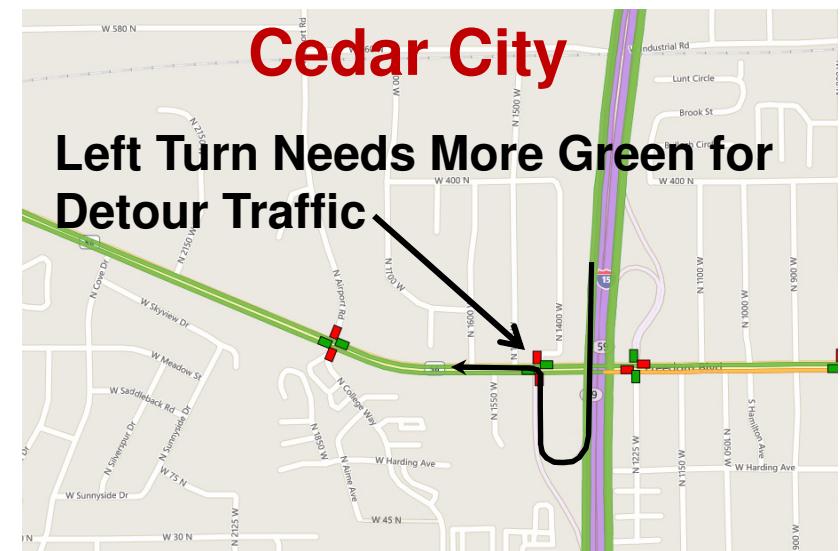
Freeway Closure Example using SPMs - Nevada



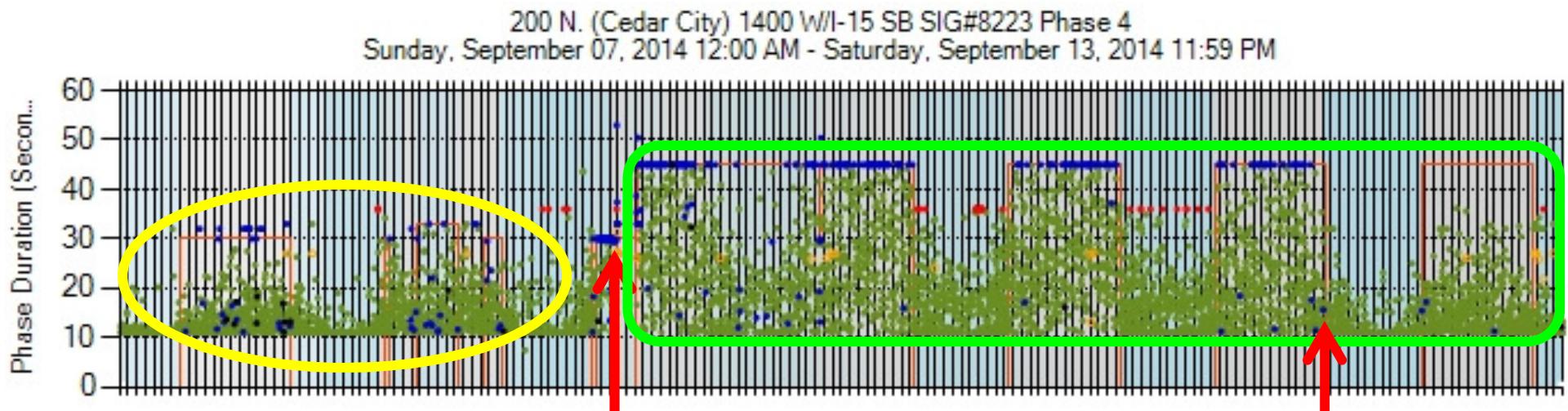
Closure: September 9-12, 2014

I-15 Closed Southbound in Nevada

- 4 day closure
- Detour thru Cedar City to get to Las Vegas.



Phase 4 Split Monitor - (Thru & Left Turn for SB off-ramp) Freeway off-ramp - One week of data

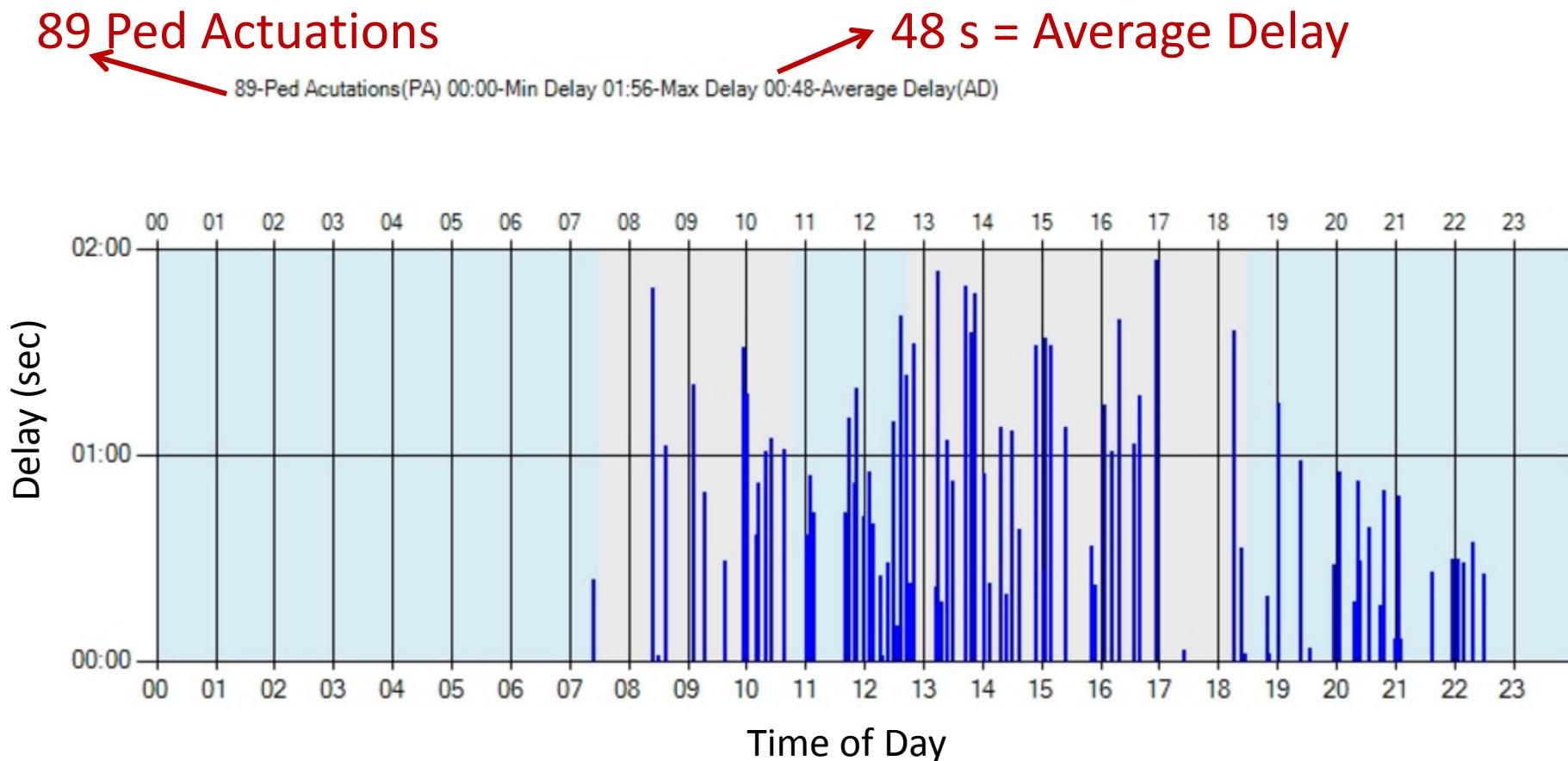


- Gap out
- Pedestrian activation
- Max out
- Force off

Pedestrian Delay

(Time from pedestrian call received to start of the walk indication)

Phase 4 – Side Street – Friday September 16th 2016



Detection

Setback Count Zones



Available Metrics

➤ Purdue Coordination Diagram

➤ Approach Volume

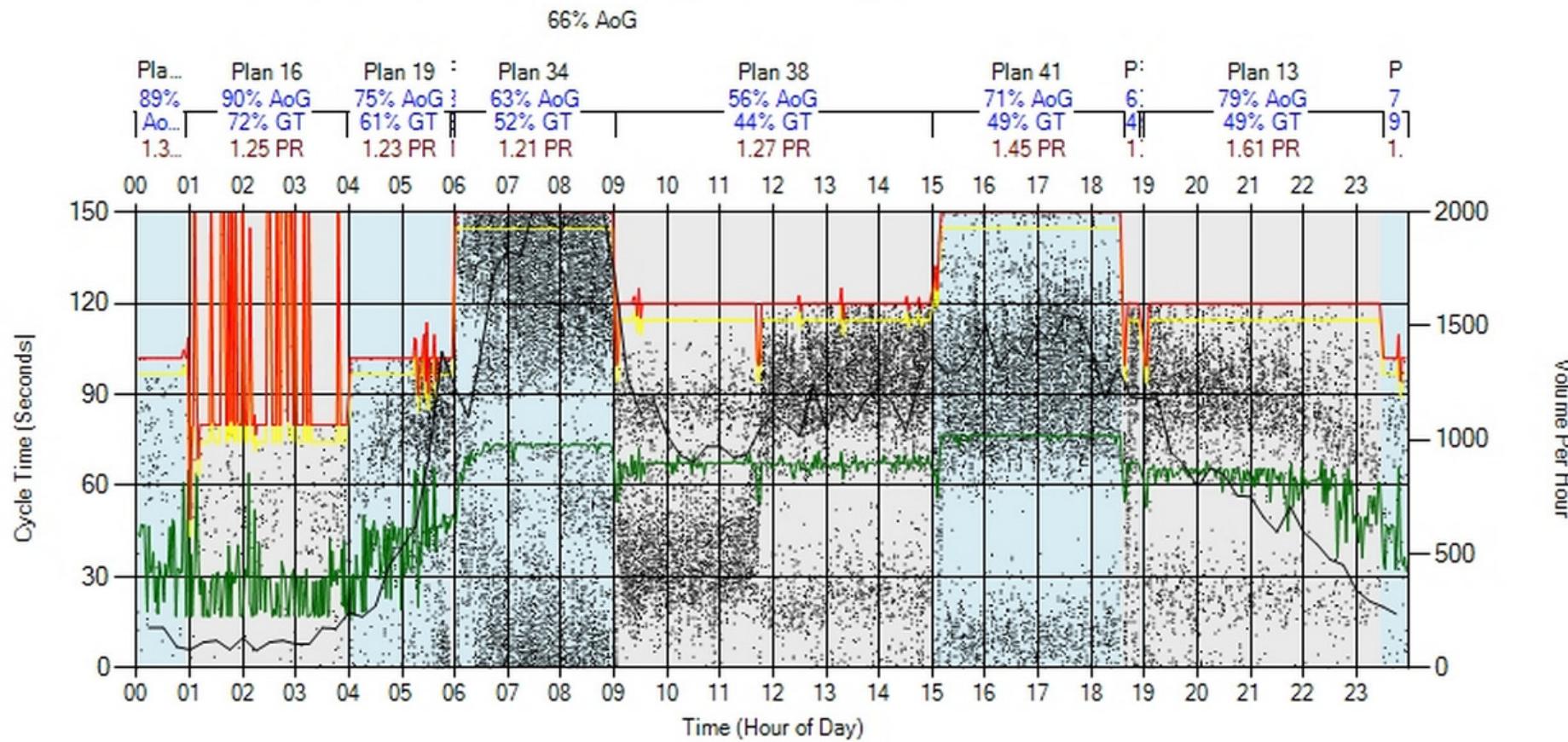
➤ Arrivals on Red

➤ Approach Delay

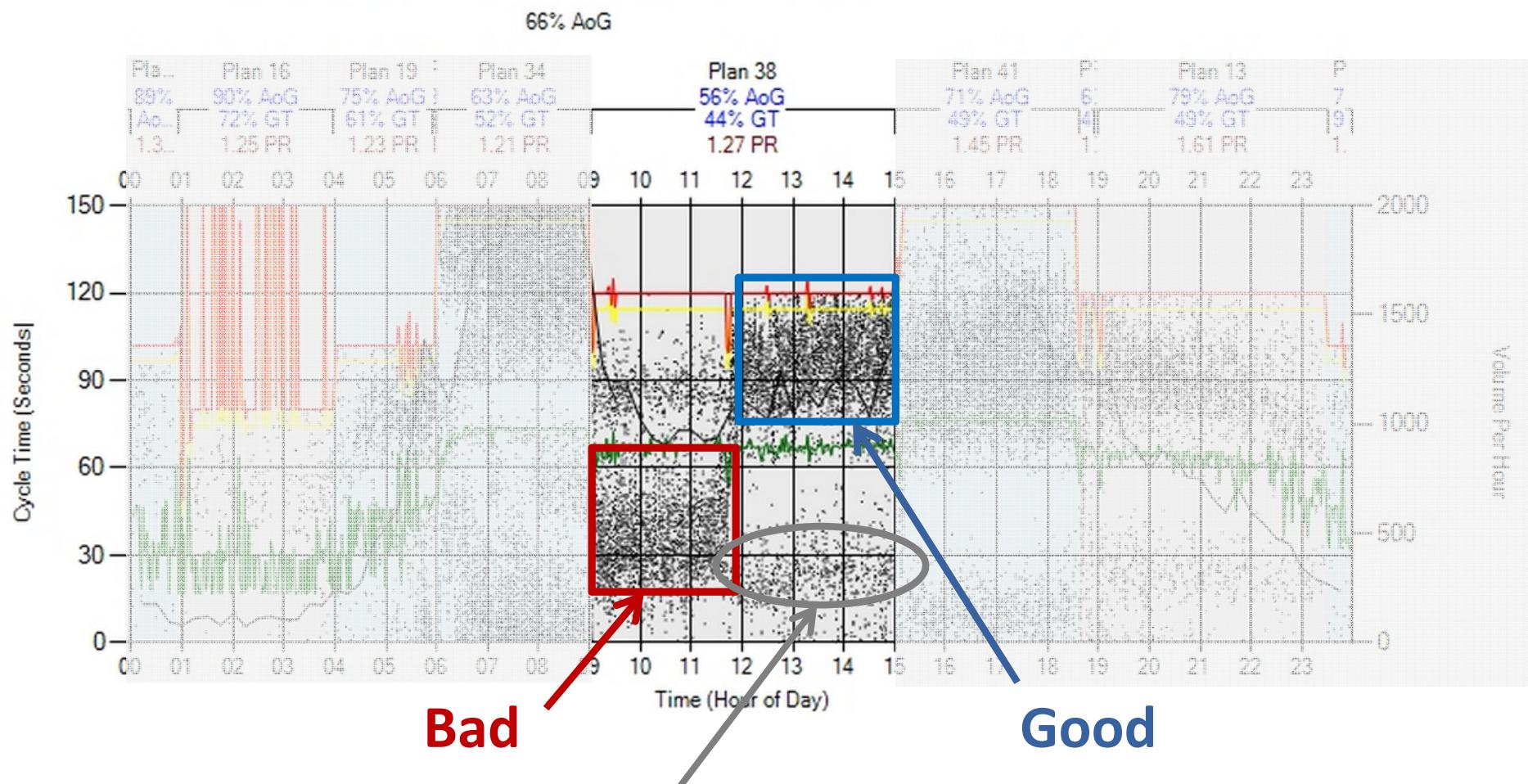
665 traffic signals

Purdue Coordination Diagram

Bangerter Hwy (SR-154) 5400 South (SR-173) Signal 7063 Overlap: 10 Northbound
Thursday, March 07, 2013 12:00 AM - Thursday, March 07, 2013 11:59 PM

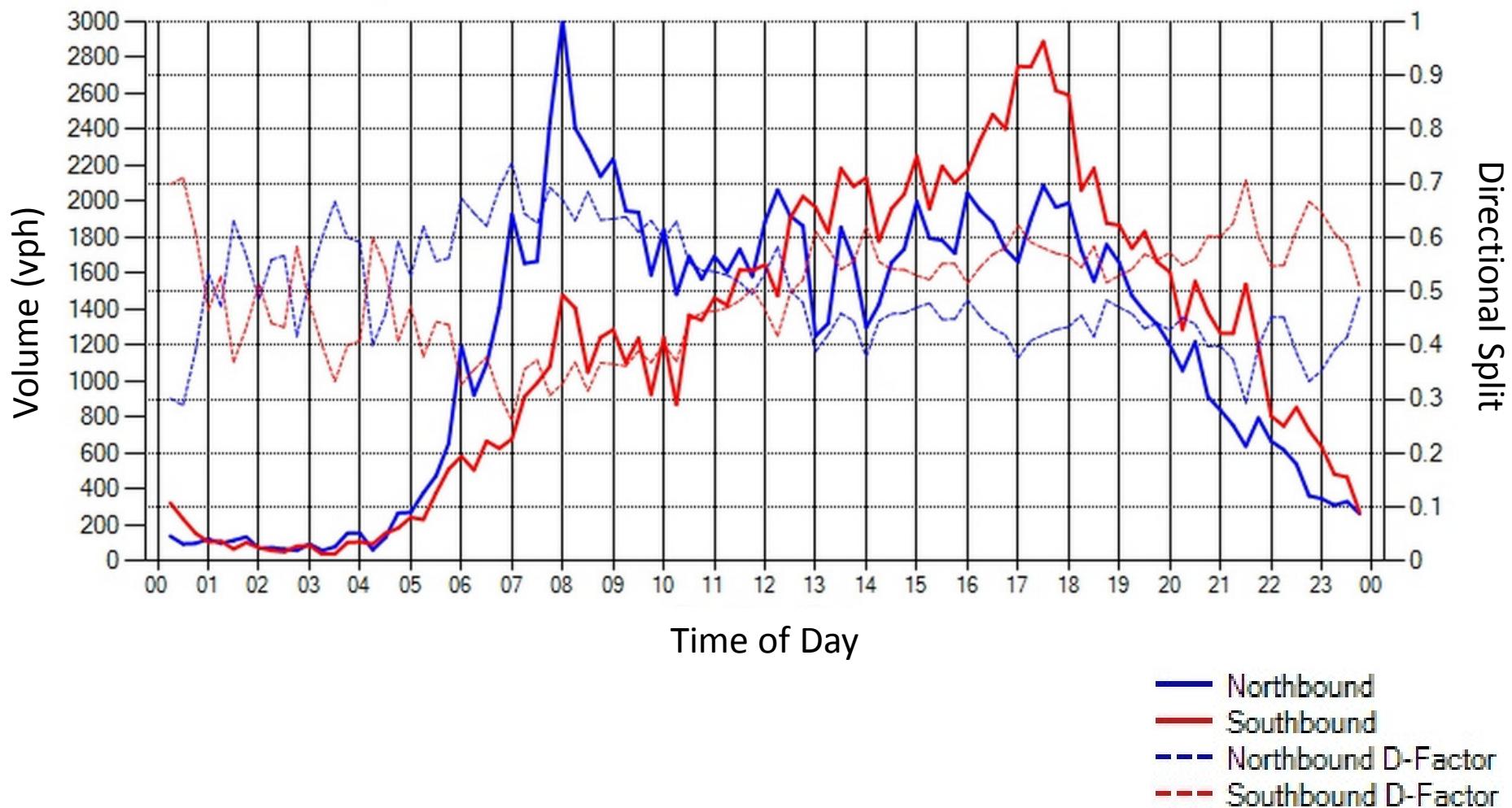


Purdue Coordination Diagram



Left turns from upstream signal

Metric: Approach Volume

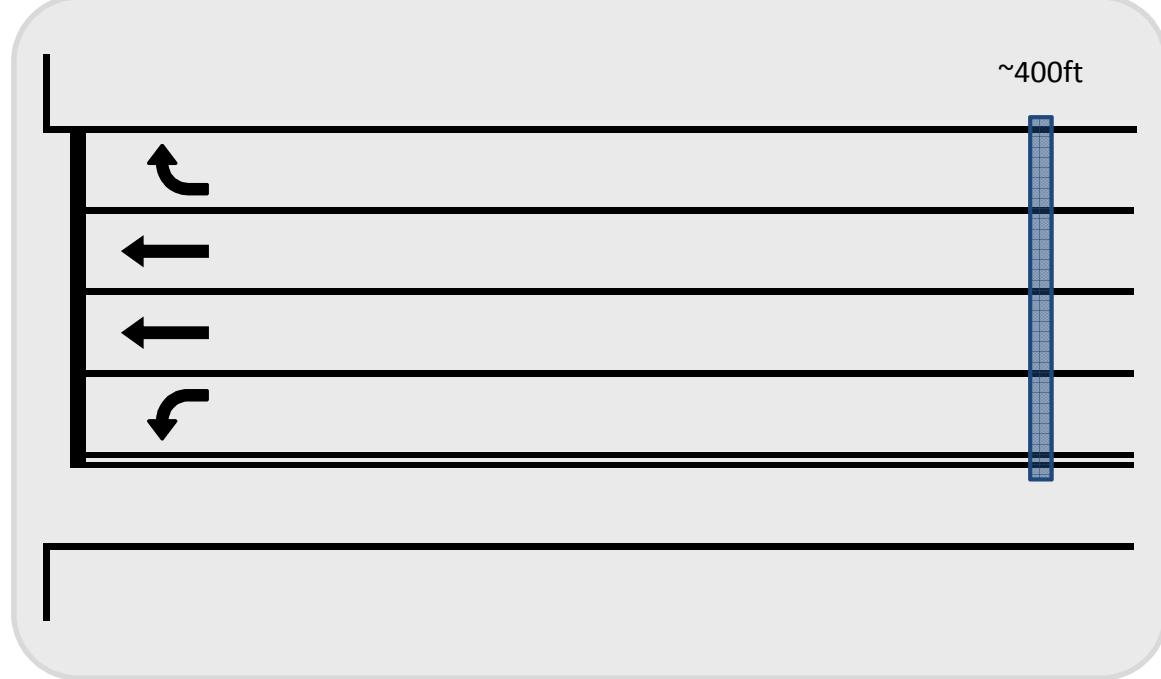


Detection

Setback Count Zones
with speed

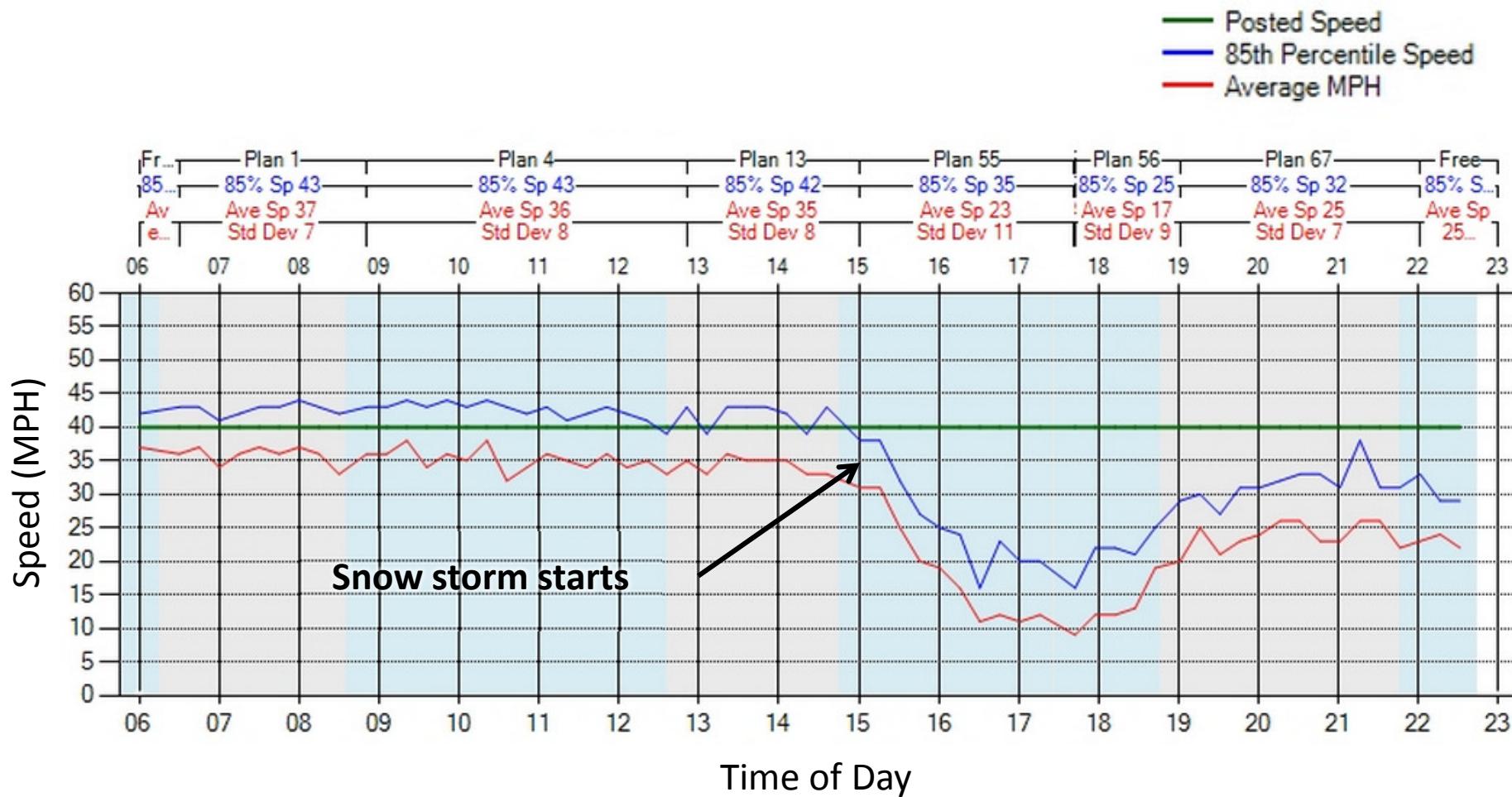
Available Metrics

Approach Speed



660 traffic signals

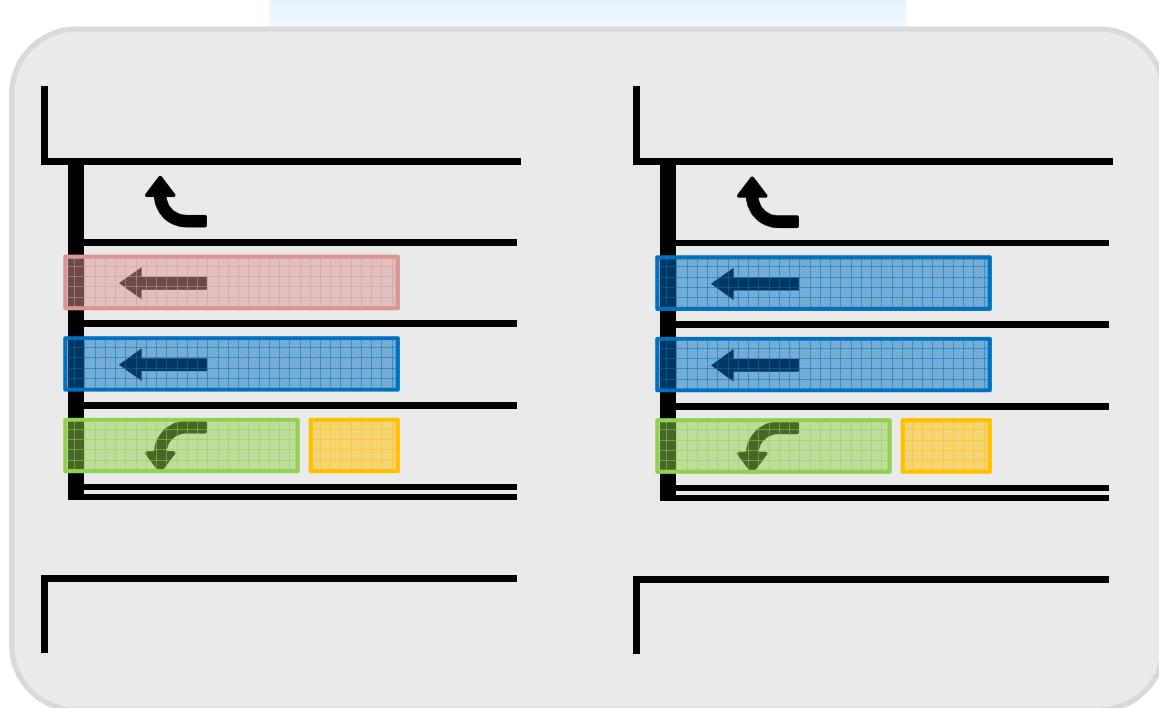
Metric: Approach Speed



Detection

Lane-by-lane Presence

Lane Group Presence



Available Metrics

➤ Purdue Split Failure

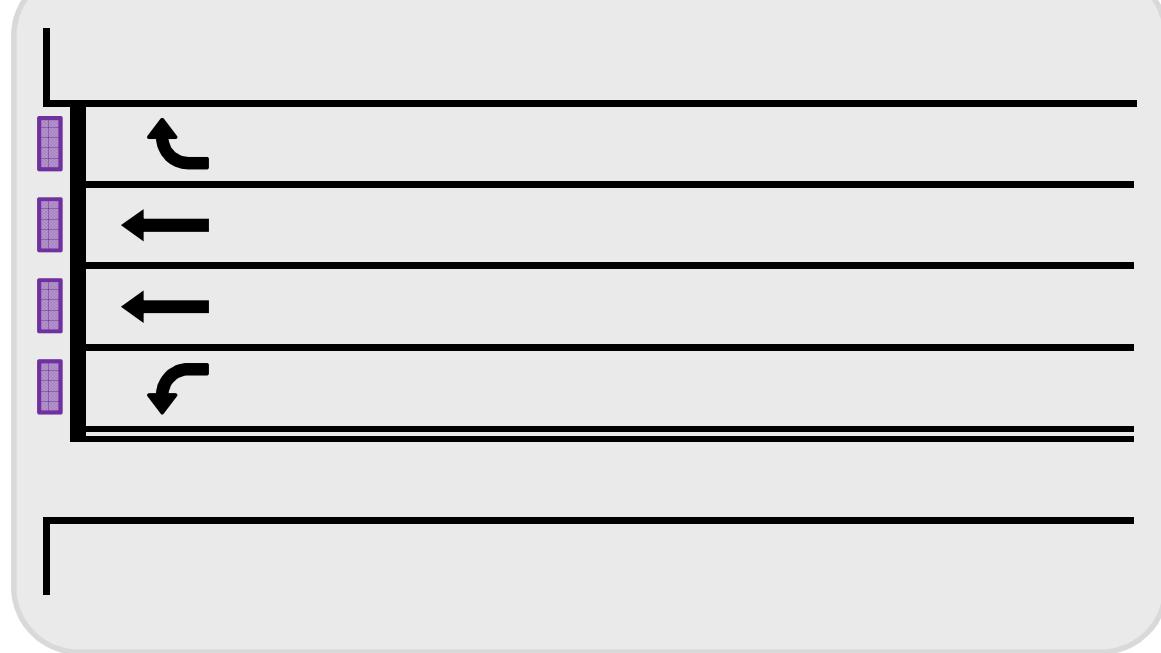
253 traffic signals

Detection

Lane-by-lane Count

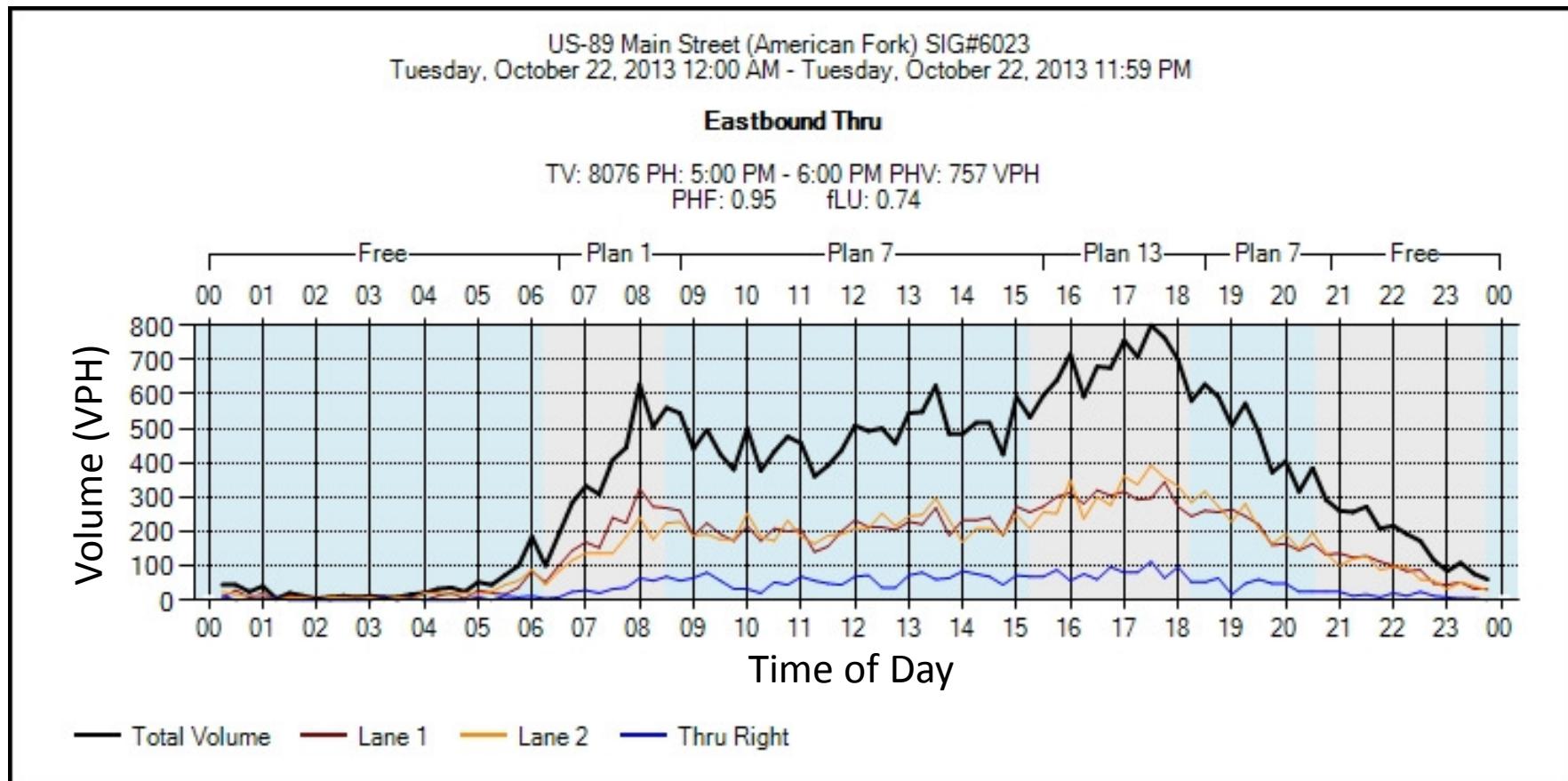
Available Metrics

Turning Movement Counts



343 traffic signals

Metric: Turning Movement Counts



System Health

SPM Alerts for 5/22/2016



SPMWatchdog@utah.gov

to marktaylor, me, signaldesk, shanejohnson, bryan.meenen, kbarnes, SWinters, tforbush, jay.smith, i

–The following signals had too few records in the database:
4671 - 13400 South & 4500 West - Phase: 0 (Missing Records)
5701 - 500 South & 400 East (Btfl) - Phase: 0 (Missing Records)

–The following signals had too many force off occurrences:
1224 - North Temple & Main Street - Phase: 3 (Force Offs 97.6%)
7252 - 500 South & Main Street - Phase: 2 (Force Offs 100%)
7252 - 500 South & Main Street - Phase: 6 (Force Offs 100%)

–The following signals had too many max out occurrences:
1123 - Wolcott St & 100 South - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Guardsman Way - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Guardsman Way - Phase: 6 (Max Outs 100%)
4024 - 7000 South (Fort Union) & 1300 East - Phase: 7 (Max Outs 92.6%)
4029 - 7200 South & 700 East - Phase: 1 (Max Outs 100%)
4103 - 4680 South (Murray-Holladay) & 2320 East (Holladay) - Phase: 5 (Max Outs 100%)
4118 - 6200 South & 3655 West (Dixie) - Phase: 2 (Max Outs 100%)
4511 - 4100 South & 3200 West - Phase: 4 (Max Outs 100%)
4820 - 4835 South & 2700 West - Phase: 2 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 4 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 8 (Max Outs 100%)
5080 - Washington & Adams - Phase: 5 (Max Outs 100%)
5170 - 200 N (Kaysville) & Main St. - Phase: 4 (Max Outs 100%)
5305 - Main St. & 200 North (Logan) - Phase: 7 (Max Outs 96.2%)
5900 - 900 W. (Kays Dr.) & 200 North, (Kaysville) - Phase: 4 (Max Outs 90.4%)
6035 - Pioneer Crossing & Millpond Drive - Phase: 8 (Max Outs 91.9%)
6608 - 100 West & 100 North - Phase: 8 (Max Outs 98.5%)
7107 - Redwood Road & 4700 South - Phase: 5 (Max Outs 93.2%)

–The following signals had unusually low detector hits:
5134 - SR-193 (700 S) & I-15 NB (Clearfield) - Phase: 2 (Has Unusually Low Counts.)
7061 - Bangerter Hwy (SR-154) & 4100 South - Phase: 1 (Has Unusually Low Counts.)
7061 - Bangerter Hwy (SR-154) & 4100 South - Phase: 7 (Has Unusually Low Counts.)
7361 - Bangerter Hwy (SR-154) & 13400 South - Phase: 1 (Has Unusually Low Counts.)

–The following signals have stuck ped detectors:
1023 - South Temple & 200 West - Phase: 2 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 4 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 6 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 8 (Stuck Ped)
4511 - 4100 South & 3200 West - Phase: 4 (Stuck Ped)
6009 - Main (Lehi) & I-15 SPUI - Phase: 6 (Stuck Ped)
7826 - 9800 S (Little Cottonwood Rd) & Wasatch Blvd (3500 E) - Phase: 4 (Stuck Ped)

1694 traffic signals

1 No SPM Data

2 Too many max outs

3 Too many force offs

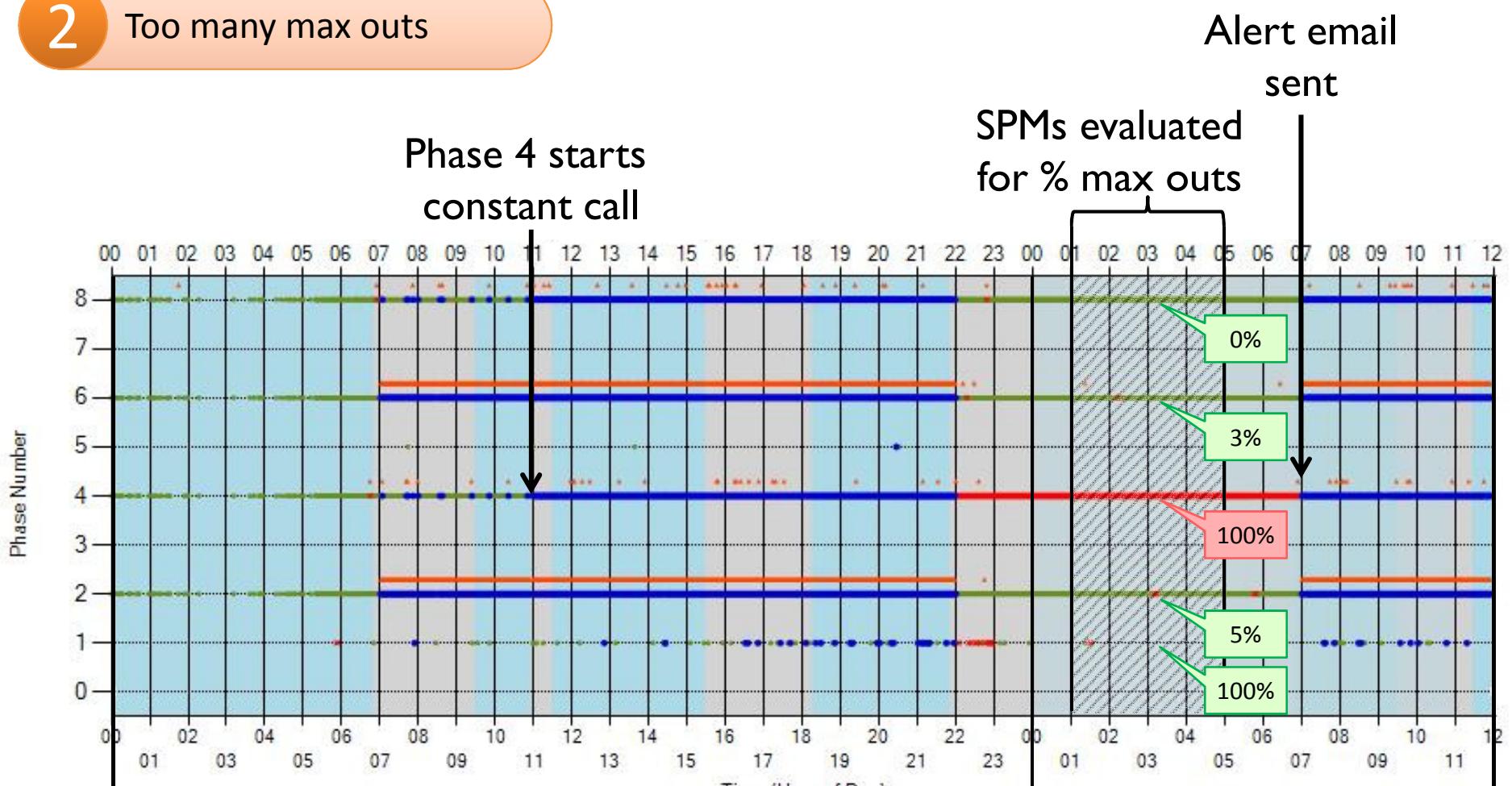
4 Too many ped calls

5 Low PCD detector count

6 High PCD detector count

2

Too many max outs



Gap out

Max out

Force off

Pedestrian activation (shown above phase line)

Skip

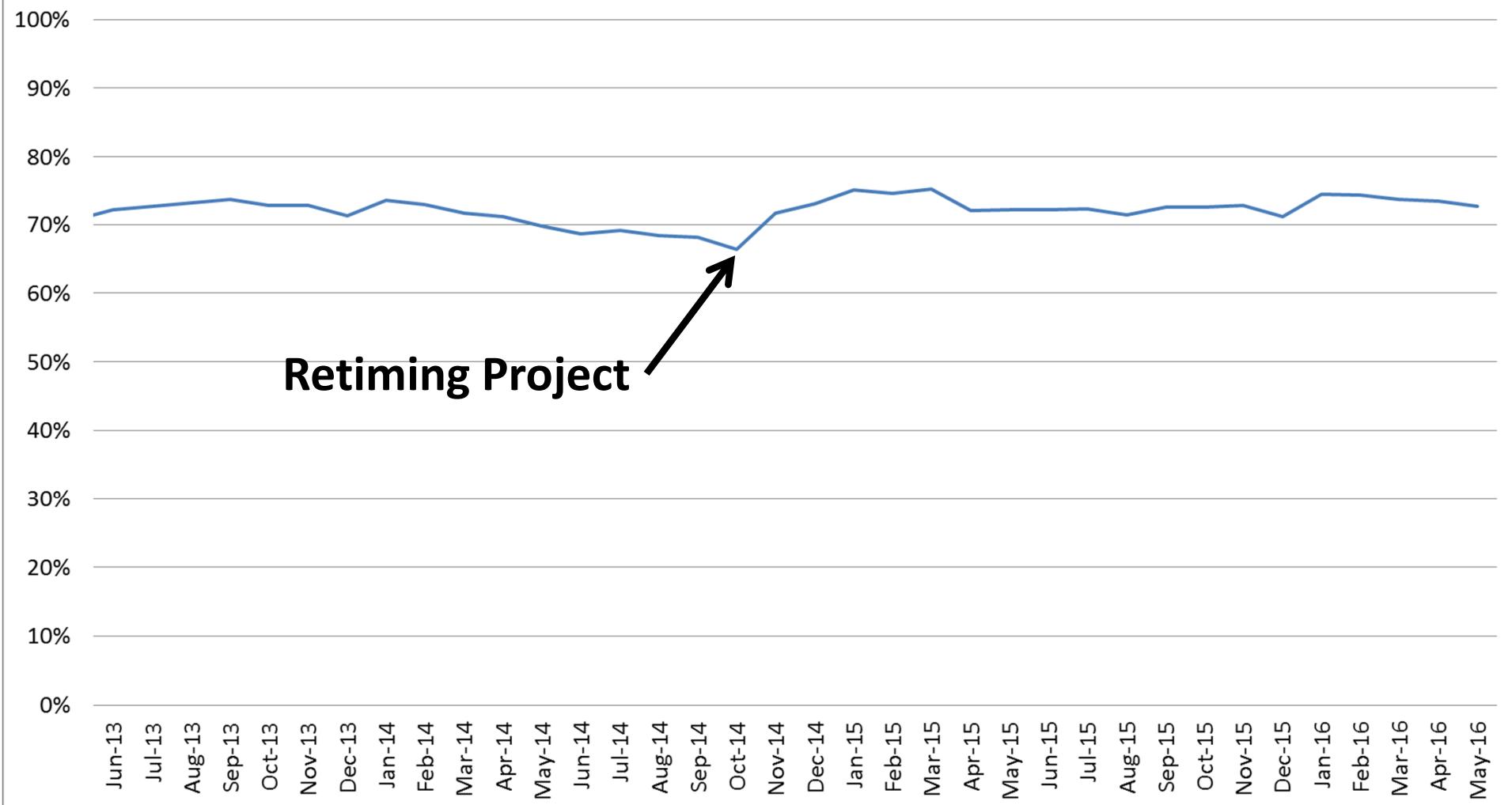
Metric: Purdue Phase Termination
Detection Requirements: None

Monitoring Trends

(Riverdale Rd – 11 intersections)

Percent of Vehicles Arriving on Green - Riverdale Rd

10:00 AM to 2:00 PM Monday through Friday

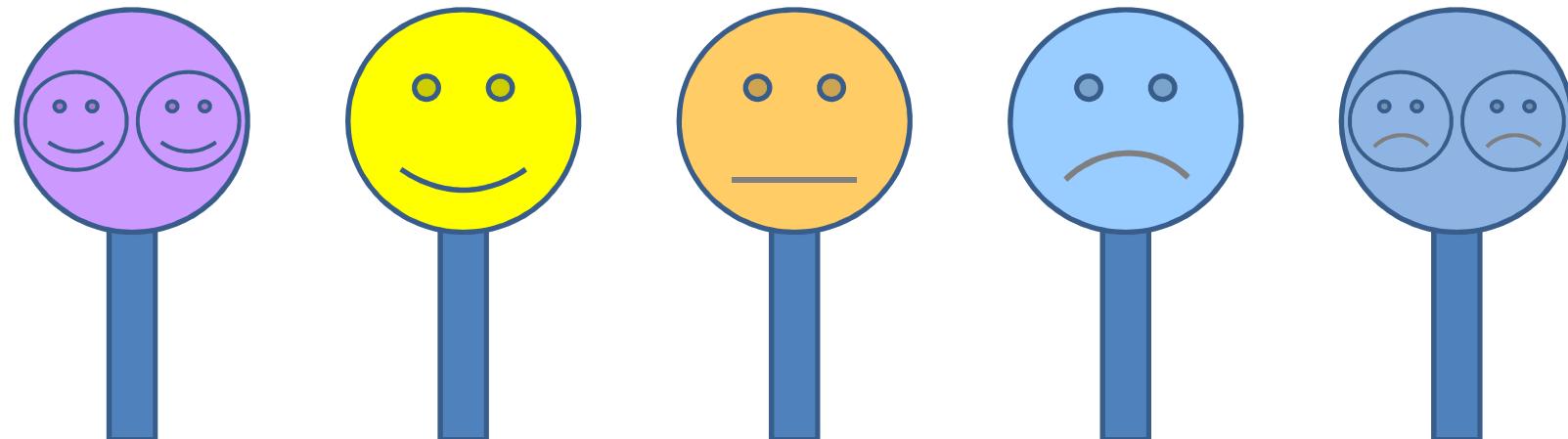


UDOT Signal Timing Focus Group (July 2014)

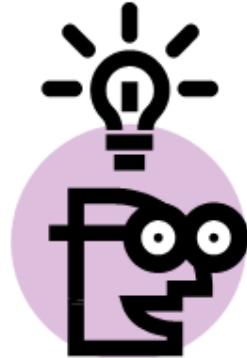
- *How do you feel about UDOT?*



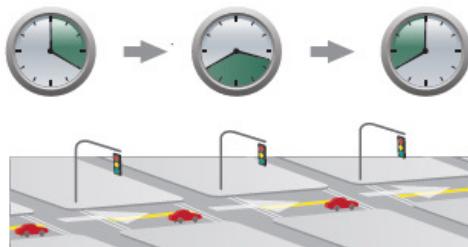
- *How do traffic signals make you feel?*



Focus Group Key Findings (July 2014)



UDOT is perceived positively, with innovation as the primary driver of positive impressions.



Drivers believe traffic signal synchronization is improving.



Drivers feel UDOT should be open about its accomplishments in a way that protects its credibility.

60 S Commercial – Love green lights? So do UDOT traffic engineers



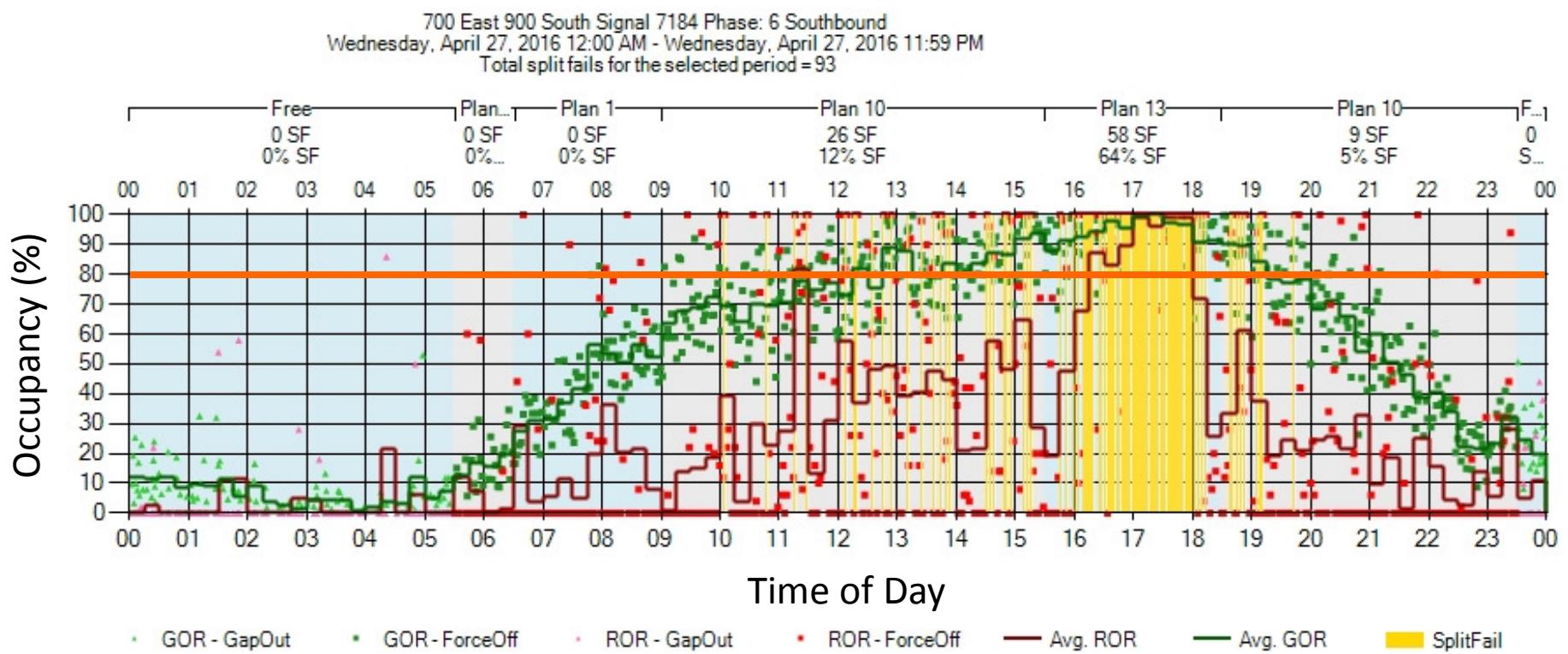
<http://udot.utah.gov/greenlights>

udottraffic.utah.gov/signalperformancemetrics

Mark Taylor
marktaylor@utah.gov

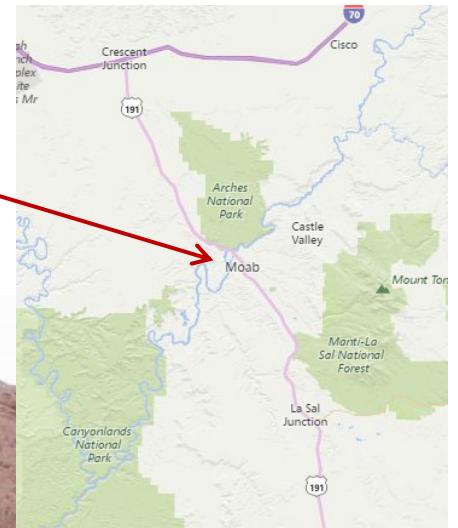


Metric: Purdue Split Failure



Case Study: Moab, Utah

- The Adventure Capital of the U.S.A.
- Two National Parks within 20 miles



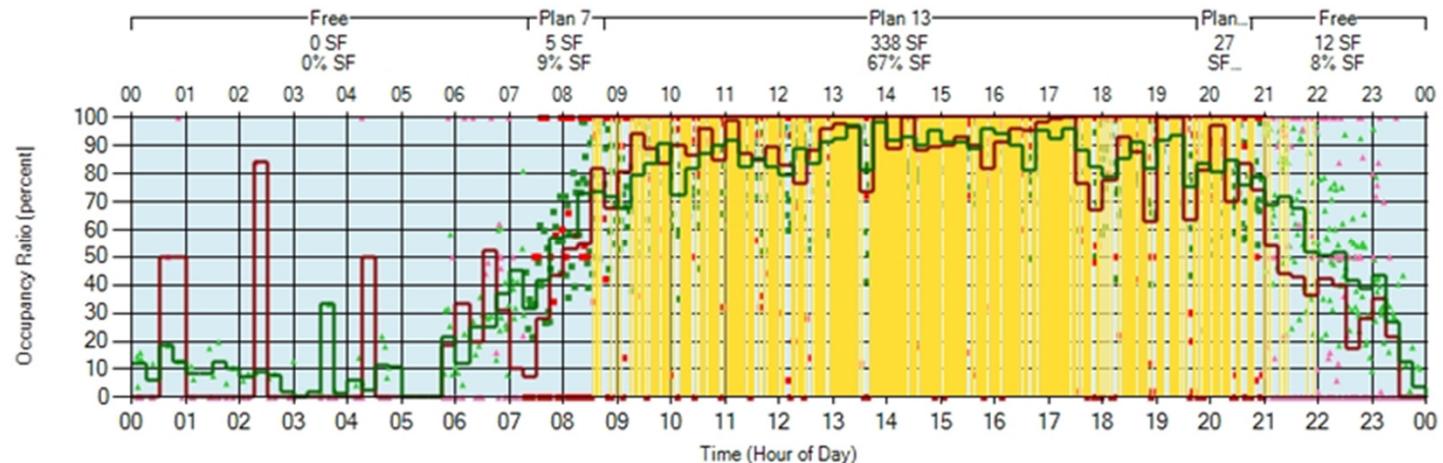
Purdue Split Failure – Center St & Main St – Moab, Utah

Memorial Day Weekend – Saturday

NORTHBOUND

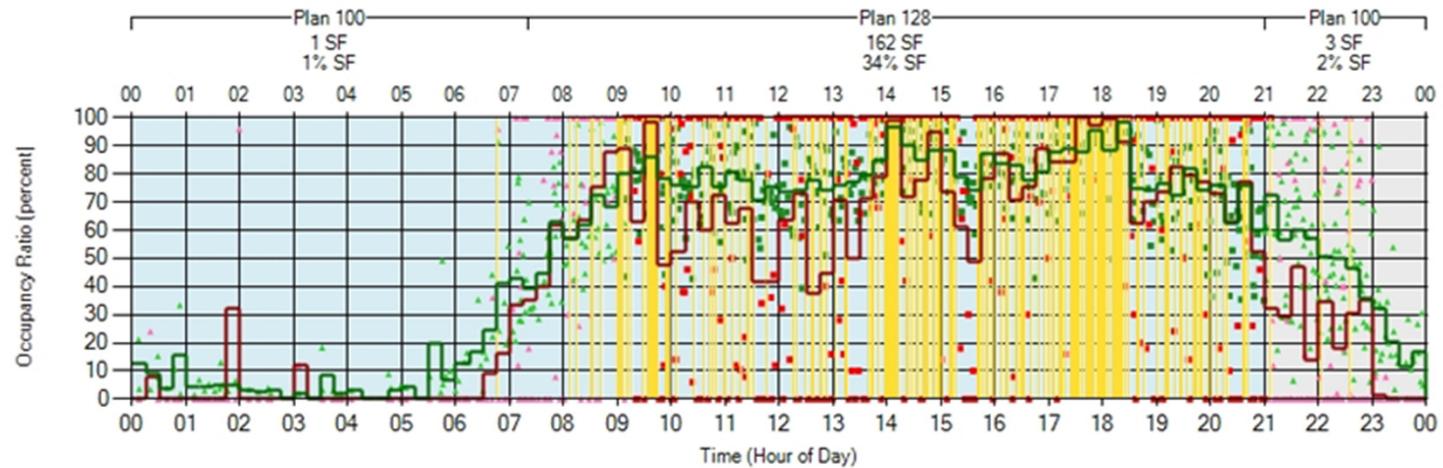
- SplitFail
- GOR - GapOut
- GOR - ForceOff
- ROR - GapOut
- ROR - ForceOff
- Avg. ROR
- Avg. GOR
- Percent Fails

2015

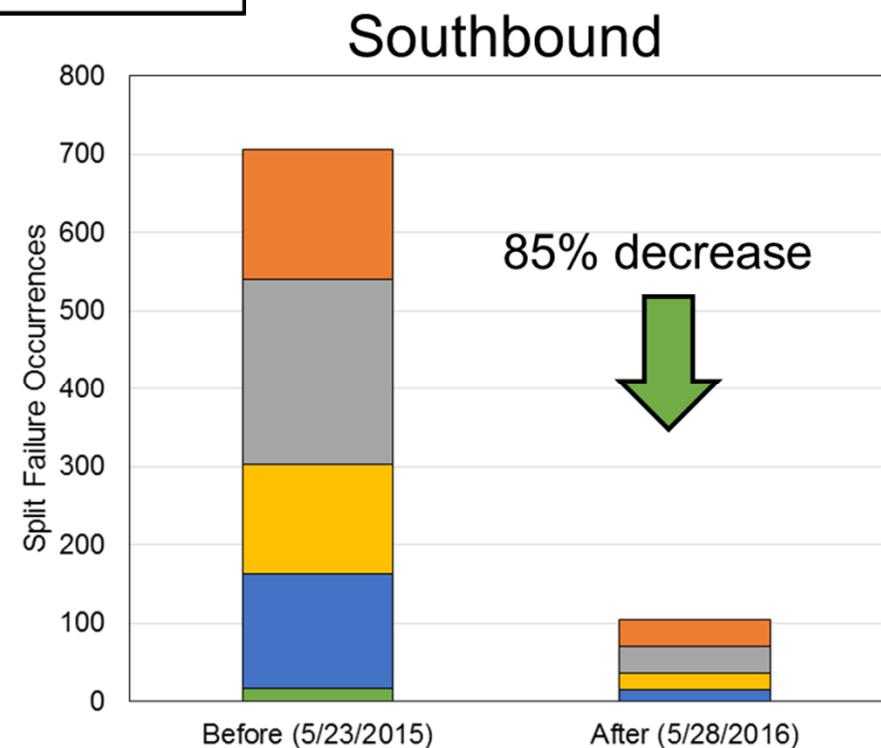
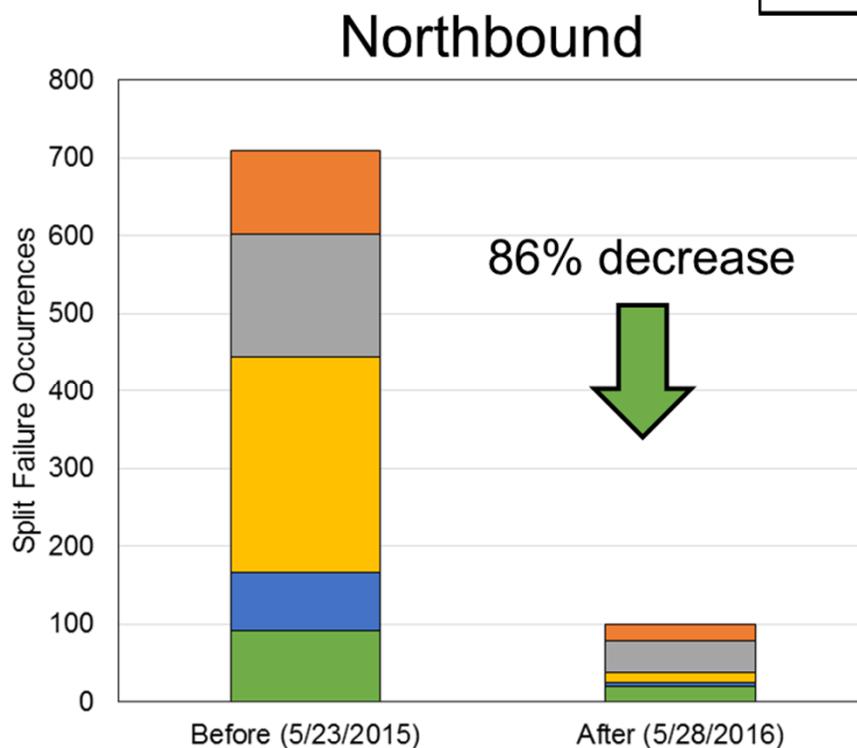


- SplitFail
- GOR - GapOut
- GOR - ForceOff
- ROR - GapOut
- ROR - ForceOff
- Avg. ROR
- Avg. GOR
- Percent Fails

2016



Moab - Split Failure Results



Moab - Split Failure Results

