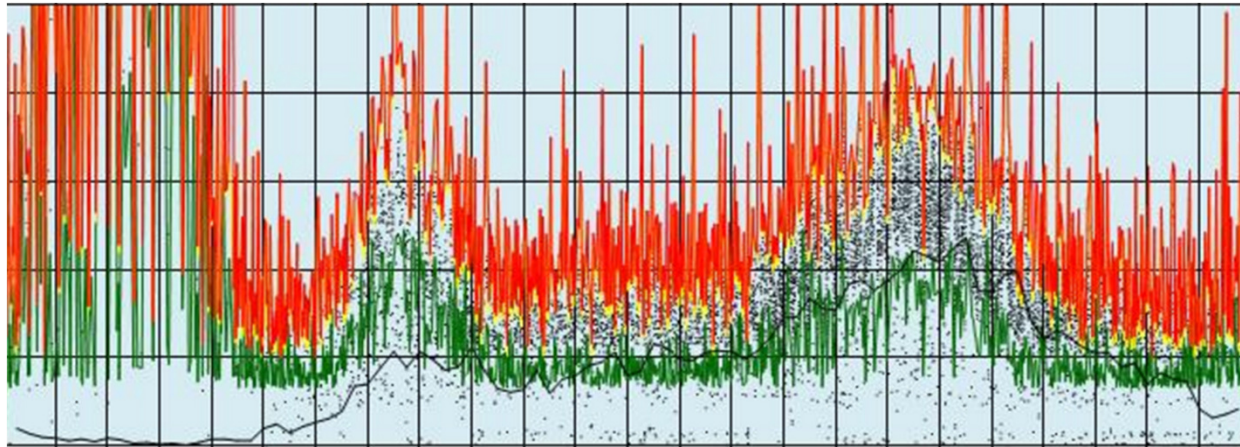


UDOT's Experience



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

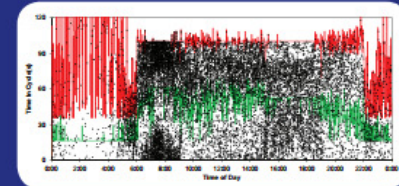


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PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

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



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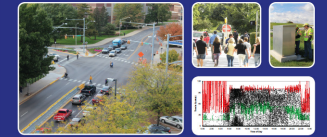
POOLED FUND STUDY

INDIANAPOLIS

NOVEMBER 12, 2014

PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach



Christopher M. Gray, Cheryl M. Aubock, Howell Li, Stephen M. Dennis, Alexander M. Hahn, Richard S. Fraga, Amanda L. Stevens, James R. Shubert, and Thomas M. Brown



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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*

<http://docs.lib.purdue.edu/atspmw>



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)

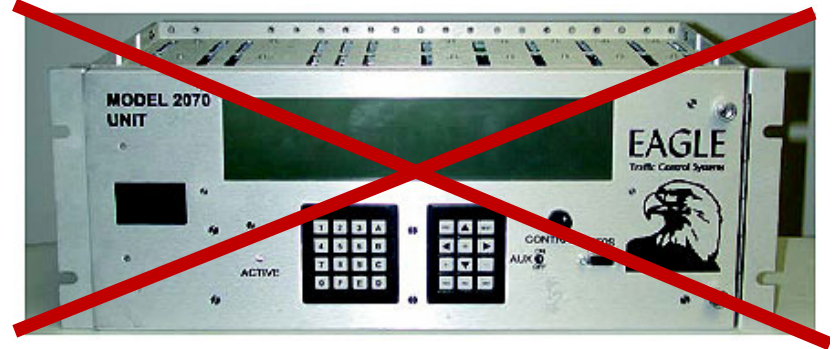
A Central Signal System is NOT used or Needed!

Why Model what you can Measure?

System Requirements



2070's don't work without 1C CPU



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+

Data Logger records to the 1/10 second resolution



Signal Performance Metrics



Charts Reports Log Action Taken Links FAQ

->Signal Metrics

Selected Signal
 No Signal Selected

Signals

Region

Metric Type

Filter

Signal List

Map

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

Volume Y Axis Maximum

Volume Bin Size

Dot Size

Show Plan Statistics

Show Volumes

[Export Data](#)

Upload Current Data

Dates

Start Date

End 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

1694 traffic signals

<http://challenger.nvfast.org/spm>



Signal Performance Metrics



Charts Reports Links FAQ

Signal
Time Space Diagram
Enter Chart Comments

Selected Signal:

Signals

Region:

Metric Type:

Filter:

Signal List

Map

Metric Settings

Metric Type

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

Time Y Axis Maximum:

Volume Y Axis Maximum:

Volume Bin Size:

Dot Size:

Show Plan Statistics

Show Volumes

[Export Data](#)

Dates

Start Date:

End 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



Signal Performance Metrics



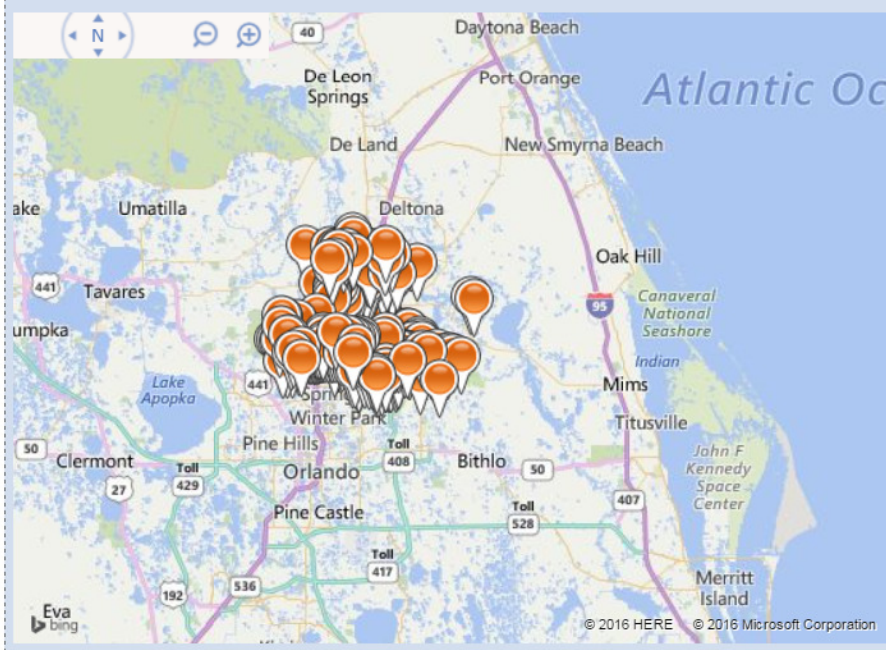
->Signal Metrics

Selected Signal

Signals
Region:
Metric Type:
Filter:

Signal List

Map



Metric Settings

Metric Type

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

Time Y Axis Maximum:
Volume Y Axis Maximum:
Volume Bin Size:
Dot Size:

Show Plan Statistics
 Show Volumes
[Export Data](#)
 Upload Current Data

Dates

Start Date: AM
End Date: 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

316 traffic signals



http://signalmetrics.ua.edu

Signal Performance Metrics

->Signal Metrics

Selected Signal
 No Signal Selected

Signals
 Region:
 Metric Type:
 Filter:

Signal List

Map

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:
 Volume Y Axis Maximum:
 Volume Bin Size:
 Dot Size:
 Show Plan Statistics
 Show Volumes
[Export Data](#)
 Upload Current Data



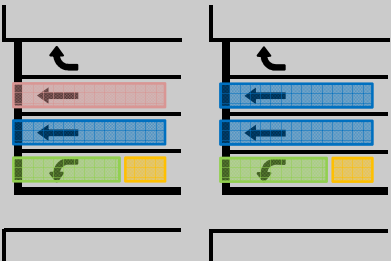
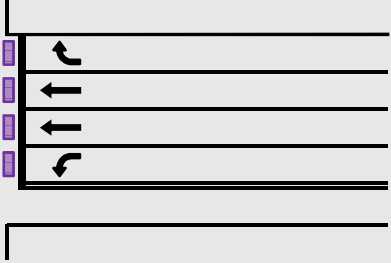
Dates
 Start Date:
 End Date:

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

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

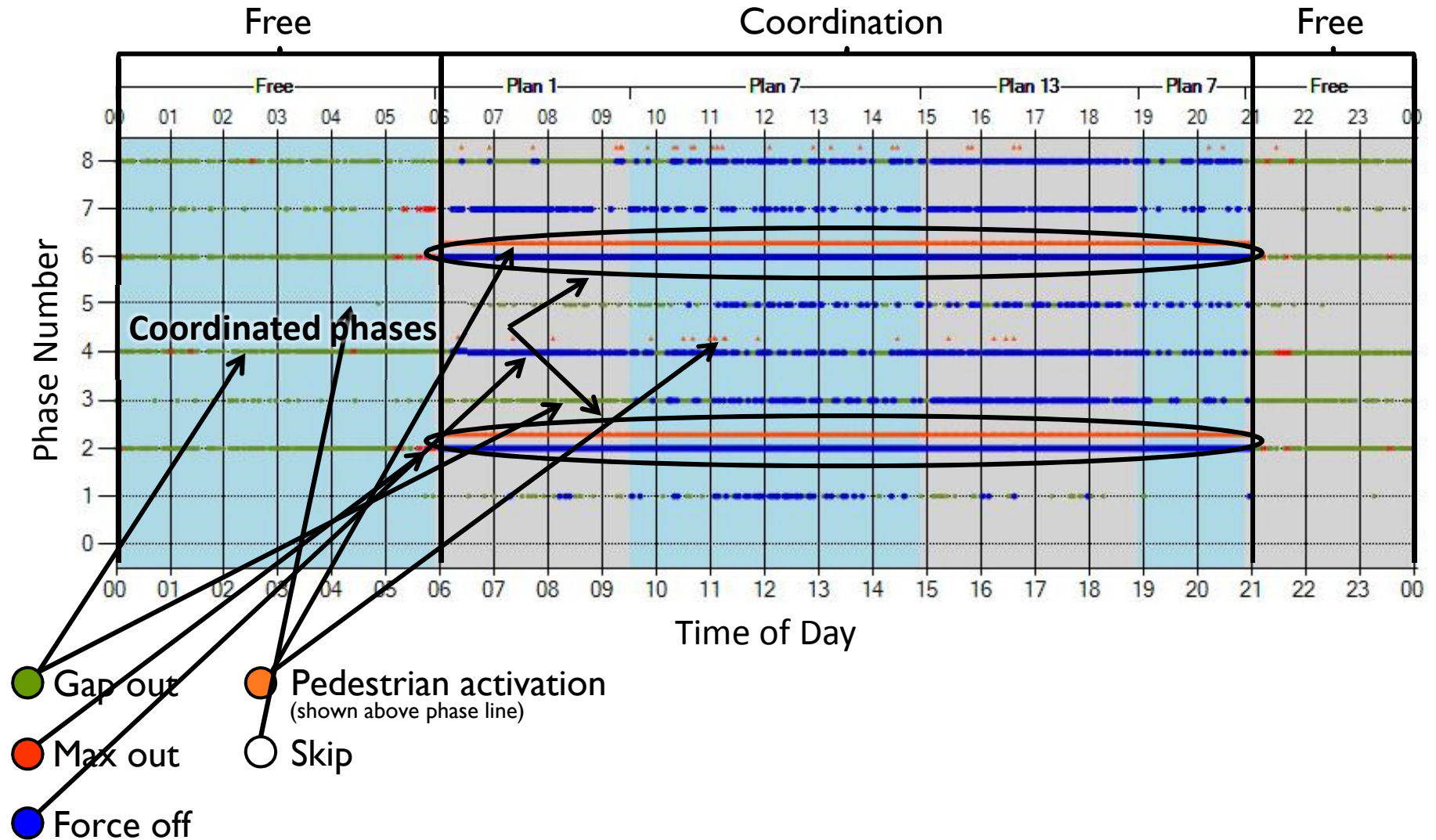
None

Available Metrics

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

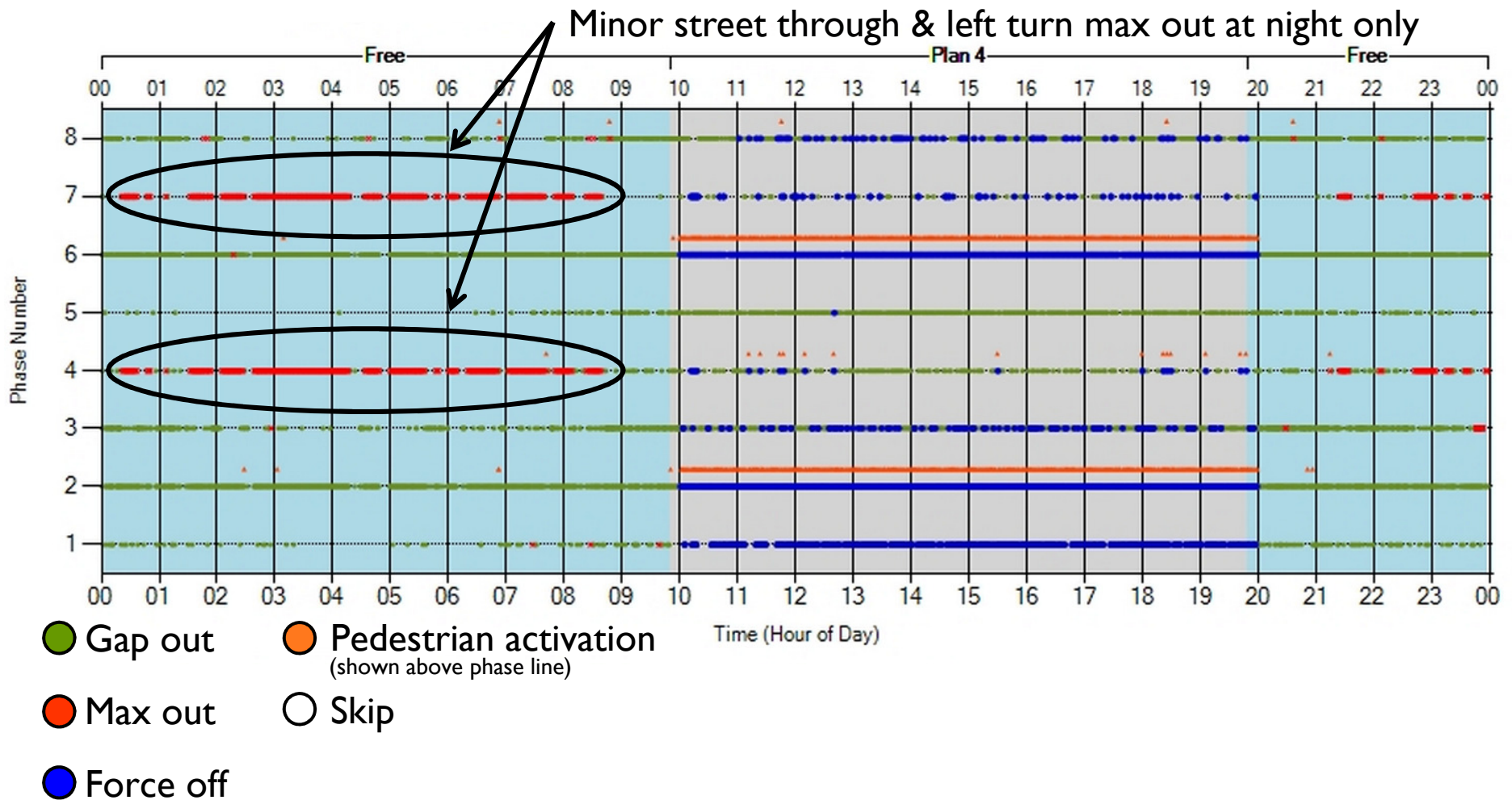
1694 traffic signals

Metric: Purdue Phase Termination



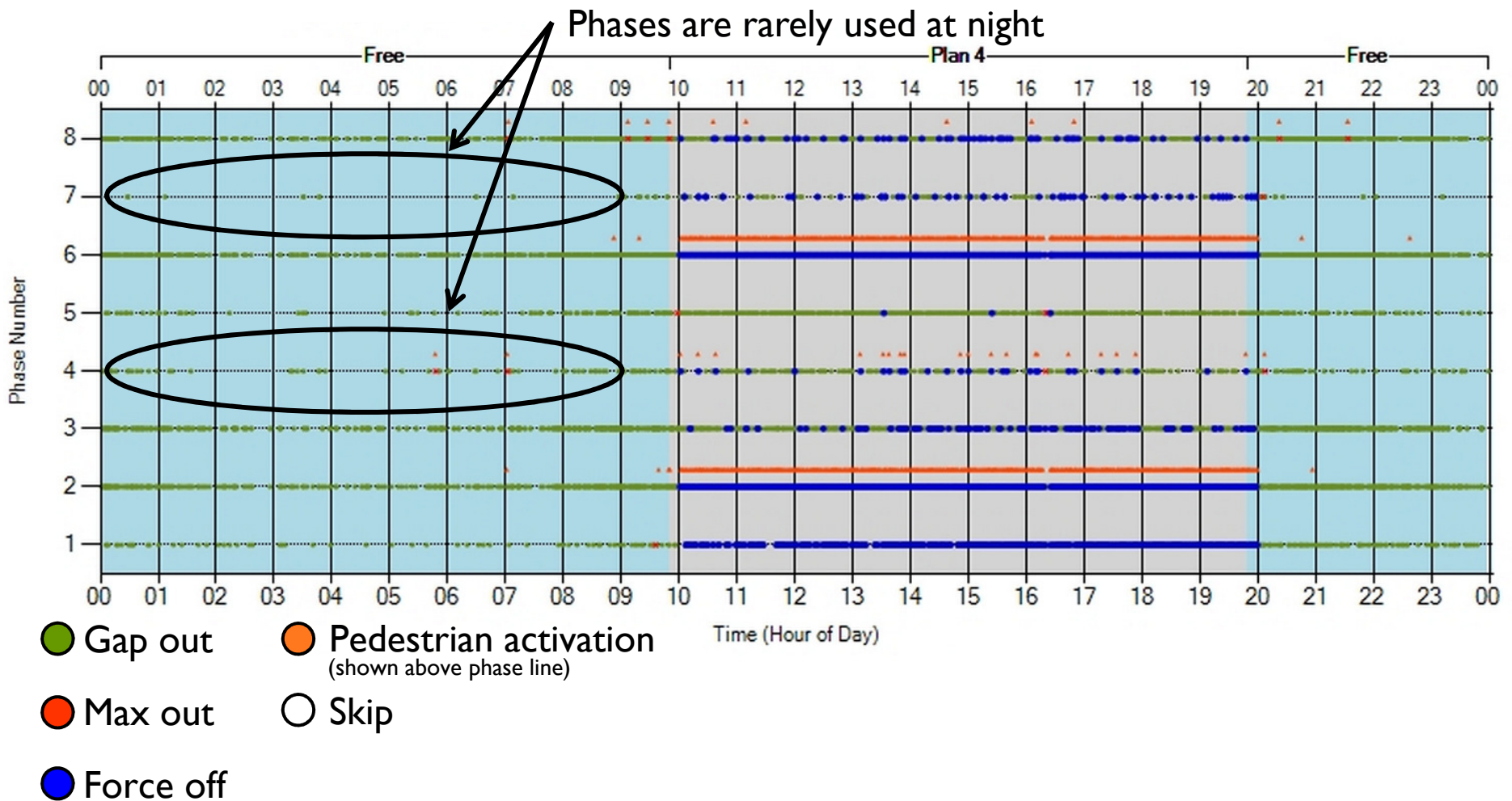
Nighttime detection problem

- ▶ BEFORE: Video detection not working at night



Nighttime detection problem – Fixed!

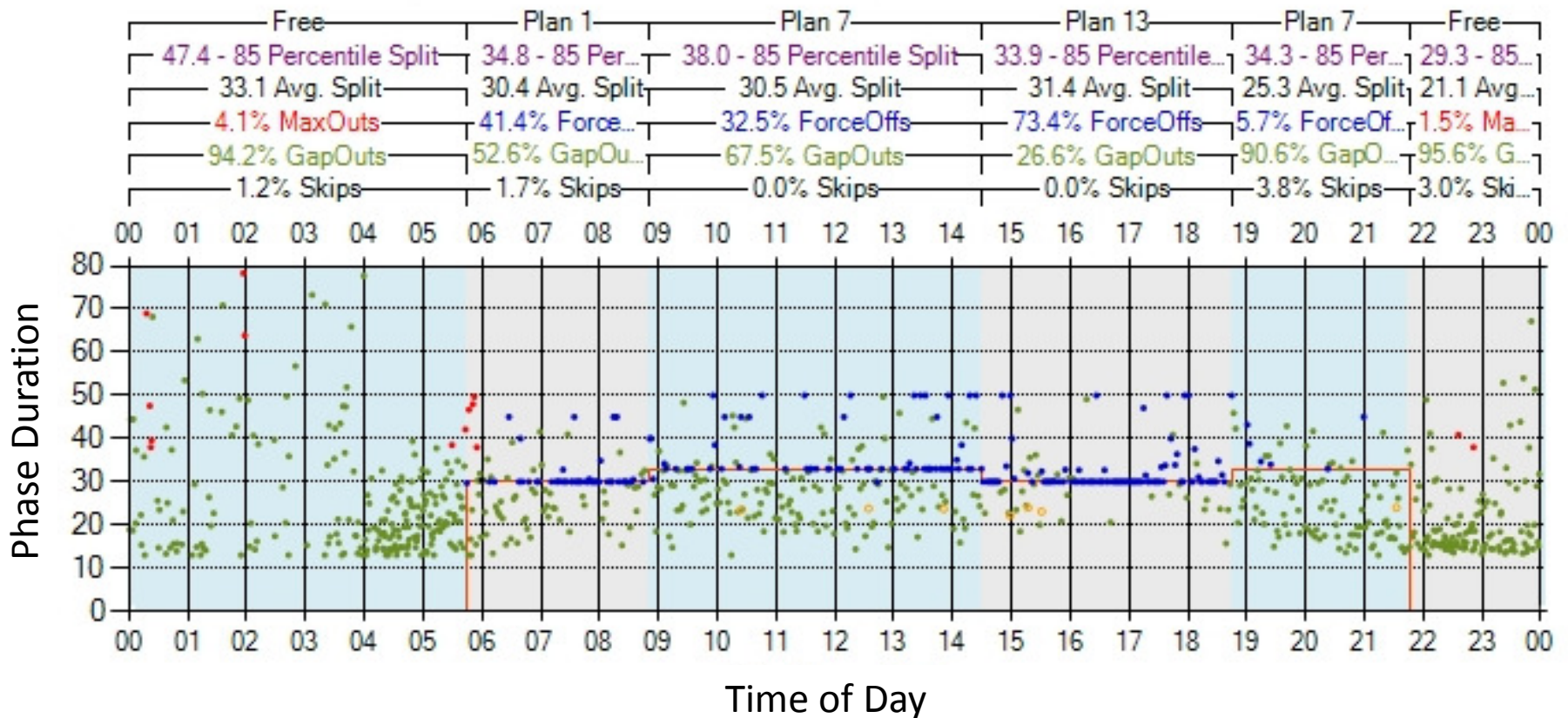
▶ AFTER: New detection technology installed



Metric: Split Monitor

Phase 6

US-89 2700 North SIG#5372 Phase 6
 Wednesday, March 09, 2016 12:00 AM - Thursday, March 10, 2016 12:00 AM



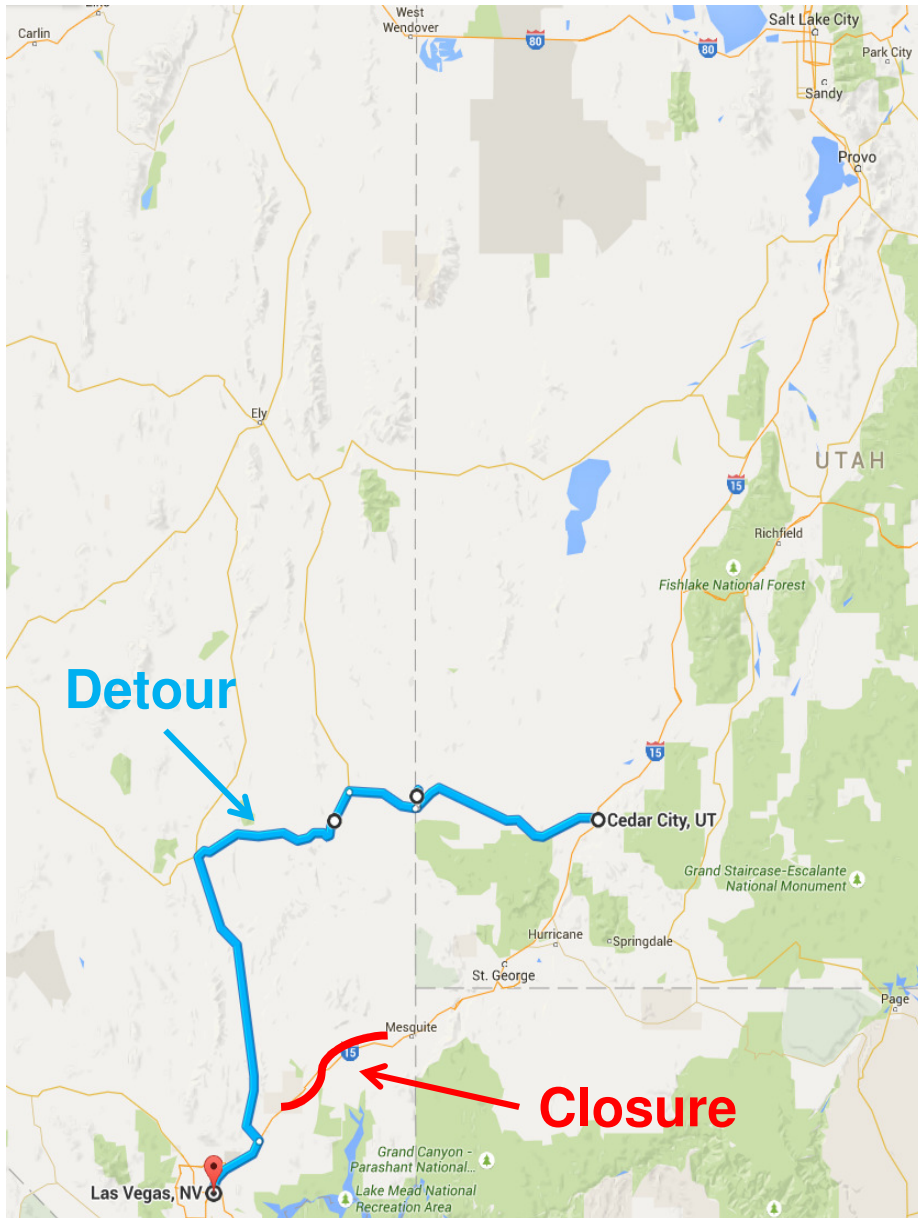
Freeway Closure Example using SPMs - Nevada



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

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

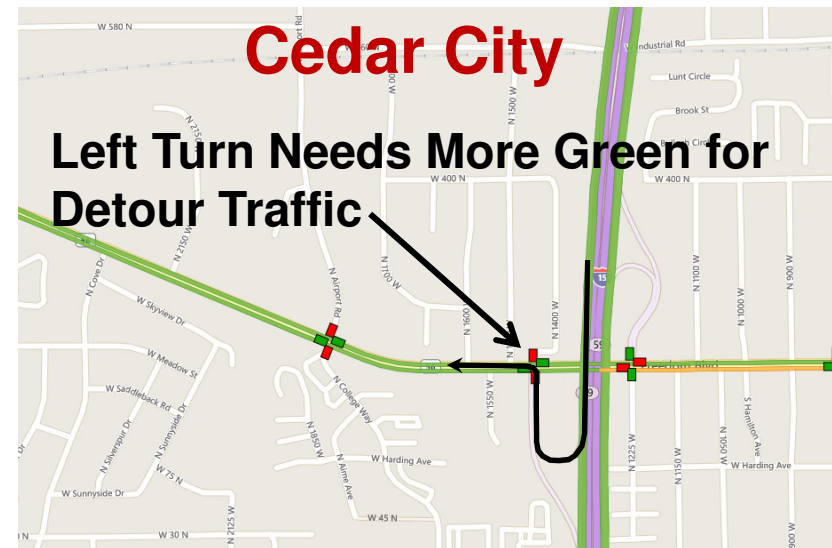
Freeway Closure Example using SPMs - Nevada



Closure: September 9-12, 2014

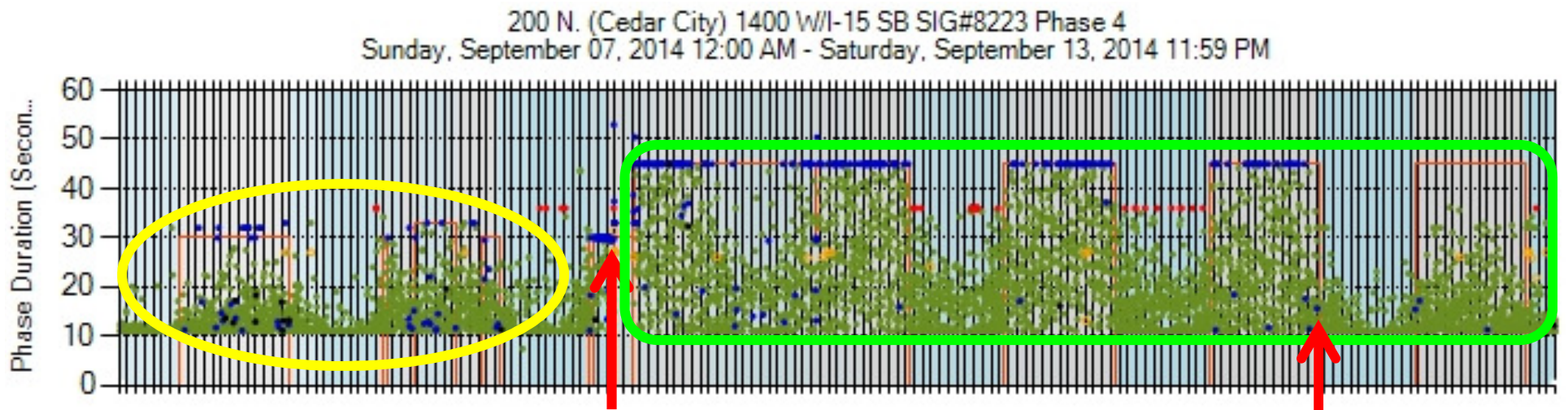
I-15 Closed Southbound in Nevada

- 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



Normal Traffic on Sunday and Monday

Increased traffic began on Friday morning on Friday after a split due to freeway washout in Nevada as shown by more frequent gap-out and lower split being used and higher split being used

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

Pedestrian Delay

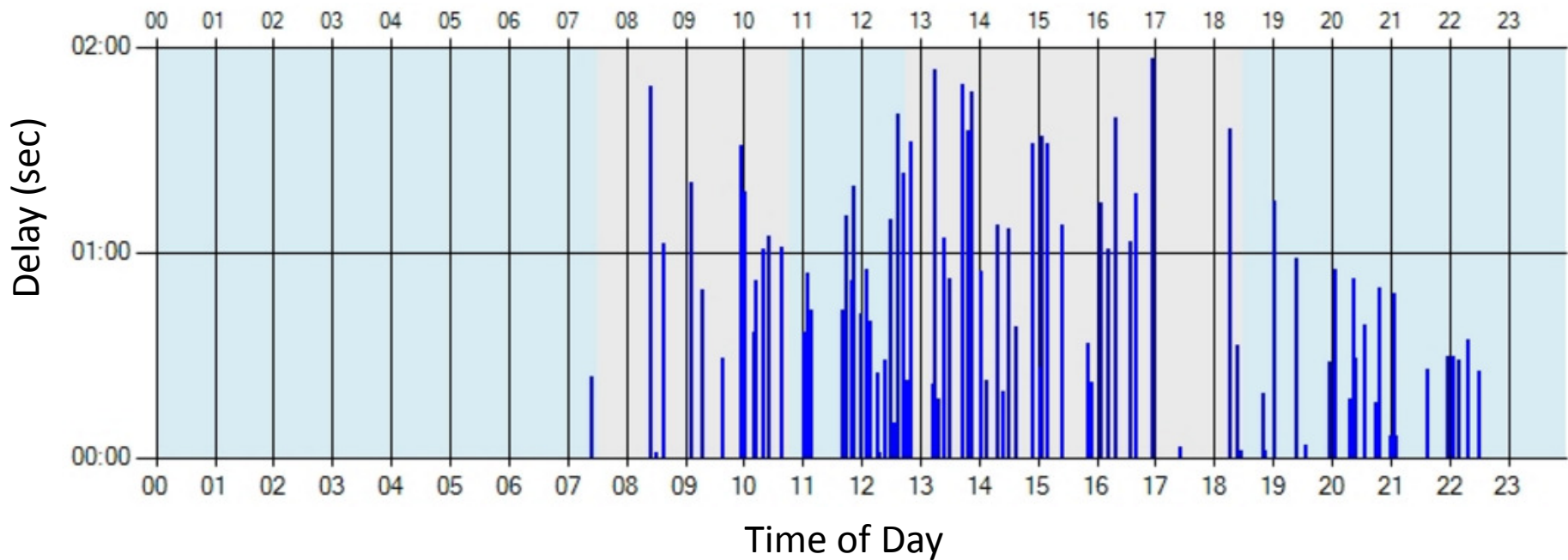
(Time from pedestrian call received to start of the walk indication)

Phase 4 – Side Street – Friday September 16th 2016

89 Ped Actuations

48 s = Average Delay

89-Ped Actuations(PA) 00:00-Min Delay 01:56-Max Delay 00:48-Average Delay(AD)



Detection

Setback Count Zones

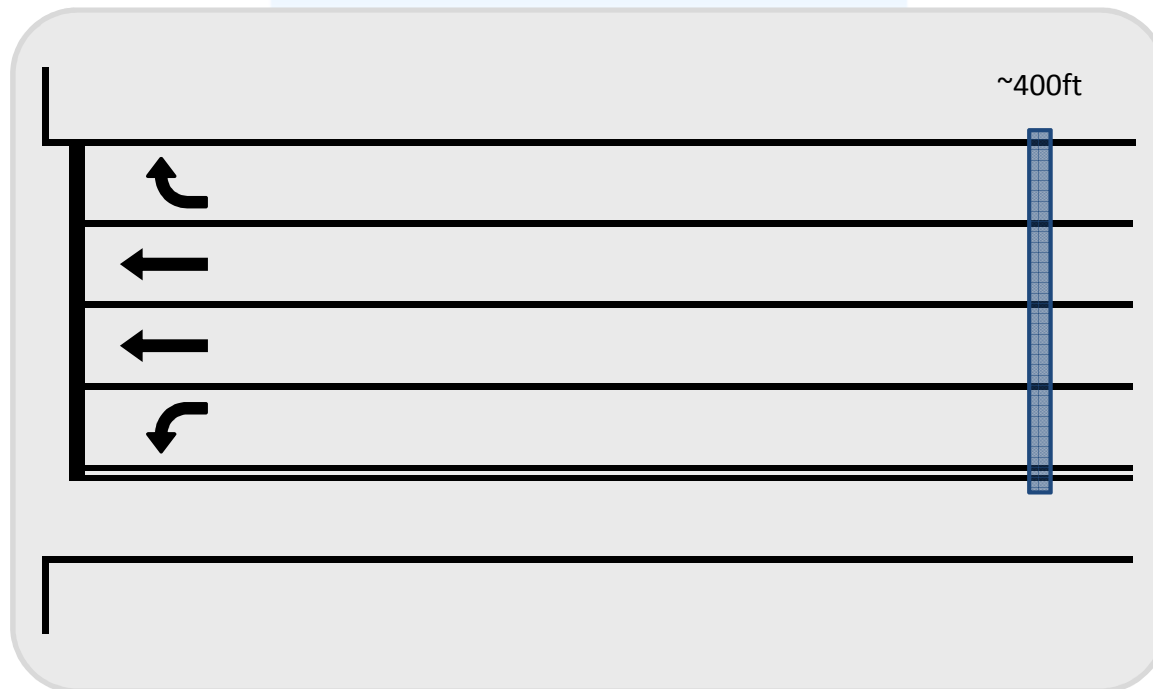
Available Metrics

➤ Purdue Coordination Diagram

➤ Approach Volume

➤ Arrivals on Red

➤ Approach Delay

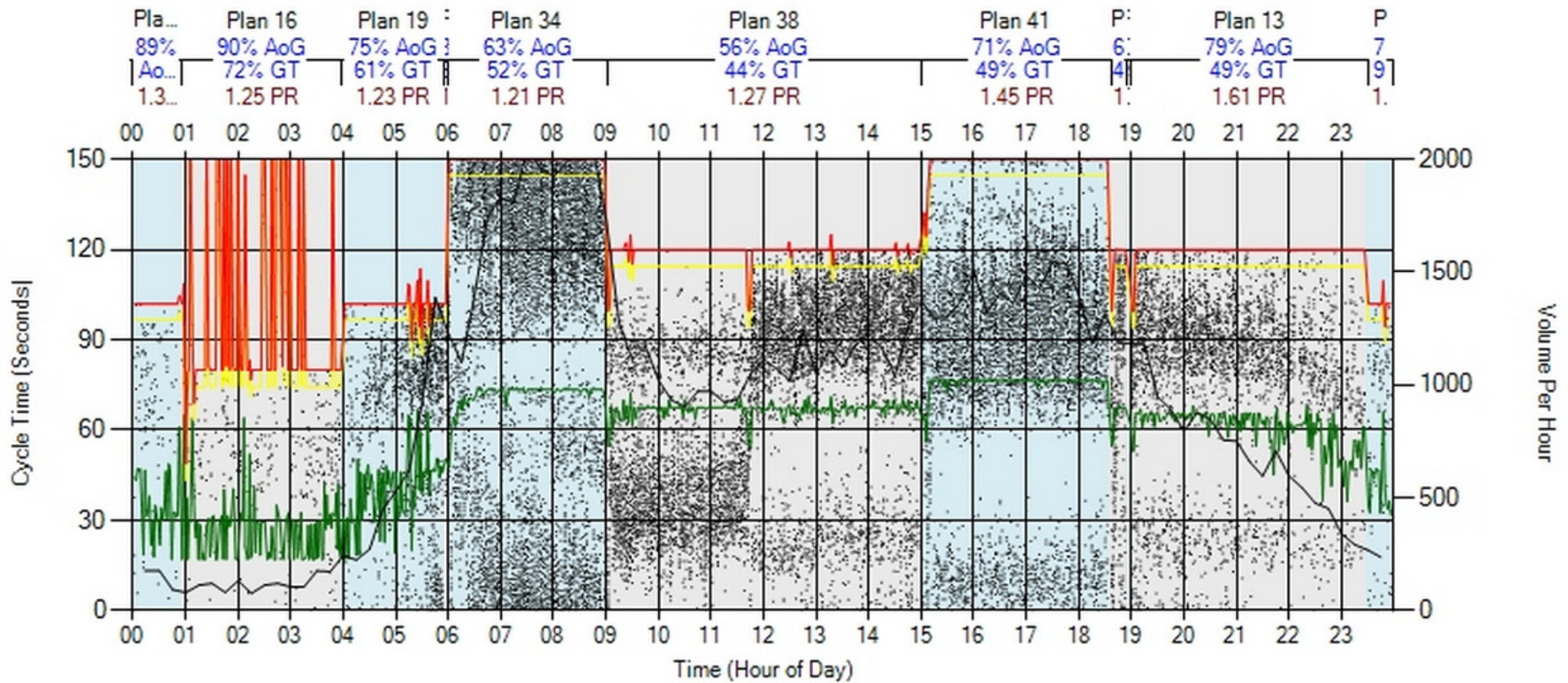


665 traffic signals

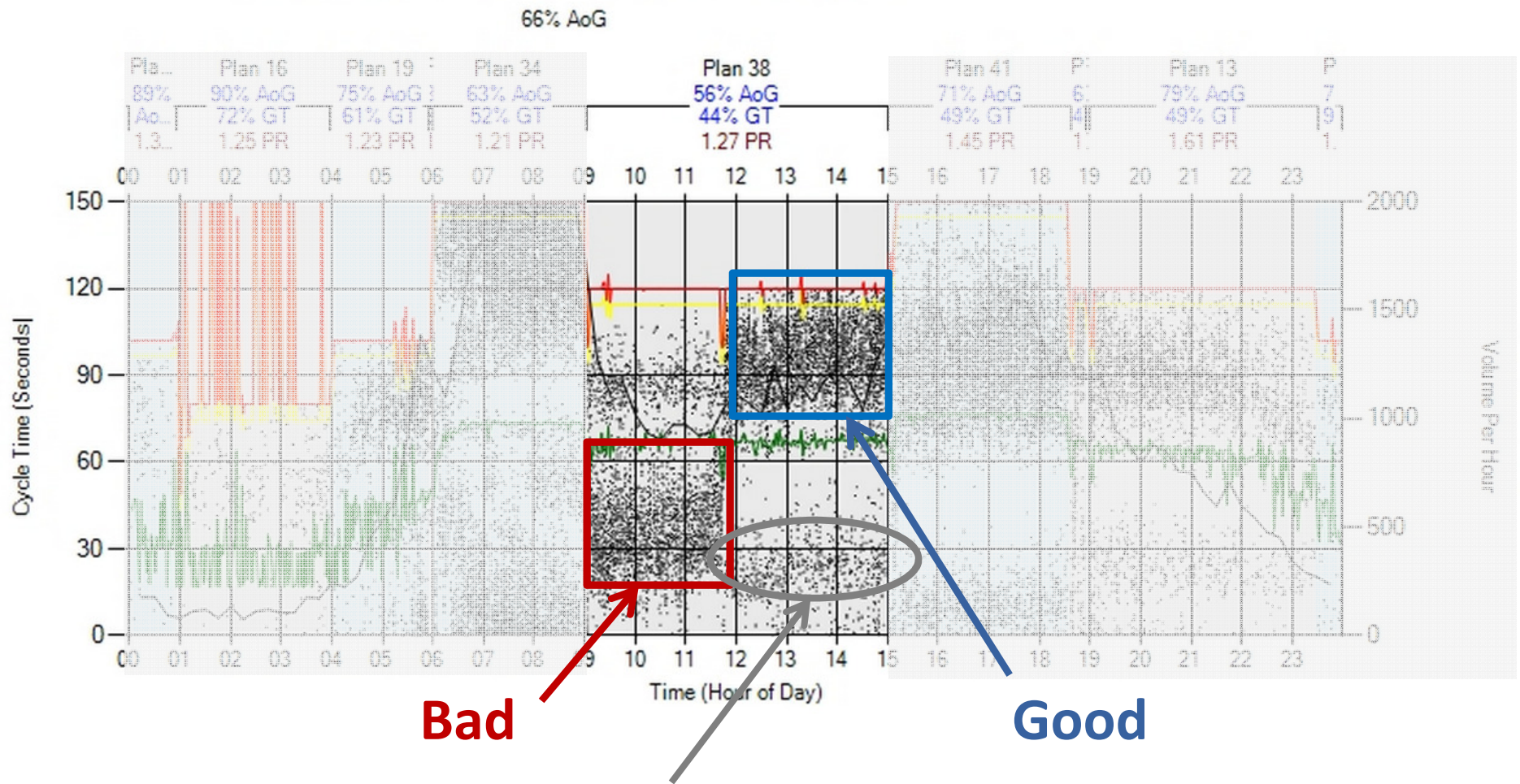
Purdue Coordination Diagram

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

66% AoG

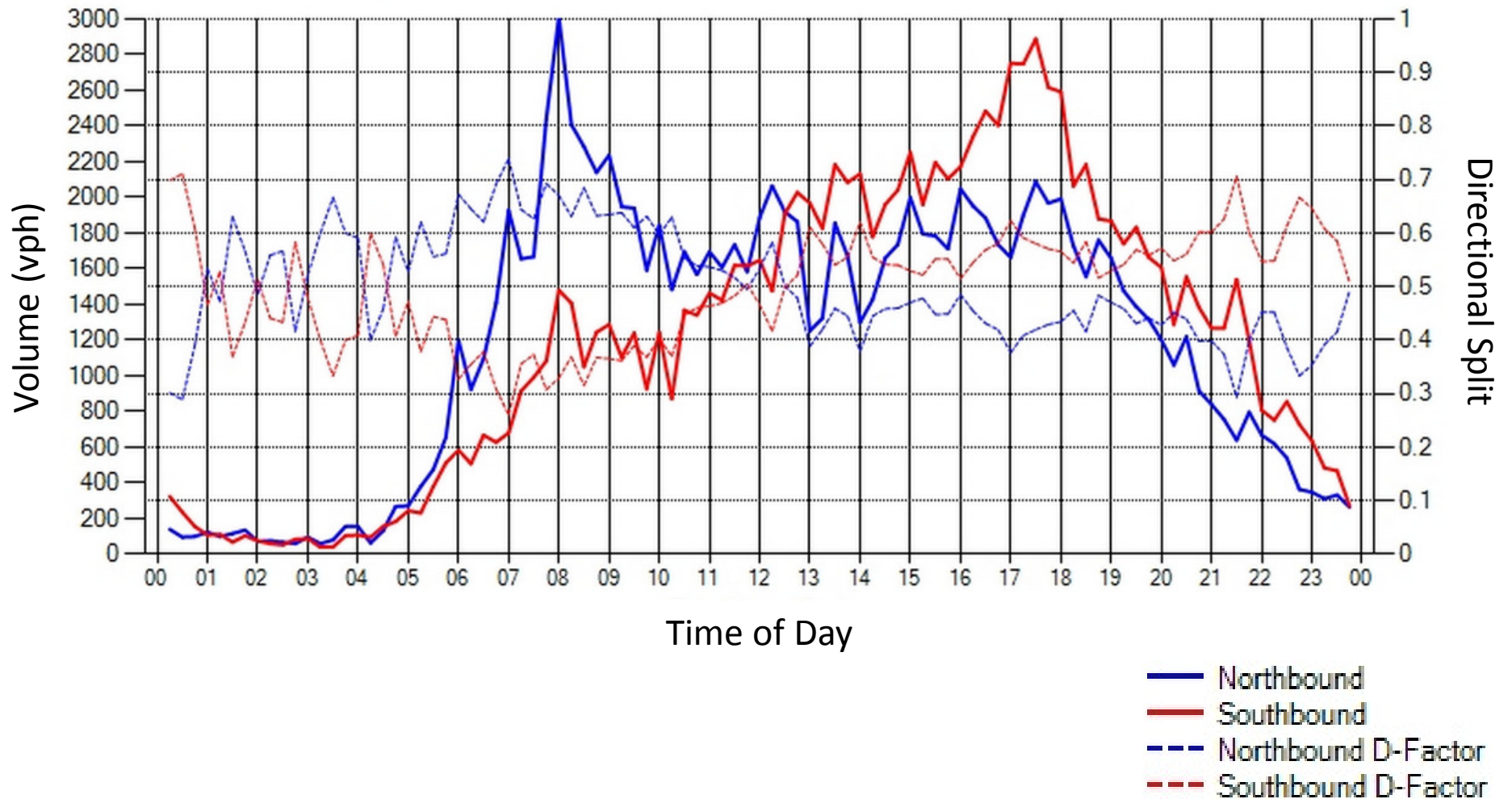


Purdue Coordination Diagram



Left turns from upstream signal

Metric: Approach Volume



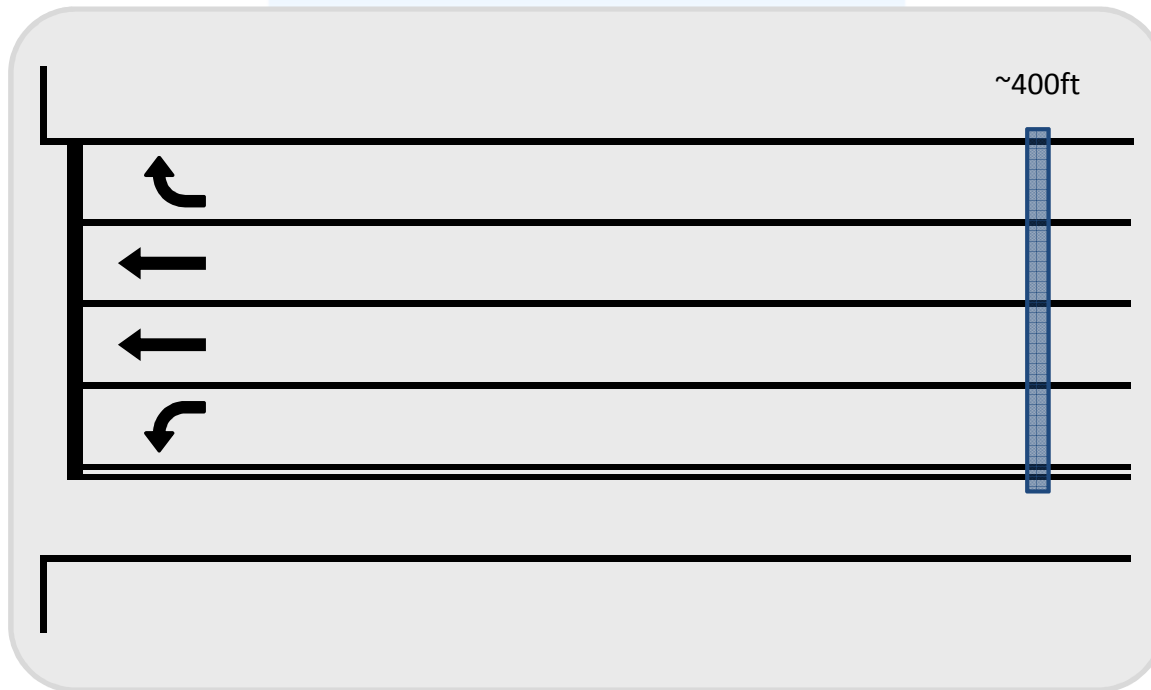
Detection

Setback Count Zones
with speed

Available Metrics

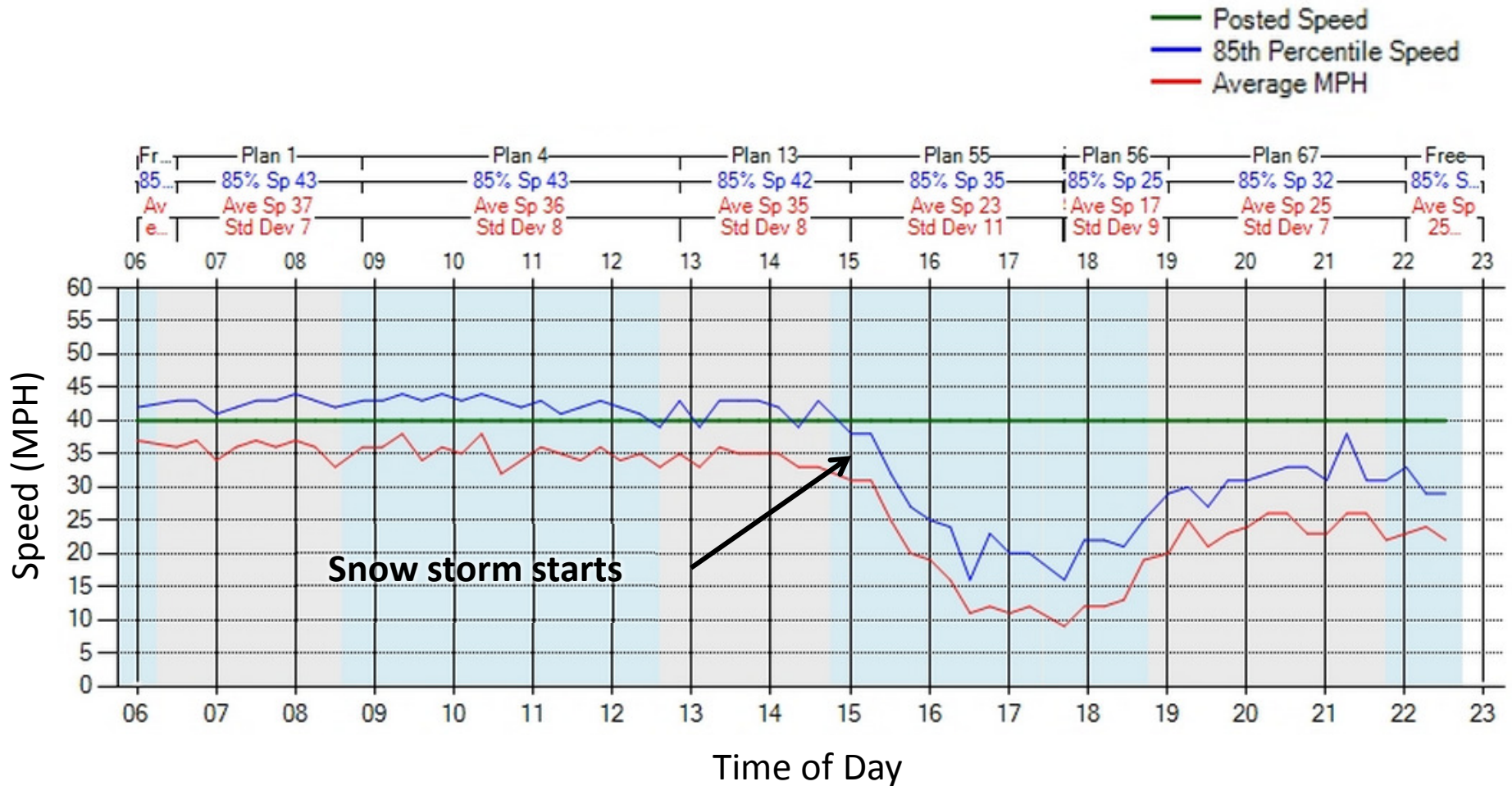


Approach Speed



660 traffic signals

Metric: Approach Speed



Detection

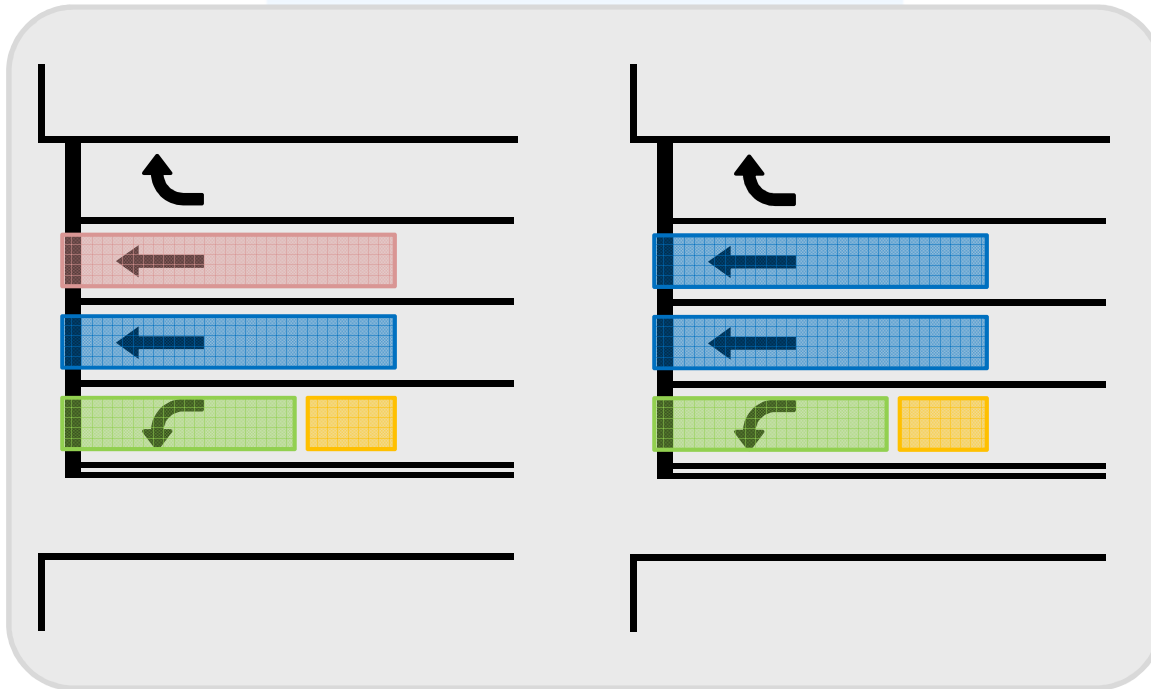
Lane-by-lane Presence

Lane Group Presence

Available Metrics



Purdue Split Failure



253 traffic signals

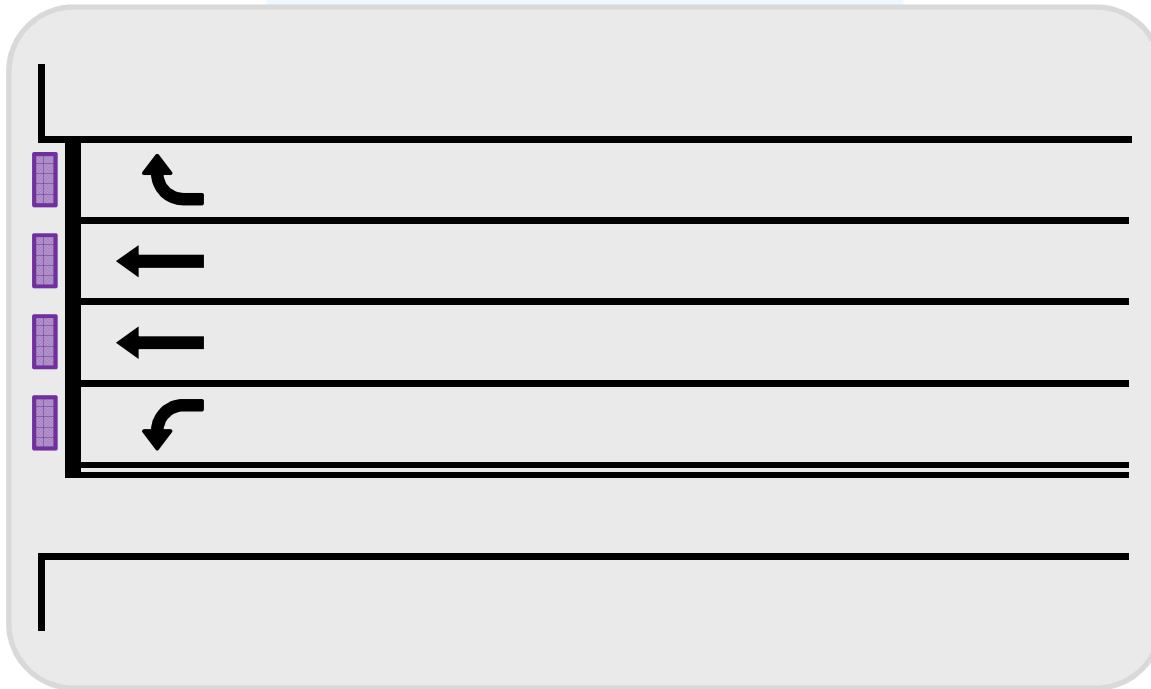
Detection

Lane-by-lane Count

Available Metrics

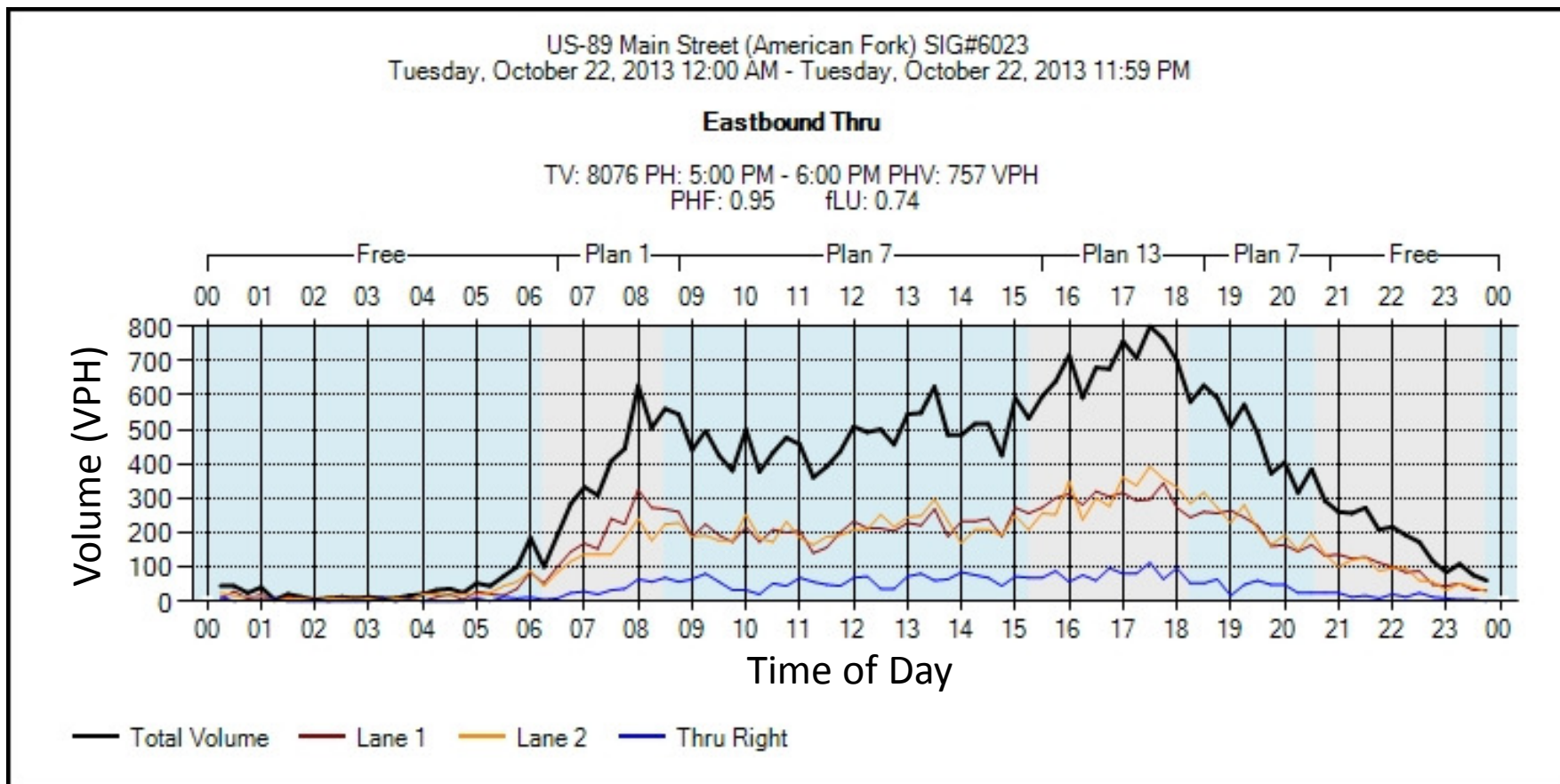


Turning Movement Counts



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,

--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) & Gaurdsman Way - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Gaurdsman 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 - Bangarter Hwy (SR-154) & 4100 South - Phase: 1 (Has Unusually Low Counts.)
7061 - Bangarter Hwy (SR-154) & 4100 South - Phase: 7 (Has Unusually Low Counts.)
7361 - Bangarter 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)

1 No SPM Data

2 Too many max outs

3 Too many force offs

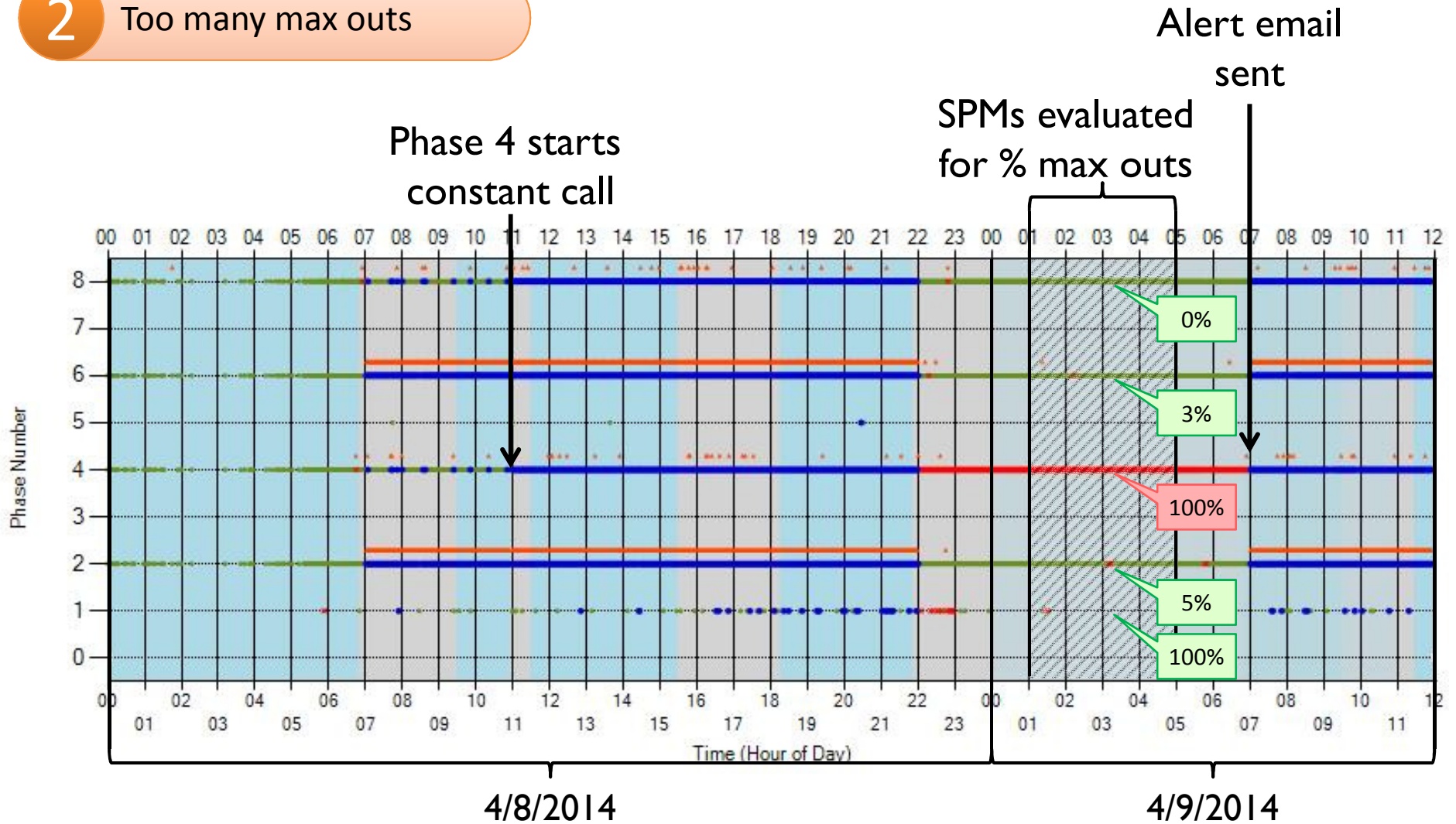
4 Too many ped calls

5 Low PCD detector count

6 High PCD detector count

1694 traffic signals

2 Too many max outs



- Gap out
- Pedestrian activation (shown above phase line)
- Max out
- Skip
- Force off

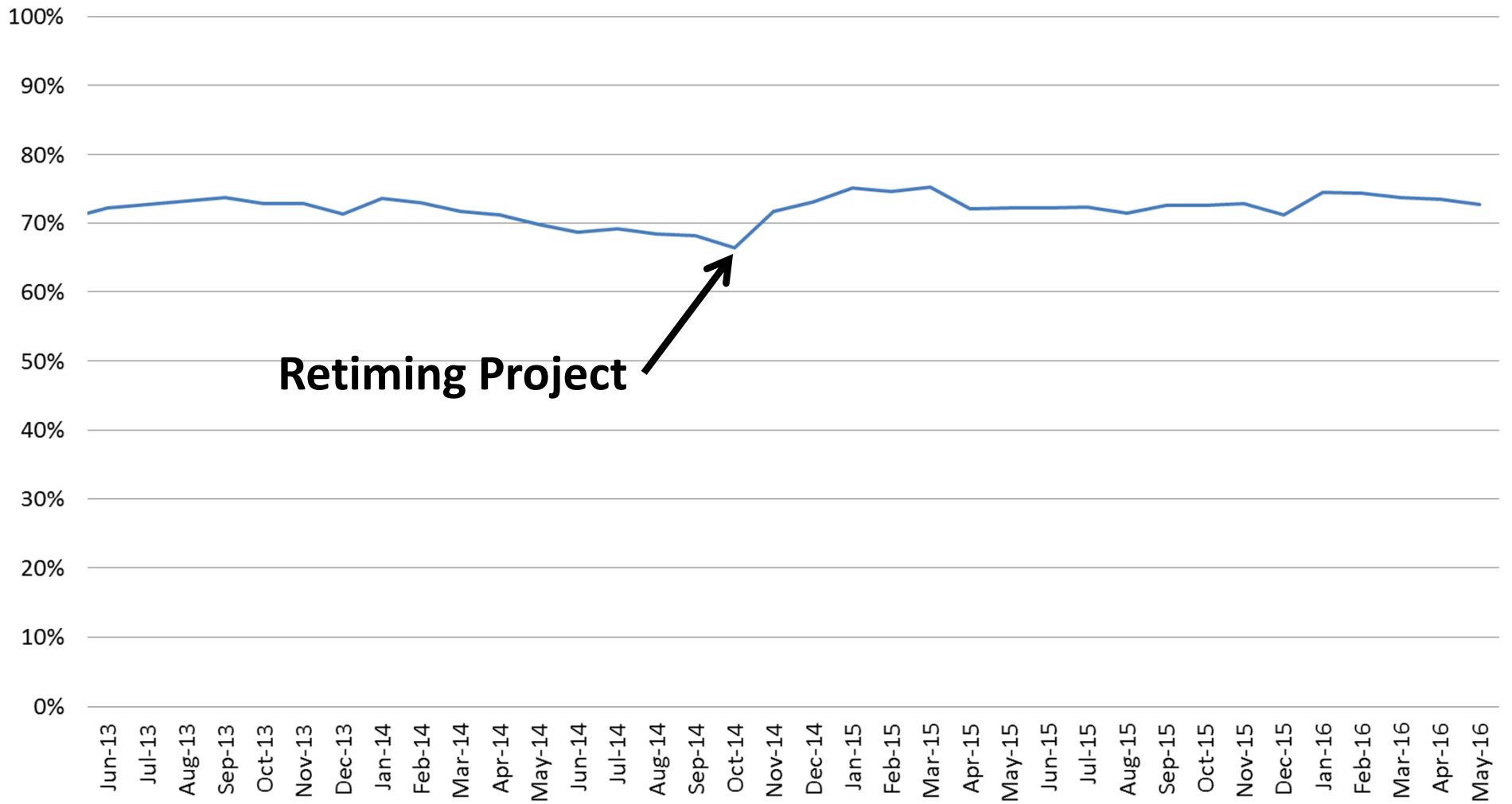
Metric: Purdue Phase Termination
Detection Requirements: None

Monitoring Trends

(Riverdale Rd - 11 intersections)

Percent of Vehicles Arriving on Green - Riverdale Rd

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

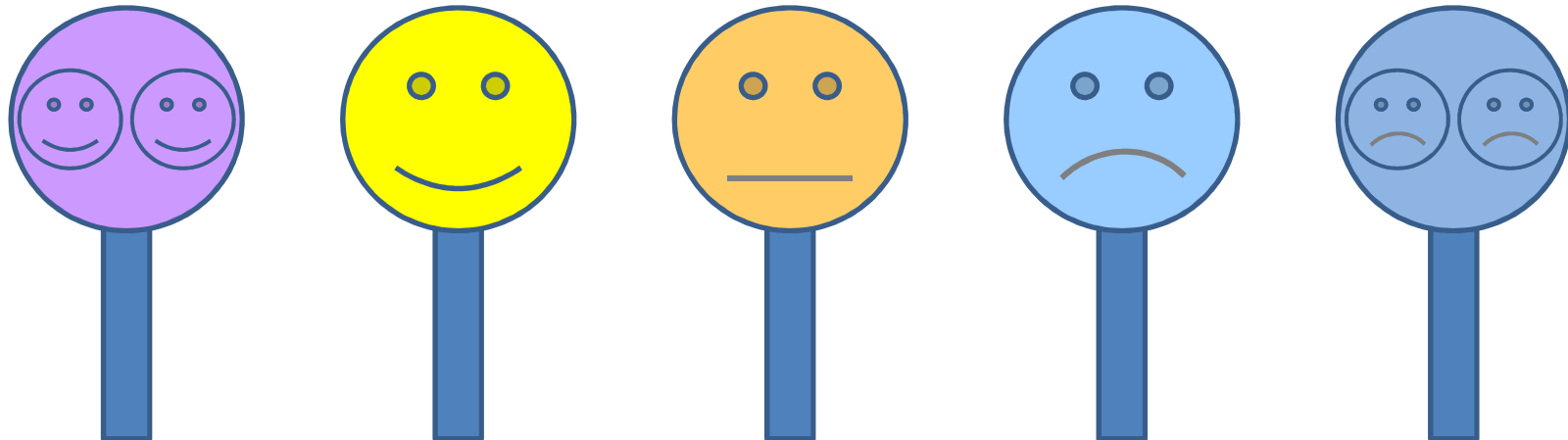


UDOT Signal Timing Focus Group (July 2014)

- *How do you feel about UDOT?*



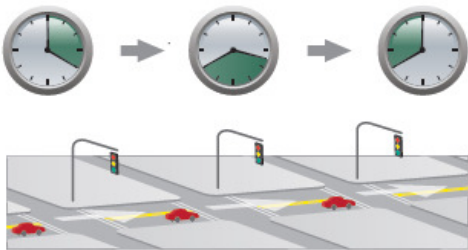
- *How do traffic signals make you feel?*



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>

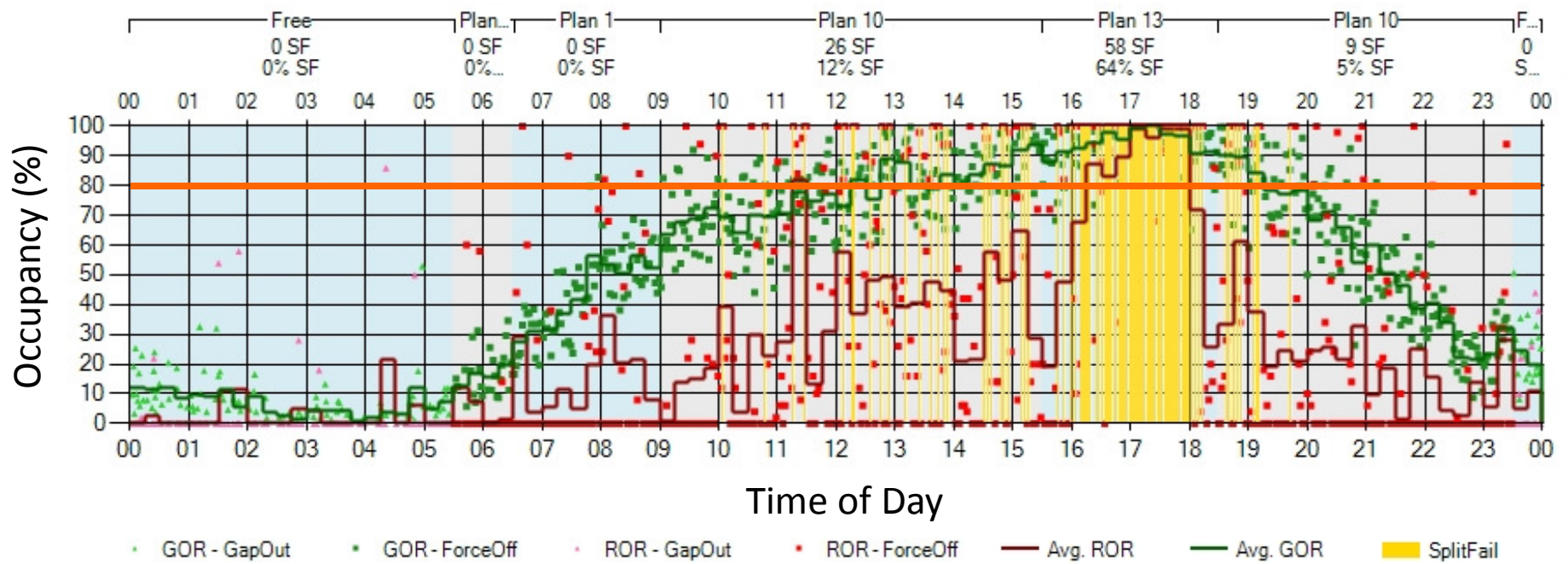
udottraffic.utah.gov/signalperformancemetrics

Mark Taylor
marktaylor@utah.gov



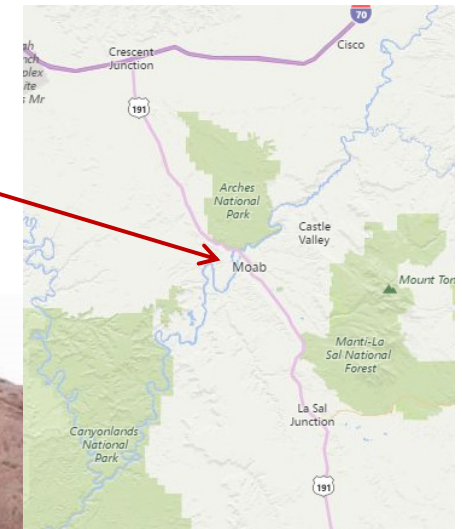
Metric: Purdue Split Failure

700 East 900 South Signal 7184 Phase: 6 Southbound
Wednesday, April 27, 2016 12:00 AM - Wednesday, April 27, 2016 11:59 PM
Total split fails for the selected period = 93



Case Study: Moab, Utah

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

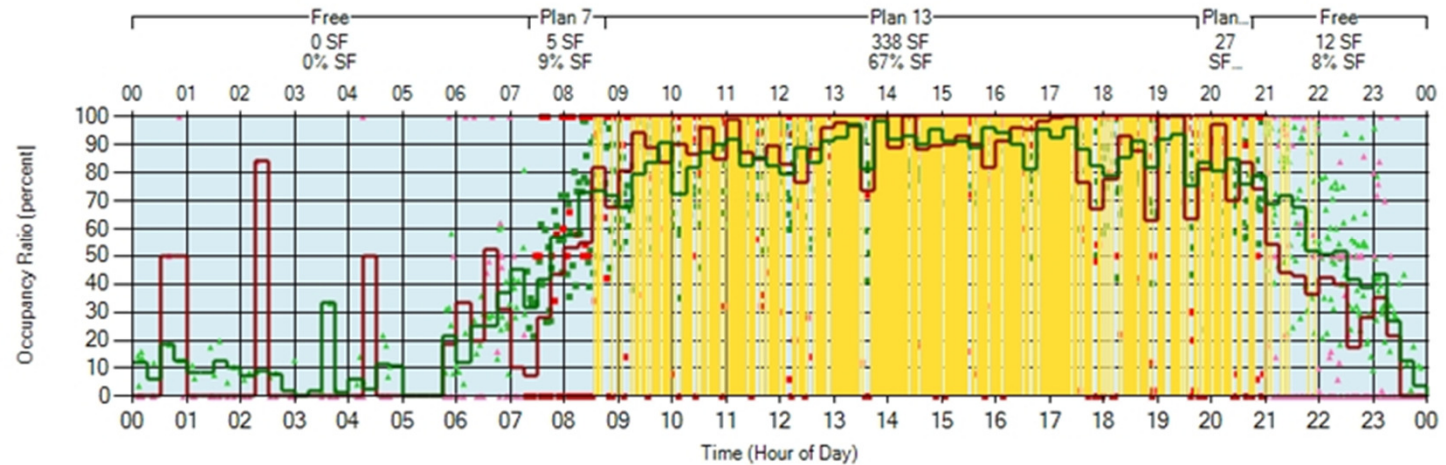


Purdue Split Failure – Center St & Main St – Moab, Utah

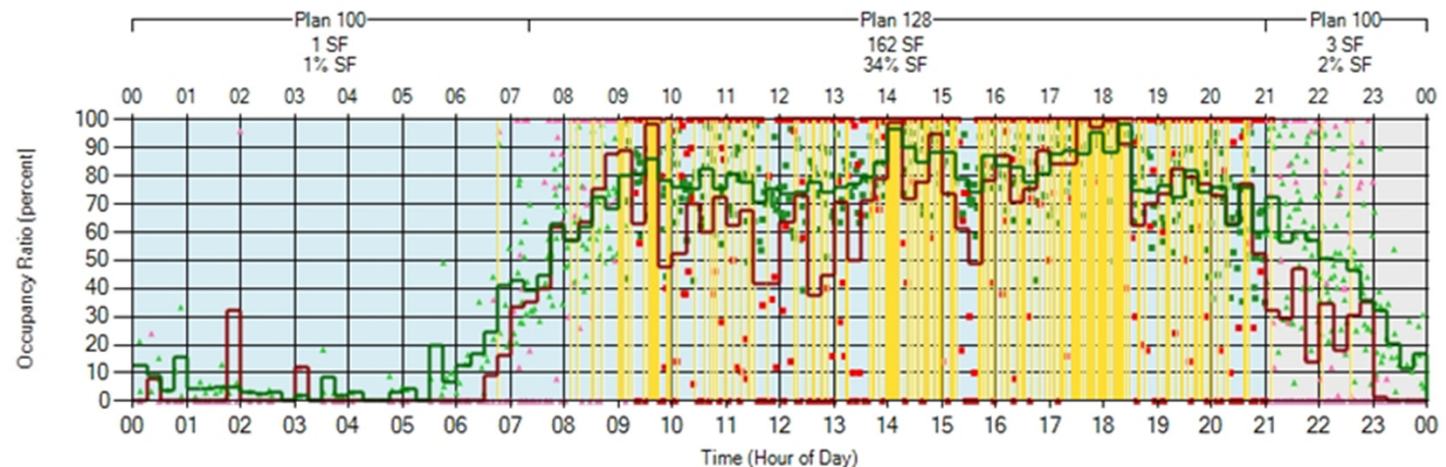
Memorial Day Weekend – Saturday

NORTHBOUND

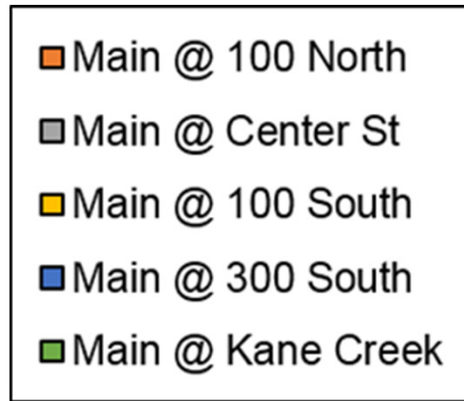
2015



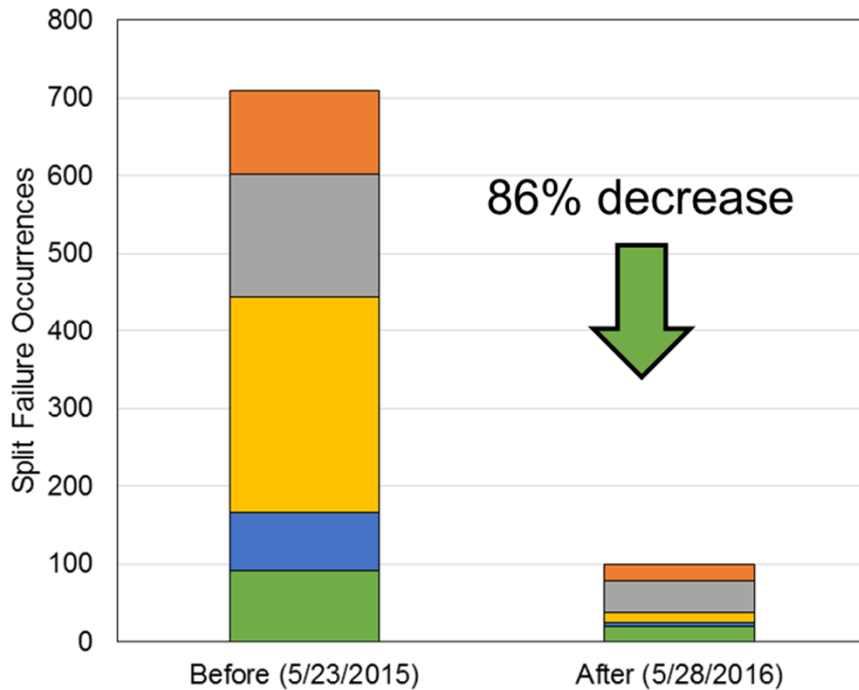
2016



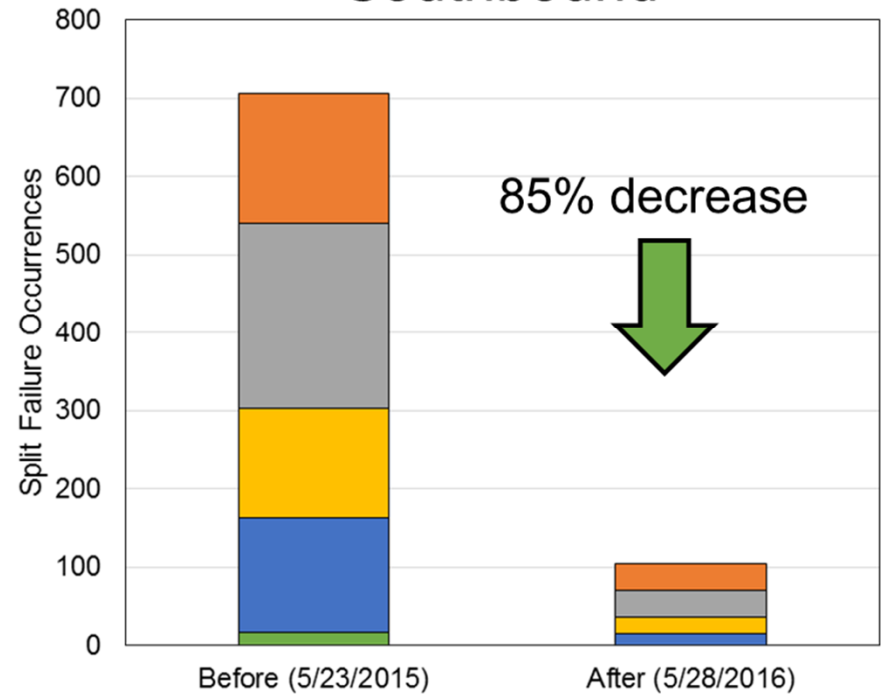
Moab – Split Failure Results



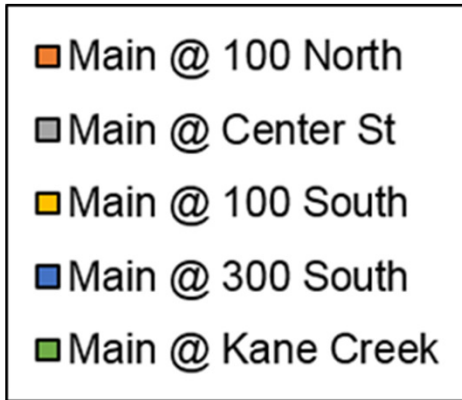
Northbound



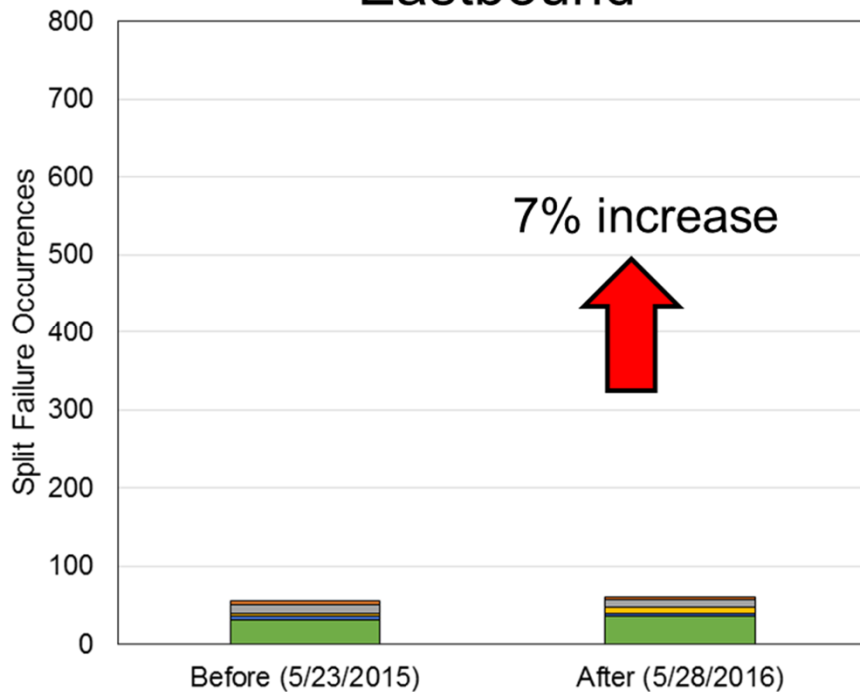
Southbound



Moab – Split Failure Results



Eastbound



Westbound

