

UTAH'S EXPERIENCE WITH AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

Mark Taylor, P.E., PTOE
Utah Department of Transportation
Traffic Signal Operations Engineer
marktaylor@utah.gov

UDOT Asset Management Tiers (2015 & Prior)

- Asset Management Tiers range from 1 to 3, Tier 1:
 - Highest value combined with highest risk of negative financial impact for poor management.
 - Very important to UDOT.
 - Receive separate funding source.
 - Targets and measures are set and tracked.

Tier 1 Assets
Pavement
Bridges

Tier 2 Assets
ATMS / Signal Devices
Pipe Culverts
Signs
Barriers & Walls
Rumble Strips
Pavement Markings

Tier 3 Assets
Cattle Guards
Interstate Lighting
Fences
Curb & Gutter
Rest Areas

UDOT Asset Management Tiers (2016 & Future)

- Asset Management Tiers range from 1 to 3: Tier 1:
 - Highest value combined with highest risk of negative financial impact for poor management.
 - Very important to UDOT.
 - Receive separate funding source.
 - Targets and measures are set and tracked.

Tier 1 Assets

Pavement

Bridges

ATMS / Signal Devices



Tier 2 Assets

Pipe Culverts

Signs

Barriers & Walls

Rumble Strips

Pavement Markings

Tier 3 Assets

Cattle Guards

Interstate Lighting

Fences

Curb & Gutter

Rest Areas

ATSPM

Automated Traffic Signal Performance Measures

Started Development November 2012.

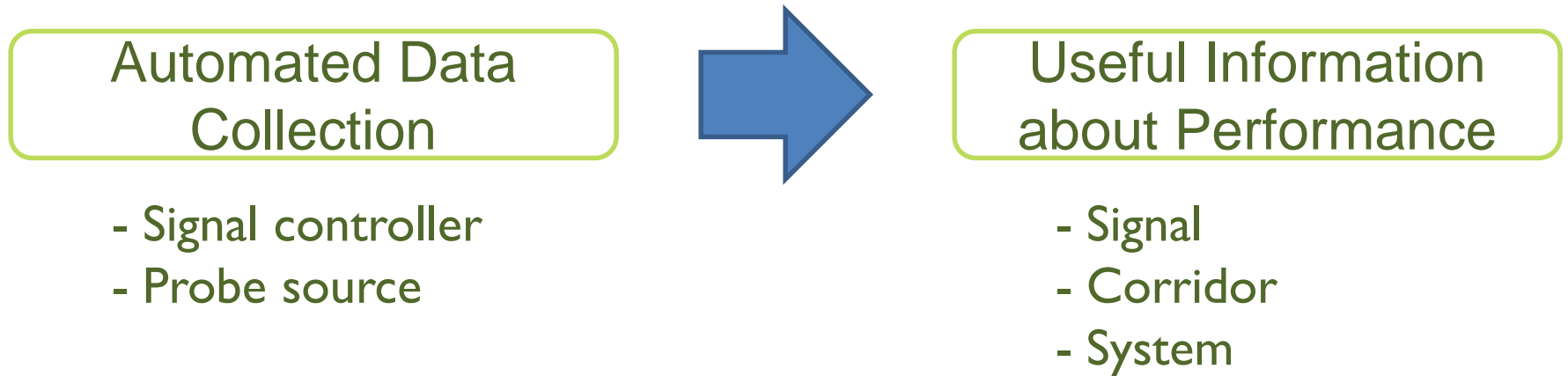
- State of Utah Department of Technology Services

**Estimate 8,000+ hours of UDOT development
(November 2012 to February 2018)**

History of ATSPMs

- ✓ 2005: Purdue & InDOT initiated research to develop new performance measures.
- ✓ 2012: Purdue publishes “Indiana Traffic Signal Hi Resolution Data Logger Enumerations”.
- ✓ 2012: UDOT (with Purdue & InDOT assistance) started development on ATSPMs.
- ✓ 2013: “Pooled Fund” on “Traffic Signal Systems Operations & Management” – InDOT & Purdue.
- ✓ 2014: AASHTO Innovation Initiative (AASHTO Aii) accelerated ATSPMs.
- ✓ 2016: UDOT released UDOT ATSPMs as open source and free to everyone (public & private).
- ✓ 2017: FHWA EDC-4 accelerated ATSPMs.
- ✓ April/May 2018: ATSPM Version 4.2.0 will be available.

Automated Traffic Signal Performance Measures (ATSPM) Basic Concept



Why Model what you can Measure?

UDOT ATSPM Source Code

<https://www.itsforge.net>

U.S. Department of Transportation
Federal Highway Administration

OSADP

HOME INFORMATION COMMUNITY CONTACT LOGIN

Search ...

Explore Applications

APPLICATION CATEGORIES

All Active Releases	48
Arterial Management	21
Collision Avoidance	5
Collision Notification	5
Commercial Vehicle Operations	9
Crash Prevention & Safety	10
Driver Assistance	19
Electronic Payment & Pricing	0
Emergency Management	6
Freeway Management	20
Information Management	23
Intermodal Freight	7
Road Weather Management	5
Roadway Operations & Maintenance	7
Traffic Incident Management	6

Sort by Name

Show 5 Items

<< First < Previous Next > Last >>

Filter Applications

AMS_TCA_Aimsun_v1 STABLE

Trajectory Conversion Algorithm-Aimsun (TCA-A)

Version: **AMS_TCA_Aimsun_v1**
Modified: **May 24, 2017**
Downloads: 7

Keywords: **Connected Vehicles** **traffic simulation** **communication**

ATSPM
Automated Traffic Signal Performance Measures

Automated Traffic Signal Performance Measures (ATSPM) 4.0.1 STABLE

Automated Traffic Signal Performance Measures 4.0.1

Version: **ATSPM-4.0.1**
Modified: **Apr 20, 2017**
Downloads: 64

Keywords: **signals** **ATSPM** **Performance Measures** **Signal Metrics**

Signal Measures

CV-DSRC-Msg-Parser 1.1 STABLE

Connect Vehicles - Dedicated Short-Range Communications

Version: **CV-DSRC-MsgParser 1.1**
Modified: **Mar 31, 2016**
Downloads: 107

Keywords: **bsm** **dsrc** **parsing** **analysis** **data**

Open Source ATSPM Implementation Cost Estimate

	Small System (~50 signals)	Large System (~1000 signals)
Controllers w/ High-definition Loggers	Unknown	Unknown
Communication or In-cabinet Data Storage	Unknown	Unknown
ATSPM Open Source Software	\$0	\$0
Server	\$3,000	\$20,000
SQL Database License	\$7,000	\$100,000
IT Consultant (software installation)	\$5,000	\$10,000
Engineering Consultant (detector configuration)	\$5,000	\$100,000
Total	\$20,000	\$230,000
<i>Cost per signal</i>	<i>\$400</i>	<i>\$230</i>

22+ Installations of ATSPMs



High-resolution Data Example ↙ 0.1-second resolution

	Timestamp	Event Code	Event Parameter
	6/27/2013 1:29:51.1	10	8
Detector 5 ON	6/27/2013 1:29:51.1	82	5
	6/27/2013 1:29:52.2	1	2
	6/27/2013 1:29:52.2	1	6
	6/27/2013 1:29:52.3	82	2
	6/27/2013 1:29:52.8	82	4
	6/27/2013 1:29:52.9	81	4
	6/27/2013 1:29:54.5	81	2
	6/27/2013 1:30:02.2	8	2
	6/27/2013 1:30:02.2	8	6
	6/27/2013 1:30:06.1	10	2
Phase 8 GREEN	6/27/2013 1:30:06.1	10	6
	6/27/2013 1:30:08.1	1	8
Detector 5 OFF	6/27/2013 1:30:15.8	81	5
	6/27/2013 1:30:18.5	82	6
	6/27/2013 1:30:27.5	81	6
Phase 8 YELLOW	6/27/2013 1:30:30.4	8	8

Why is High-resolution Data Important?

Advanced Detector Count Comparison

High-definition Data
 (1/10-sec resolution)



Central System
 (1/3-sec resolution)

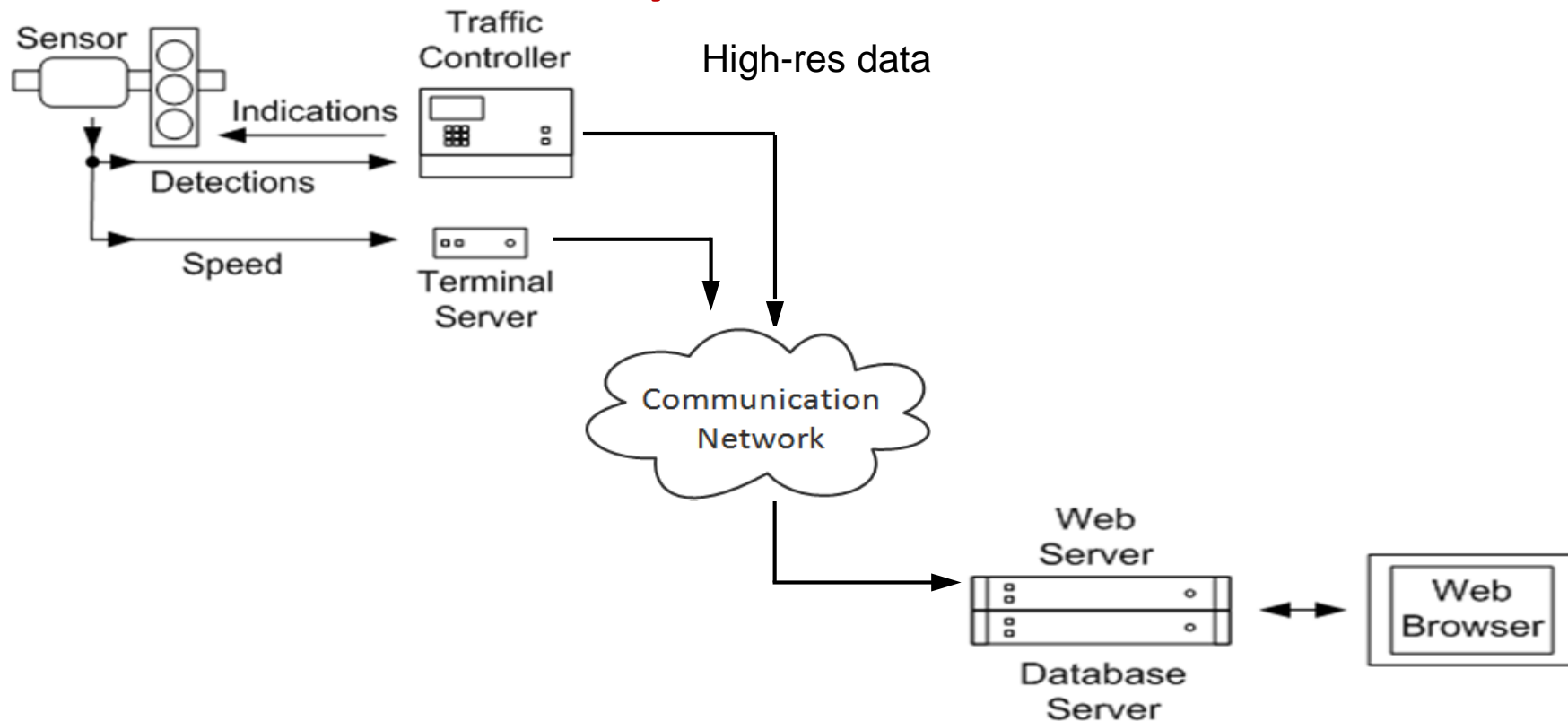


14:34:00

14:34:30

14:35:00

ATSPM System Architecture



UDOT's ATSPM Website

<https://udottraffic.utah.gov/ATSPM>



Measures Reports Log Action Taken Links FAQ About Register Log in

Signal

Signal Selection

Signal ID

7220 Foothill Drive @ 1300 South

Signal List

Signal Map

Region: --Select Region--

Metric Type: --Select a Metric--

Chart Selection

Metrics List

- 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

Phase Termination Options

Y-axis Max

Auto

Consecutive Count

1

Show Plans

Show Ped Activity

Date Selection

Start Date

04/19/2017 12:00 AM

End Date

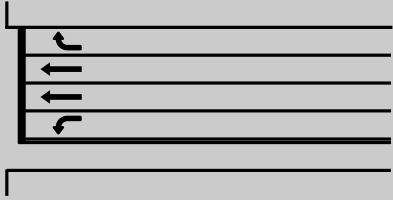
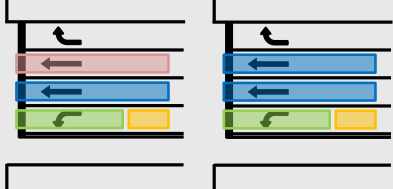

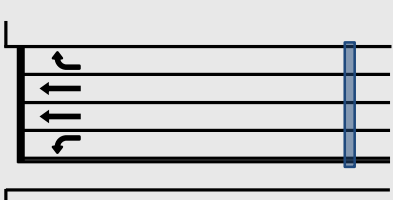
04/19/2017 11:59 PM

Reset Date

April 2017

Su	Mo	Tu	We	Th	Fr	Sa
						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						

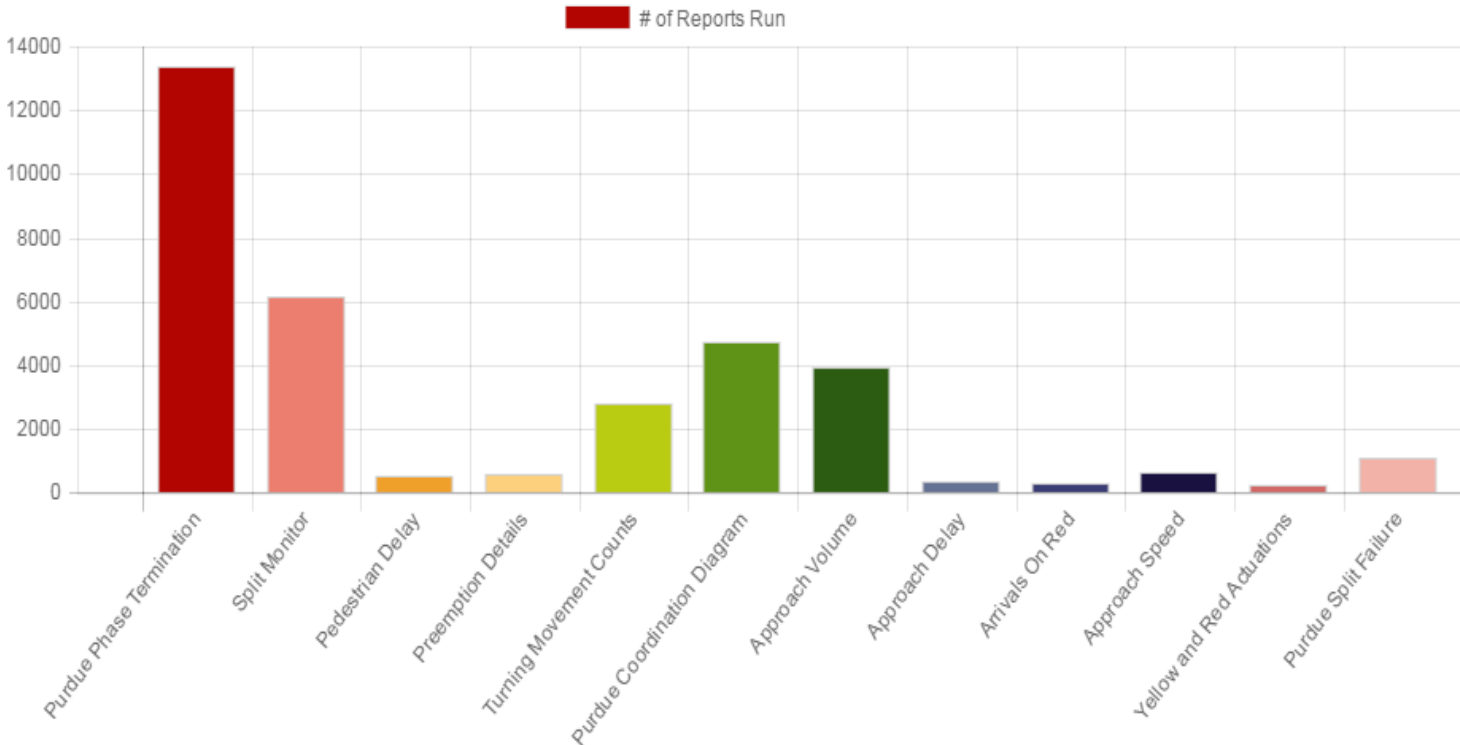
Create Chart

Detection	Metric
<p>None</p> 	<p>Phase Termination Chart Split Monitor Preemption Details Pedestrian Delay</p>
<p>Lane-by-lane or Lane Group Presence</p> 	<p>Purdue Split Failure</p>
<p>Lane-by-lane Stop Bar Count</p> 	<p>Turning Movement Counts</p>
<p>Advanced Count</p> 	<p>Purdue Coordination Diagram Purdue Link Pivot Offset Optimization Approach Volume Approach Speed (requires detection with speed service)</p>

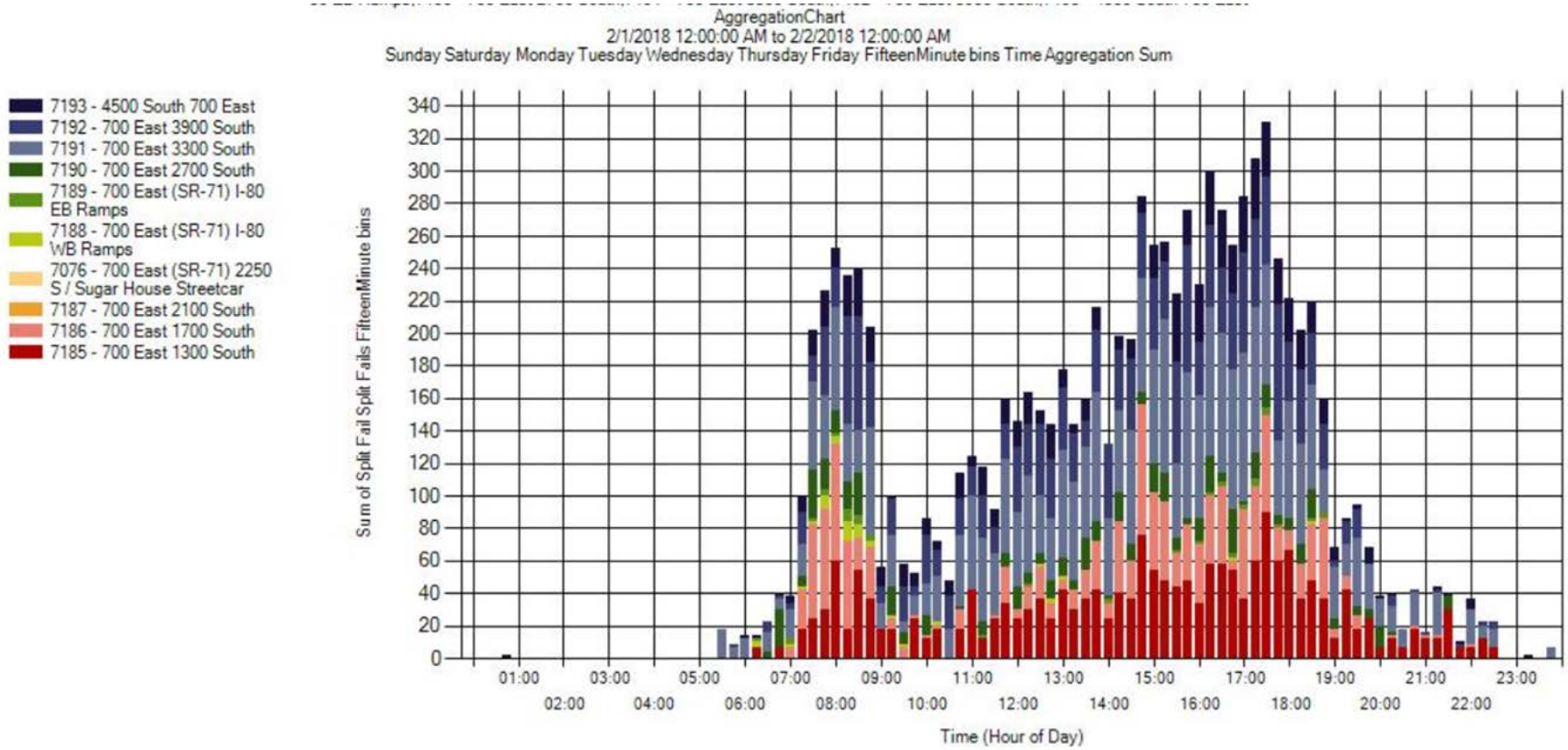
Metric Usage

Metrics Run
 1/1/2017 – 5/21/2017

Collected by automatic logger

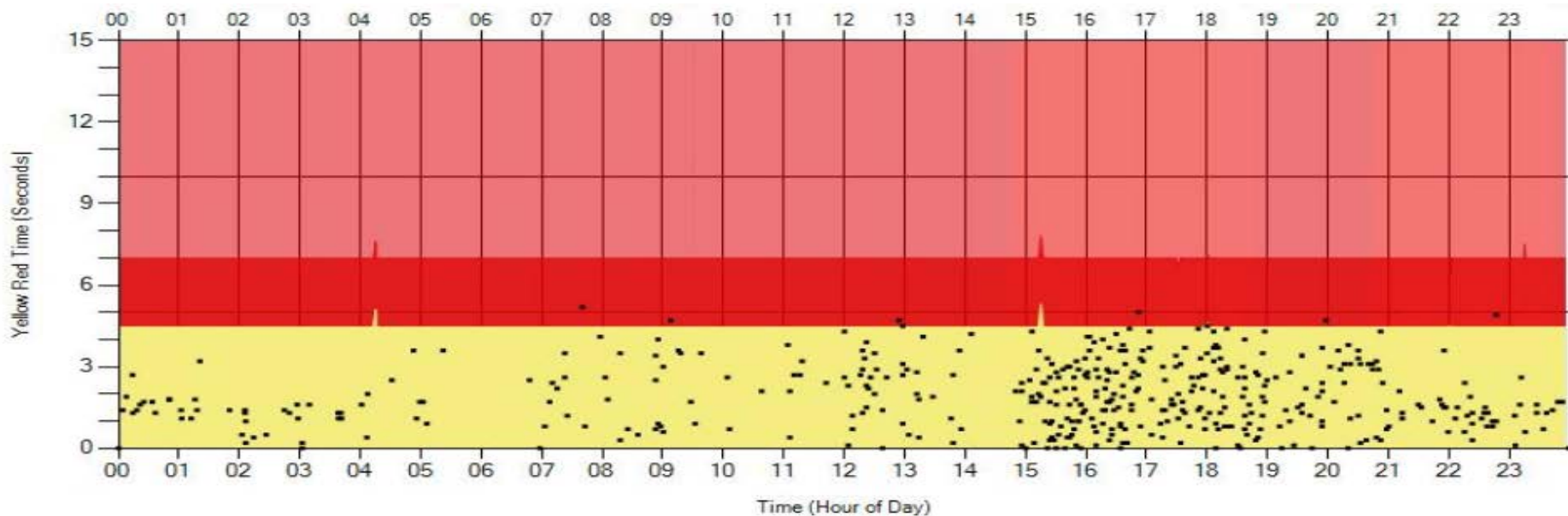


Corridor Metrics: Purdue Split Fail

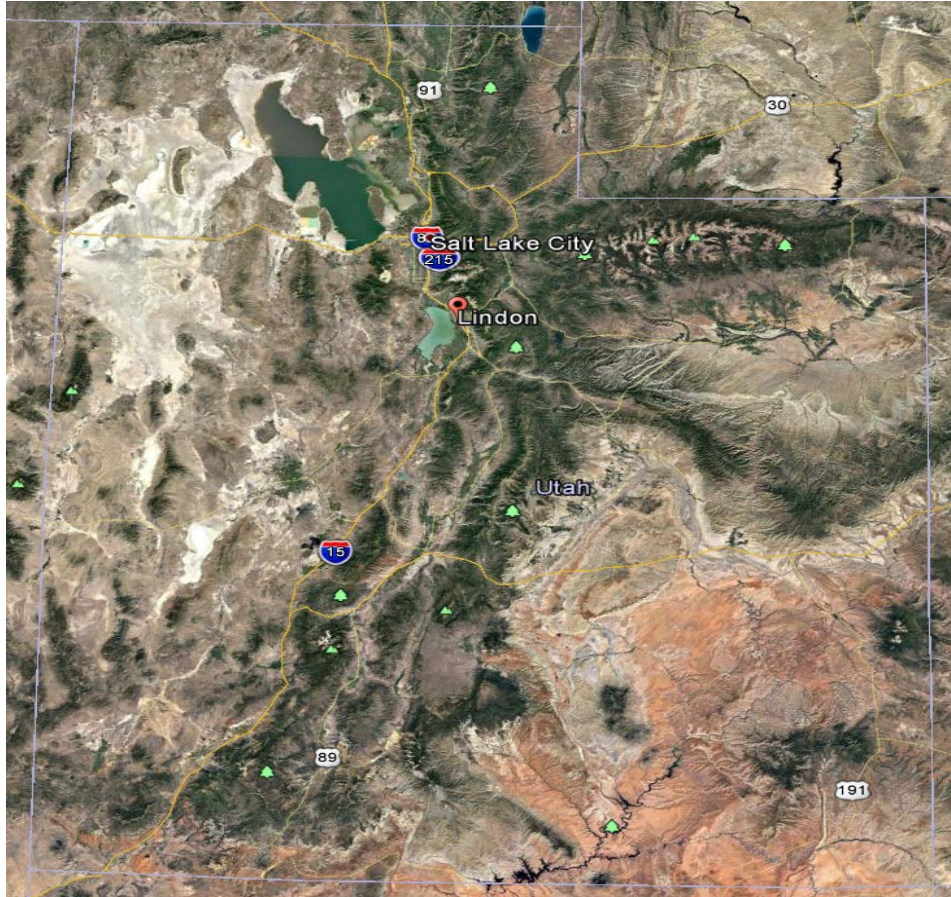


Yellow & Red Actuations (Southbound Through)

5600 West & 2700 South – October 17, 2017



Railroad Preemption Example – Lindon Utah





**City of Lindon,
Utah**

200 South

Geneva Rd

114

W 200 S St

S 1060 West

© 2016 Google

Google

**City of Lindon,
Utah**

200 South

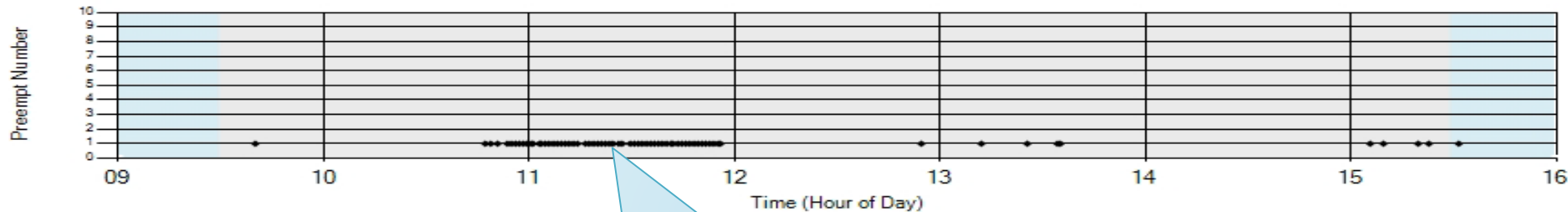
Geneva Rd





Preemption Calls

Wednesday May 25, 2016 between 9:00 AM and 4:00 PM

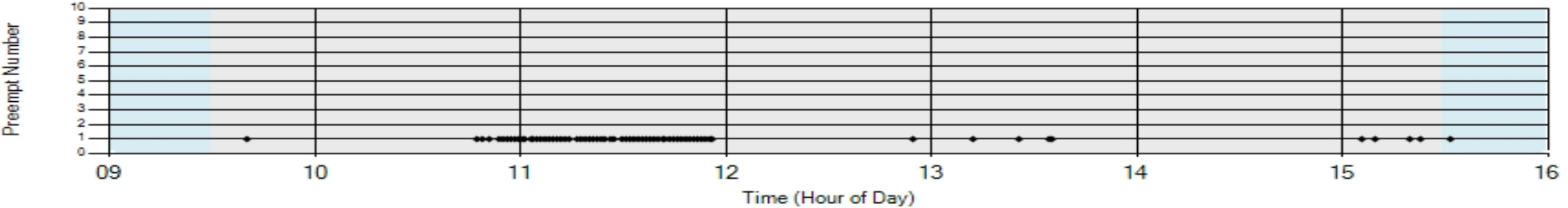


56 Preempt Requests & Services in **70** minutes
Gate down **35%** of the time

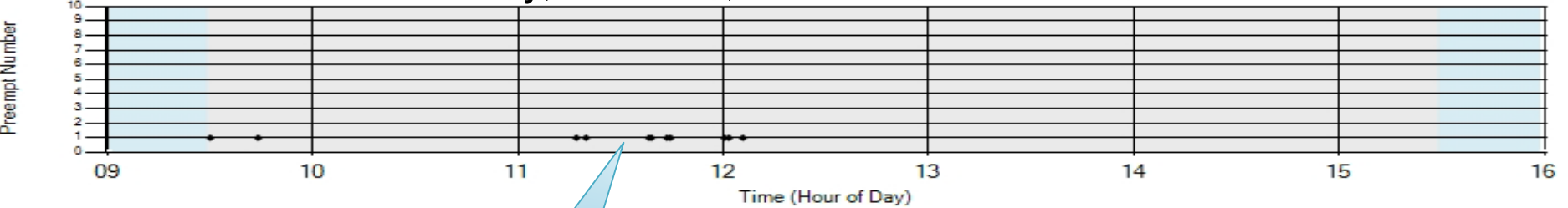
- Train passes through 2x a day Monday, Wednesday, Friday
- Complaints received monthly for a long time. Techs frustrated at this signal.
- Previously, there was no data to provide Union Pacific.

Union Pacific installed some isolation on the spur line where the track switched so the circuit wasn't being falsely triggered

Wednesday, May 25, 2016: 9:00 AM to 4:00 PM



Wednesday, June 22, 2016: 9:00 AM to 4:00 PM

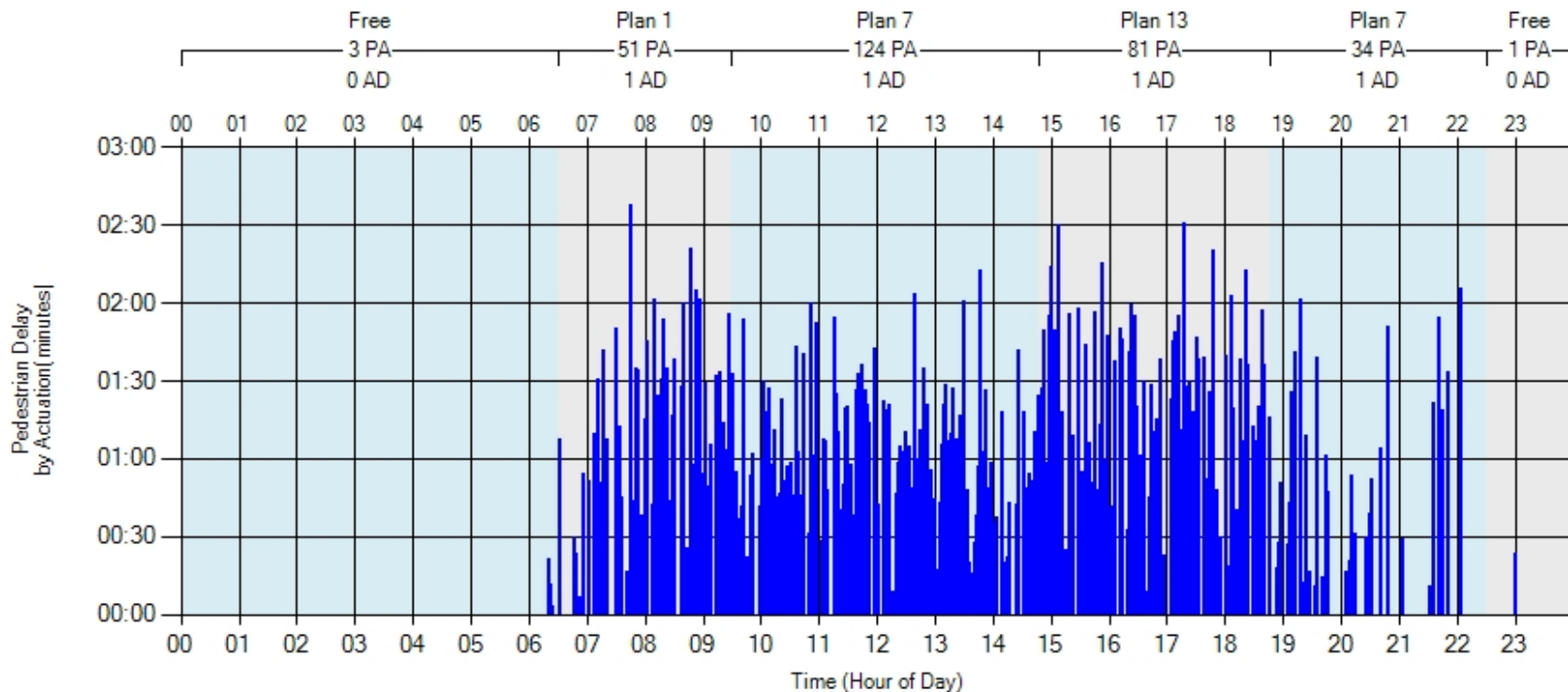


Fixed!

Pedestrians: Delay & Actuations

West Leg of Intersection: 500 South & Guardsman Way – Wed. February 14, 2018

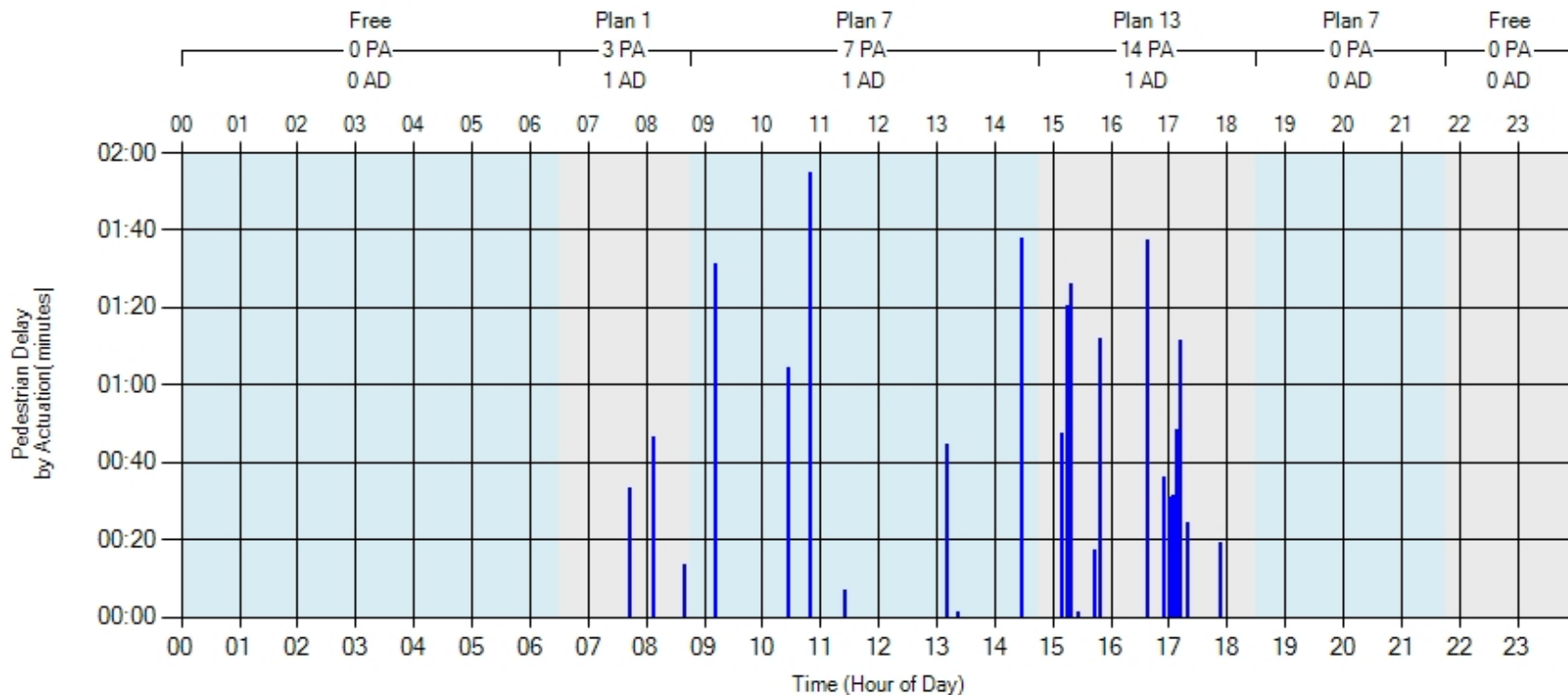
Ped Actuations(PA) = 294; Min Delay = 00:00; Max Delay = 02:37; Average Delay(AD) = 01:06



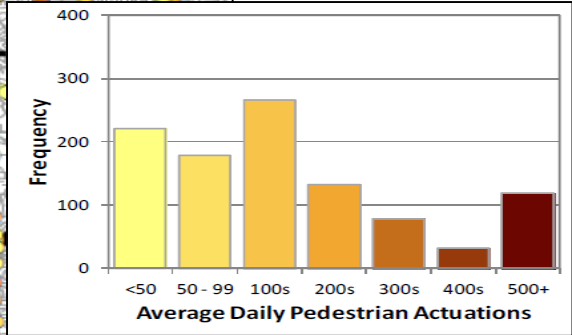
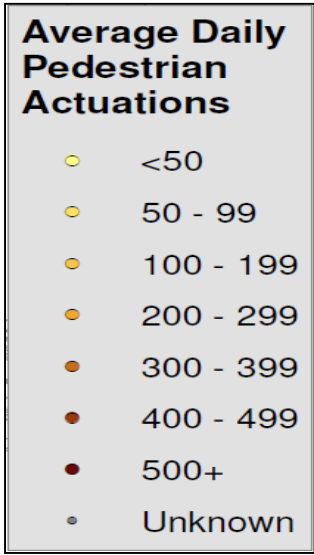
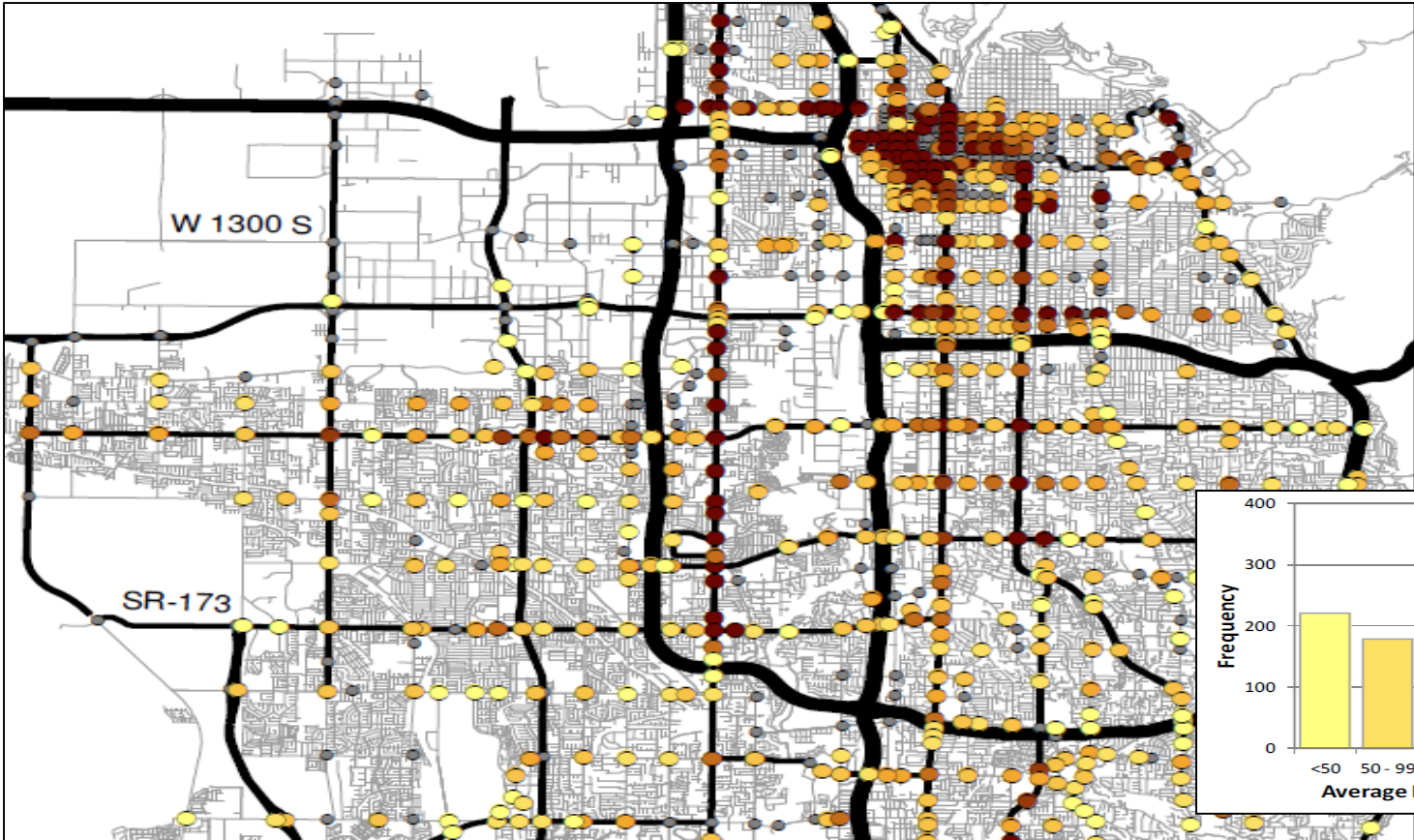
Pedestrians: Delay & Actuations

North Leg of Intersection: 8890 South (Newcastle) & Highland– Monday Feb 12, 2018

Ped Actuations(PA) = 24; Min Delay = 00:01; Max Delay = 01:54; Average Delay(AD) = 00:48



Pedestrian Actuations



Example: I-15 Freeway Closure, September 9-12, 2014



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

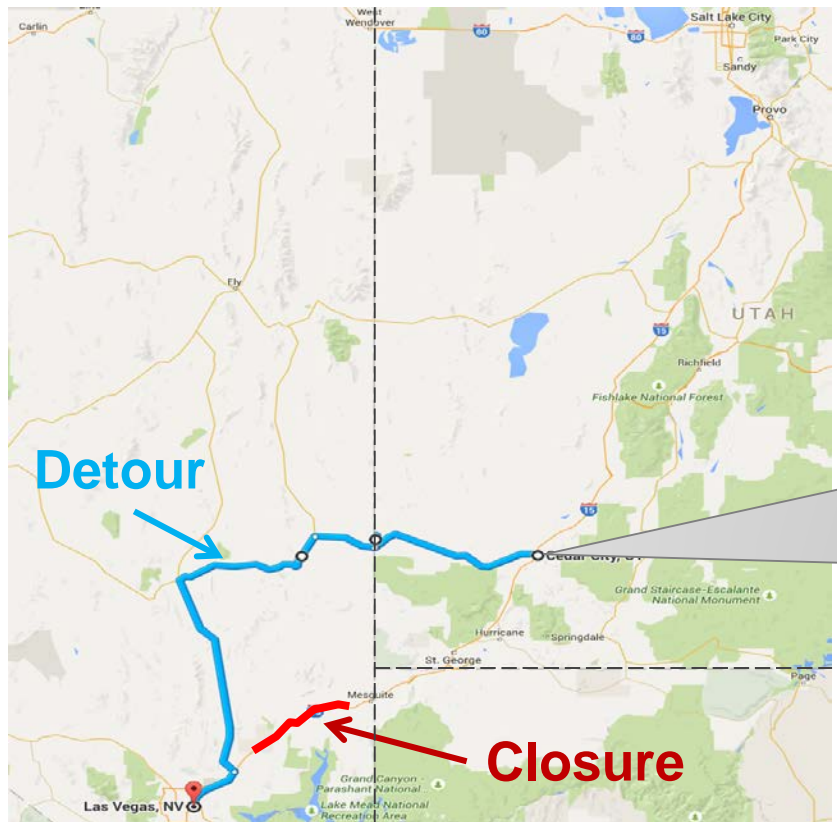
By Ken Ritter, Michelle Rindels , Associated Press | Posted Sep 9th, 2014 @ 7:44pm



© Reuters



Example: I-15 Freeway Closure, September 9-12, 2014



Southbound I-15 Closed in Nevada

- 4-day closure
- Detour to Las Vegas: Exit I-15 in Cedar City

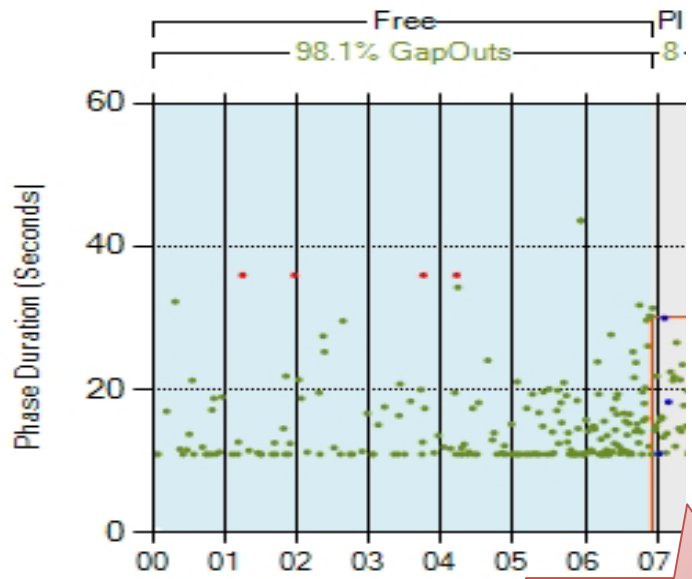


Split Monitor for Incident Management

Split Monitor

200 N. (Cedar City) @ 1400 W/I-15 SB - SIG#8223
 Tuesday, September 09, 2014 12:00 AM - Tuesday, September 09, 2014 11:59 PM

Phase 4 Revise Timing Plan for better % gap outs



Detour starts

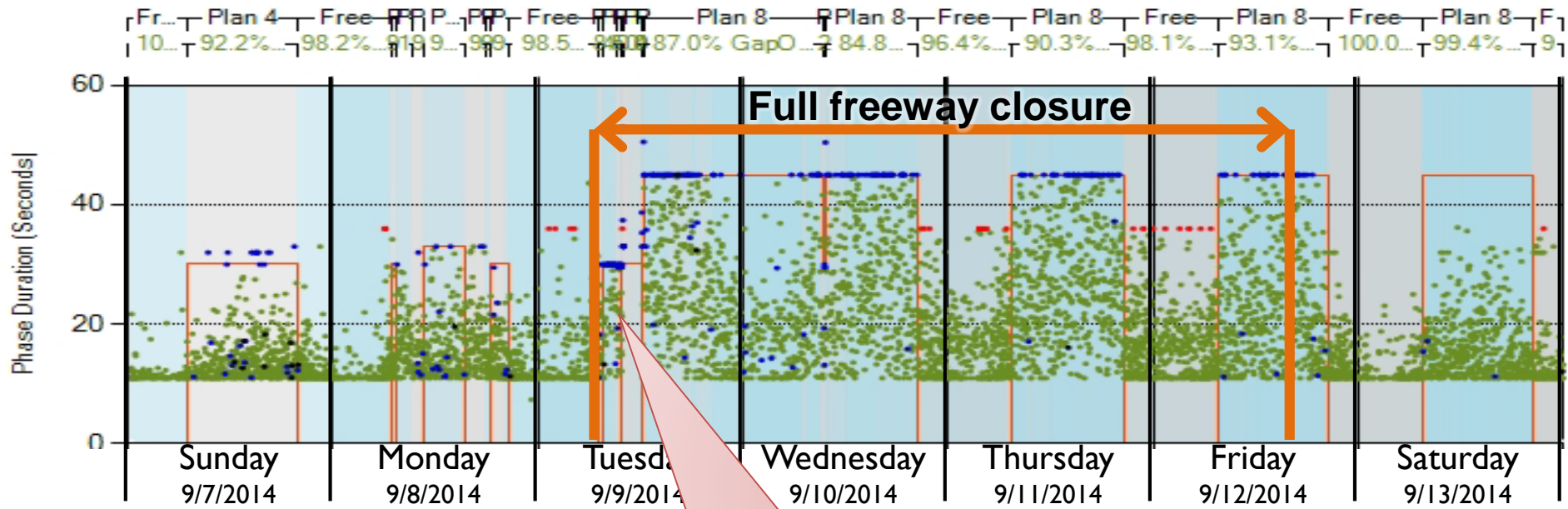
Implement Timing Plans

Split Monitor for Incident Management

Split Monitor

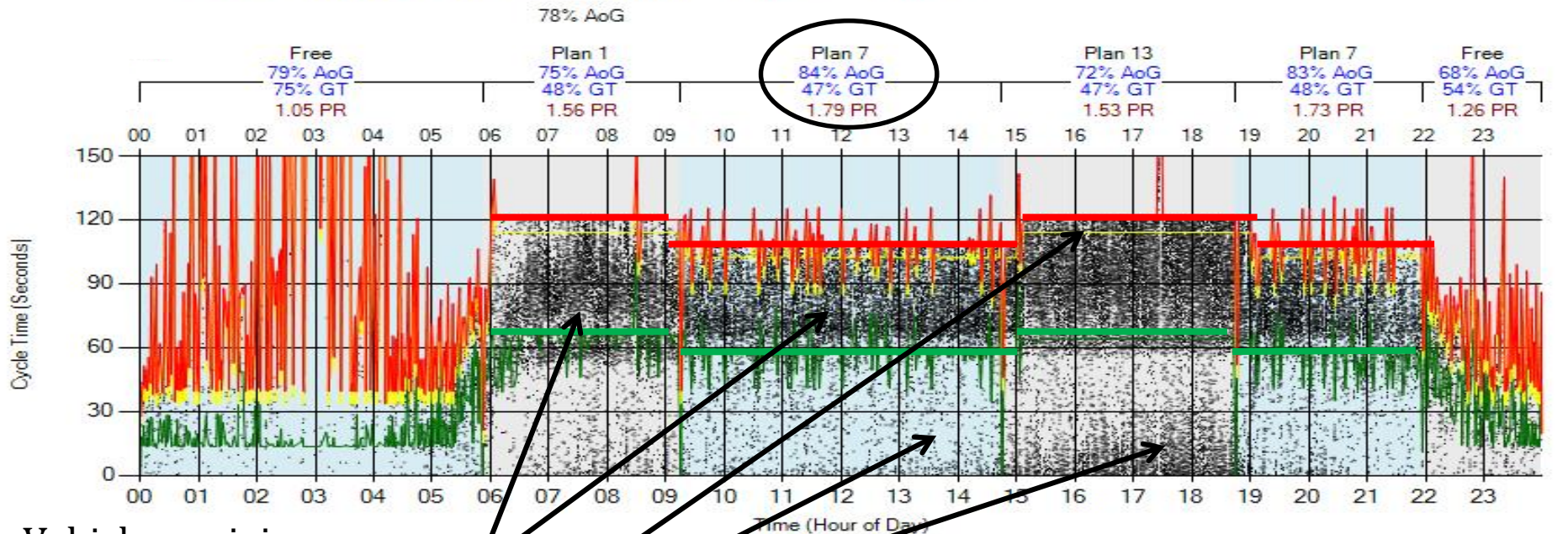
200 N. (Cedar City) @ 1400 W/I-15 SB - SIG#8223
 Sunday, September 07, 2014 12:00 AM - Saturday, September 13, 2014 11:59 PM

Phase 4



Implemented timing plans

Purdue Coordination Diagram



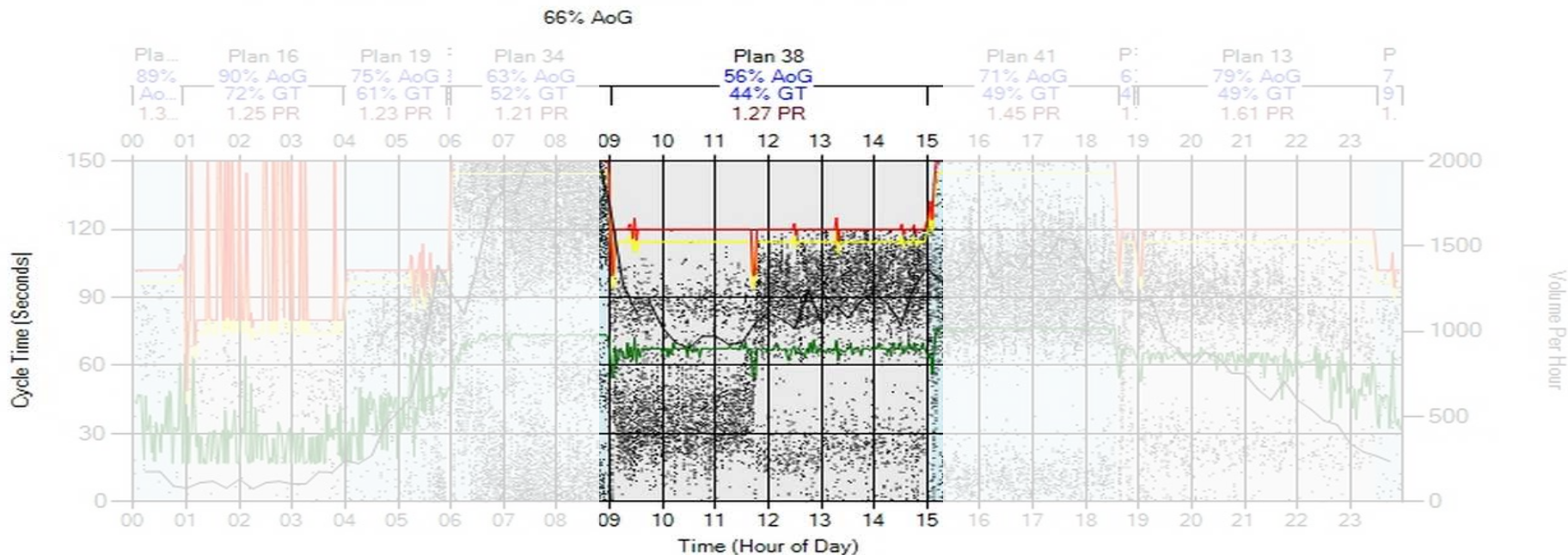
Vehicles arriving on green

Vehicles arriving on yellow

Vehicles arriving on red

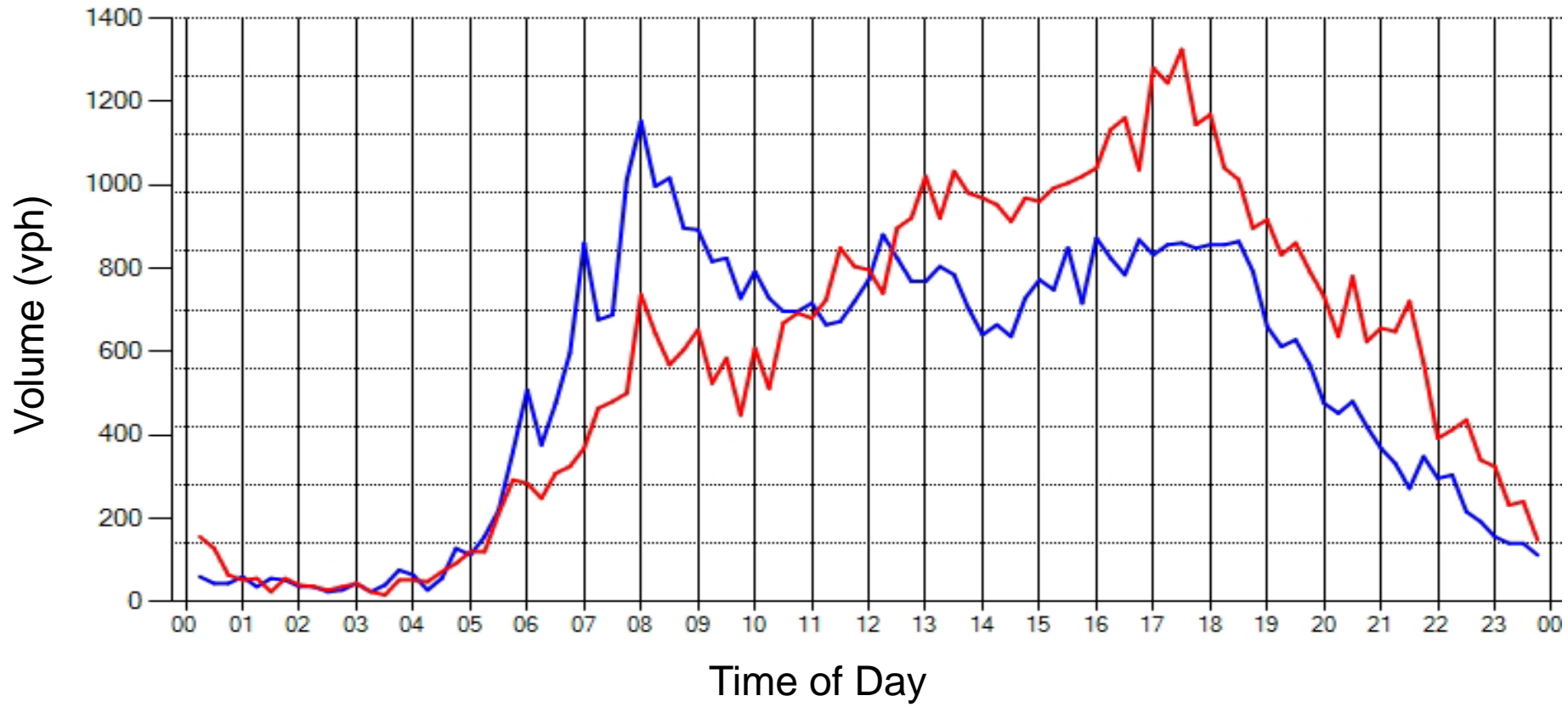
- Detector Activation
- Change to Green
- Change to Yellow
- Change to Red
- Volume Per Hour
- AoG - Arrival On Green
- GT - Green Time
- PR - Platoon Ratio

Complaint: Too many vehicles arriving during red (starting at 9:00 AM)



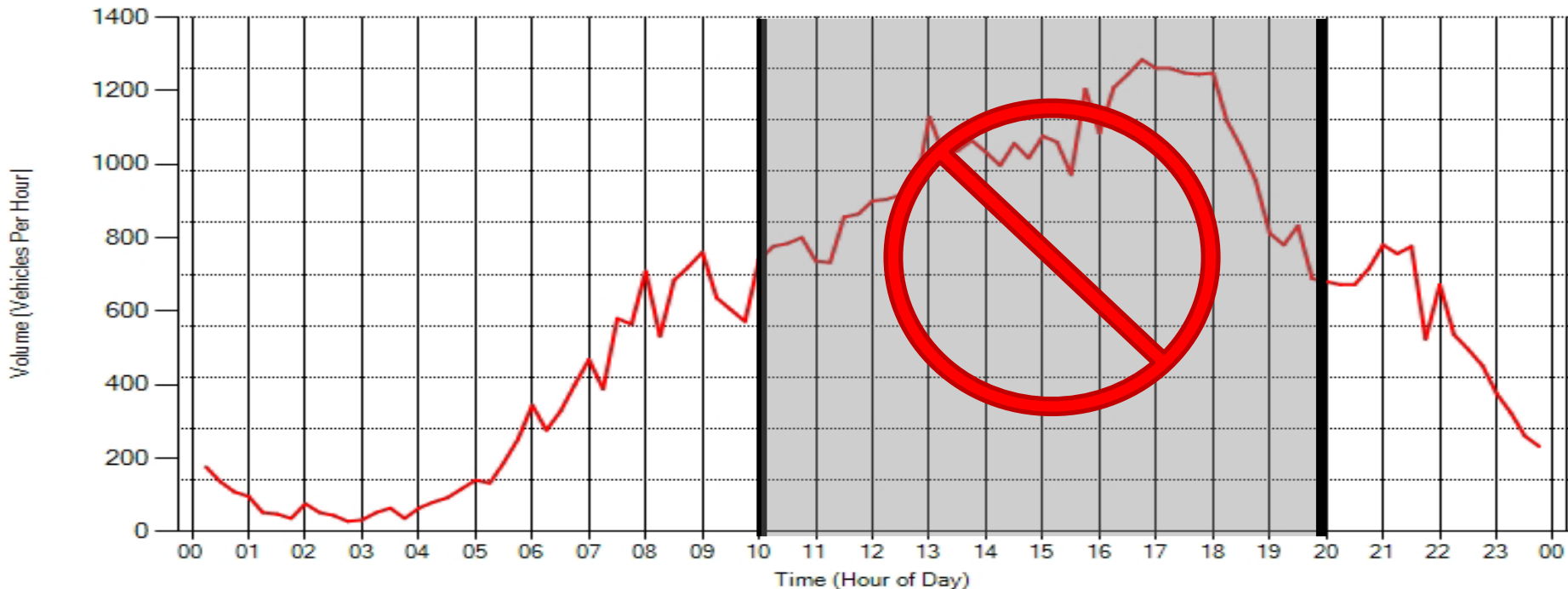
Metric: Approach Volume

- Northbound
- Southbound
- - - Northbound D-Factor



Allow Lane Closures?

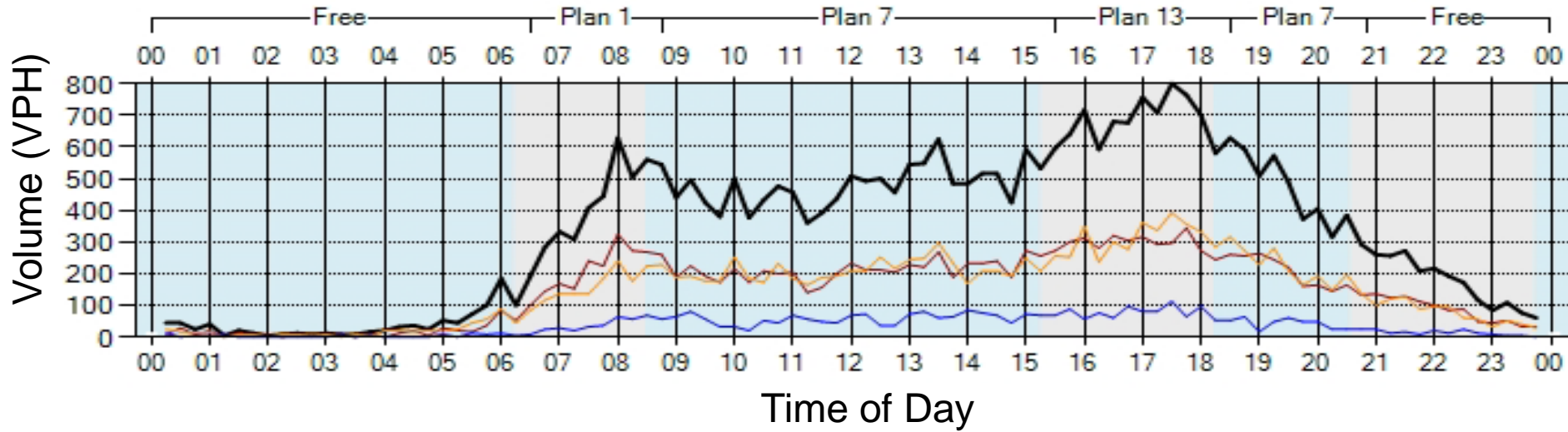
Volume report for University Avenue East Bay Boulevard on the Northbound and Southbound approaches.
 7/7/2016 12:00:00 AM - 7/7/2016 11:59:00 PM - Using Advanced Detection



Metric: Turning Movement Counts

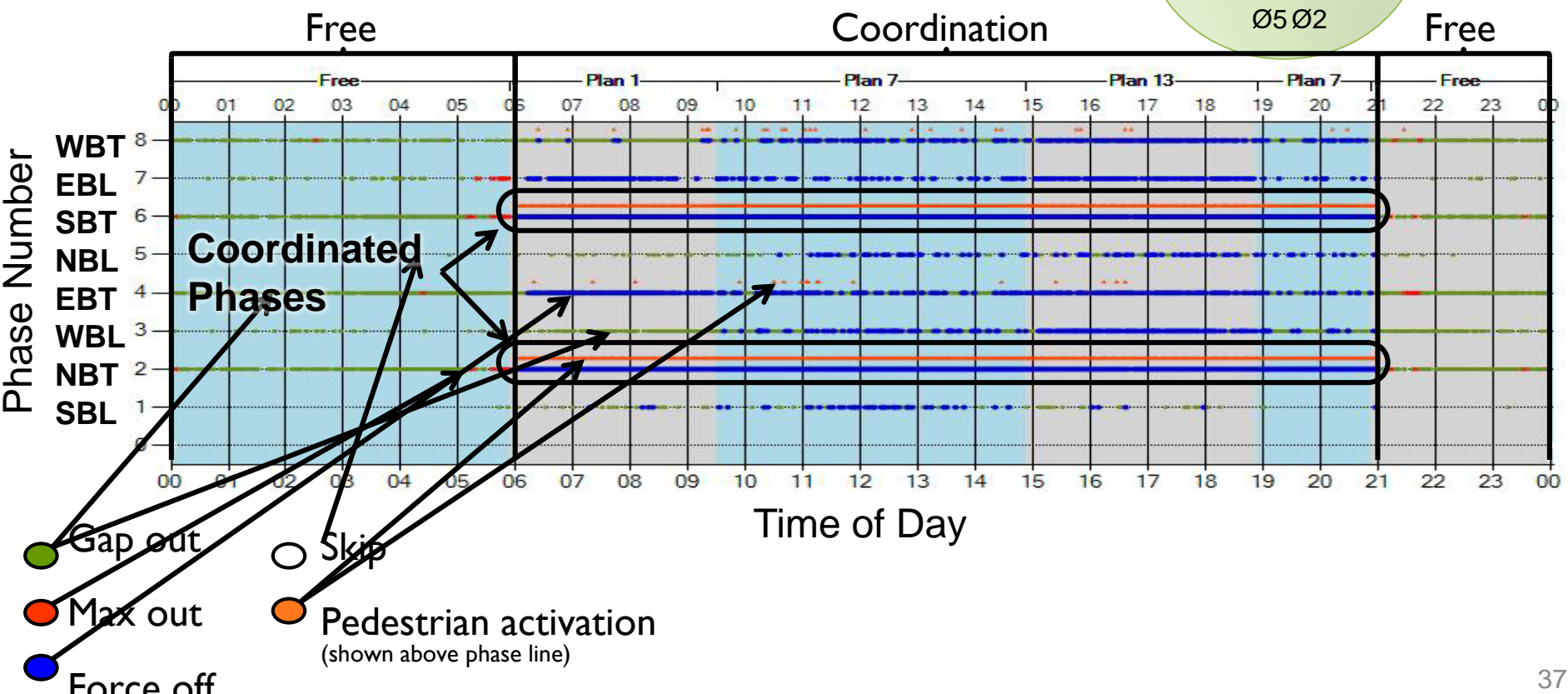
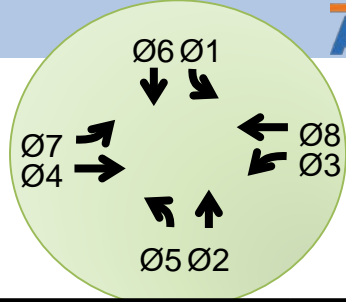
Eastbound Thru

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



— Total Volume — Lane 1 — Lane 2 — Thru Right

Metric: Phase Termination Chart

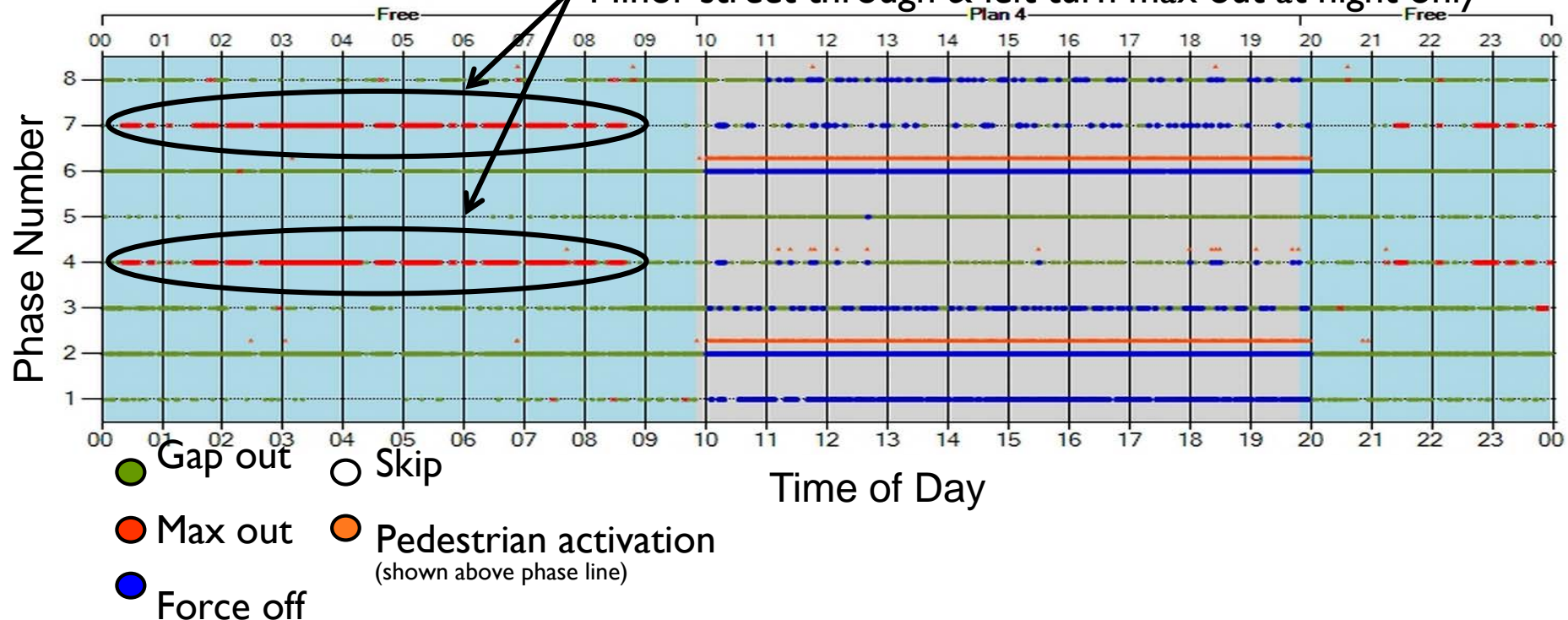


Complaint: Long main street red at 2 a.m.

Before

Video detection not working at night

Minor street through & left turn max out at night only

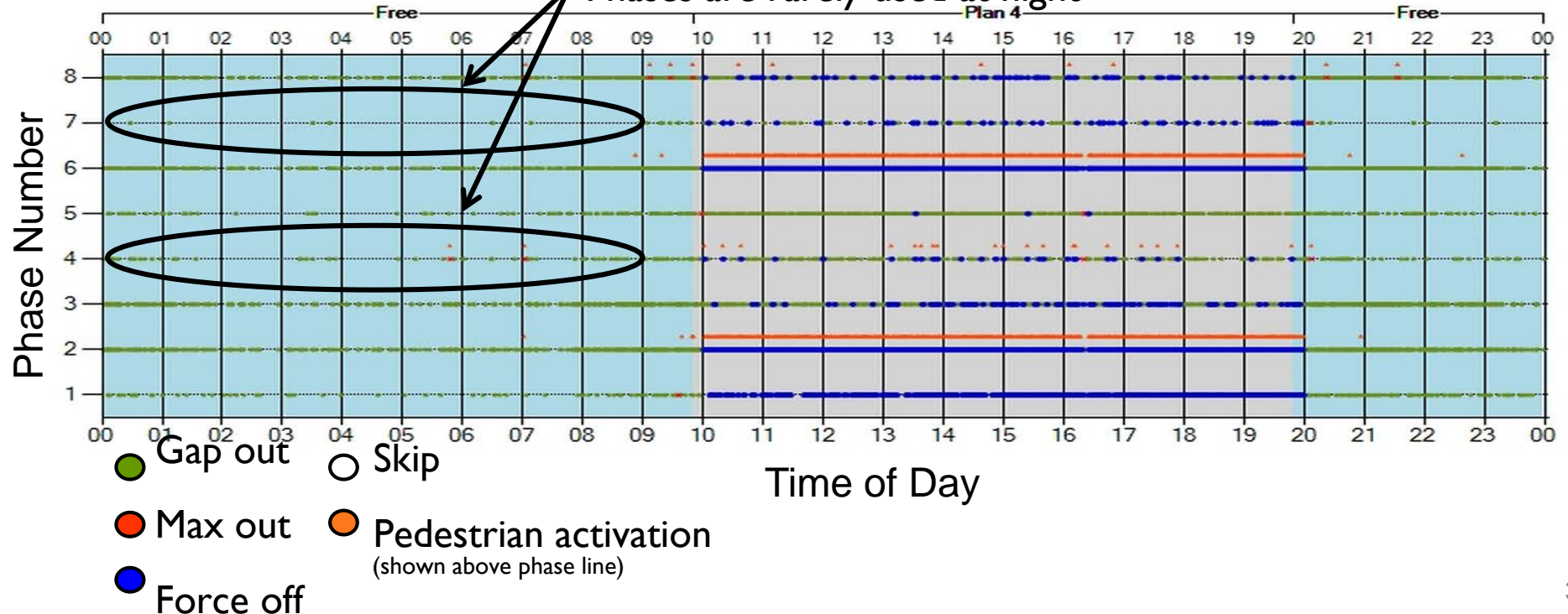


Complaint: Long main street red at 2 a.m.

After

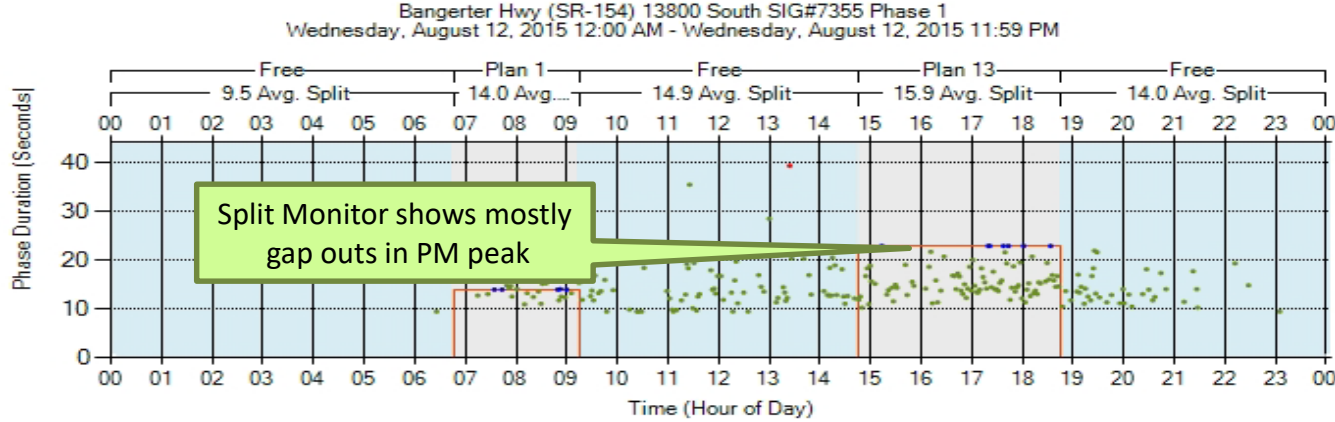
New detection technology installed

Phases are rarely used at night

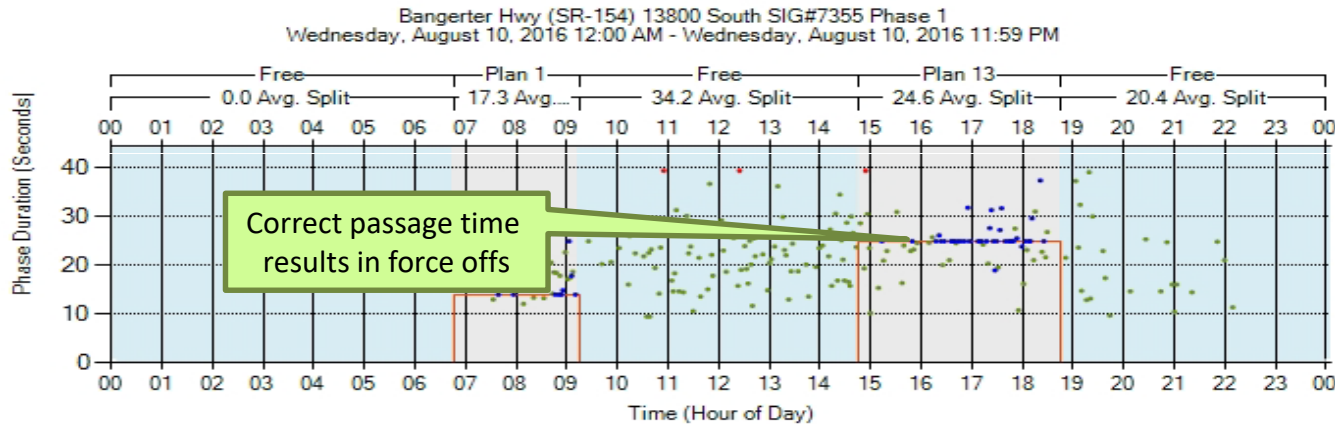


Complaint: Long queue, short green, PM peak

Before



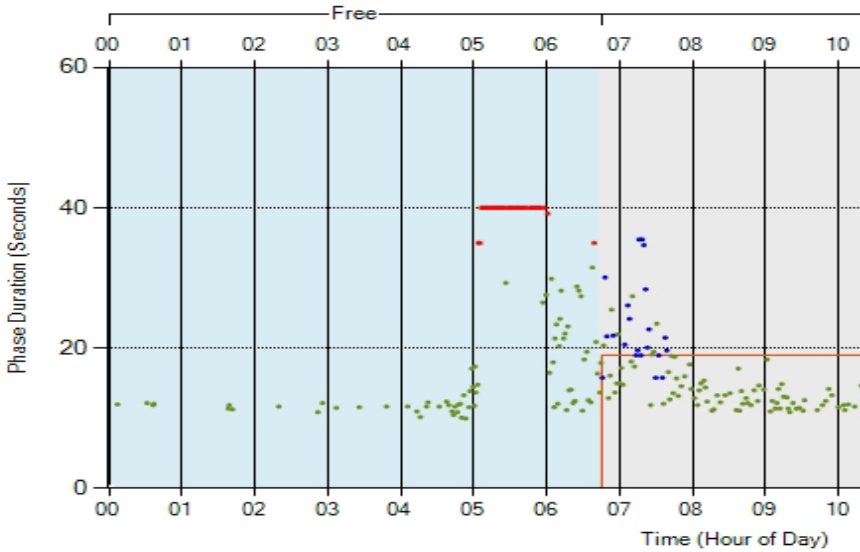
After



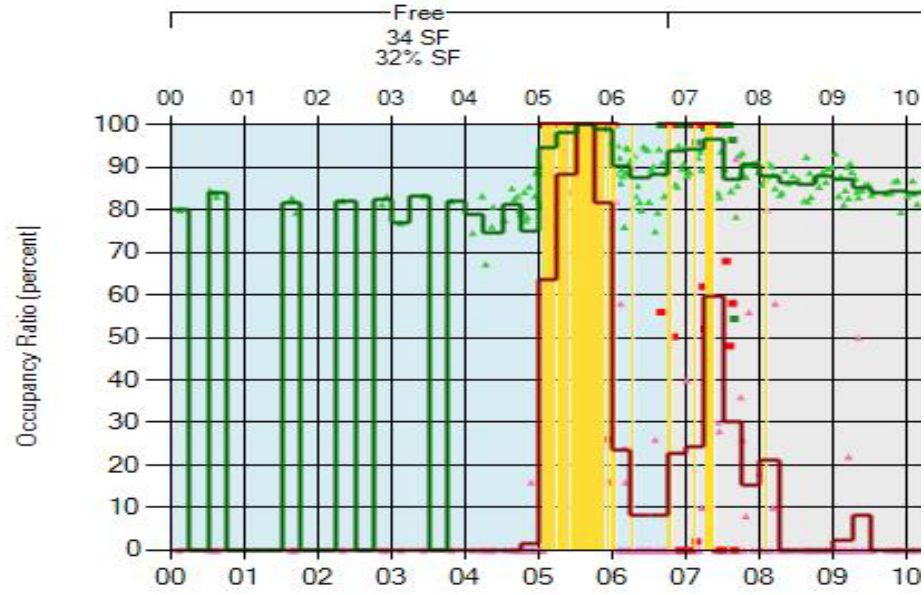
Complaint: Green too short in the morning

Before

Split Monitor



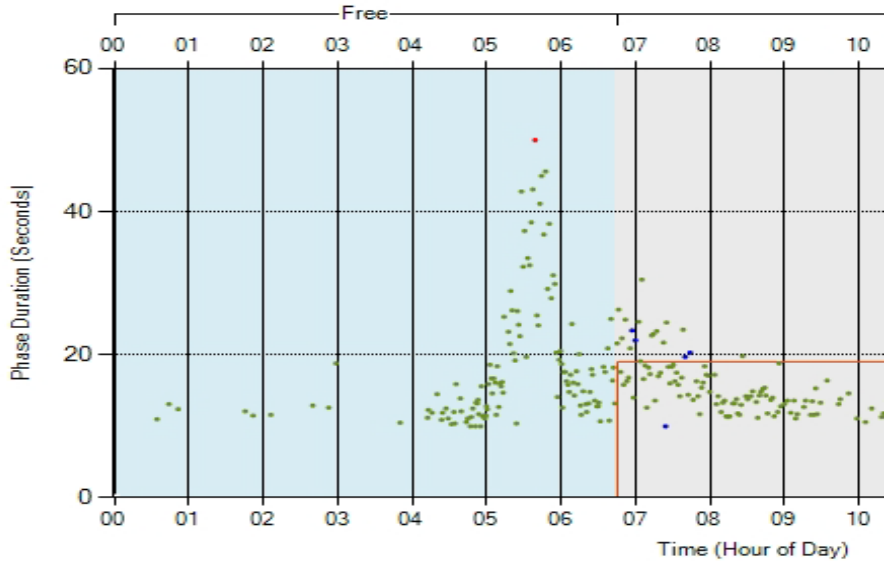
Purdue Split Failure



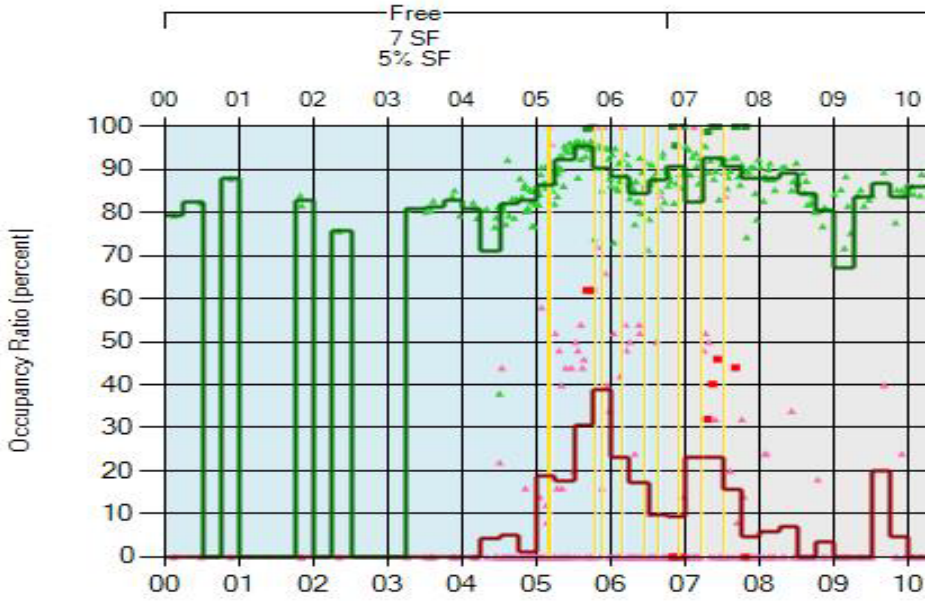
Complaint: Green too short in the morning

After

Split Monitor



Purdue Split Failure



SYSTEM HEALTH ALERTS FOR PROACTIVE MAINTENANCE

UDOT Automated Traffic Signal Performance Measures

System Health Alerts

1

No ATSPM data: identifies signals with less than 500 records in the database between midnight and midnight the previous day

2

Too many max outs: identifies phases with more than 90% max outs in at least 50 activations between 1 a.m. and 5 a.m.

3

Too many force offs: identifies phases with more than 90% force offs in at least 50 activations between 1 a.m. and 5 a.m.

4

Too many ped calls: identifies phases with more than 200 pedestrian activations between 1 a.m. and 5 a.m.

5

Low PCD detector count: identifies phases with PCD detectors that have less than 100 vehicles counted between 5 p.m. and 6 p.m. the previous day.

SPM Alerts for 5/22/2016



SPMWatchdog@utah.gov

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

--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%)

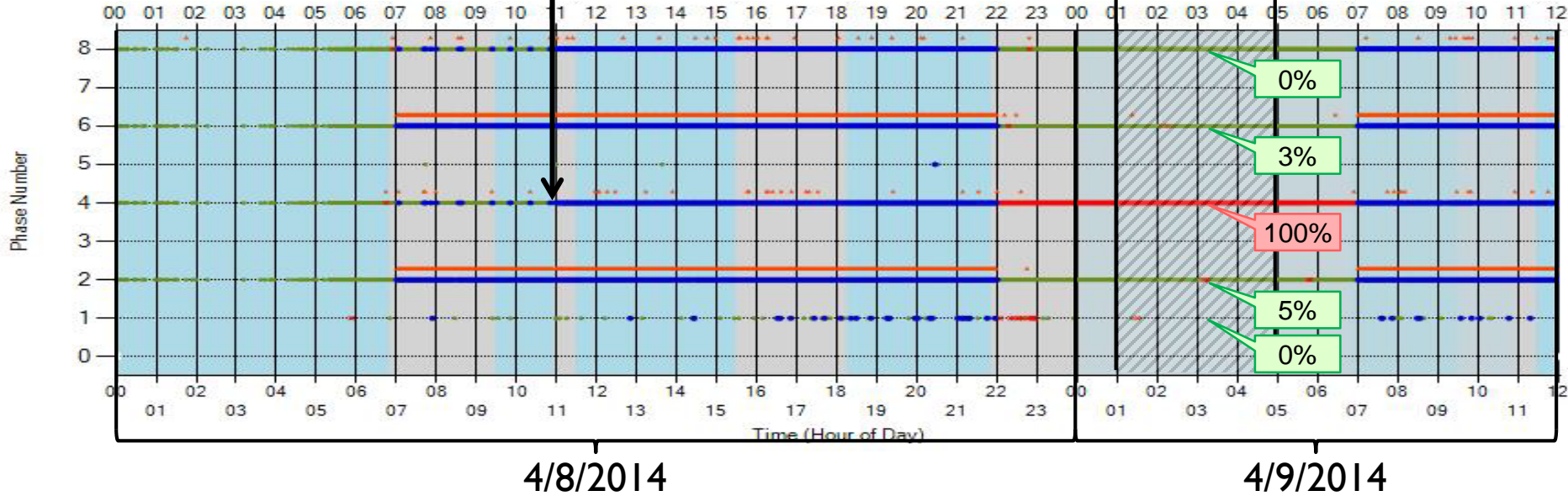
--The following signals had unusually low detector hits:
5134 - SR-193 (700 S) & I-15 NB (Clearfield) - Phase: 2 (Has Unusually Low Counts.)
7061 - Bangerter Hwy (SR-154) & 4100 South - Phase: 1 (Has Unusually Low Counts.)
7061 - Bangerter Hwy (SR-154) & 4100 South - Phase: 7 (Has Unusually Low Counts.)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

2 Too many max outs

Phase 4 starts
constant call

Alert email
sent
ATSPMs evaluated
for % max outs

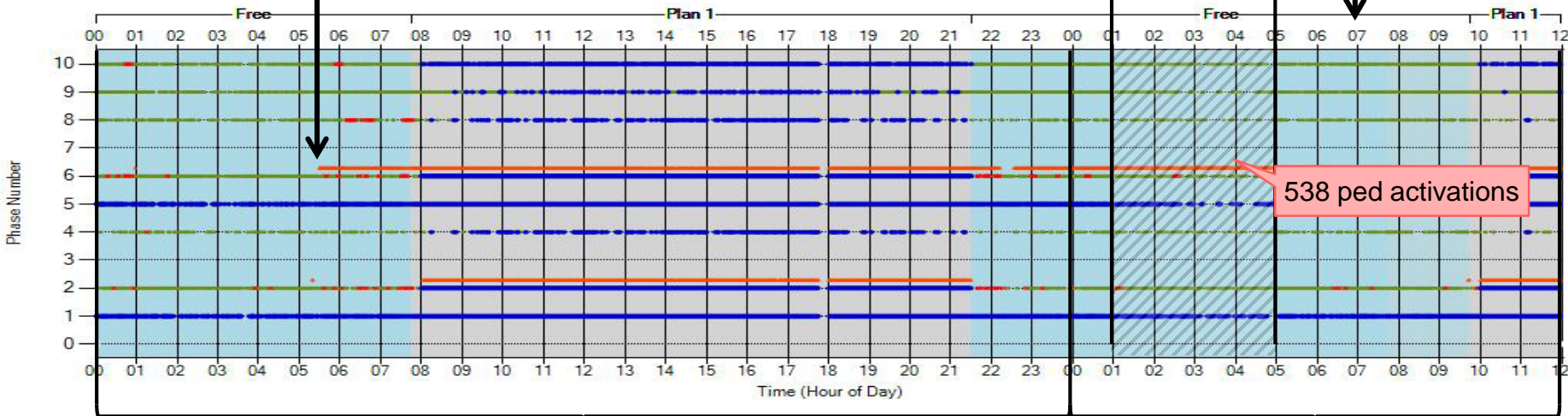


- Gap out
- Max out
- Force off
- Pedestrian activation (shown above phase line)
- Skip

4 Too many ped calls

Ph6 Ped
Constant Call

Alert email
sent
ATSPMs evaluated
for Ped Activations



5/21/2016

5/22/2016

More Information

UDOT ATSPMs

Mark Taylor

UDOT Traffic Signal Operations Engineer
marktaylor@utah.gov

ATSPM Website

<https://udottraffic.utah.gov/ATSPM>

Green Lights Commercial

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

FHWA's Open Source Application Development Portal (OSADP)

<https://www.itsforge.net>

ATSPM Forums

National Operations Center of Excellence (NOCoE)

<http://forum.transportationops.org/forum/5-traffic-signals/>

➤ General ATSPM topics

FHWA's Open Source Application Development Portal (OSADP)

<https://www.itsforge.net/forum/ATSPM>

➤ Questions regarding UDOT's ATSPM source code

udottraffic.utah.gov/ATSPM

Mark Taylor
marktaylor@utah.gov

