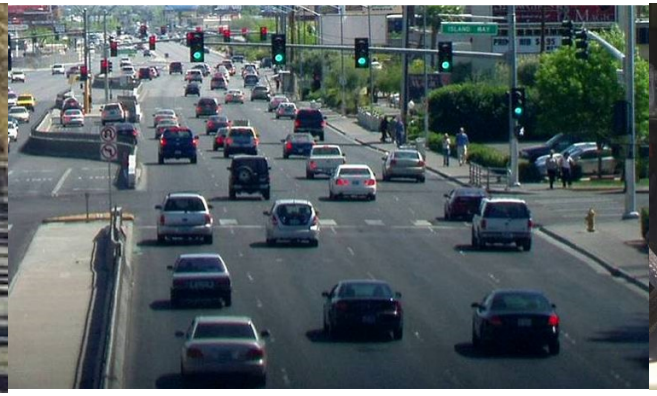
Automated Traffic Signal Performance Measures

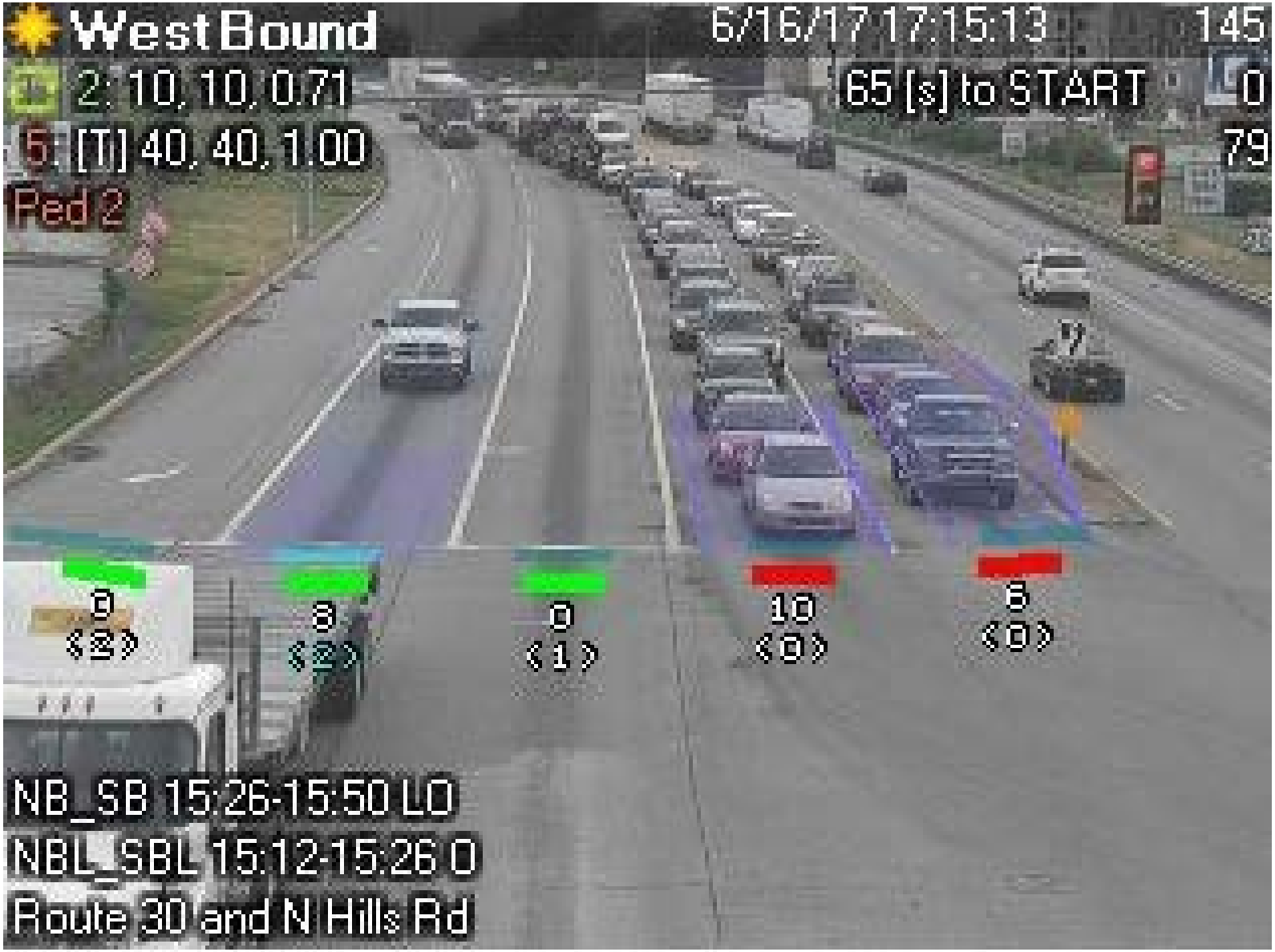
ATSPM
Automated Traffic Signal Performance Measures



pennsylvania
DEPARTMENT OF TRANSPORTATION

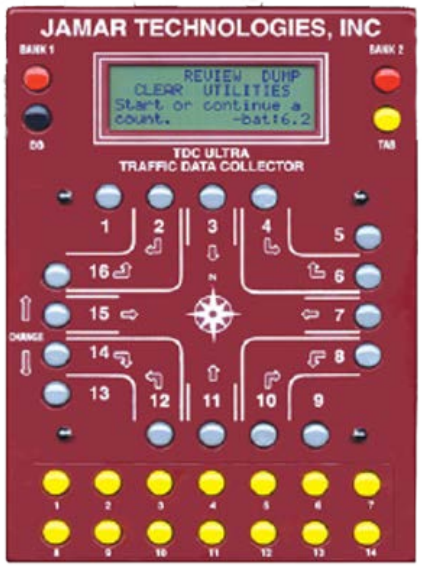
Penn State Transportation Engineering & Safety Conference
December 6, 2018

Acceptable signal operation?



Signal Timing Development in Pennsylvania

"The way we've always done it"



+

=

LOS

Is this better?

+

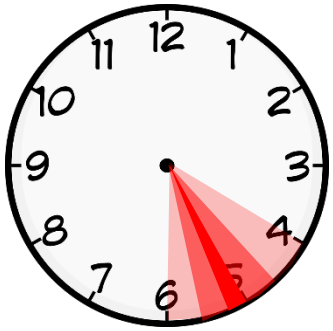
=

LOS

Traditional: Model a lot… Measure a little

APRIL						
S	M	T	W	T	F	S
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					

One "typical" day

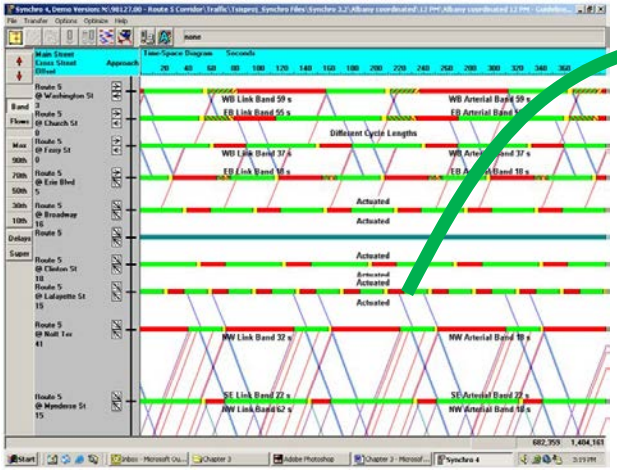


Count a few peak periods

Find peak hour

Apply peak hour factor
Analyze peak 15 min.

2 peak hours on 1 day =
0.005% of a year



<u>Outputs:</u>
Cycle Length
Splits
Offsets

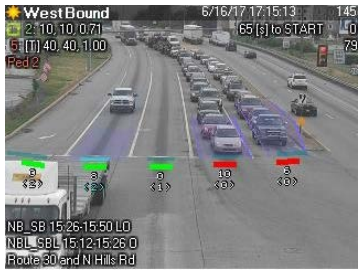
All of our metrics are based on **<u>outputs</u>** not Objectives

Source: INDOT/FHWA

Is this better?

+

=



A Better Way

Traditional Process (Reactive)

Adapted from UDOT

Trigger → Collect Data → Model & Optimize → Implement ~~& Fine Tune~~

Complaints
Developer Impact

Outputs:
Cycle Length
Splits
Offsets

Modified Process with Performance Data (Proactive)

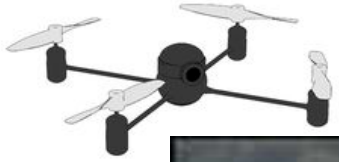
Review Metrics
Field Observation → Model → Optimize → Implement & Fine Tune

How do measures compare to agency goals?

Output:
Offsets

Using Data to Measure Arterial Performance

Corridor Level



- Probe speed data
- RITIS/PDA Suite

Intersection Level

- High resolution data
- UDOT ATSPM software

Corridor Level Metrics

Phase 1: Proof of Concept

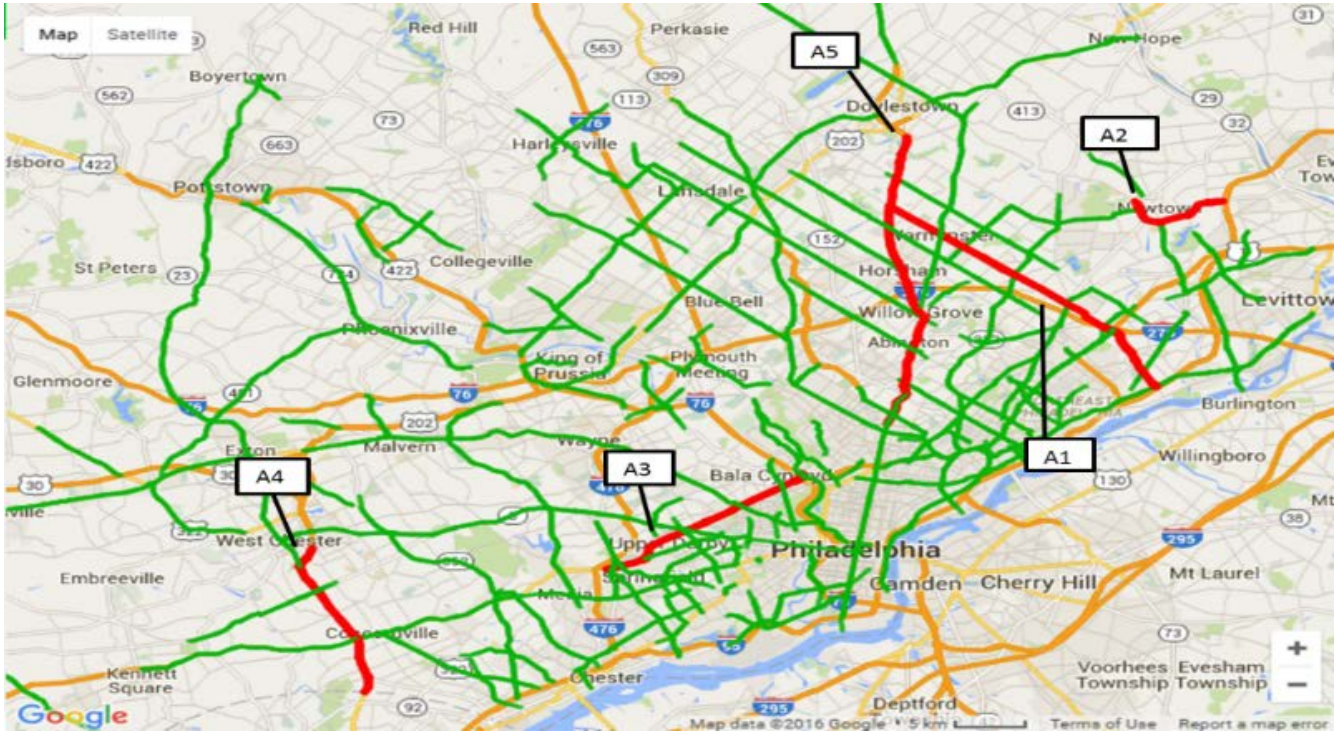
Phase 2: Enabling Access, Scalability, and Usability

Probe Data

- Pennsylvania INRIX coverage
  - 25,000 TMC segments = 16,600 miles
  - 112,000 XD segments = 23,200 miles (20,200 on arterials)

Research / Proof of Concept

- TRB Annual Meeting 2017 Paper # 17-00314
  - http://docs.trb.org/prp/17-00314.pdf
- Proof of Concept
  - 138 "Super-Critical" corridors in Philadelphia area
  - Covered 2,184 signals on 766 miles of arterials



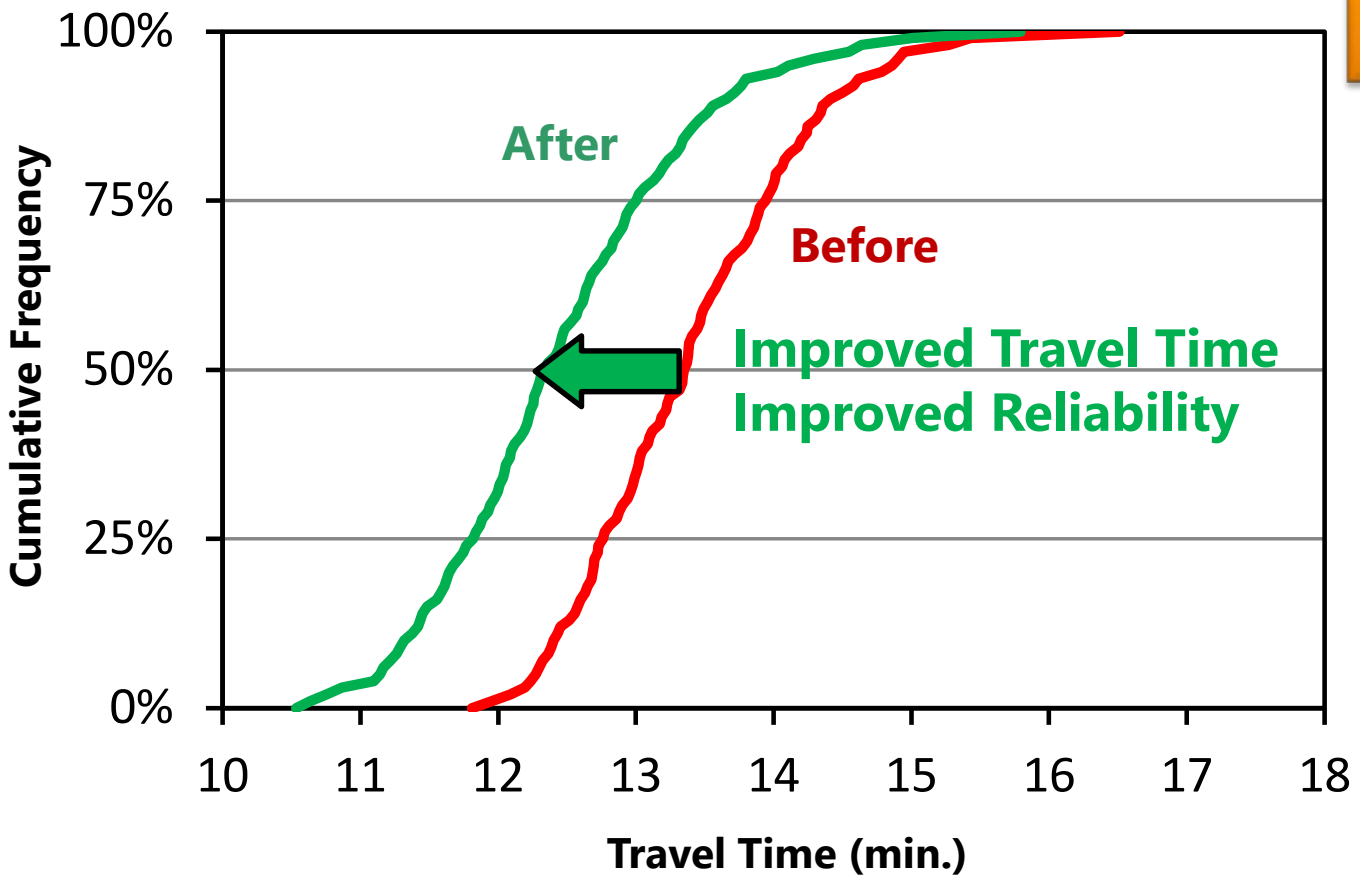
Travel Time Comparison

- Travel Time
- Reliability

MARCH 2012						
S	M	T	W	T	F	S
				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

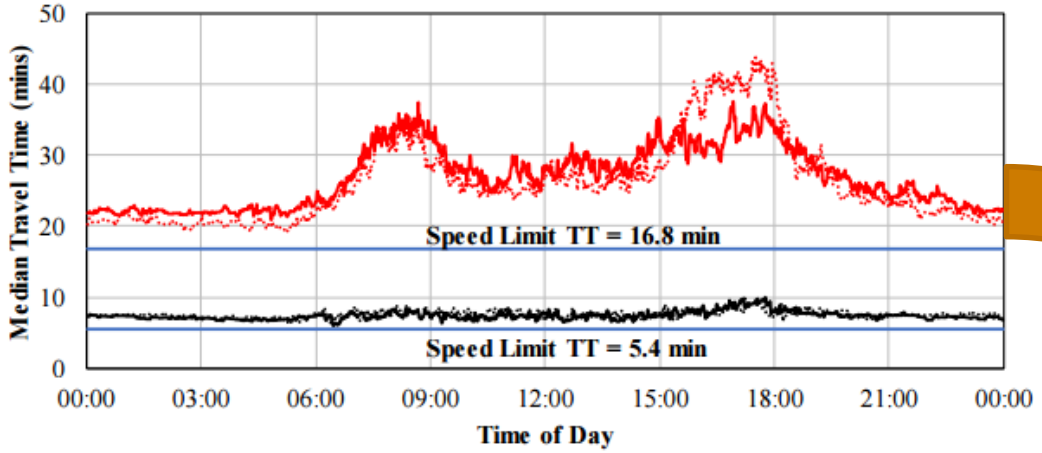
APRIL 2012						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

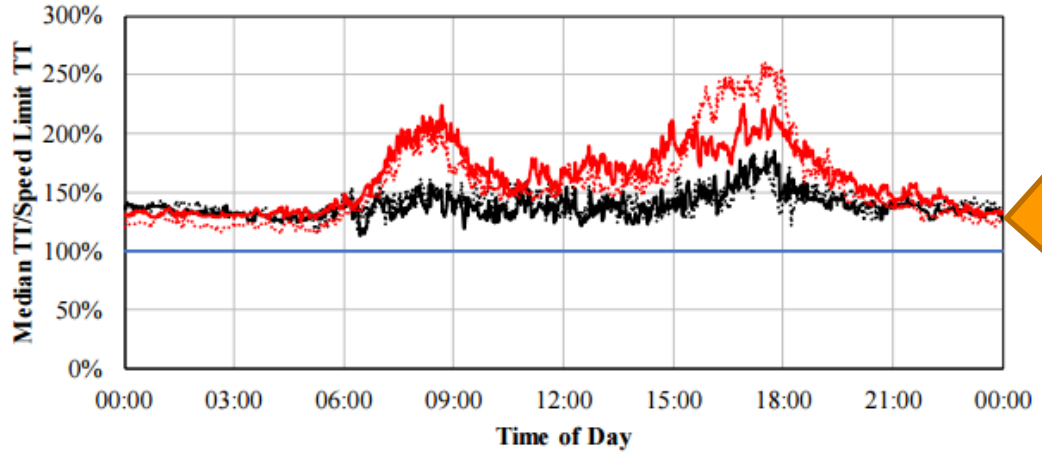
Retiming Week



Travel Time Normalization

- Normalize corridors of difference length and speed limits
- Identify corridors with below average performance

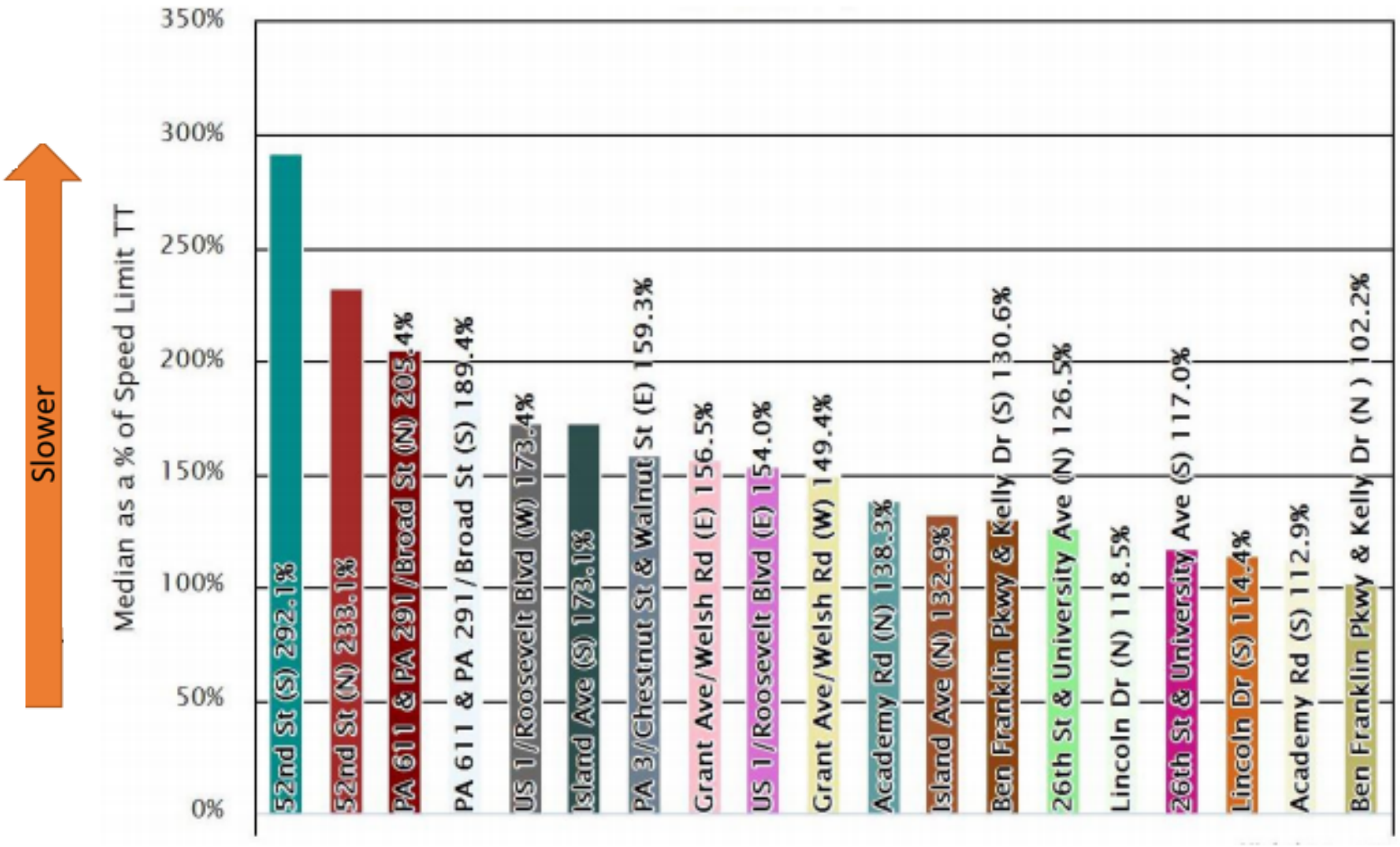




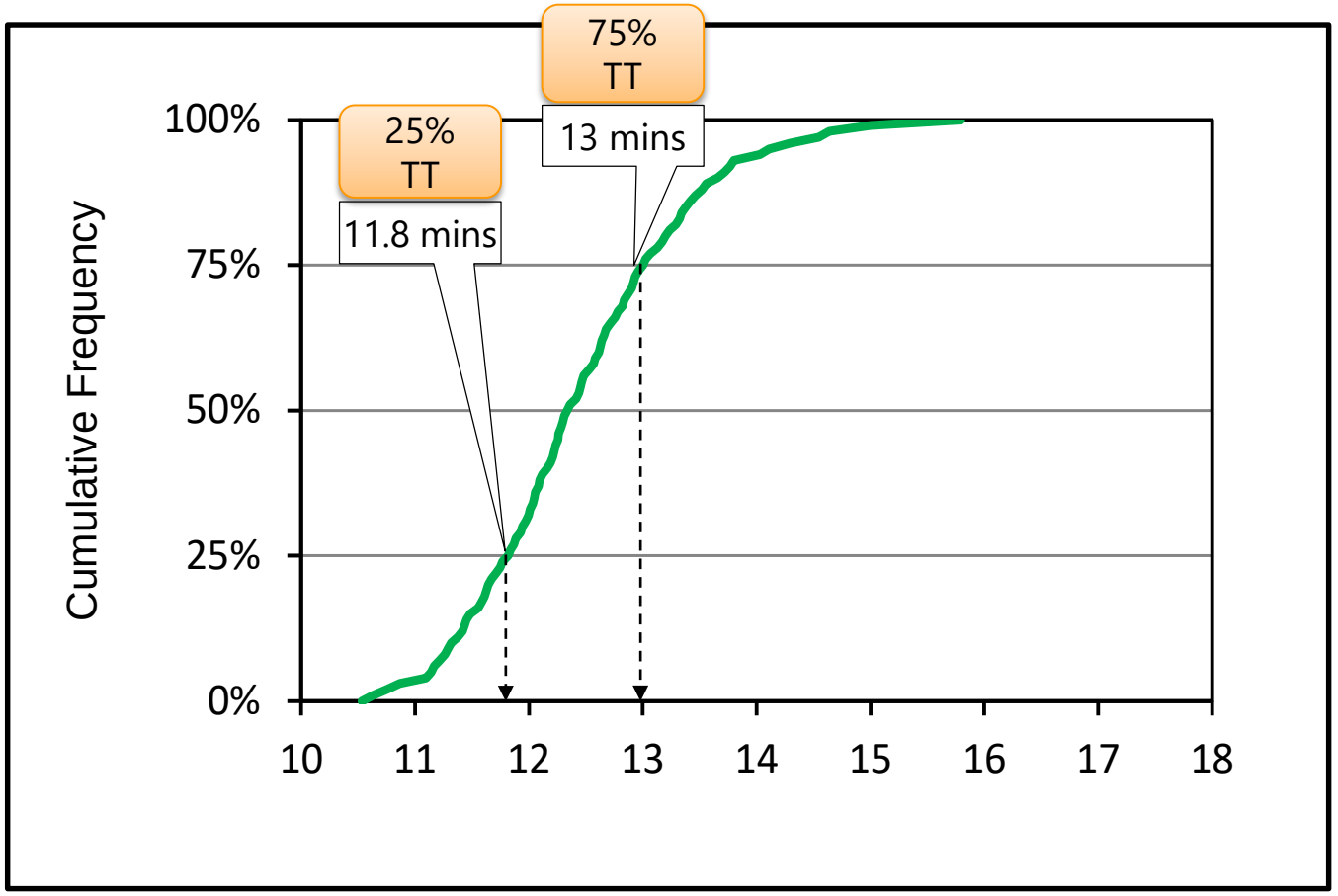
Normalize travel times

$$\frac{\text{Median TT}}{\text{Speed Limit TT}}$$

Travel Time Normalization



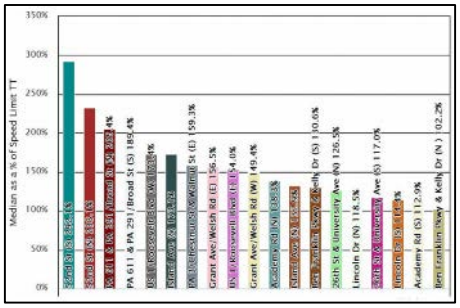
Interquartile-Range (IQR) Normalization



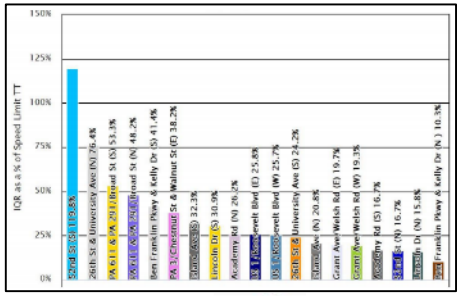
$$\text{Normalized IQR} = \frac{(75th\ percentile\ TT - 25th\ percentile\ TT)}{Speed\ limit\ TT}$$

Travel Time Delta Ranking

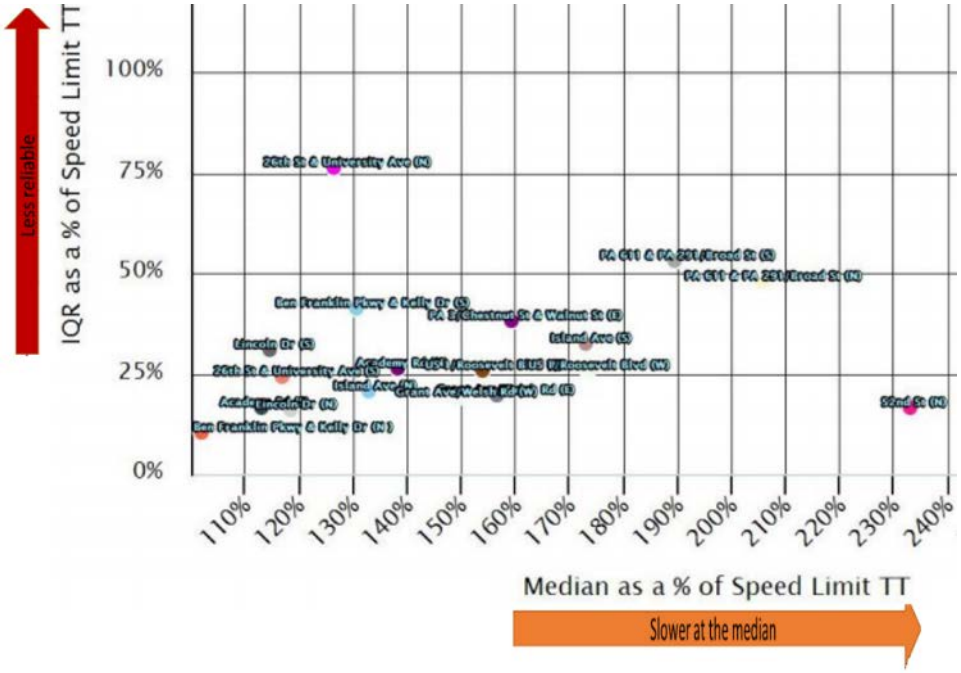
Travel Time Normalization Ranking



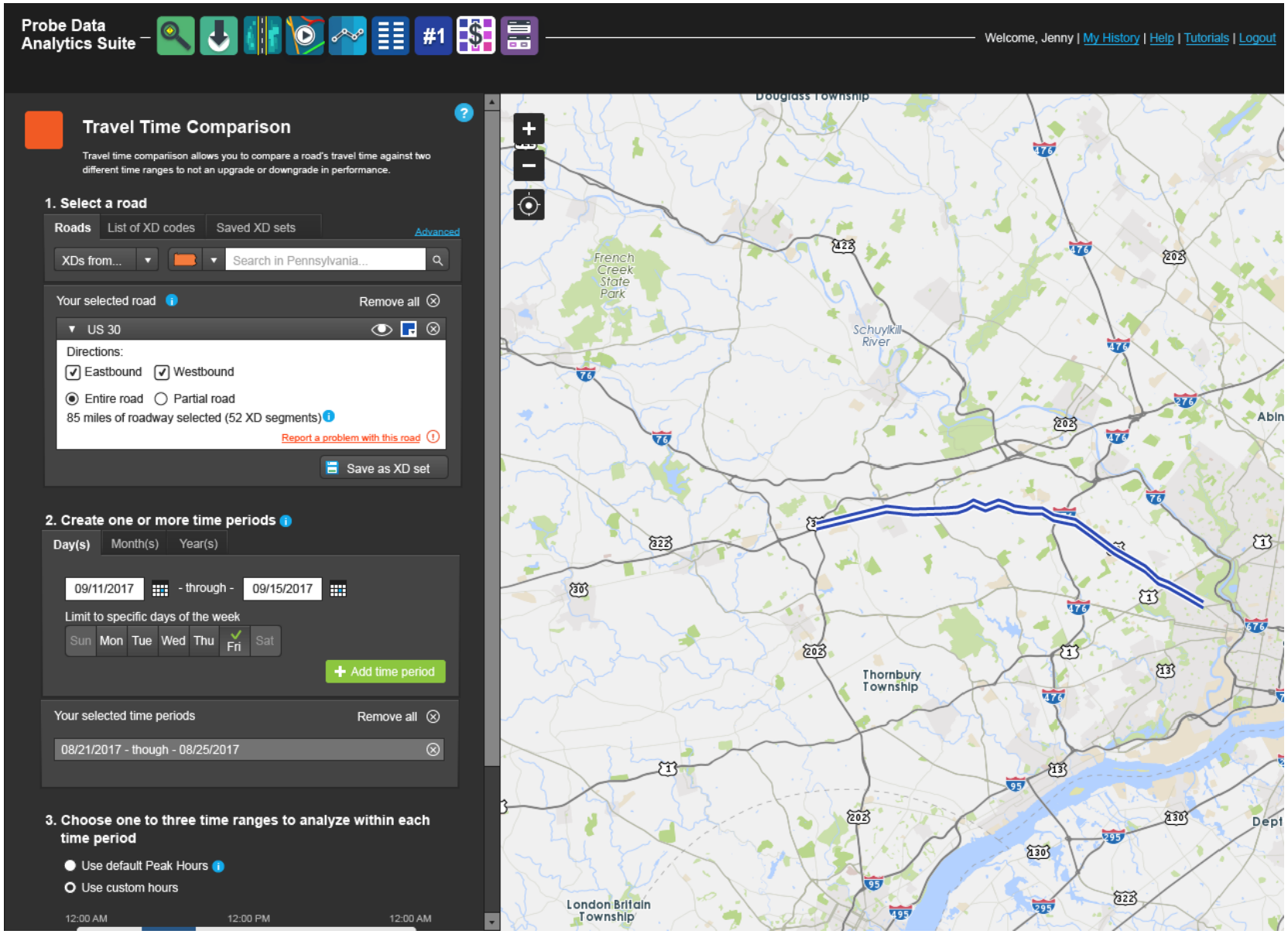
Interquartile-Range (IQR) Normalization Ranking



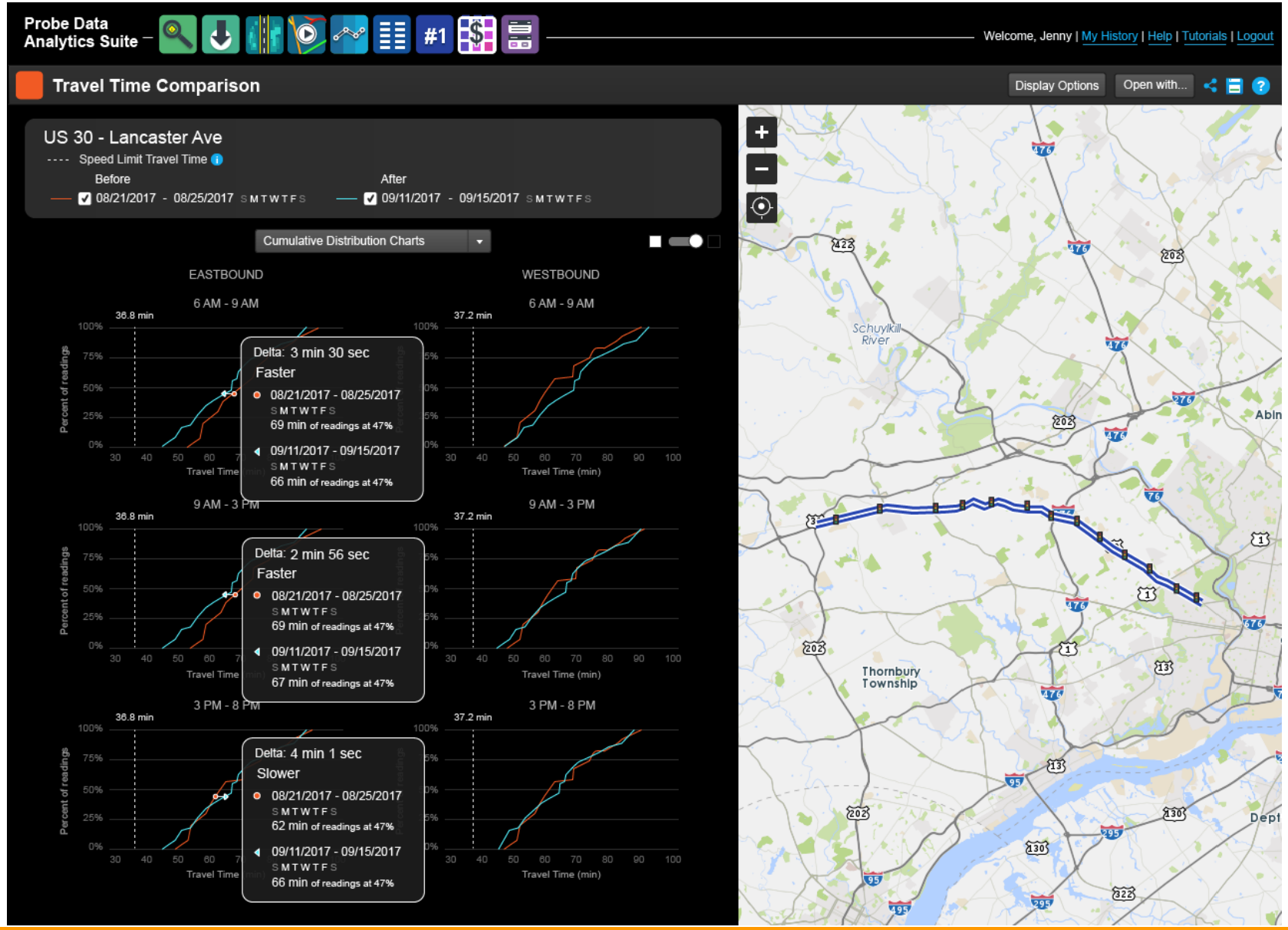
Reliability vs Central Tendency



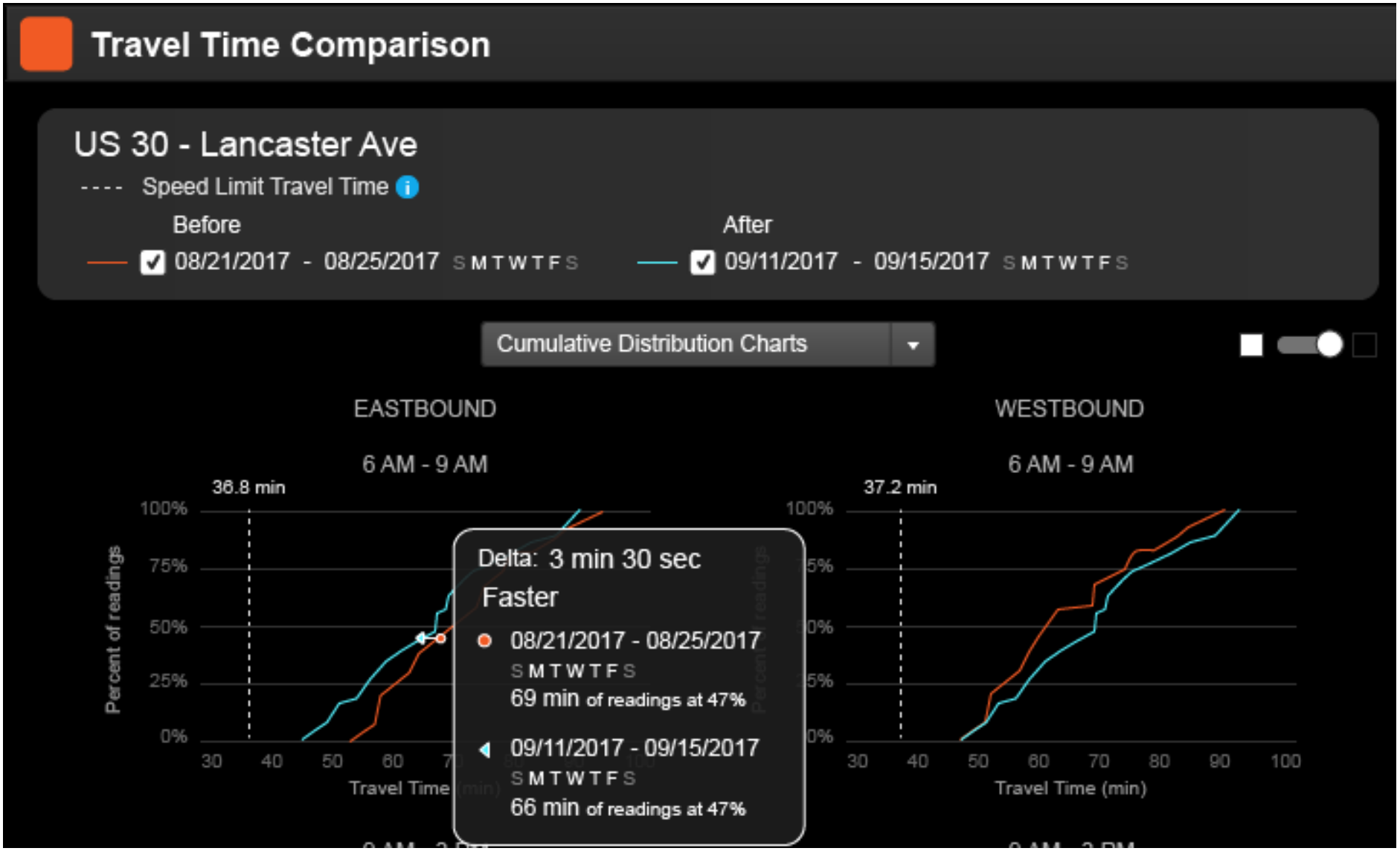
PDA Suite: Corridor and Time Selection



PDA Suite: Travel Time Comparison

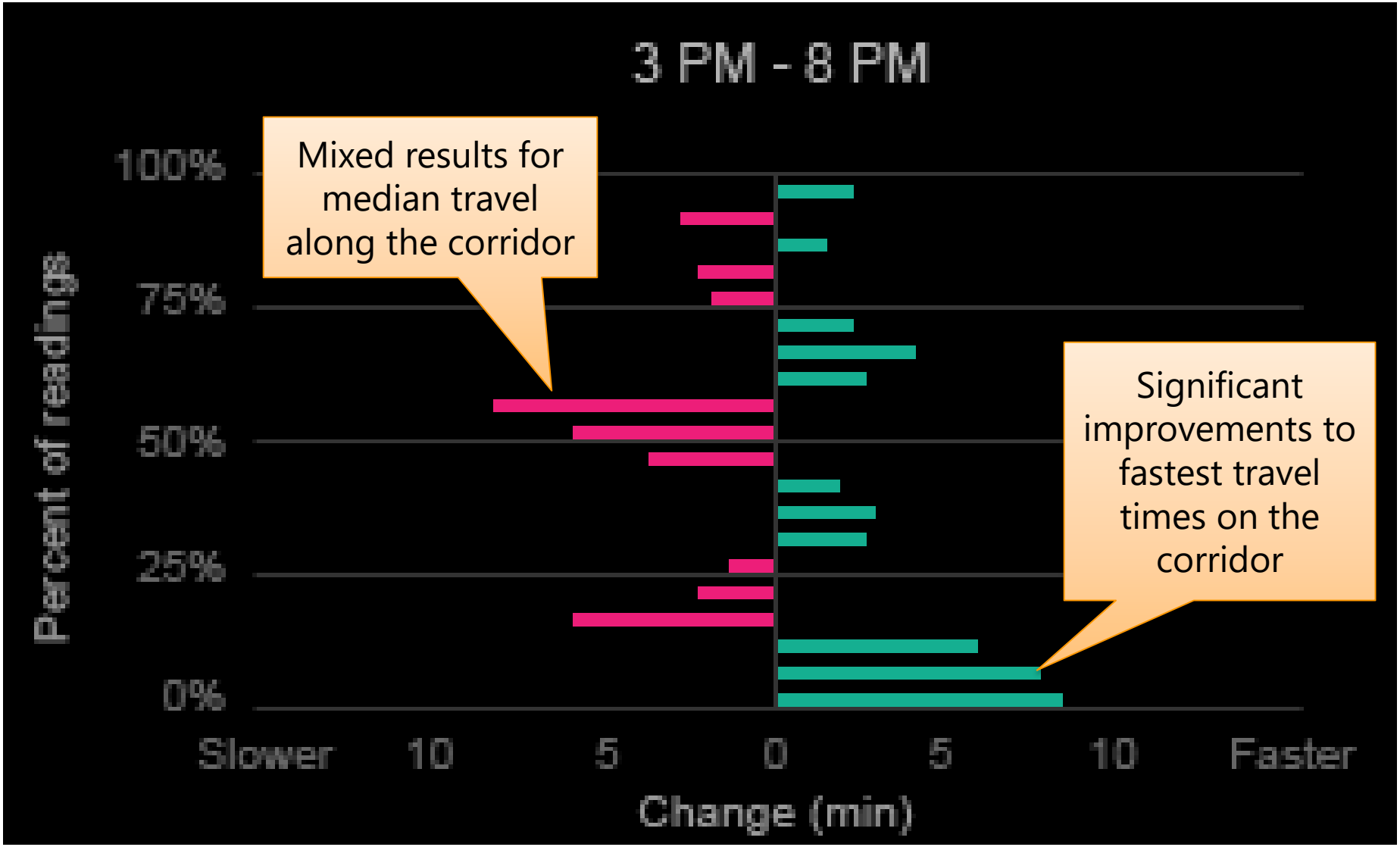


PDA Suite: Cumulative Distribution Chart

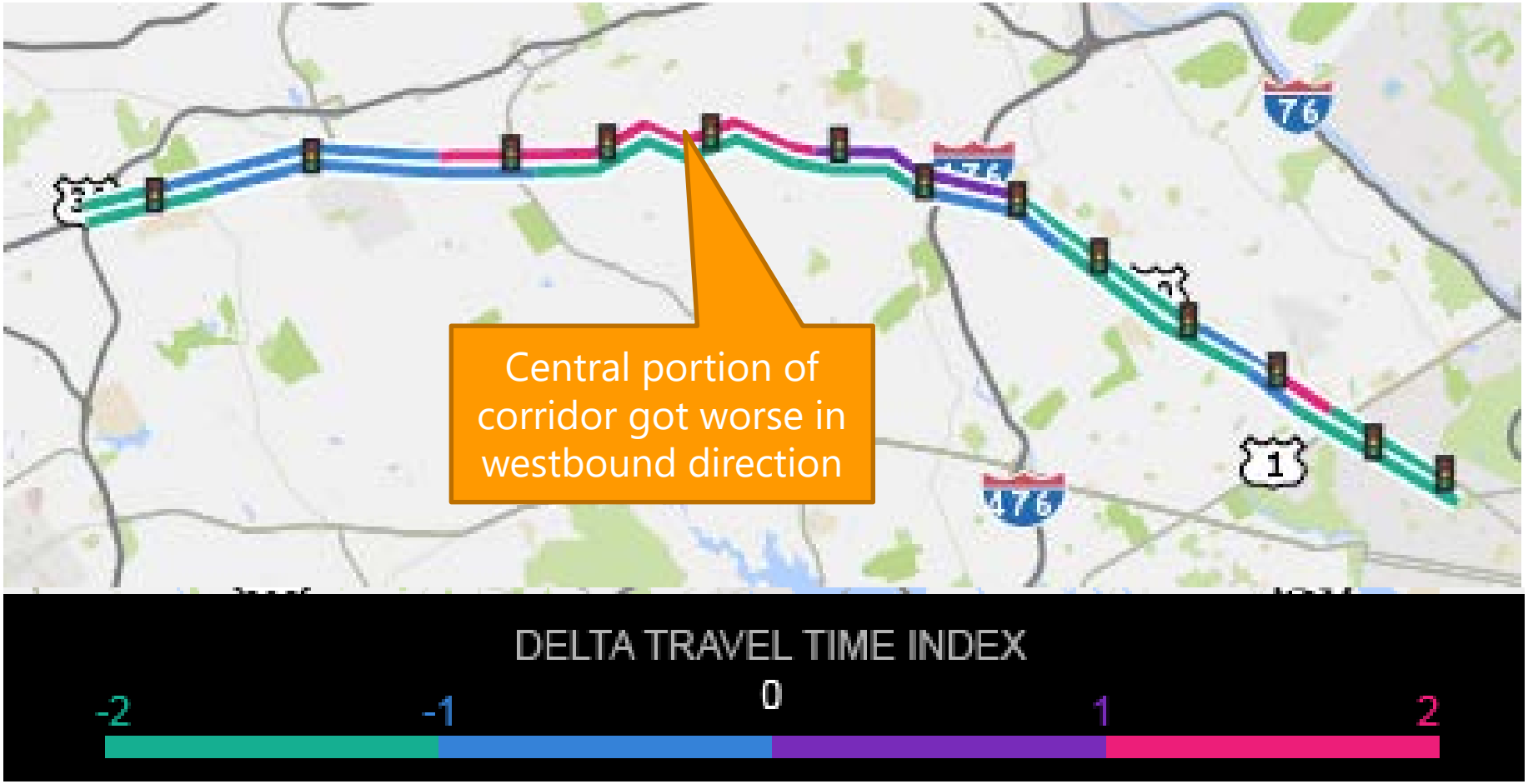


PDA Suite: Change Between Dates

PDA Suite: Change Between Dates



PDA Suite: Change Between Dates



PDA Suite: Travel Time Delta Ranking

Probe Data Analytics Suite

My History | Help | Tutorials | Logout

Travel Time Delta Ranking

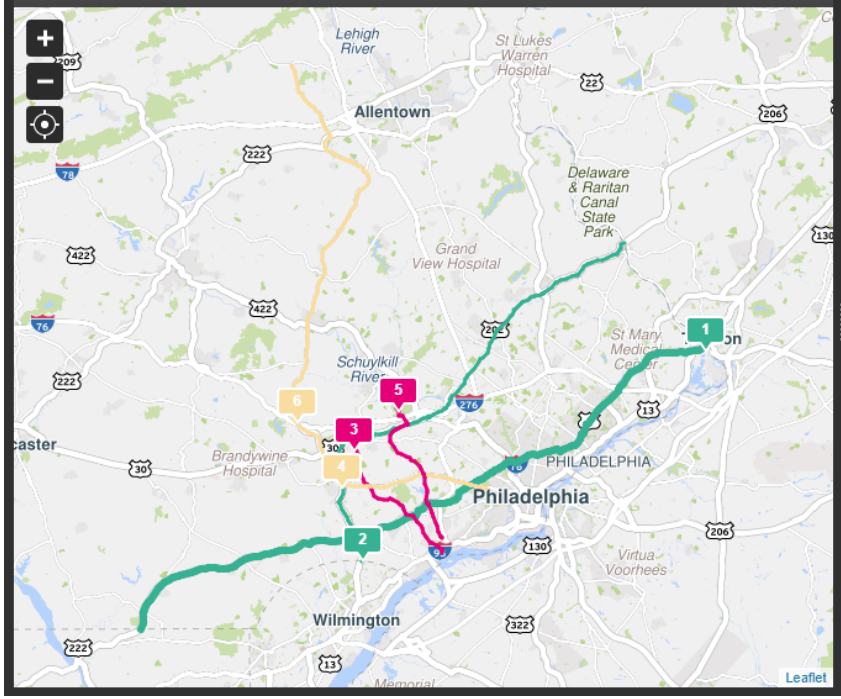
Before
08/21/2017 - 08/25/2017 S M T W T F S

After
08/21/2017 - 08/25/2017 S M T W T F S

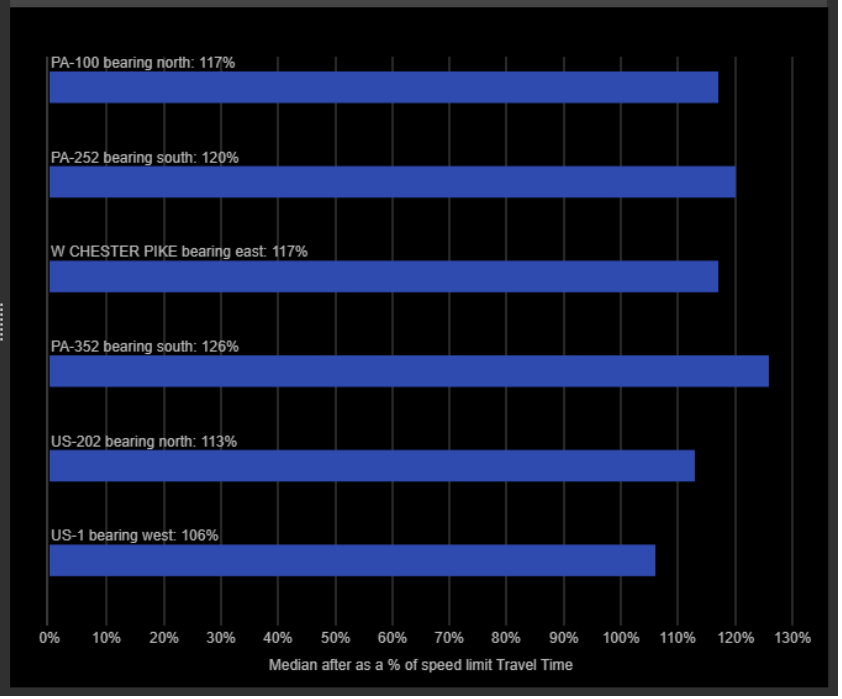
Hours of day
6 AM - 6 PM

Rank	Map	Corridor	Direction	TTSL	Median Before	Median After	Δ Median	IQR Before	IQR After	Δ IQR	Incidents
1	☑	US-1 bearing west	West	106	112%	106%	-6	28%	18%	-10	0
2	☑	US-202 bearing north	North	77	118%	113%	-5	25%	23%	-2	0
3	☑	PA-352 bearing south	South	27	123%	126%	3	21%	23%	2	0
4	☑	W CHESTER PIKE bearing east	East	25	117%	117%	0	28%	28%	0	0
5	☑	PA-252 bearing south	South	31	117%	120%	3	25%	25%	0	0
6	☑	PA-100 bearing north	North	76	117%	117%	0	26%	26%	0	0

Map | Display Options



Bar Chart | X axis: Median After | Display Options



PDA Suite: Travel Time Delta Ranking (Slope Chart)

Intersection-Level Metrics

High Res Data: A Fitness Tracker for Traffic Signals

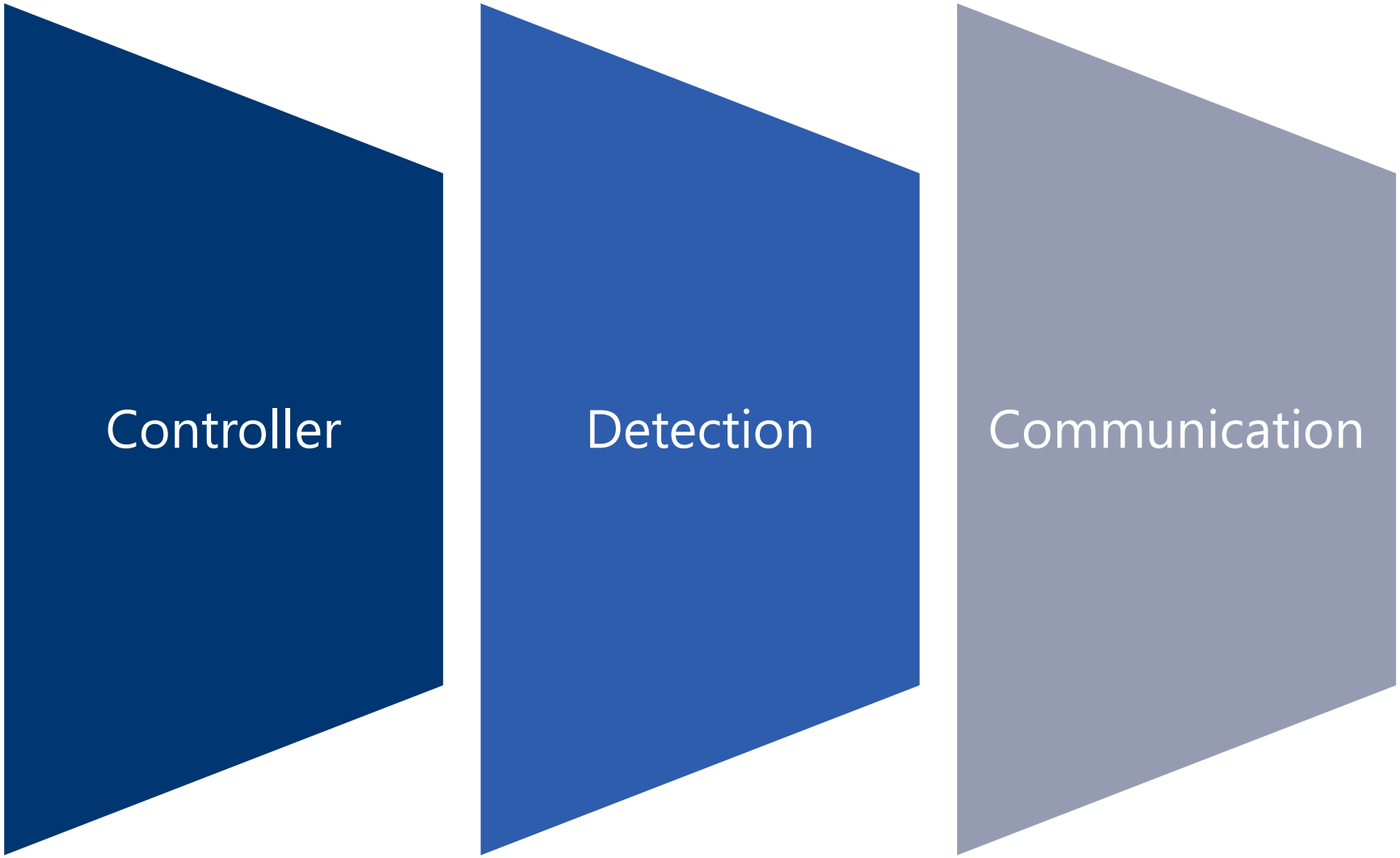
High Resolution Data Collection

Data Analysis & Performance Reporting

Source: FHWA

Center for Transportation Research

ATSPM Implementation



Implementing ATSPM: Controllers

- Buy a new controller for about the same price as doing one round of count, analyze & retime
- Vendor neutral
  - Bulletin 15 #'s in bold below
  - Links to manufacturer product sheets below

Econolite Cobalt: Any version **ECO-127P, 128P & 129P**
Econolite ASC3 NEMA: v2.50+ & OS 1.14.03+ **ECO-116P**
Econolite 2070 w/ 1C CPU: v 32.50+

Peek ATC: Greenwave 03.05.0528+ **PTS-042P**

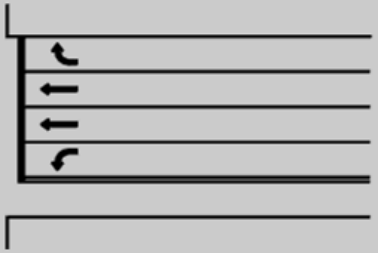
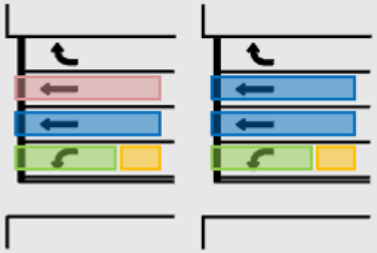
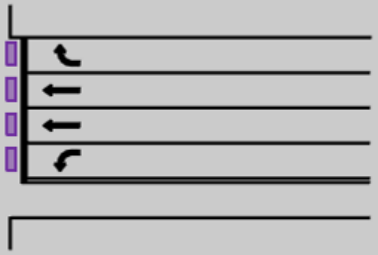
McCain ATC Omni eX 1.6+ **MCC-018P**

Trafficware Model 980**ATC:** v 76.10+ **TFW-011P**
Trafficware ATC Controller: v76.10+

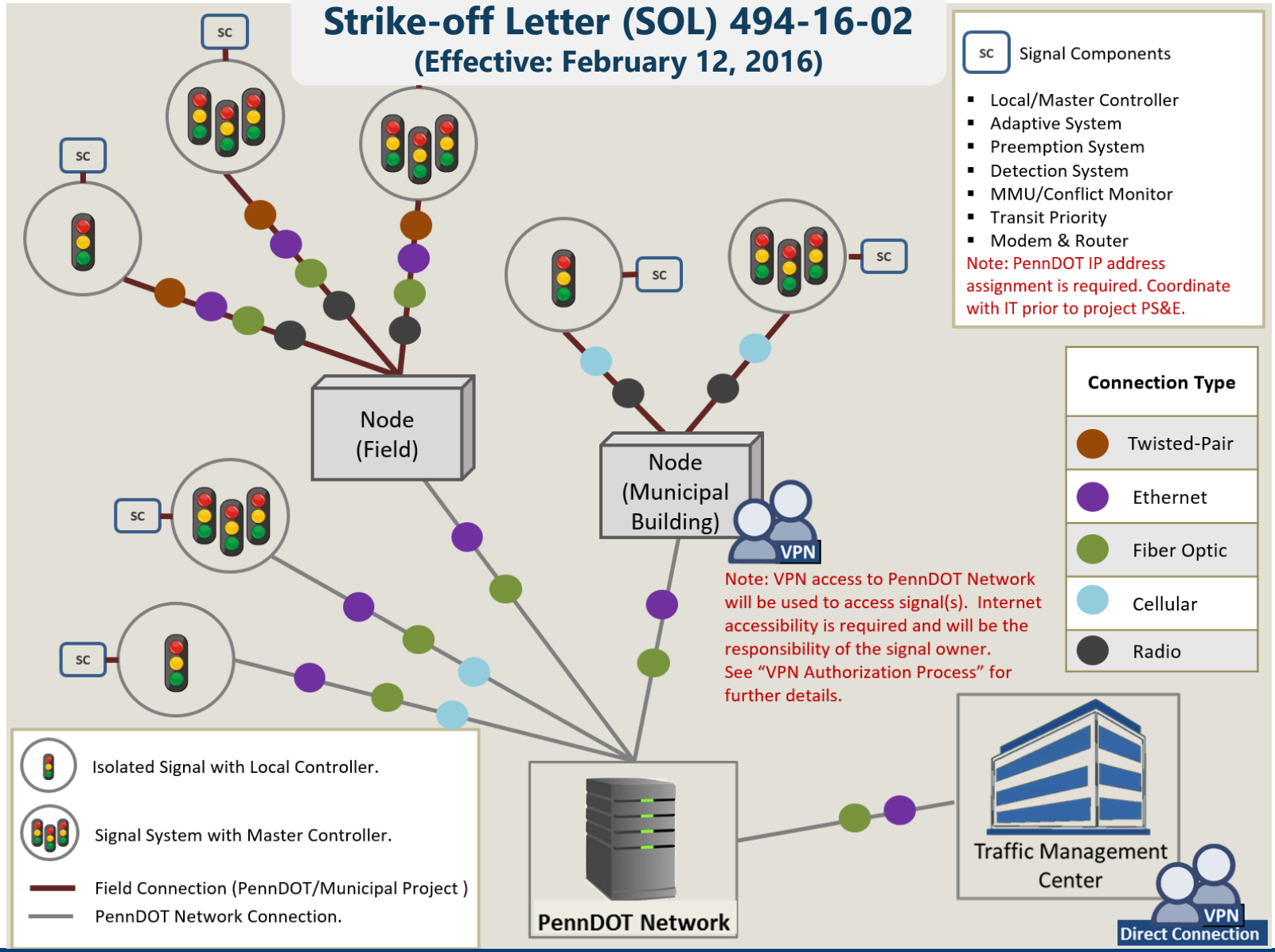
Intelight: Maxtime v1.7.0+ **INT-009P, 010P & 011P**

Siemens M50 *Linux*
Siemens M60 ATC **SMS-231P**
ECOM v 3.52+
NTCIP v 4.53+

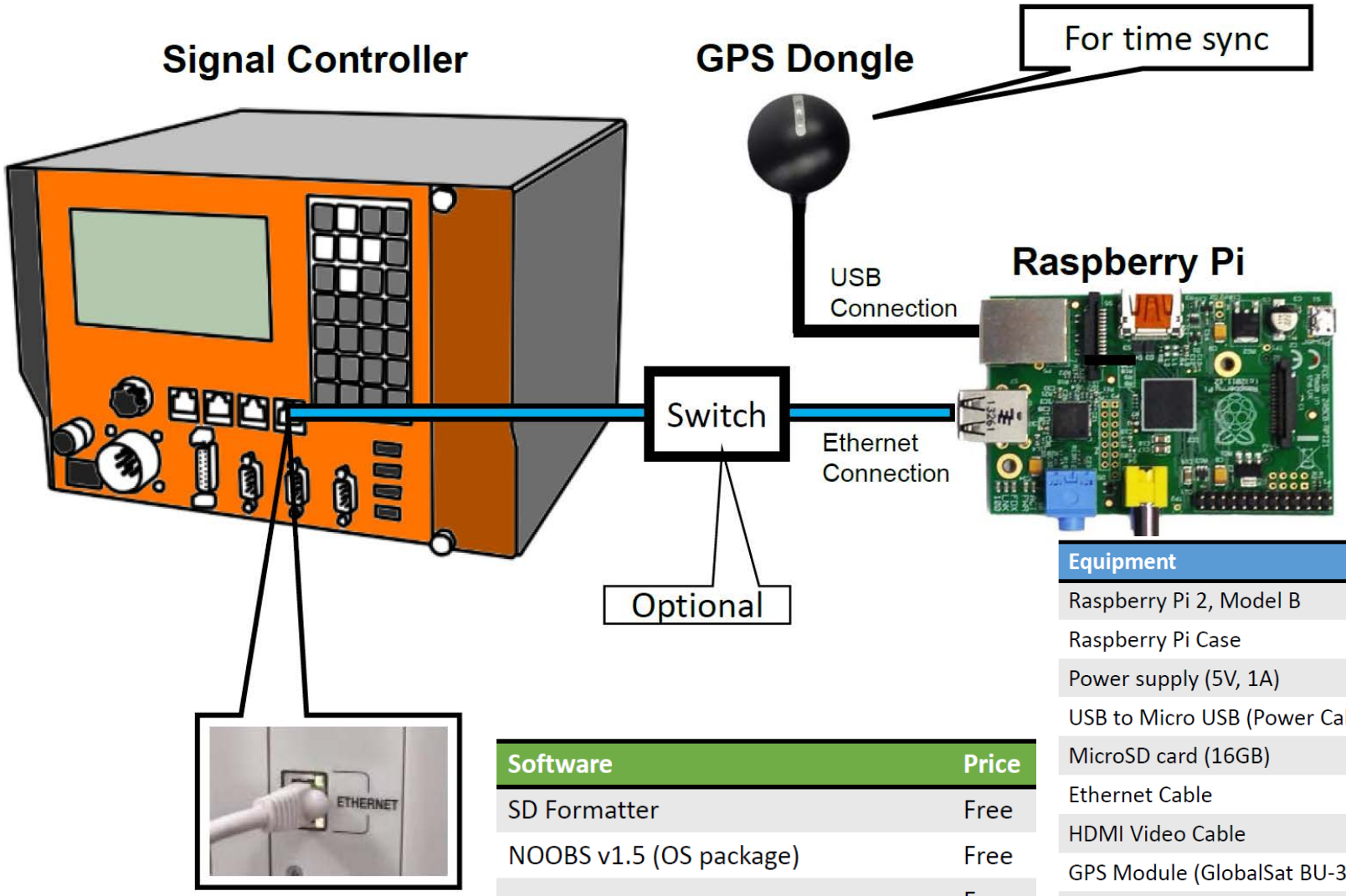
Implementing ATSPM: Detection

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

Implementing ATSPM: Communication



Implementing ATSPM: No Communication

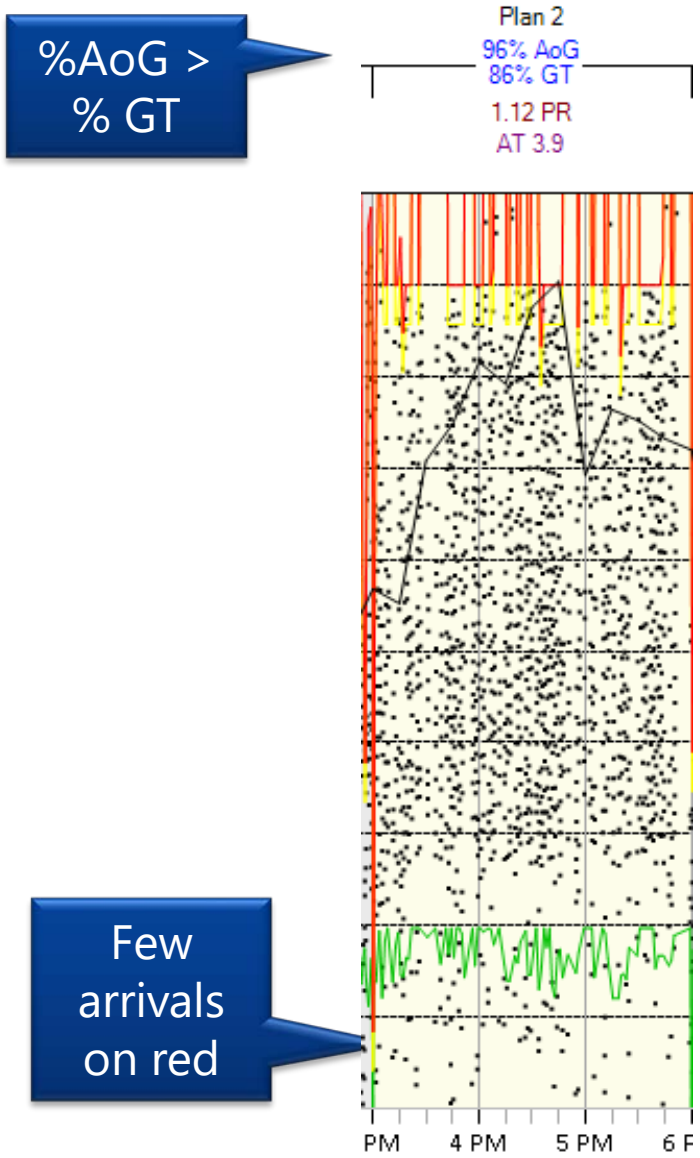


Software	Price
SD Formatter	Free
NOOBS v1.5 (OS package)	Free
cgps	Free
signalrpi (Purdue)	Free

Equipment	Price
Raspberry Pi 2, Model B	$35
Raspberry Pi Case	$10
Power supply (5V, 1A)	$6
USB to Micro USB (Power Cable)	$4
MicroSD card (16GB)	$10
Ethernet Cable	$2
HDMI Video Cable	$8
GPS Module (GlobalSat BU-353-S4)	$30
Ethernet Switch – *optional*	$25
Total	**$130**

ATSPM: Improve progression on critical corridors

- Purdue Coordination Diagram



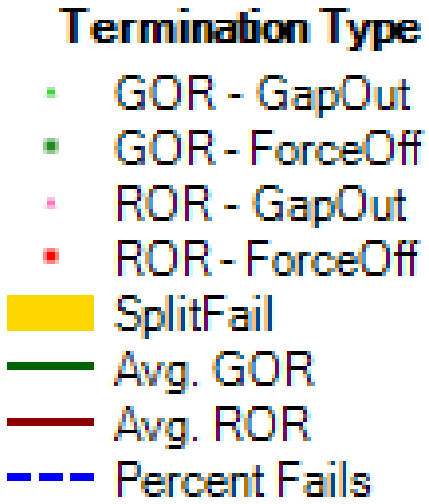
ATSPM: Split Failures

- **Green Occupancy Ratio (GOR)**
  - % of time detection zone occupied while signal is **green** for the lane(s) served by the phase
- **Red Occupancy Ratio (ROR)**
  - % of time detection zone occupied during **first 5 seconds of red** for the lane(s) served by the phase
- **Split Failure**

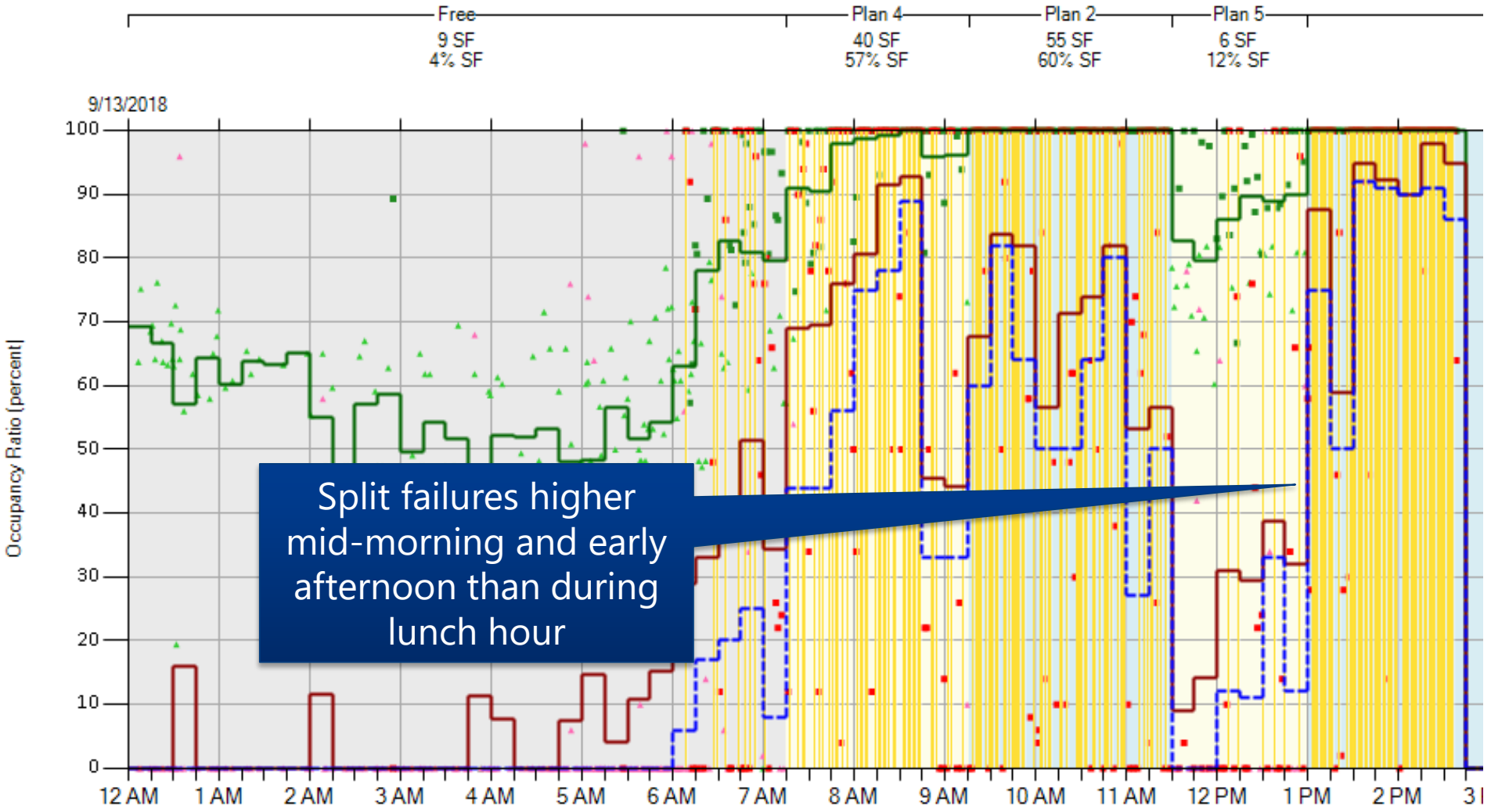
  80%+ **GOR**

  AND

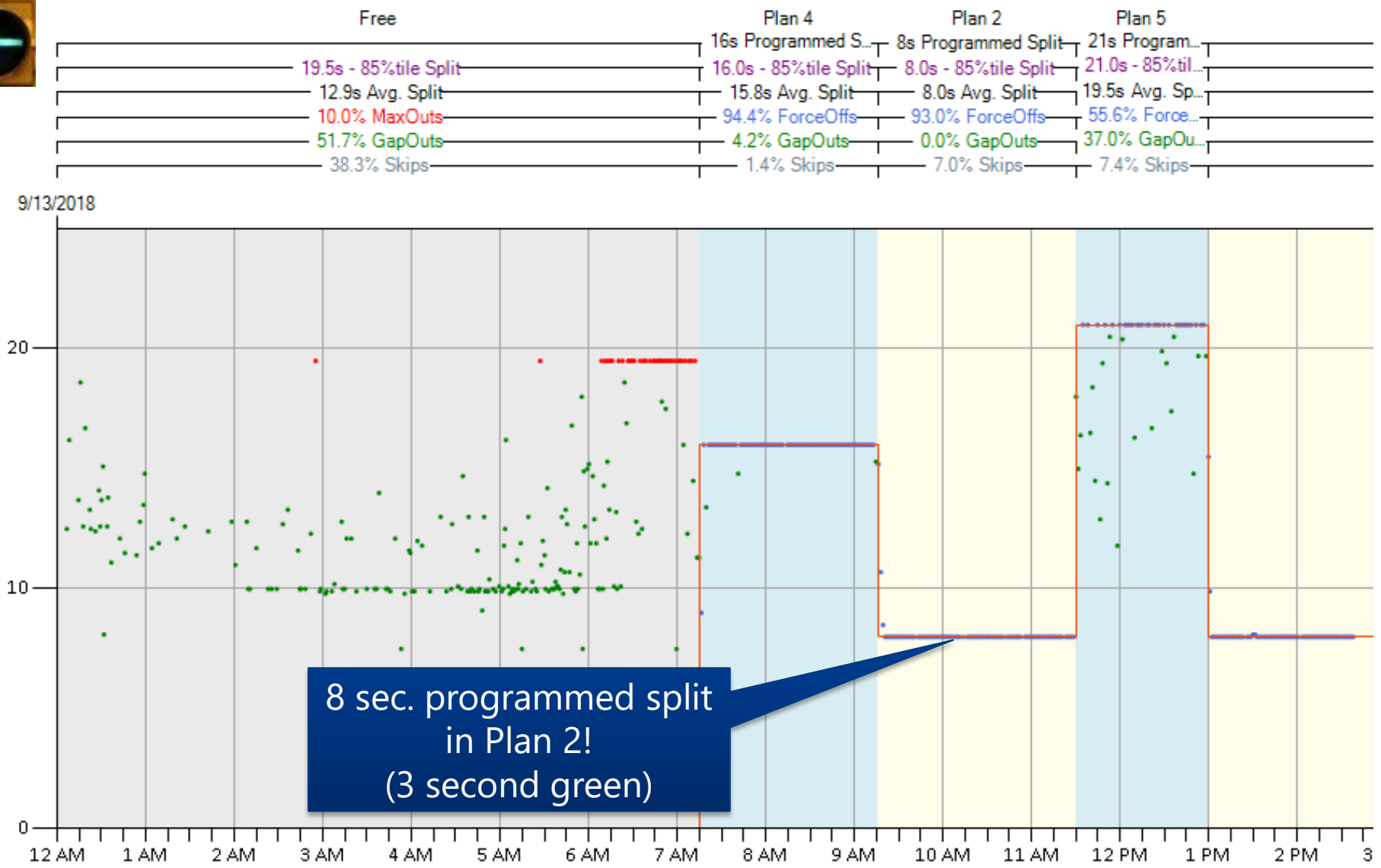
  80%+ **ROR**



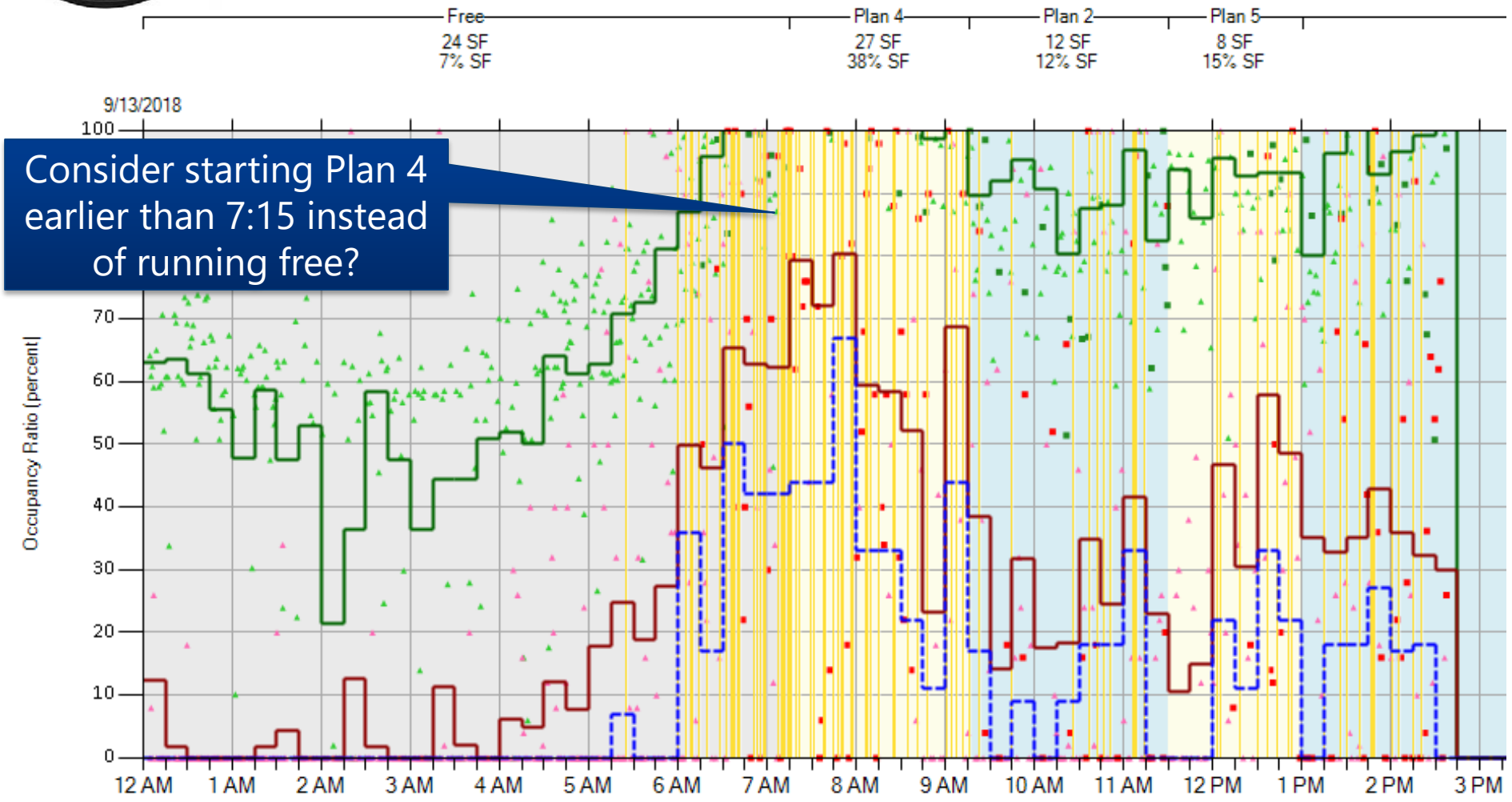
ATSPM: Minimize delay for intersecting users



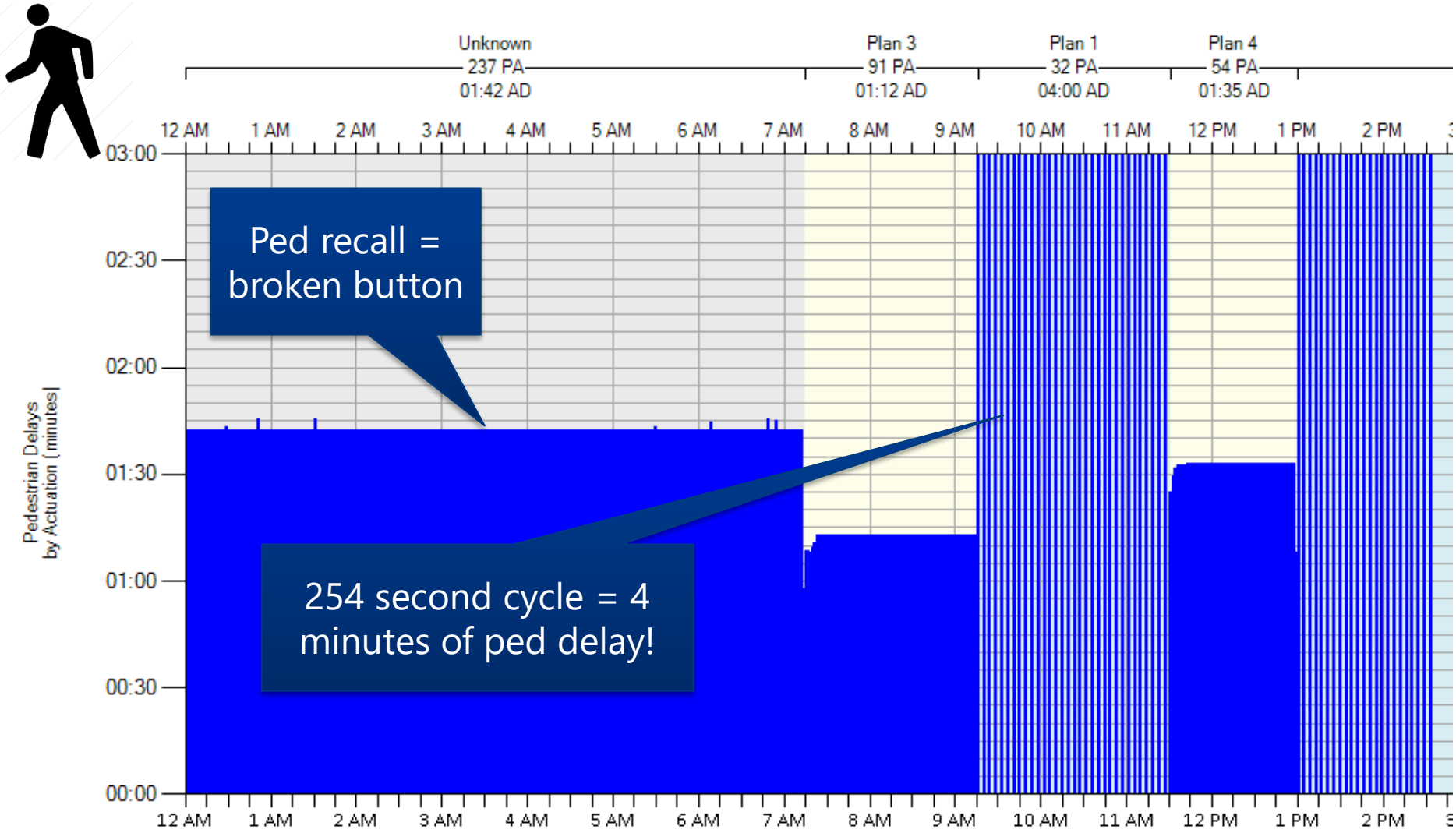
Minimize delay for intersecting users



Minimize delay for intersecting users



ATSPM: Minimize delay for intersecting users



ATSPM: Maintain equipment

Free	Plan 3	Plan 1	Plan 4
	0s Programmed Split	0s Programmed Split	60s Program...
65.0s - 85%tile Split	35.5s - 85%tile Split	209.5s - 85%tile Split	55.5s - 85%til...
65.0s Avg. Split	34.5s Avg. Split	208.3s Avg. Split	55.2s Avg. Sp...
98.7% MaxOuts	92.3% ForceOffs	87.5% ForceOffs	87.0% Force...
1.3% GapOuts	7.7% GapOuts	9.4% GapOuts	11.1% GapO...
0.0% Skips	0.0% Skips	3.1% Skips	1.9% Skips

9/13/2018

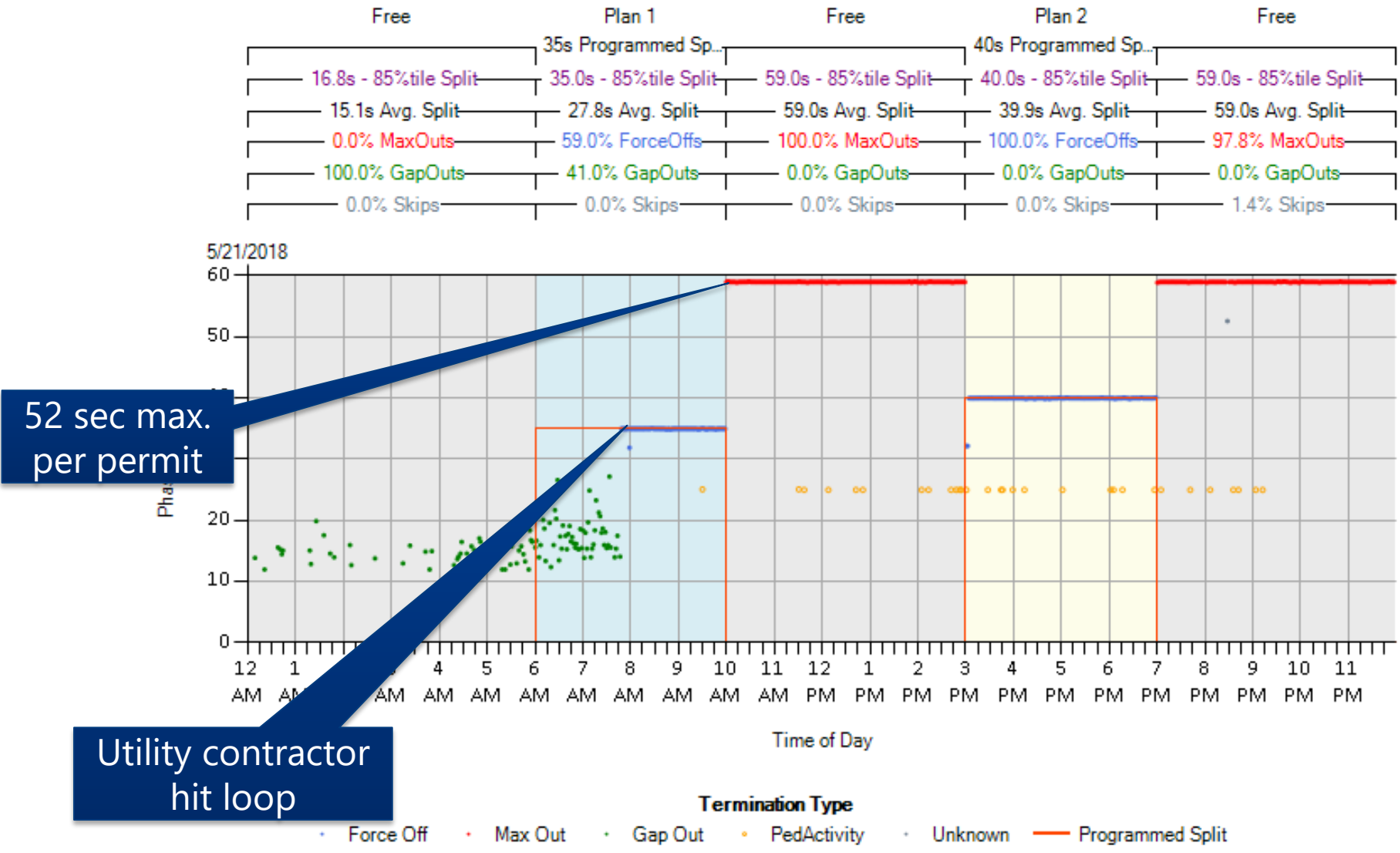
Phase Split (s)

250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

12 AM 1 AM 2 AM 3 AM 4 AM 5 AM 6 AM 7 AM 8 AM 9 AM 10 AM 11 AM 12 PM 1 PM 2 PM

209 second split?
254 second cycle?
Programming error!

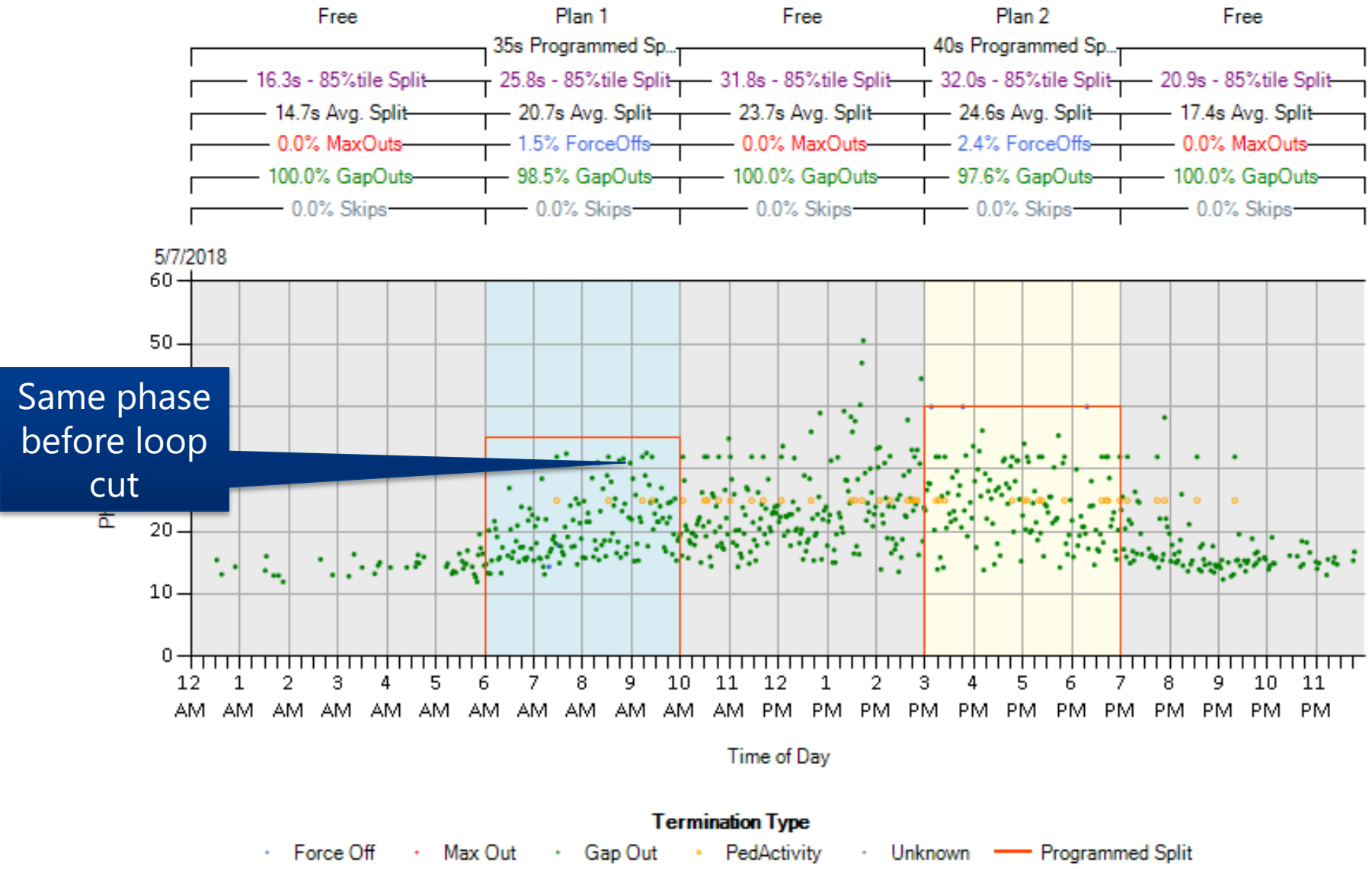
ATSPM: Maintain equipment



52 sec max. per permit

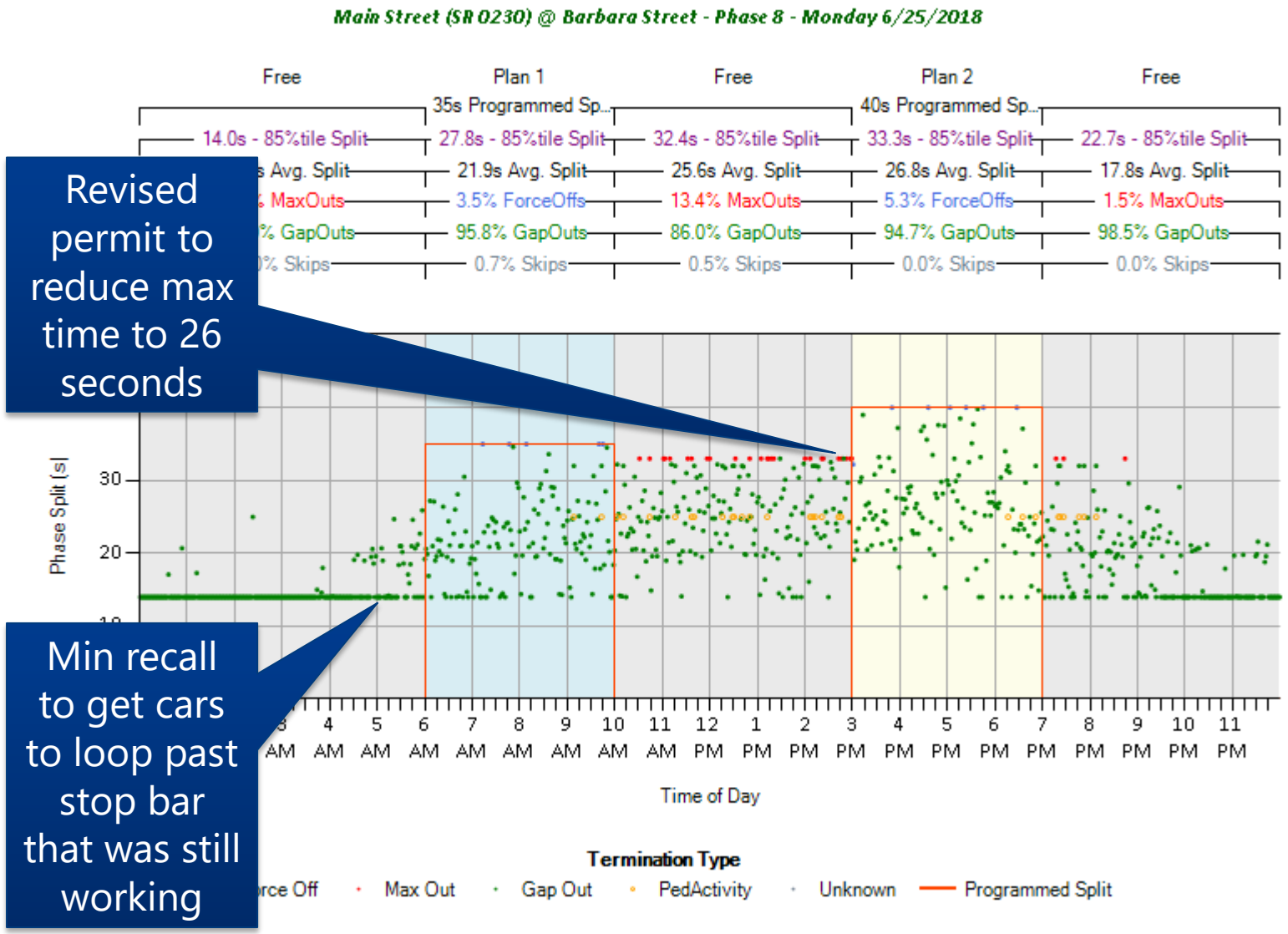
Utility contractor hit loop

ATSPM: Maintain equipment



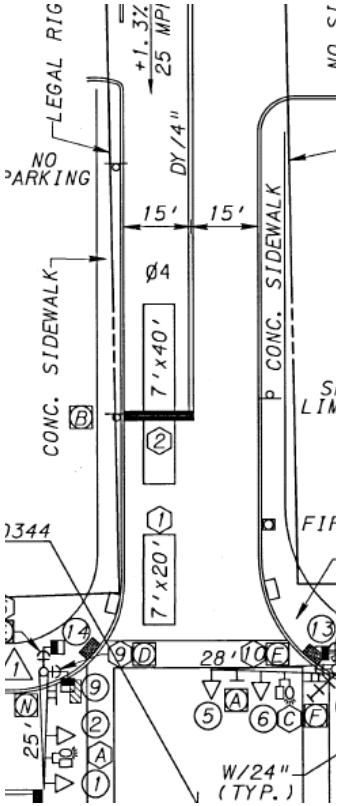
Same phase before loop cut

ATSPM: Maintain equipment

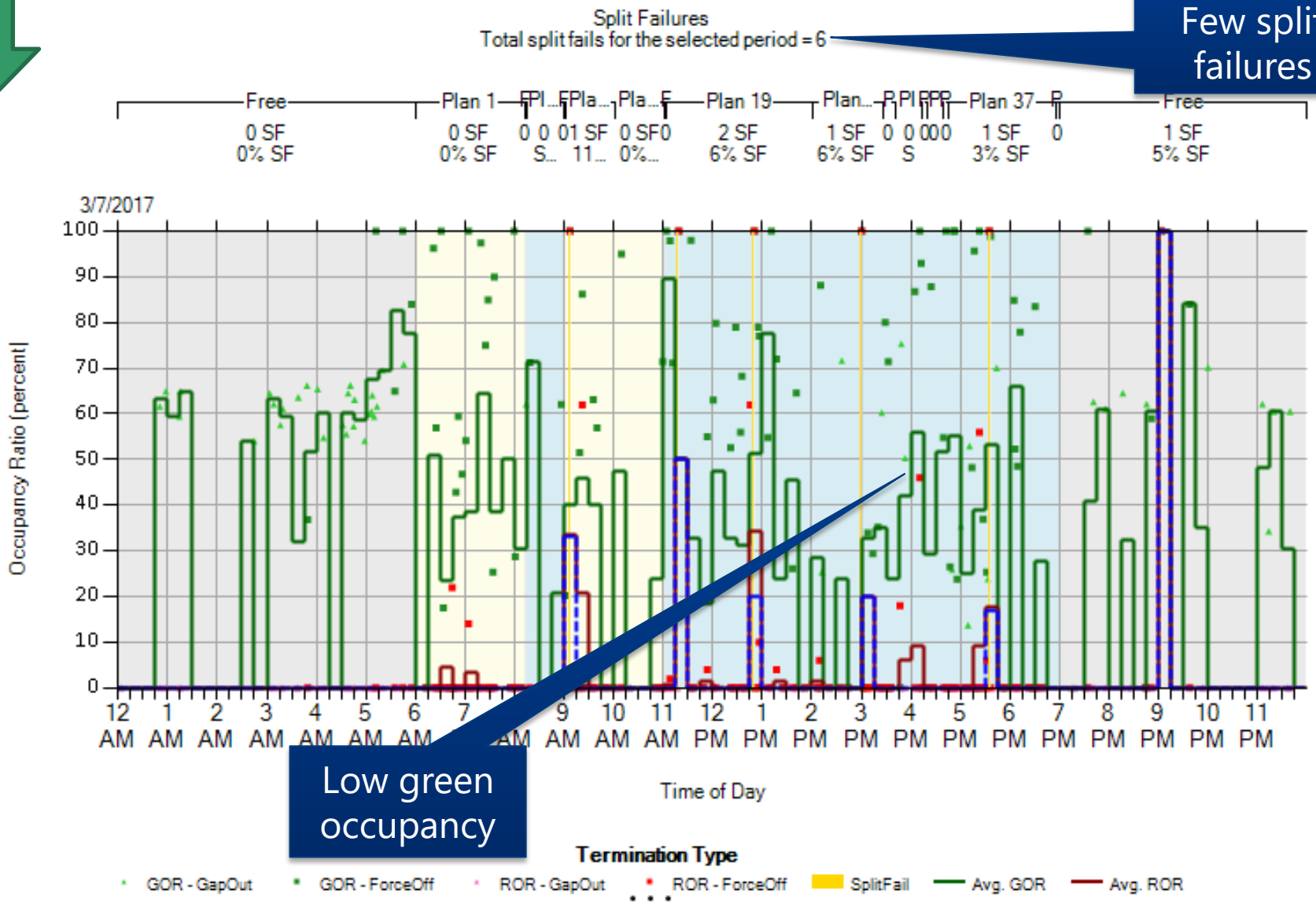


Revised permit to reduce max time to 26 seconds

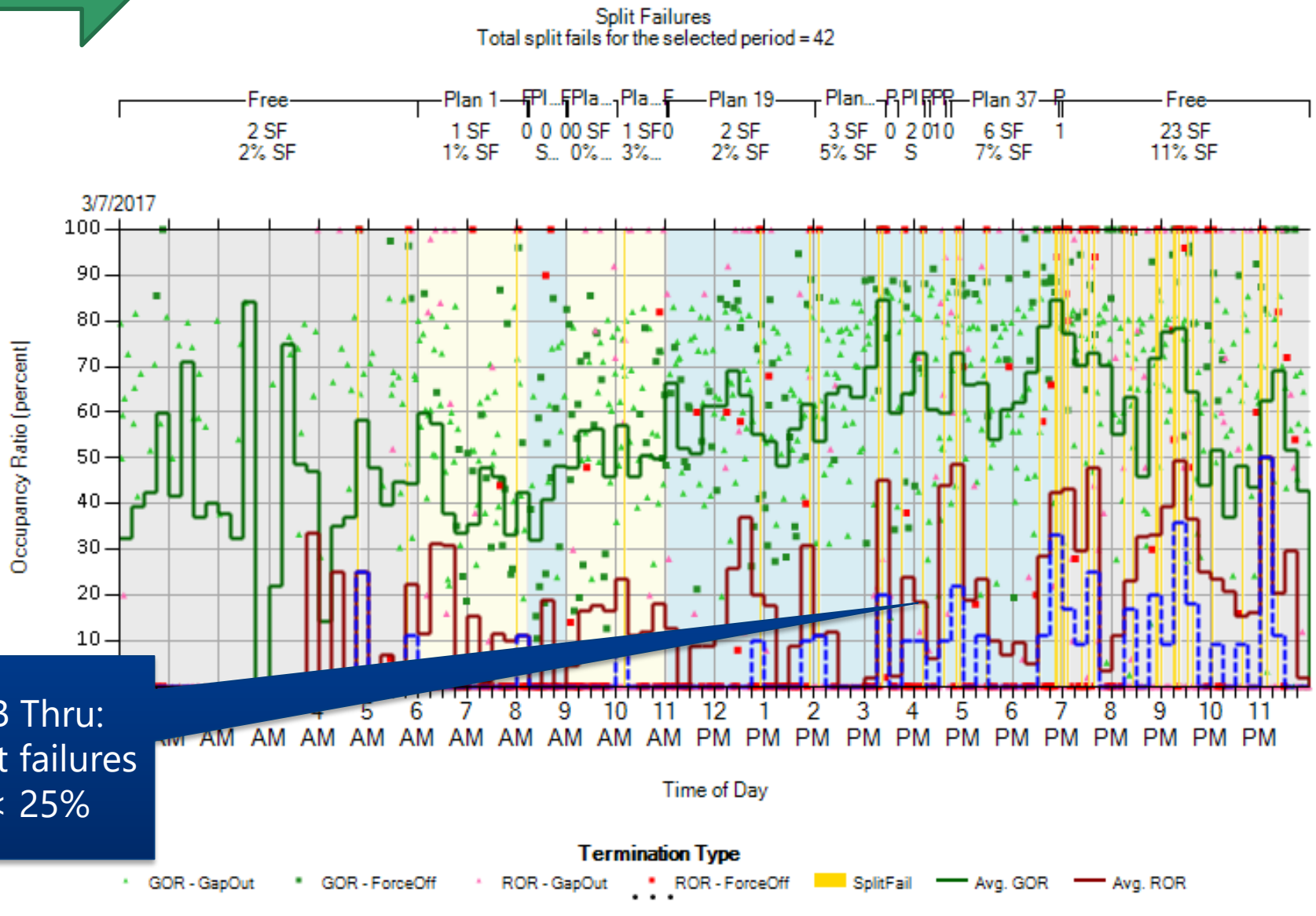
Min recall to get cars to loop past stop bar that was still working



ATSPM: Example (Shippensburg, PA)

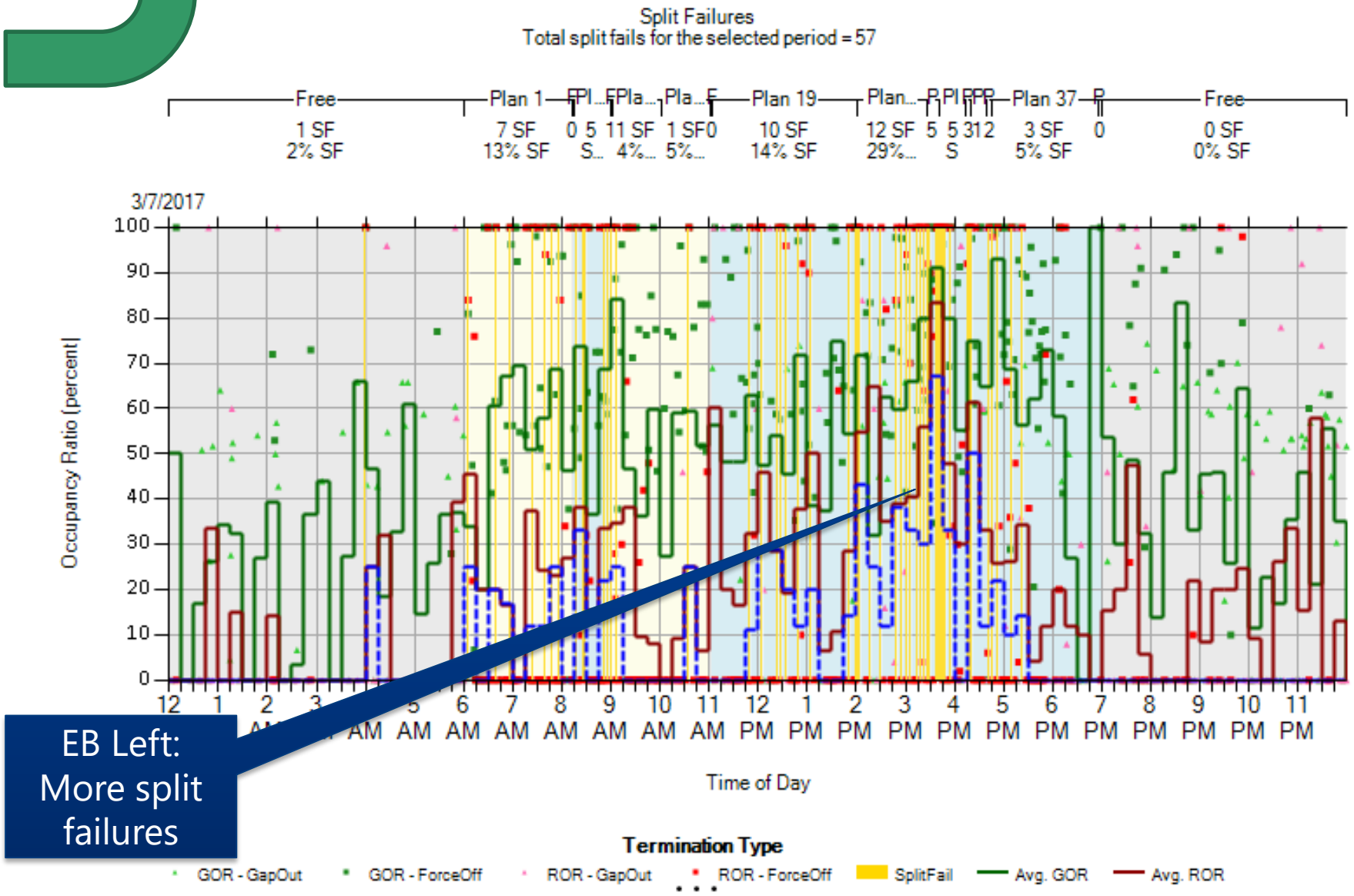


ATSPM: Example (Shippensburg, PA)



EB Thru: Split failures < 25%

ATSPM: Example (Shippensburg, PA)



EB Left: More split failures

Automated Traffic Signal Performance Measures

Steve Gault, P.E., PTOE

Statewide Traffic Signal Operations Engineer

Pennsylvania Department of Transportation

717.787.6988

sgault@pa.gov