THE EASTERN TRANSPORTATION COALITION

CONNECTING FOR SOLUTIONS

Everything You've Ever Wanted To Know About ATSPMs:

Harnessing The Power Of Automated Signal Performance Metrics For Your Agency

November 9, 2022

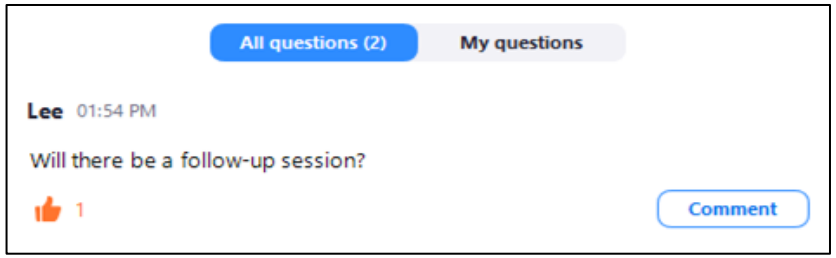
Welcome

- We are using **Zoom Webinar**
- **AUDIO (Computer):** Use your computer speakers and microphone by clicking the “Join Audio” button at the bottom left of the screen. You will be muted.
- **Alternate Audio (Phone):** Call into the meeting by dialing the phone number based on your location (provided in the confirmation email) and enter the Meeting ID at the prompt. You will be muted.
- **This web meeting is being recorded.**
- **Questions** with the audio or web? Please contact Esther via email (ekleit@kmjinc.com)

Asking Questions in the Q&A Box

- Click on the Q&A icon at the bottom of your screen

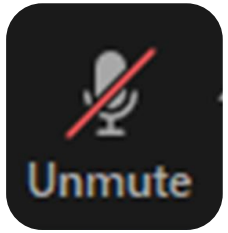
- The questions in the Q&A box will be monitored and answered either between presentations or at the end of the meeting
- You can keep track of your questions in the "My Questions" tab in the Q&A box



Asking Questions Verbally

- Please raise your hand *(click on the hand icon at the bottom of the screen)*, and a host will unmute you.
- Please give your name and agency before asking your question

- **Please mute yourself when you are finished speaking**



Welcome

Denise Markow
TSMO Program Director
The Eastern Transportation Coalition

Lisa Miller
Innovation Program Manager
The Eastern Transportation Coalition

Coalition Update

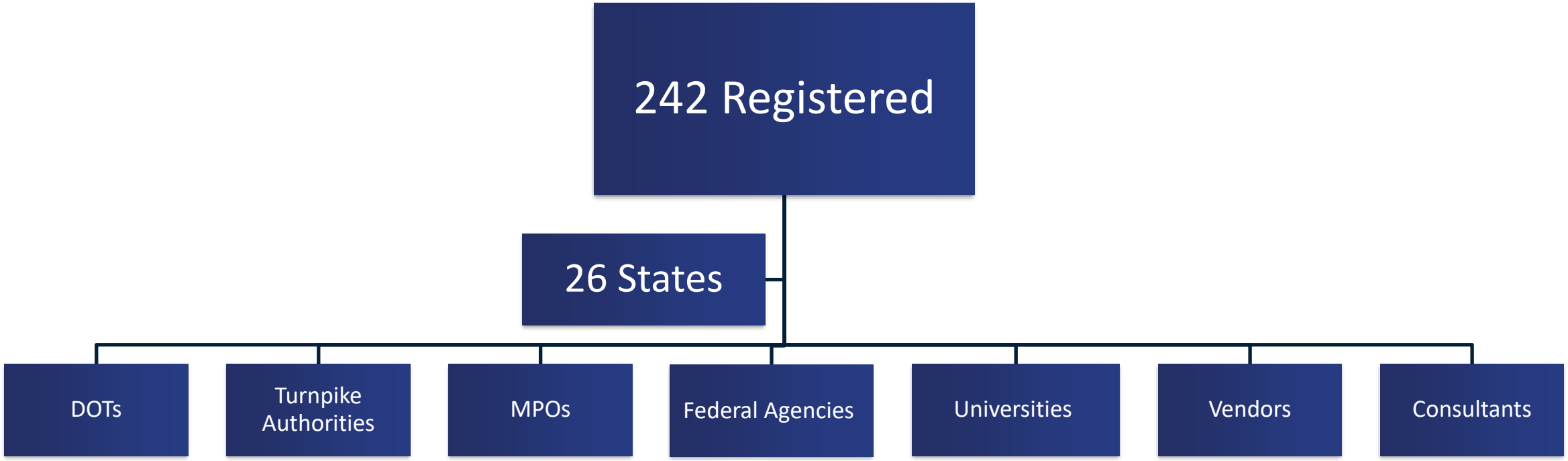
RECENT

- ✓ All Things ADAS (Advanced Driver Assist Systems) Webinar - Sept. 27, 2022
- ✓ Transportation Data Marketplace: Waypoint, Origin-Destination, and Freight Vendor Forums (*invite only*) - Aug. & Sept. 2022
- ✓ Potomac HOGs Exchange (In Person) (*invite only*) - Oct. 18, 2022
- ✓ Del-Val HOGs Exchange (In Person) (*invite only*) - Nov. 2, 2022

UPCOMING

- ➢ RITIS Workshop #3 - After Action Templates - Nov. 17, 2022
- ➢ Southern HOGs Exchange (In Person) (*invite only*) - Dec. 6-7, 2022
- ➢ NHTS Nex Gen Webinar - Jan. 26, 2023
- ➢ RITIS User Group Meeting - Feb. 2, 2023

The Eastern Transportation Coalition Sponsored Event



Agenda

Topic	Speaker
Housekeeping	Joanna Reagle, KMJ Consulting, Inc.
Welcome & Update by the Eastern Transportation Coalition Harnessing the Power of Automated Traffic Signal Performance Metrics for your Agency	Lisa Miller, Innovation Program Associate, The Eastern Transportation Coalition
History and Progress of ATSPMs	Mark Taylor, Traffic Signal Operations Engineer, Utah DOT
ATSPMs for Everyone	Joanna Bush, Traffic Signal Engineer, Mead and Hunt
Adaptive to ATSPM – A User's Guide	Kelly McVeigh, Supervising Engineer, New Jersey DOT
Incorporating Energy and GHG into ATSPMs	Stanley Young, Chief Data Officer, The Eastern Transportation Coalition
Q&A/Discussion	Lisa Miller

Speakers

Mark Taylor

Traffic Signal Operations Engineer

Utah DOT

Kelly McVeigh

Supervising Engineer

New Jersey DOT

Joanna Bush

Traffic Signal Engineer

Mead and Hunt

Stanley Young

Chief Data Officer

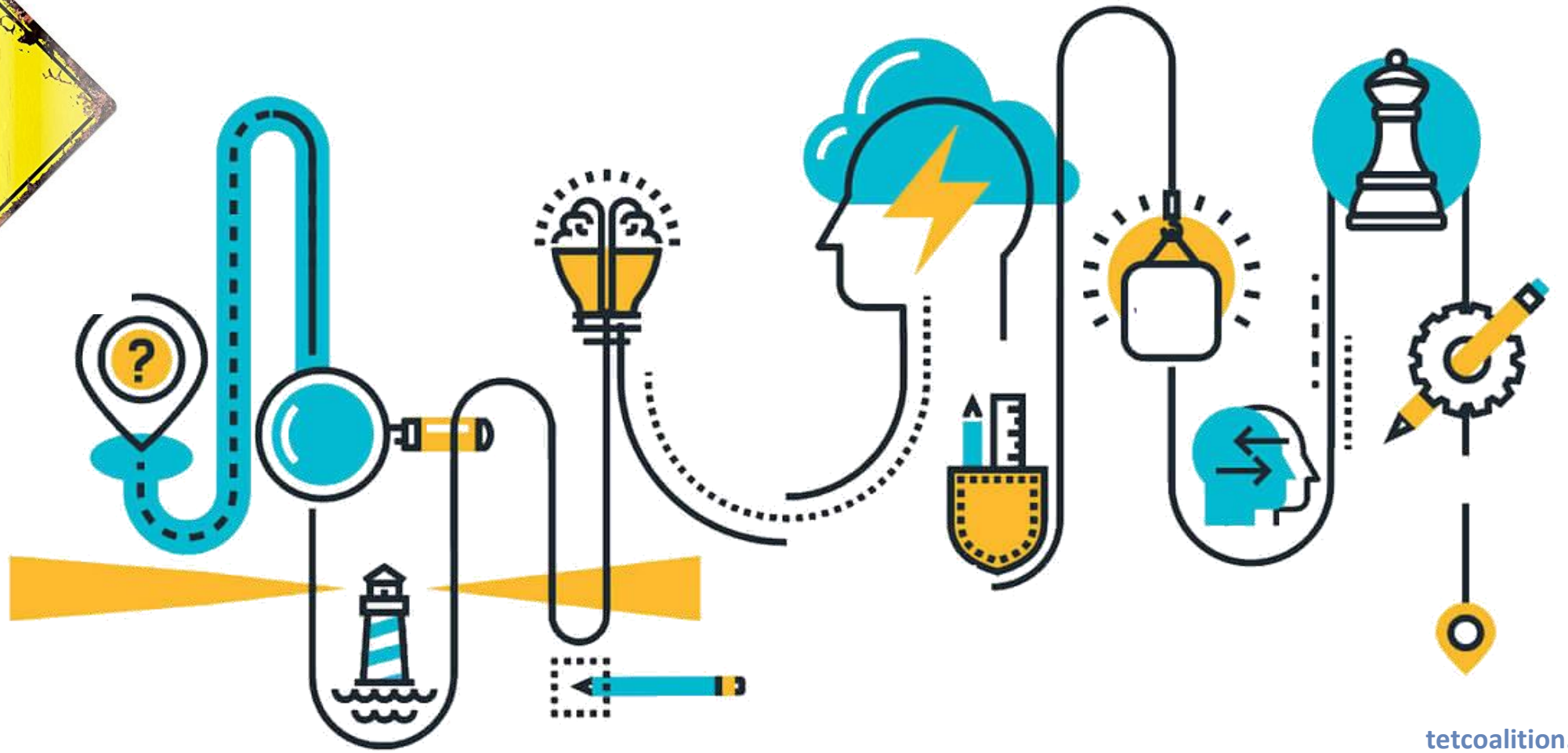
The Eastern Transportation Coalition

tetcoalition.org

Harnessing the Power of Automated Traffic Signal Performance Metrics for your Agency

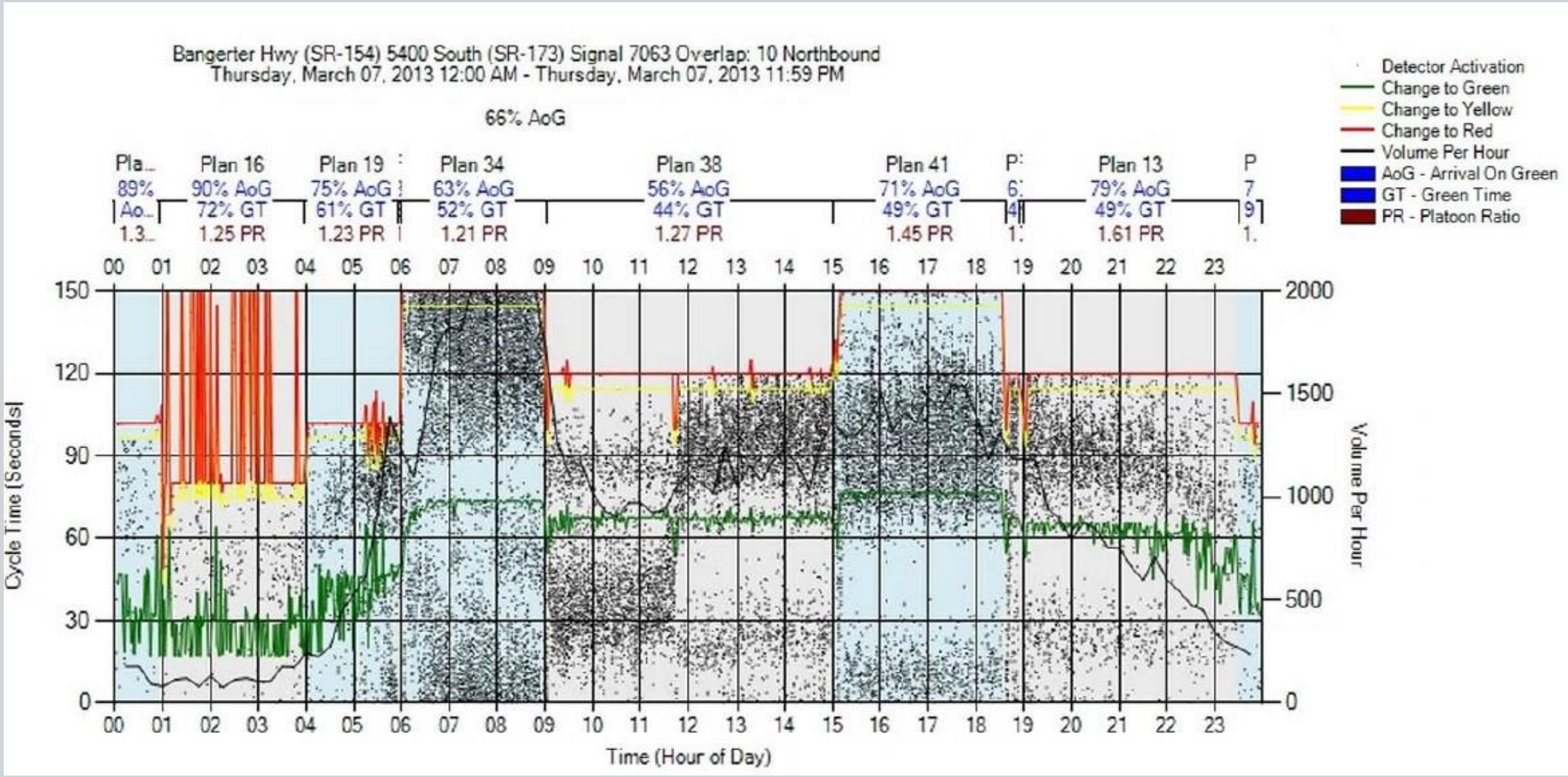
Lisa Miller
Innovation Program Manager
The Eastern Transportation Coalition

Doing Business



tetcoalition.org

What the Signal Engineer Sees…

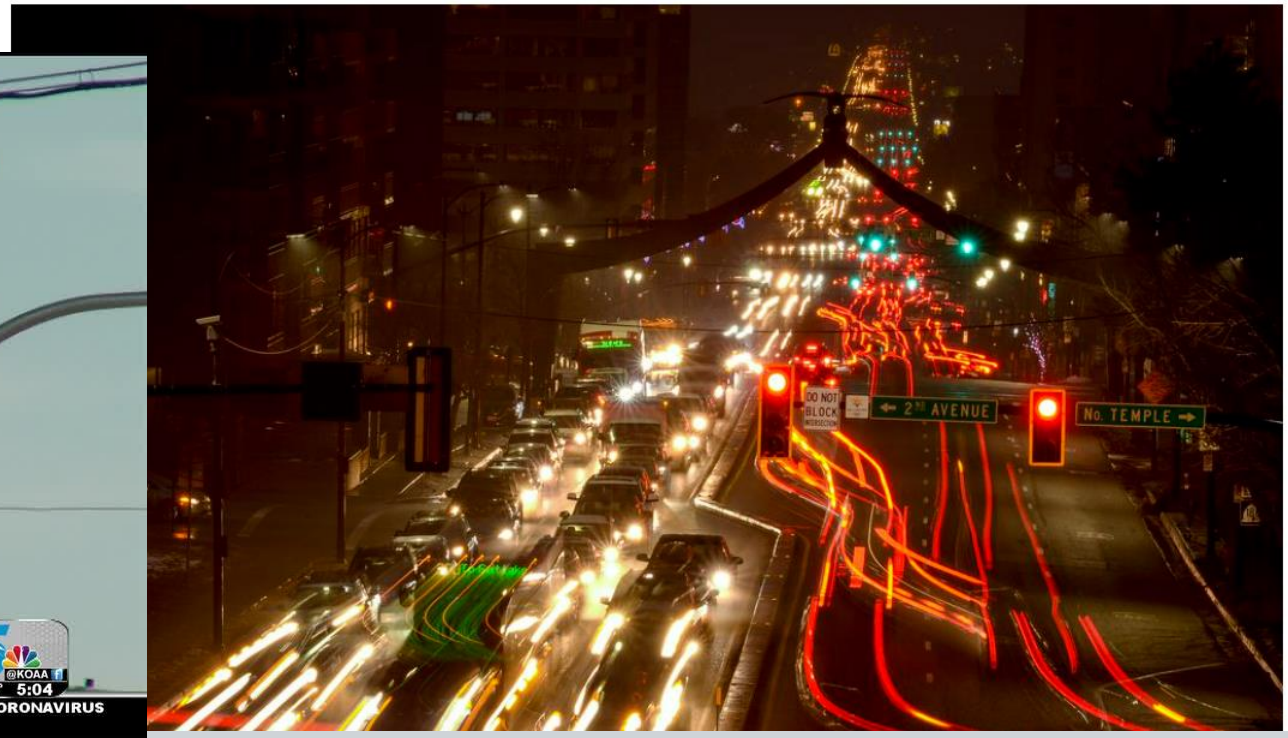


tetcoalition.org

What the Public Sees…

How are traffic lights timed in your neighborhood? Here's how you can find out.

UDOT tracks some 2,000 intersections, and you can access all that data.



Poll 1: What's your use/implementation of ATSPMs?

1. Fully institutionalized
2. We're doing a pilot
3. We're thinking about a pilot
4. I don't know what ATSPM stands for

Poll 2: What are your agency policies regarding signal timing updates?

1. We can do updates whenever it's valuable
2. We need to have approval before any changes
3. It's a blend of approvals and as-needed

Poll 3: How are your signals operated within your jurisdiction?

1. State DOT operates all signals
2. Municipality/county and State DOT operation is blended
3. It depends on the jurisdiction
4. The State DOT does not operate any signals

History and Progress of ATSPMs

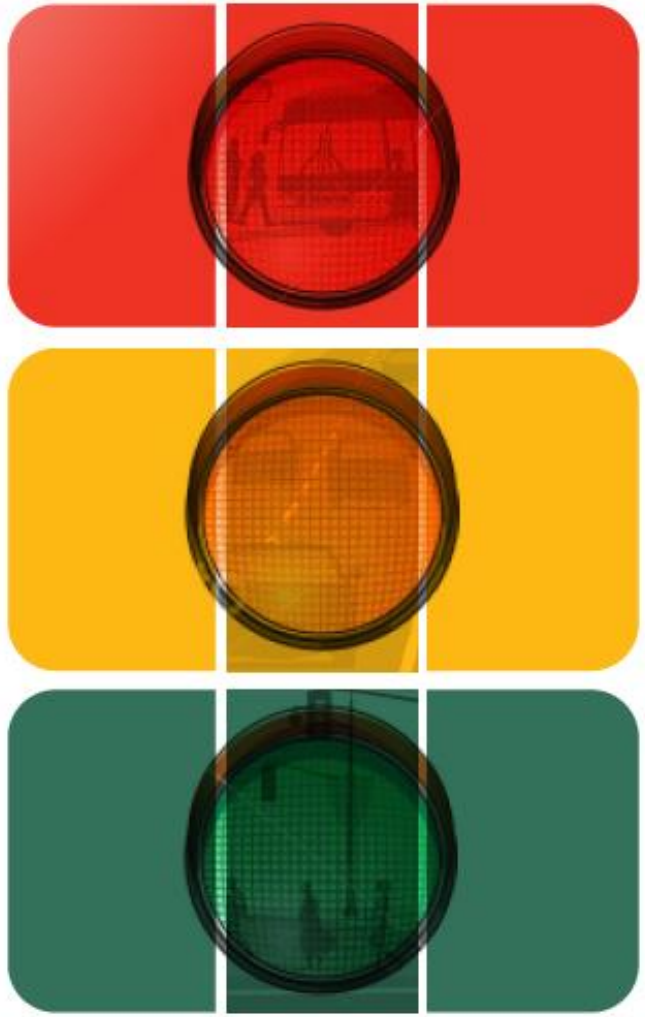
Mark Taylor
Traffic Signal Operations Engineer
Utah DOT

History and Progress of ATSPMs

Mark Taylor, P.E., PTOE
Traffic Signal Operations Engineer
Utah Department of Transportation

Number of Traffic Signals & Connectivity in Utah

Jurisdiction	# Signals	% Signals	% Connected
Total (Utah)	2314	100%	95%
UDOT	1323	57%	99.5%
Cities	991	43%	88%
USA Total	327,860 (Year 2018)	Utah: 0.69% of USA	~65%*

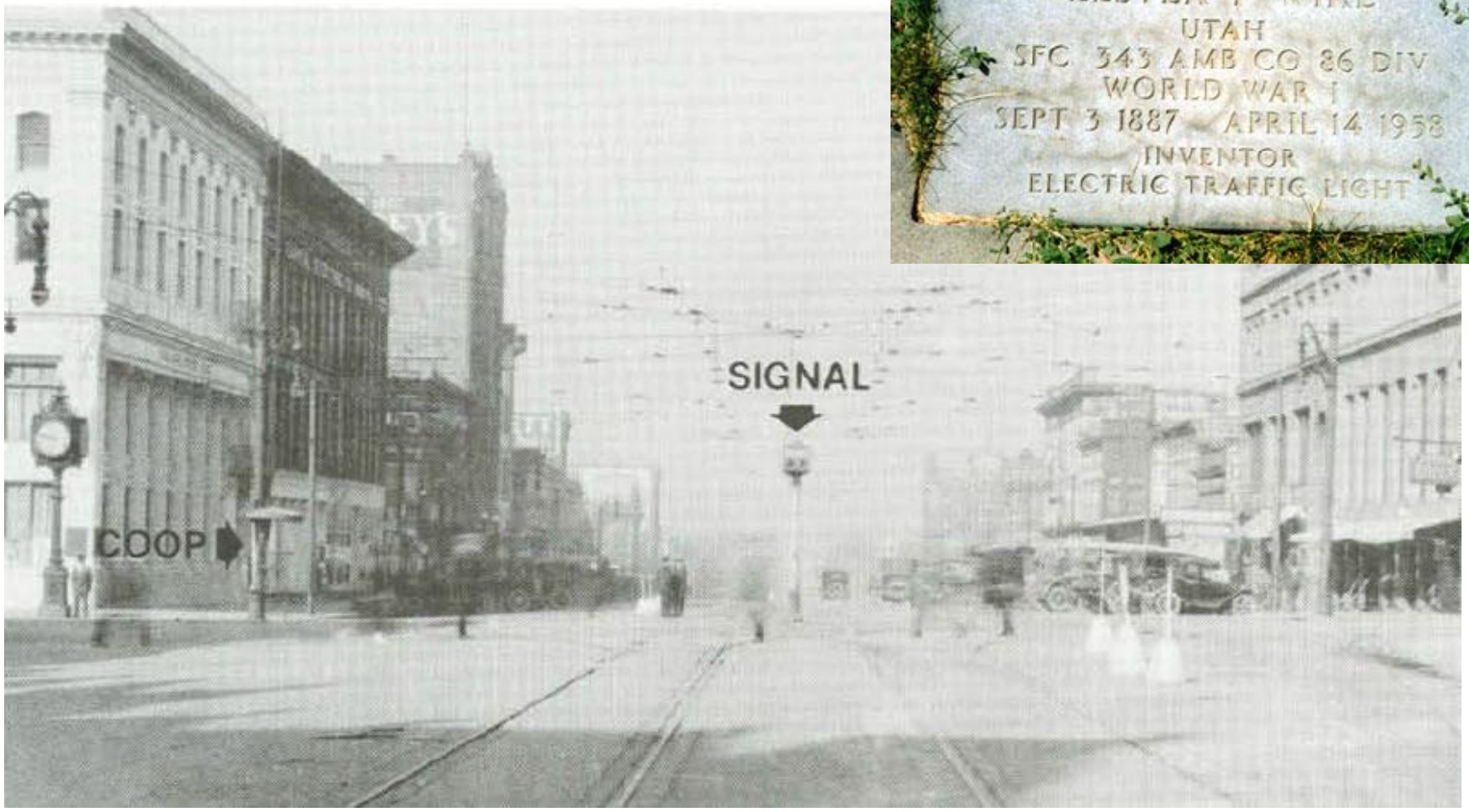


*17 states surveyed December 2018
Revision: October 17, 2022

54 Jurisdictions in Utah Own Traffic Signals

1st Traffic Light in World – Lester Wire

Year: 1912 - Main St & 200 South, Salt Lake City, Utah



Evolution of Traffic Signal Performance Measures

Electromechanical

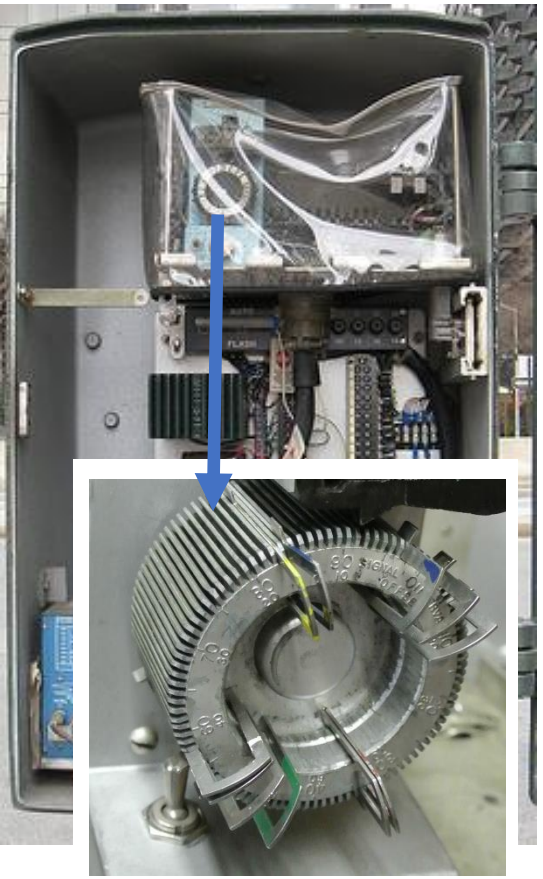


Photo Courtesy: Econolite & New York City

Serial Input Test Location – Purdue

Photo Courtesy: INDOT & PURDUE University

Solid State – With Data Loggers

Year 2011: “Improve Traffic Signal Operations”

Utah Governor Jon Huntsman Jr.

Indiana Traffic Signal Hi Resolution Data Logger Enumerations


Darcy Bullock


Howell Li


Chris Day


Alex Hainen


Jim Sturdevant

November 2012 - https://docs.lib.purdue.edu/jtrpdata/3/

August 2020 - https://docs.lib.purdue.edu/jtrpdata/4/

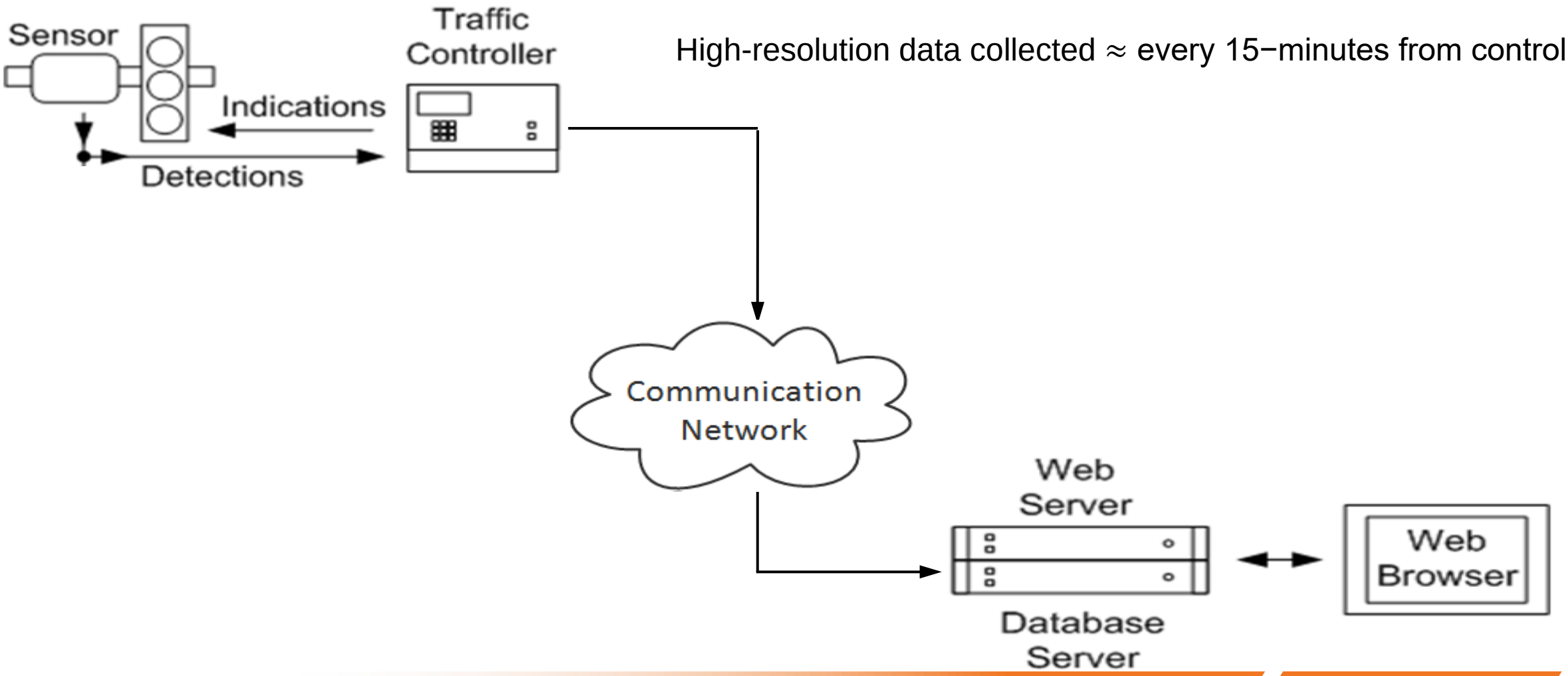
History of ATSPMs

- 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.
- 2020: “Pooled Fund” updated “Indiana Traffic Signal Hi Resolution Data Logger Enumerations”.
- 2021/2022: Infrastructure Investment & Jobs Act – Supports & mentions ATSPMs

Source: UDOT

Source: Deseret News

ATSPM System Architecture



High-resolution data collected ≈ every 15−minutes from controller

High-resolution Data Example

https://docs.lib.purdue.edu/jtrpdata/4/

0.1-second resolution

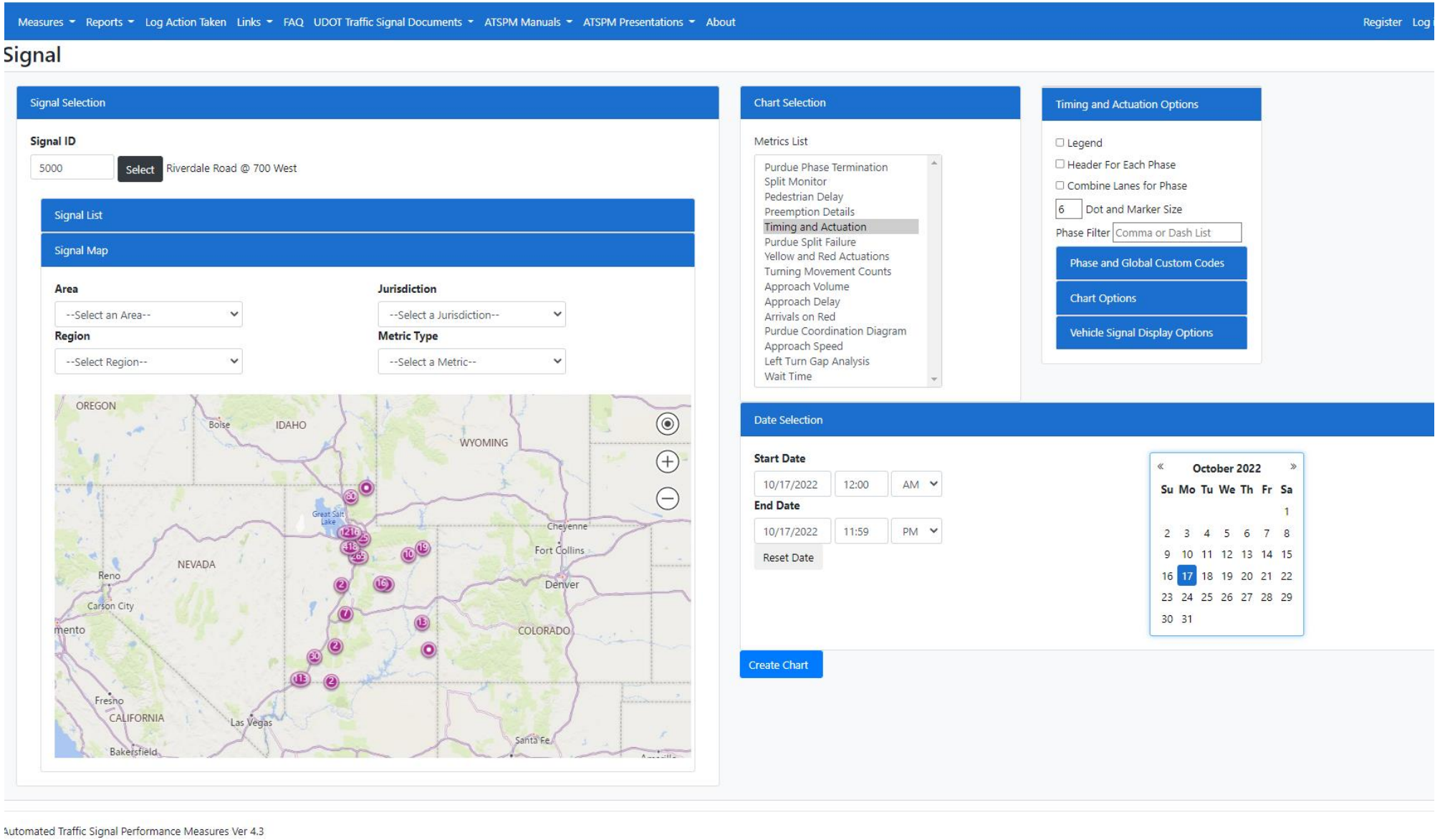
Timestamp	Event Code	Event Parameter
6/27/2013 1:29:51.1	10	8
6/27/2013 1:29:51.1	82	5
6/27/2013 1:29:52.2	1	2
6/27/2013 1:29:52.2	1	6
6/27/2013 1:29:52.3	82	2
6/27/2013 1:29:52.8	82	4
6/27/2013 1:29:52.9	81	4
6/27/2013 1:29:54.5	81	2
6/27/2013 1:30:02.2	8	2
6/27/2013 1:30:02.2	8	6
6/27/2013 1:30:06.1	10	2
6/27/2013 1:30:06.1	10	6
6/27/2013 1:30:08.1	1	8
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
6/27/2013 1:30:30.4	27 8	8

Detector 5 ON

Phase 8 GREEN

Detector 5 OFF

Phase 8 YELLOW

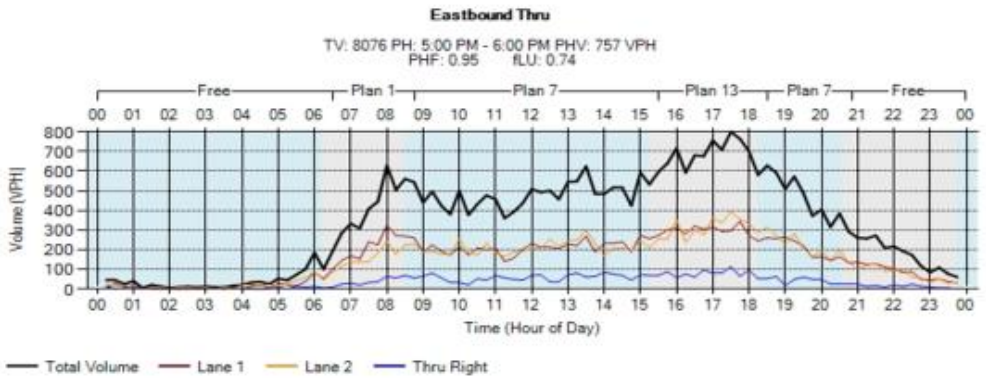


UDOT Keeping Utah Moving

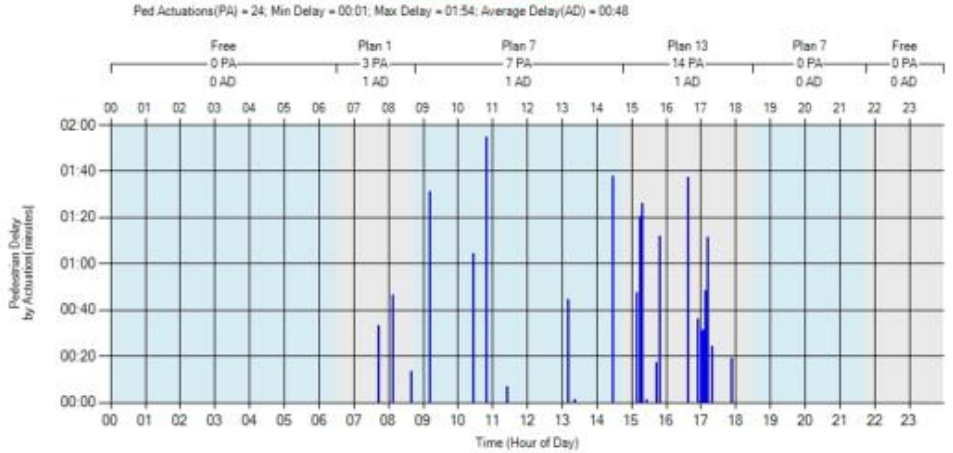
ATSPM Automated Traffic Signal Performance Measures

https://udottraffic.utah.gov/atspm

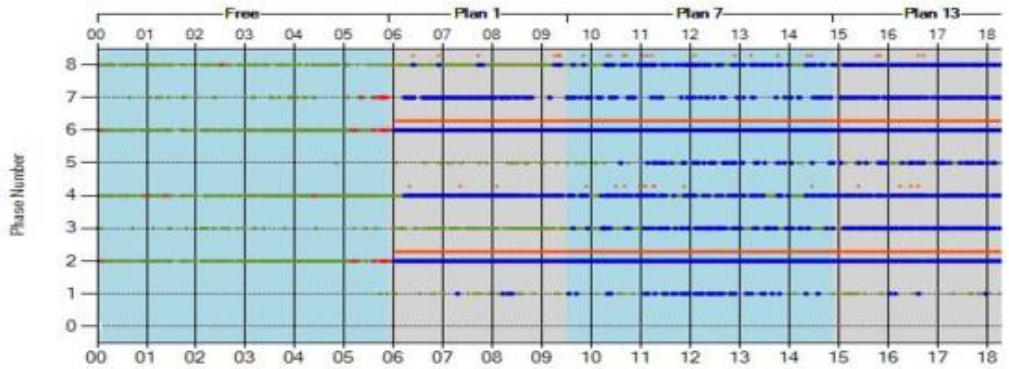
Turning Movement Counts



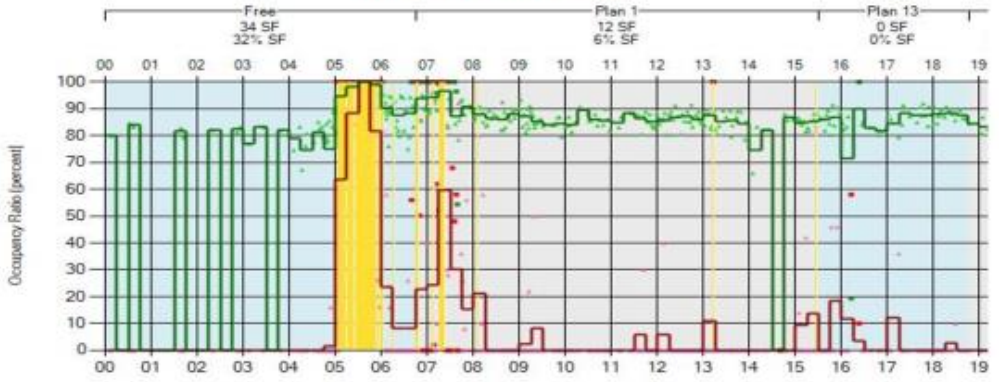
Pedestrian Delay



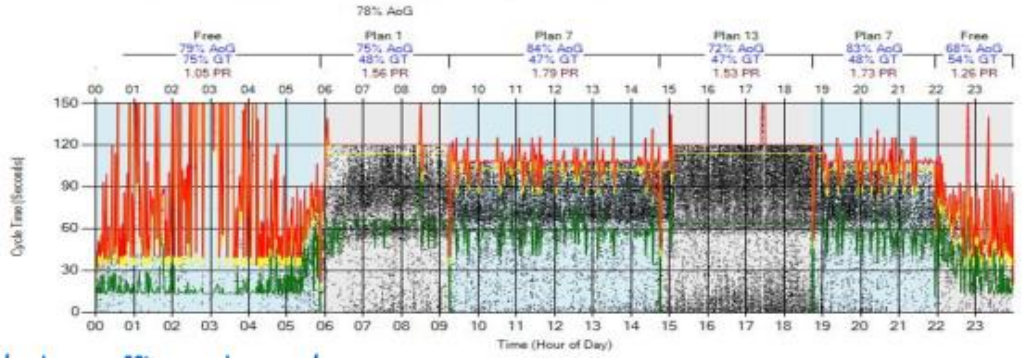
Purdue Phase Termination



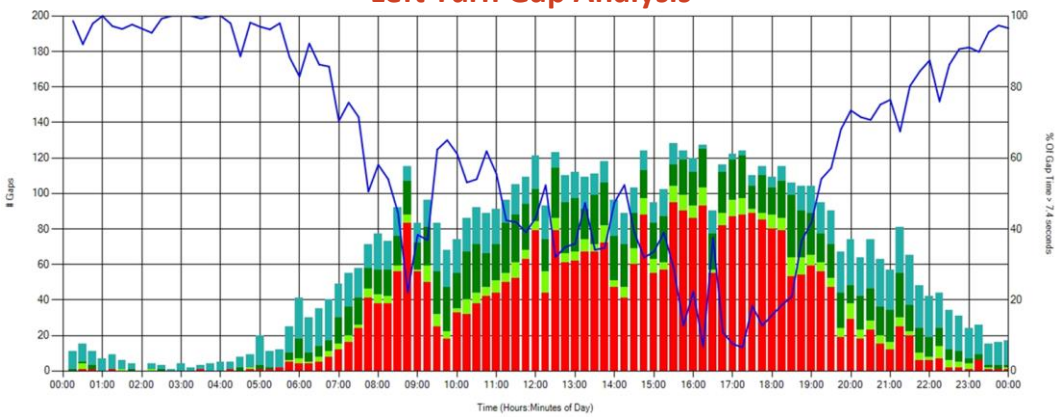
Purdue Split Failure



Purdue Coordination Diagram



Left Turn Gap Analysis

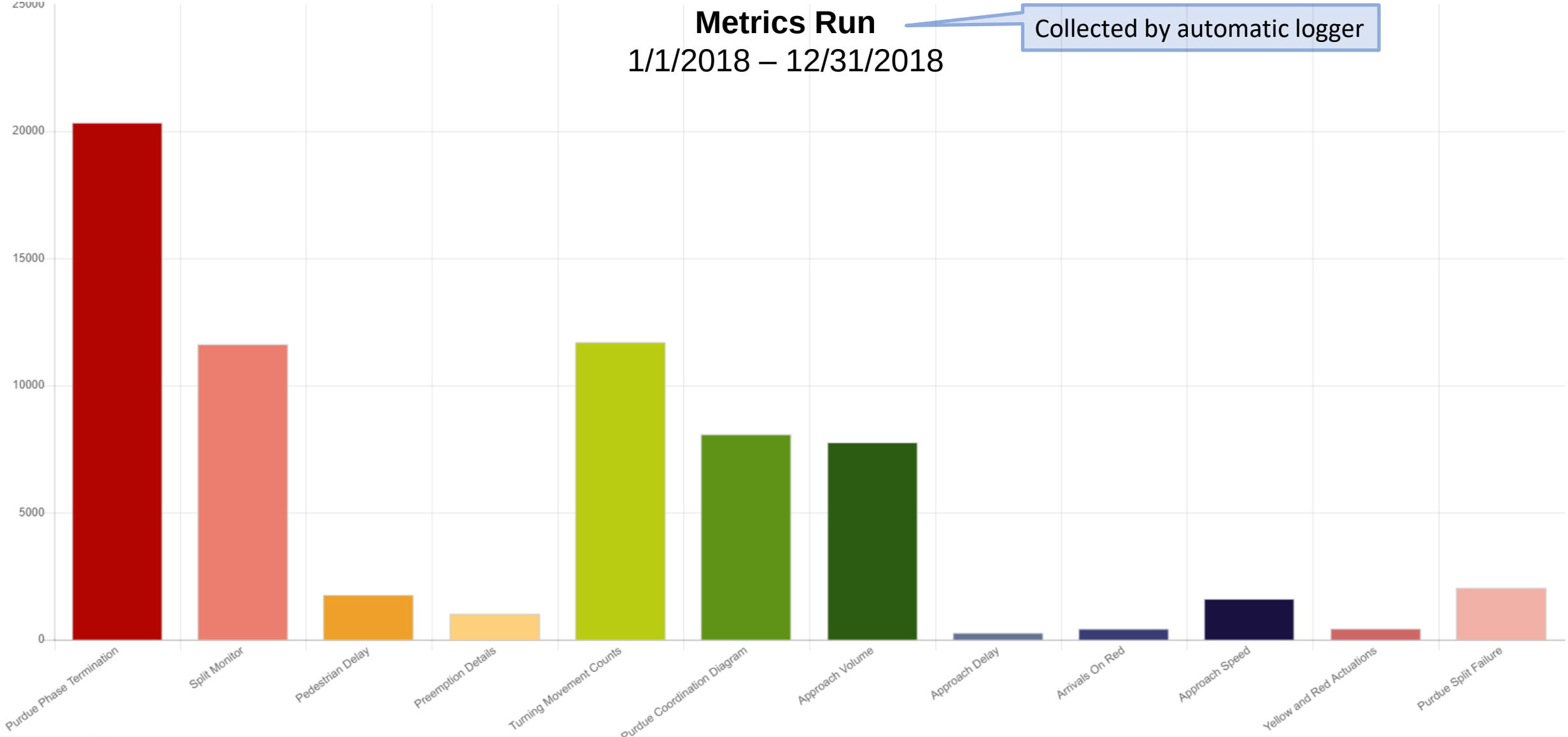


https://udottraffic.utah.gov/atspm

UDOT Metric Usage: 67,088 times

Metrics Run
1/1/2018 – 12/31/2018

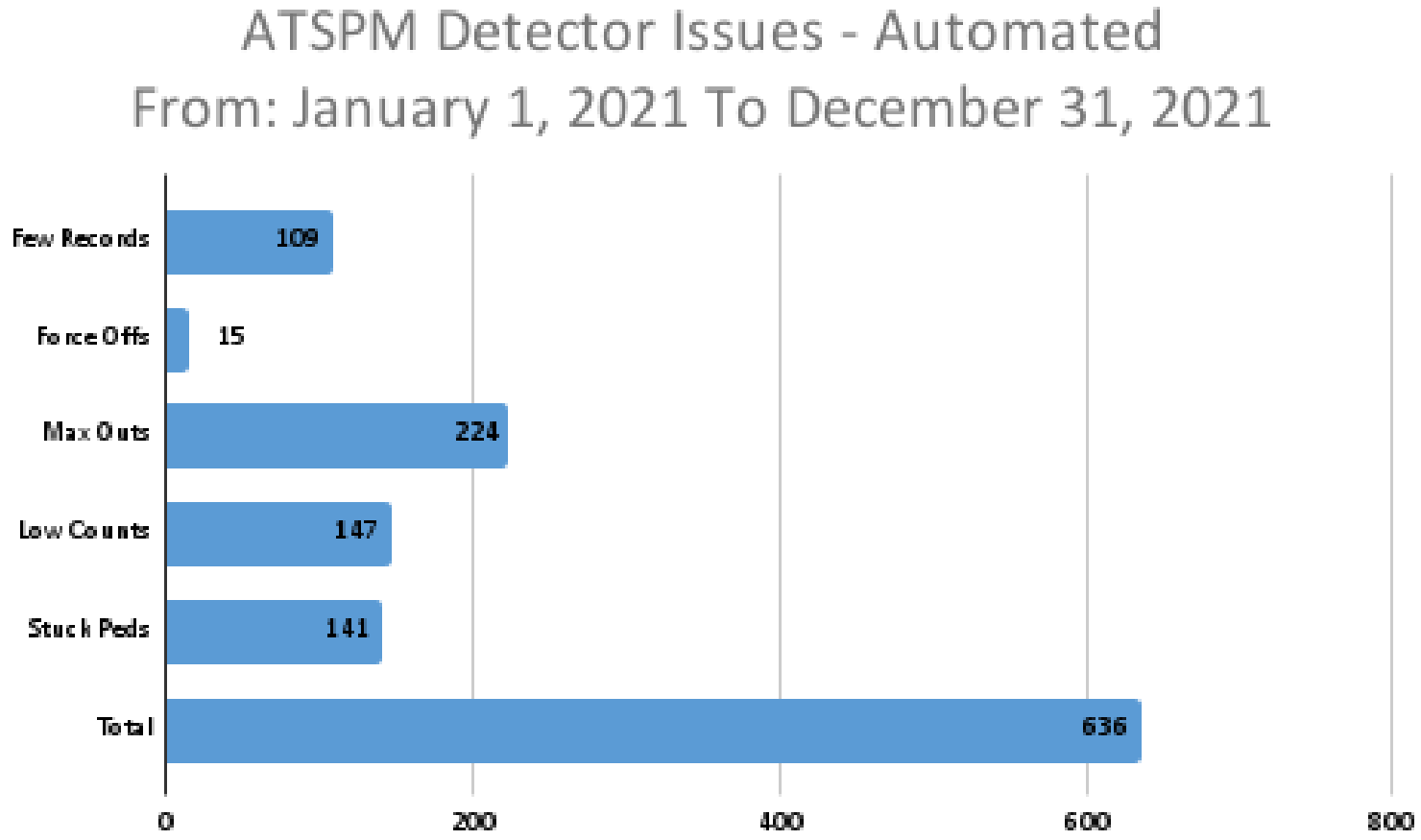
Collected by automatic logger



System Health Alerts

(Daily emails of detector problems)

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.



ATSPM WatchDog Email Detection – Each Day

ATSPM Alerts for 12/14/2020 Inbox × MOE Health ×

SPMWatchdog@utah.gov Mon, Dec 14, 7:56 AM (2 days ago)

to bryan.meenen, trafficsignals, parkcitytcc, tforbush, efelix, me, monty.thurber, jlamora, jay.smith, sc

--The following signals had too few records in the database on 12/11/2020:
1809 - WIlson Ave (1760 S) & 1300 E (Missing Records - IP: 10.205.18.155)
5713 - 400 N & 400 E Bountiful (Missing Records - IP: 10.203.13.111)
6163 - 100 N (SR-198) & Main St (SR-115) (Missing Records - IP: 10.210.233.15)
6257 - 200 N (US-40) & Union St (HAWK) (Missing Records - IP: 10.175.123.143)
7051 - 5600 West & 4700 South (Missing Records - IP: 10.208.6.51)

--The following signals had too many force off occurrences between 1:00 and 5:00:
1058 - 800 South & 200 East - Phase 4 (Force Offs 100%)
1058 - 800 South & 200 East - Phase 8 (Force Offs 100%)
1098 - South Temple & 900 East - Phase 3 (Force Offs 91%)

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	$10,000	$40,000
SQL Database License	$15,000	$125,000
IT Consultant (software installation)	$10,000	$15,000
Engineering Consultant (detector configuration)	$10,000	$150,000
Total	$45,000	$330,000
Cost per signal	*$900*	*$330*

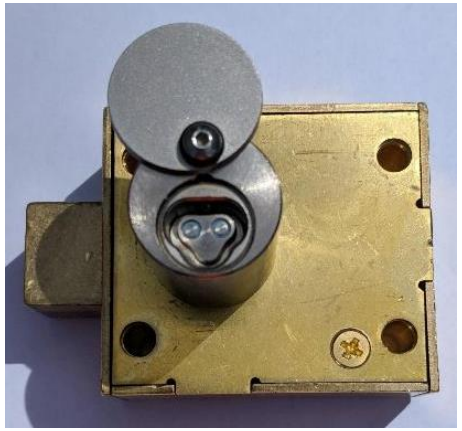
Some Other Innovative Things We're Doing

- Electronic locks and keys (CyberKey)
- Electronic Logbook
- Heat Tape on Traffic Signal Visors
- Lithium Ion UPS Battery Backup System

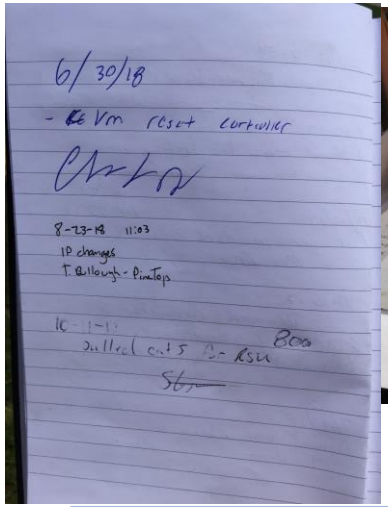
More Attention to Security at our Cabinets – Electronic Locks

March 26, 2019 – Report of suspicious people in our cabinet near Salt Lake City. We dispatched police to investigate.

Electronic Locks & Keys – Jan. 2020



Electronic Logbook for Traffic Signal and ITS Locations



Signal ID# **5000** Riverdale

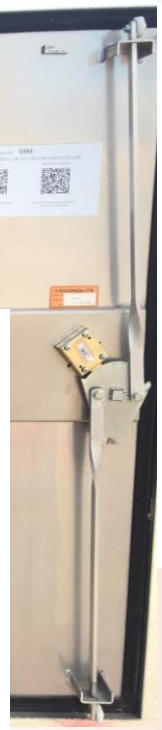
Riverdale Rd (SR-26) 700 W

Log Book

Signal Documents

https://udottraffic.utah.gov/logbook

https://drive.google.com/drive/folders/0AB2HHG1wvhcyUk9PVA



ITS ID 5000 Search

ITS ID : 5000

ITS Type : Signal

ITS Location : Riverdale Rd / SR-26 @ 700 W, RDL

Date of Response

10/18/2022 15:40

Location of Response

On Site ◉ Remote ○

Reason For Response - Check all that apply

- ☐ Complaint/Work Order (CW)
- ☐ Preventative Maintenance (PM)
- ☐ On-call/After Hours (EMR)
- ☐ Failed Equipment (E)
- ☐ Detection Related (D)
- ☐ Timing (T)
- ☐ Other (O)

Comment

Save

Comments 23 Comment Text Search

AIMS Work Orders Log 18

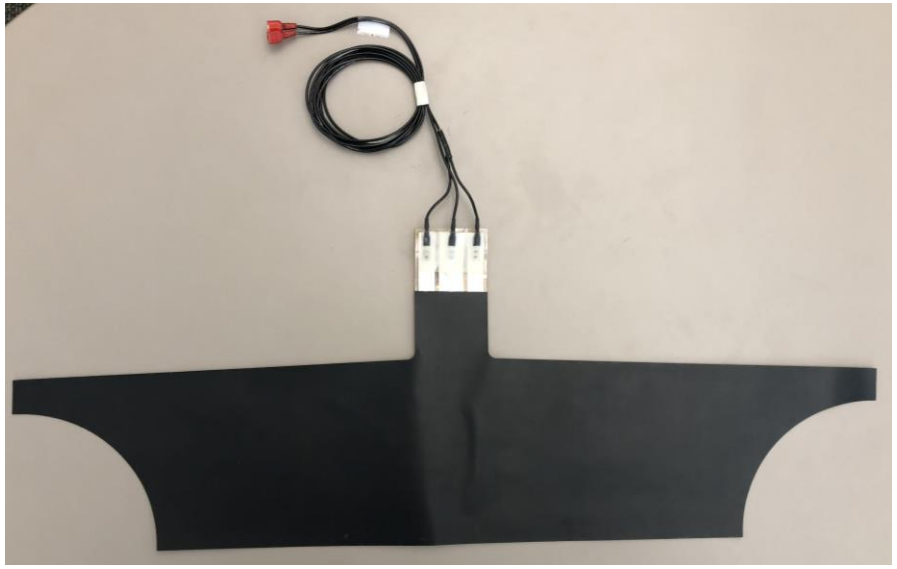
MaxView Log 25

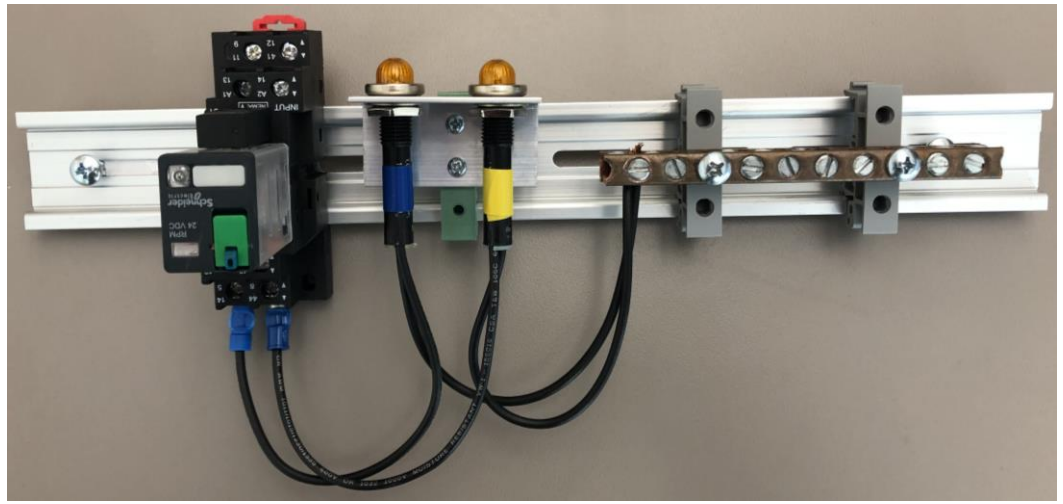
CyberLock Log 13

Comments

Date	User	Reasons For Response
Location of Response	**Comment**	
10/18/2022 10:11	Jereme Fullmer	O
Onsite	Equipment inventory. No changes	
09/07/2022 10:36	Scott Besaw	O
Onsite	Fiber inventory	
04/18/2022 14:27	Josh Boudrero	CW
Onsite	Reset radio	
01/04/2022 17:03	Carly Morrison	D
Remote	Rebooted EB Matrix	

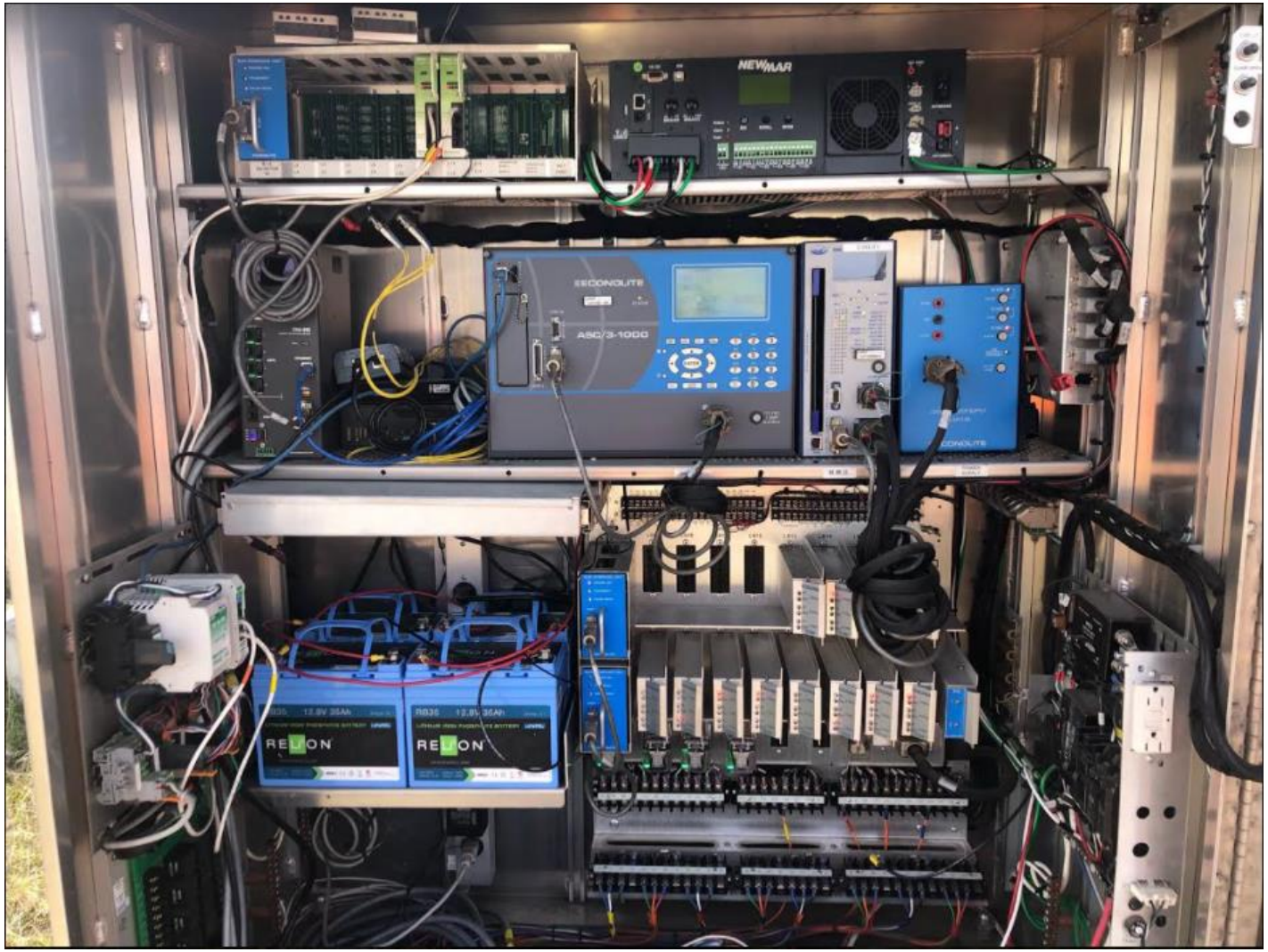
Heat Tape on Signal Head Visors to eliminate Snow Buildup





Lithium Ion Battery Backup System

- Batteries last 10+ years
- Fits inside signal cabinets
- Cost savings compared to previous BBS systems used in Utah (273% savings)
- Better reliability to traffic signals at freeways, complex intersections, CAV locations



60s Commercial – Green Lights

http://udot.utah.gov/greenlights

UDOT

Keeping Utah Moving

ATSPMs for Everyone

Joanna Bush
Traffic Signal Engineer
Mead and Hunt

Mead & Hunt | EXPERIENCE EXCEPTIONAL

ATSPMs for Everyone

THE EASTERN TRANSPORTATION COALITION

November 9, 2022

About Joanna

- 10 years as State Traffic Signal Systems Engineer for Wisconsin Department of Transportation
- Led WisDOT's early implementation of Automated Traffic Signal Performance Measures (ATSPMs)

Joanna Bush, PE

23 YEARS OF INDUSTRY EXPERIENCE

WISCONSIN DEPARTMENT OF TRANSPORTATION

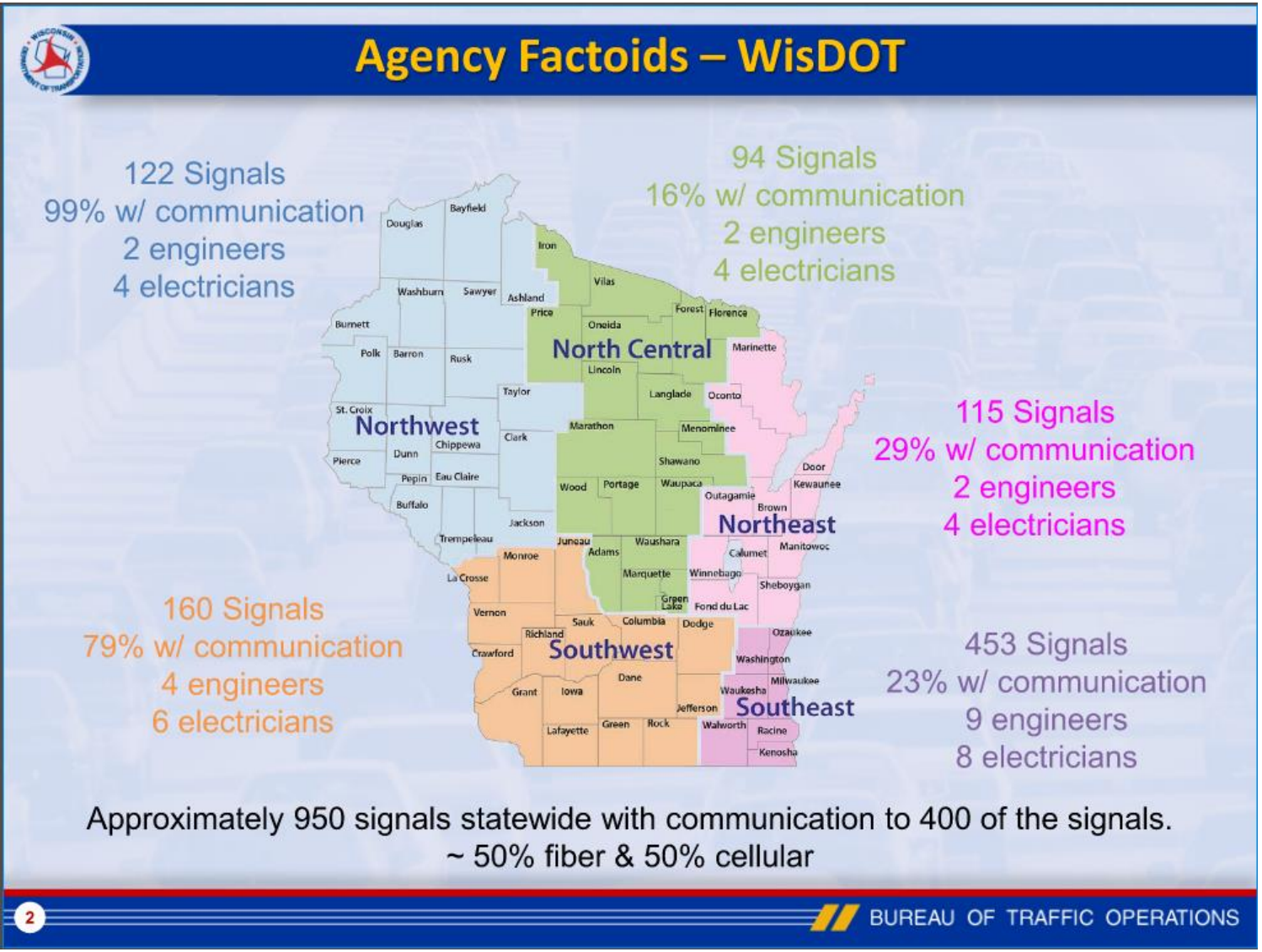
WisDOT's ATSPM Journey

- 2010 – Joanna travels to Utah and meets Mark Taylor!
- 2014 – IT project approved for ATSPMs (leveraged federal funding opportunity to have UDOT assist with deploying source code)
- 2015 – Test intersections added
- 2016 – ATSPM Workshop

  Presentations and Posters (purdue.edu)

PRESENTATIONS FROM JANUARY 26–27, 2016

WisDOT – the "little sister" at the ATSPM Workshop

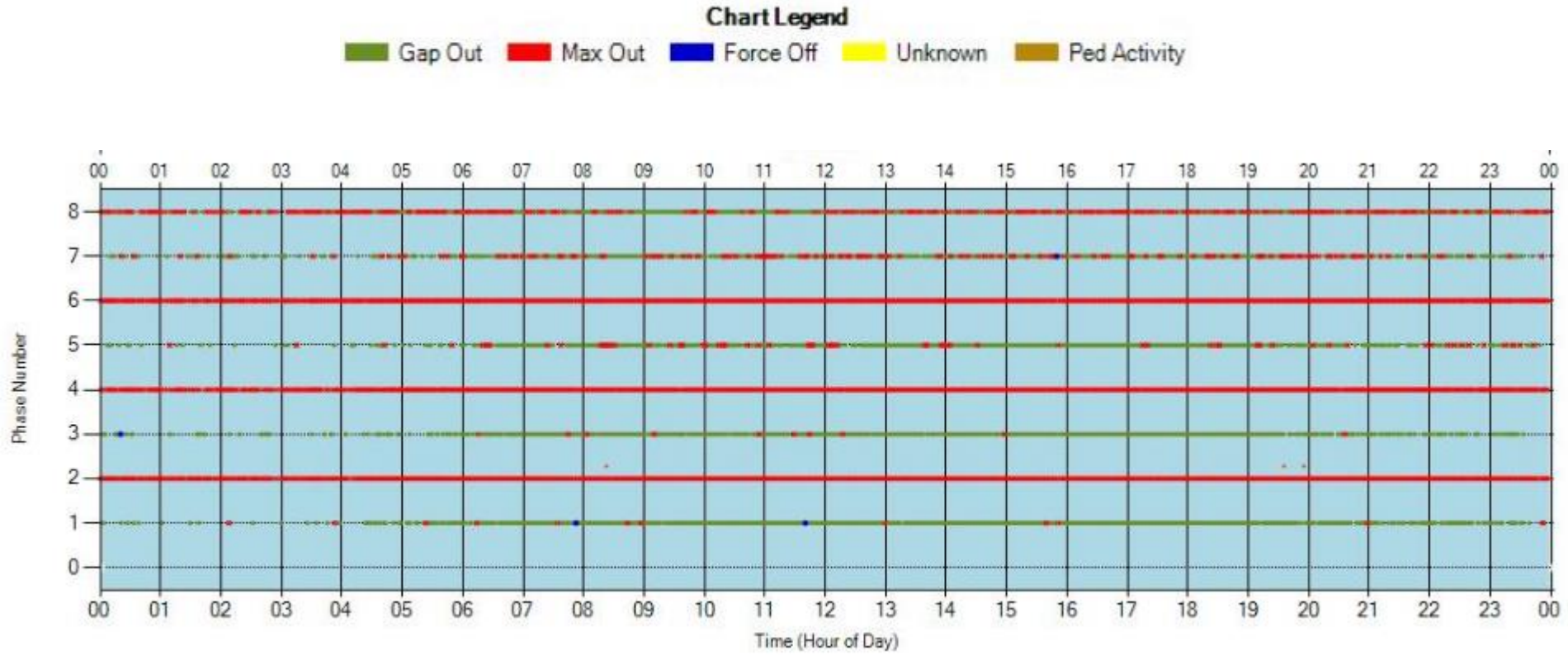


- 950 signals statewide
- 400 signals with communication
  - 50% fiber
  - 50% cellular
- 170 signals collecting ATSPM data (only Econolite)
- Needed to figure out how to add EPACs, connect via cellular, establish alarms…

We still had a LONG way to go!

Leveraged the ATSPM information

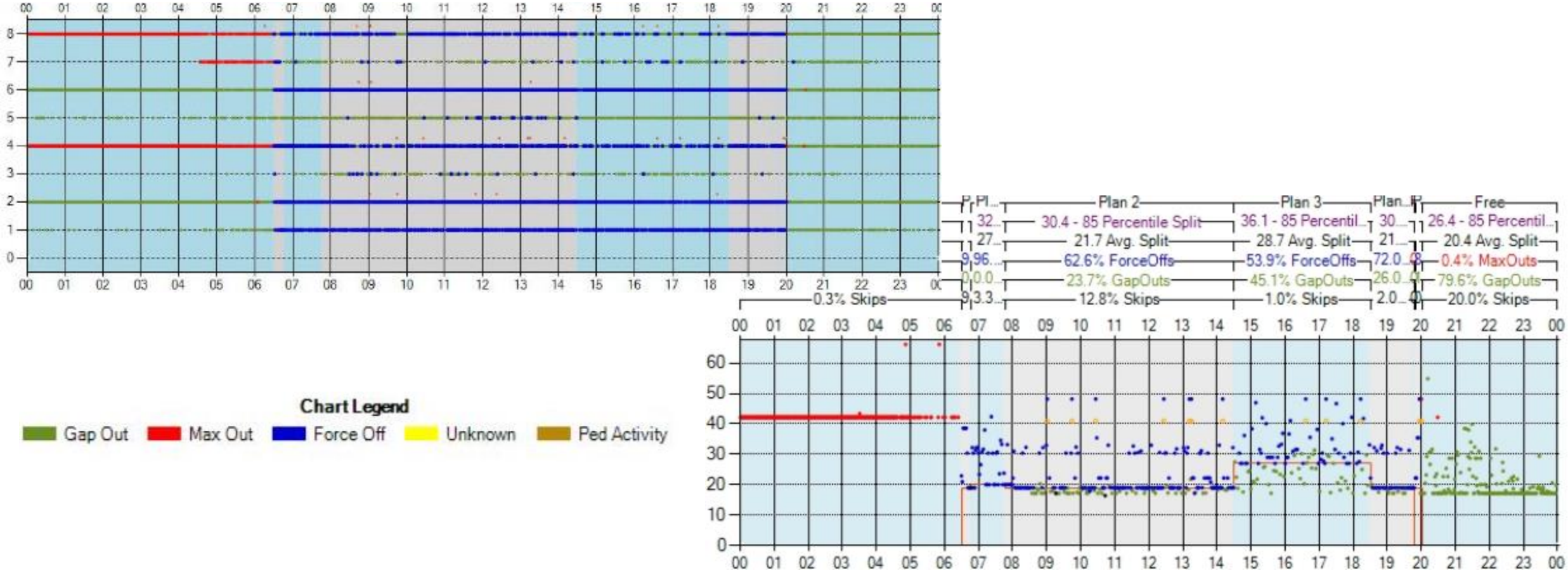
- Detection Issues Identified



Used to redirect funding from retiming to communication

Leveraged the ATSPM information

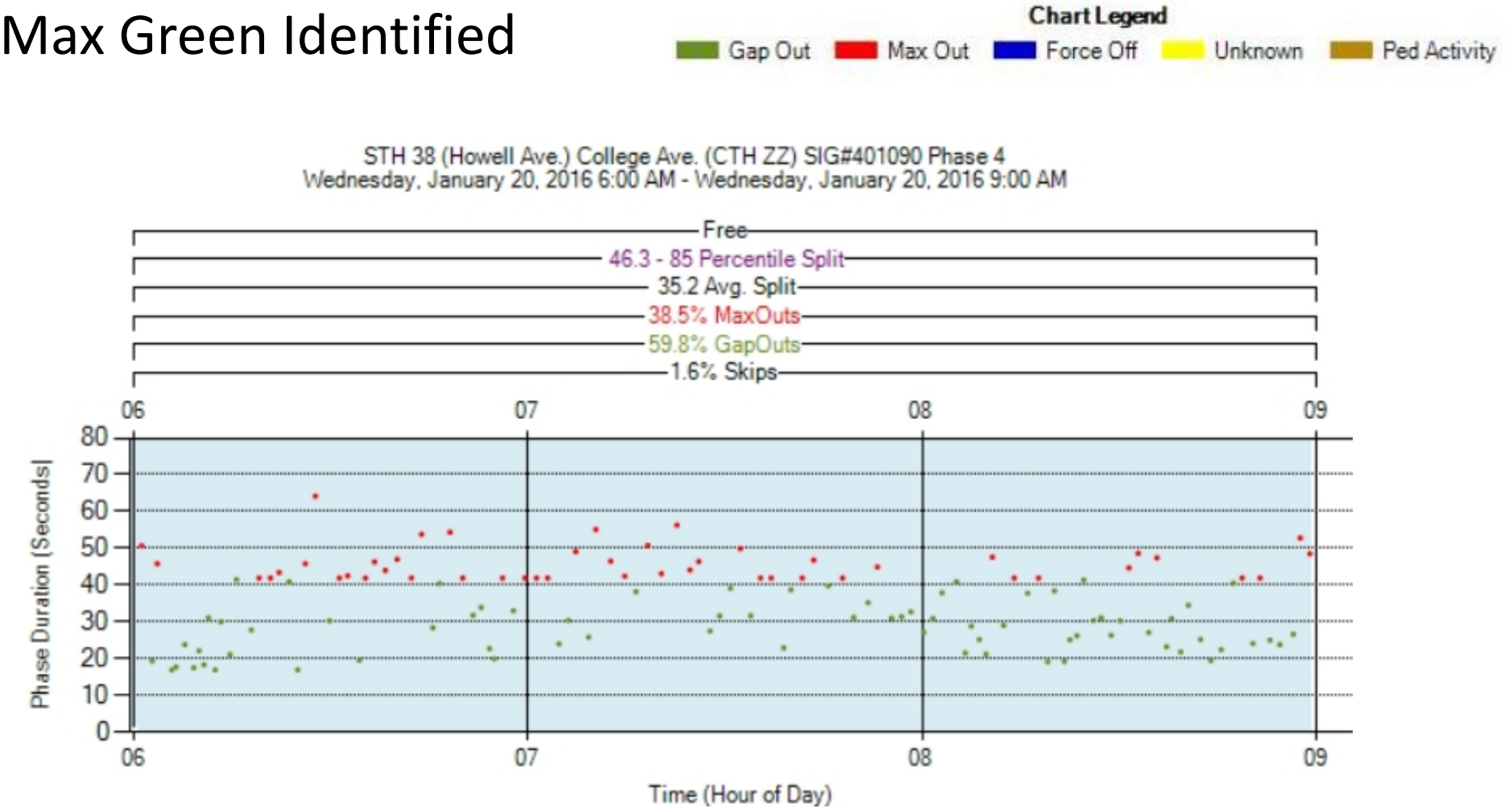
- Detection Issues Identified



Changed the way we handled maintenance calls

Leveraged the ATSPM information

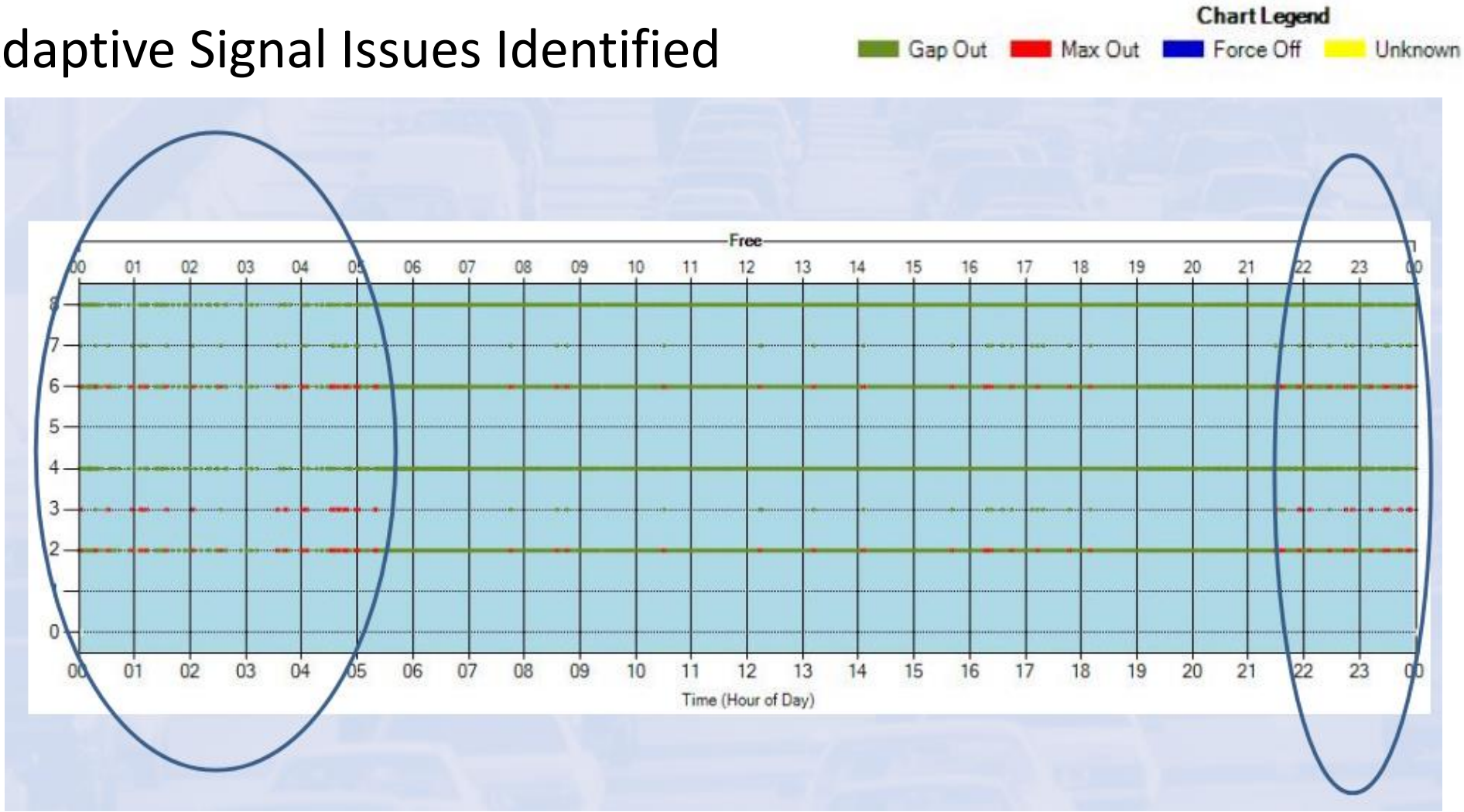
- Short Max Green Identified



Added retiming non-system signals to our priorities

Leveraged the ATSPM information

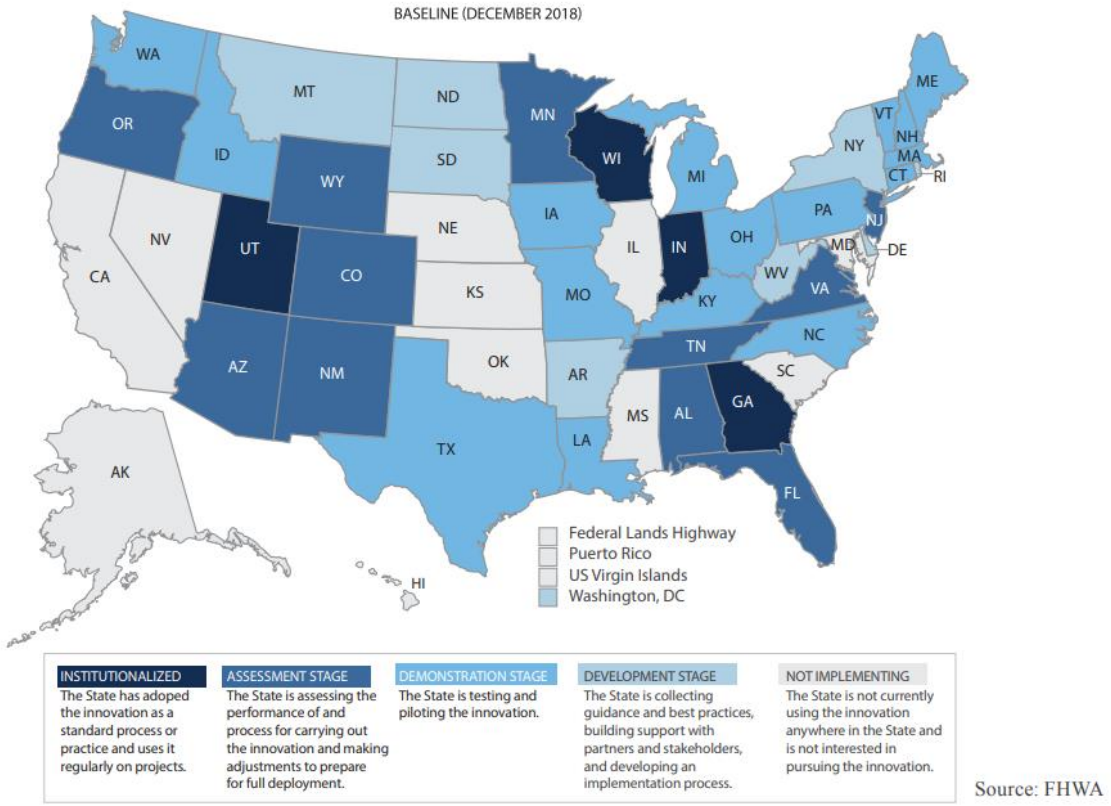
- Adaptive Signal Issues Identified



Reshaped our message regarding adaptive signals

WisDOT 2022

- ~100% of signals collecting ATSPMs
- Next Steps?
  - Move to a cloud server to address space issues
  - Transition to public facing platform
  - Expand to include local agencies
  - Develop internal guidelines for retiming signals with ATSPMs
  - Leverage consultants to retime signals using ATSPMs



Source: FHWA

Figure 9. Map. Status of automated traffic signal performance measures implementation adoption in December 2018.

ATSPM
Automated Traffic Signal Performance Measures

Measures ▾ Reports ▾ Log Action Taken Links ▾ FAQ UDOT Traffic Signal Documents ▾ ATSPM Manuals ▾ ATSPM Presentations ▾ About Register Log in

ATSPMs for Everyone

- Don't wait! You don't need everything ready before you take your first step.
- Take advantage of the various options and shared knowledge/experience available within the industry.
- Establish your vision and leverage your successes along the way to pave the way to your next milestone.
- Unlock the potential of your controller with big data.

ATSPMs for Everyone

- Take advantage of the opportunities available with SMART Grants

Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program | US Department of Transportation

Questions?

Joanna Bush, PE

Joanna.bush@meadhunt.com

608-572-5726

Thank you!

Adaptive to ATSPM – A User's Guide

Kelly McVeigh
Supervising Engineer
New Jersey DOT

Adaptive to ATSPM – A User's Guide

TETCoalition – Everything You've Ever Wanted To Know About ATSPMs

November 9, 2022

Kelly McVeigh – Supervising Highway Engineer

NJDOT – Transportation Mobility

Mobility Engineering

AGENDA

- Adaptive vs ATSPM
- Translating the data
- Reporting Performance or Improving Performance

ADAPTIVE VS ATSPM

Why focus on Adaptive and ATSPM in NJ?

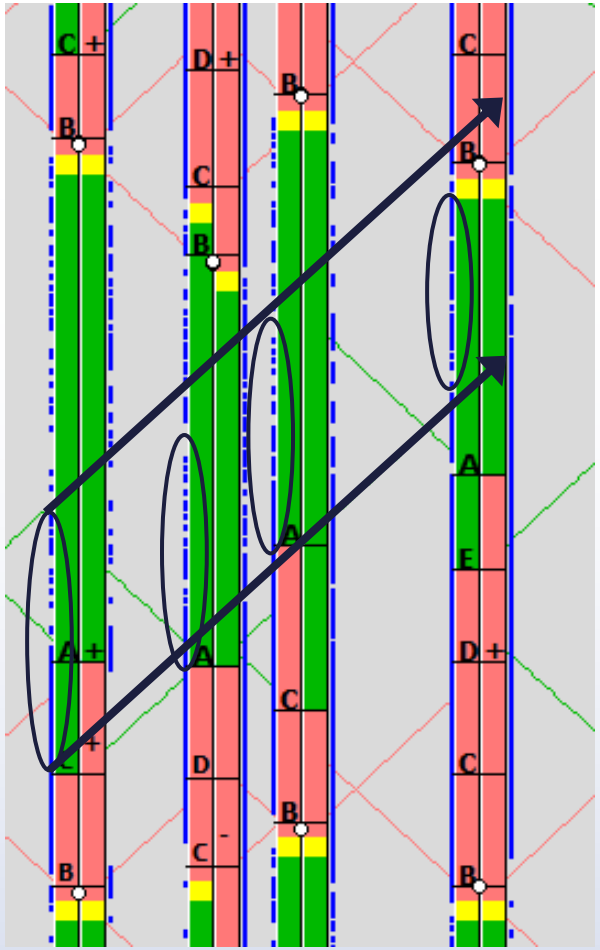
Full Operation:
NJ-18 = 13 Signals
US-1 = 35 Signals
US-130 = 18 Signals
NJ-73 = 29 Signals

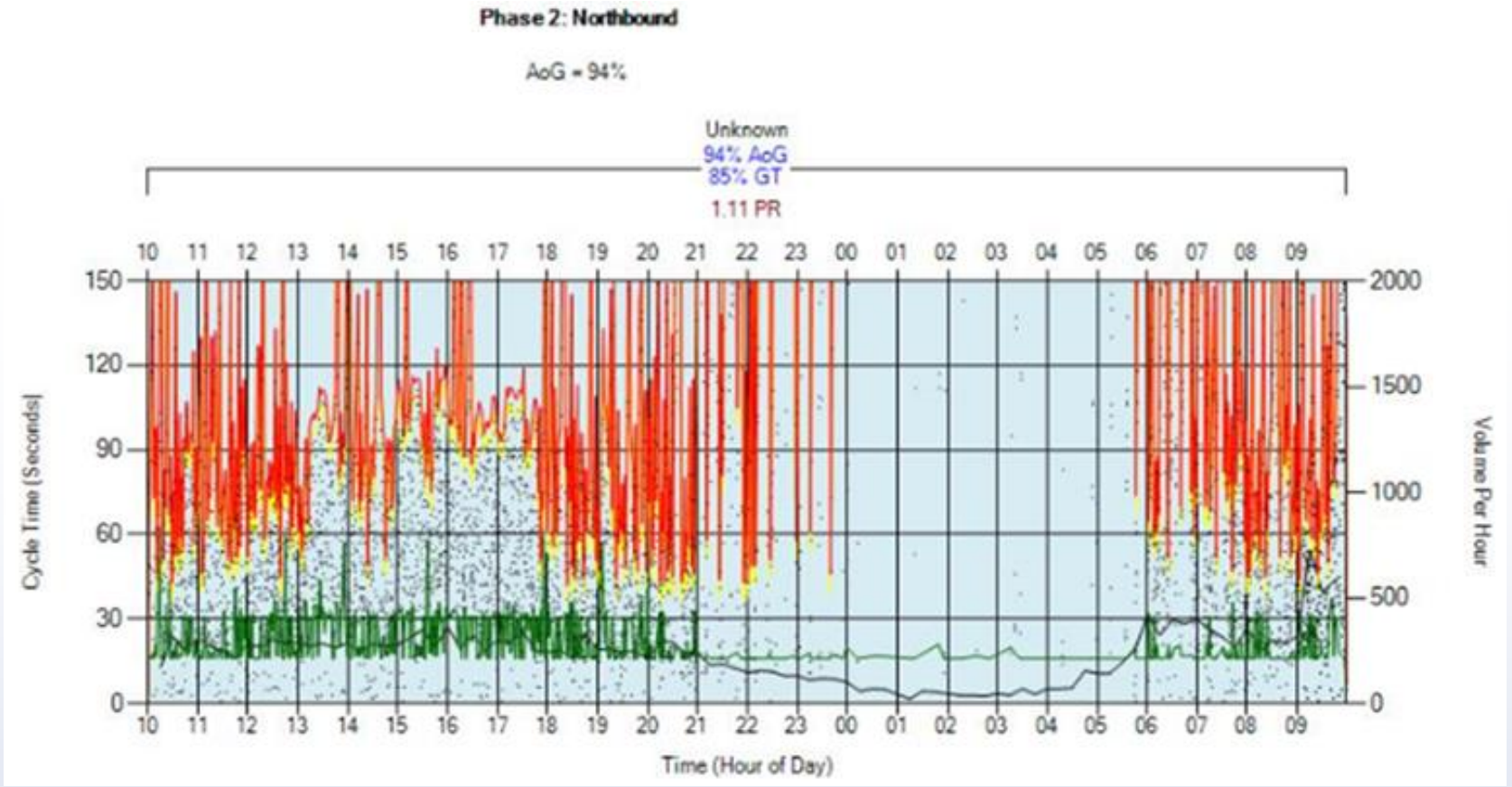
Construction:
US-322 & US-40 = 27 Signals
US-130 = 18 Signals
NJ-70 = 28 Signals

Final Design:
11 Corridors = 122 Signals

ADAPTIVE VS ATSPM

Tools for the same purpose?



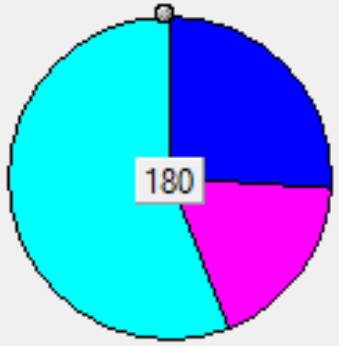


ADAPTIVE VS ATSPM

Tools for the same purpose?

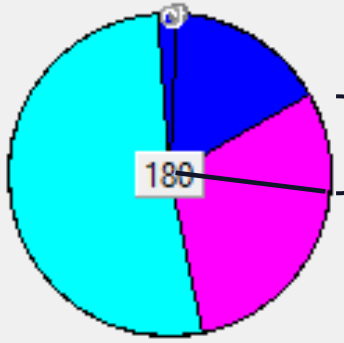
Active Plan

<A>	56%	101
B	26%	47
C	18%	32

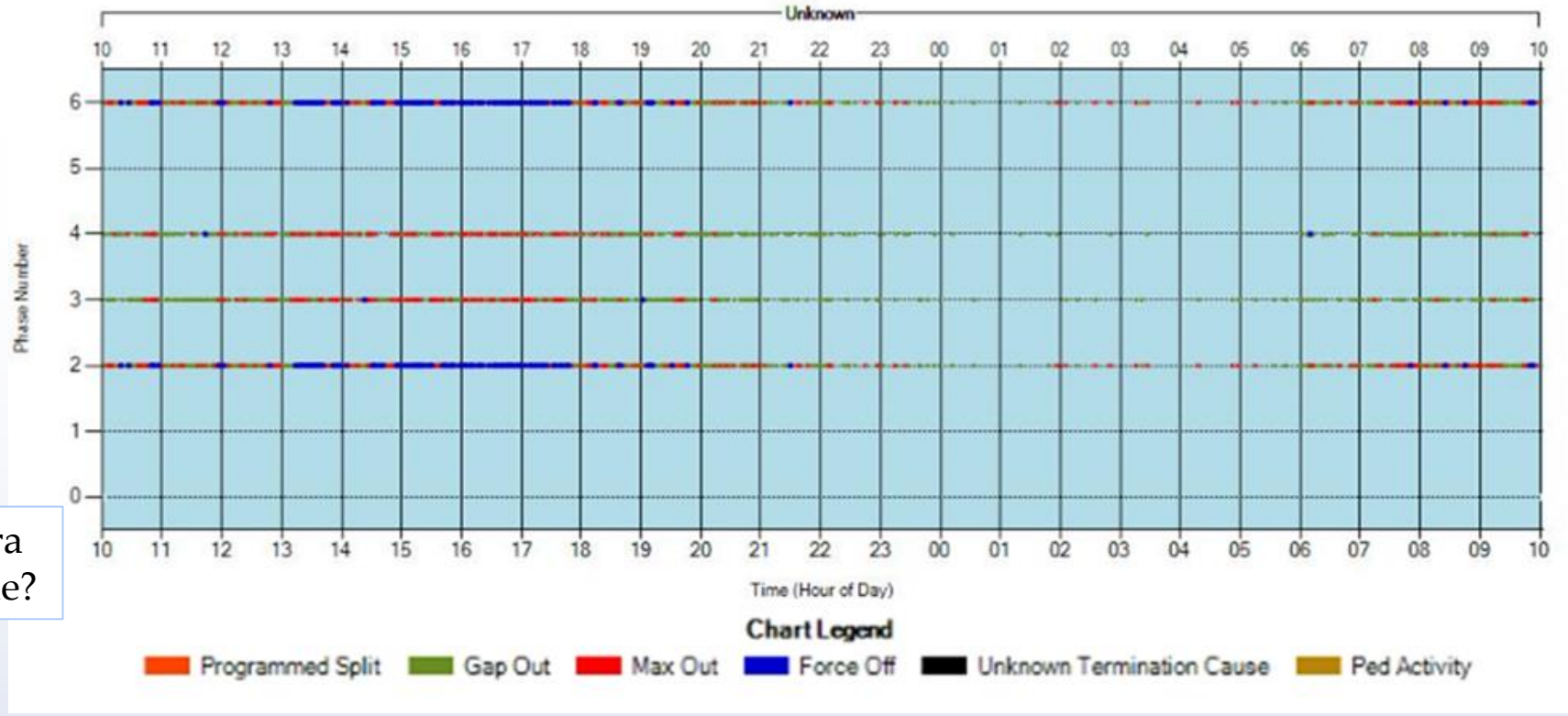


Site Operation

<A>	95	0
B	3	44
C	53	0

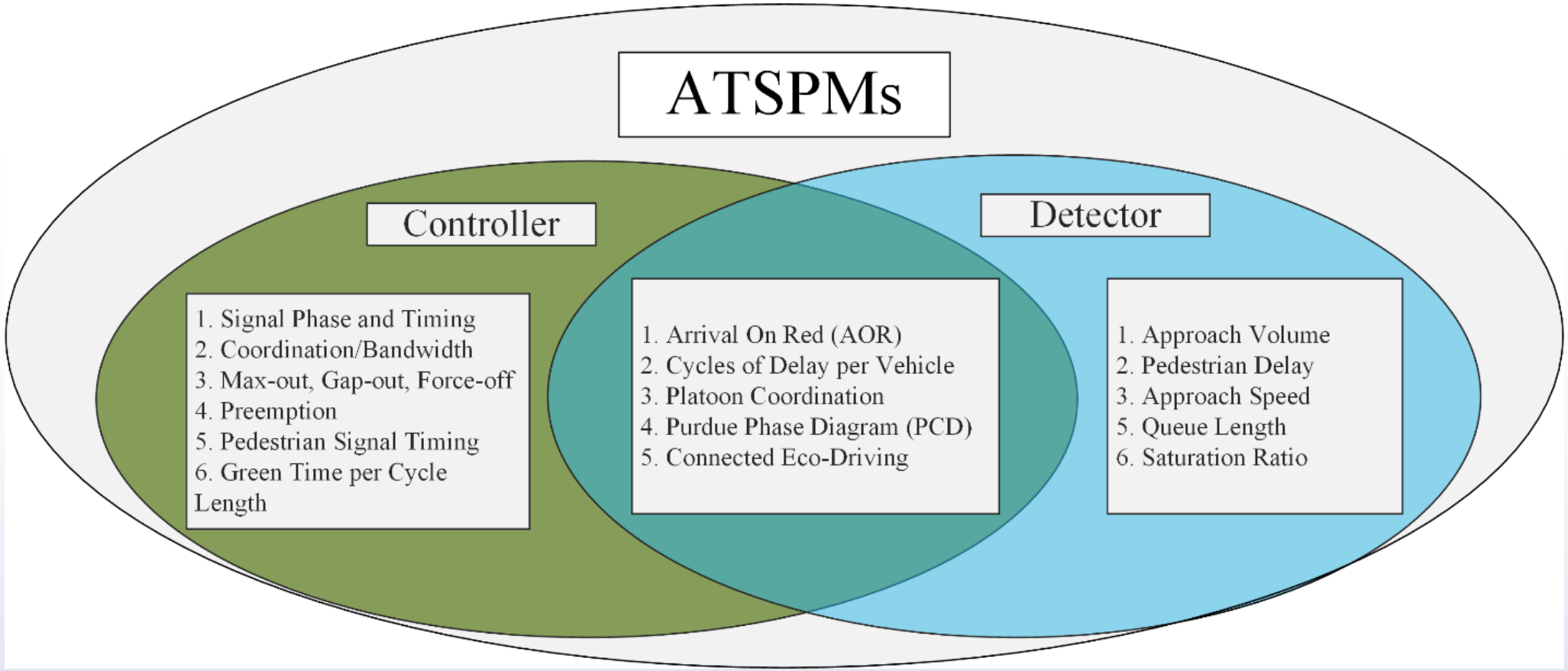


Extra Time?



Translating the Data

What data specifically?



Translating the Data

What data specifically?

ATSPM High-Resolution Active Phase Events and Codes

Event Code	Event Descriptor	Event Code	Event Descriptor
0	Phase On	8	Phase Begin Yellow Clearance
1	Phase Begin Green	9	Phase End Yellow Clearance
2	Phase Check	10	Phase Begin Red Clearance
3	Phase Min Complete	11	Phase End Red Clearance
4	Phase Gap Out	12	Phase Inactive
5	Phase Max Out	21	Pedestrian Begin Walk
6	Phase Force Off	43	Phase Call Registered
7	Phase Green Termination	45	Pedestrian Call Registered
81	Detector Off	82	Detector On

Indiana Traffic Signal Hi Resolution Data Logger Enumerations

Translating the Data

Time to Translate

SCATS Log File

Time	Event description
6:56:53	Current running phase=A. Flags=[stretch phase]
6:57:36	Cycle generator: restart
6:58:33	Current running phase=A. Flags=[stretch phase]
6:59:16	Cycle generator: restart
7:00:01	Phase demand: B=On
7:00:02	Phase termination request: next phase=B
7:00:02	Phase termination request confirmation from controller: current phase=A
7:00:03	Phase termination request: next phase=B
7:00:03	Controller request to terminate phase: no request termination for A

ATSPM Standard Code

Results | Messages

	SignalID	Timestamp	EventCode	EventParam
3...	103	2018-10-21 06:58:33.000	0	2
3...	103	2018-10-21 06:58:33.000	0	6
3...	103	2018-10-21 06:58:33.000	1	2
3...	103	2018-10-21 06:58:33.000	1	6
3...	103	2018-10-21 07:00:01.000	2	2
3...	103	2018-10-21 07:00:01.000	2	6
3...	103	2018-10-21 07:00:03.000	3	2
3...	103	2018-10-21 07:00:03.000	3	6

Phase On

GreenBegin

- Phase A contains Movement 2&6, which is stored in metadata file.
- The **Phase-On Event** and **Green-Begin Event** were created for movements 2&6.
- The translated records are inserted into the database with timestamp information.

Translating the Data

Time to Translate

Translator Output

	SignalID	Timestamp	EventCode	EventParam
97	10015	2020-02-25 00:08:52.000	2	4
98	10015	2020-02-25 00:08:57.000	3	4
99	10015	2020-02-25 00:08:57.000	7	4
100	10015	2020-02-25 00:08:57.000	8	4
101	10015	2020-02-25 00:08:57.000	4	4
102	10015	2020-02-25 00:09:01.000	9	4
103	10015	2020-02-25 00:09:01.000	10	4
104	10015	2020-02-25 00:09:04.000	11	4
105	10015	2020-02-25 00:09:04.000	0	2
106	10015	2020-02-25 00:09:04.000	0	6

SCATS Log

Time	Event
0:08:49	Signal group: SG4=On
0:08:50	Cycle generator: restart
0:08:50	Phase termination: phase=A MX=0 GT=76 CG=0
0:08:50	Phase status flags: [Flag 4 (Mx Ack) = 0 (Off)]
0:08:50	Alarm timer: value=0
0:08:50	Current running phase=C. Flags=[]
0:08:50	Phase status flags: [Flag 9 (Phase Time Calculated) = 1 (On)]
0:08:50	Phase interval: Minimum green
0:08:52	Phase demand: A=On
0:08:56	Phase status flags: [Flag 3 (Phase Gapped) = 1 (On)]
0:08:56	Signal group: SG4=Off
0:08:57	Phase interval: Yellow
0:09:01	Phase interval: All red
0:09:03	Phase demand: A=Off
0:09:03	Signal group: SG6=On SG2=On
0:09:04	Phase termination: phase=C MX=13 GT=14 CG=16
0:09:04	Phase status flags: [Flag 3 (Phase Gapped) = 0 (Off)]
0:09:04	Alarm timer: value=1
0:09:04	Current running phase=A. Flags=[stretch phase]
0:09:04	Phase status flags: [Flag 9 (Phase Time Calculated) = 1 (On)]
0:09:04	Phase interval: Minimum green
0:09:11	Phase interval: Rest or extension green
0:09:11	Controller request to terminate phase: request termination for A

Logic

When the record displays *"Phase status flags:[Flag 3 (Phase Gapped)= 0 (Off)]" at the end of the phase,* create *GapOut* event. The Timestamp is the same as GreenTermination.

Gap Out

Translating the Data

Time to Translate

AutoScope

CPU Identifier	Autoscope Description	Detector ID	Detector Title	Date	Time	Duration	Status	Ticks (millisec.)	State
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/26/2020	4:38:19 PM	00:00:00	207 (ISSCLAPI_POLL_STATUS_CREATING_POLL_ON_AUTOSCOPE)		
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/26/2020	4:38:19 PM	00:00:00	207 (ISSCLAPI_POLL_STATUS_CREATING_POLL_ON_AUTOSCOPE)		
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	129		2/26/2020	4:38:19 PM	00:00:00	207 (ISSCLAPI_POLL_STATUS_CREATING_POLL_ON_AUTOSCOPE)		
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:42:28 PM		100	1578161124	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:42:28 PM		100	1578161124	32769
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	129		2/25/2020	2:42:28 PM		100	1578161124	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	129		2/25/2020	2:42:46 PM	00:00:18	100	1578179210	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:42:57 PM	00:00:29	100	1578191156	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	129		2/25/2020	2:42:59 PM	00:00:13	100	1578192791	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:43:23 PM	00:00:55	100	1578217150	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:44:43 PM	00:01:20	100	1578297001	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:44:44 PM	00:00:01	100	1578297335	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:44:45 PM	00:00:01	100	1578298470	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:46:25 PM	00:03:28	100	1578398809	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:46:26 PM	00:00:01	100	1578399777	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:47:14 PM	00:00:48	100	1578447627	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:47:59 PM	00:00:45	100	1578492341	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:48:16 PM	00:00:17	100	1578509493	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	129		2/25/2020	2:48:35 PM	00:05:36	100	1578528647	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	129		2/25/2020	2:49:43 PM	00:01:08	100	1578596652	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	127		2/25/2020	2:49:45 PM	00:01:29	100	1578599054	0
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:50:09 PM	00:05:24	100	1578622646	1
0C050DFF9A676E28	3 -- 2020,02,24 9:09:33 -- 10.5.0 -- 0(	125		2/25/2020	2:51:33 PM	00:01:24	100	1578706468	0

Wavetronix

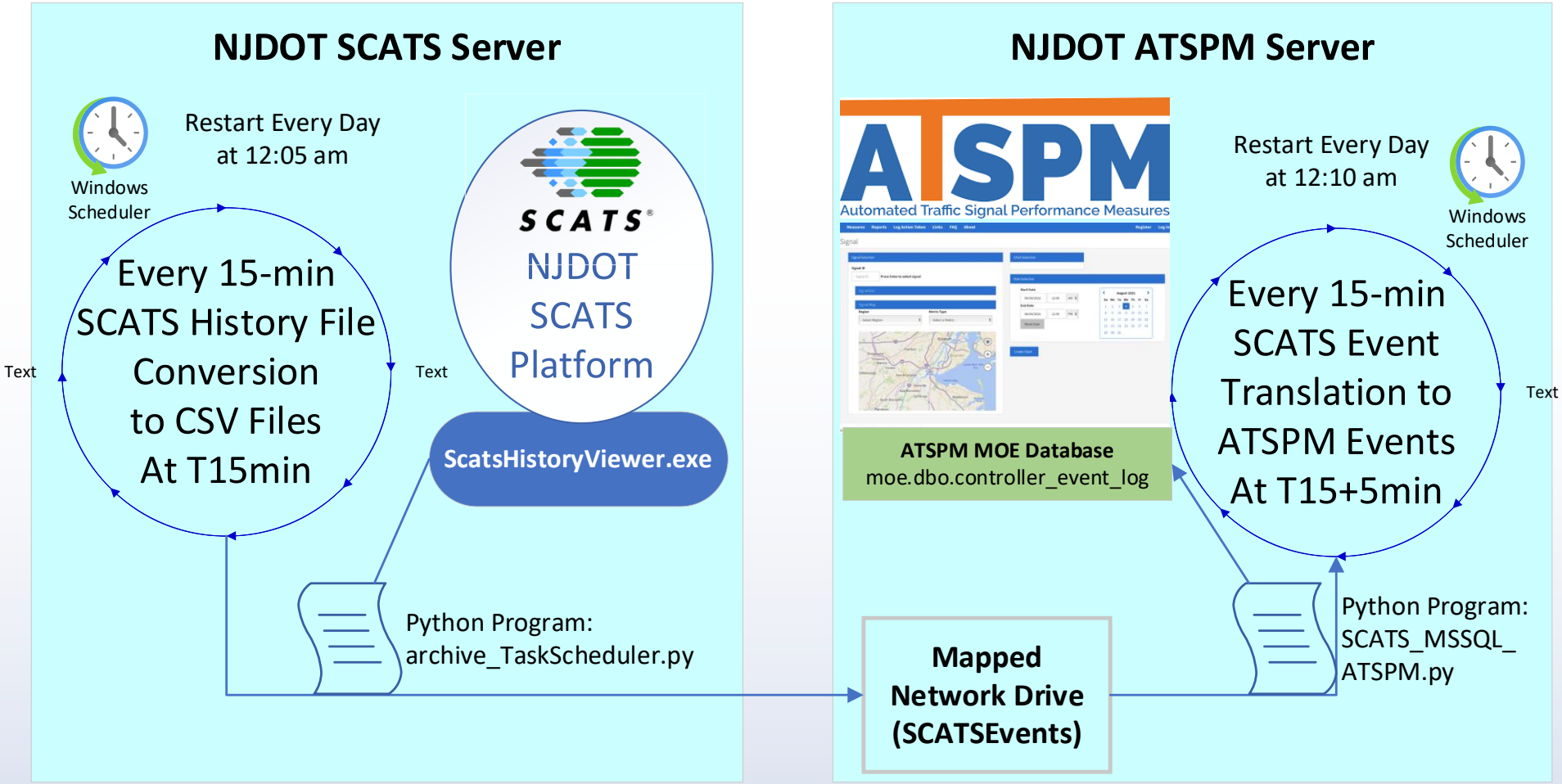
30-Jul-20	SS126 U10	Site 5 SB	Rt 1 NB MI	North	
LANE	LENGTH	(MPH)	CLASS	RANGE	YYYY-MM-DD HH:MM:SS.sss
#2_Lane2	13	68	2	85	07/30/2020 11:14:29.9
#1_Lane1	16	75.2	2	70	07/30/2020 11:14:30.0
#3_Lane3	11	66	2	96	07/30/2020 11:14:31.1
#2_Lane2	13	61.4	2	83	07/30/2020 11:14:34.7
#1_Lane1	16	61	2	71	07/30/2020 11:14:42.9
#3_Lane3	13	60.4	2	96	07/30/2020 11:14:43.1
#2_Lane2	15	65.9	2	82	07/30/2020 11:14:43.5
#2_Lane2	14	64.9	2	84	07/30/2020 11:14:48.3
#3_Lane3	18	54.6	2	95	07/30/2020 11:14:48.8
#3_Lane3	17	54.7	2	96	07/30/2020 11:14:51.1
#1_Lane1	9	60.4	1	74	07/30/2020 11:14:51.4
#2_Lane2	18	60.1	2	82	07/30/2020 11:14:51.9
#1_Lane1	18	65.3	2	69	07/30/2020 11:14:53.1
#2_Lane2	14	63.7	2	86	07/30/2020 11:14:55.1
#1_Lane1	14	66.3	2	70	07/30/2020 11:14:55.2
#3_Lane3	20	56.7	3	96	07/30/2020 11:14:56.5
#2_Lane2	15	64.6	2	84	07/30/2020 11:14:59.8
#3_Lane3	18	53.9	2	96	07/30/2020 11:15:00.4
#3_Lane3	10	52.7	2	96	07/30/2020 11:15:02.3
#2_Lane2	13	66.2	2	83	07/30/2020 11:15:02.9
#2_Lane2	15	63.6	2	83	07/30/2020 11:15:05.0
#2_Lane2	66	55.9	7	80	07/30/2020 11:15:12.6
#3_Lane3	13	49.8	2	98	07/30/2020 11:15:13.1
#1_Lane1	17	66.5	2	71	07/30/2020 11:15:13.5
#3_Lane3	16	50.2	2	96	07/30/2020 11:15:14.3
#2_Lane2	70	55.6	7	83	07/30/2020 11:15:15.6
#1_Lane1	10	67	2	74	07/30/2020 11:15:17.9
#1_Lane1	9	67.9	1	70	07/30/2020 11:15:19.3

Vehicle Occurrence Data: Detector data events conversion into ATSPM Events (#82, On) and (#81, Off)

Speed trajectory slices: Wavetronix data event converted into short speed trajectories ➔ a series of ATSPM Events (#82 On)

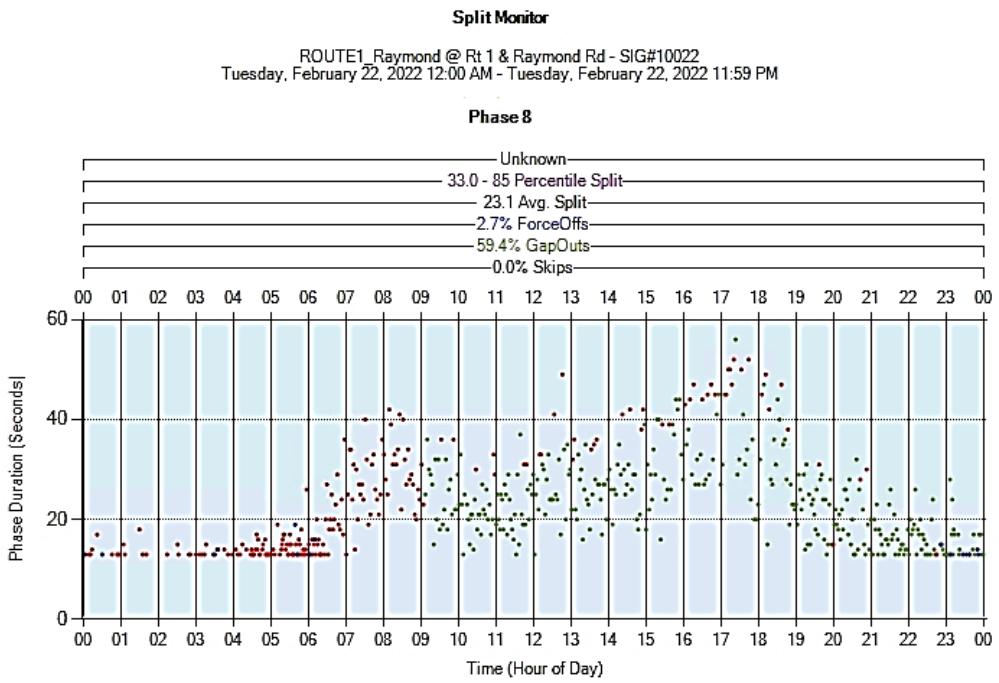
Translating the Data

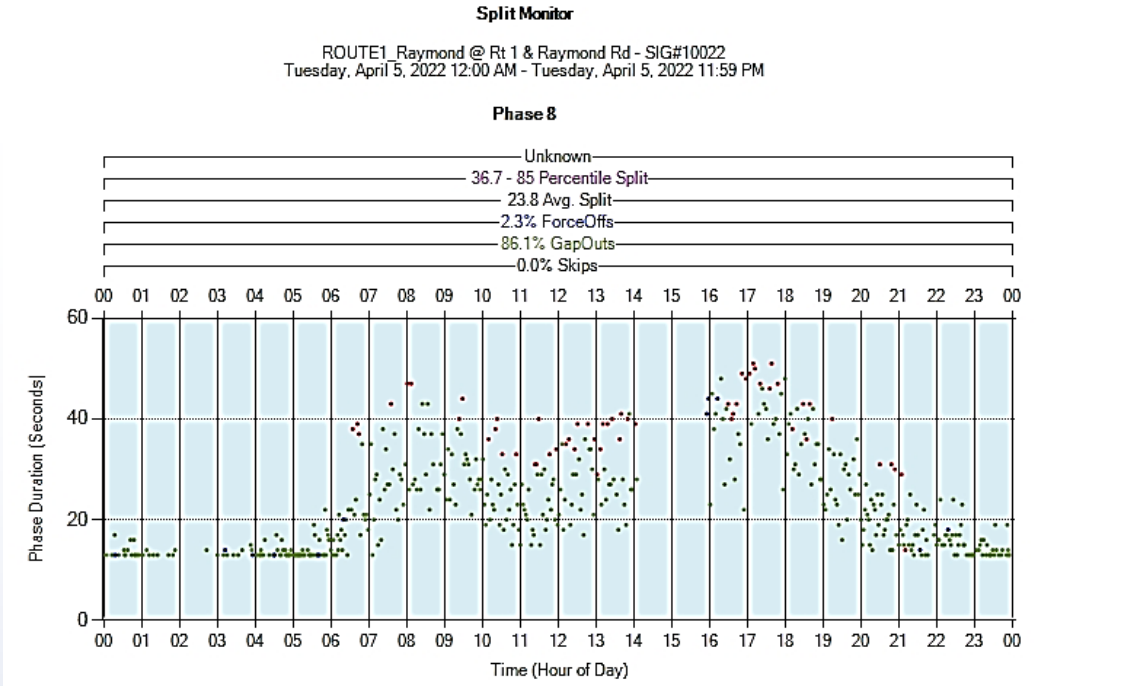
Time to Translate



Reporting Performance or Improving Performance

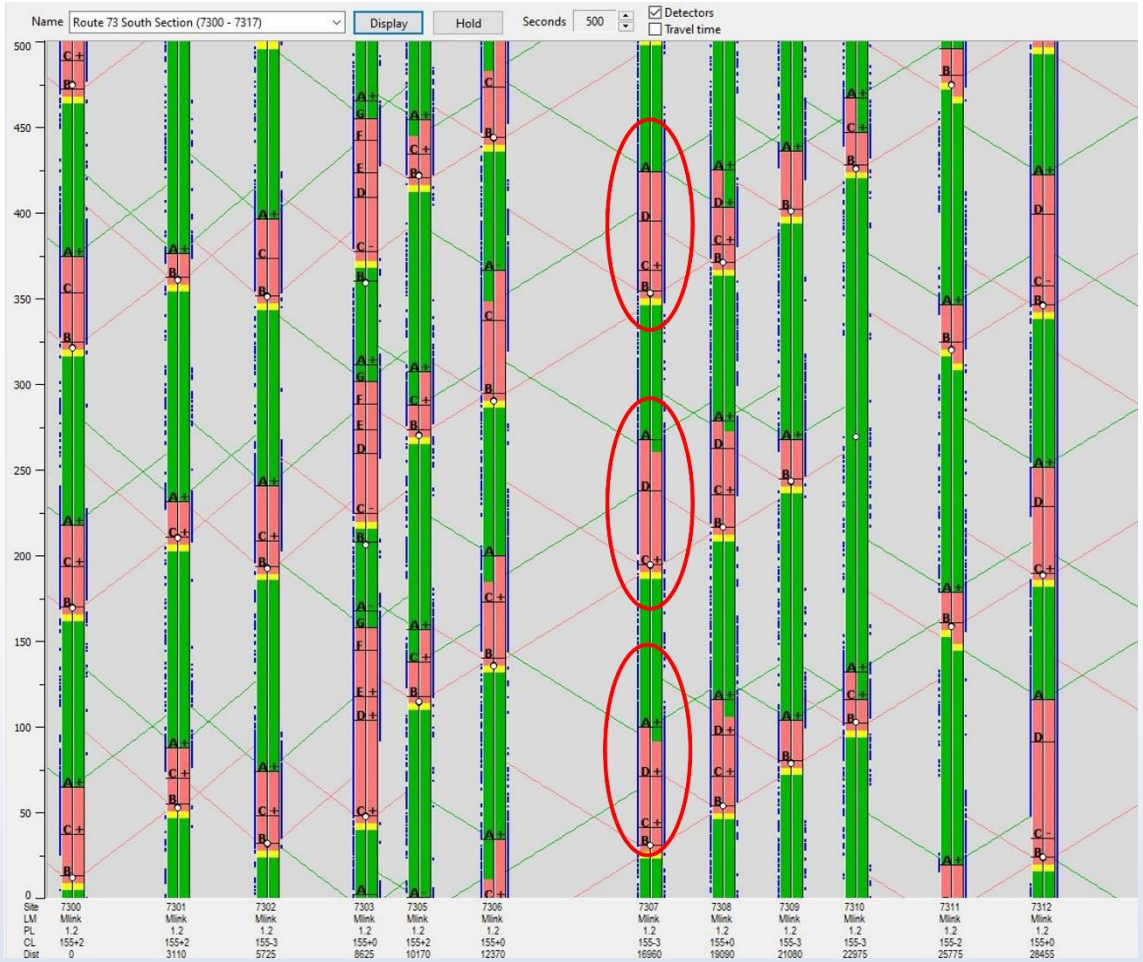
Who is listening? – The Engineer

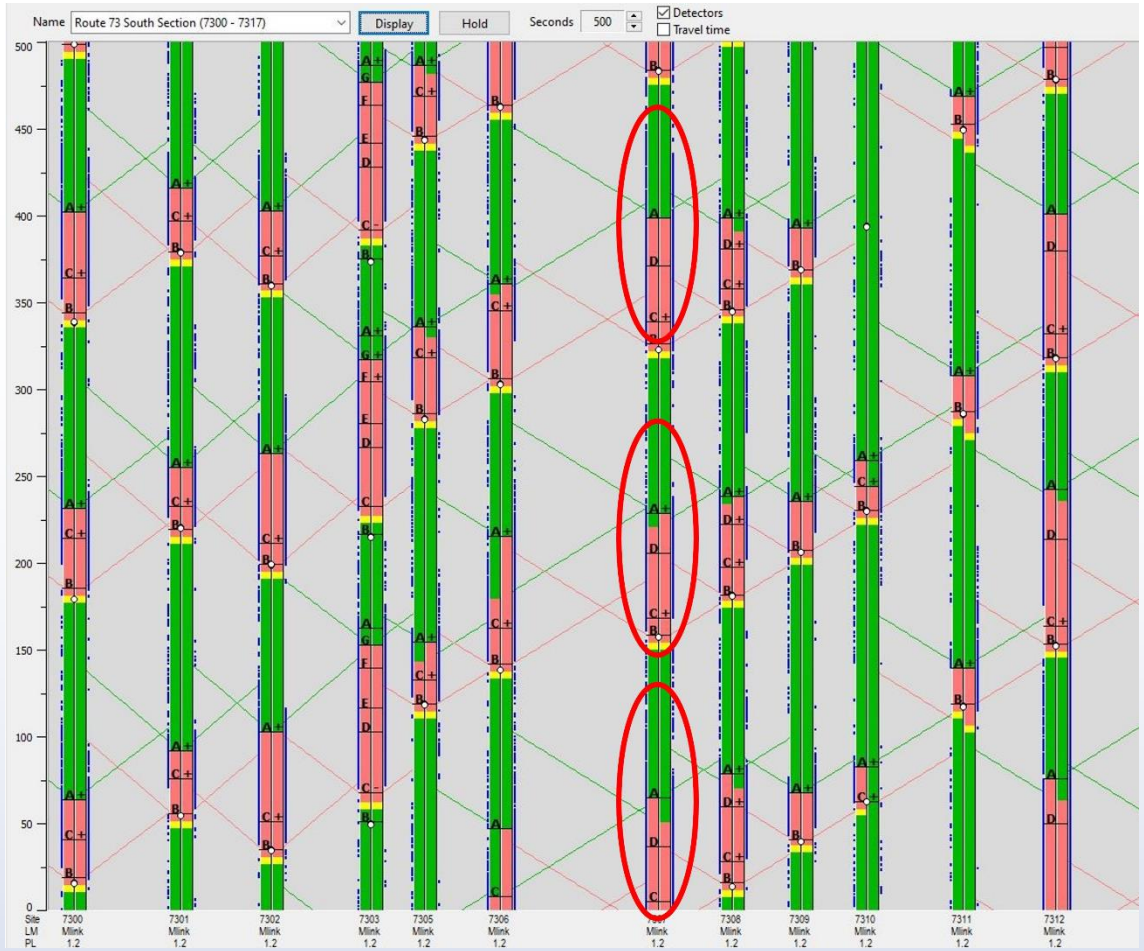




Reporting Performance or Improving Performance

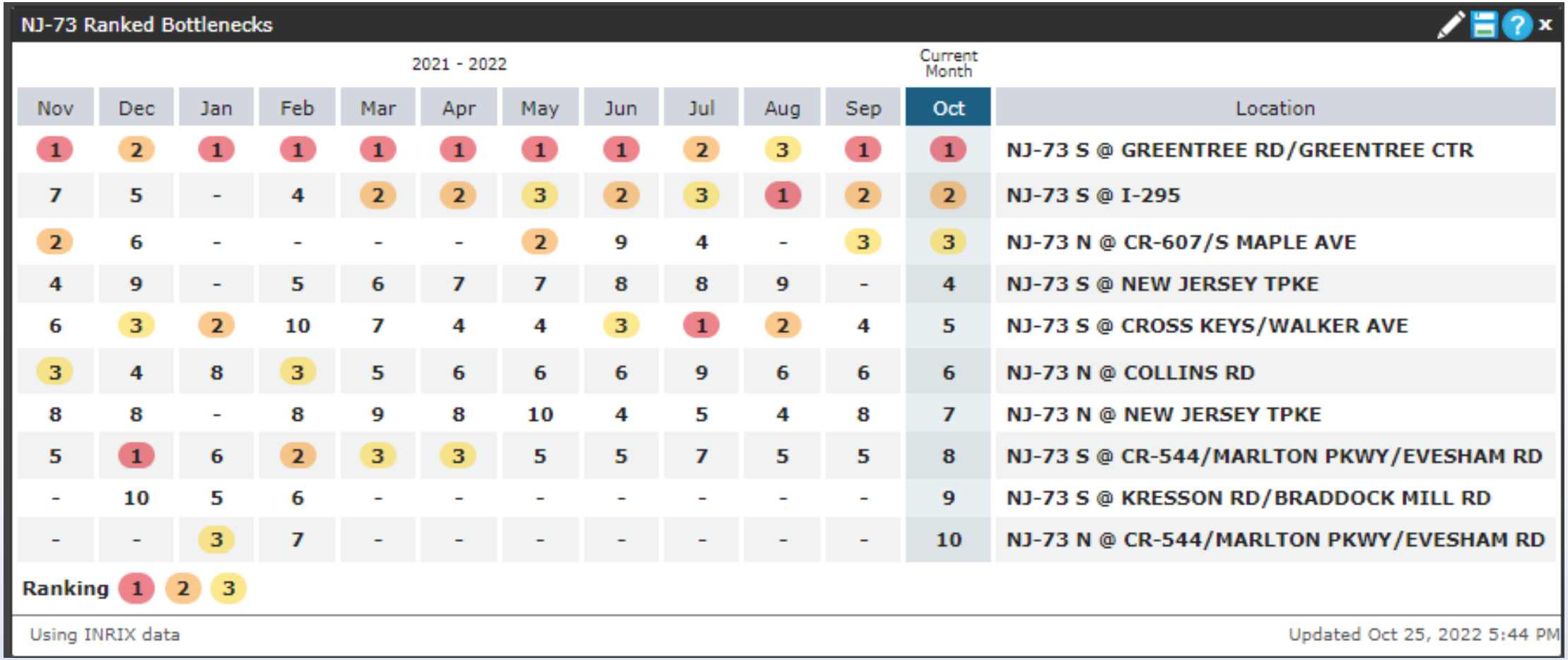
Who is listening? – The Engineer





Reporting Performance or Improving Performance

Who is listening? – The Public/Management



NJ-73 Ranked Bottlenecks

2021 - 2022											Current Month	
Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Location
1	2	1	1	1	1	1	1	2	3	1	1	NJ-73 S @ GREENTREE RD/GREENTREE CTR
7	5	-	4	2	2	3	2	3	1	2	2	NJ-73 S @ I-295
2	6	-	-	-	-	2	9	4	-	3	3	NJ-73 N @ CR-607/S MAPLE AVE
4	9	-	5	6	7	7	8	8	9	-	4	NJ-73 S @ NEW JERSEY TPKE
6	3	2	10	7	4	4	3	1	2	4	5	NJ-73 S @ CROSS KEYS/WALKER AVE
3	4	8	3	5	6	6	6	9	6	6	6	NJ-73 N @ COLLINS RD
8	8	-	8	9	8	10	4	5	4	8	7	NJ-73 N @ NEW JERSEY TPKE
5	1	6	2	3	3	5	5	7	5	5	8	NJ-73 S @ CR-544/MARLTON PKWY/EVESHAM RD
-	10	5	6	-	-	-	-	-	-	-	9	NJ-73 S @ KRESSON RD/BRADDOCK MILL RD
-	-	3	7	-	-	-	-	-	-	-	10	NJ-73 N @ CR-544/MARLTON PKWY/EVESHAM RD

Ranking 1 2 3

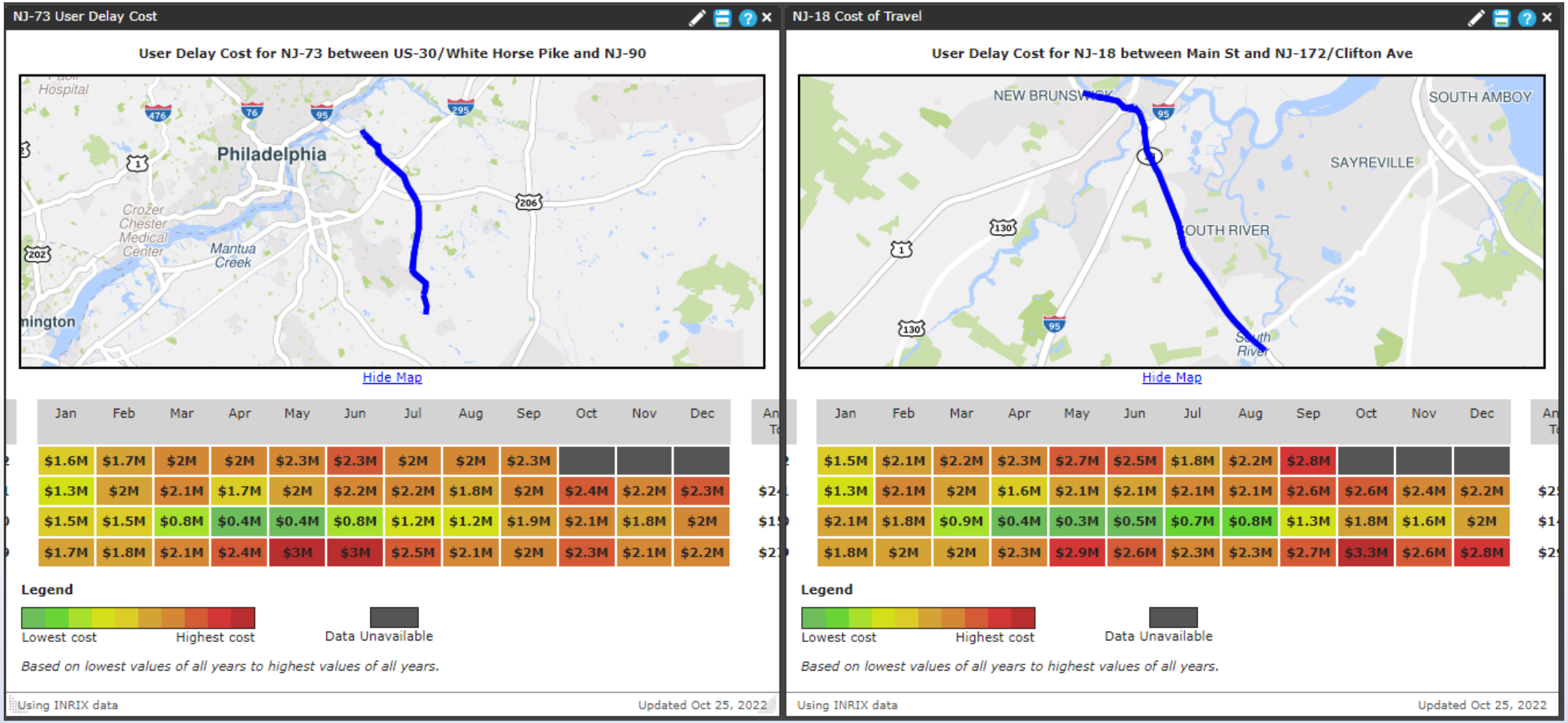
Using INRIX data

Updated Oct 25, 2022 5:44 PM

NJDOT – Transportation Mobility "Improving Lives by Improving Mobility"

Reporting Performance or Improving Performance

Who is listening? – The Public/Management



NJDOT – Transportation Mobility "Improving Lives by Improving Mobility"

Key Points

ATSPMs are a tool to optimize signal timings closer to real-time.

Event codes for inputs and outputs provides a framework for creating metrics.

There is a difference between reporting on performance metrics and using metrics to optimize signals.

THANK YOU

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NJDOT

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Incorporating Energy and GHG into ATSPMs

Stanley Young
Chief Data Officer
The Eastern Transportation Coalition

Incorporation of Excessive Energy Measures into ATSPM

TETC Webinar: Everything You've Ever Wanted To Know About ATSPMS

Presented by

Dr. Stanley E. Young

NJIT New Jersey Institute of Technology

NREL Transforming ENERGY

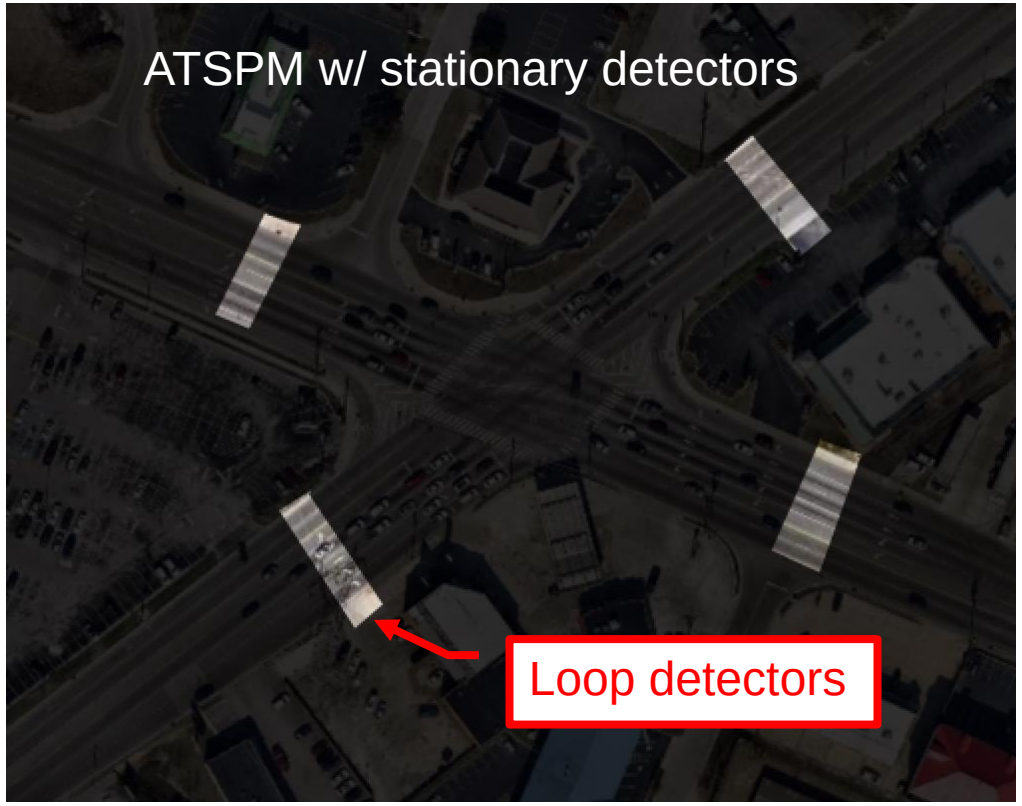
Overview

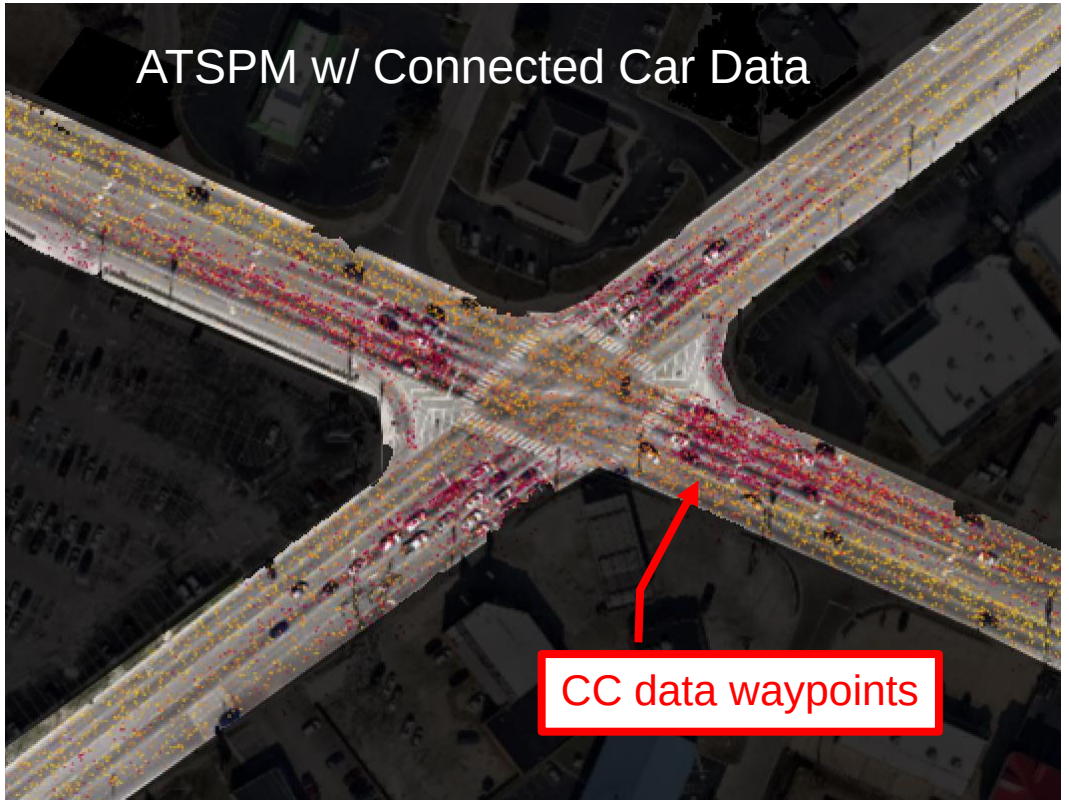
- Project: Incorporation of Excessive Energy Measures into Automated Traffic Signal Performance Metrics
- Duration: Oct. 2021 – Mar. 2023
- Team members
  - NJIT:
    - Dr. Branislav Dimitrijevic, Assistant Professor
    - Dr. Zijia (Gary) Zhong, Senior Transportation Engineer
    - Dr. Dejan Besenski, Deputy Director of ITS Resource Center
  - NREL:
    - Dr. Stanley E. Young, Advanced Transportation & Urban Scientist
    - Joseph Fish, Transportation Data Researcher
    - Stanley A. Young, Researcher

Background

- Traffic signals contribute to 329 million US vehicle hours of delay annually (about 19% of all congestion causes)* and signal optimization projects have benefit-cost ratio exceeding 40:1 (NTOC, 2012)**
- **Crowd-sourced vehicle trajectory data** (sometimes called Connected Vehicle Data or Probe Vehicle Data) provides nearly ubiquitous collection of high-precision individual vehicle waypoints owing to advanced vehicle telematics integrated in passenger vehicles.
- **ATSPMs can be accurately replicated even with low-penetration-rate (1% to 5%) trajectory data, without the need expensive ad hoc sensing infrastructure*****
- **Excessive energy** is integral to the holistic view of the overall impact of traffic control at signalized intersections – parallel to delay.

Intersection Observability





Connected car (CC) data provide ubiquitous coverage w/o ad hoc intersection sensors (e.g., loop detectors, cameras)

NJIT New Jersey Institute of Technology

NREL Transforming ENERGY

Scope of Work - Objectives

- Conceptualize excessive energy performance metric(s)
- Correlate energy metrics with other ATSPM metrices (stops/AoG, delays, etc.)
- Integrate the module for calculating excess energy into the ATSPM codebase
- Produce ATSPMs for signalized corridors in Chattanooga, TN region
- Refine and release enhanced ATSPM codebase
- Conduct outreach (webinar) to traffic control professionals and researchers

NB_US64

	Delay	Stop	AOG	TTAvg	TT50	TT80	LOTTR	n_value	Energy
('Chickamauaga', '20-22', 'LOS A')	6.4	0.27	0.71	16.8	14.2	24.6	1.73	52	0.12
('Chickamauaga', '16-18', 'LOS A')	5.8	0.13	0.86	15.0	9.2	13.1	1.42	319	0.08
('Chickamauaga', '14-16', 'LOS A')	4.7	0.07	0.93	14.4	9.8	12.8	1.31	301	0.09
('E Brainerd', '18-20', 'LOS A')	4.0	0.09	0.88	10.5	5.6	17.7	3.19	313	0.11
('Chickamauaga', '6-8', 'LOS A')	3.8	0.04	0.96	12.6	8.7	11.1	1.27	218	0.10
('Chickamauaga', '22-24', 'LOS A')	3.6	0.11	0.87	13.9	12.2	15.3	1.25	45	0.08
('E Brainerd', '10-12', 'LOS A')	3.3	0.08	0.92	8.9	5.4	16.1	2.96	392	0.07
('Chickamauaga', '12-14', 'LOS A')	3.3	0.10	0.90	12.8	9.7	11.9	1.23	301	0.06
('E Brainerd', '12-14', 'LOS A')	3.2	0.06	0.93	7.8	4.9	15.4	3.11	403	0.14

Excessive energy column(s)

"Excessive energy" is the energy parallel of "delay"

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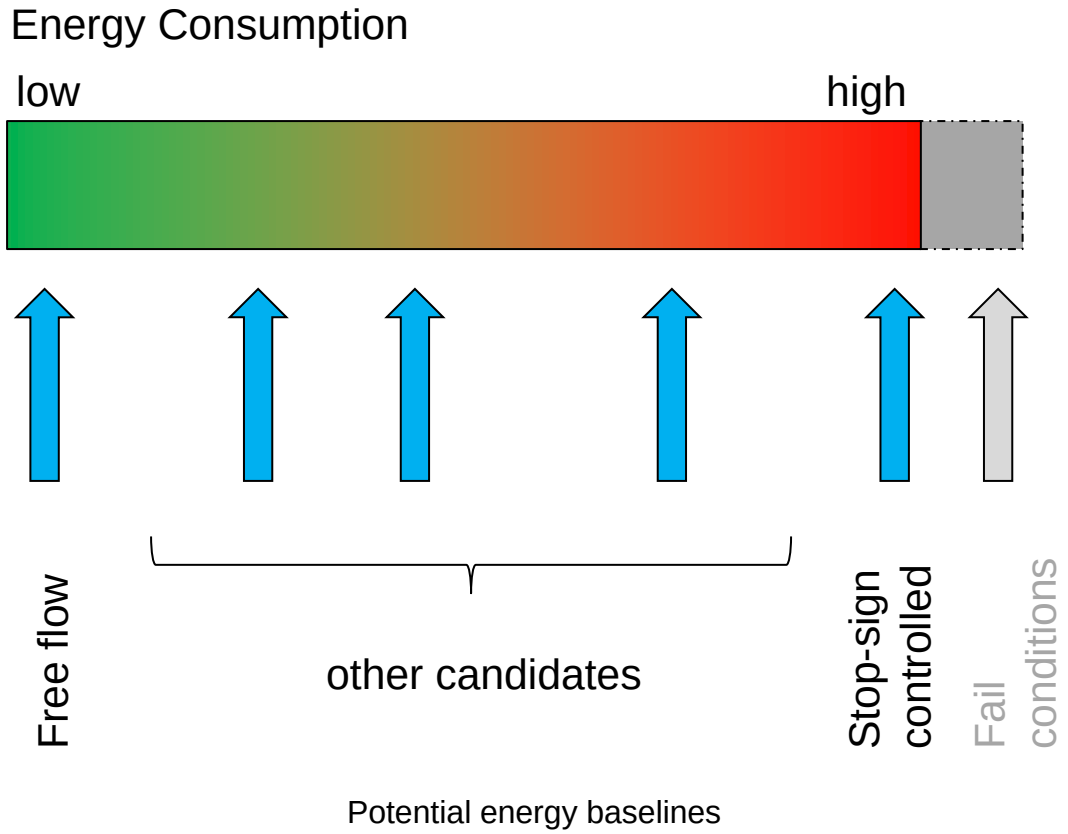
Defining Baseline Energy

- Key challenges:
  - Determining the “expected”, baseline condition for assessing the excess energy.
  - Definitions understood by a general public (for instance, the travel time reliability indexes by USDOT)
- Energy consumption spectrum
  - MAX: **STOP-sign controlled** (all vehicles stop at the intersection)
    - as if zero arrival on green (AOG)
  - MIN: **Free flow** (analogue to defining free-flow speed)
    - as if no signal control (AOG = 100%)
    - existing ATSPM use free-flow (speed limit) as a baseline



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Wejo Vehicle Trajectory Data

- Infrastructure agnostic (no ad hoc field sensors)
- Coverage:
  - Near ubiquitous across roadways
  - Collected exclusively from certain OEMs passenger vehicles
- Resolution:
  - Spatial: lane-level (6-digit geocoordinates)
  - Temporal: 3-s ping interval (w/ minimal deviation)

Signals & Wejo data at downtown area

wejo © Wejo Ltd.


```
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  "dataPointId": "ce200d96-0058-40b7-8db9-e2da8a2987de",
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Wejo vehicle movement data

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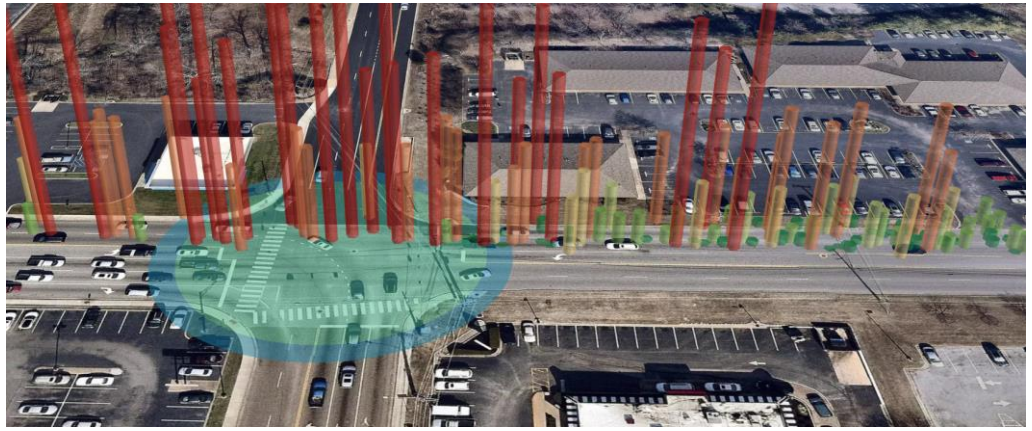
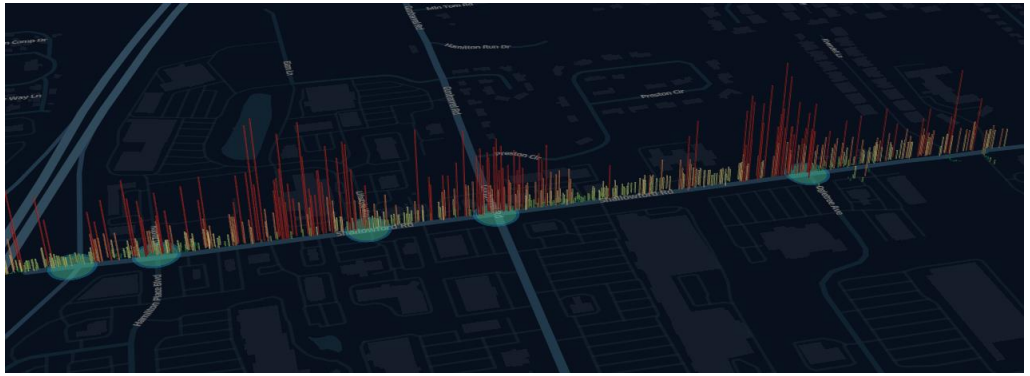
Trajectory-level Energy Consumption



Waypoint-based energy consumption (intersection thru. movement)



Waypoint-based energy consumption (corridor view)

- The Future Automotive Systems Technology Simulator (FASTSim)
- Waypoint up-sample to 1 Hz from the original 1/3 Hz (3 s)
- A basic sedan model (i.e., Toyota Corolla) in FASTSim is used

FASTSim

Percent Difference Downsampled	Percent Difference Upsampled: Linear	Percent Difference Upsampled: Polynomial (2nd order)	Percent Difference Upsampled: Polynomial (3rd order)
0.76%	0.73%	0.15%	0.12%

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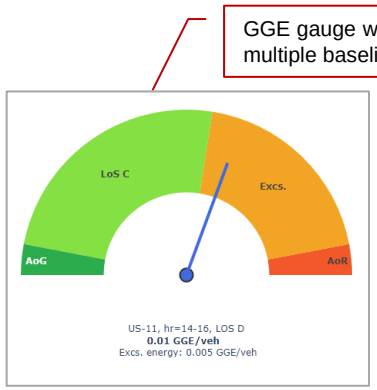
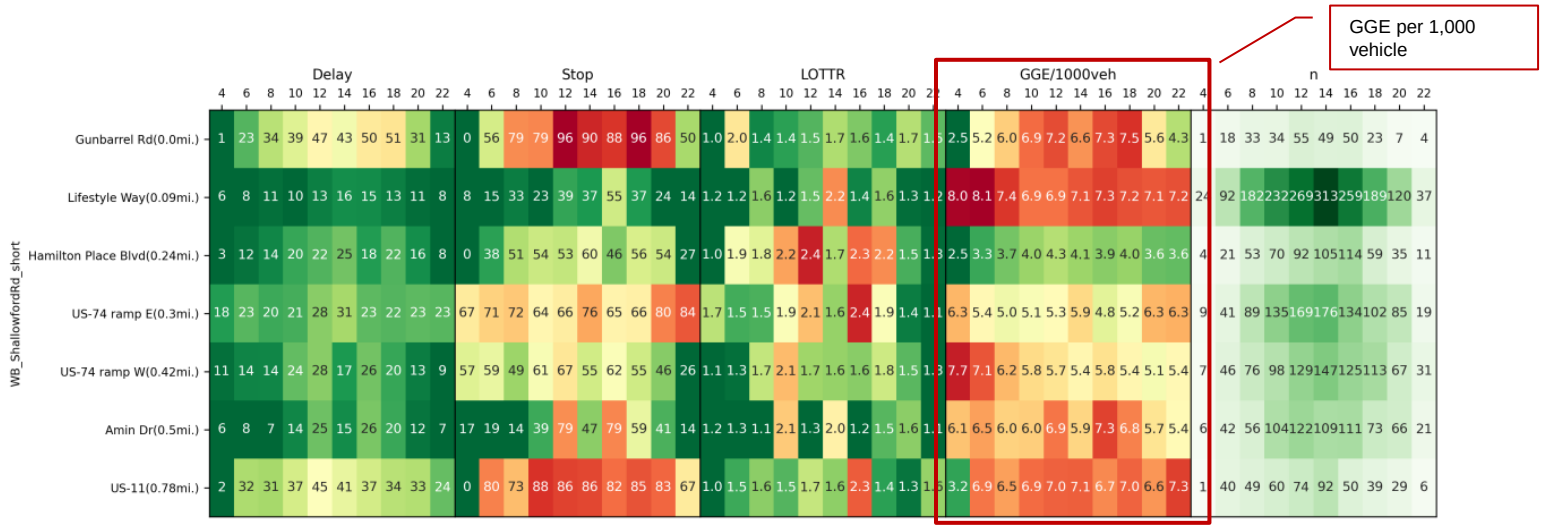
Energy ATSPM Example

- Based on Shallowford Rd corridor
- Energy module: NREL's FASTSim fuel consumption data
- Energy baseline implemented
  - Arrival on Green (AoG) baseline: best case
  - Level of service (LoS C): "reasonable" range
  - Arrival on Red (AoR) baseline: worst case
- Excessive Energy added to the ATSPM output performance matrix
  - Gasoline gallon equivalent (GGE) used as the performance measure

*heatmap shows the worse segment first



GGE gauge with multiple baselines



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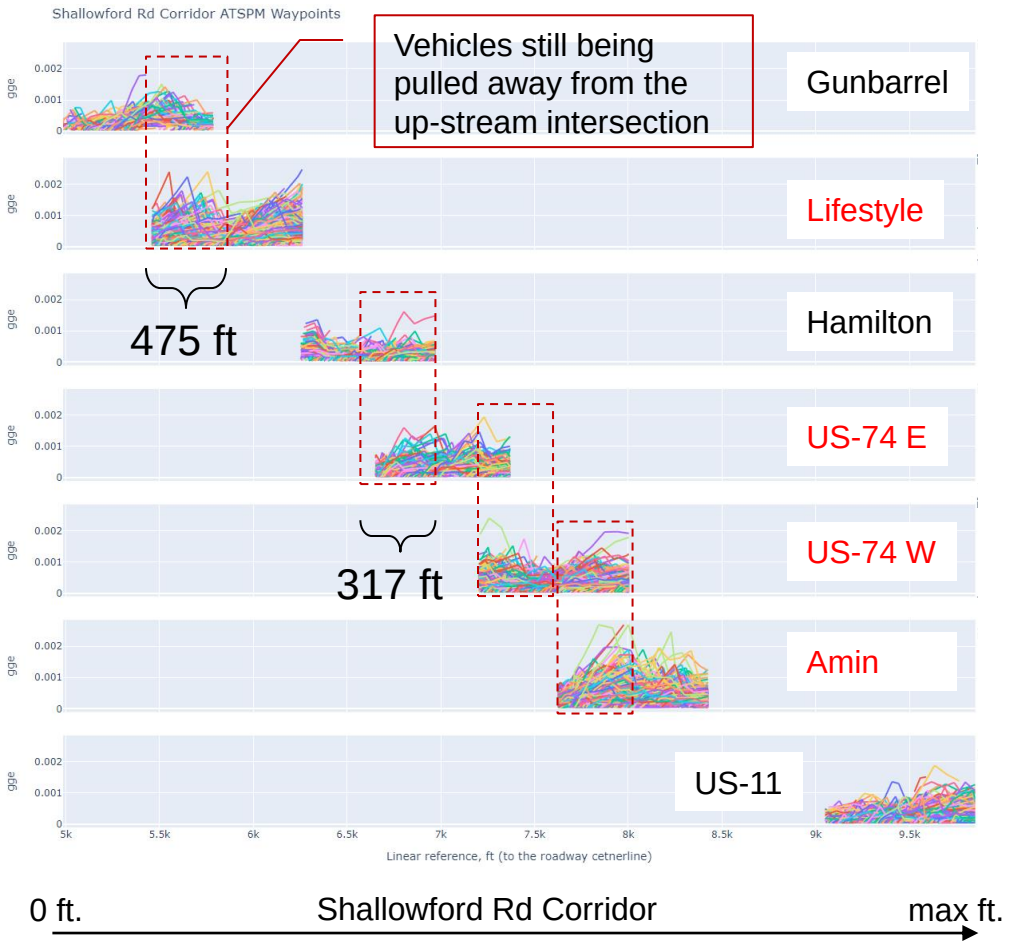
Coupled vs. Regular Intersection (Shallowford Rd example)



- Waypoints used for ATSPM & energy calculation for each intersection
- "Energy-space" diagram
- ± 400 ft. up- and down-stream
- Overlapping segments observed (marked by red rectangular)
- Possibility of vehicles still accelerating from an up-stream intersection (causing high GGE, with relatively short traverse time)
- Kinetic Energy: $E_k = \frac{1}{2}mv^2$ (quadric relationship between speed and kinetic energy)

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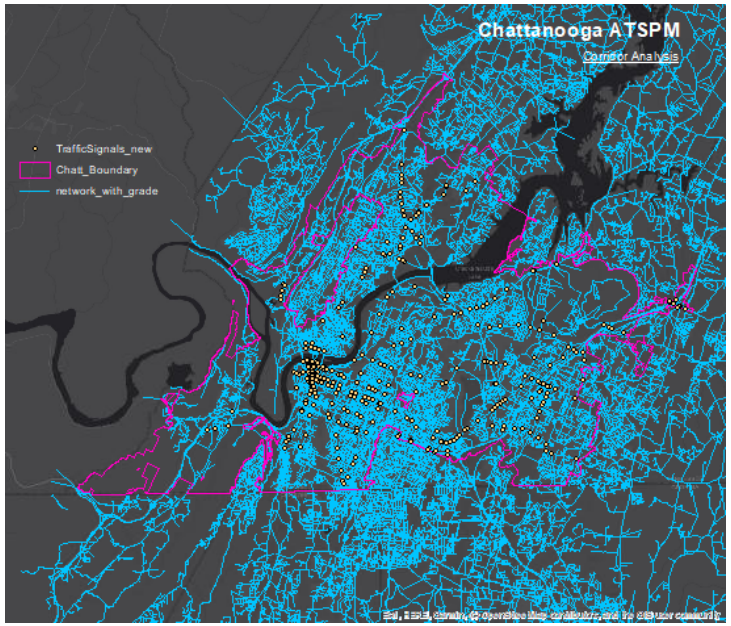
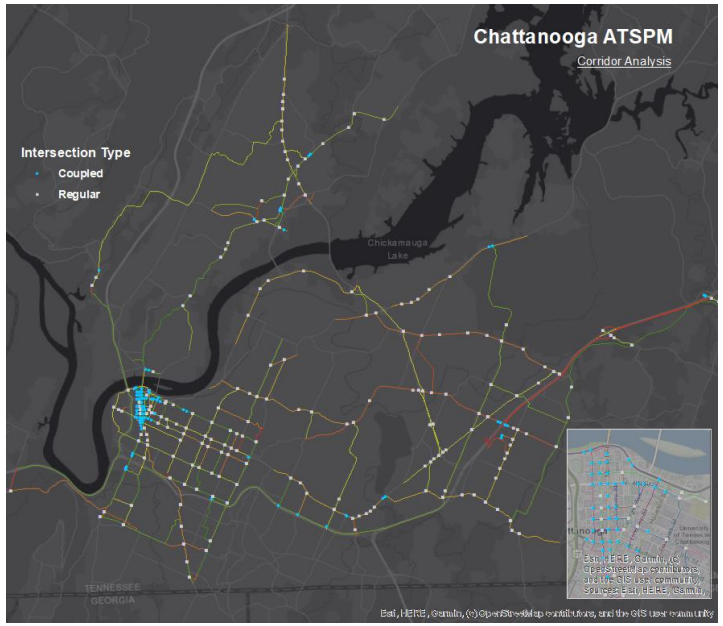
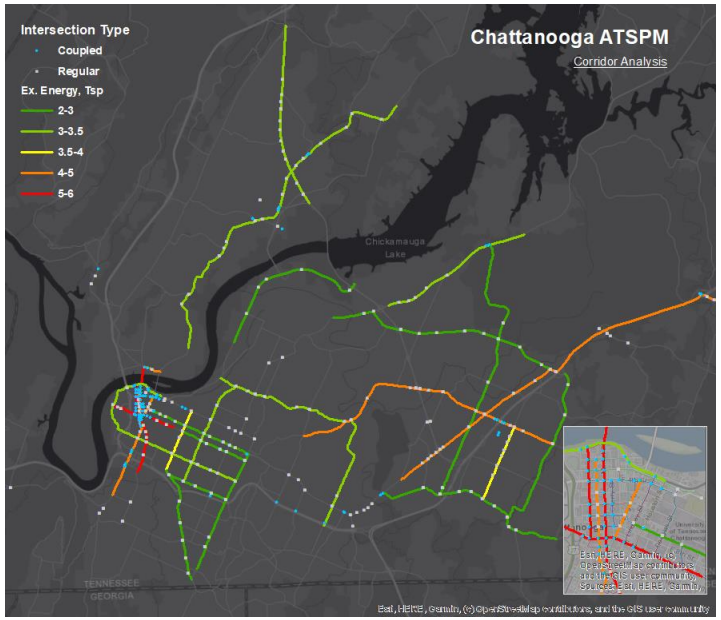
Scaling Energy-ATSPM



Signalized intersections & transportation network in Chattanooga, TN



ID corridors & intersection type



Normalized corridor excessive energy

- Deployed Energy-ATSPM framework on Eagle supercomputer cluster at NREL for massive parallel computing
  - 28 corridors (w/ both through movements) covering 237 (71%) of all signalized intersections
  - Based on 1-month Wejo vehicle trajectory data

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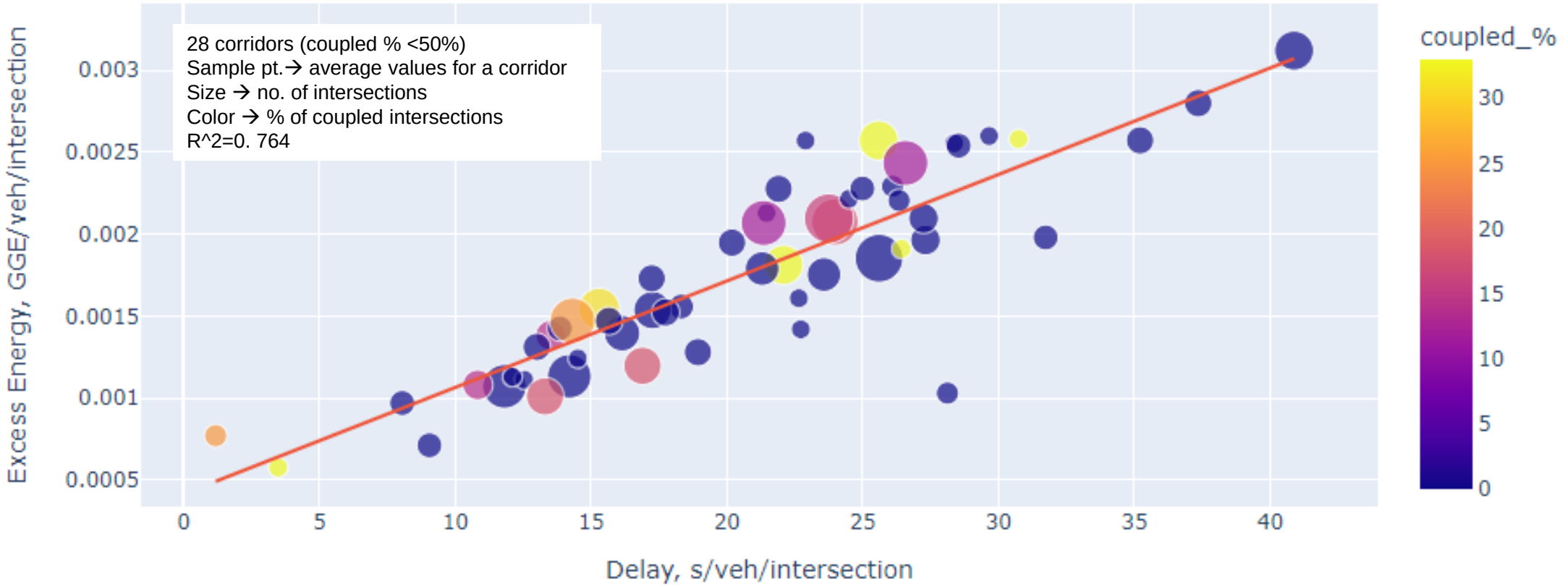
Delay vs. Excessive Energy (preliminary)



- Corridor excessive energy (GGE/veh./intersection) for through movements.
- Corridors comprised of less than 50% coupled intersections (Non-coupled intersections > 500 ft. distance).

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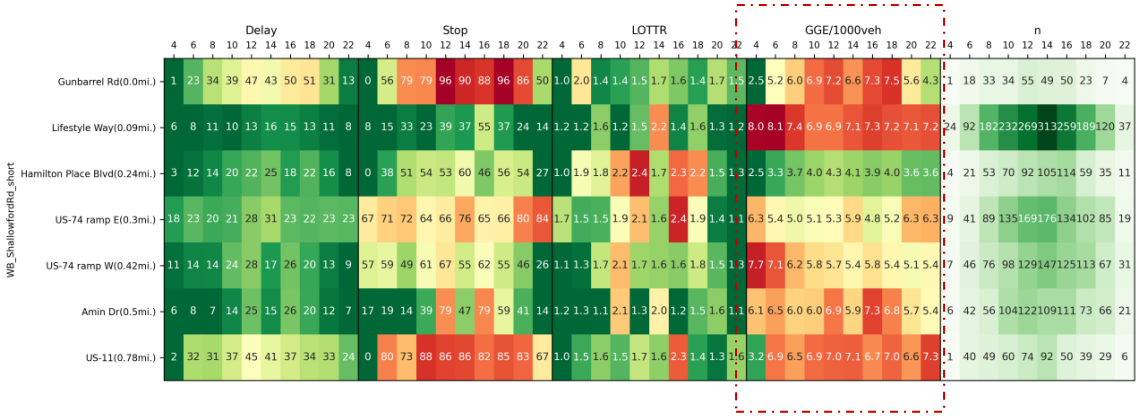
Conclusions

- Conceptualized excessive energy and integrated energy baseline into the existing ATSPM framework
- Developed and exercised using the Shallowford Rd corridor as a case study, then scaled up to the Chattanooga area
- Initial analysis of the correlation between the traffic mobility metrics (delays) and excessive energy metrics
- Next steps
  - Fine-tune the corridor identification algorithm
  - Further explore the relationship between traffic (mobility) and energy (fuel consumption) metrics
  - Update and refine the codebase and documentation



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Q&A Discussion

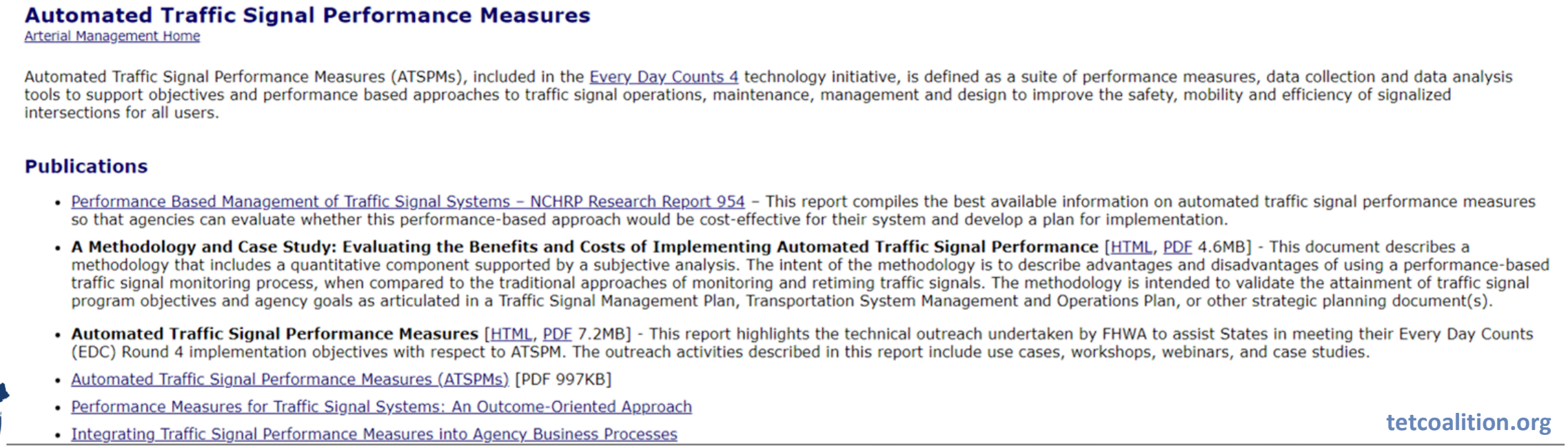
Lisa Miller
Innovation Program Manager
The Eastern Transportation Coalition

Poll 4: What is preventing you from using ATSPMs?

- Please use the pop-up box to submit your answer

Resources

- Grants
- Peer to Peer
- Websites (Purdue, UDOT, Georgia DOT, etc!)
- FHWA Case Studies



Automated Traffic Signal Performance Measures

Arterial Management Home

Automated Traffic Signal Performance Measures (ATSPMs), included in the Every Day Counts 4 technology initiative, is defined as a suite of performance measures, data collection and data analysis tools to support objectives and performance based approaches to traffic signal operations, maintenance, management and design to improve the safety, mobility and efficiency of signalized intersections for all users.

Publications

- Performance Based Management of Traffic Signal Systems – NCHRP Research Report 954 – This report compiles the best available information on automated traffic signal performance measures so that agencies can evaluate whether this performance-based approach would be cost-effective for their system and develop a plan for implementation.
- **A Methodology and Case Study: Evaluating the Benefits and Costs of Implementing Automated Traffic Signal Performance** [HTML, PDF 4.6MB] - This document describes a methodology that includes a quantitative component supported by a subjective analysis. The intent of the methodology is to describe advantages and disadvantages of using a performance-based traffic signal monitoring process, when compared to the traditional approaches of monitoring and retiming traffic signals. The methodology is intended to validate the attainment of traffic signal program objectives and agency goals as articulated in a Traffic Signal Management Plan, Transportation System Management and Operations Plan, or other strategic planning document(s).
- **Automated Traffic Signal Performance Measures** [HTML, PDF 7.2MB] - This report highlights the technical outreach undertaken by FHWA to assist States in meeting their Every Day Counts (EDC) Round 4 implementation objectives with respect to ATSPM. The outreach activities described in this report include use cases, workshops, webinars, and case studies.
- Automated Traffic Signal Performance Measures (ATSPMs) [PDF 997KB]
- Performance Measures for Traffic Signal Systems: An Outcome-Oriented Approach
- Integrating Traffic Signal Performance Measures into Agency Business Processes

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CONNECTING FOR SOLUTIONS

THANK YOU

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