FEATURE
CORE INNOVATION AREA
PRESENTATION

CIA TEAM

MOBILITY & OPS

NJDOT – Sal Cowan & Wayne Patterson

FHWA – Ek Phomsavath

NJDOT – Transportation Mobility

"Improving Lives by Improving Mobility"

Automated Traffic Signal Performance Measures

NJ State Transportation Innovation Council

May 7th, 2019

Kelly McVeigh, Principal Traffic Engineer

NJDOT – Transportation Mobility

Outline

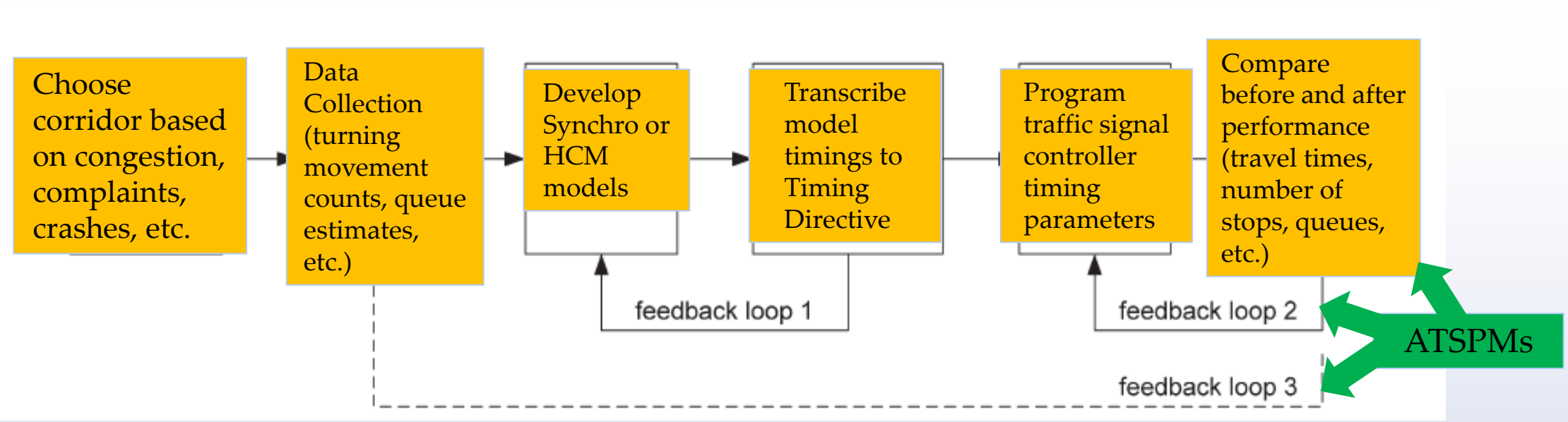
- Introduction to Automated Traffic Signal Performance Measures (ATSPMs)
- NJDOT Research Project
- Future work involving ATSPMs
- Questions

Introduction to ATSPMs

- What is the **NEED**?

Introduction to ATSPMs

- Traffic Engineers **NEED** to know how signal timings perform.
- Traditional process of knowing is a lengthy one.



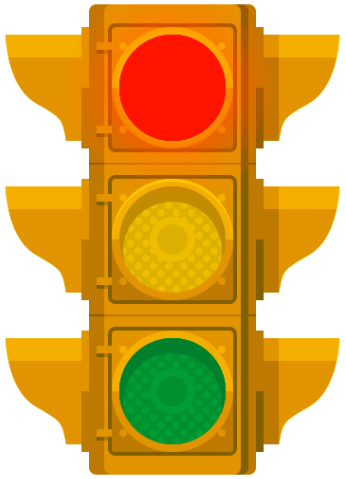
Introduction to ATSPMs

- Most practitioners would agree.

Introduction to ATSPMs

- **HOW** do you generate ATSPMs?

Indiana Traffic Signal Hi Resolution Data Logger Enumerations



6 Events occur at the signal head:
1. Begin of Green
2. End of Green
3. Begin of Yellow
4. End of Yellow
5. Begin of Red
6. End of Red

When a controller timestamps those events, they become **Hi-resolution Data**

Introduction to ATSPMs

- **WHY** would you generate ATSPMs?
- **Increased Safety.** A shift to proactive operations and maintenance practices can improve safety by reducing the traffic congestion that results from poor and outdated signal timing.
- **Targeted Maintenance.** ATSPMs provide the actionable information needed to deliver high-quality service to customers, with significant cost savings to agencies.
- **Improved Operations.** Active monitoring of signalized intersection performance lets agencies address problems before they become complaints.
- **Improved Traffic Signal Timing and Optimization Policies.** Agencies are able to adjust traffic signal timing parameters based on quantitative data without requiring a robust data collection and modeling process.

NJDOT Research Project

NJDOT Project 2016-14
Real-Time Traffic Signal Performance Measurement

NJDOT – Transportation Mobility
“Improving Lives by Improving Mobility”

NJDOT Research Project

Project Team

NJDOT Research
Kim Davis, Section Chief, Statewide Planning
NJDOT Transportation Mobility
Kelly McVeigh, Principal Engineer Traffic
Shazia Khizir, Assistant Engineer Traffic
Rutgers Center for Advanced Infrastructure and Transportation (CAIT)
Peter Jin, Ph.D., Assistant Professor
The College of New Jersey (TCNJ)
Thomas Brennan, Ph.D., PE., Associate Professor
Rowan University
Mohammad Jalayer, Ph.D., Assistant Professor

NJDOT Research Project

- **Objectives:**
  - Development of metrics, guidelines, and implementation strategies for Automated Traffic Signal Performance Measures.
  - Based on the **existing infrastructure** operated and maintained by NJDOT.
  - Develop a prototype ATSPM system.
- **NJDOT Infrastructure:**
  - Centralized control (servers)
  - Fiber-optic communication
  - **Adaptive Signal Control Technology (ASCT)**

NJDOT Research Project

- NJDOT is actively deploying ASCT.

Full Operation:
NJ-18 (SCATS) = 13 Signals
US-1 (InSync) = 22 Signals
US-130 (SCATS) = 18 Signals
US-130 (InSync) = 12 Signals
NJ-168 (InSync) = 11 Signals
MASSTR (SCATS) = 123 Signals

Under Construction/Final Design:
US-1 = 12 Signals
NJ-73 = 29 Signals
US-322 & US-40 = 27 Signals

Concept Development:
11 Corridors = 122 Signals

NJDOT – Transportation Mobility
"Improving Lives by Improving Mobility"

NJDOT Research Project

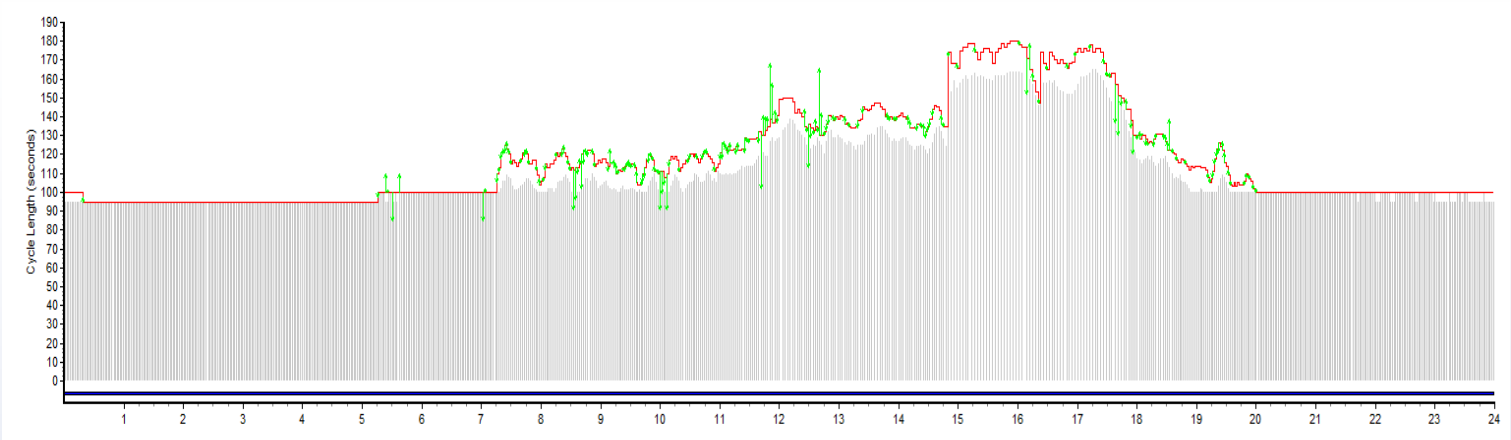
- **What do Adaptive Systems have to offer?**

Time	Duration	Movement	Phase 2 (NT)		Phase 3 (WL)		Phase 4 (ET)		Phase 6 (ST)		Period
			Q	W	Q	W	Q	W	Q	W	
06:03:32 AM	148		13	47	1	15	0	0	6	31	200
06:05:09 AM		Ped Called									
06:06:09 AM	17		0	0	2	172	1	77	0	0	200
06:06:24 AM		Ped Sent									
06:06:33 AM	34		0	0	0	0	2	100	3	21	200
06:07:14 AM	101		0	0	1	29	0	0	11	62	200
06:09:04 AM	17		0	0	2	139	1	19	1	3	200

NJDOT – Transportation Mobility
"Improving Lives by Improving Mobility"

NJDOT Research Project

- **What do Adaptive Systems have to offer?**

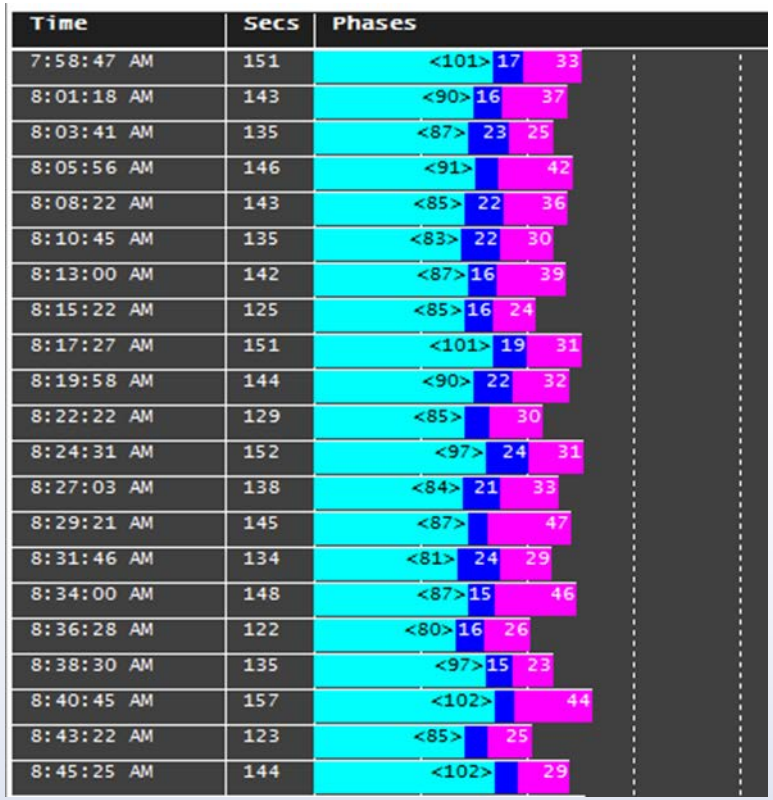


Time	Secs	Phases
7:58:47 AM	151	<101> 17 33
8:01:18 AM	143	<90> 16 37
8:03:41 AM	135	<87> 23 25
8:05:56 AM	146	<91> 42
8:08:22 AM	143	<85> 22 36
8:10:45 AM	135	<83> 22 30
8:13:00 AM	142	<87> 16 39
8:15:22 AM	125	<85> 16 24
8:17:27 AM	151	<101> 19 31
8:19:58 AM	144	<90> 22 32
8:22:22 AM	129	<85> 30
8:24:31 AM	152	<97> 24 31
8:27:03 AM	138	<84> 21 33
8:29:21 AM	145	<87> 47
8:31:46 AM	134	<81> 24 29
8:34:00 AM	148	<87> 15 46
8:36:28 AM	122	<80> 16 26
8:38:30 AM	135	<97> 15 23
8:40:45 AM	157	<102> 44
8:43:22 AM	123	<85> 25
8:45:25 AM	144	<102> 29

NJDOT – Transportation Mobility
“Improving Lives by Improving Mobility”

NJDOT Research Project

- **Project Team Challenge:**
- Translate Adaptive Signal Data to ATSPM Source Code Data



Time	Secs	Phases
7:58:47 AM	151	<101> 17 33
8:01:18 AM	143	<90> 16 37
8:03:41 AM	135	<87> 23 25
8:05:56 AM	146	<91> 42
8:08:22 AM	143	<85> 22 36
8:10:45 AM	135	<83> 22 30
8:13:00 AM	142	<87> 16 39
8:15:22 AM	125	<85> 16 24
8:17:27 AM	151	<101> 19 31
8:19:58 AM	144	<90> 22 32
8:22:22 AM	129	<85> 30
8:24:31 AM	152	<97> 24 31
8:27:03 AM	138	<84> 21 33
8:29:21 AM	145	<87> 47
8:31:46 AM	134	<81> 24 29
8:34:00 AM	148	<87> 15 46
8:36:28 AM	122	<80> 16 26
8:38:30 AM	135	<97> 15 23
8:40:45 AM	157	<102> 44
8:43:22 AM	123	<85> 25
8:45:25 AM	144	<102> 29

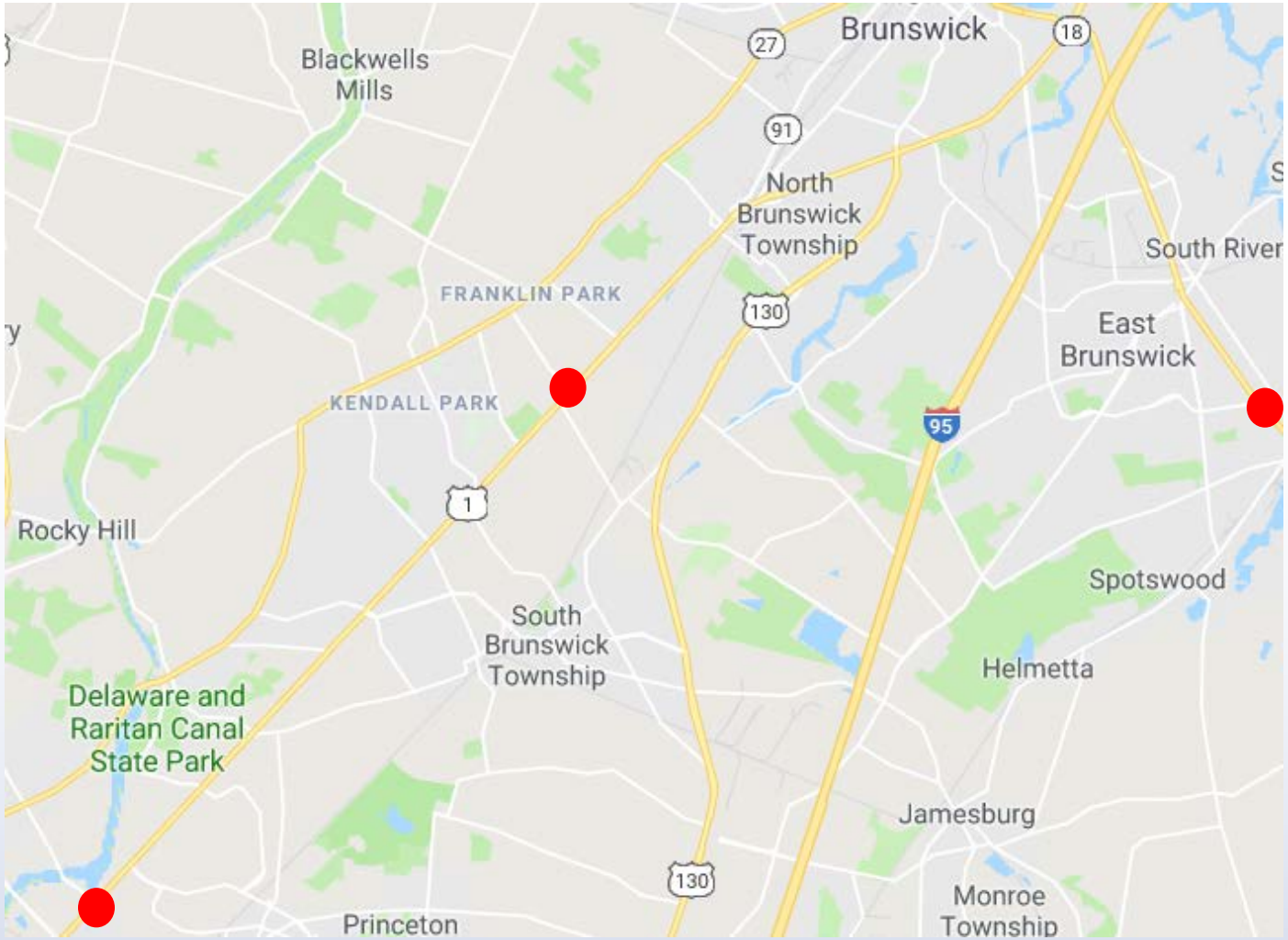
Indiana Traffic Signal Hi Resolution Data Logger Enumerations

Event Code	Event Descriptor	Parameter	Description
Active Phase Events:			
0	Phase On	Phase # (1-16)	Set when NEMA Phase On becomes active, either upon start of green or walk interval, whichever occurs first.
1	Phase Begin Green	Phase # (1-16)	Set when either solid or flashing green indication has begun. Do not set repeatedly during flashing operation.
2	Phase Check	Phase # (1-16)	Set when a conflicting call is registered against the active phase. (Marks beginning of MAX timing)
3	Phase Min Complete	Phase # (1-16)	Set when phase min timer expires.
4	Phase Gap Out	Phase # (1-16)	Set when phase gaps out, but may not necessarily occur upon phase termination. Event may be set multiple times within a single green under simultaneous gap out.
5	Phase Max Out	Phase # (1-16)	Set when phase MAX timer expires, but may not necessarily occur upon phase termination due to last car passage or other features.
6	Phase Force Off	Phase # (1-16)	Set when phase force off is applied to the active green phase.

NJDOT Research Project

- **Project Test Intersections**

- US-1 at Harrison (InSync)
- US-1 at Henderson (InSync)
- NJ-18 at Hillsdale (SCATS)



NJDOT – Transportation Mobility
"Improving Lives by Improving Mobility"

NJDOT Research Project

Insync Signal Event Conversion

Convertible Signal Event

Code	Event	Insync Translator Logic
0	PhaseOn	Get from movement start time
1	PhaseBeginGreen	Get from movement start time
2	PhaseCheck	Get from conflicting movement
3	PhaseMinComplete	Duration > Minimum Green time
4	PhaseGapOut	Movement is Truncated Based on Insync Log
5	PhaseMaxOut	if not Gapout, then it will be Maxout
7	PhaseGreenTermination	Movement End Time
8	PhaseBeginYellowClr	Begin Yellow is the same as green termination
9	PhaseEndYellowClr	Phase end time + yellow change interval
10	PhaseBeginRedClr	Begin Red Clearance is the same as end of Yellow Interval
11	PhaseEndRedClr	Begin of Red + Red Clearance Interval
12	PhaseInactive	If a movement not exist in a certain cycle, then create phaseInactive
21	PedBeginWalk	"pedestrian Sent" is in Insync log
43	PhaseCallRegistered	conflicting movements have waiting time
45	PedestrianCallRegistered	"Pedestrian Called" is in Insync log

SCATS Signal Event Conversion

Convertible Signal Event

Code	Event	Insync Translator Logic
0	PhaseOn	"Current Running" in SCATS message
1	PhaseBeginGreen	"Current Running" in SCATS message
2	PhaseCheck	"Phase demand" in SCATS message
3	PhaseMinComplete	"Signal Group: SG6=off" in SCATS message
4	PhaseGapOut	Green Duration < Maxium Green
5	PhaseMaxOut	Green Duration > Maxium Green
7	PhaseGreenTermination	"Phase interval: Yellow" in SCATS message
8	PhaseBeginYellowClr	"Phase interval: Yellow" in SCATS message
9	PhaseEndYellowClr	"Phase interval: All Red" in SCATS message
10	PhaseBeginRedClr	"Phase interval: All Red" in SCATS message
11	PhaseEndRedClr	keyword: "Phase termination"
12	PhaseInactive	If a movement not exist in a certain cycle, then create phaseInactive
21	PedBeginWalk	keywords: "Walk"+"Active=On"
22	PedBeginClearance	Keywords: "Walk" + "Active=Off"
45	PedestrianCallRegistered	keywords: "Walk"+"Demand=On"

NJDOT – Transportation Mobility
"Improving Lives by Improving Mobility"

NJDOT Research Project

Key ATSPM Performance Metrics translated from Adaptive Systems	ATSPM Event Code Used
Purdue Coordinate Diagram (PCD)	Controller timing of red, yellow, and green intervals (event 1, event 7, event 8, event 9, event 10, event 11)
Purdue Phase Termination Charts	Termination reasons (event 4, event 5)
Split Monitor	Phase Termination Events (event 0, event 7, event 8, event 9, event 11)
Pedestrian Delay	Pedestrian Actuation (event 21, event 43, event 45)

NJDOT Research Project

- Translator:

```python
def NEMAphaseNumber():
    # get NEMA Phase and Number hashtable from metadata
    global InsyncMetaData
    nemaPhase2Number = {}
    nemaNumber2Phase = {}
    phaseFieldNum = []
    movesAndNums = set(zip(InsyncMetaData["phaseMove"],InsyncMetaData["phaseNum"]))
    for item in movesAndNums:
        moves, nemaNumbers = item
        for item in zip(moves.split("/"),nemaNumbers.split("/")) :
            nemaPhase2Number[item[0]] = int(item[1])
            nemaNumber2Phase[item[1]] = item[0]
            phaseFieldNum.append(int(item[1]))
    phaseFieldNum = list(set(phaseFieldNum))
    phaseFieldNum.sort()
    return  nemaPhase2Number, nemaNumber2Phase, phaseFieldNum
```

Python Code

NJDOT Research Project

- Example Event Translation: Pedestrian Delay (SCATS to ATSPM)

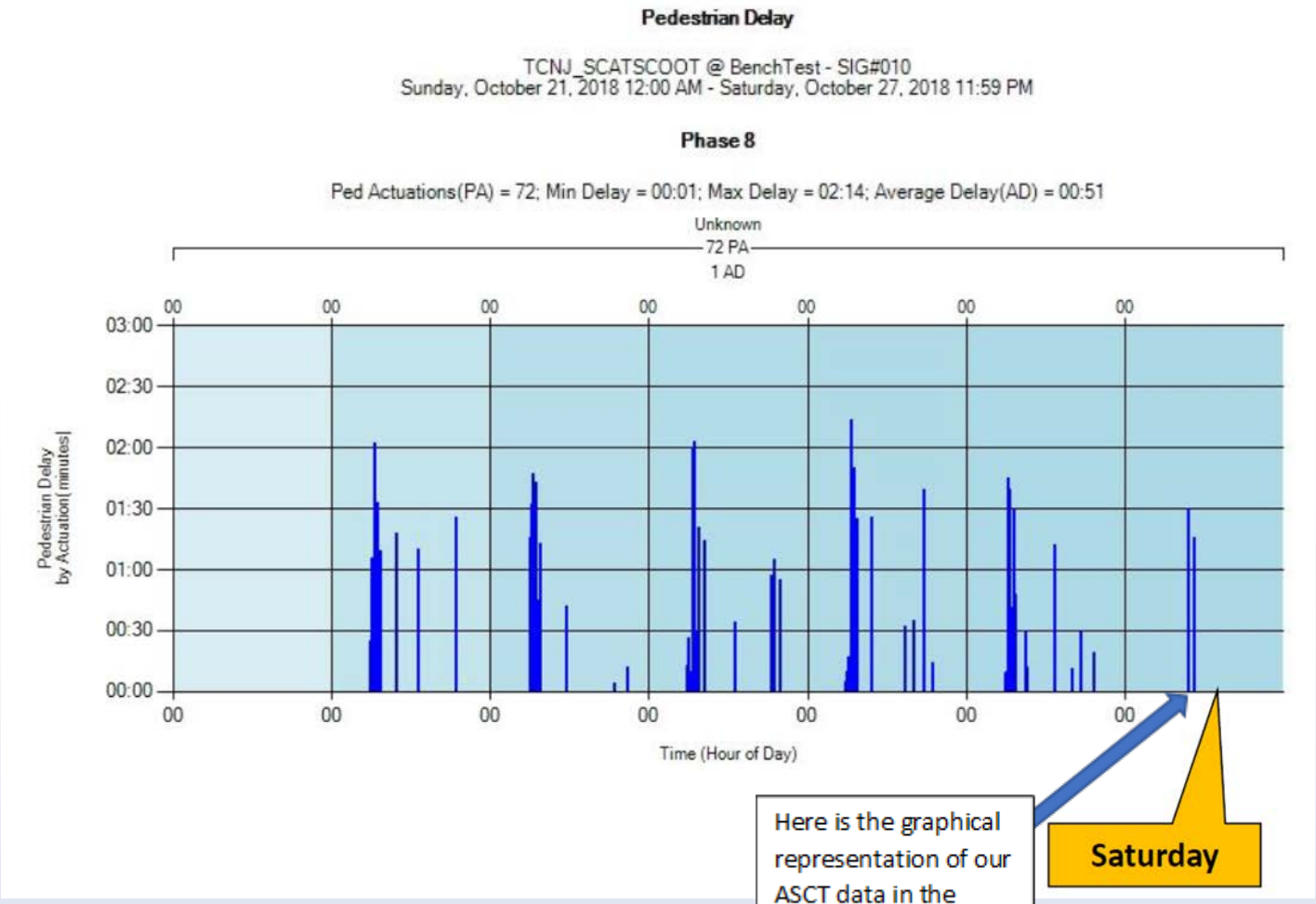
9:38:22 AM	Walk: statuses=[Walk 8: Demand=On]
9:38:37 AM	Phase interval: Rest or extension green
9:38:40 AM	Controller request to terminate phase: request termination for A
9:38:42 AM	Controller request to terminate phase: no request termination for A
9:38:46 AM	Cycle length: changes=[Active=112]
9:38:51 AM	Controller request to terminate phase: request termination for A
9:38:56 AM	Controller request to terminate phase: no request termination for A
9:39:43 AM	Phase termination request confirmation from controller: current phase=A
9:39:44 AM	Signal group: SG2=Off SG6=Off
9:39:45 AM	Phase interval: Yellow
9:39:50 AM	Cycle generator: restart
9:39:50 AM	Phase interval: All red
9:39:52 AM	Phase demand: B=Off
9:39:52 AM	Signal group: SG8=On SG24=On SG4=On
9:39:52 AM	Walk: statuses=[Walk 8: Demand=Off Active=On]
9:39:53 AM	Phase termination: phase=A MX=0 GT=94 CG=3
9:39:53 AM	Alarm timer: value=0
9:39:53 AM	Current running phase=B. Flags=[]
9:39:53 AM	Phase interval: Minimum green
9:39:57 AM	Phase demand: A=On
9:39:59 AM	Signal group: SG24=Off
9:39:59 AM	Walk: statuses=[Walk 8: Active=Off]

This SCATS logged event indicates that the Phase 8 pedestrian push button was triggered. This translates to **ATSPM Event Code 45: "Pedestrian Call Registered".**

This SCATS logged event indicates that the Phase 8 pedestrian walk signal is on. This translates to **ATSPM Event Code 21: "Pedestrian Begin Walk".**

NJDOT Research Project

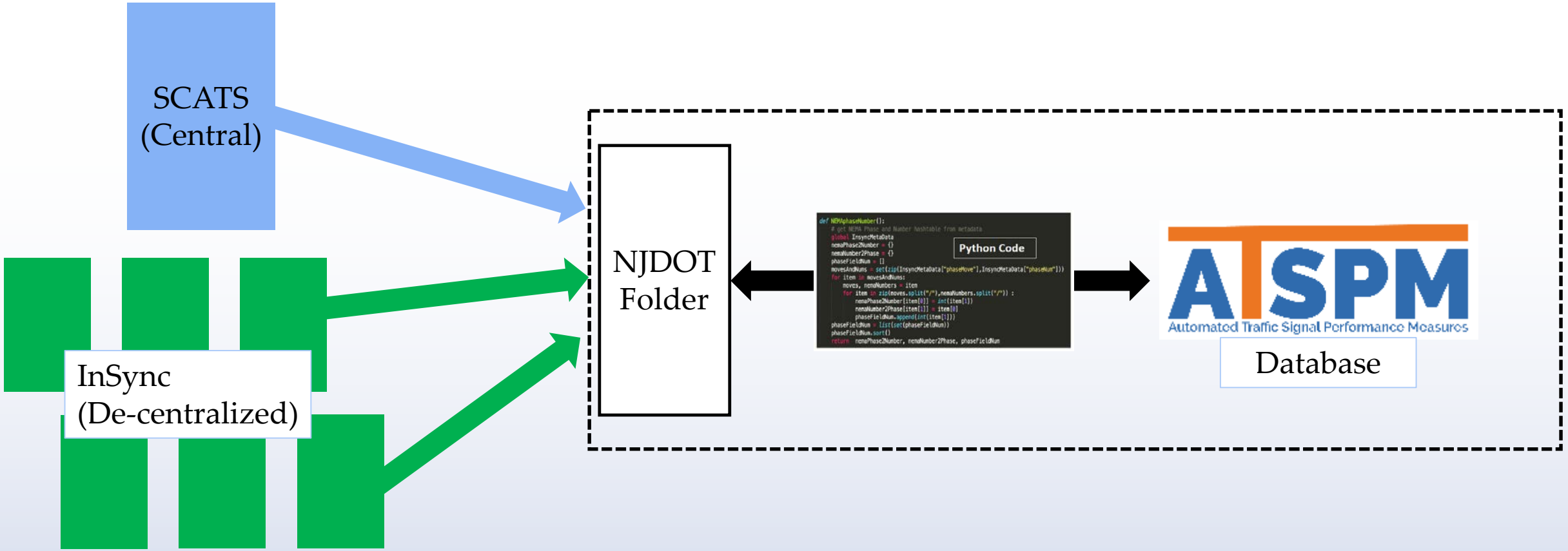
- Example Event Translation: Pedestrian Delay (SCATS to ATSPM)



NJDOT – Transportation Mobility
"Improving Lives by Improving Mobility"

NJDOT Research Project

- Overall Process:



NJDOT – Transportation Mobility
"Improving Lives by Improving Mobility"

NJDOT Research Project

- **Challenges:**
- Python Code sits outside of ATSPM software. This process is mostly independent of the ATSPM software.
- Estimating maximum green time for individual phases (Adaptive). Issue for Phase Termination.
- Obtaining the hi-resolution detector inputs is not currently possible. Limits available measures.

- **Successes:**
- Able to provide Purdue Phase Termination graph, Pedestrian Delay, Split Monitor, Purdue Coordination Diagram (without detector actuations).
- Able to automatically generate an ATSPM file that can be read by the FHWA ATSPM source code.

Future ATSPM Work

- Develop NJDOT ATSPM architecture.
  - Work with OIT to assign server for ATSPM suite of applications (includes Web Server) and SQL DB.
  - Map ATSPM server to InSync and SCATS Data Folders.
  - Download Python Software Package and web-scraper tool.
  - Update field hardware (TS Controllers) for traditional ATSPM deployment.
- ATSPM source code edits.
  - 3rd party software developer proficient in C# and Adaptive Vendors.
  - SCATS Degree of Saturation, Original Volume, and Corrected Volume.
  - InSync Queue and Wait Times.
- Determine how to best utilize ATSPM outputs.
  - Develop policy for changing signal timings (e.g. using Link Pivot algorithm).
  - Potential for utilizing specific ATSPMs in an Adaptive or Responsive mode of operation.


Question?