ATSPM

Automated Traffic Signal Performance Measures

AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES FOR EVERYONE

PENN STATE TRANSPORTATION ENGINEERING & SAFETY CONFERENCE

DECEMBER 6, 2023 – WORKSHOP

pennsylvania
DEPARTMENT OF TRANSPORTATION

Agenda

Introduction	9:00-9:05
ATSPM Implementation	9:05-9:15
Ad-Hoc ATSPM Tool	9:15-9:20
Intersection Configuration	9:20-9:30
ATSPM Metrics	9:30-9:50
Break/Case Study Setup	9:50-10:00
Case Studies 1-4	10:00-10:50
Break	10:50-11:00
Case Studies 5-6	11:10-11:30
Detector Configuration	11:30-11:40
Signal Controller Operation	11:40-11:50

ATSPM IMPLEMENTATION

9:05

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Traditional ATSPM Requirements

Controller

- High Res Data Logger
- Ethernet port

Detection

- Advance/Upstream
- Stop Bar
- Lane by Lane

Communications

- IP-addressable
- Always on connection

Server

- Archive data
- App to produce visual performance measures

Implementing ATSPM: Controllers

- Buy a new controller for about the same price as doing one round of count, analyze & retime
- Vendor neutral
  - PennDOT 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 eX/eX2 Omni 1.6+ **MCC-018P**
McCain Flex Omni 1.6+ **MCC-019P**



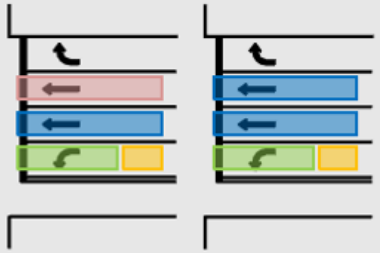
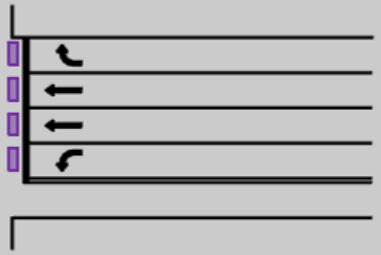
Trafficware Model 980**ATC:** v 76.10+ **TFW-011P**
Trafficware ATC Controller: v76.10+ **TFW-013P**
Trafficware Commander: Scout software **TFW-015P**

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+

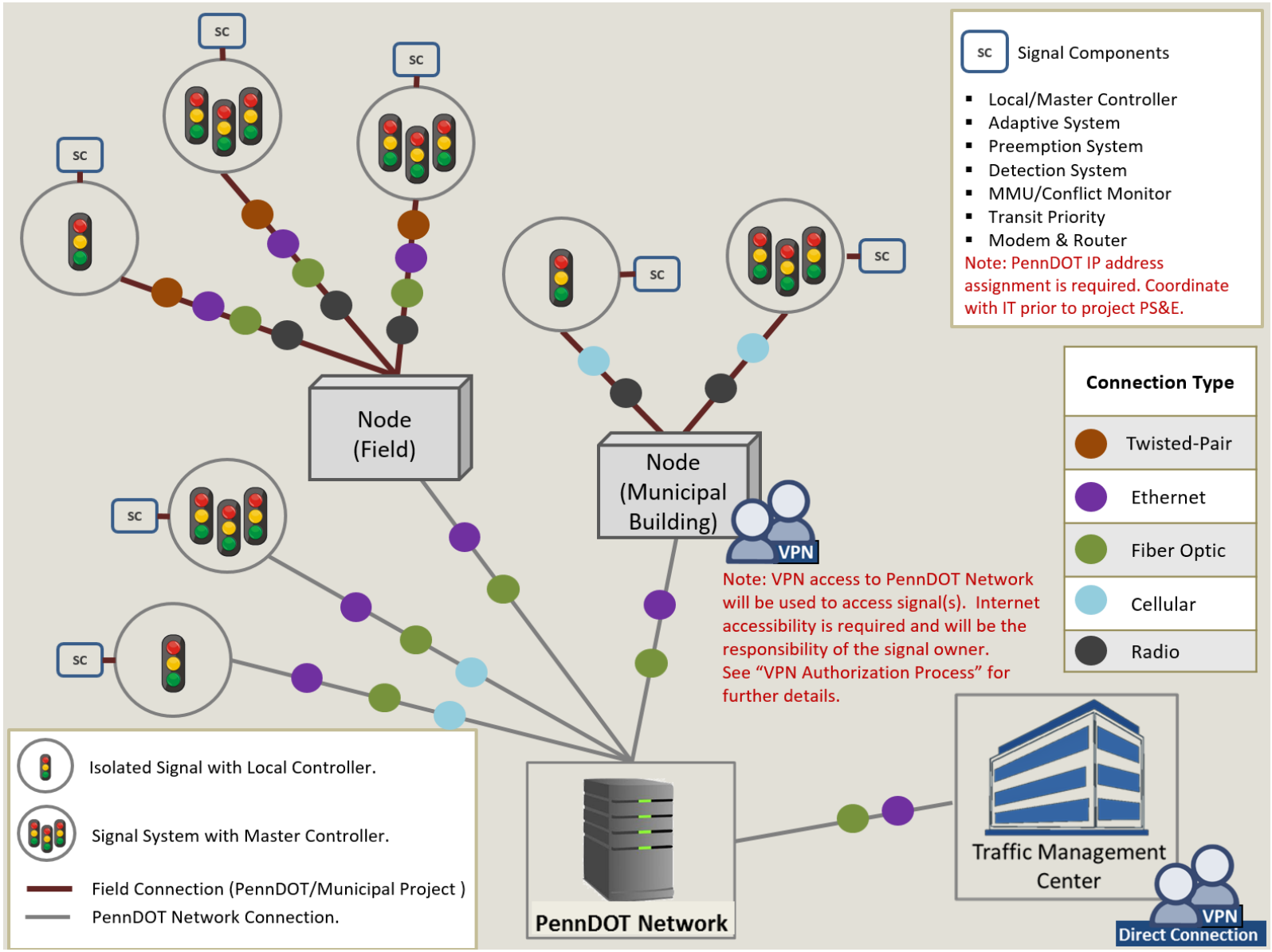
Implementing ATSPM: Detection

- Detection location determines what metrics are available
- Technology agnostic: Is a vehicle in a rectangle at the specified location?

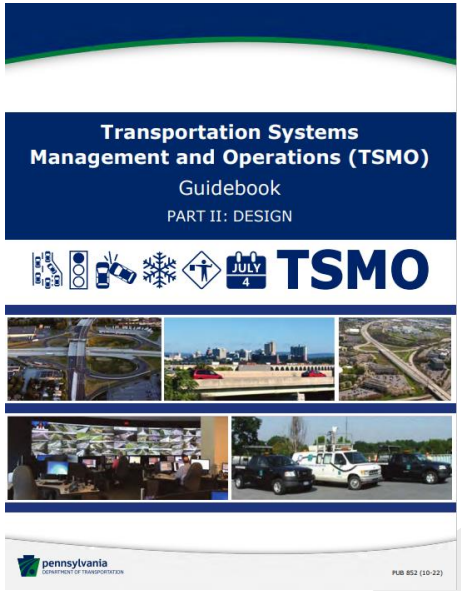
Detection		Metric
None		Phase Termination Chart Split Monitor Preemption Details Pedestrian Delay
Lane-by-lane Presence Lane Group Presence		Purdue Split Failure
Lane-by-lane Stop Bar Count		Turning Movement Counts
Advanced Count		Purdue Coordination Diagram Approach Volume Approach Speed (requires detection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

Source: Utah Department of Transportation

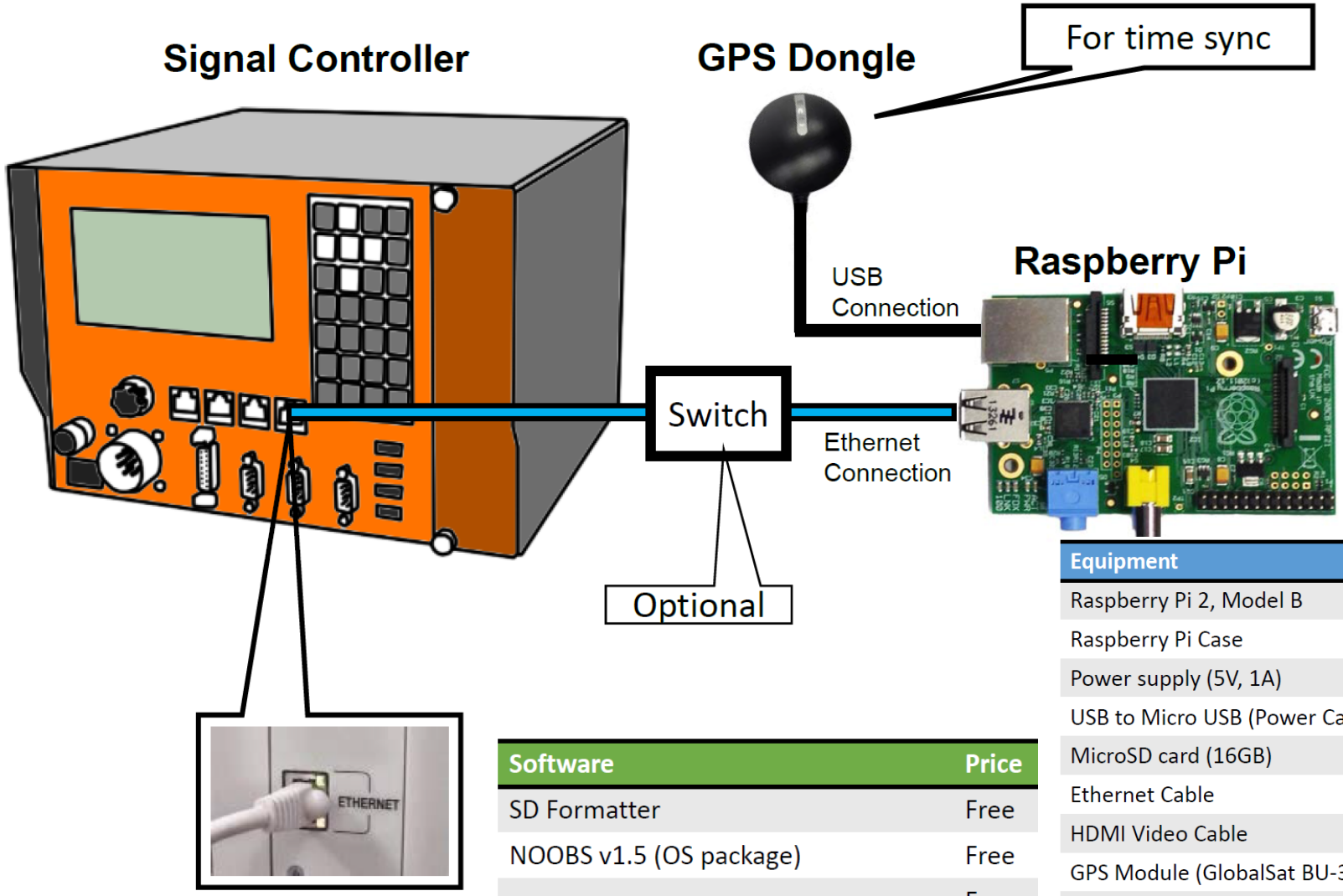
Implementing ATSPM: Communication



- Ideal case
- Network from signal controller to central server
- Archive data 24/7/365
- Pub 852→



Implementing ATSPM: No Comm



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**

Source: Howell Li, Purdue University

Implementing ATSPM: No Comm

Linux Controller

+

Flash Storage

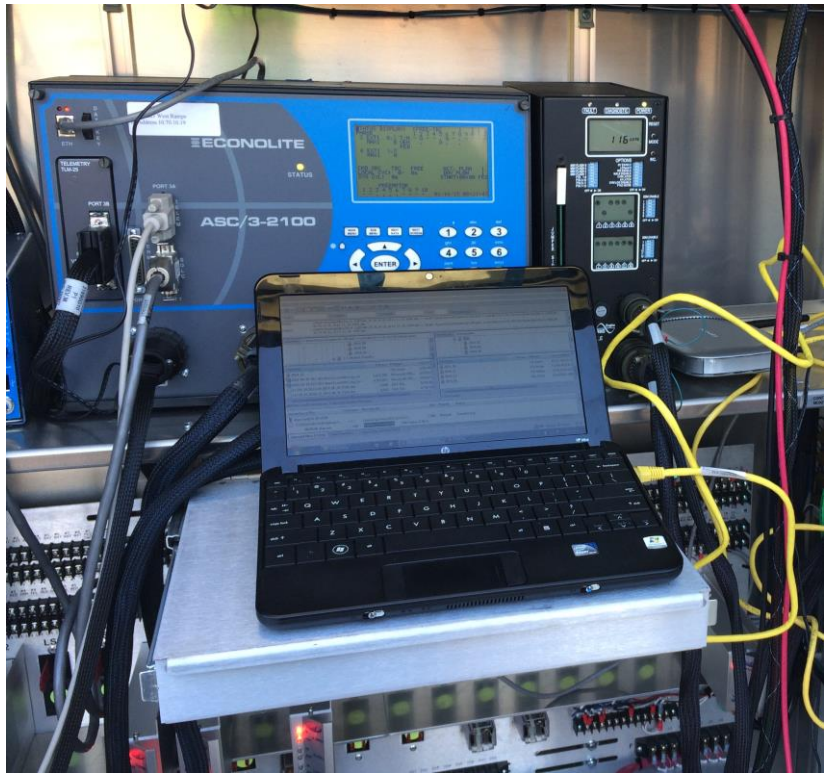
$5

Implementing ATSPM: Minimal Data

Controller

+

Laptop Computer



+

Ethernet Cable

~24 hours of data

Traditional ATSPM Requirements

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Hello, I'd Like to Get My Own Server

UDOT System Configuration

- Database Server
- Web Server for WCF Services
- SAN for Database
- Web Server for Web Site
- Host for Speed Listener Service
- Web Server for Web Site
- Application Server for Scheduled Tasks
- Load Balancer for Web Sites
- Share for Chart Images
- Email Server

Getting IT approvals for a server:

AD-HOC ATSPM

ATSPM: The Unwritten ConOps

- Operate with signal staff without need for IT support
  - No server software or back-end database
  - No software to install on user computers
- Analyze data from controllers in field without comms
- Generate high quality graphics suitable for reports & presentations
- Export raw event data for Excel analysis (deep dive)

Ad-Hoc ATSPM Tool

- Static webpage
  - Can be hosted on any web server that serves static page
  - No server-rendering of pages or performance measure graphics
  - No database server (BYOD - bring your own data)
  - All processing done in user's browser
- Designed use case
  - 1 calendar day of data (up to 24 hours)
  - Analyze 1 intersection at a time
- Intersection configurations
  - Can be saved and uploaded into the page
  - Can be saved on web server as static files to load by intersection ID
- Export graphics as SVG for high resolution import into Office for reports or presentations
- Export compiled data to CSV for more detailed analysis in Excel
- PennDOT-hosted site: open to anyone

https://www.dot.state.pa.us/public/Bureaus/BOMO/Portal/ATSPM/index.html

Ad-Hoc ATSPM Tool

- Disclaimer
  - This is **not** professional software
  - Written by a traffic engineer with a civil engineering degree, not a computer science degree
  - Ongoing refinements
    - Bug fixes
    - Add new metrics from open source UDOT software
    - Create new metrics based on a real world problem to solve
  - Always open to suggestions, but no guarantee of implementation
  - New metrics being added, some are beta

Ad-Hoc ATSPM Tool

Go to webpage

Upload high resolution data

Configure intersection

Click on desired metric

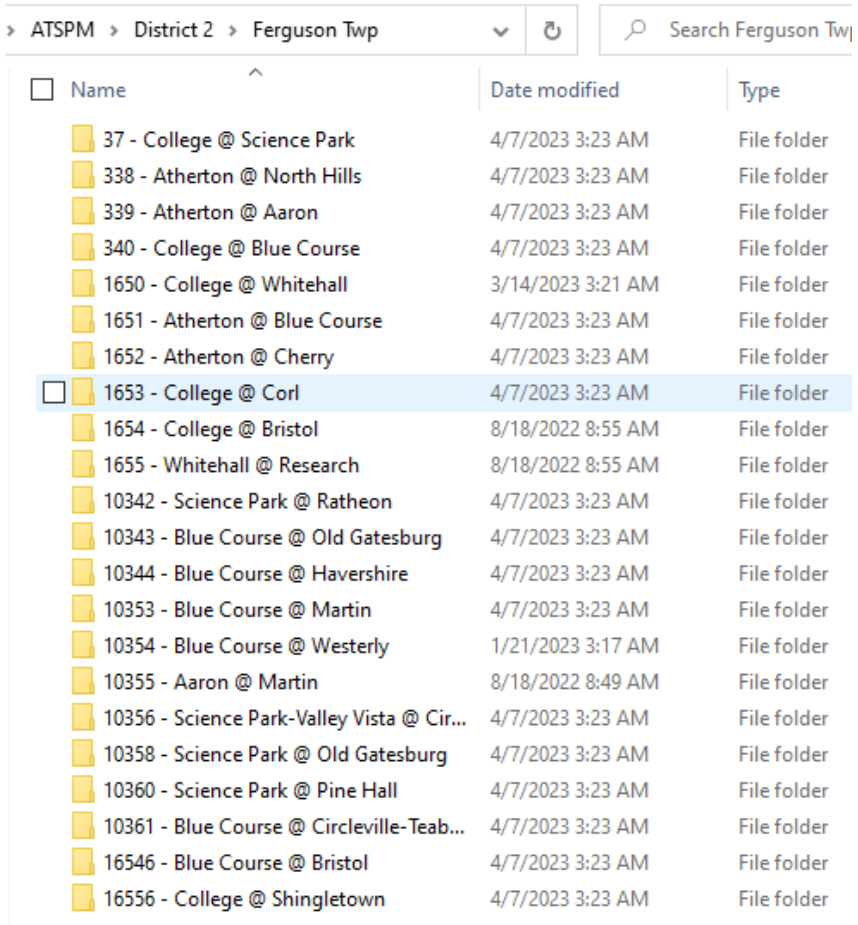
Ad-Hoc ATSPM Tool: BYOD

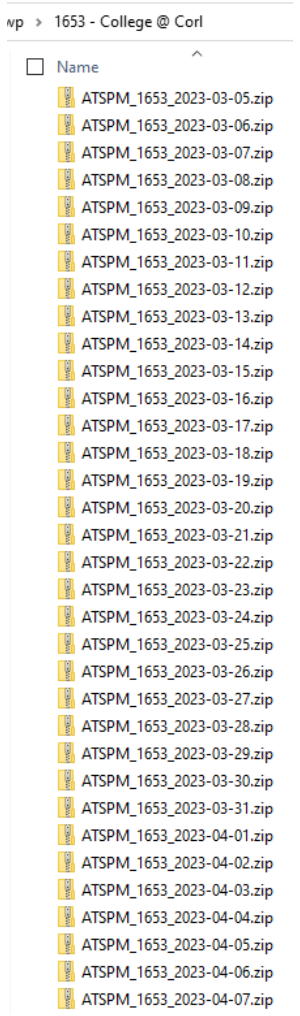
- Method 1: Directly upload .dat files from a controller
  - Works for Econolite and McCain
  - Siemens and Trafficware decoders are proprietary and don't work in a browser. Need to convert to CSV first using vendor tool
- Method 2: Create .zip file with all the .dat files for a day
  - Filename: ATSPM_###_YYYY-MM-DD.zip
  - ### is an intersection ID number
  - Ad-hoc tool can lookup intersection configurations by the ID number

- Click "Choose Files" OR
- Drag and Drop files into the "No files chosen" area of the page

Ad-Hoc ATSPM Tool: Log File Mgmt

- My approach
  - Folder for each intersection
  - ZIP files within each intersection folder by date
  - Easy to drag files from Windows Explorer into the webpage
- Currently have 106GB of data

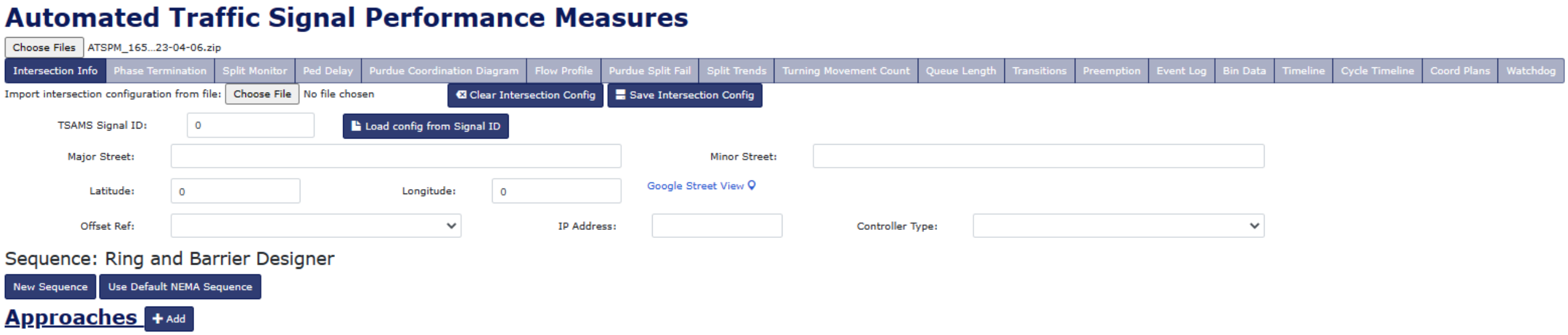




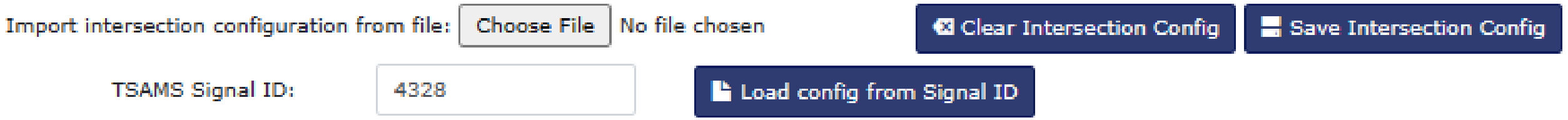
INTERSECTION CONFIGURATION

Intersection Configuration

- After uploading data, the intersection configuration will be displayed
- If ZIP file with intersection ID is used, configuration static file will be loaded and pre-populated
- Basic metrics don't require configuration
- Detectors must be configured for other metrics

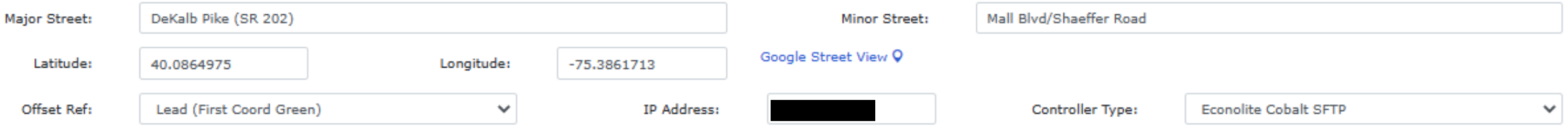


Intersection Config: Management



- Save Intersection Config
  - Downloads a .json file to your computer
- Import configuration from file
  - Can import a previously downloaded .json file by clicking “choose file” or drag and drop into “No file chosen” area
- Clear Intersection Config
  - This will reset the configuration if you upload new log data for a different intersection
  - Can also refresh browser window to clear
- Load config from Signal ID
  - Pulls ID from .zip filename and automatically loads
  - If uploading .dat files (unzipped) then type signal ID and click the button to load a configuration file saved on the web server

Intersection Config: Basics



- Street names are used for chart titles
- Latitude/longitude coordinates
  - Can be used to quickly get to Street View of intersection
  - May be used in future for mapping functionality
- Offset Ref
  - Only used for coordination timeline metric
- IP address
  - Not used currently
- Controller type
  - Not used currently
  - May be used to determine connection type to download data in the future

Intersection Config: Sequence

Sequence: Ring and Barrier Designer

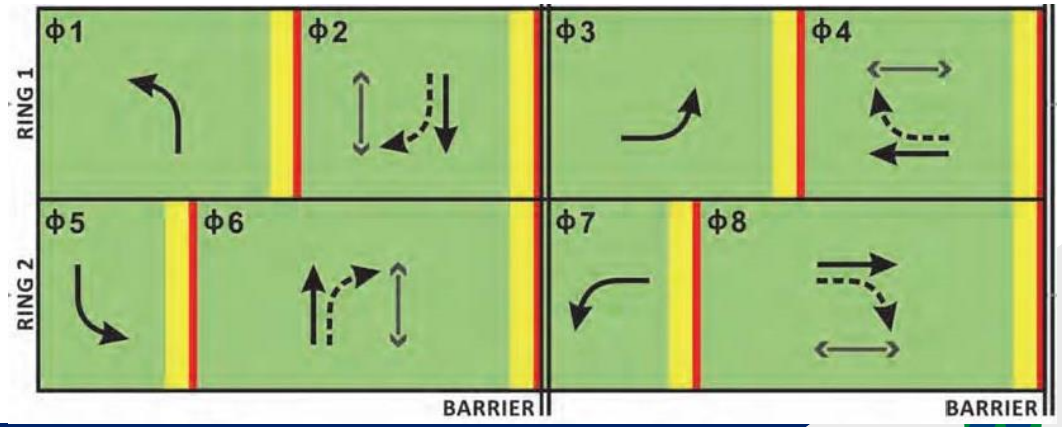
New Sequence | Use Default NEMA Sequence

Sequence: Ring and Barrier Designer

0	2	1	4	9	10	13	14	0	0	0	0	0	0	0	0
5	6	0	0	11	12	15	16	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- Ring and Barrier sequence is used for cycle-by-cycle timeline metrics
- Phases not in use are ignored
- Default NEMA sequence:

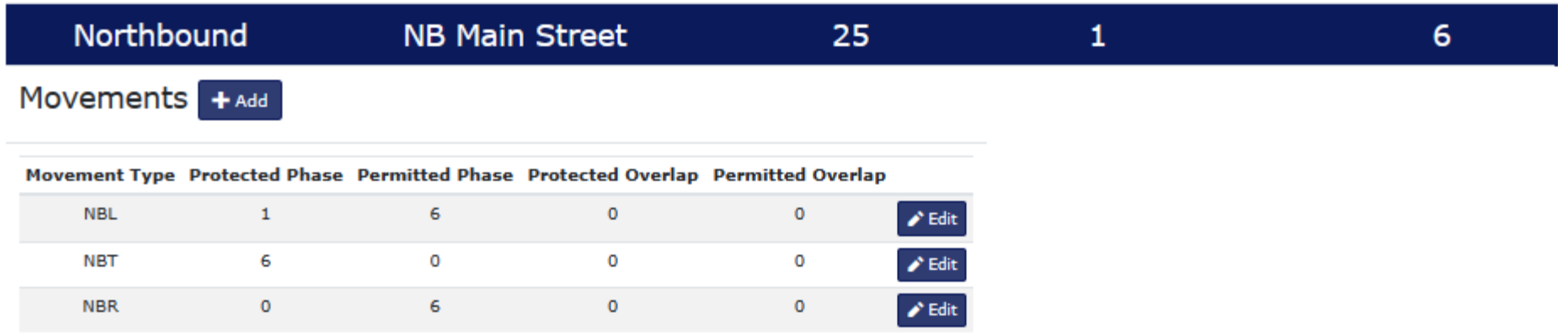
1	2	3	4	9	10	13	14
5	6	7	8	11	12	15	16
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0



Intersection Config: Approaches

- Click "Add" for each approach to the intersection
- For each approach enter the following:
  - Direction (NB,SB,EB,WB,etc.) from dropdown menu
  - Description – used for chart titles
  - Approach speed (mph)
  - Protected phase
    - If there is a protected left turn phase, enter it here (1,3,5,7)
    - Otherwise, enter the thru movement phase (2,4,6,8)
  - Permitted phase
    - If there is a protected left turn phase, enter the phase when the left turn is permitted here
    - Otherwise, can leave blank
  - Pedestrian phase
  - Check box if protected, permitted or ped is an overlap

Intersection Config: Movements



- Click "Add" to add each movement on an approach (typically left, thru, and right)
  - Identify when movement is protected and permitted
  - Typically, thru movements are always protected
  - Left turns may be both protected and permitted
  - Right turns are permitted w/ thru phase if there is a parallel crosswalk
- For overlaps, enter the number (Overlap A=1, B=2, etc.)

Intersection Config: Detectors

Detectors + Add

Mvmt Type	Channel	Lane #	Dist to Stop Bar	Date Added	Detection Types	Lane Type	Min Speed Filter	Decision Pt	Mvmt Delay	
Left	1	1	0	2/9/22	StopBarPresence	Vehicle				Edit
ThruRight	6	2	0	2/9/22	StopBarPresence	Vehicle				Edit
Left	9	1	0	2/9/22	LaneByLaneCount	Vehicle				Edit
ThruRight	14	2	0	2/9/22	LaneByLaneCount	Vehicle				Edit

- Click "Add" to add each detector on an approach
- Three primary types of detectors
  - Stop bar presence – used for split failures and occupancy
  - Lane by lane count – small zone at stop bar used for turning movement counts
  - Advance count – used for Purdue Coordination Diagram (typically positioned like a volume density loop)
- Dist to Stop Bar is zero for stop bar zones
- Number lanes from center to curb
- Options based on UDOT code, but not all used currently

ATSPM: THE METRICS

9:30

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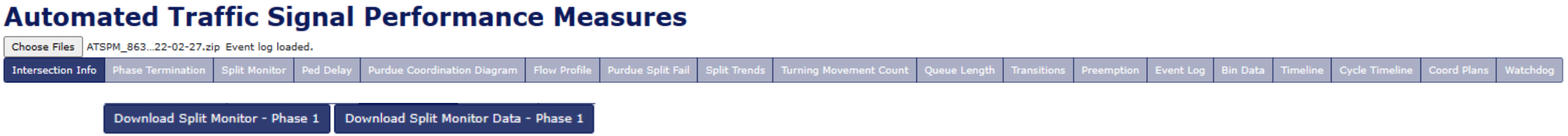
Ad-Hoc ATSPM Tool: Metrics

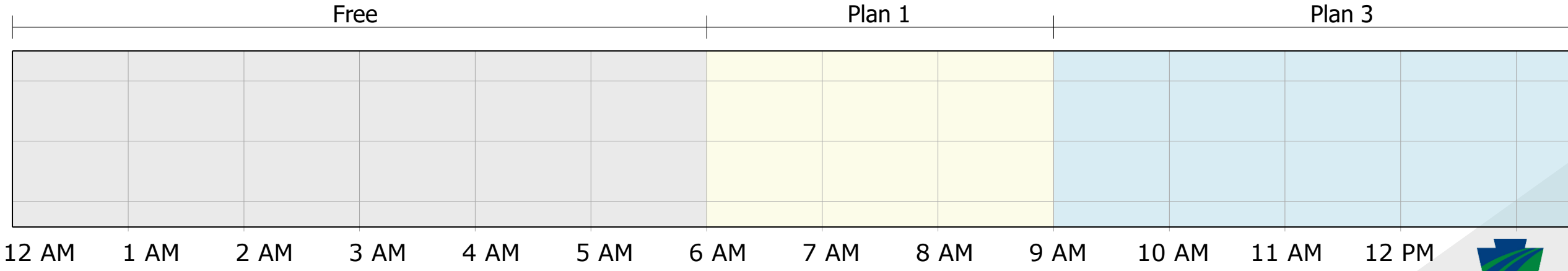
- Buttons for metrics will appear after log data is successfully loaded
- Click on button to go to that metric
- If configuration is needed and not provided, or no data for the metric, it may be blank
- Some take a while to load, especially Purdue Split Fail
- Metrics may have options to download charts and/or data



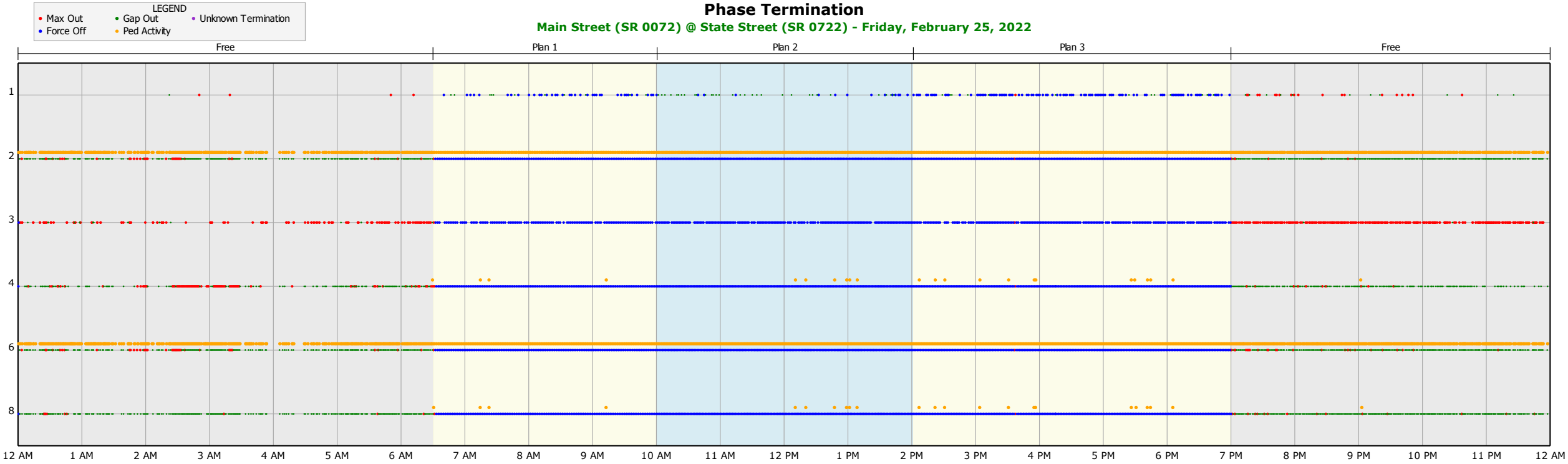
ATSPM Metrics: General Themes

- X Axis is 24 hours
  - Midnight to midnight
  - Vertical gridlines for each hour
- Y Axis varies by metric
  - Phase
  - Seconds
  - Percent
  - Vehicles

- Shading represents timing plan in effect
  - Yellow and blue alternate for coordinated plans
  - Gray for free plans
  - Pink for manual control
  - Gold for flash
- Statistics at top by timing plan vary by metric



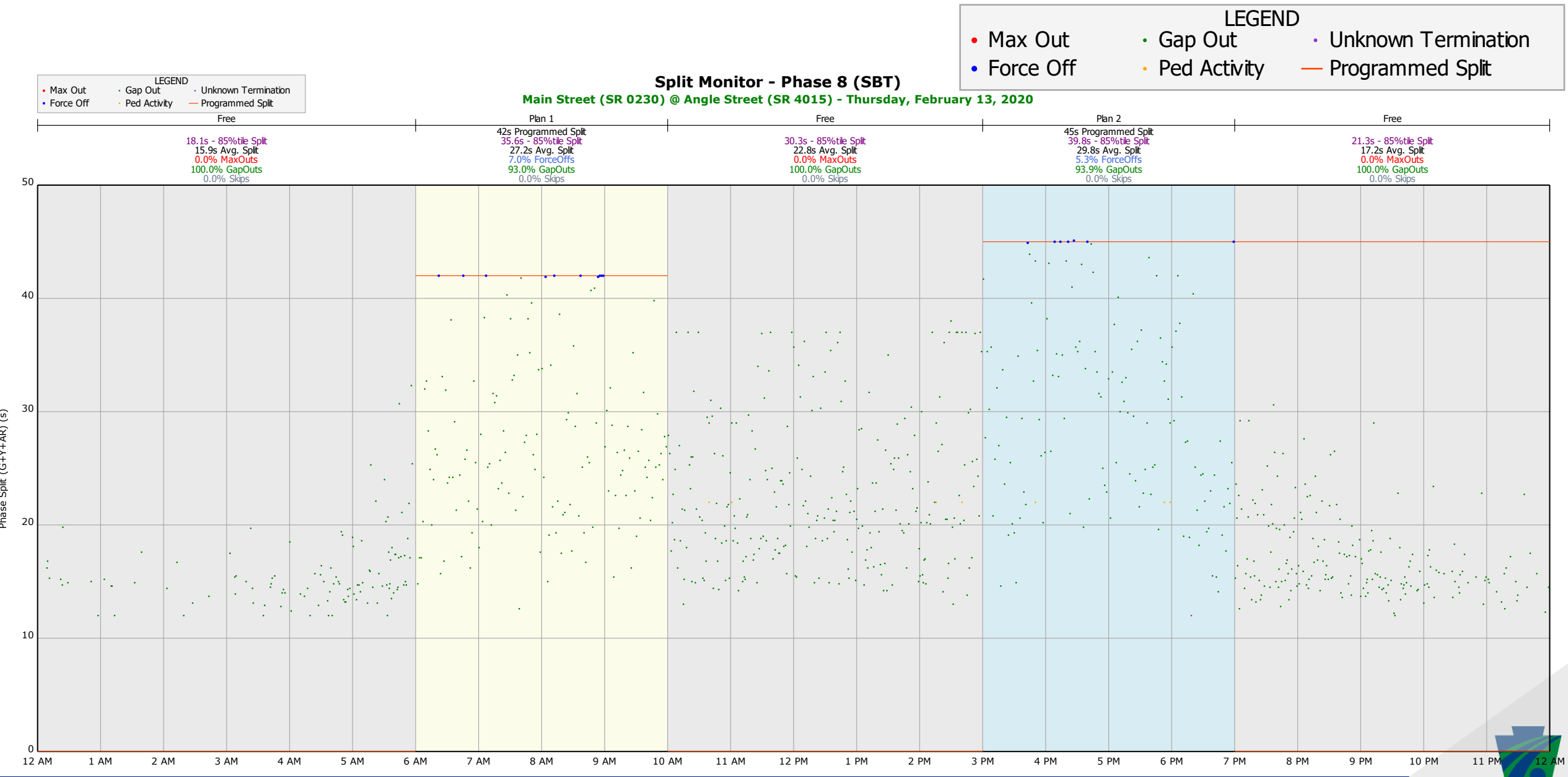
Phase Termination Example



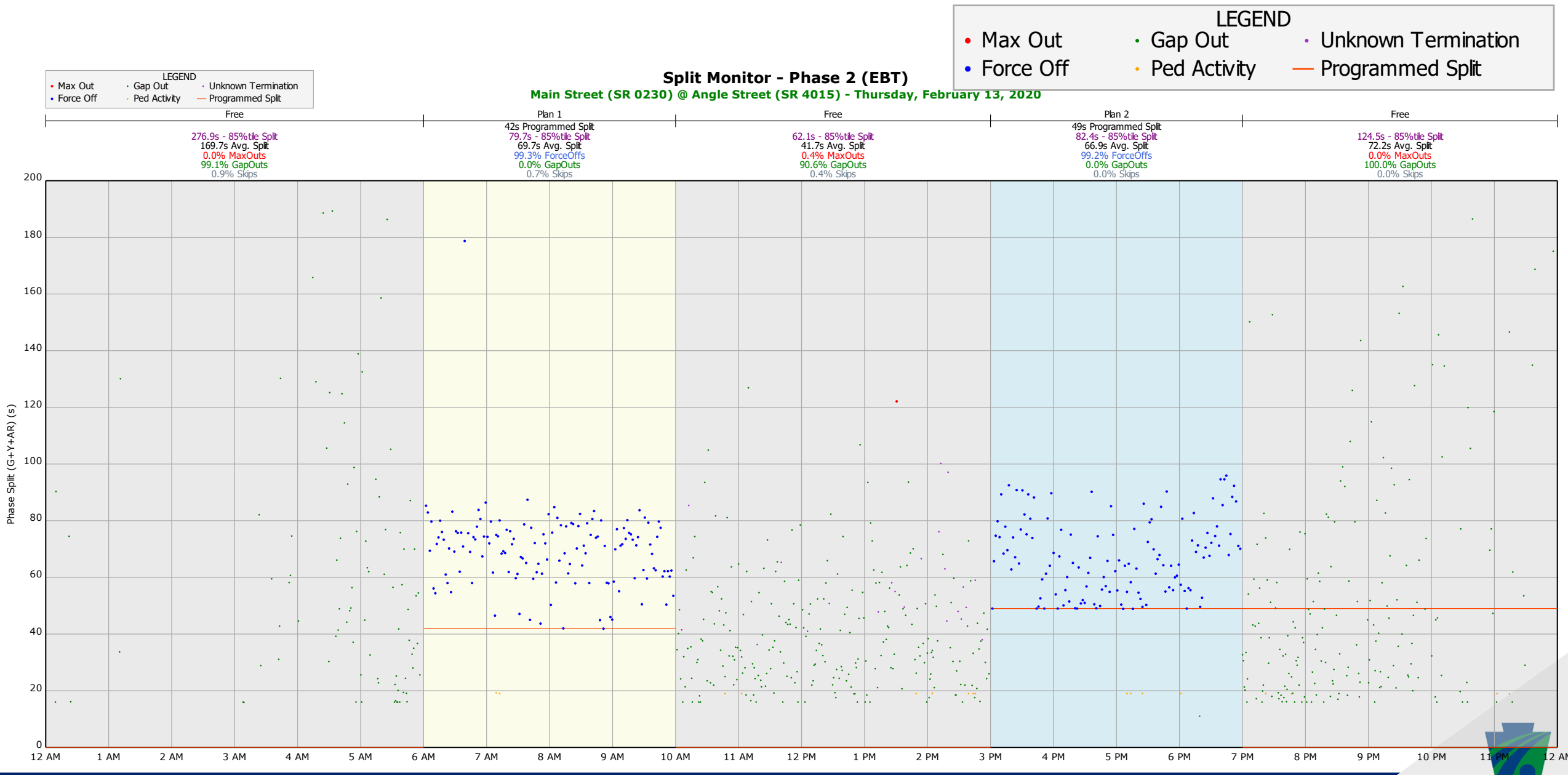
LEGEND

- Max Out
- Force Off
- Gap Out
- Ped Activity
- Unknown Termination

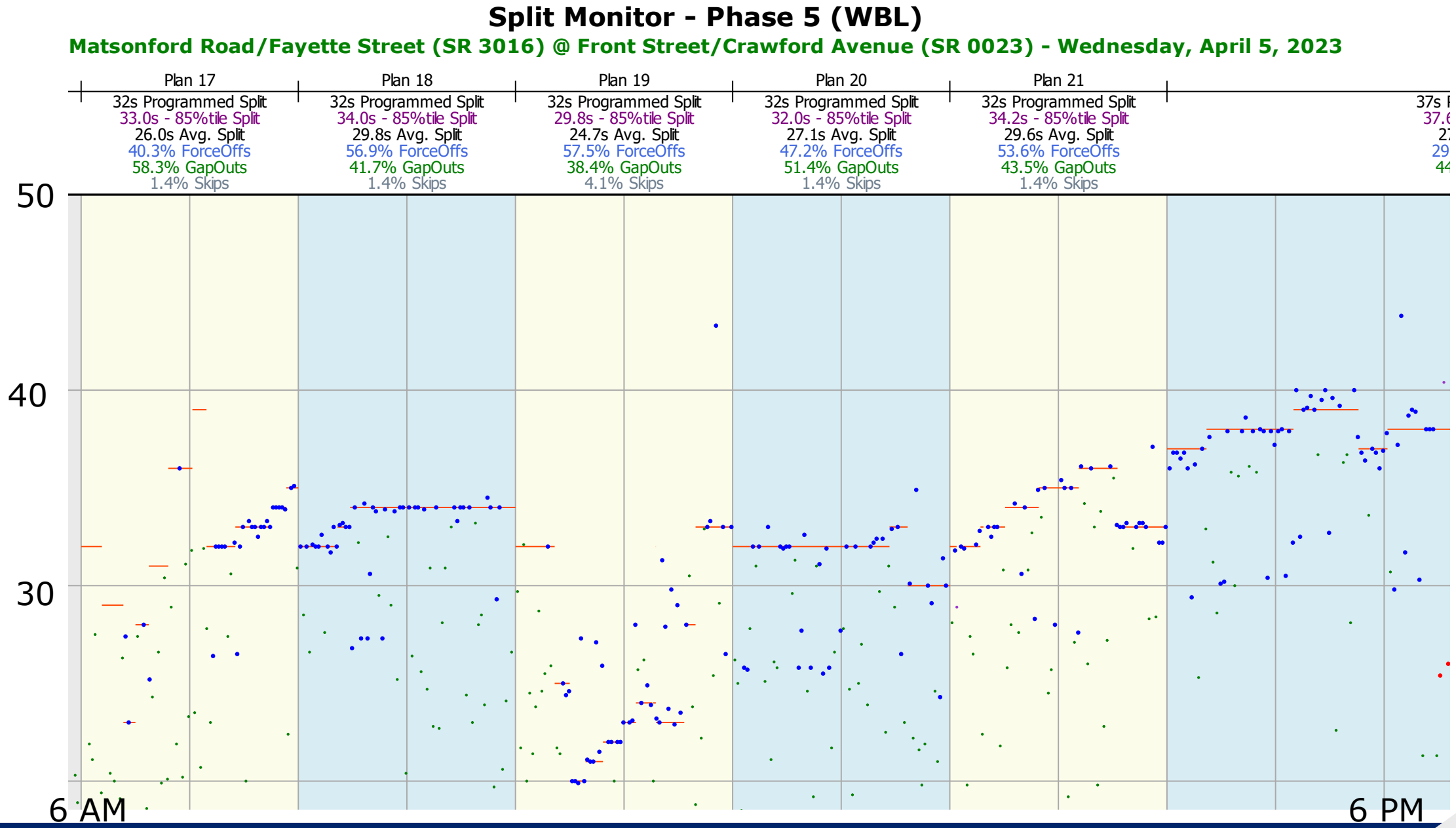
Split Monitor Example



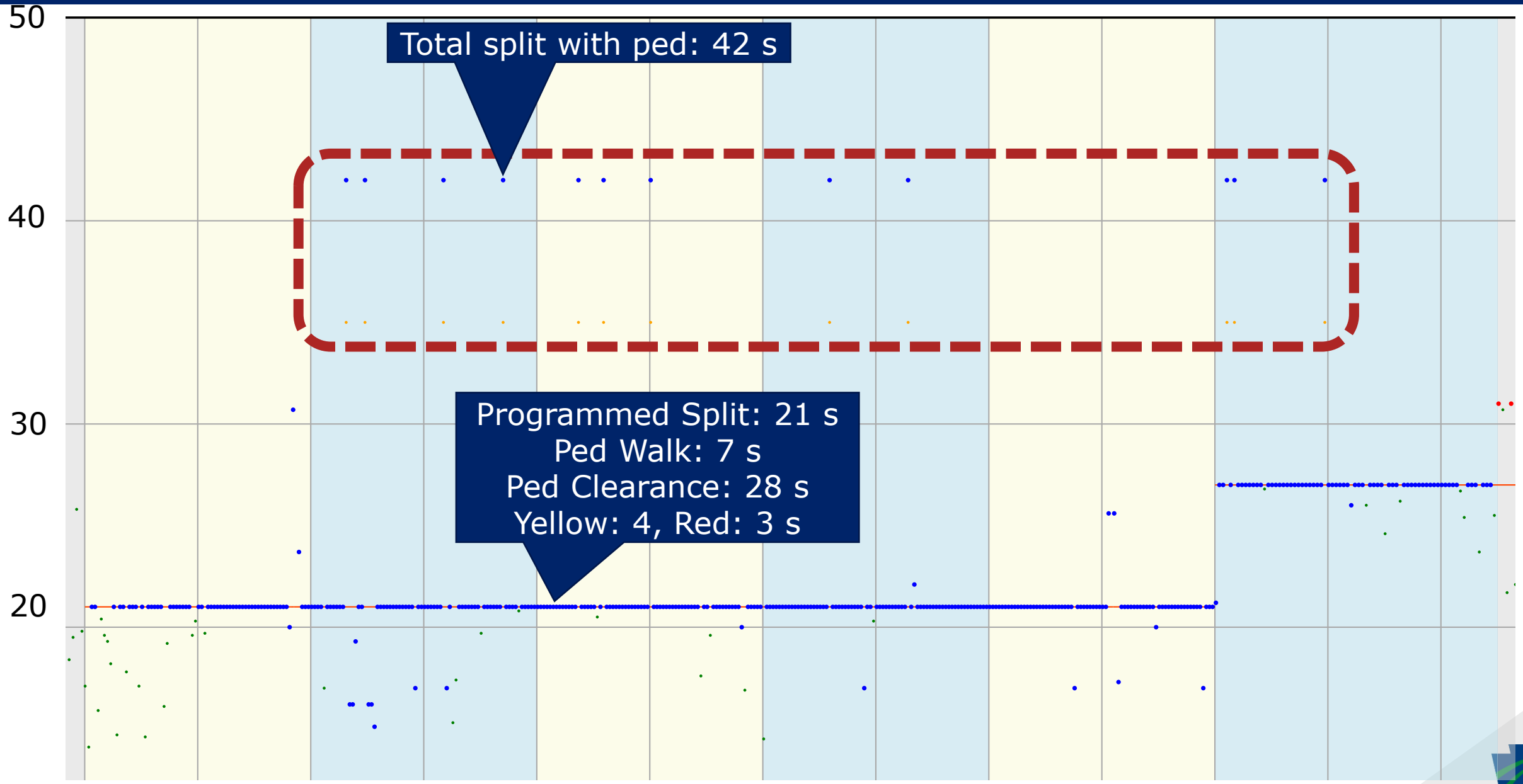
Split Monitor Example: Coord Phase



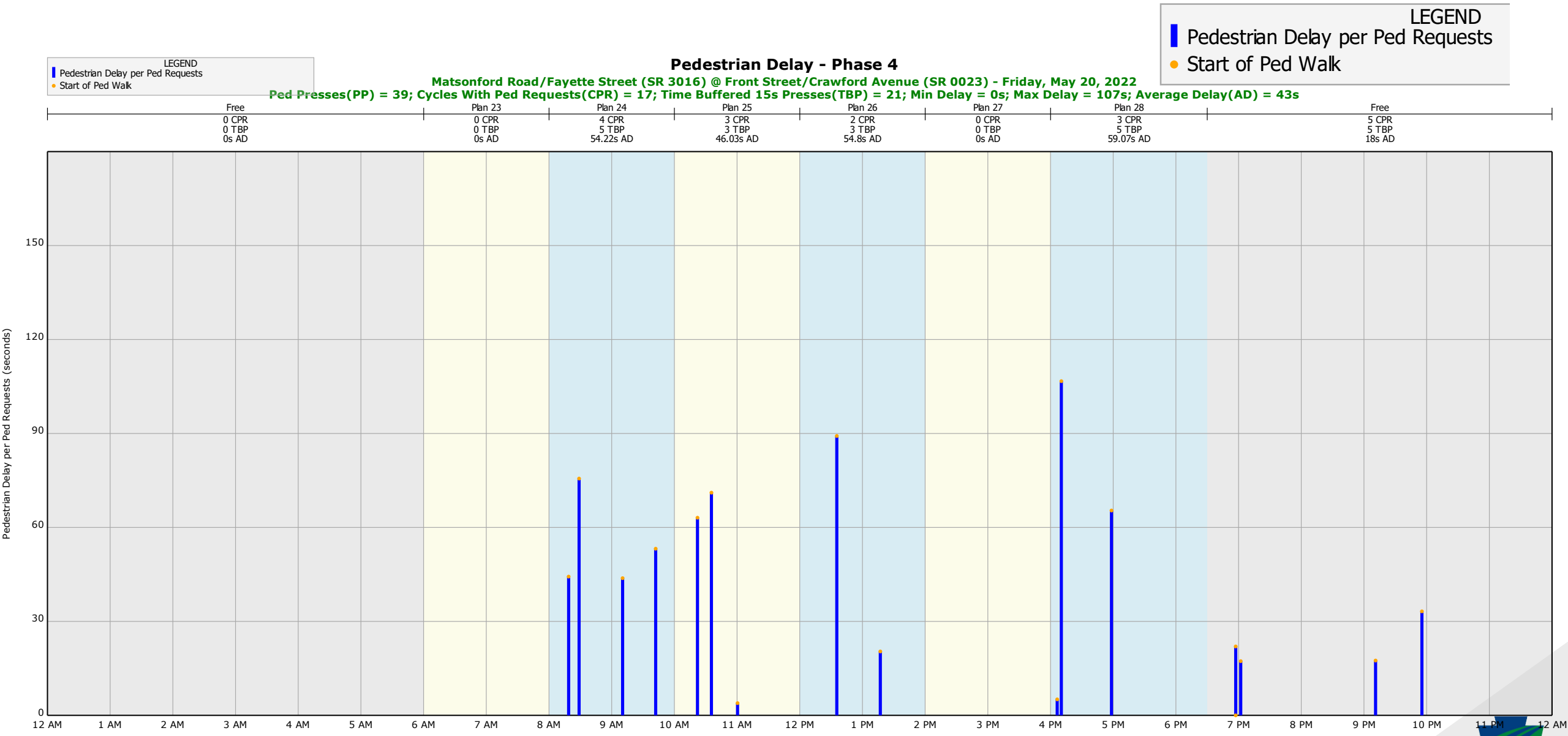
Split Monitor: Edaptive



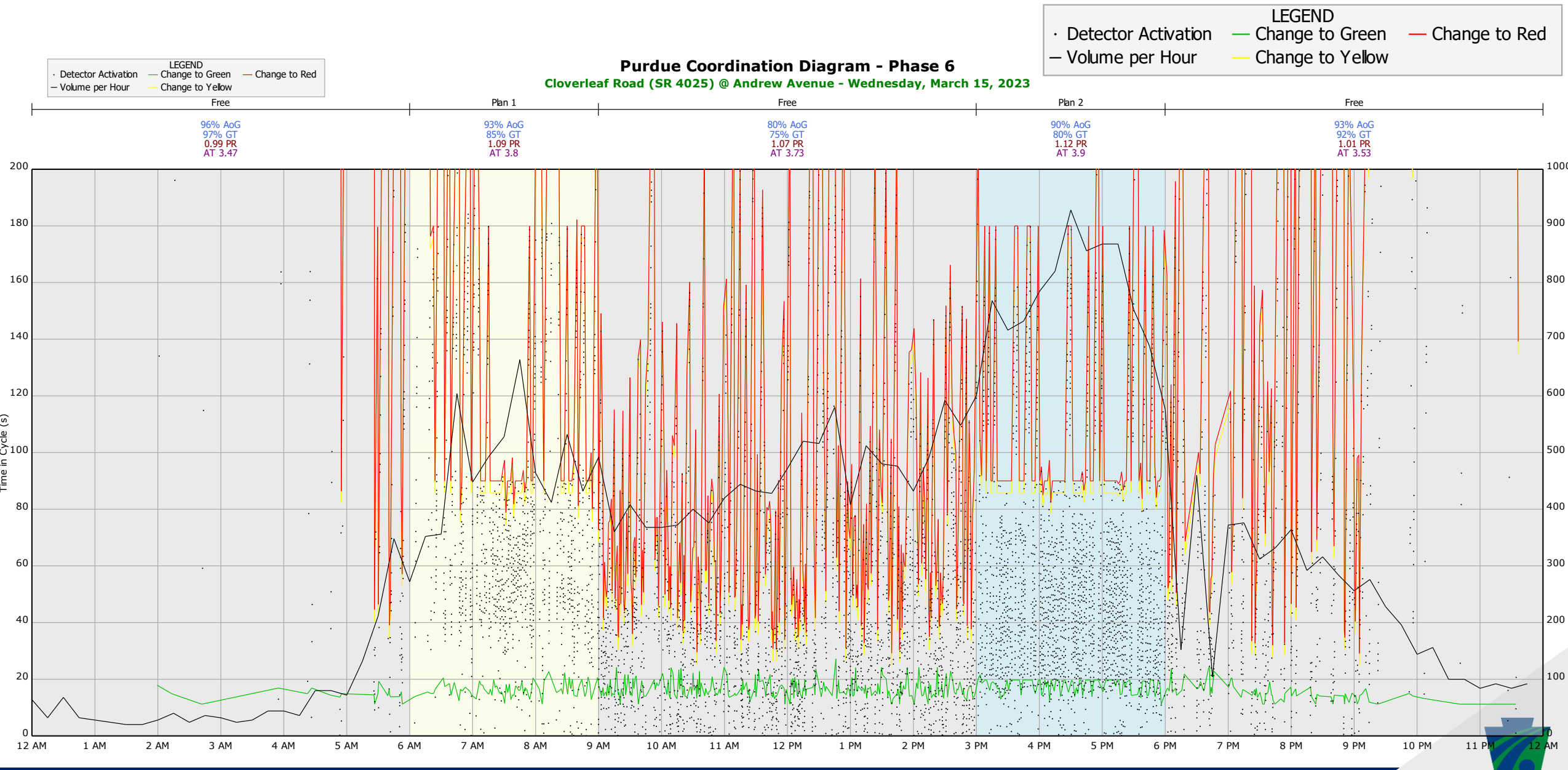
Split Monitor: Oversize Ped



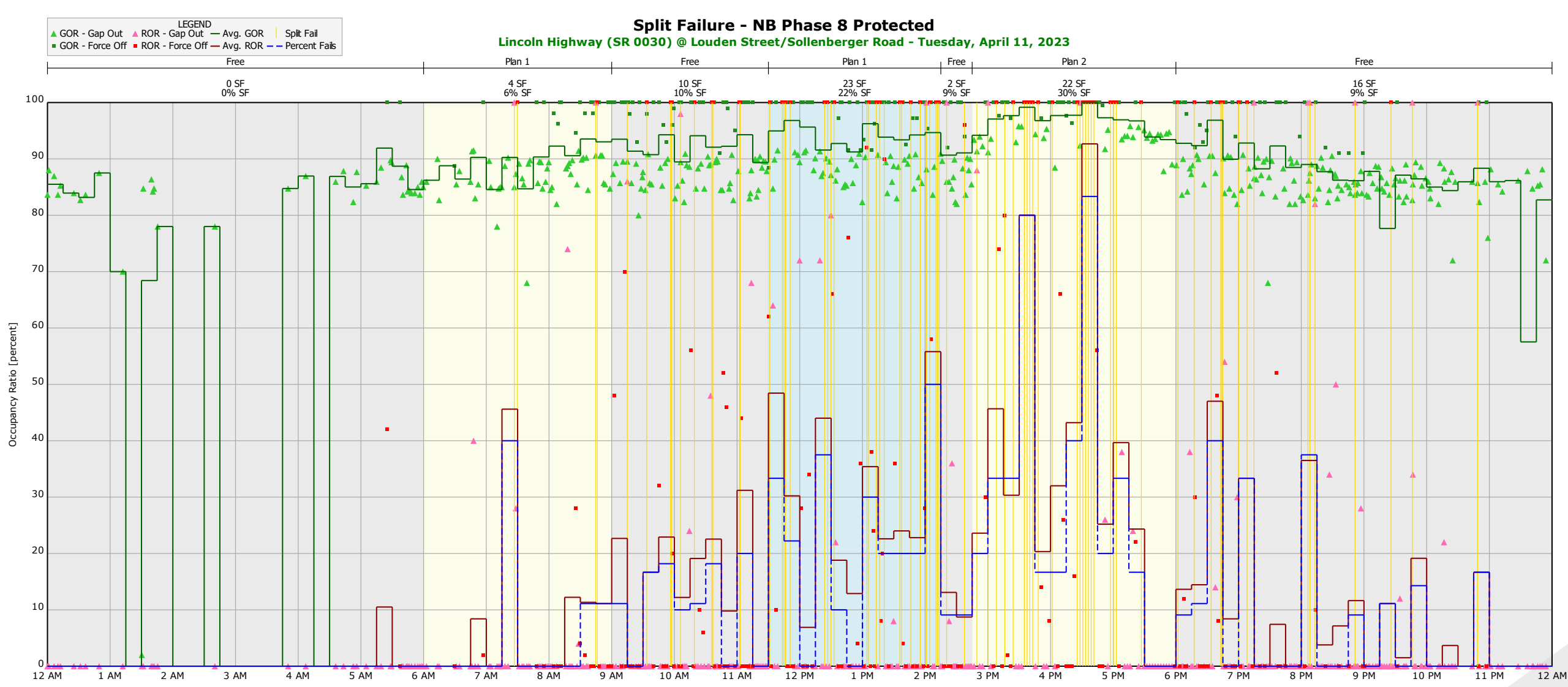
Ped Delay Example



Purdue Coordination Diagram Example



Purdue Split Fail Example

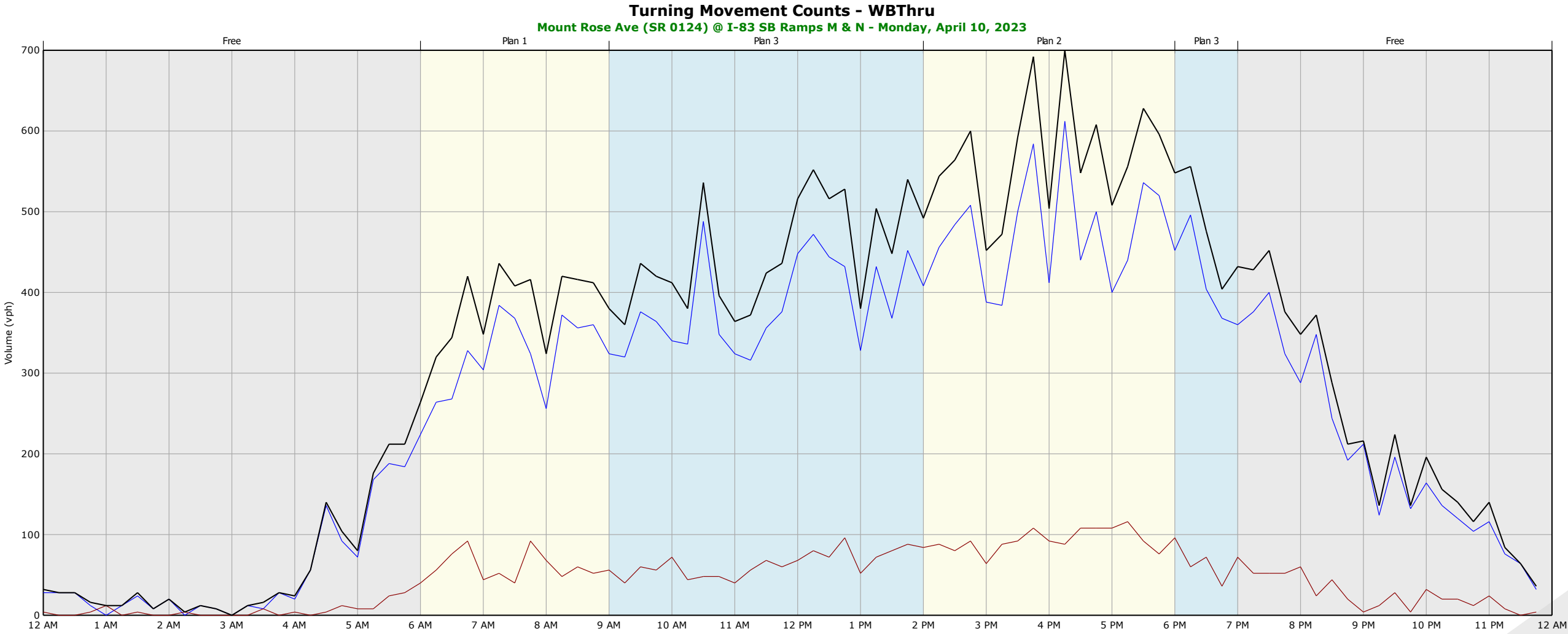


Turning Movement Count Example

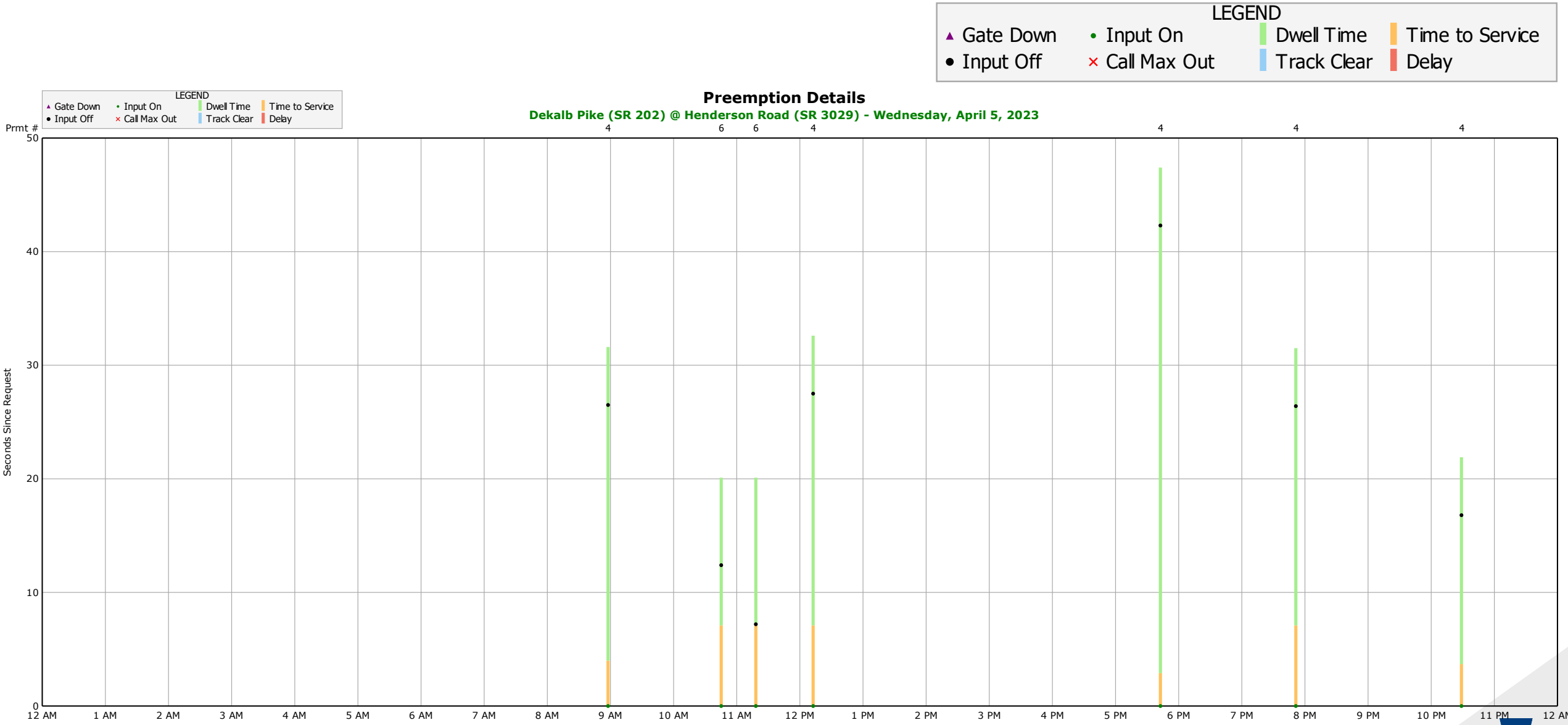
Mon 4/10/23	Peak Hour (PHF = 0.95)								
	Eastbound			Westbound			Northbound		
	Thru	ThruRight	Total	Left	Thru	Total	Right	Total	Vehicle Total
3:45 PM - 4:45 PM	311	467	778	364	611	975	891	891	2644

Mon 4/10/23	Vehicle								
	Eastbound			Westbound			Northbound		
	Thru	ThruRight	Total	Left	Thru	Total	Right	Total	Vehicle Total
12:00 AM	4	4	8	6	8	14	16	16	38
12:15 AM	3	7	10	5	7	12	13	13	35
12:30 AM	3	5	8	4	7	11	7	7	26
12:45 AM	4	3	7	2	4	6	10	10	23
1:00 AM	1	4	5	7	3	10	4	4	19
1:15 AM	2	1	3	4	3	7	7	7	17
1:30 AM	1	1	2	2	7	9	6	6	17
1:45 AM	4	2	6	2	2	4	5	5	15
2:00 AM	1	1	2	1	5	6	2	2	10
2:15 AM	0	2	2	5	1	6	6	6	14
2:30 AM	1	1	2	2	3	5	4	4	11
2:45 AM	1	4	5	3	2	5	5	5	15
3:00 AM	1	4	5	4	0	4	3	3	12
3:15 AM	3	3	6	5	3	8	13	13	27
3:30 AM	3	2	5	6	4	10	10	10	25
3:45 AM	2	5	7	5	7	12	7	7	26
4:00 AM	3	5	8	10	6	16	5	5	29

Turning Movement Count Example



Preemption Example



Watchdog Example

Watchdog Report - 8619 - State Road (S
Friday, March 24, 2023

Critical Alarms

Cabinet door opened 8619 at 03/24/2023 07:10:43.5 AM

Cabinet door closed 8619 at 03/24/2023 07:13:43.3 AM

Cabinet door opened 8619 at 03/24/2023 07:47:21.6 AM

Flash condition: mmu at 03/24/2023 08:46:50.1 AM

Flash condition: notFlash at 03/24/2023 08:46:58.7 AM

Manual control enabled at 03/24/2023 08:47:38.0 AM

Manual control disabled at 03/24/2023 08:48:28.2 AM

Cabinet door closed 8619 at 03/24/2023 09:14:22.6 AM

Cabinet door opened 8619 at 03/24/2023 10:23:36.8 AM

Cabinet door closed 8619 at 03/24/2023 10:24:10.9 AM

Max Out Concerns between 1:00 AM and 5:00 AM

This error could indicate a detector malfunction causing a signal to provide excessive time to a phase.

Phase 5 Max Outs 100%

No force off concerns were found between 1:00 AM and 5:00 AM

No new high pedestrian activation errors between 1:00 AM and 5:00 AM

No new low advanced detection count errors between 17:00 and 18:00

NON-UDOT METRICS

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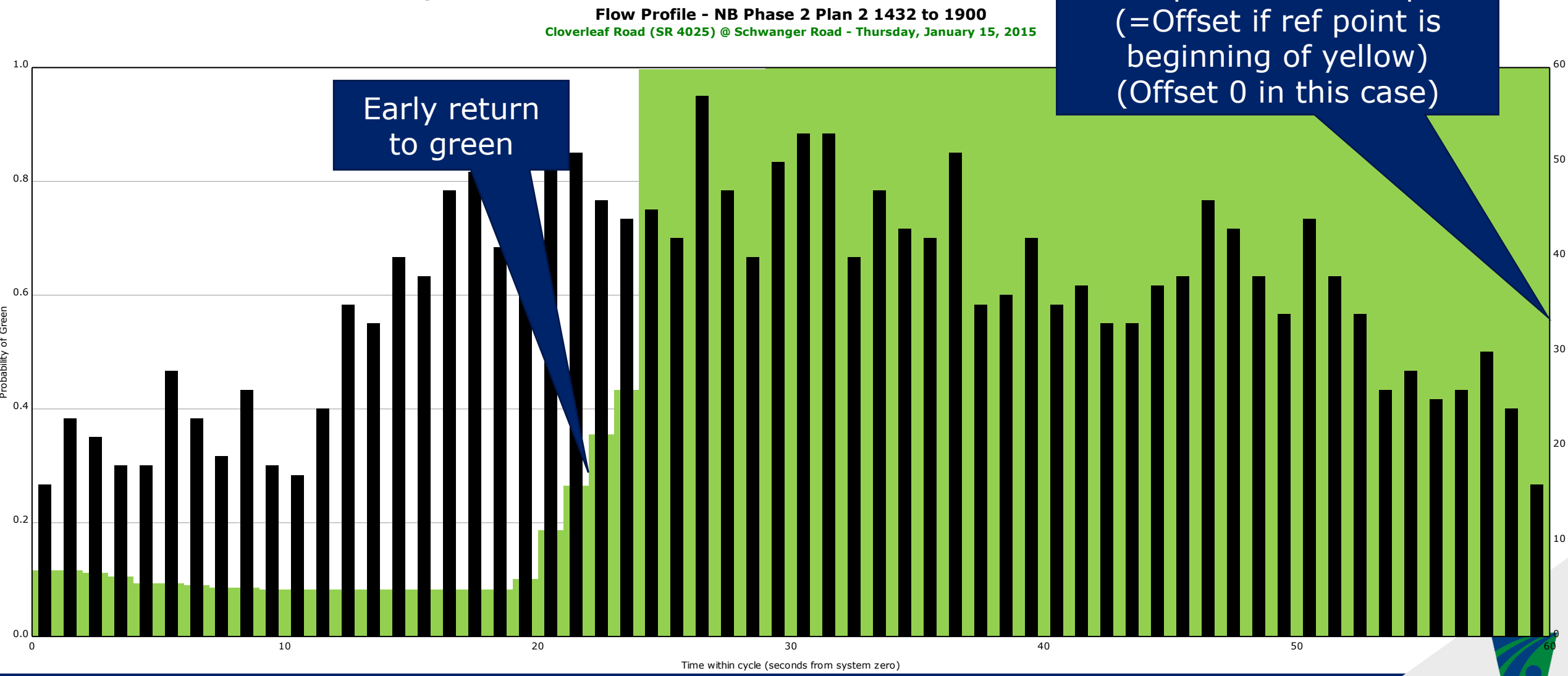
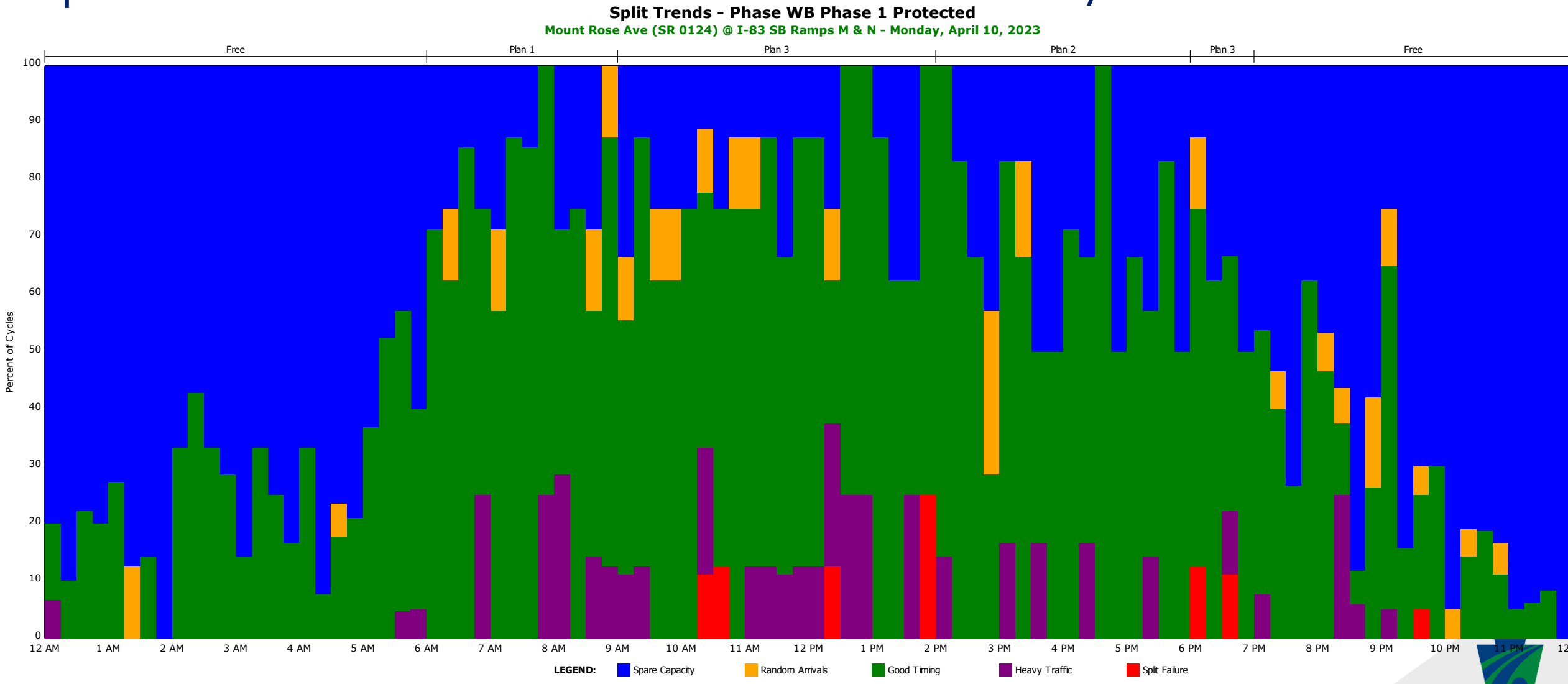
Flow Profile Example

- Generated for each coordinated phase with advance detection for duration of each pattern



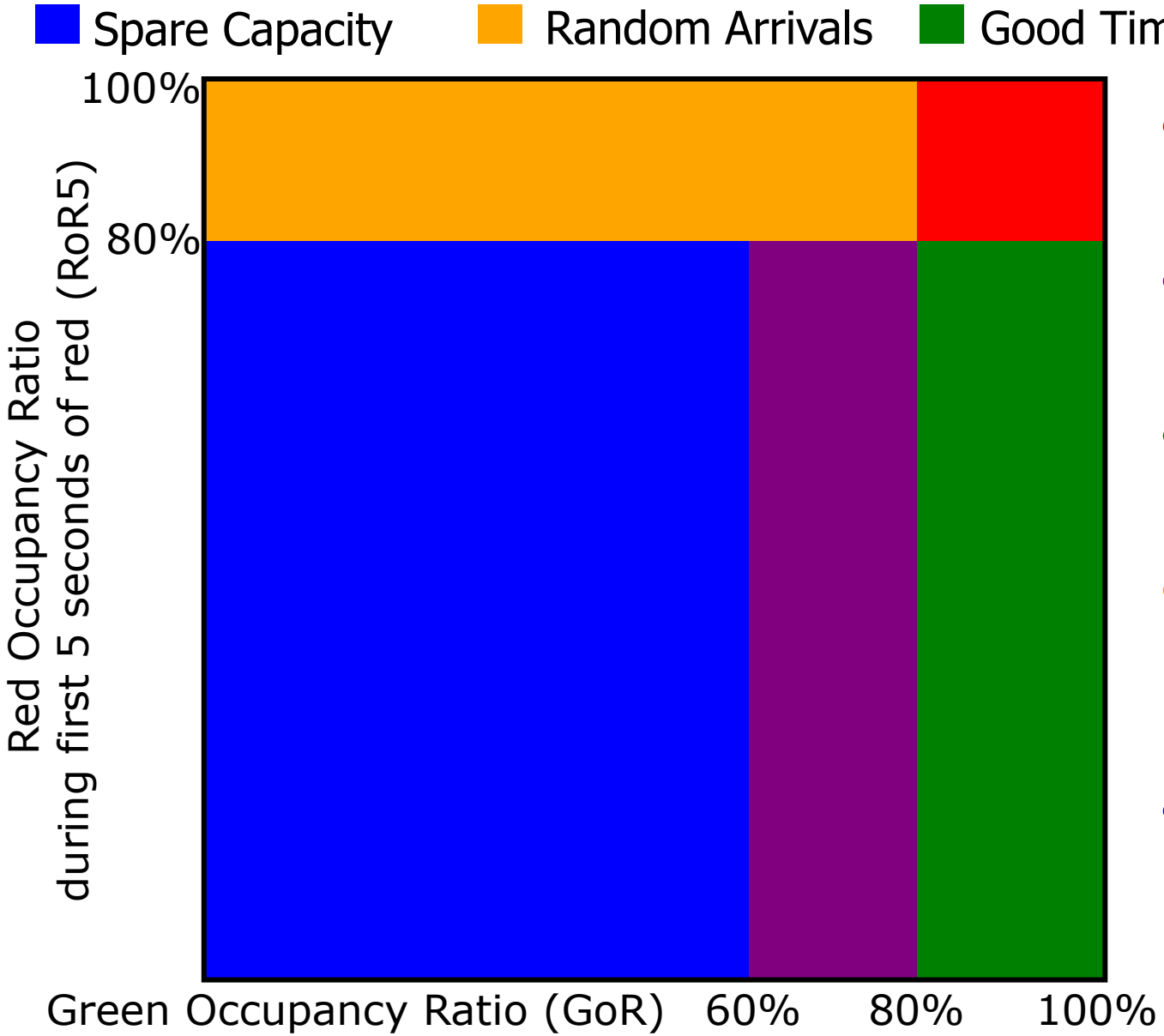
Split Trends Example

- Extends split failure framework to identify timing performance for other combinations of GOG/ROR5



Source: Miovision https://help.miovision.com/s/article/Insights-Split-Trends-in-Miovision-TrafficLink-portal?language=en_US

Split Trends: Framework



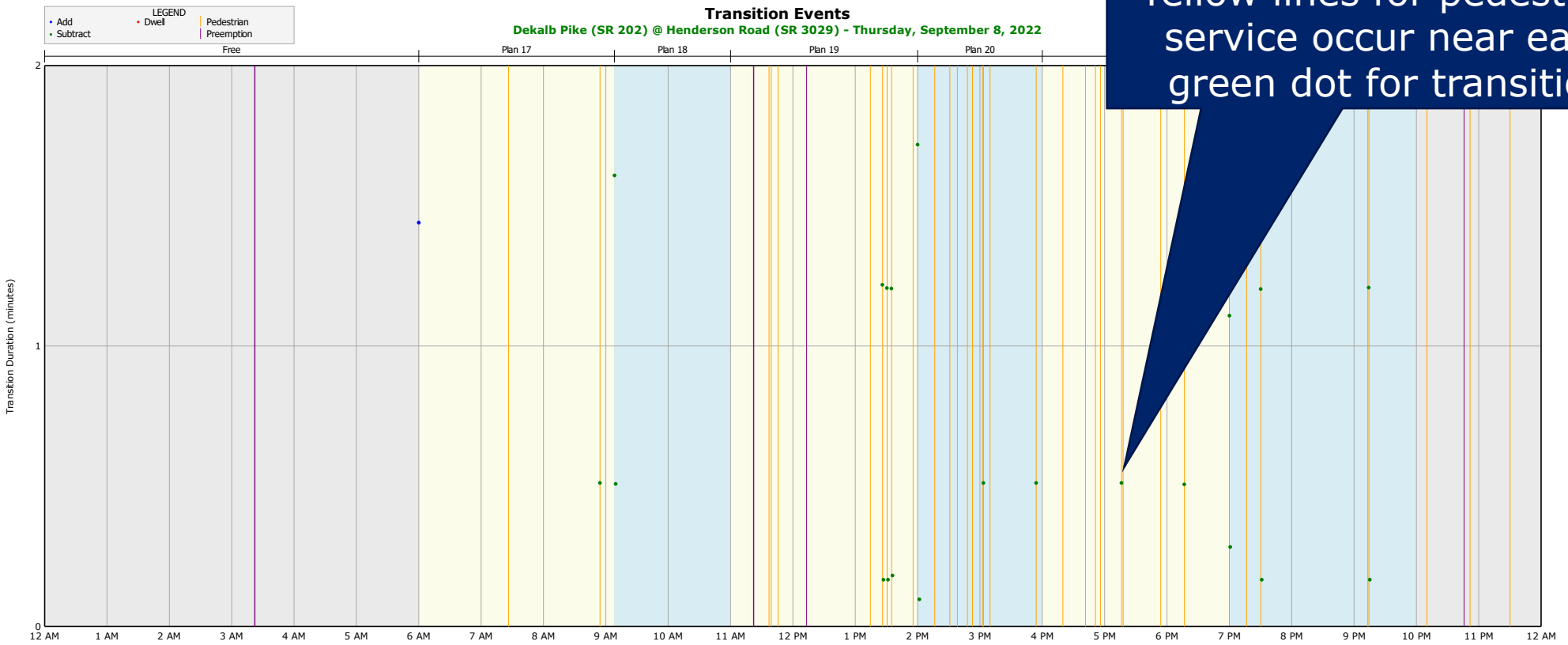
- **Split Failure:** left over demand
- **Heavy Traffic:** highly saturated but not failing
- **Good Timing:** Excellent green utilization
- **Random Arrivals:** Frequent arrivals just after green termination
- **Spare Capacity:** Underutilized green for movement

Source: Miovision https://help.miovision.com/s/article/Insights-Split-Trends-in-Miovision-TrafficLink-portal?language=en_US

Transitions Example

- Identifies when signal is in transition (coord not in sync)
- Includes flags of potential causes
  - Pedestrian phase service
  - Preemption service

LEGEND
- Add
- Subtract
- Dwell
- Pedestrian
- Preemption



Yellow lines for pedestrian service occur near each green dot for transition

Event Log

- Converts raw high resolution log to human-readable form
- Parameter description includes text for coded fields
- Can filter for various types of events and parameters
- Currently displayed data can be exported to .csv for Excel

Download Data

Timestamp	Event Code	Event Description	Event Parameter	Parameter Description
Wed 04/05/2023 12:00:00.0 AM	173	Unit Flash Status change	2	notFlash
Wed 04/05/2023 12:00:00.0 AM	174	Unit Alarm Status 1 change	64	Local Free
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	1	Special Function #1
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	2	Special Function #2
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	3	Special Function #3
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	4	Special Function #4
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	5	Special Function #5
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	6	Special Function #6
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	7	Special Function #7
Wed 04/05/2023 12:00:00.0 AM	177	Special Function Output off	8	Special Function #8

Bin Data

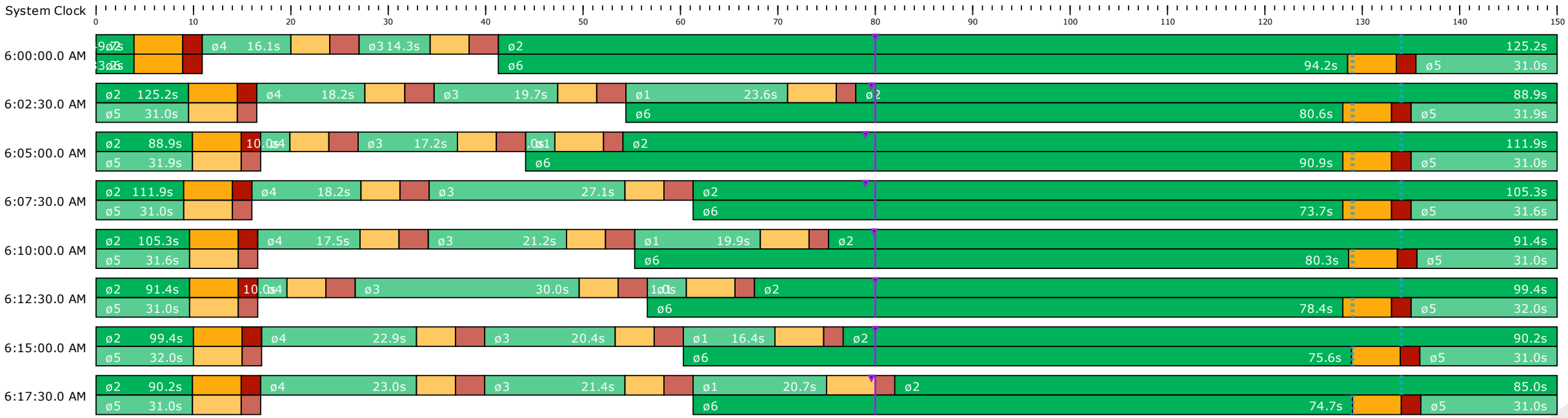
- Compiles detector data for each detection channel in 15-minute bins
  - Volume based on count of event 82 (Detector On) in each interval
  - Occupancy calculated as % of detector on time in each interval
    - Slow to calculate
- Easy tool to see what detection channels have data for mapping to lanes/movements/phases

Detector Volume | Detector Occupancy

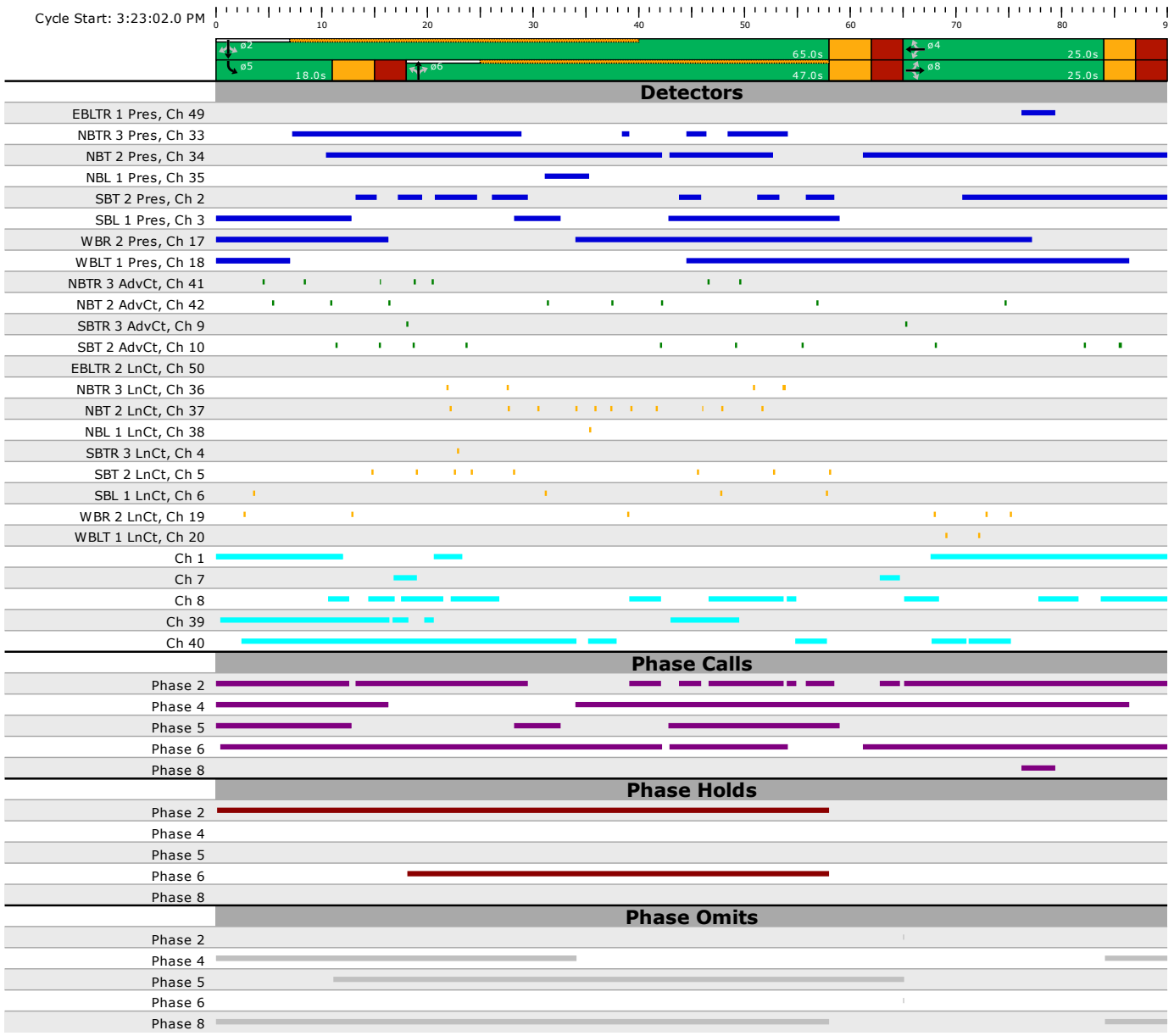
Wed 4/5/2023	Det 1	Det 2	Det 3	Det 4	Det 5	Det 6	Det 7	Det 8	Det 9	Det 10	Det 11	Det 12	Det 13	Det 17	Det 18	Det 19	Det 20	Det 21	Det 22	Det 23	Det 24	Det 25	Det 26	Det 33	Det 34	Det 35	Det 36	Det 37	Det 38	Det 39	Det 40	Det 41	Det 42	Det 43	Det 44	Det 45	Det 49	Det 50	Det 51	Det 52	Det 53	Det 54	Det 55	Det 56	Det 57	Det 58	Ped 3	Ped 6
12:00 AM	9	26	14	8	8	20	13	9	30	20	30	23	8	1	16	2	0	0	0	3	13	3	13	4	10	20	4	4	13	9	2	11	21	13	27	2	6	9	6	7	9	7	7	11	7	11	0	0
12:15 AM	6	16	11	5	5	19	14	11	22	21	22	23	7	5	16	6	1	0	0	3	13	4	16	7	12	14	4	6	8	12	6	14	26	15	31	2	5	5	5	5	8	5	6	13	5	13	0	0
12:30 AM	6	22	18	9	5	25	12	11	21	23	22	24	9	7	9	0	0	0	0	7	6	8	7	6	16	32	2	6	21	13	2	22	28	24	39	3	5	11	4	6	13	3	8	16	9	17	0	0
12:45 AM	5	16	6	6	6	13	6	8	12	15	13	22	7	12	28	10	3	0	1	9	10	10	10	2	11	13	0	2	7	7	0	9	20	9	21	0	1	8	2	1	7	1	2	9	2	9	0	0
1:00 AM	4	18	9	8	3	19	7	8	18	21	18	23	7	16	8	5	4	0	0	10	9	11	9	2	6	12	2	2	5	6	2	7	18	7	18	3	0	7	2	0	9	1	1	9	1	9	0	0
1:15 AM	6	14	11	4	6	15	11	4	18	16	20	20	4	5	7	2	2	0	0	5	6	5	6	2	7	14	5	2	6	7	2	12	17	13	23	0	2	5	4	2	5	5	2	6	2	7	0	0
1:30 AM	2	12	13	5	2	11	13	1	13	11	13	17	5	10	3	3	2	0	0	3	4	4	4	0	2	10	2	0	1	4	2	1	8	1	10	0	3	7	0	2	3	0	2	5	2	5	0	0
1:45 AM	4	15	16	11	3	15	11	15	17	28	19	30	14	6	24	4	0	0	0	3	11	3	12	0	3	7	0	0	4	3	0	4	5	5	8	0	4	3	4	3	2	3	3	4	3	4	0	0
2:00 AM	4	12	9	4	4	9	6	4	11	14	10	16	5	4	1	1	2	0	0	2	1	2	1	2	5	14	4	2	5	2	4	5	13	5	17	2	5	8	3	3	8	2	3	11	3	9	0	0
2:15 AM	2	5	5	5	2	3	4	6	7	8	8	9	5	6	8	1	3	1	0	5	3	7	3	2	6	4	1	2	4	1	1	6	11	6	13	1	4	5	0	3	6	0	3	6	3	6	0	0
2:30 AM	4	13	4	7	3	10	2	6	12	10	13	8	4	4	7	0	2	0	0	2	3	4	6	3	7	11	0	2	7	3	0	7	11	7	11	0	1	3	1	1	3	1	2	4	2	5	0	0
2:45 AM	4	9	4	5	4	7	5	4	11	9	9	10	3	0	0	1	0	0	0	1	1	1	2	1	3	9	1	1	2	3	1	2	8	2	6	1	1	1	1	1	1	1	1	2	1	2	0	0
3:00 AM	3	12	6	4	3	8	4	7	10	10	9	10	4	7	9	0	2	1	0	6	6	7	5	2	6	12	4	2	4	3	1	8	21	9	19	3	3	1	3	1	1	3	1	2	1	2	0	0
3:15 AM	6	8	5	4	5	10	4	3	9	8	9	9	3	4	5	0	2	0	0	5	3	5	4	1	7	12	4	2	4	5	5	4	12	4	16	2	2	2	2	2	3	2	1	6	1	7	0	0

Coord Timeline

- Shows every cycle within a coordinated pattern referenced to system (master) clock zero
- Coordinated phases shown in darker green
- Purple line represents local zero (offset)

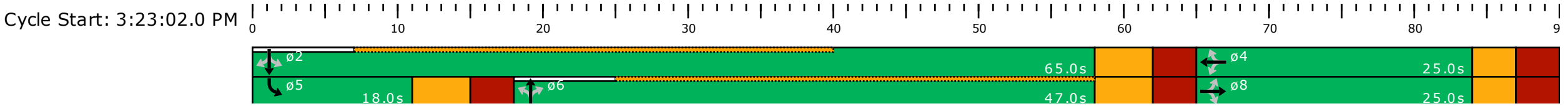


Cycle Timeline Example



- Shows one cycle at a time
- Includes overlaps
- Shows pedestrian timing
- Aligns detector calls, phase calls, phase holds, and phase omits with active phase displays
- Detectors color-coded by type
- Referenced to sequence (similar to Synchro)

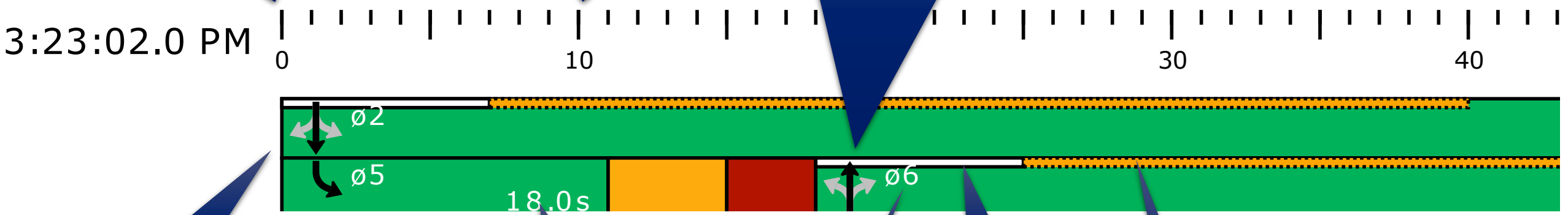
Cycle Timeline Example



Time zero @ 3:23:02.0 PM

Seconds since beginning of cycle

Protected movements shown in black
Permitted movements shown in gray



Rings 1 and 2

Total split duration (green + yellow change + red clear)

Phase

Ped Walk

Ped Clearance

Coord Plans

- Shows time of day when controllers switch timing plans
- Cycle, splits, and offset shown for coordination plans
- Does this match approved timings?

Time	Pattern #	Cycle Length	Offset Length	Split 1	Split 2	Split 3	Split 4	Split 5	Split 6	Split 7	Split 8	Split 9	Split 10	Split 11	Split 12	Split 13	Split 14	Split 15	Split 16
0:00:00.0	Free																		
6:30:01.0	Plan 1	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00:40.0	Plan 2	85	0	15	35	0	22	0	50	0	35	0	0	0	0	0	0	0	0
14:01:30.1	Plan 3	90	0	13	34	14	29	0	47	0	43	0	0	0	0	0	0	0	0
19:00:01.1	Free																		

BREAK

Download data from PennDOT Traffic Signal Portal
www.dot.state.pa.us/signals → click on ATSPM
Load the ATSPM Ad-Hoc Tool in your web browser
(Use Chrome or Edge)

9:50-10:00

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CASE STUDY 1

Is there a problem, and is a phasing change the right solution?

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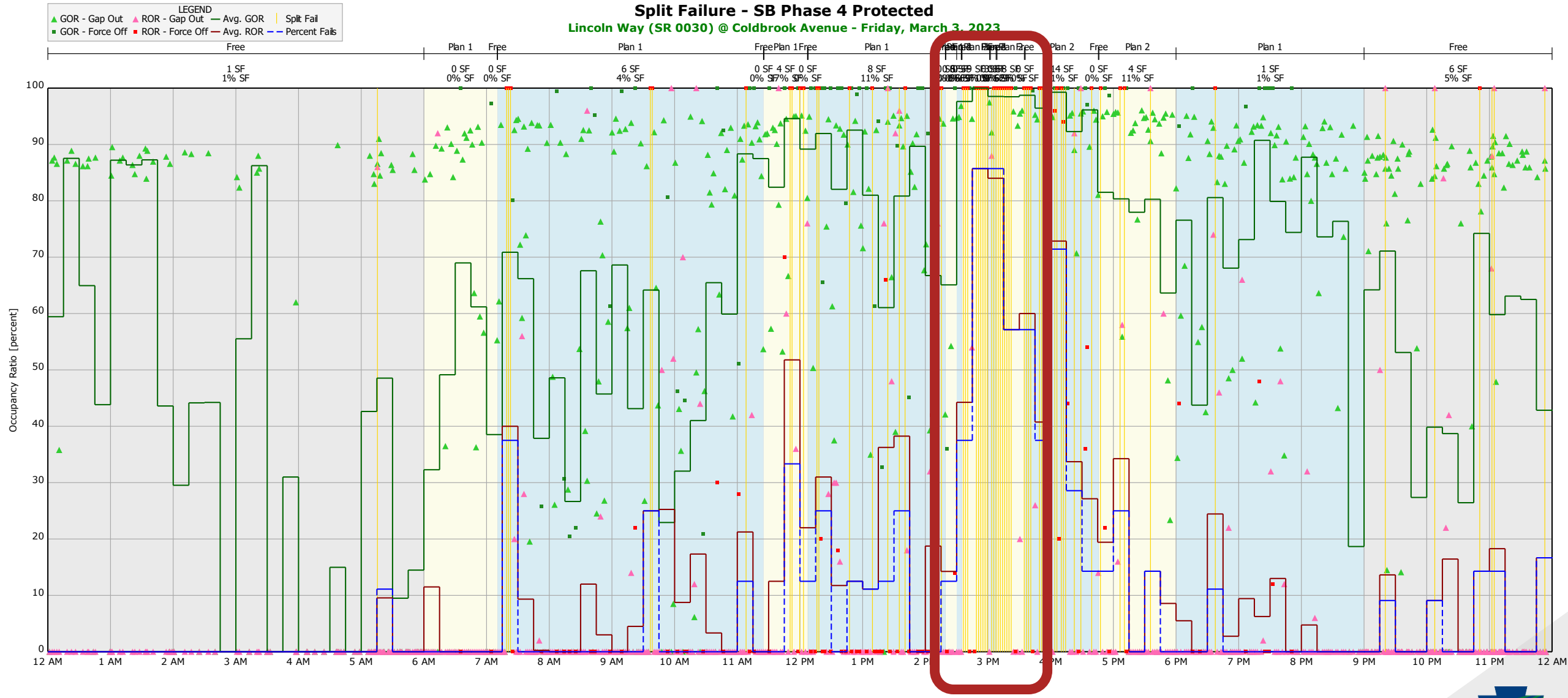
Case Study 1: Context

1. Detector Counts/Conflict Factor

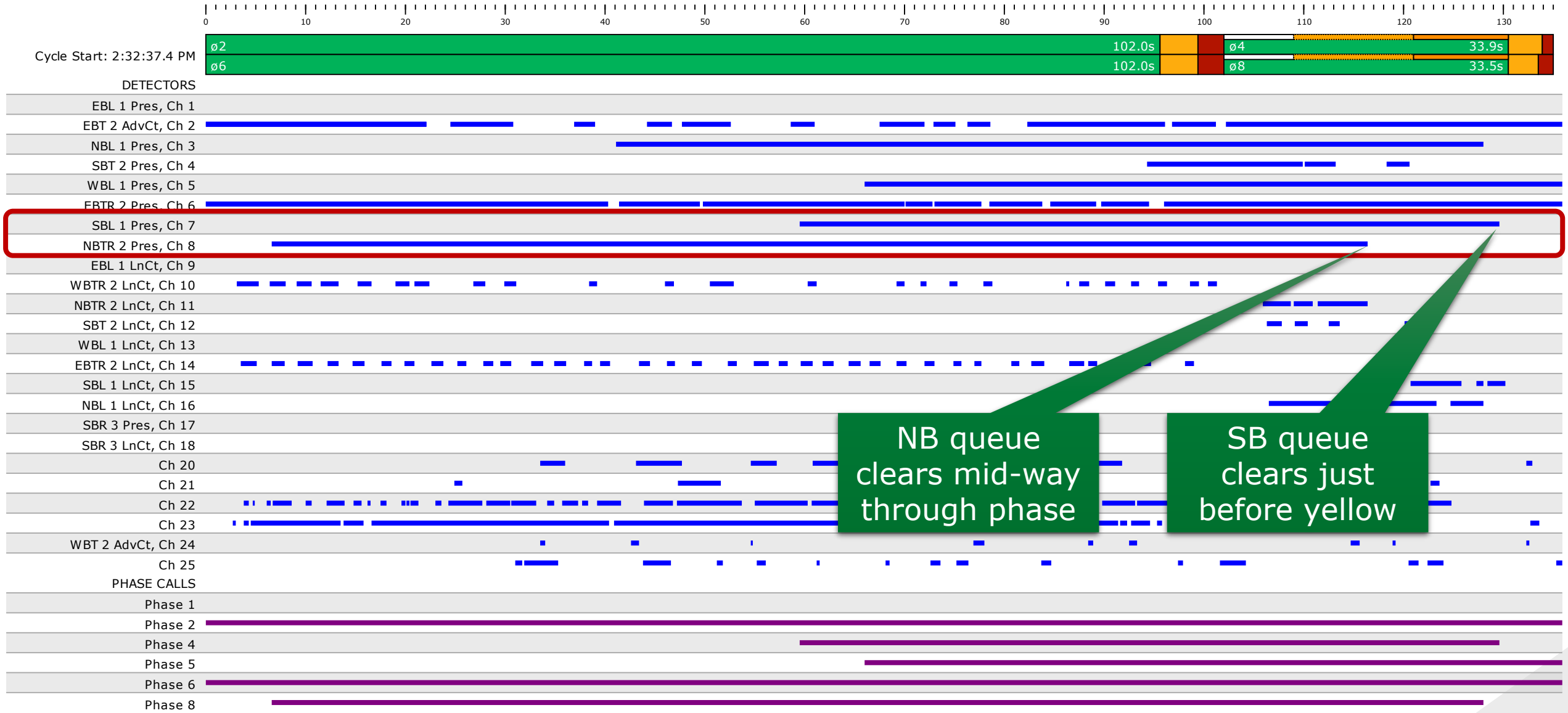
Detector	16 NB L	11 NB TR	15 SB L	12 SB T	18 SB R
2:00-3:00 PM	55	35	72	21	17
3:00-4:00 PM	31	41	71	31	9
4:00-5:00 PM	52	43	84	31	17
5:00-6:00 PM	44	36	65	18	7

Conflict Factor	NB L	SB L
2:00-3:00 PM	1155	2520
3:00-4:00 PM	961	2911
4:00-5:00 PM	1612	3612
5:00-6:00 PM	792	2340

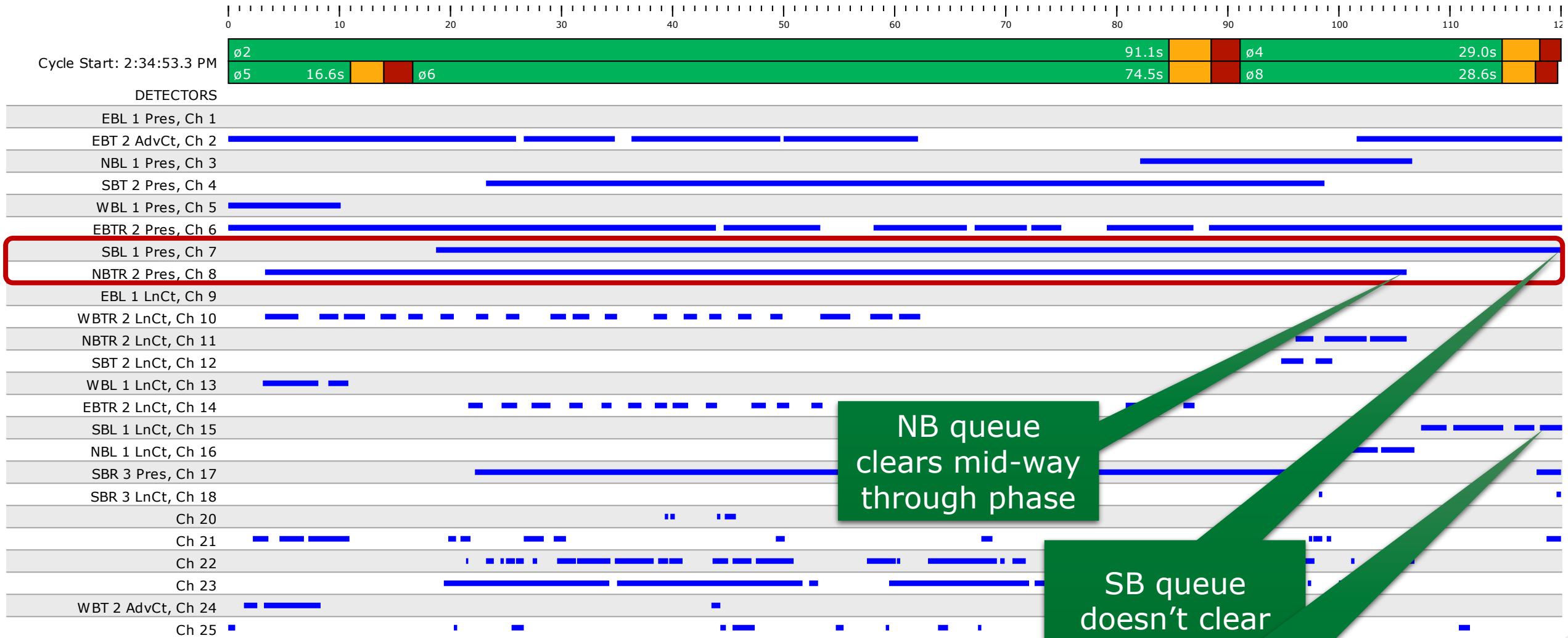
2. Split Failure Analysis



3. Cycle by Cycle Analysis



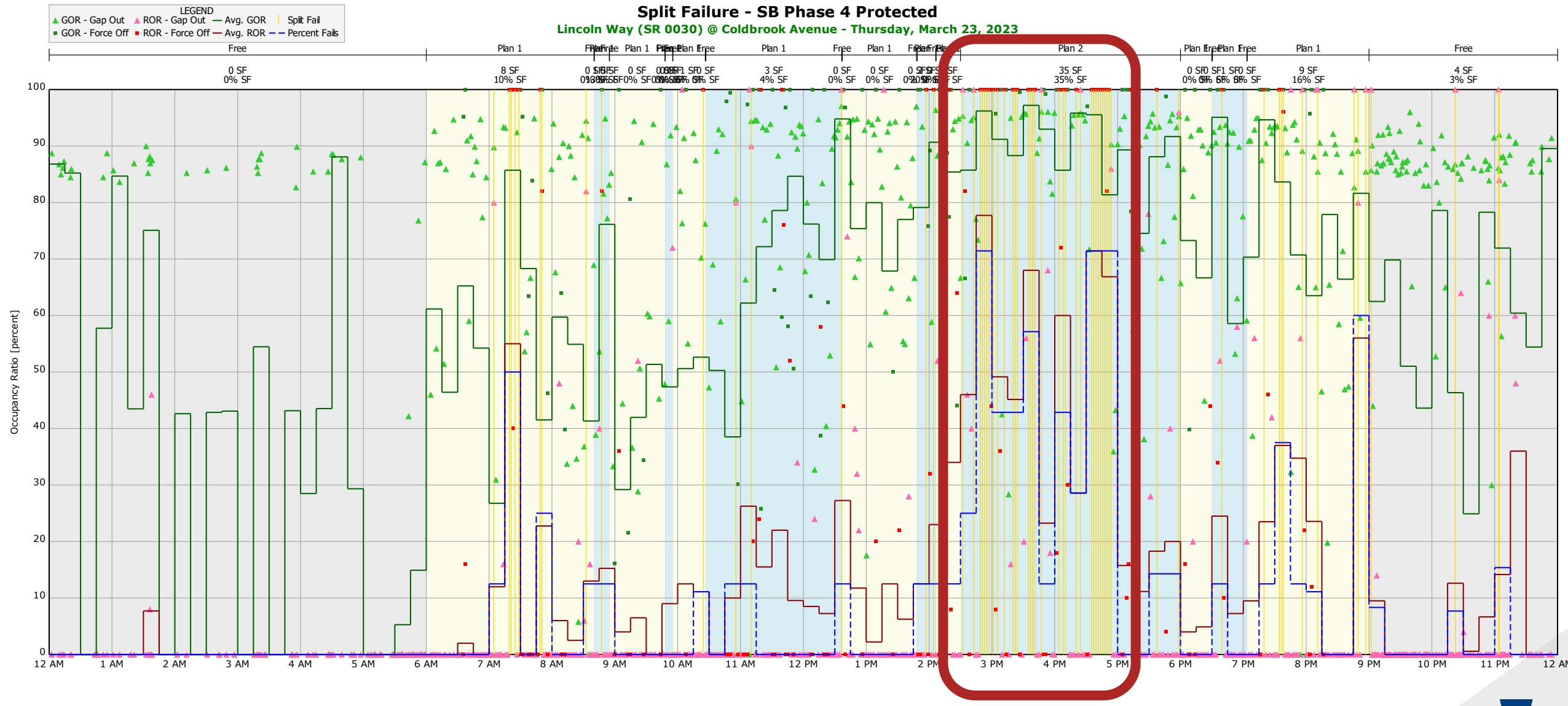
3. Cycle by Cycle Analysis



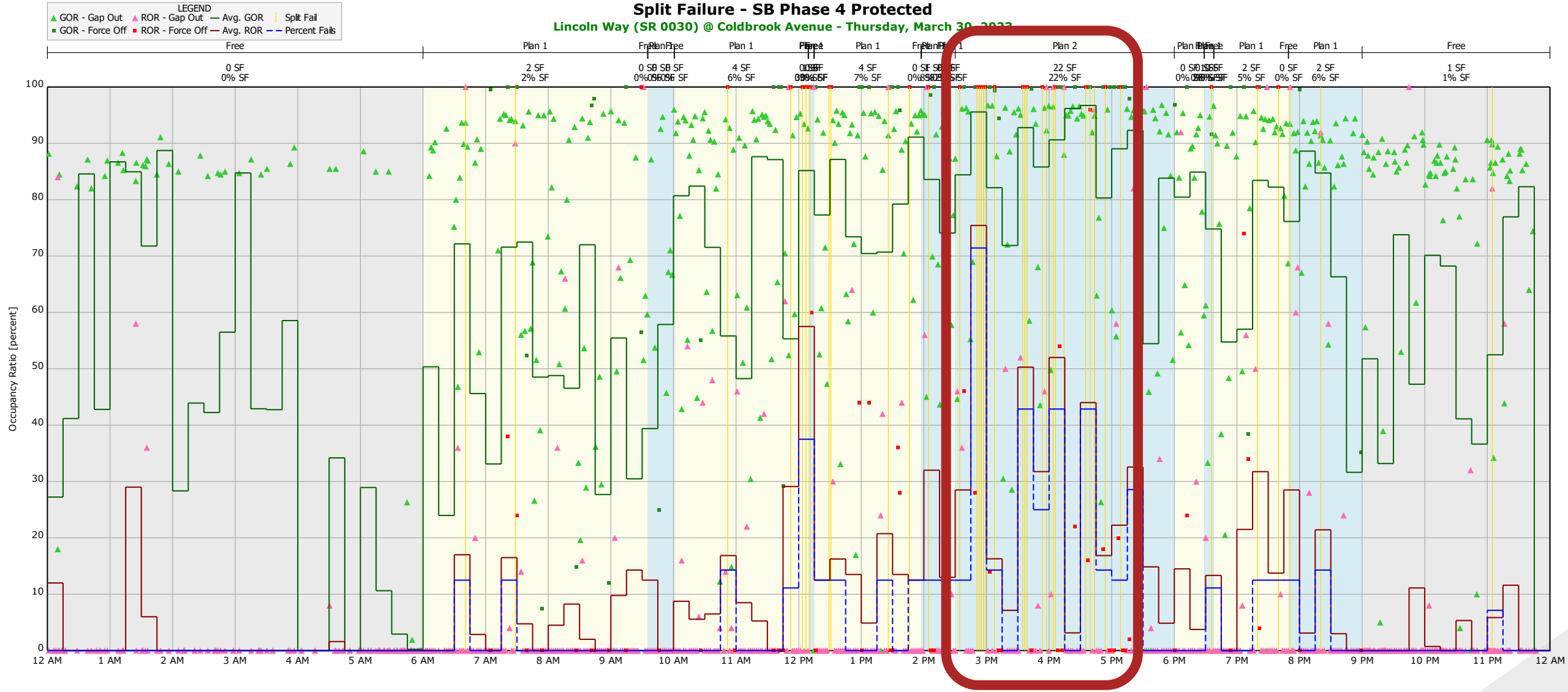
Add Left Turn Phase?

- Left turn phase timing
  - 3s min green, but 7s min for split time desirable
  - 3.4s Y + 2.0s R = 5.4s
  - Min desirable split = 13s
- Adding phase increases lost time
- Since NB isn't using all the green time, a few extra seconds of green split could solve the issue with less lost time
  - Shifted **5s** from 2+6 to 4+8 during PM plan (125s cycle)
  - Shifted **3s** from 2+6 to 4+8 during other plan (110s cycle)
- Using ATSPM, we can try it and compare before/after results

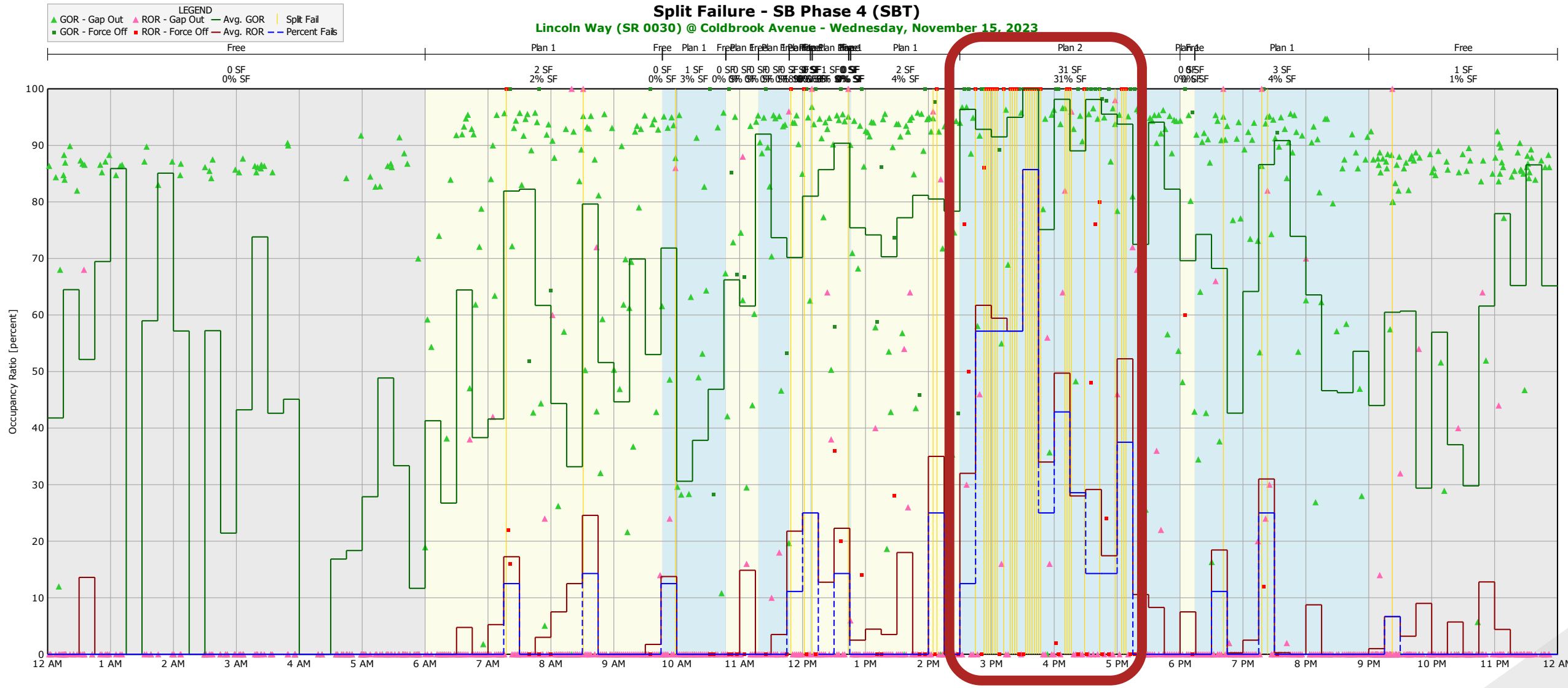
Thursday Before Split Adjustment



Thursday After Split Adjustment



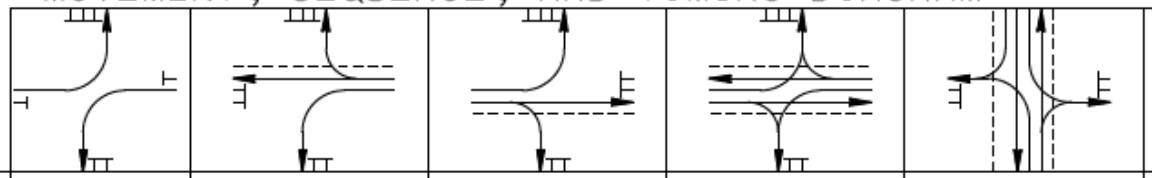
8 Months Later



Bonus Question

- What do you notice about the yellow change interval for phases 4+8?

MOVEMENT, SEQUENCE, AND TIMING DIAGRAM



PHASE	1+5			2+5				1+6				2+6				4+8			
INTERVAL / SIGNAL	1	2	3	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	R/G	R/A①	R①	G/G	G/G	Y③	R④	R	R	R	R	G	G	Y	R	R	R	R	R
2	R	R	R	G	G	Y④	R④	R	R	R	R	G	G	Y	R	R	R	R	R
3	R/G	R/A②	R②	R	R	R	R	G/G	G/G	Y③	R④	G	G	Y	R	R	R	R	R
4	R	R	R	R	R	R	R	G	G	Y④	R④	G	G	Y	R	R	R	R	R
5,6	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	G	G	Y	R
7,8	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	G	G	Y	R
9,10	H	H	H	M*	FH*	H	H	H	H	H	H	M*	FH*	H	H	H	H	H	H
11,12	H	H	H	H	H	H	H	M*	FH*	H	H	M*	FH*	H	H	H	H	H	H
13,14	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	M*	FH*	H	H
15,16	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	M*	FH*	H	H
FAIL-SAFE LAMP A	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
FAIL-SAFE LAMP B	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
FAIL-SAFE LAMP C	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
FAIL-SAFE LAMP D	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
FIXED		3.0	2.6			3.8	2.6			3.8	2.6			3.8	2.6			3.4	2.0
MINIMUM	3			3				3				12				3			
PASSAGE	1			1				1				**				1			
MINIMUM GAP												3							
MAXIMUM 1	25			25				25				70				40			
PEDESTRIAN*				⑤				⑤				7	18			7	12		
MEMORY	NL			NL				NL				MR				NL			

CASE STUDY 2

Reviewing data for a newly-connected intersection

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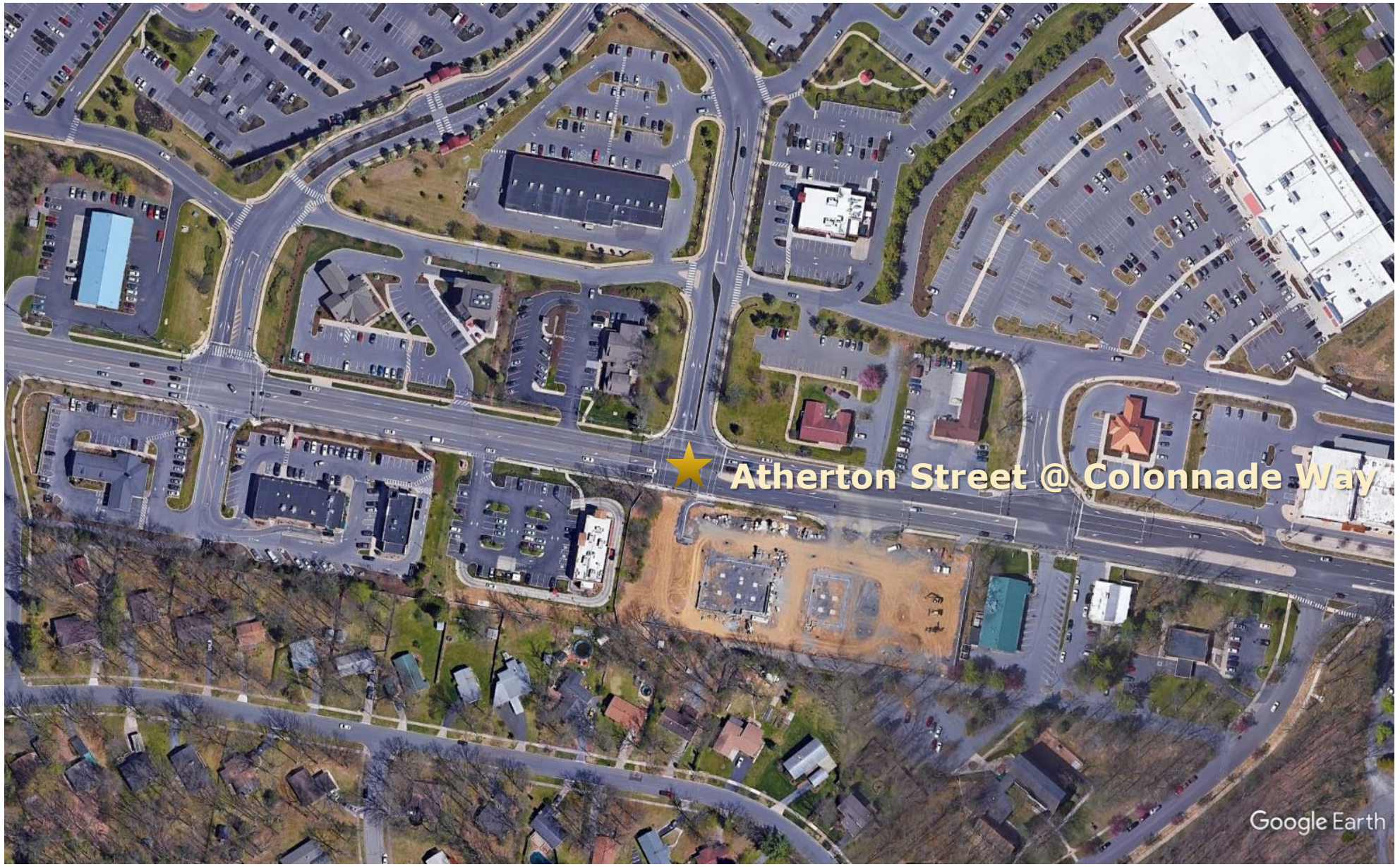
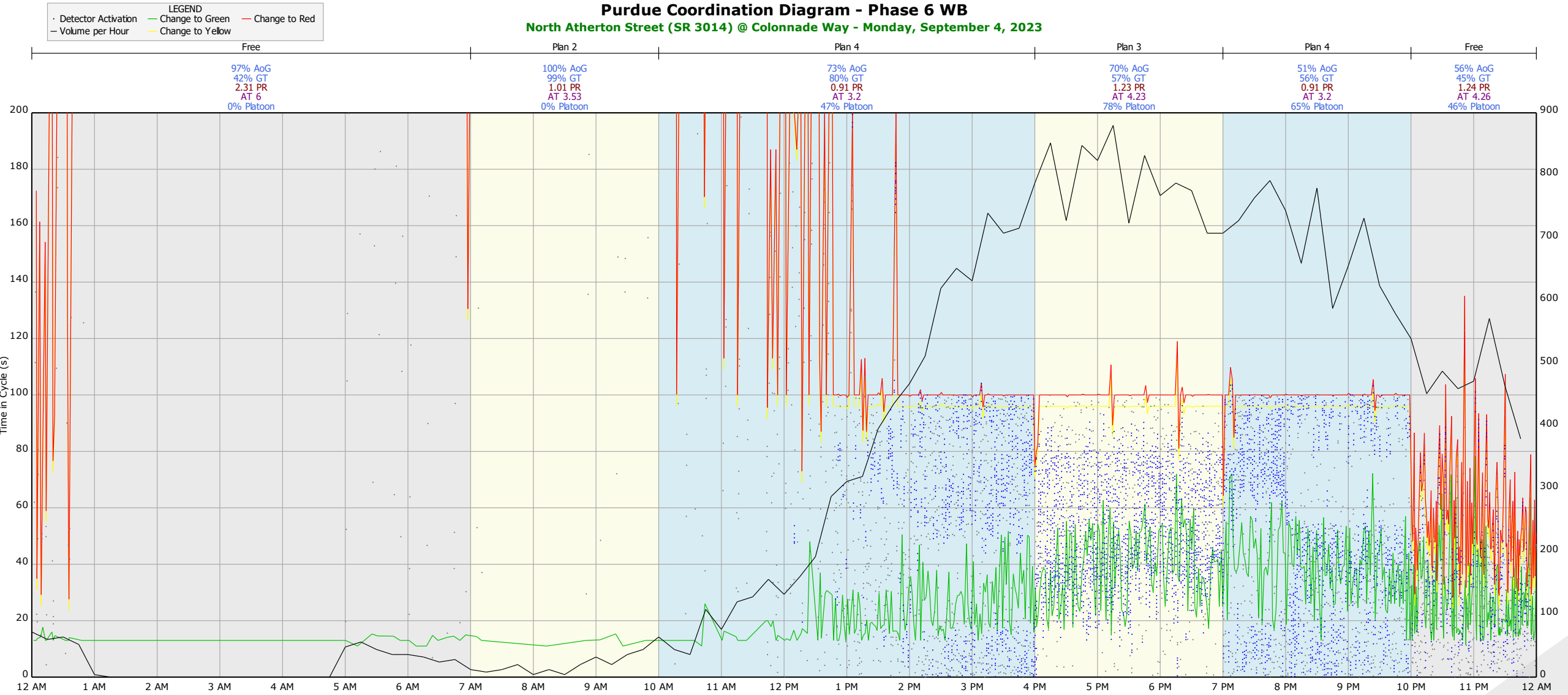
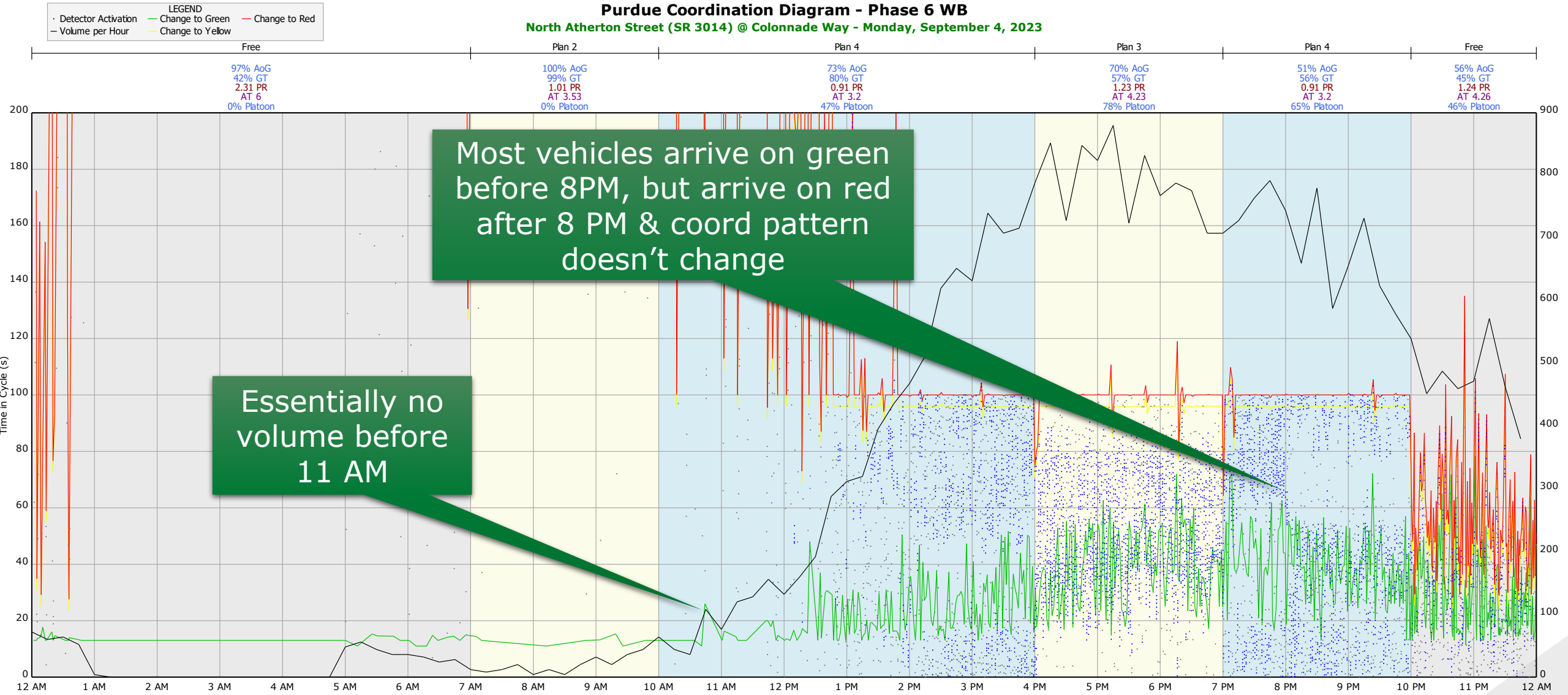
Case Study 2: Context



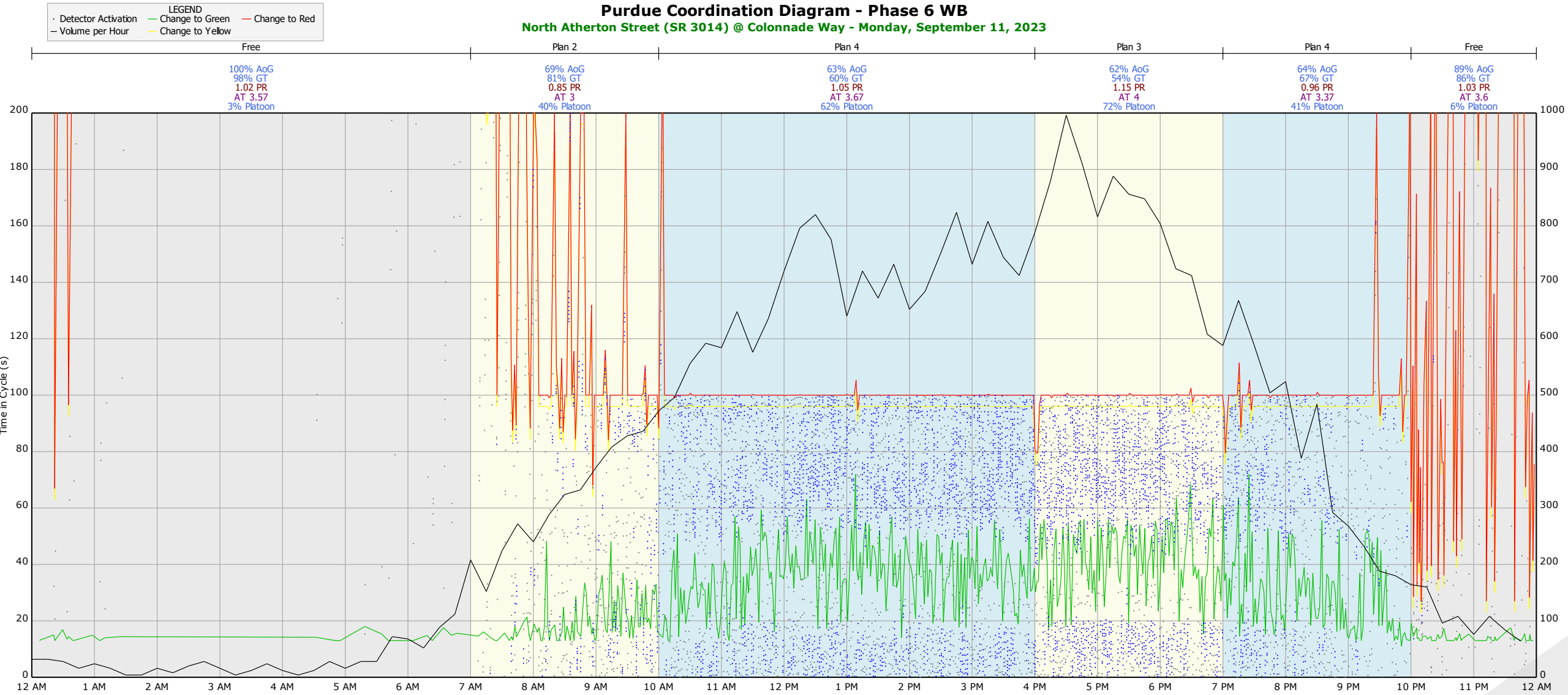
Case Study 2: PCD Before



Case Study 2: PCD Before



Case Study 2: PCD After



CASE STUDY 3

Is oversized ped phase appropriate?

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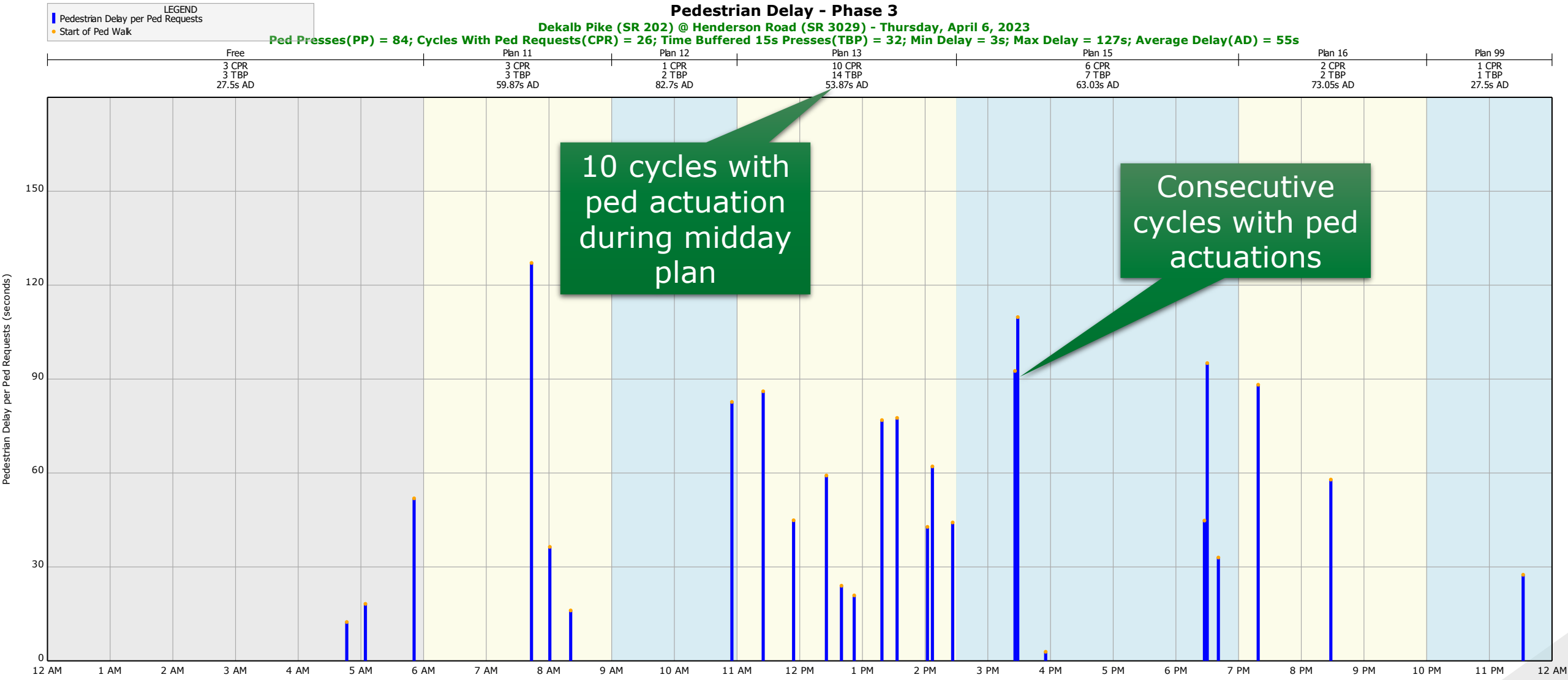
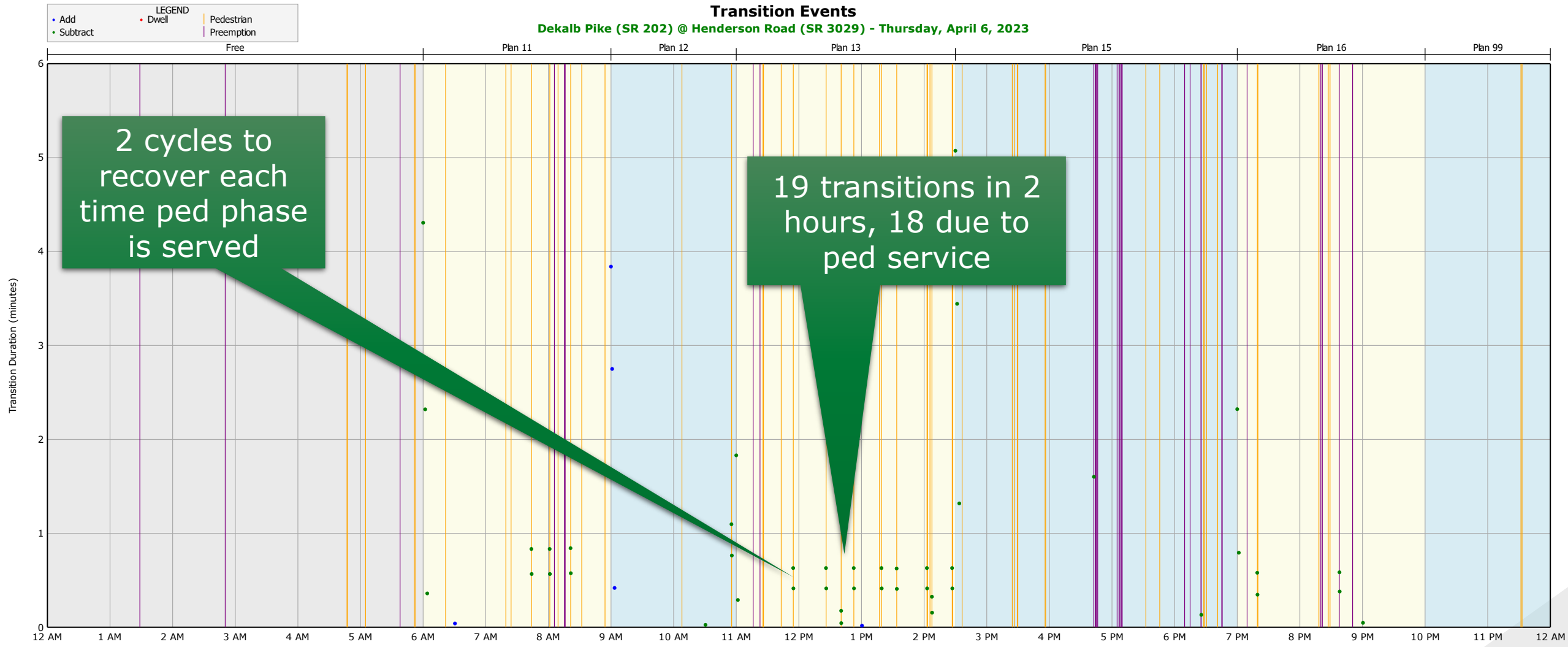
Case Study 3: Context

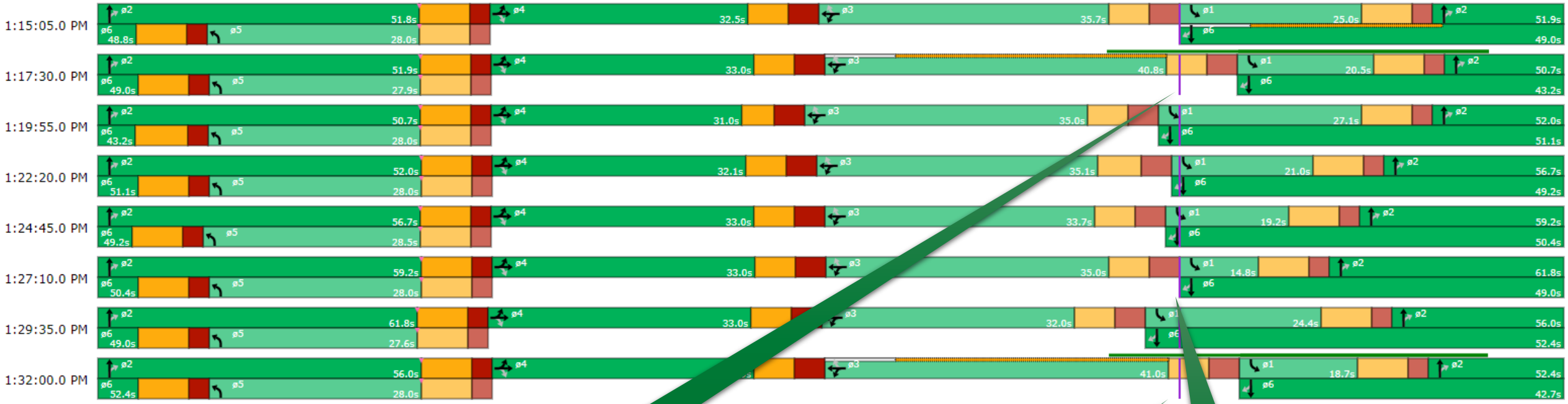
How Frequent are Peds?



Oversize Ped Recovery



Oversize Ped Recovery

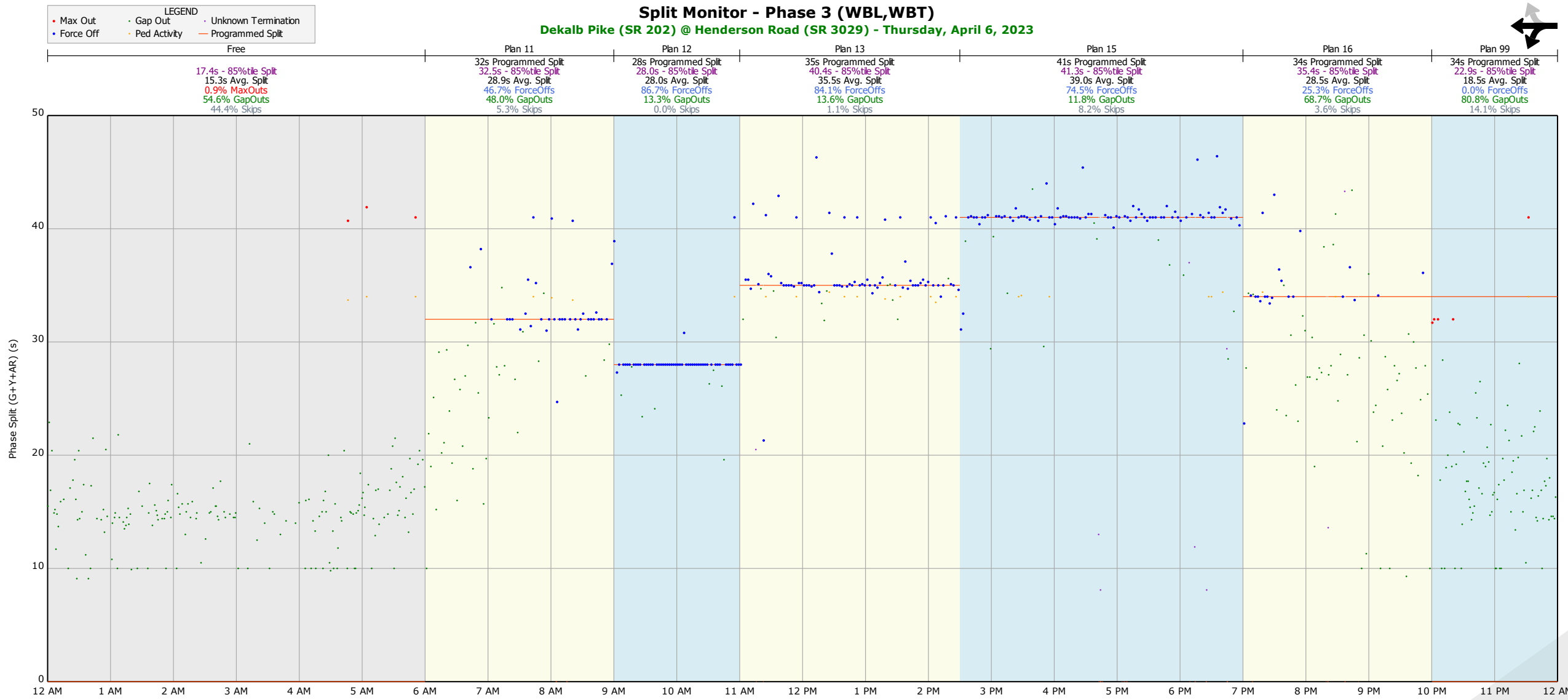


Ped pushes ø3 past programmed force off

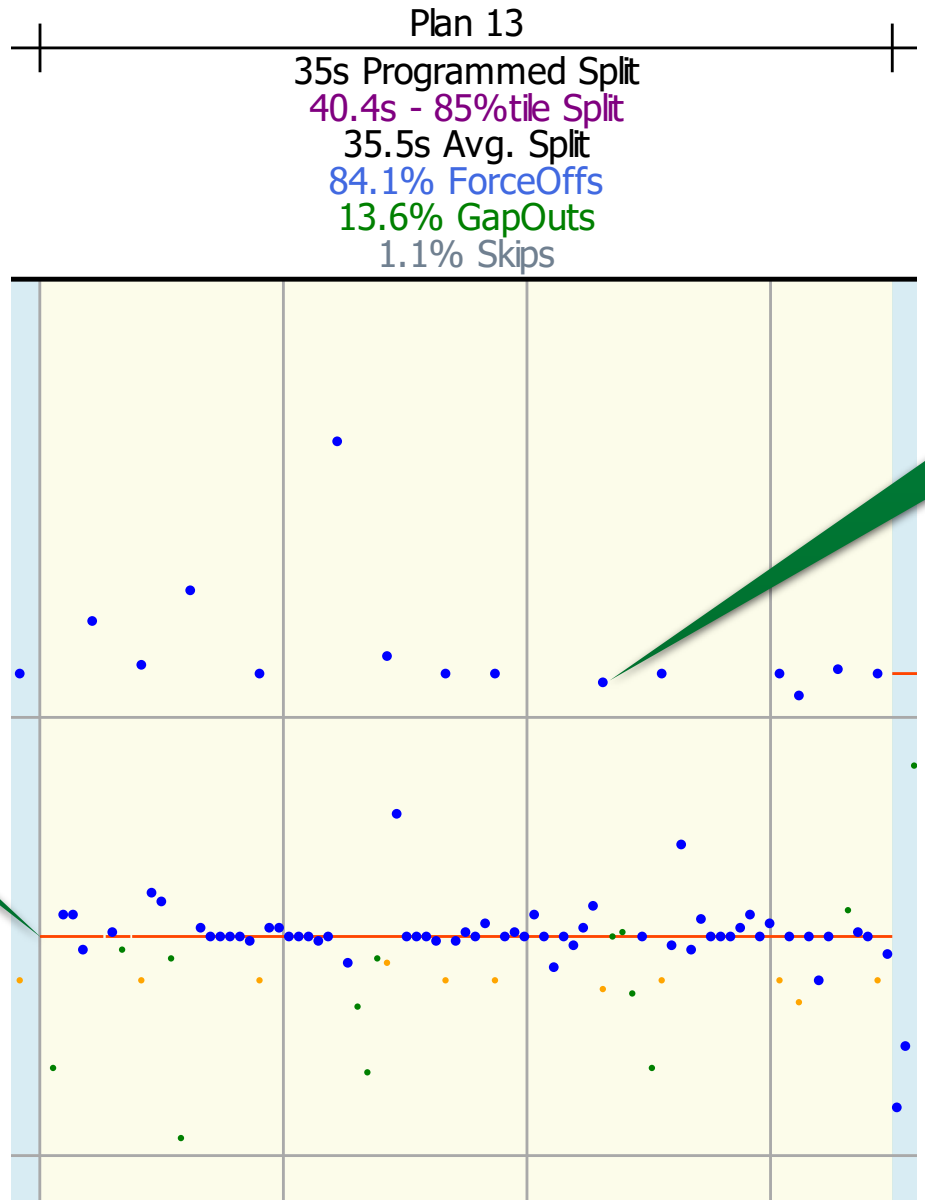
Ped pushes ø3 past programmed force off

Back in sync after 4th cycle

How Difficult to Fix?



How Difficult to Fix?



35 sec. programmed split

41 sec. required to serve peds

CASE STUDY 4

Why is signal cycling with no demand?

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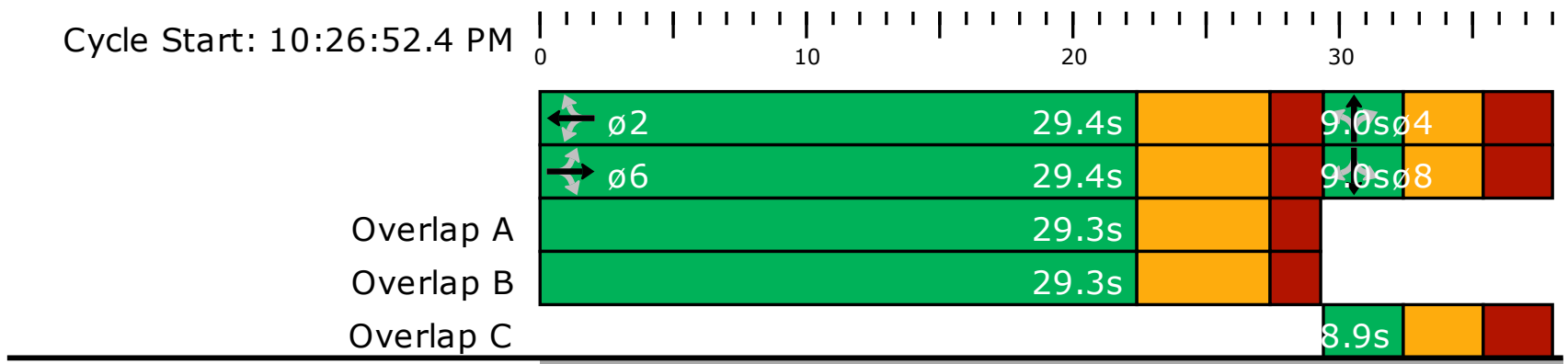
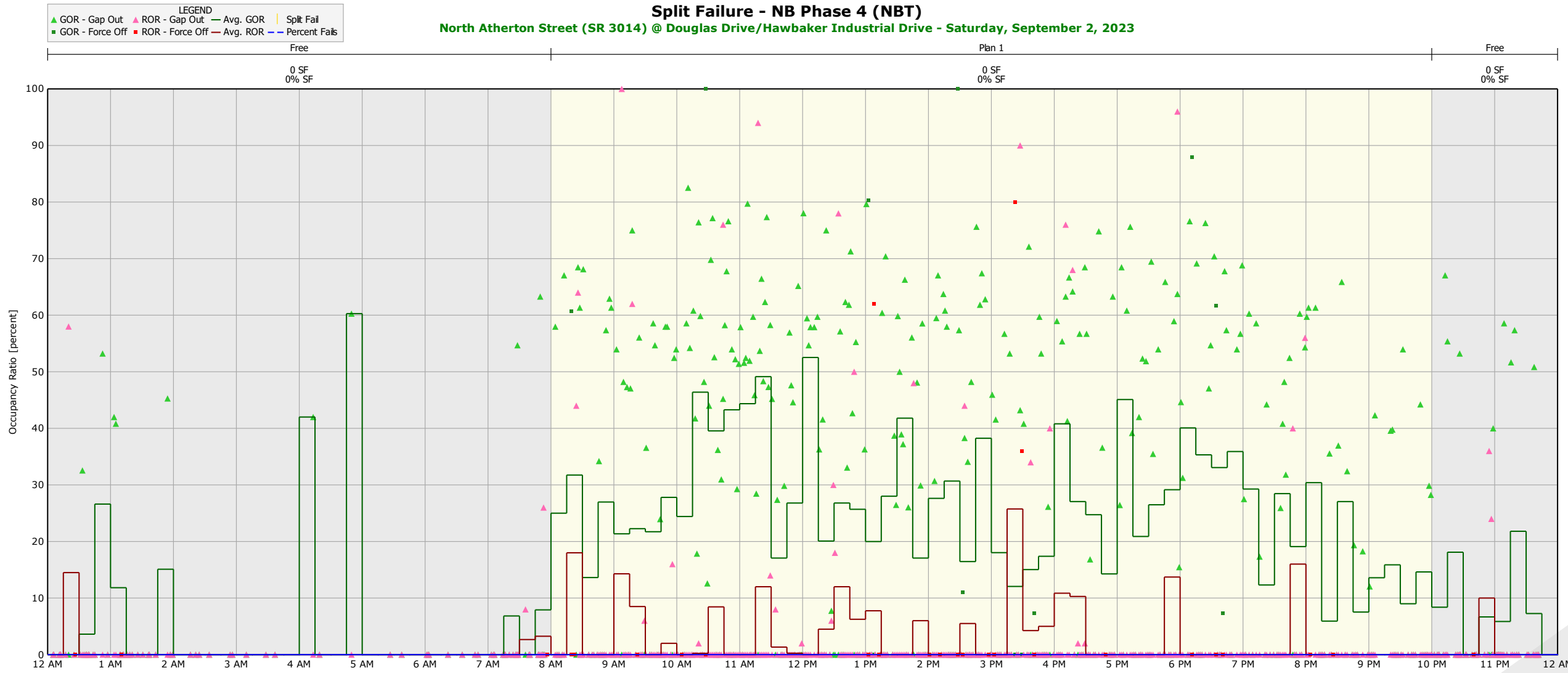
Case Study 4: Example 1 Timeline



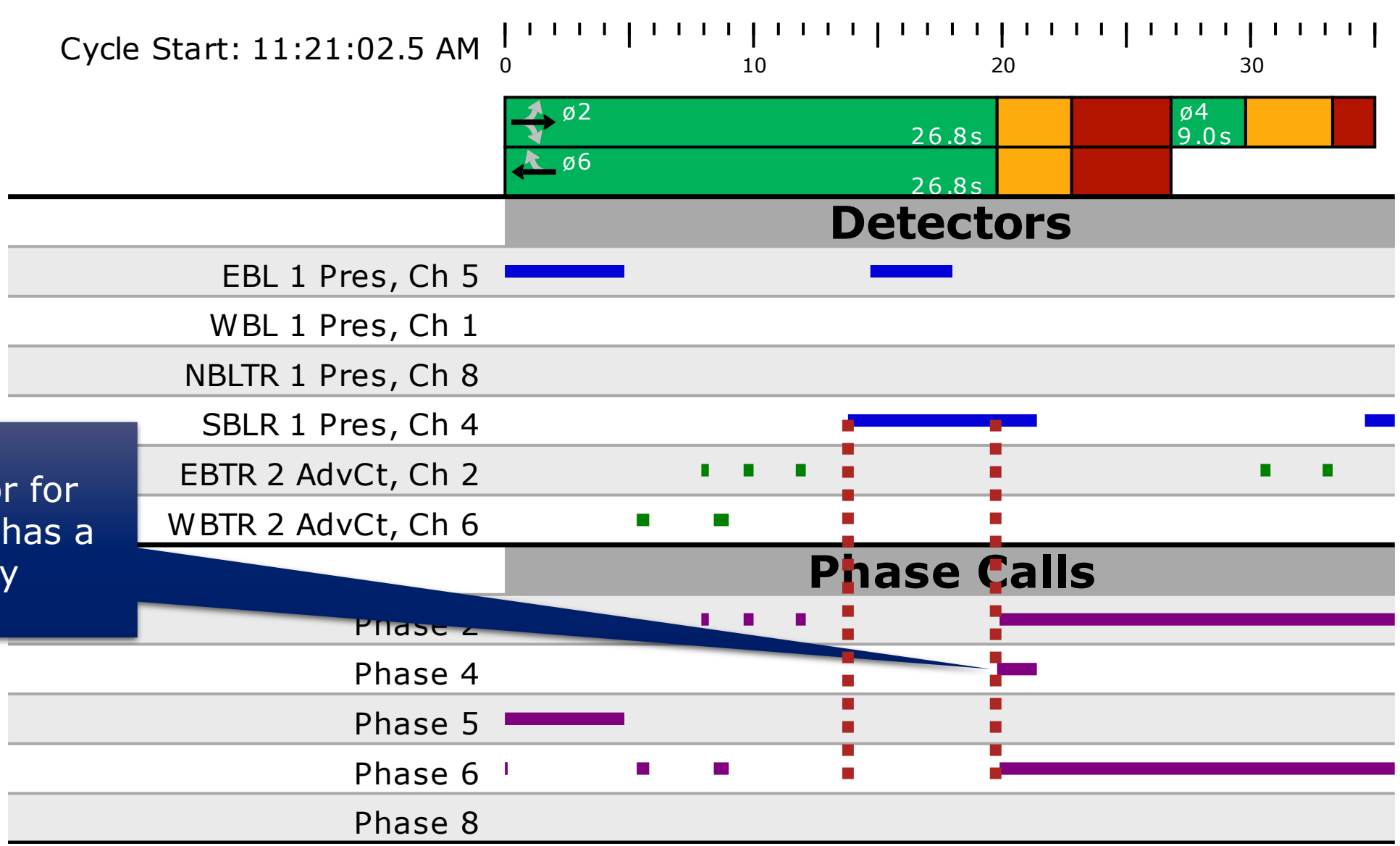
	Detectors
EBL 1 Pres, Ch 1	
NBLTR 1 Pres, Ch 4	
WBL 1 Pres, Ch 5	
SBLTR 1 Pres, Ch 8	
EBT 2 AdvCt, Ch 6	
WBT 2 AdvCt, Ch 2	

	Phase Calls
Phase 1	
Phase 2	
Phase 4	
Phase 5	
Phase 6	
Phase 8	

Case Study 4, Example 1: Split Fail

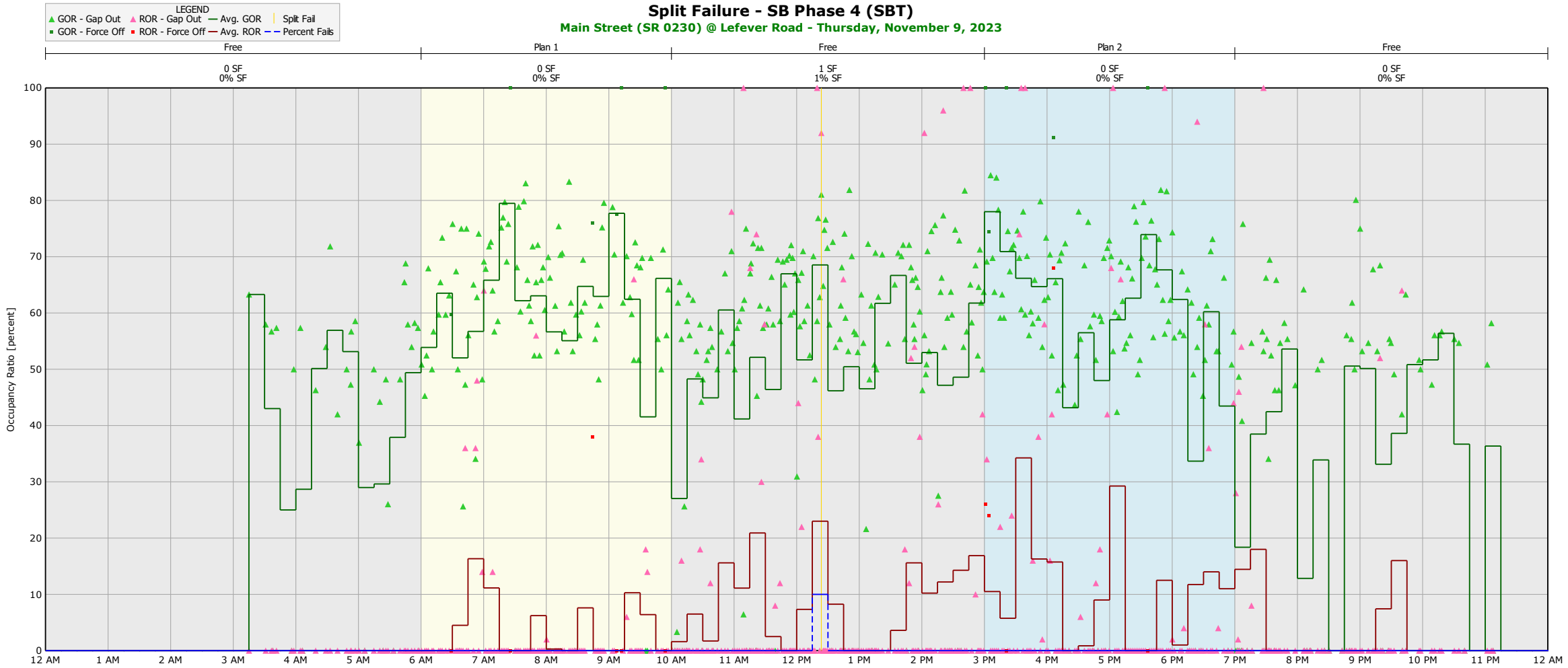


Case Study 4: Example 2 Timeline



Detector for phase 4 has a delay

Case Study 4, Example 2 Split Fail



BREAK

Download data from PennDOT Traffic Signal Portal
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Load the ATSPM Ad-Hoc Tool in your web browser
(Use Chrome or Edge)

10:50-11:00

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CASE STUDY 5

Is coordination beneficial?

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Coordination Discussion

- What are the benefits of coordination?
- What are the disadvantages of coordination?
- Does coordination help more than it hurts?

Coordination Benefits

- Smooth Flow objective
  - Reduce stops / increase arrival on green
- Schedule green for coordinated movements
  - Fixed cycle length
  - Assumed travel time between intersections
  - Implicitly assumes platoons exist
  - Implicitly assumes more traffic on coordinated approaches than on other approaches

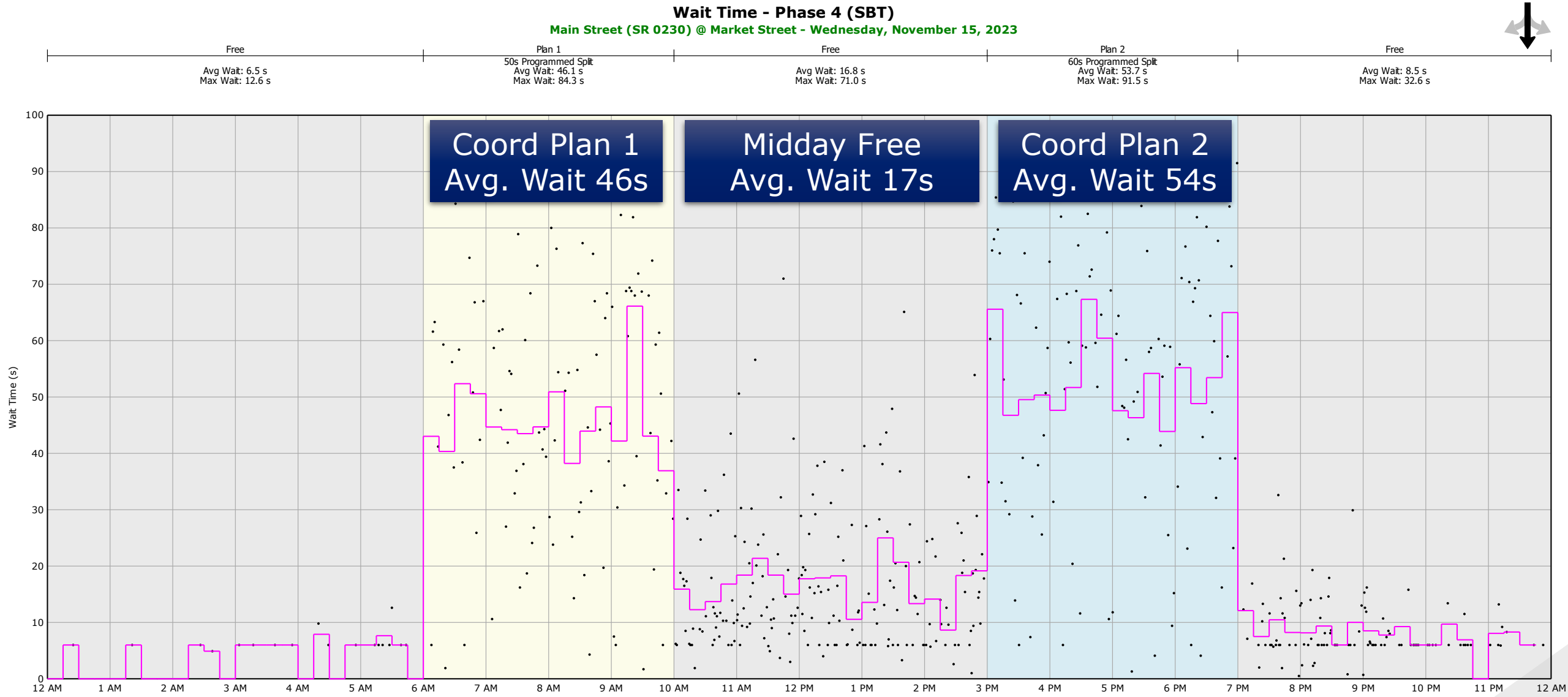
Coordination Disadvantages

- Increased delay for side streets
- Increased delay for pedestrians

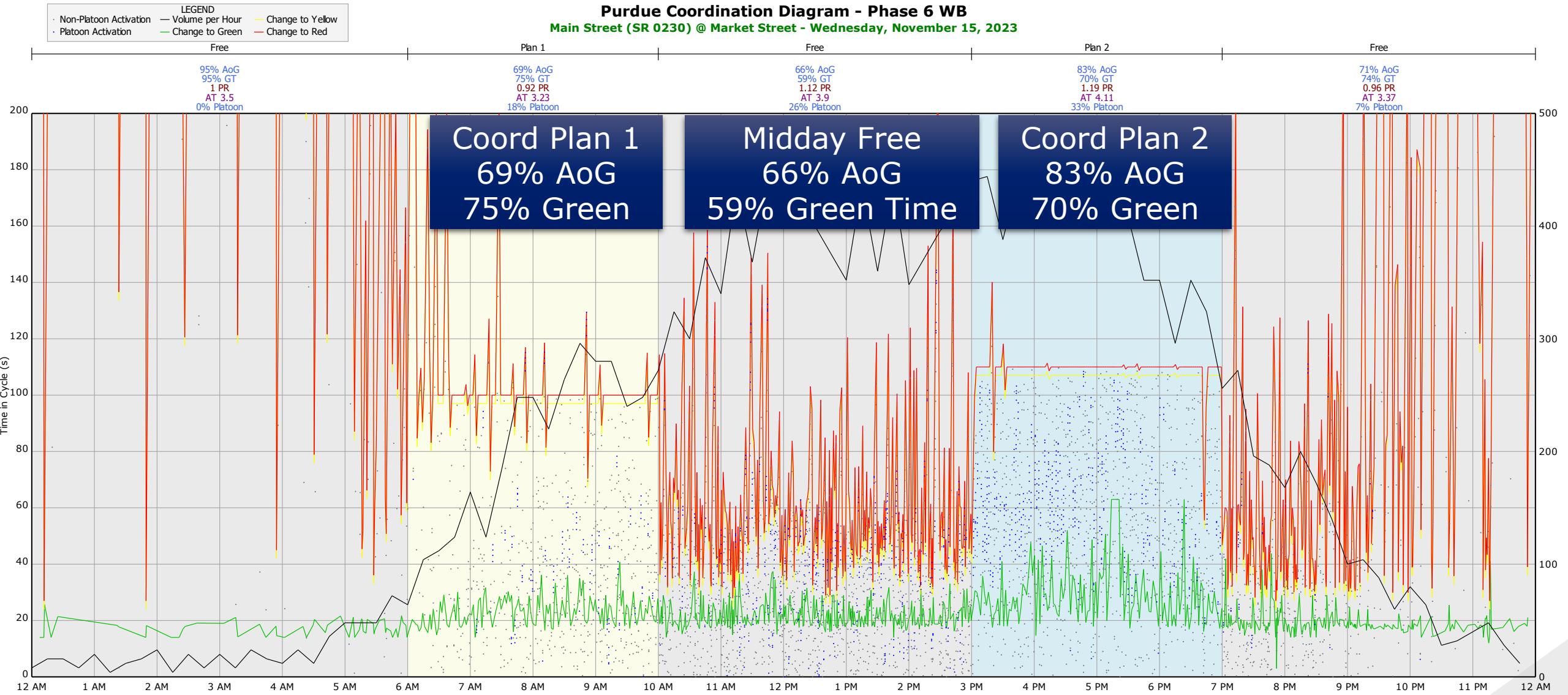
Case Study 5

- How does wait time compare during coordinated vs. free times for side street phases (4+8)?
- How does arrival on green for main street (2+6) compare during coordinated vs. free times?
- What times of day do you recommend using coordination?
  - Add coordination during midday?
  - Remove coordination during AM and/or PM peaks?

Case Study 5: Wait Time



Case Study 5: Smooth Flow



CASE STUDY 6

Is signal timing effective?

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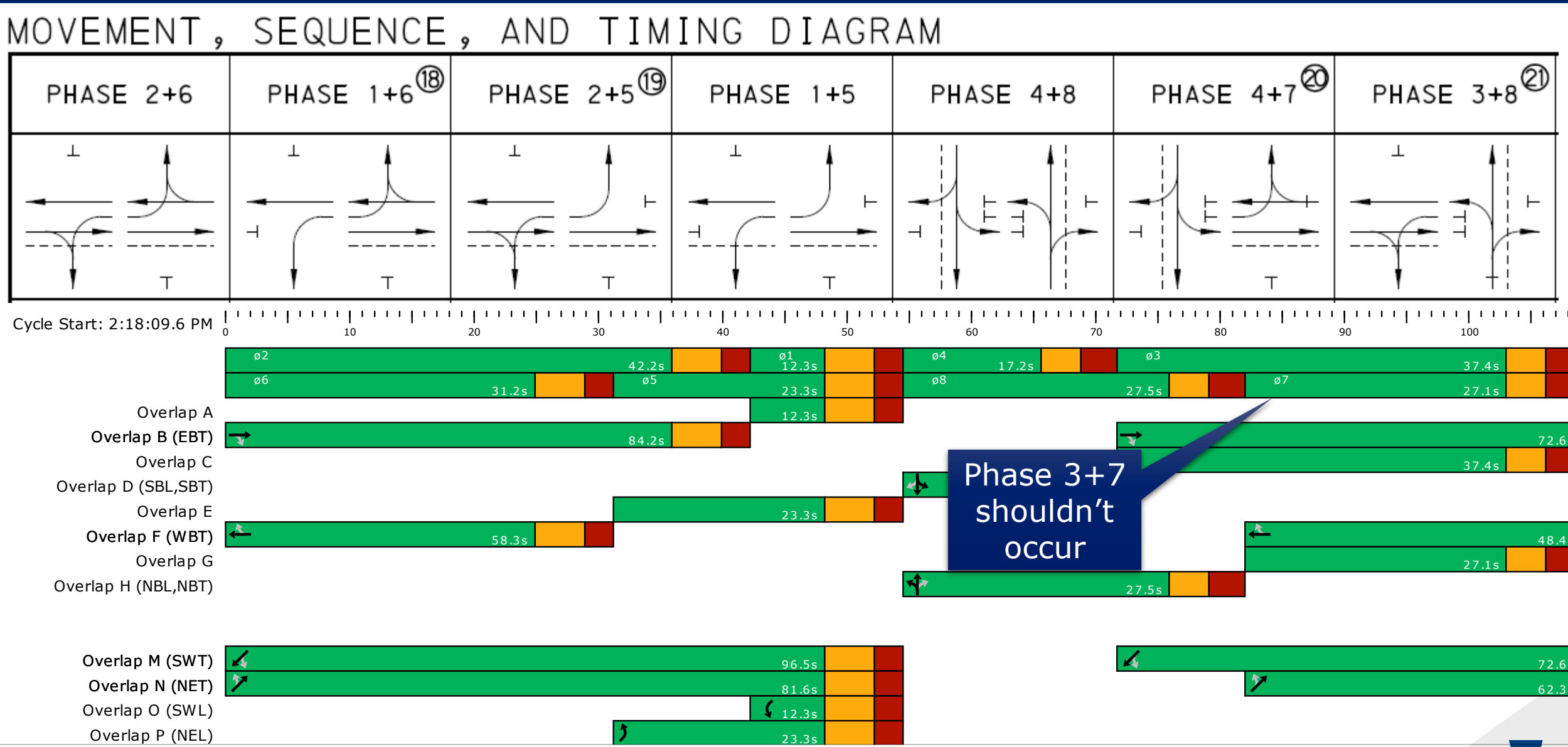
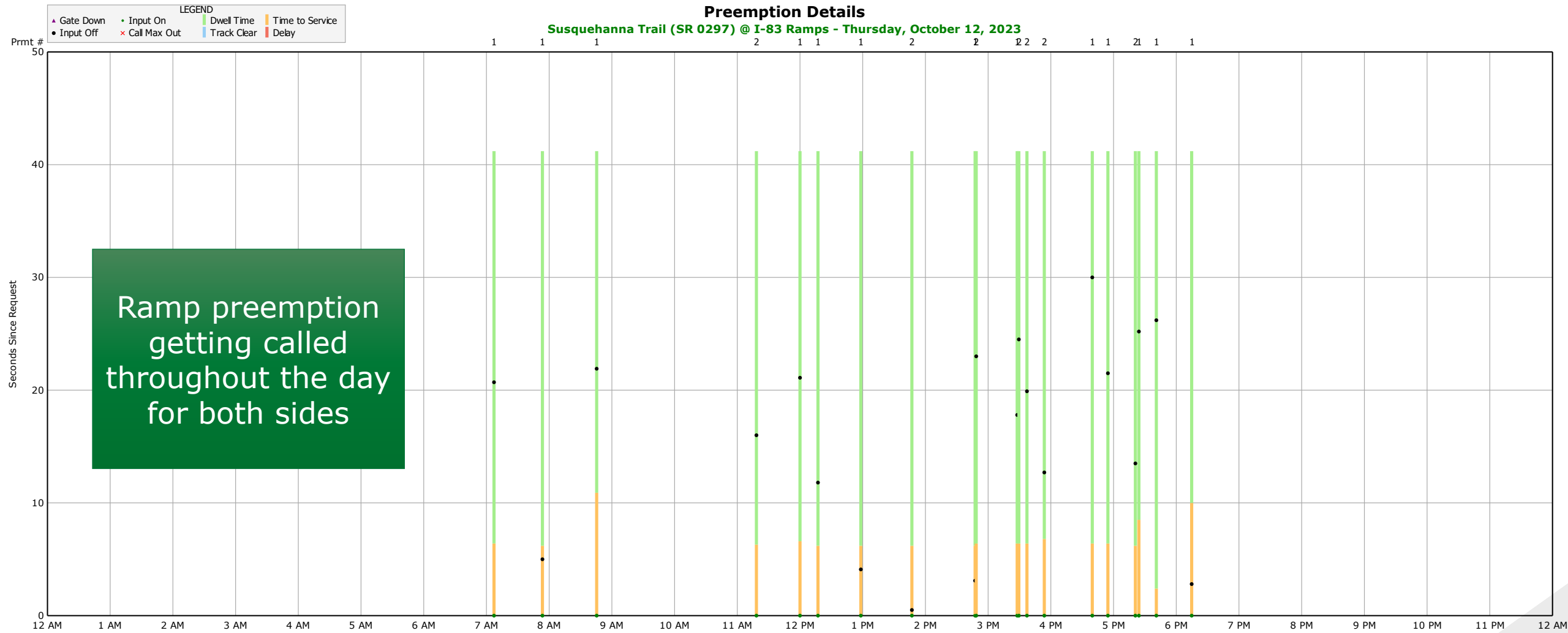
Case Study 6: I-83 Exit 28

Case study 6: Timing

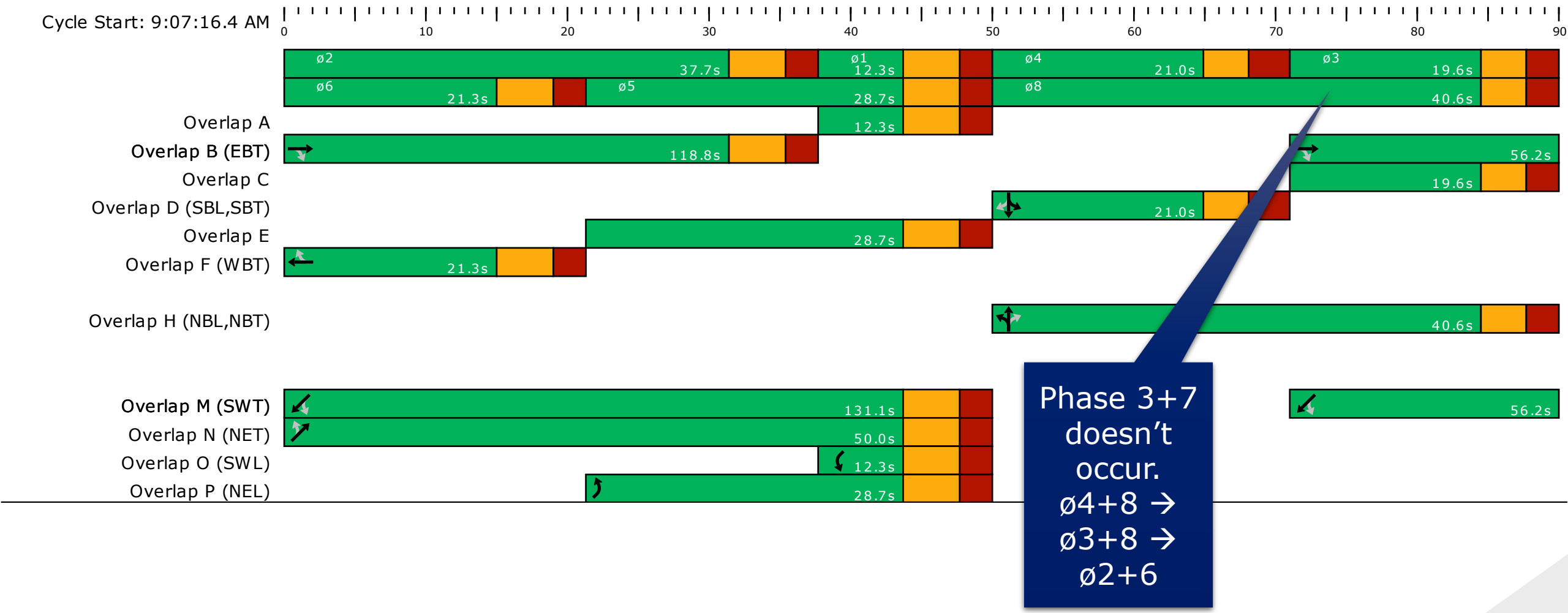


Case Study 6: Preemption

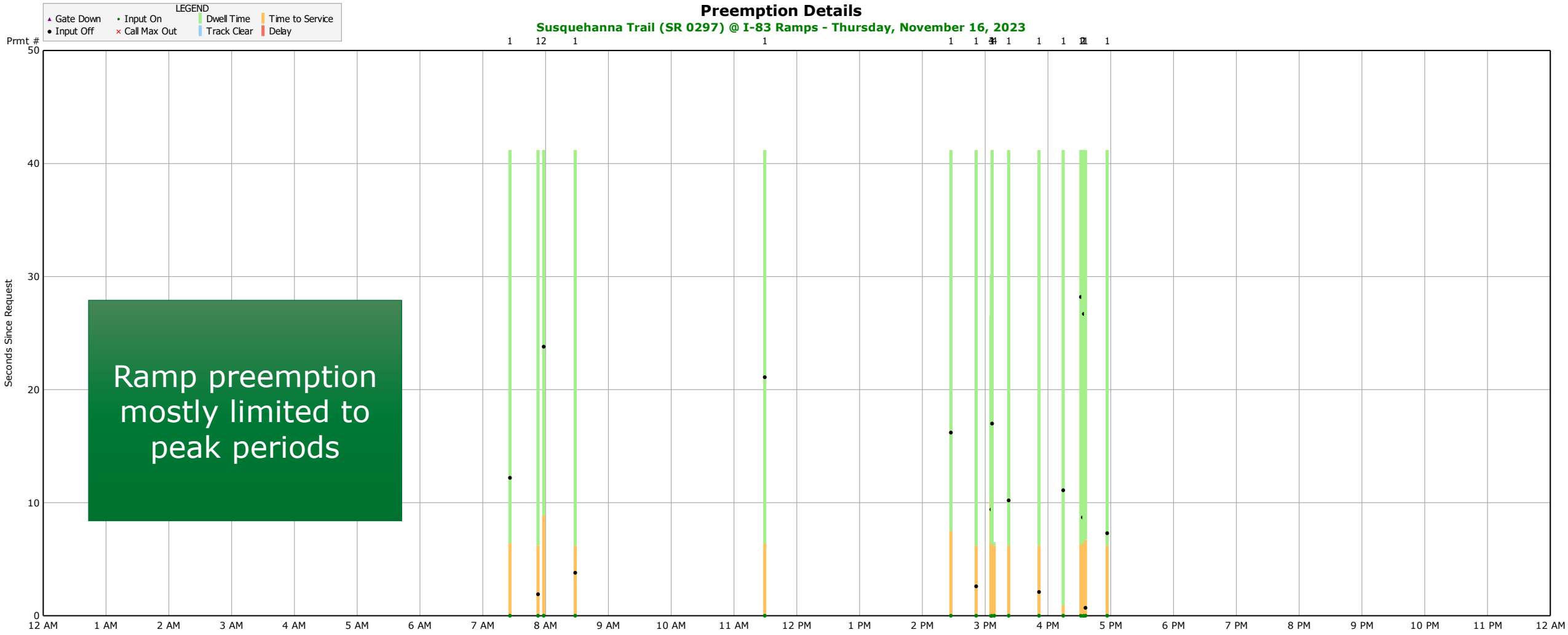


Ramp preemption getting called throughout the day for both sides

Case Study 6: After Adjustment



Case Study 6: After Adjustment



Case Study 6: Alternate Phasing

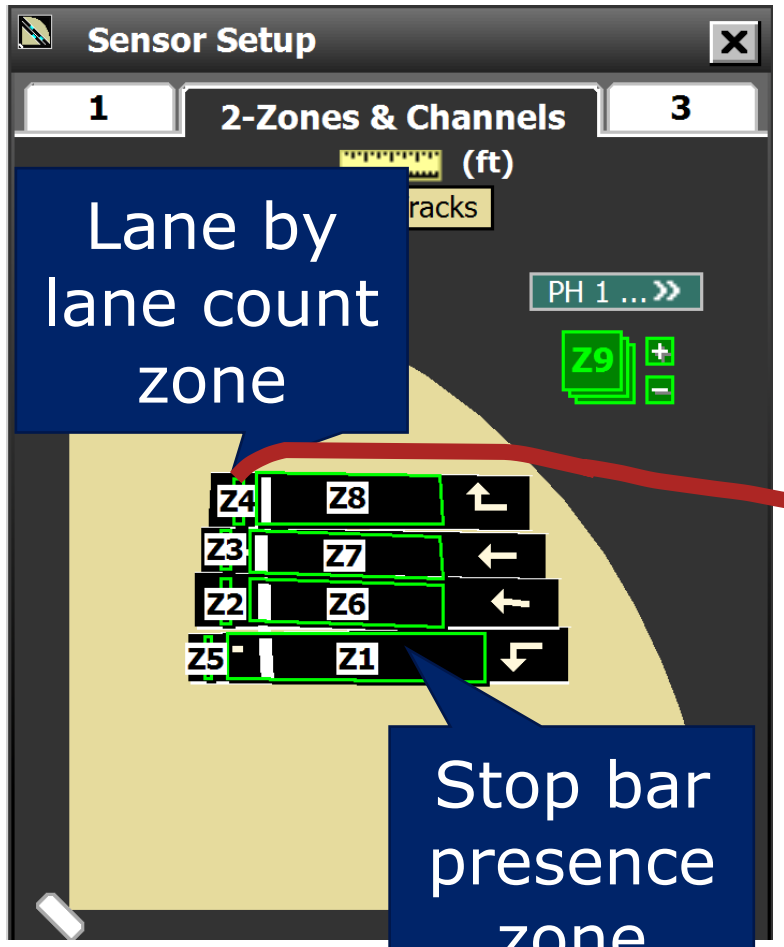
DETECTOR CONFIGURATION

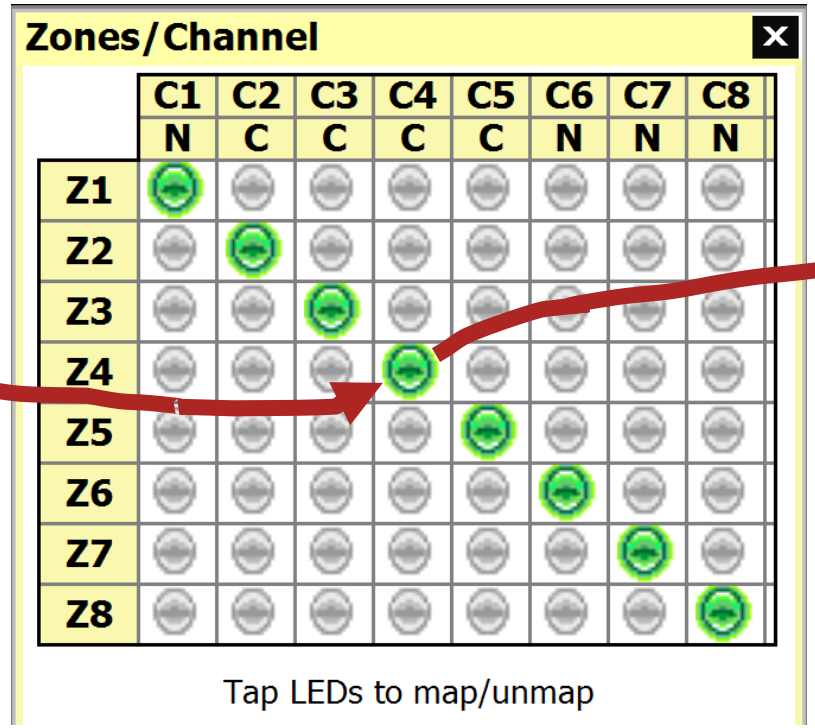
Wavetronix Matrix Setup for ATSPM

Create Zones

Map zones to sensor channels

Map sensor channels to SDLC detector inputs in Click 650/656





BIU 9 | BIU 10 | MMU

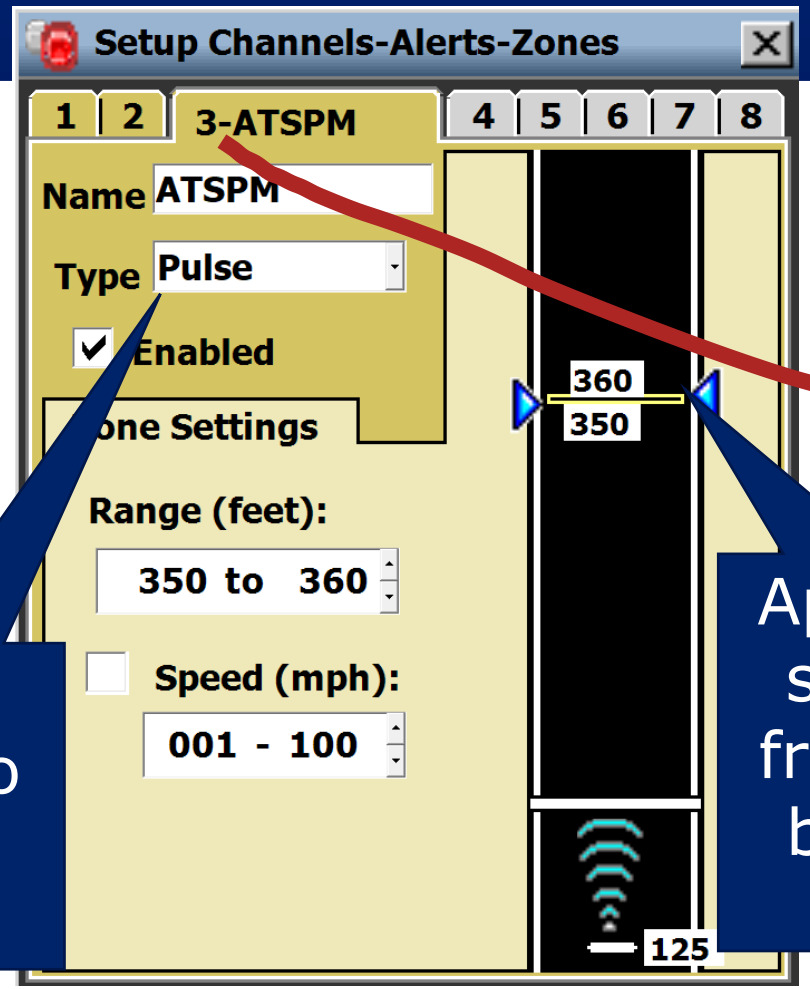
Detector Channel Map

Detector Channel	Phase	Description	Logic ID	Display Location	Sensor Channel	Add
17	6	LOOP 17	a	LOOP 1,14& 2,3,4,15,16,17	8	+
18	2	LOOP 9 COUNT	a	LOOP 8,21 & 9,10,22,23	3	+
19	2	LOOP 10 COUNT	a	LOOP 8,21 & 9,10,22,23	4	+
20	4	LOOP 19 COUNT	a	LOOP 5,18,6,7,19,20	6	+
21	4	LOOP 20 COUNT	a	LOOP 5,18,6,7,19,20	7	+
22	6	LOOP 2 COUNT	a	LOOP 1,14& 2,3,4,15,16,17	2	+
23	6	LOOP 3 COUNT	a	LOOP 1,14& 2,3,4,15,16,17	3	+
24	4	LOOP 4 COUNT	a	LOOP 1,14& 2,3,4,15,16,17	4	+
25	8	LOOP 26 COUNT	a	11,24& 12,13,25,26	6	+
26	8	LOOP 25 COUNT	a	LOOP 11,24& 12,13,25,26	5	+
27	2	COUNT ZONE 290'-300'	a	EB RT 30 @ WALKER	3	+
28	2	ADVANCE	a	EB RT 30 @ WALKER	1	+
29	2	STOPLINE	a	EB RT 30 @ WALKER	2	+
30	6	ADVANCE	a	WB RT 30 & WALKER RD	1	+
31	6	STOPLINE	a	WB RT 30 & WALKER RD	2	+
32	6	COUNT ZONE 290'-300'	a	WB RT 30 & WALKER RD	3	+

Wavetronix Advance Setup for ATSPM

Create Zones

Map sensor channels to SDLC detector inputs in Click 650/656



Pulse zone, no speed filter

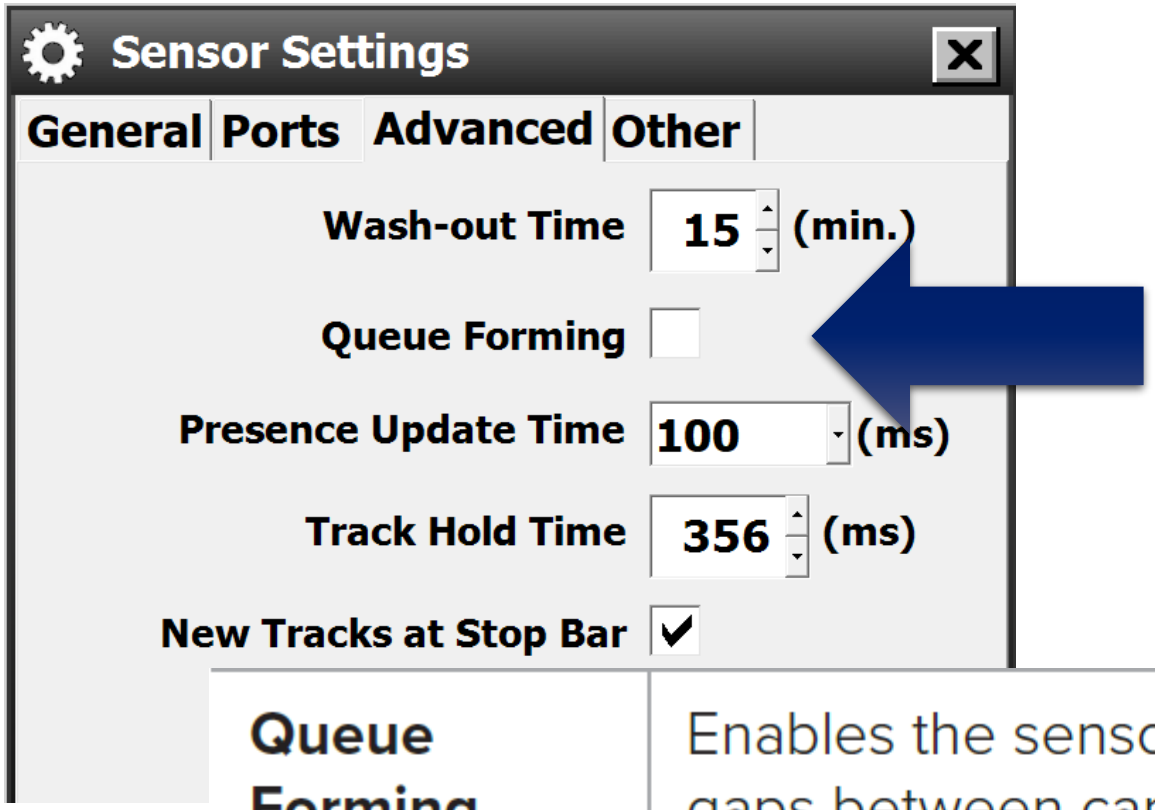
Approx. 5 seconds from stop bar (10’ min)

BIU 9 | BIU 10 | MMU

Detector Channel Map

Detector Channel	Phase	Description	Logic ID	Display Location	Sensor Channel	Add
17	6	LOOP 17	a	LOOP 1,14& 2,3,4,15,16,17	8	+
18	2	LOOP 9 COUNT	a	LOOP 8,21 & 9,10,22,23	3	+
19	2	LOOP 10 COUNT	a	LOOP 8,21 & 9,10,22,23	4	+
20	4	LOOP 19 COUNT	a	LOOP 5,18,6,7,19,20	6	+
21	4	LOOP 20 COUNT	a	LOOP 5,18,6,7,19,20	7	+
22		LOOP 2 COUNT	a	LOOP 1,14& 2,3,4,15,16,17	2	+
23	6	LOOP 3 COUNT	a	LOOP 1,14& 2,3,4,15,16,17	3	+
24	6	LOOP 4 COUNT	a	LOOP 1,14& 2,3,4,15,16,17	4	+
25	8	LOOP 26 COUNT	a	LOOP 11,24& 12,13,25,26	6	+
26	8	LOOP 25 COUNT	a	LOOP 11,24& 12,13,25,26	5	+
27	2	COUNT ZONE 290'-300'	a	EB RT 30 @ WALKER	3	+
28	2	ADVANCE	a	EB RT 30 @ WALKER	1	+
29	2	STOPLINE	a	EB RT 30 @ WALKER	2	+
30	6	ADVANCE	a	WB RT 30 & WALKER RD	1	+
31	6	STOPLINE	a	WB RT 30 & WALKER RD	2	+
32	6	COUNT ZONE 290'-300'	a	WB RT 30 & WALKER RD	3	+

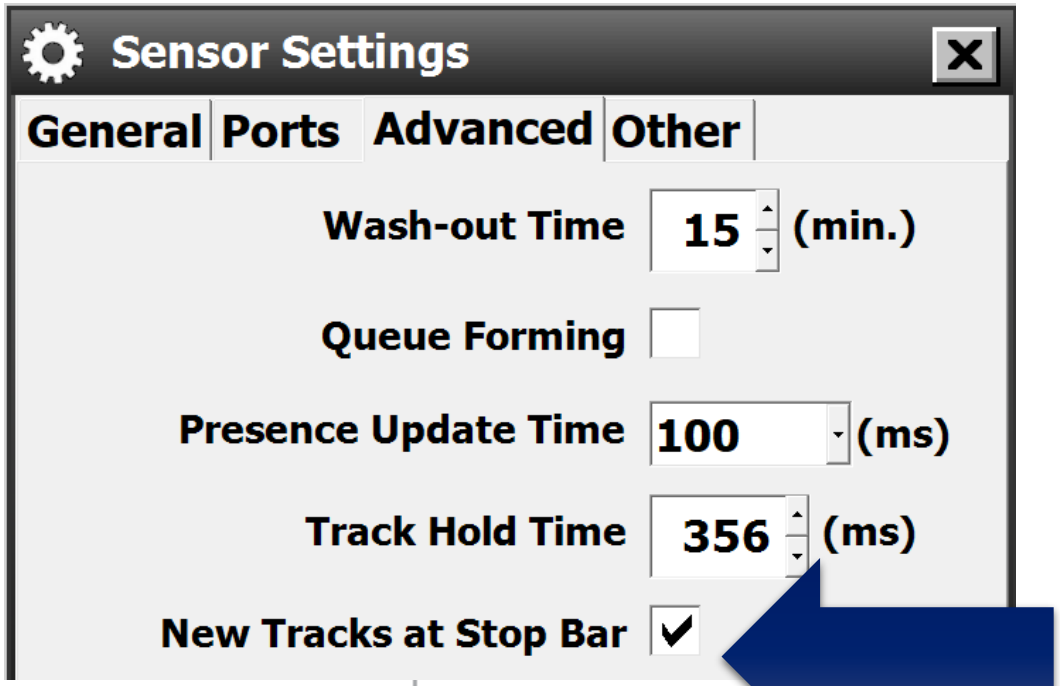
Wavetronix Matrix Count Zones



- Read the manual!

Queue Forming	Enables the sensor fill in gaps between cars in a queue.	Use this in areas where queues often form, if vehicles are frequently occluded or missed. Turning this setting off may improve counting channel accuracy.

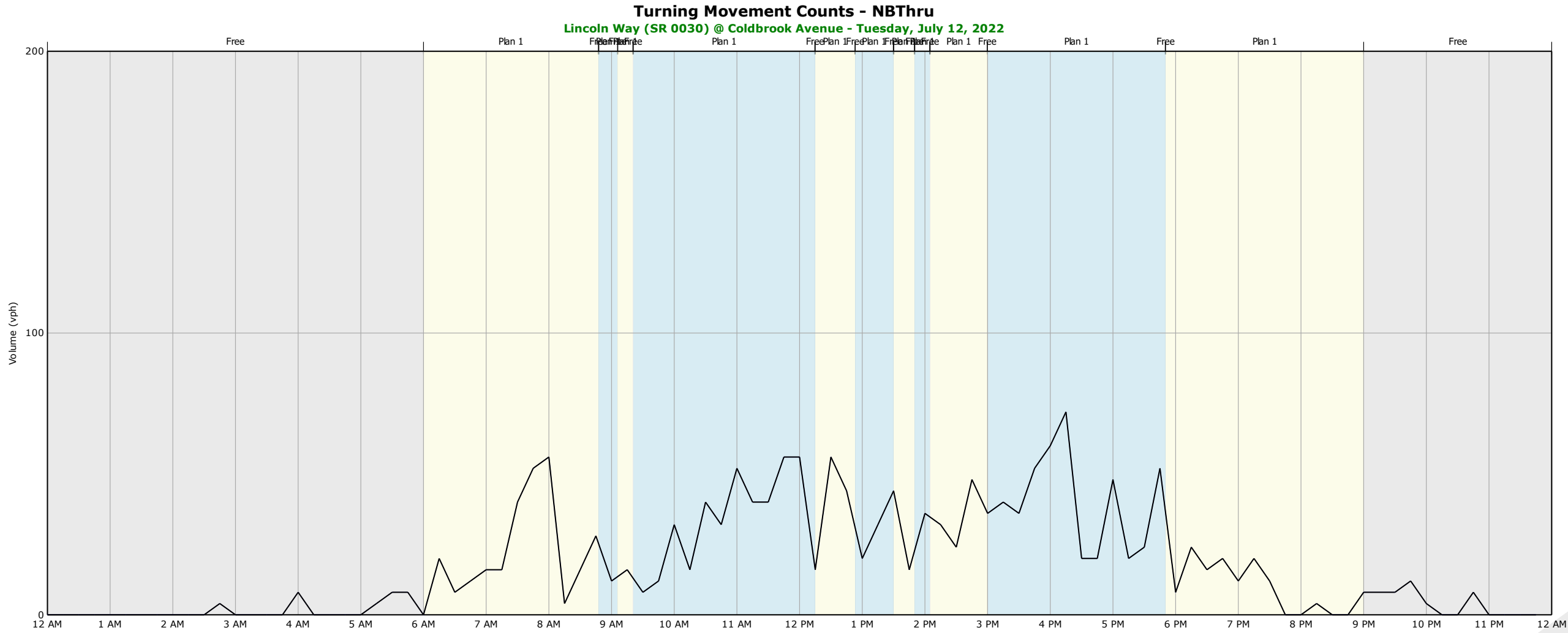
Wavetronix Matrix Count Zones



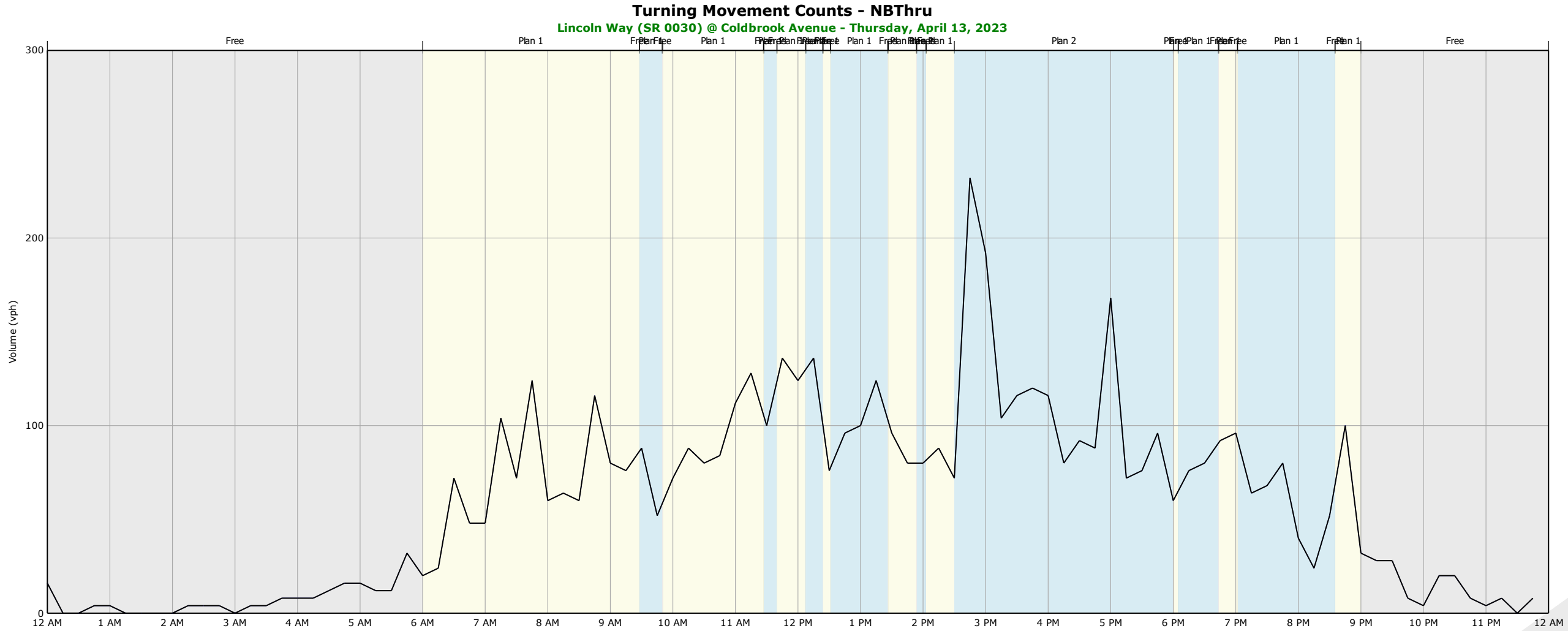
- Read the manual!

New Tracks at Stop Bar	Enables the sensor to pick up new tracks at the stop bar.	Turn this setting on if you notice the sensor dropping detections at the stop bar. This will make the area close to the stop bar more sensitive to detections.	**Note.** Changing this setting may cause you to see false detection from pedestrians or cross traffic.

Counts Before Wavetronix Fix

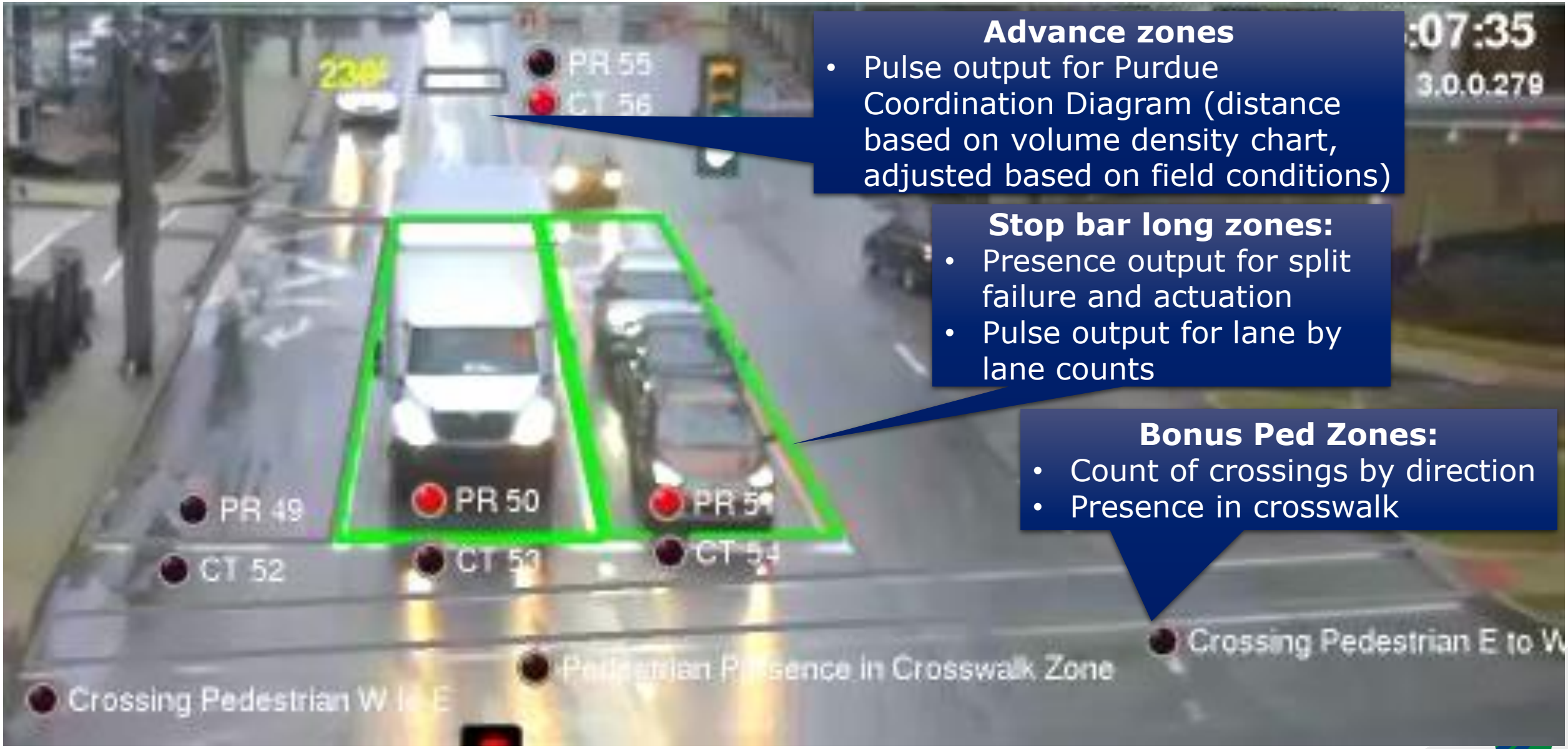


Counts After Wavetronix Fix



Autoscope Vision Setup for ATSPM

Autoscope Vision Setup for ATSPM



Advance zones

- Pulse output for Purdue Coordination Diagram (distance based on volume density chart, adjusted based on field conditions)

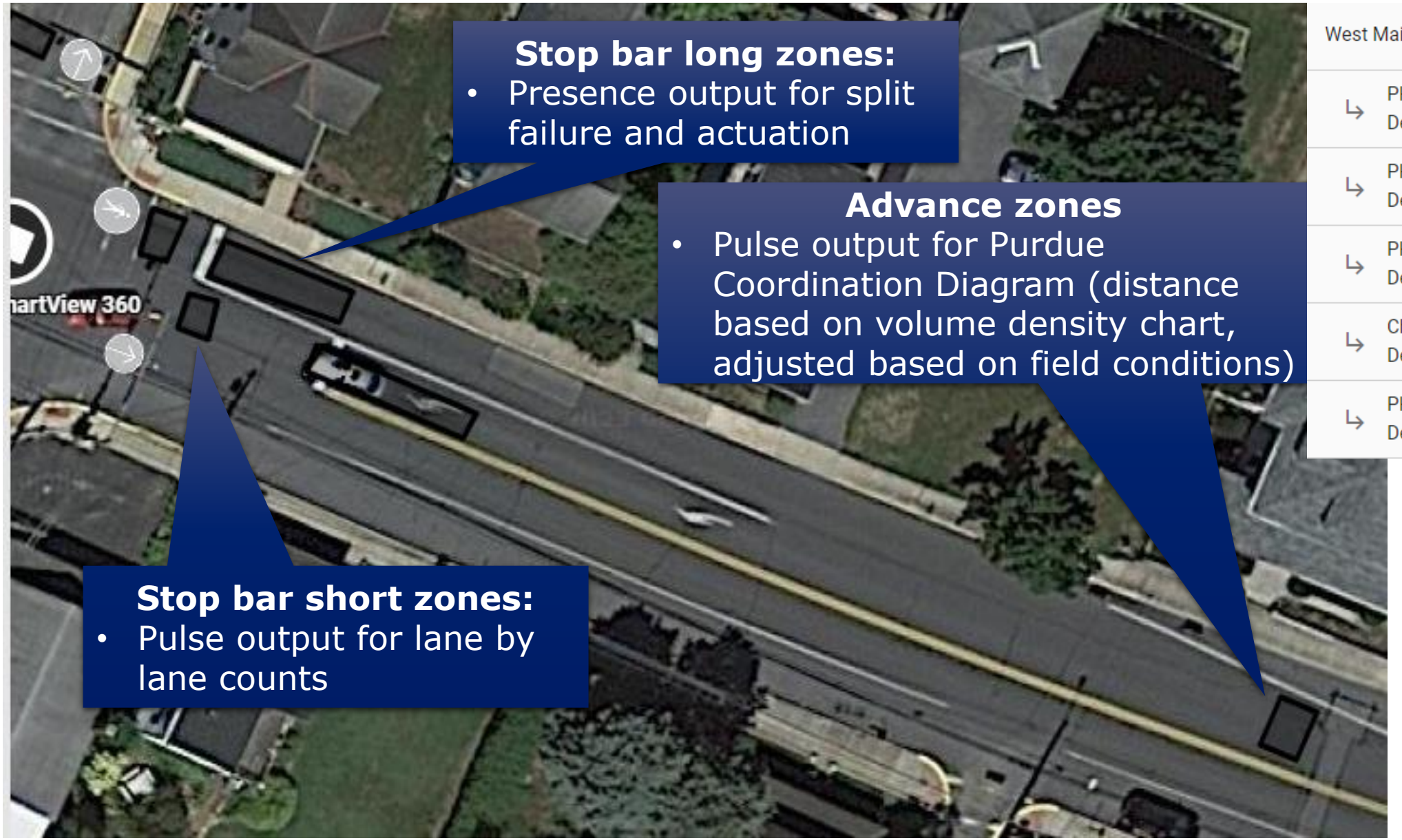
Stop bar long zones:

- Presence output for split failure and actuation
- Pulse output for lane by lane counts

Bonus Ped Zones:

- Count of crossings by direction
- Presence in crosswalk

MIOVISION SETUP FOR ATSPM



Miovision Setup For ATSPM

Configure Detector Channel 30

This is a SmartSense detector set to __lang.intersection_config.detector_dialog.smartsense_detector_type.presence. To edit these settings, Click Here.

Traffic Type *: Vehicle

Channel *: Veh. Channel 30

Label *: PH 6 COUNT Ch # 30

eg. NB LT or EB Thru LL

Approach: West Main Street (WB)

Movement

Left Only | Thru Only | Left / Right | Thru / Left | Thru / Right | L/Th/R | Right Only

Select Lane Number

1 2 3 4 5 6

Numbering from center to curb

What metrics do you want this detector to support?

- None
- Stop-Bar Occupancy
  - Failures
  - Split Trends
  - Simple Delay
  - Occupancy Ratio
- **Advanced Count**
  - Approach Volume
  - Arrivals on Red
  - Purdue Coordination Diagram

  Setback Distance * 0
- Post-Stop Bar
  - Approach Volume

(Miovision Turning Movement Counts also provide accurate approach volume date.)

Configure Zone Operations

Name: PH 6 PULSE Ch # 30

18 / 40 Movements: ↑ Thru

Vehicle Classifications: All Vehicles

Detector Output: Pulse

Delay (s): 0

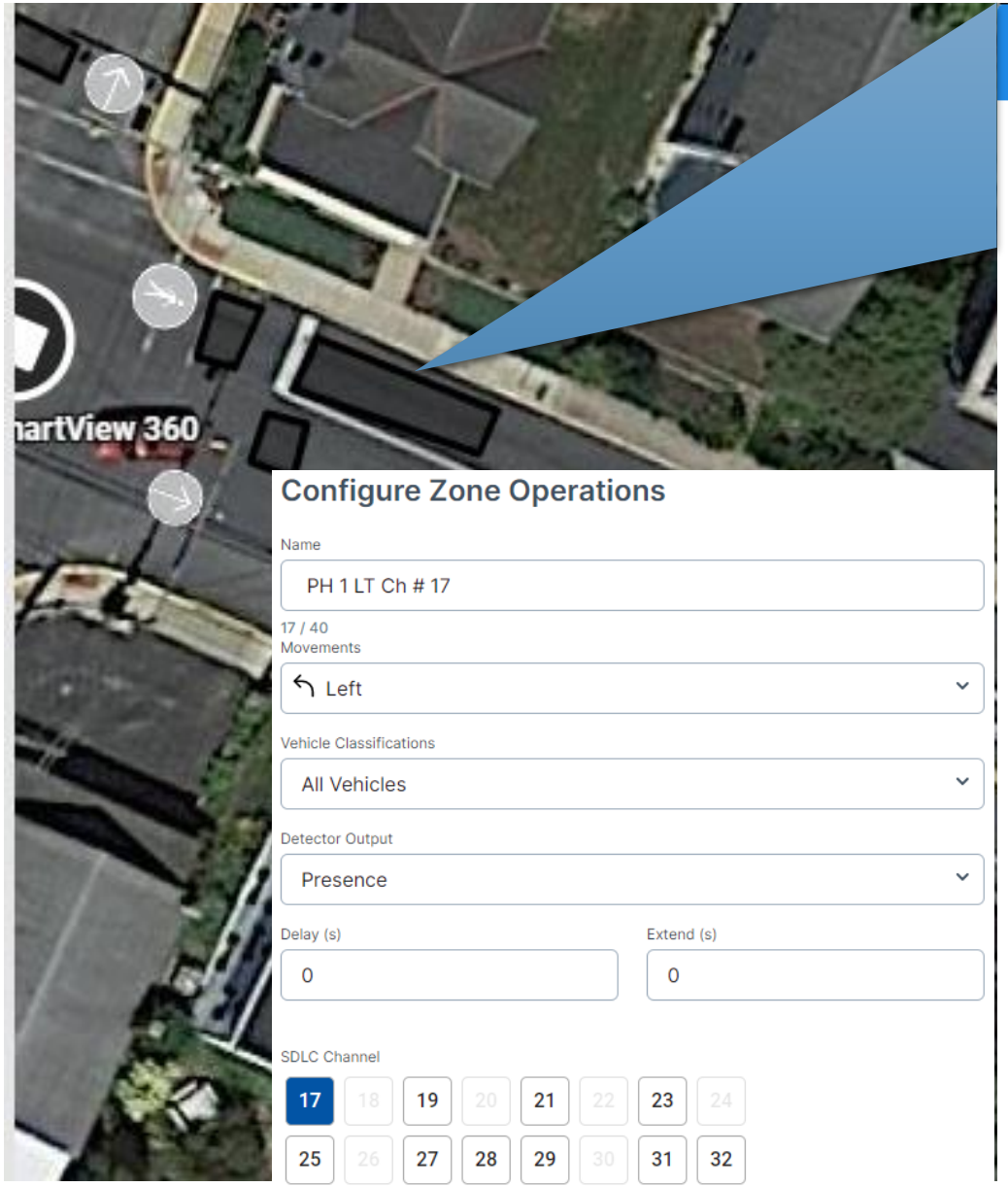
Extend (s): 0

SDLC Channel

17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32

‹ 1 2 3 4 ›

Miovision Setup For ATSPM



Configure Detector Channel 17

This is a SmartSense detector set to __lang.intersection_config.detector_dialog.smartsense_detector_type.presence. To edit these settings, Click Here.

Traffic Type *: Vehicle

Channel *: Veh. Channel 17

Label *: Channel 17 WB PH 1

eg. NB LT or EB Thru LL

Approach: West Main Street (WB)

Movement

Left Only | Thru Only | Left / Right | Thru / Left | Thru / Right | L/Th/R | Right Only

Select Lane Number

1 2 3

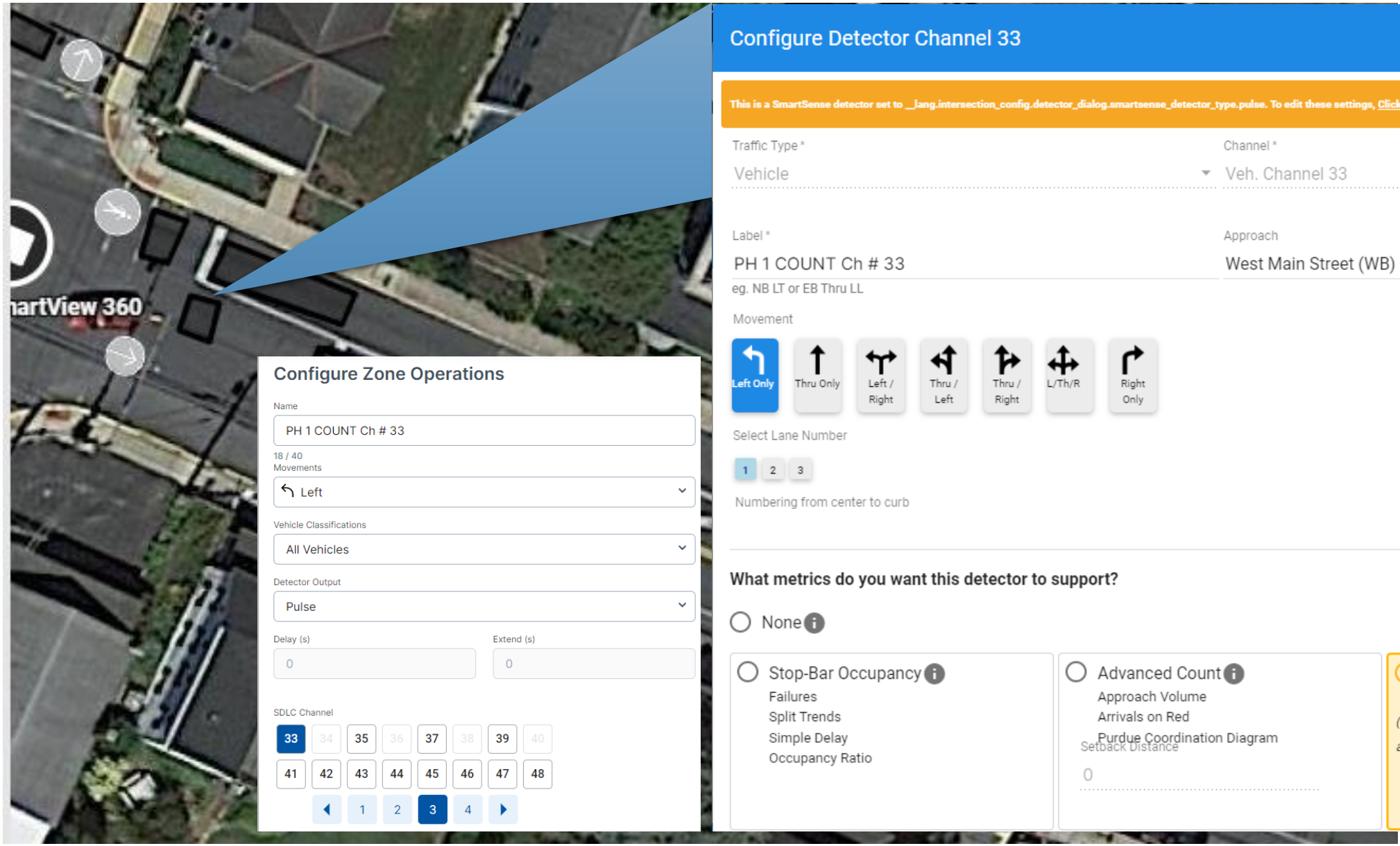
Numbering from center to curb

What metrics do you want this detector to support?

- None
- **Stop-Bar Occupancy**
  - Failures
  - Split Trends
  - Simple Delay
  - Occupancy Ratio
- Advanced Count
  - Approach Volume
  - Arrivals on Red
  - Purdue Coordination Diagram
  - Setback Distance: 0
- Post-Stop Bar
  - Approach Volume

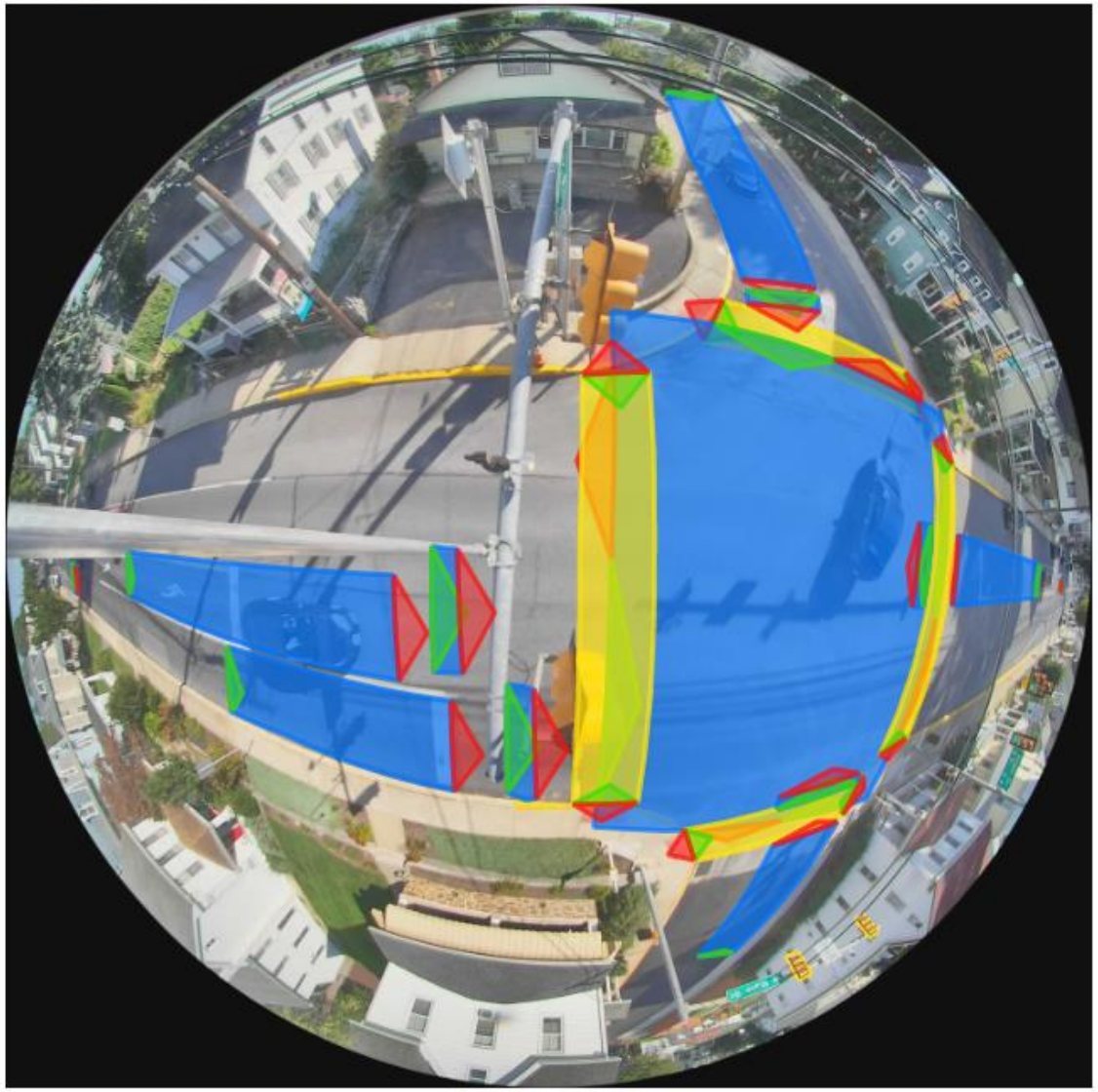
(Miovision Turning Movement Counts also provide accurate approach volume date.)

Miovision Setup For ATSPM

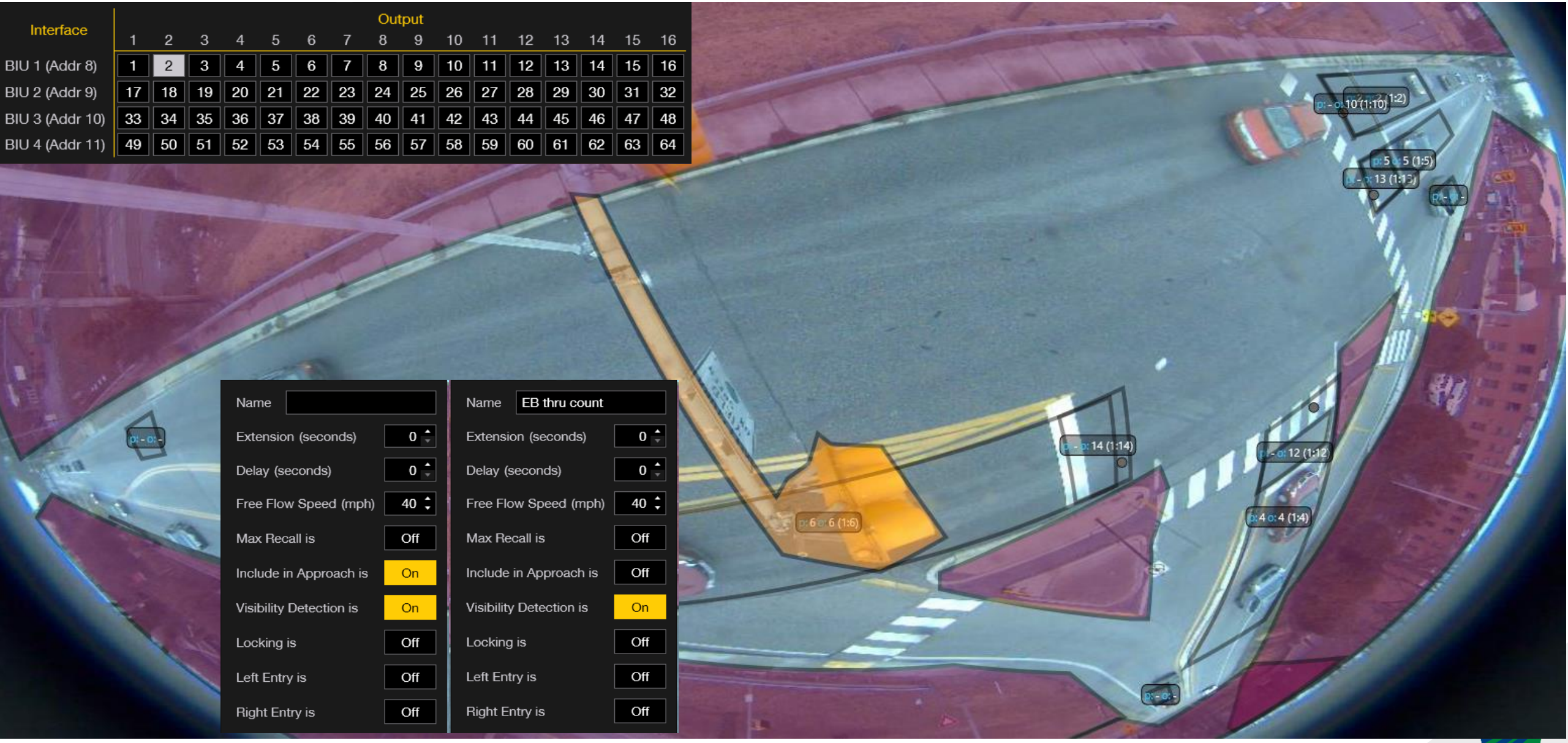


Miovision Setup for ATSPM

Miovision SmartView 360



GRIDSMART SETUP FOR ATSPM



SIGNAL CONTROLLER OPERATION 101

11:40

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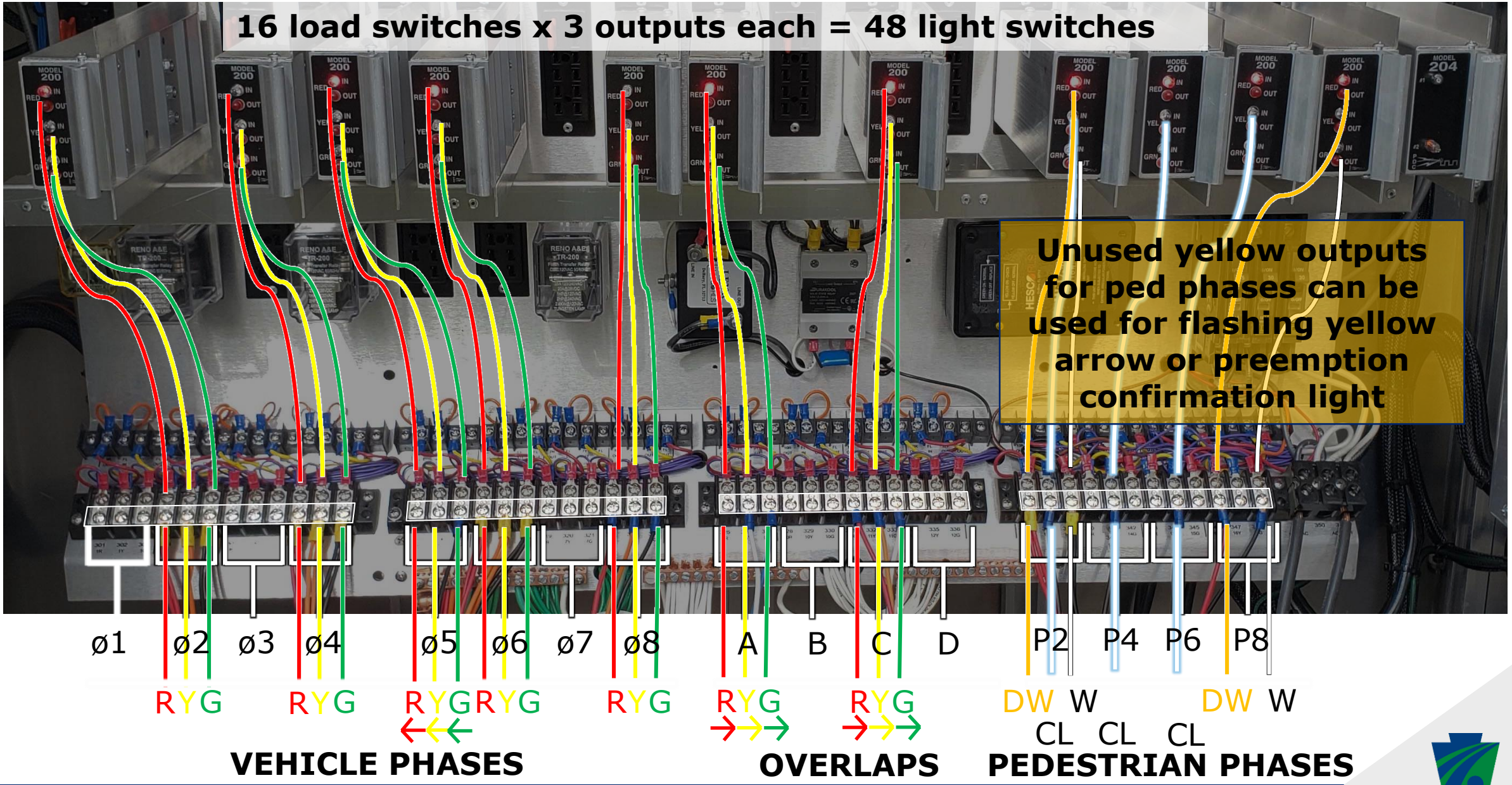
Load Switches

Each load switch is like three light switches (one for red, one for yellow, one for green)

Each load switch can control one of the following:

- A vehicular phase
- A pedestrian phase
- An overlap

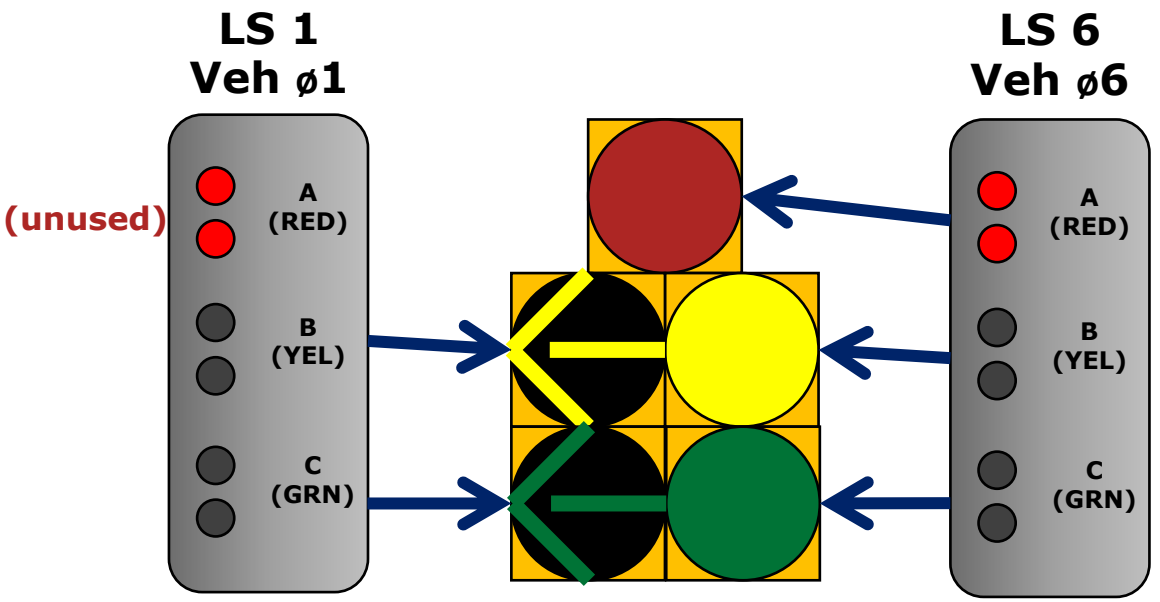
Signal Indications

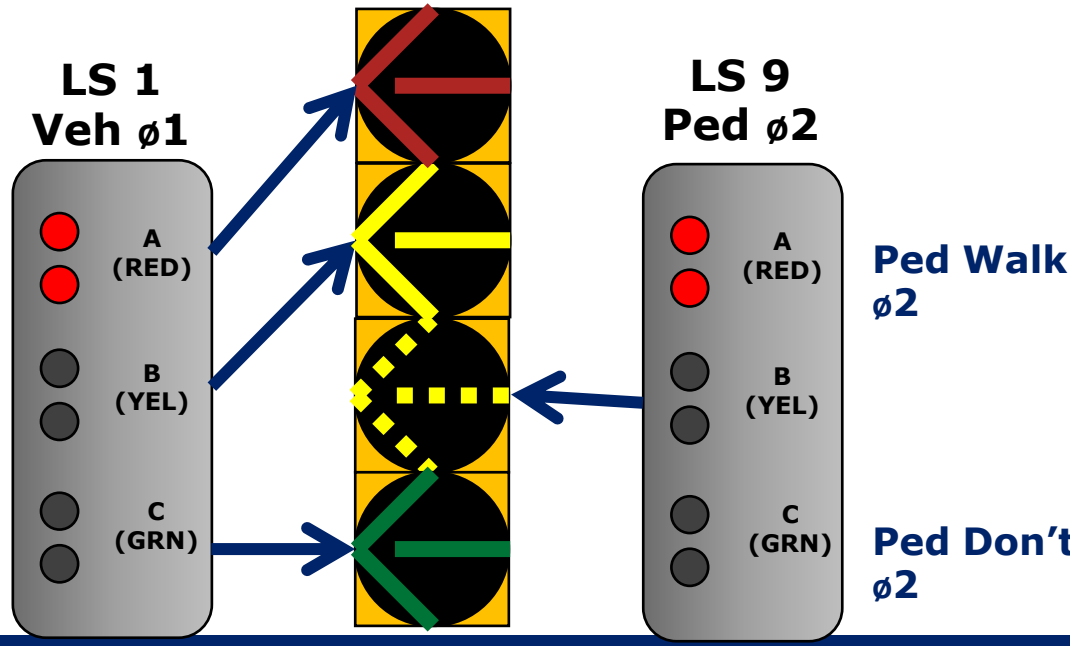


Movements

- Movement is the response of a vehicle to a "go" indication
  - Approach Direction (N, S, E, W)
  - Turn type (left, thru, right)
- Movements may be "opposed" or not by another movement
  - Protected movement: unambiguous right-of-way
  - Permitted movement: may proceed only when there is a large enough gap in the opposing traffic movement
  - Conflicting movement: not compatible and cannot be assigned right-of-way concurrently by the traffic signal

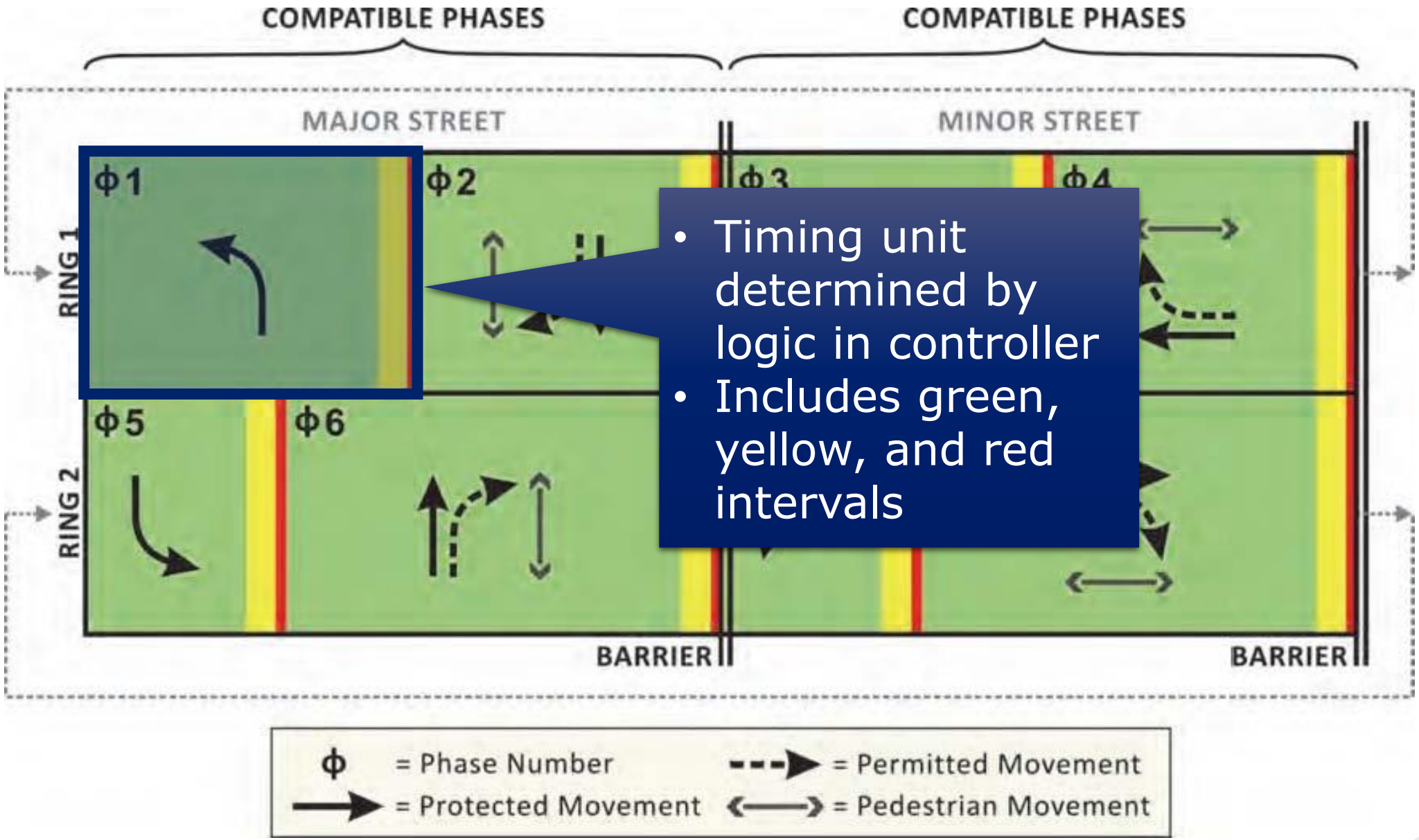
Movements





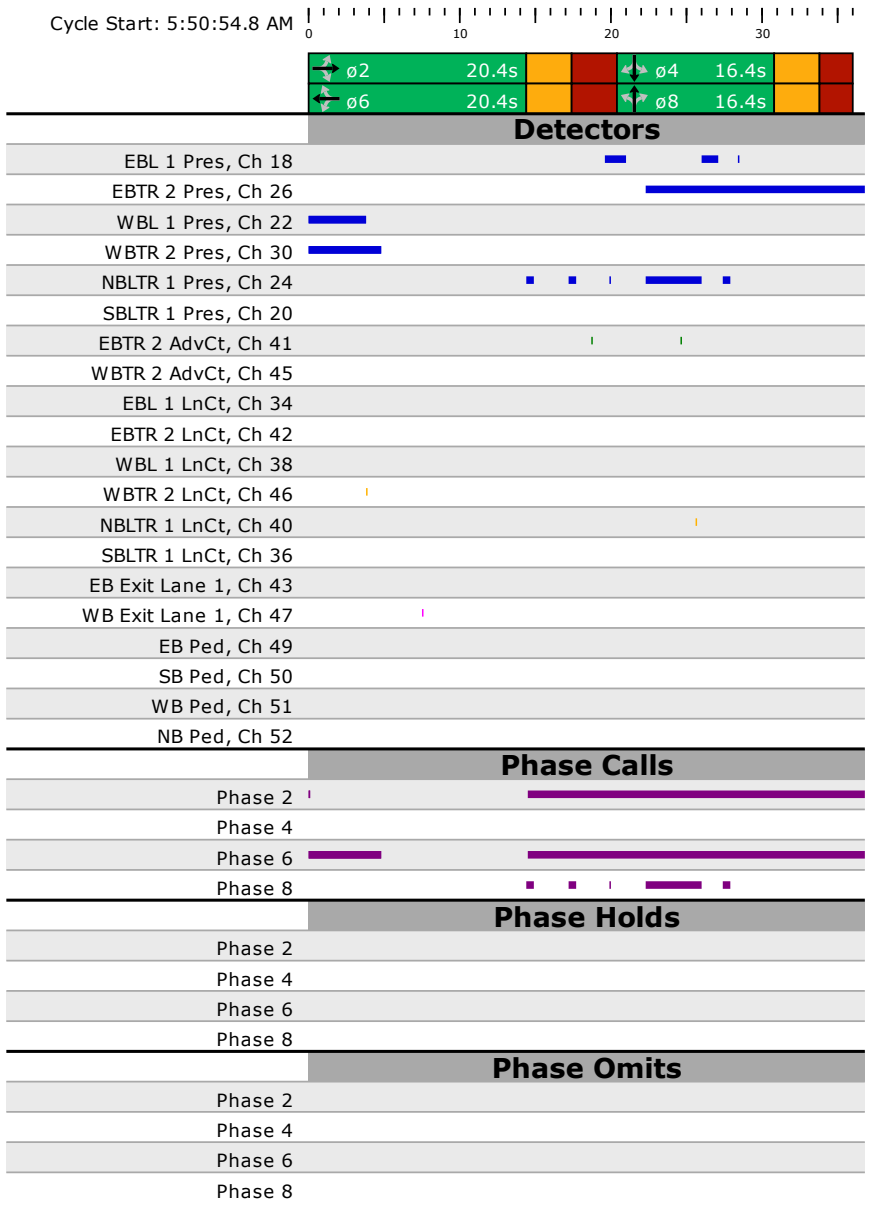
- Vehicle movements controlled by signal heads
- Signal heads driven by a phase or overlap
- Complex signal heads (4 or 5 section) may be controlled by two phases and/or overlaps
  - One load switch for protected phase
  - Other load switch for permitted phase
- Flashing yellow arrow implemented multiple ways

PHASES



Source: *Signal Timing Manual*, 2nd Edition, Exhibit 5-3

Example High Resolution Events

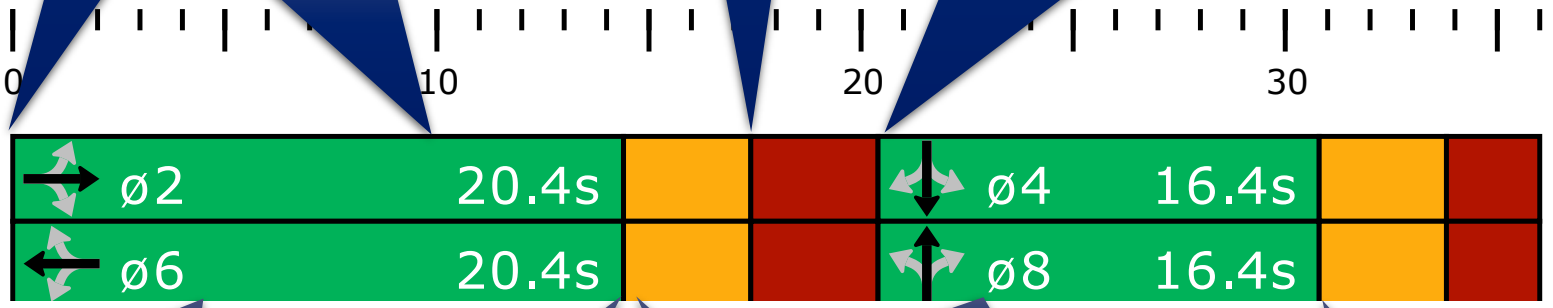


Phase End Red Clear: 4+8
Phase Inactive: 4+8
Barrier 2 Termination
Phase On: 2+6
Phase Begin Green: 2+6

Phase End Yellow: 2+6
Phase Begin Red Clear: 2+6

Phase End Red Clear: 2+6
Phase Check: 2+6
Phase Inactive: 2+6
Barrier 1 Termination
Phase On: 4+8
Phase Begin Green: 4+8

Phase Min Complete: 2+6



Detector Off: 30
Phase Call Dropped: 6

Detector On: 24
Phase Call Registered: 8
Phase Check: 8
Phase Gap Out: 2+6
Phase Green Termination: 2+6
Phase Begin Yellow: 2+6

Phase Call Registered: 2+6 (Min Recall)

Phase Min Complete: 4+8

Phase Gap Out: 4+8
Phase Green Termination: 4+8
Phase Begin Yellow: 4+8

Overlaps

- Overlaps combine phases to meet special needs by serving a movement during multiple phases
- Overlap control
  - Included (Parent) phase: typically add phases together
  - Modifier phase: typically exclude operation during modifier phases
- Beware of vendor-specific overlap configurations which don't match NTCIP standard

Overlaps Deep Dive with Dan Fedio
Today: 3:30-5:00 pm
Session 2D

Cheers to Green Lights Ahead

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