# AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES: CASE STUDIES

**INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 2 – MAY 7, 2014**

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO
THE VOICE OF TRANSPORTATION

DRIVING INNOVATION FOR TRANSPORTATION
TIG
AASHTO TECHNOLOGY IMPLEMENTATION GROUP

# ITE Webinar Series on Automated Traffic Signal Performance Measures (SPMs)

- Achieve Your Agency's Objectives Using SPMs

  April 9, 2014, 12:00 pm to 1:30 pm. Eastern
- SPM Case Studies

  May 7, 2014, 12:00 pm to 1:30 pm. Eastern
- Critical Infrastructure Elements for SPMs

  June 11, 2014, 12:00 pm to 1:30 pm. Eastern

# Automated Traffic Signal Performance Measures

**Technology Implementation Group: 2013 Focus Technology**

http://tig.transportation.org

Mission: Investing time and money to accelerate technology adoption by agencies nationwide

# Your Speakers Today

Jamie Mackey, UDOT

Amanda Stevens, INDOT

Alex Hainen, Purdue

Steve Misgen, MnDOT

Mark Taylor, UDOT

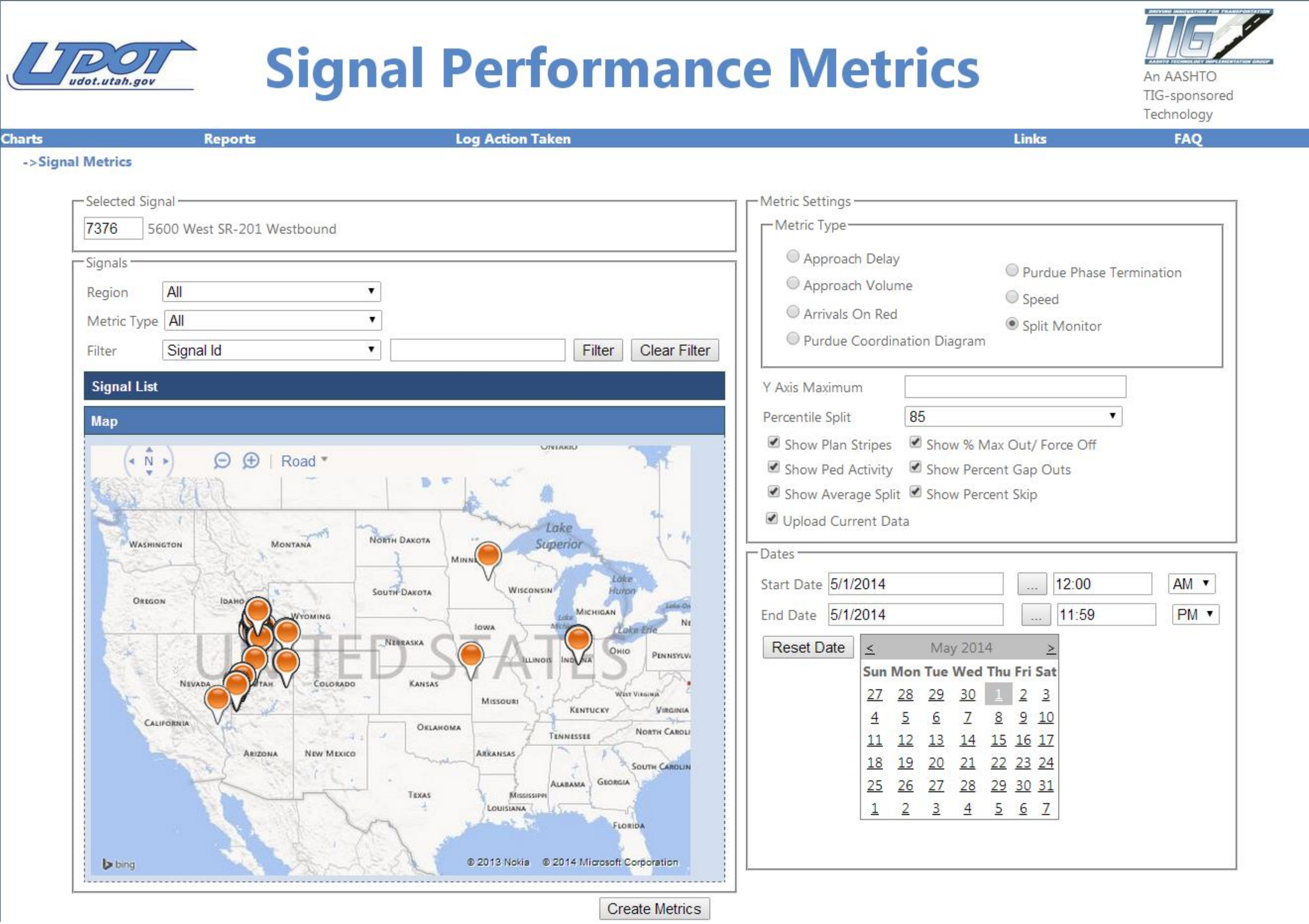
# AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES CASE STUDIES: UDOT

**INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – MAY 7, 2014**

PRESENTED BY JAMIE MACKEY, UDOT

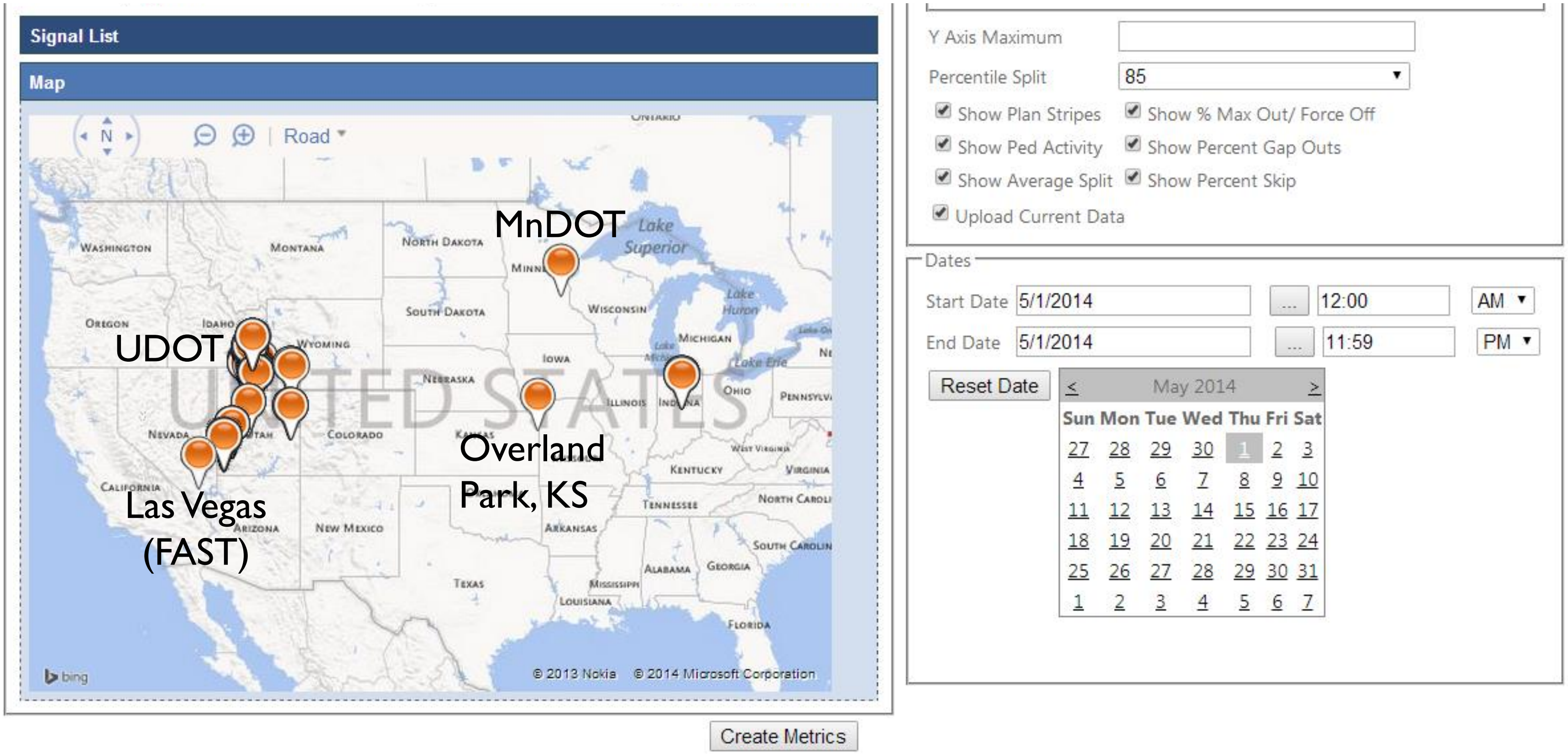
# What Can Automated Traffic Signal Performance Measures Do for You?

- Troubleshoot complaints and reduce wasted time for maintenance staff
- Catch problems as they happen
- Operate & optimize system without field data collection
- Retime signals as needed, not on a schedule
- Communicate signal/corridor/system performance to public & agency leaders



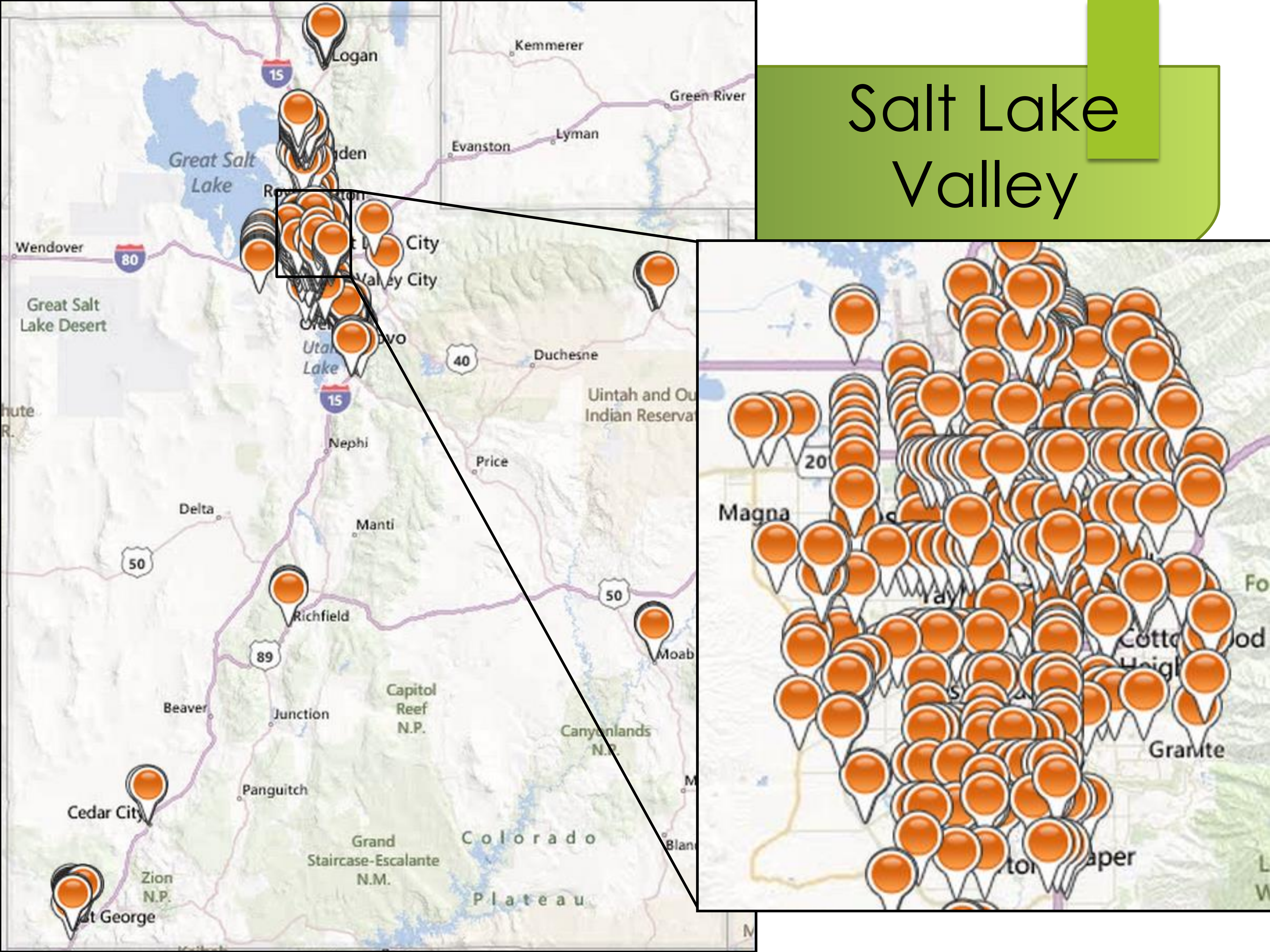

**http://udottraffic.utah.gov/signalperformancemetrics**

# Agencies using UDOT software for SPMs




**http://udottraffic.utah.gov/signalperformancemetrics**

# Salt Lake Valley



# System Requirements

Communications

High-resolution Controller

**Can be done <u>independent</u> of a Central System!**


Server

Website

Detection
(optional)

Photo courtesy of the Indiana Department of Transportation

# Metrics & Detection Requirements

## Controller high-resolution data only

**Purdue Phase Termination**

**Split Monitor**

## Advanced Count Detection (~400 ft behind stop bar)

**Purdue Coordination Diagram**

Approach Volume

Platoon Ratio

Arrivals on Red

Approach Delay

Executive Summary Reports

## Advanced Detection with Speed

Approach Speed

## Lane-by-lane Presence Detection

Split Failure (future)

## Lane-by-lane Count Detection

Turning Movement Counts

## Probe Travel Time Data (GPS or Bluetooth)

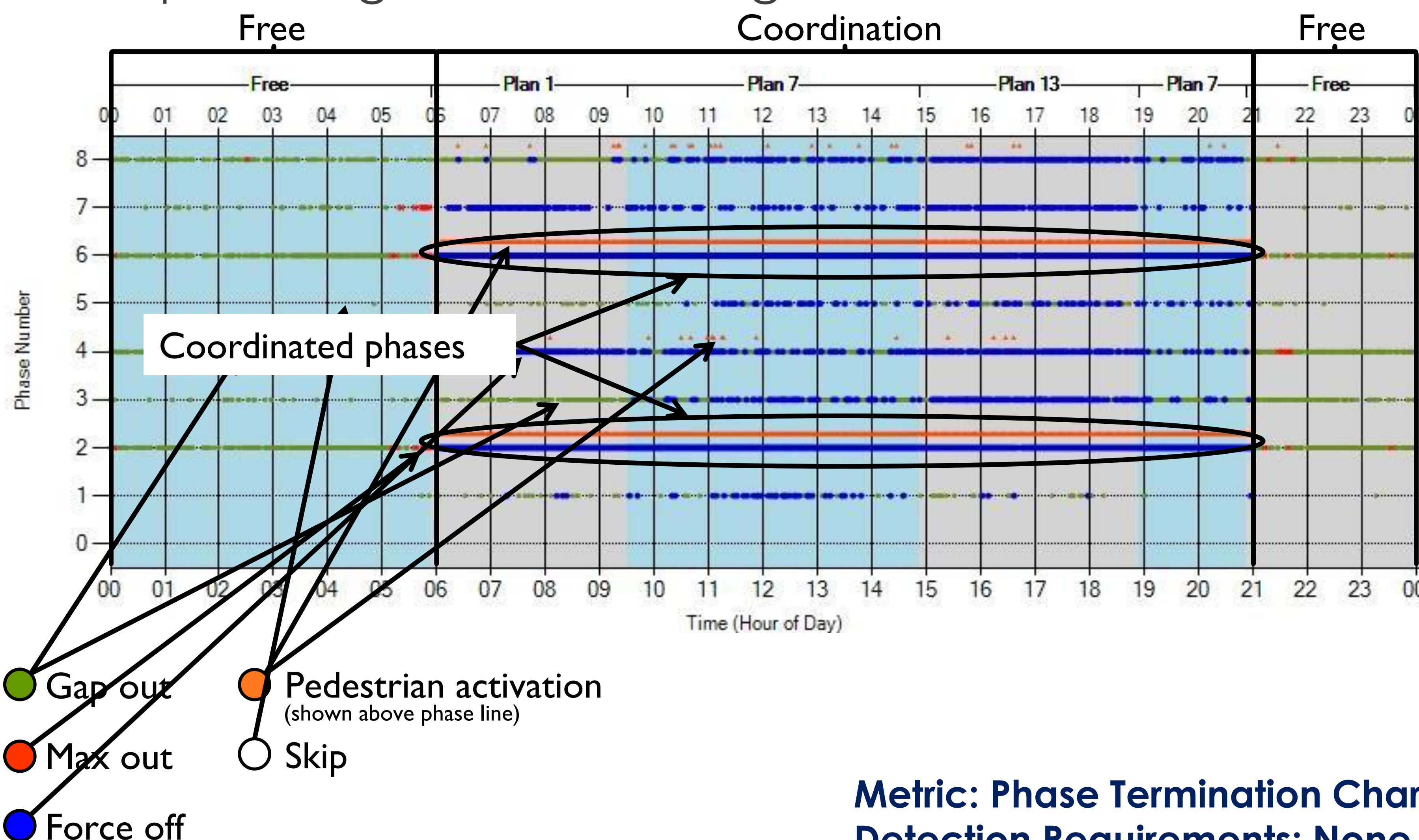
Purdue Travel Time Diagram

# UDOT Case Studies

- Complaints
- Maintenance
- Alerts
- Optimization

# Normal Intersection Example: Phase Termination Chart

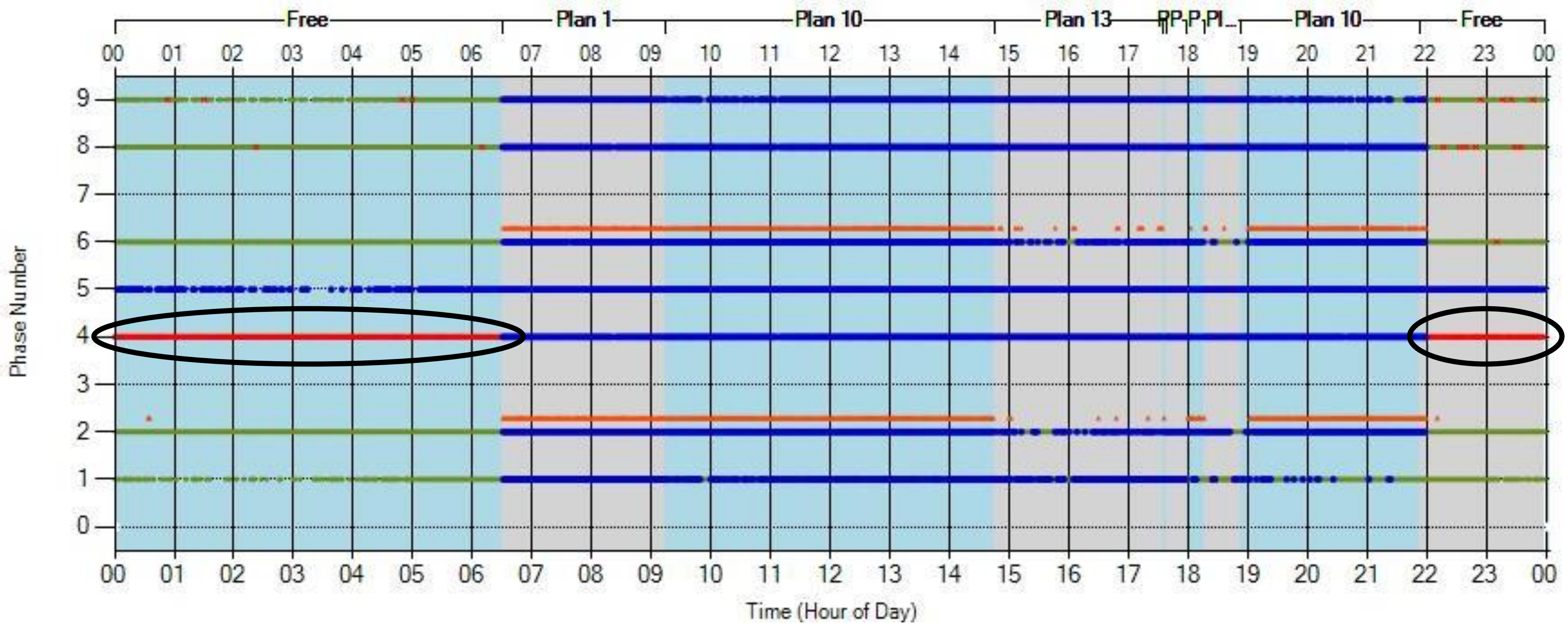
- 8-phase signal with working detection




**Metric: Phase Termination Chart**
**Detection Requirements: None**

# Complaint Example: Red light too long

- Max recall was placed for broken NB detection




Gap out

Pedestrian activation
(shown above phase line)

Max out

Skip

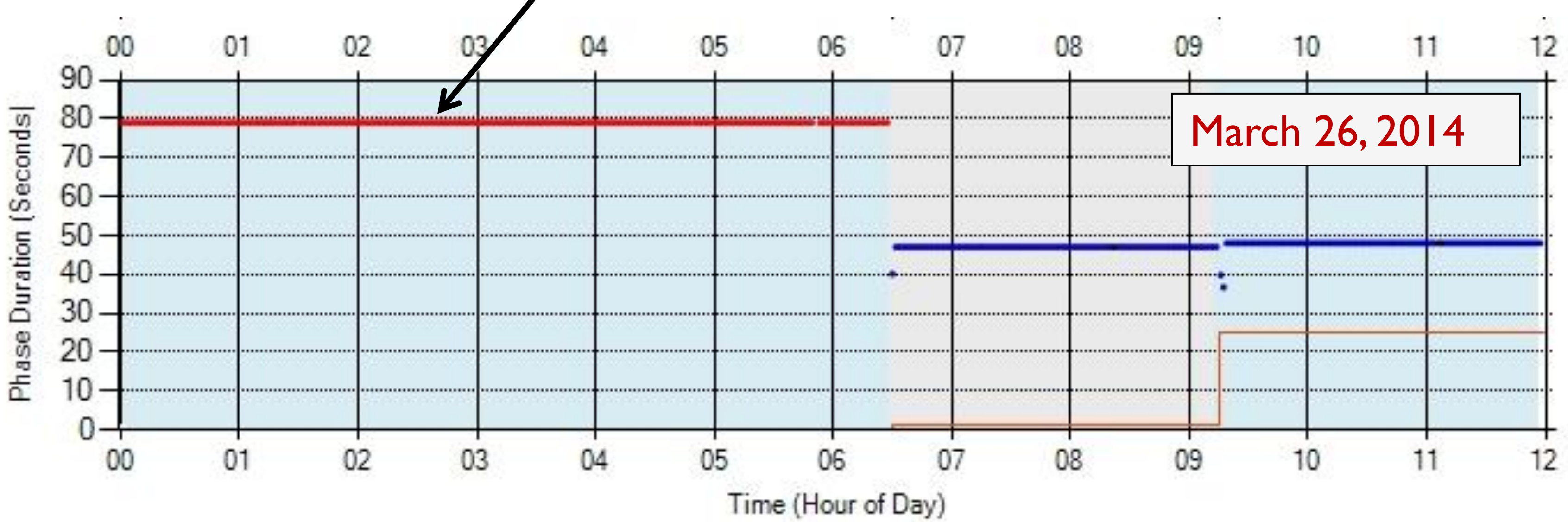
Force off

**Metric: Phase Termination Chart**
**Detection Requirements: None**

# Complaint Example: Red light too long

- Max recall was placed for broken NB detection

NB movement gets 75 sec of green time at night!




Gap out

Max out

Force off

Pedestrian activation (shown above phase line)

Skip

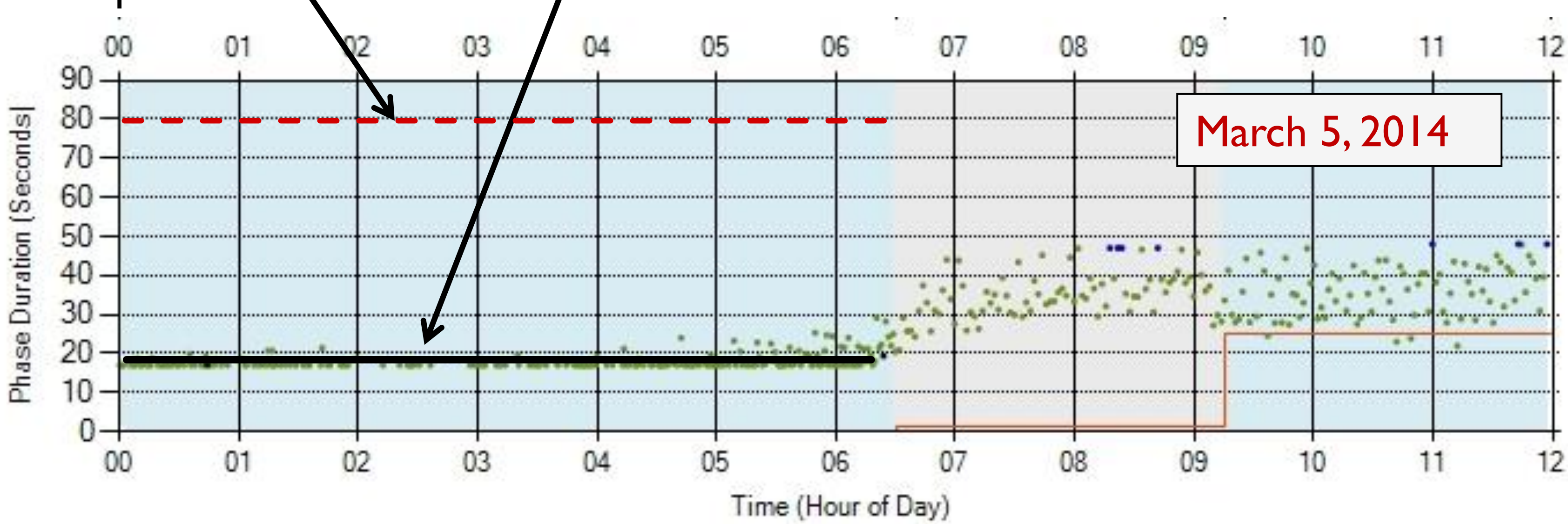
**Metric: Split Monitor**
**Detection Requirements: None**

# Complaint Example: Red light too long

- Max recall was placed for broken NB detection

Check normal operation from previous month

Current operation




Gap out

Pedestrian activation
(shown above phase line)

Max out

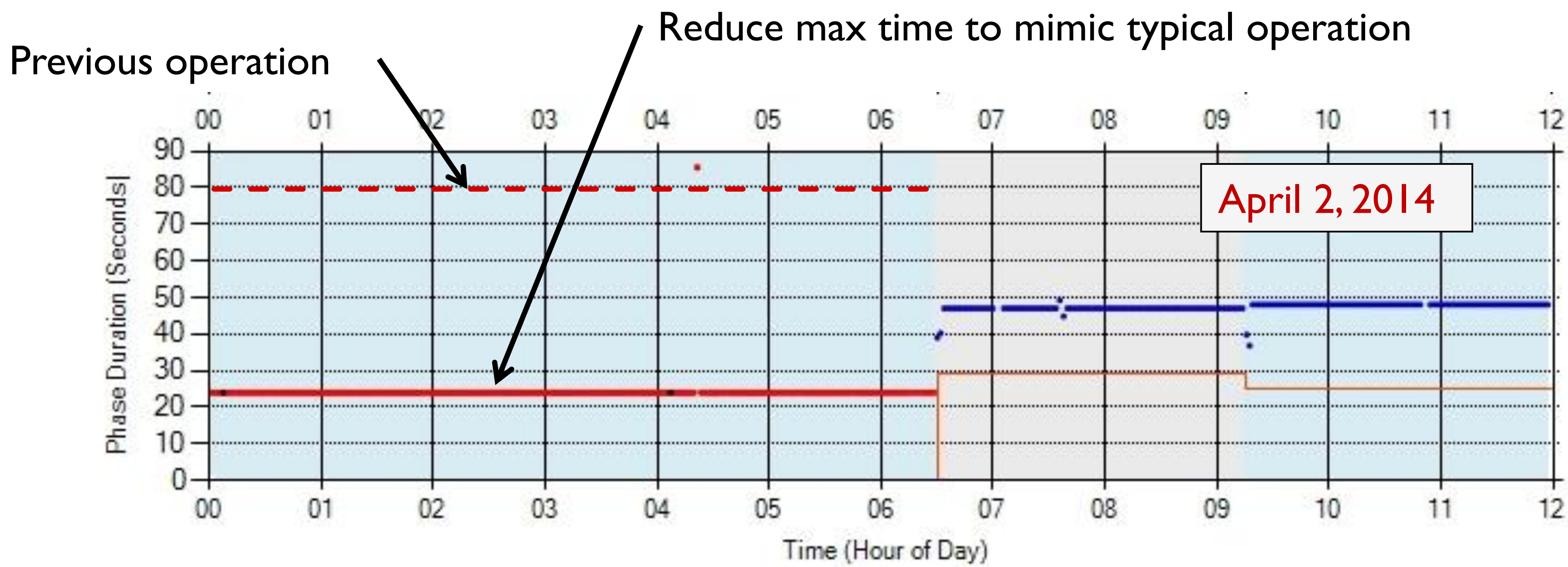
Skip

Force off

**Metric: Split Monitor**
**Detection Requirements: None**

# Complaint Example: Red light too long

- Max recall was placed for broken NB detection




Gap out

Max out

Force off

Pedestrian activation (shown above phase line)

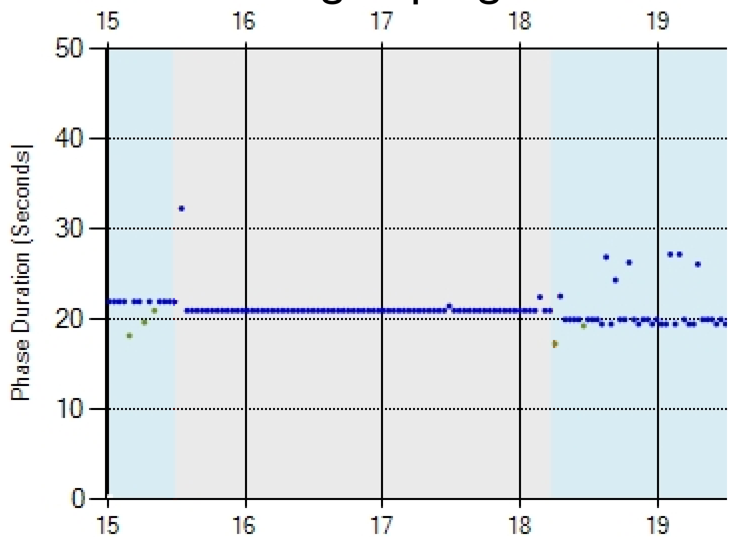
Skip

**Metric: Split Monitor**
**Detection Requirements: None**

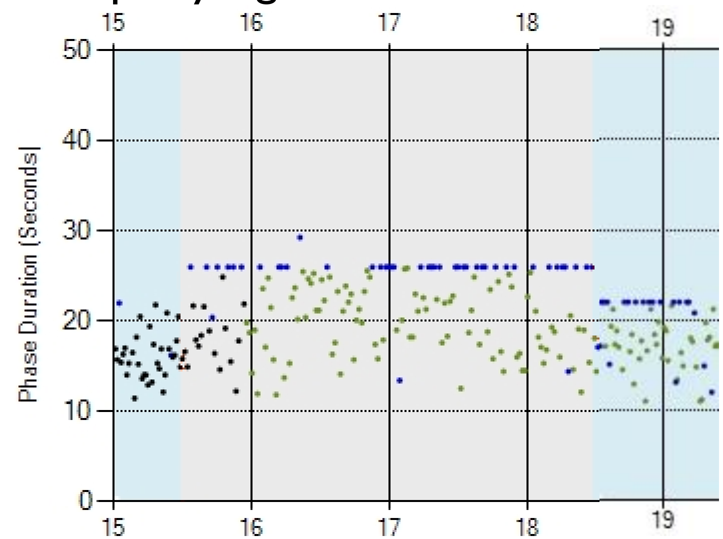
# Complaint Example: Split too short

- Is this a timing or a maintenance issue?

Timing Issue:
Phase always forces off
=> Phase is using all programmed time




Maintenance Issue:
Phase often gaps out
=> Spotty right-turn lane detection

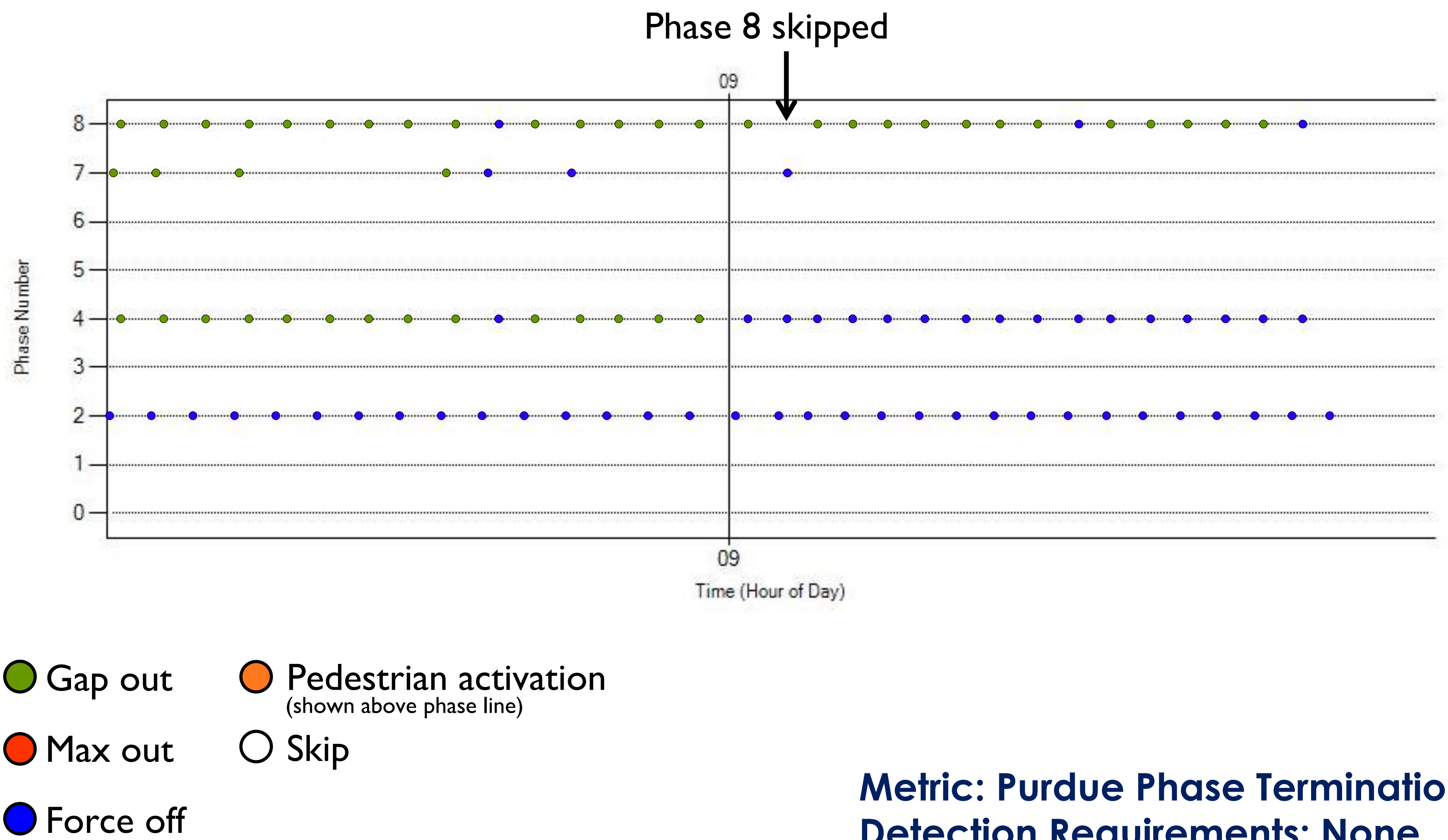



- Gap out
- Max out
- Force off
- Pedestrian activation (shown above phase line)
- Skip

**Metric: Split Monitor**
**Detection Requirements: None**

# Complaint Example: Phase skipped

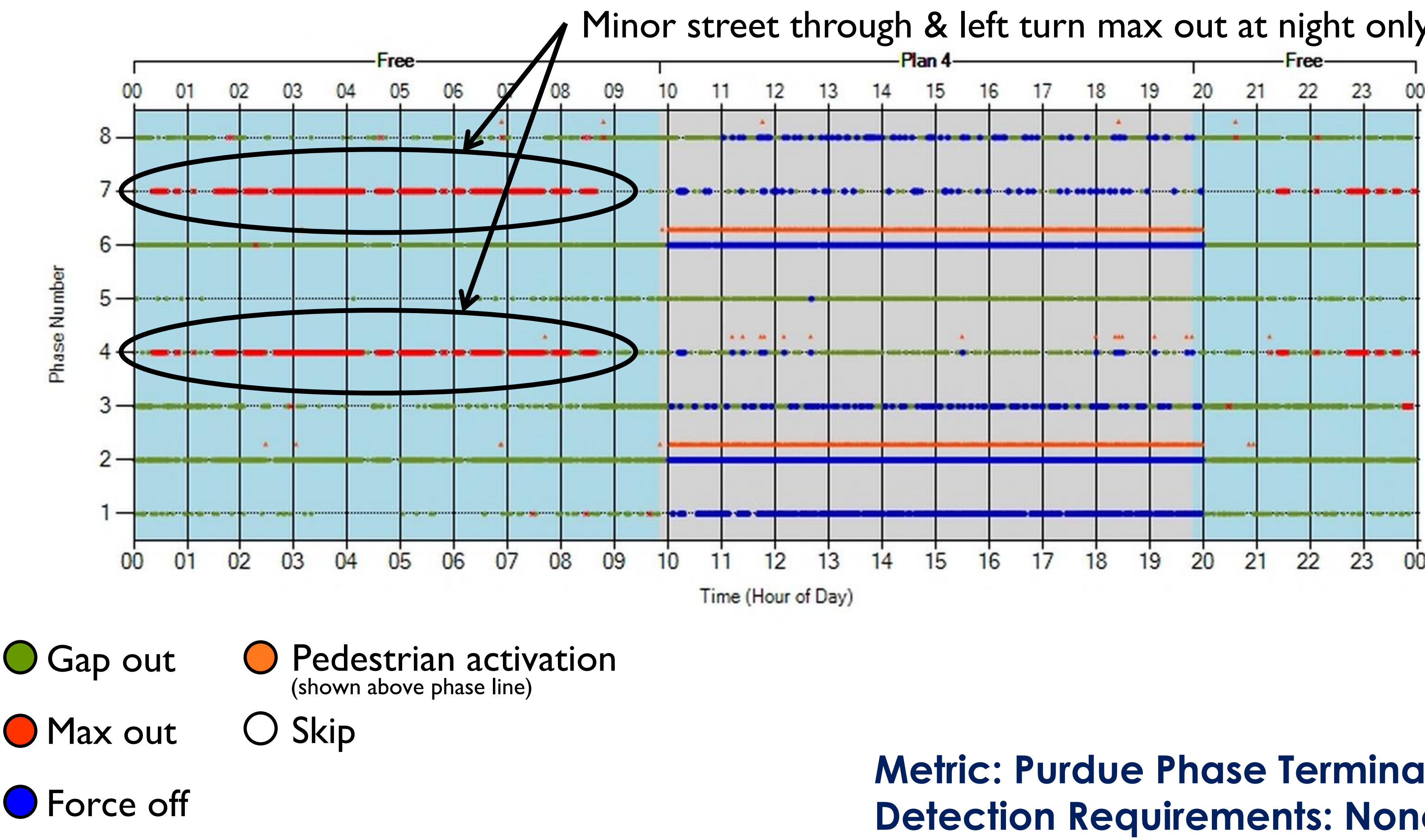
- SPMs confirm it was a fluke




**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Maintenance Example: Nighttime detection problem

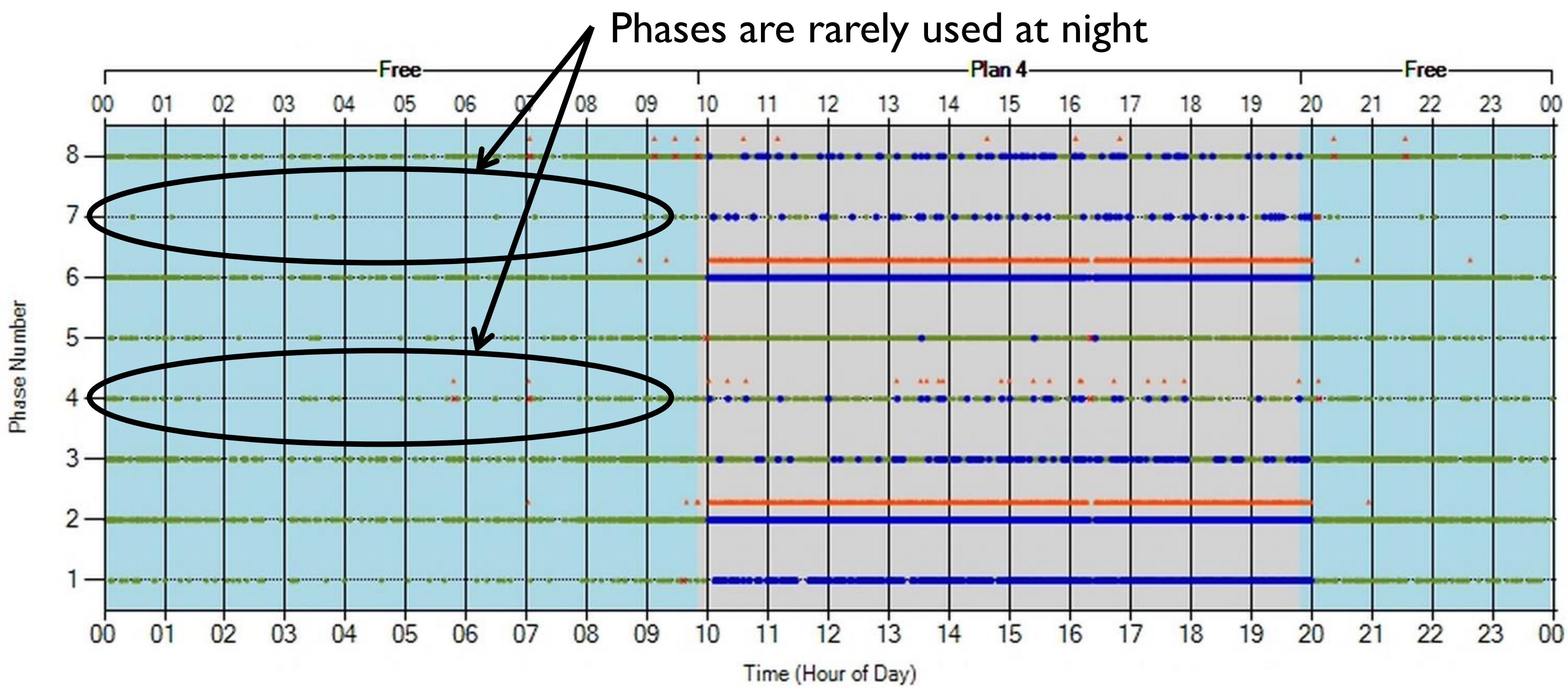
- BEFORE: Video detection not working at night




**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Maintenance Example: Nighttime detection problem

- AFTER: New detection technology installed




Gap out

Pedestrian activation
(shown above phase line)

Max out

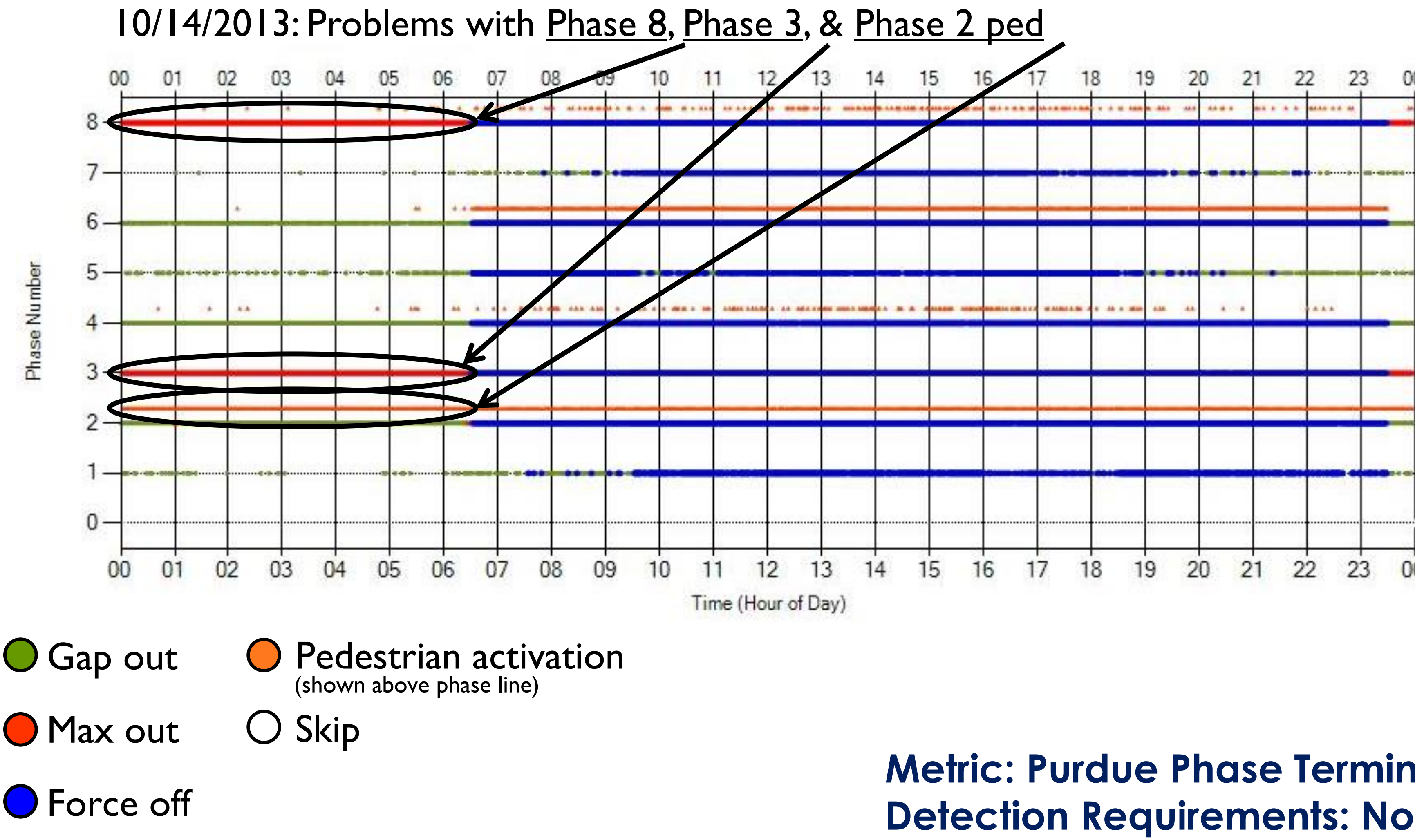
Skip

Force off

**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Maintenance Example: Check for additional problems

- Phase 2 ped problem was not noticed at field visit

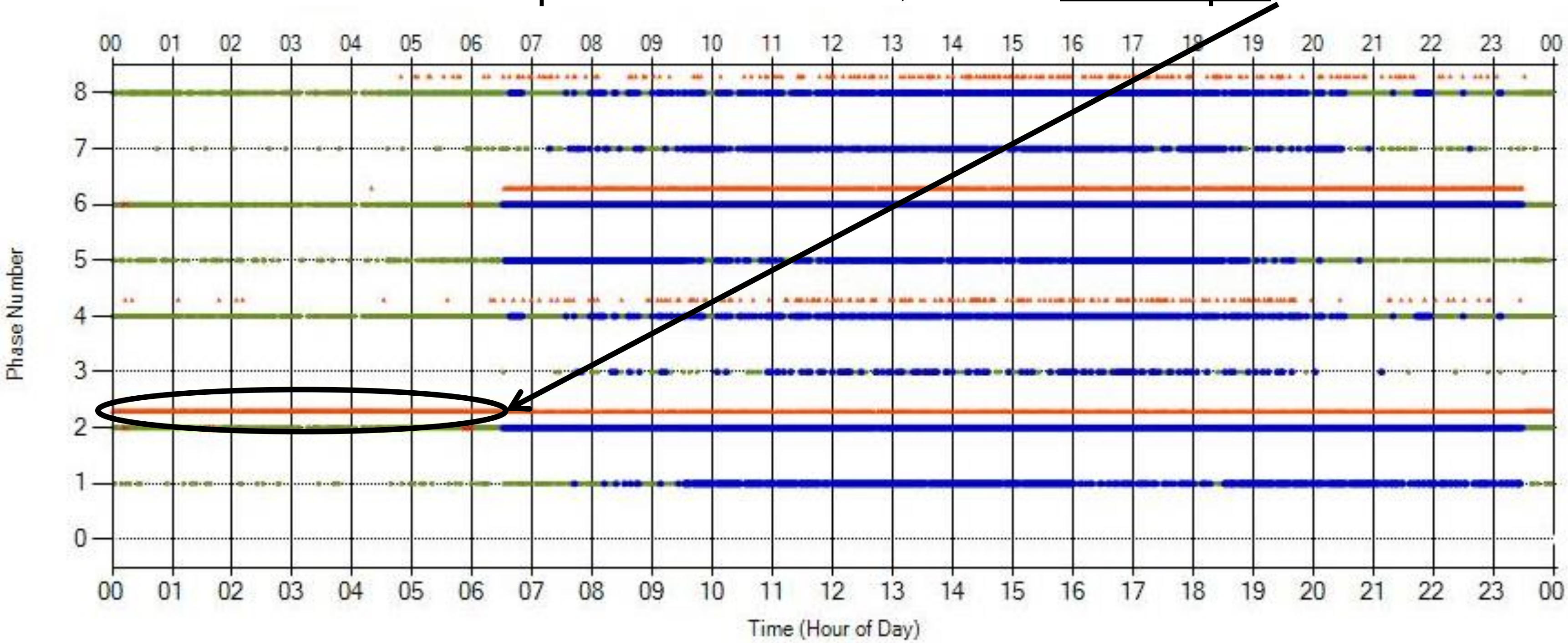



**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Maintenance Example: Check for additional problems

- Phase 2 ped problem was not noticed at field visit

10/21/2013: Phase 3 & 8 problems were fixed, but not Phase 2 ped




Gap out

Pedestrian activation (shown above phase line)

Max out

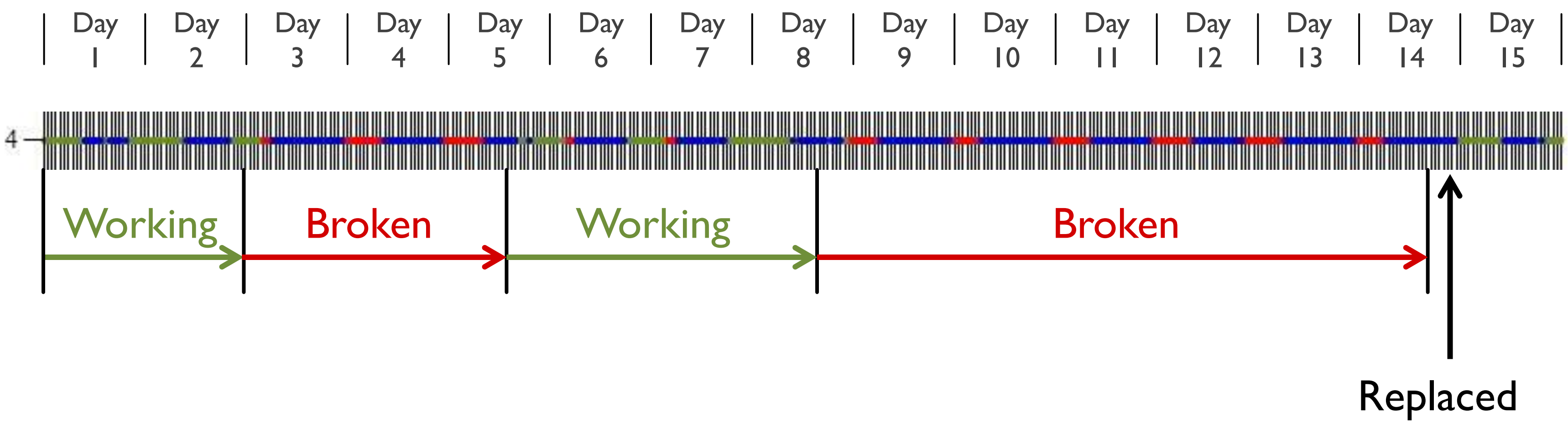
Skip

Force off

**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Maintenance Example: Detection Upgrade Justification

- Document recurring detection problems




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

**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Alert Example: 100% Max Out

SPM Alerts for 4/9/2014

**SPMWatchDog@utah.gov**

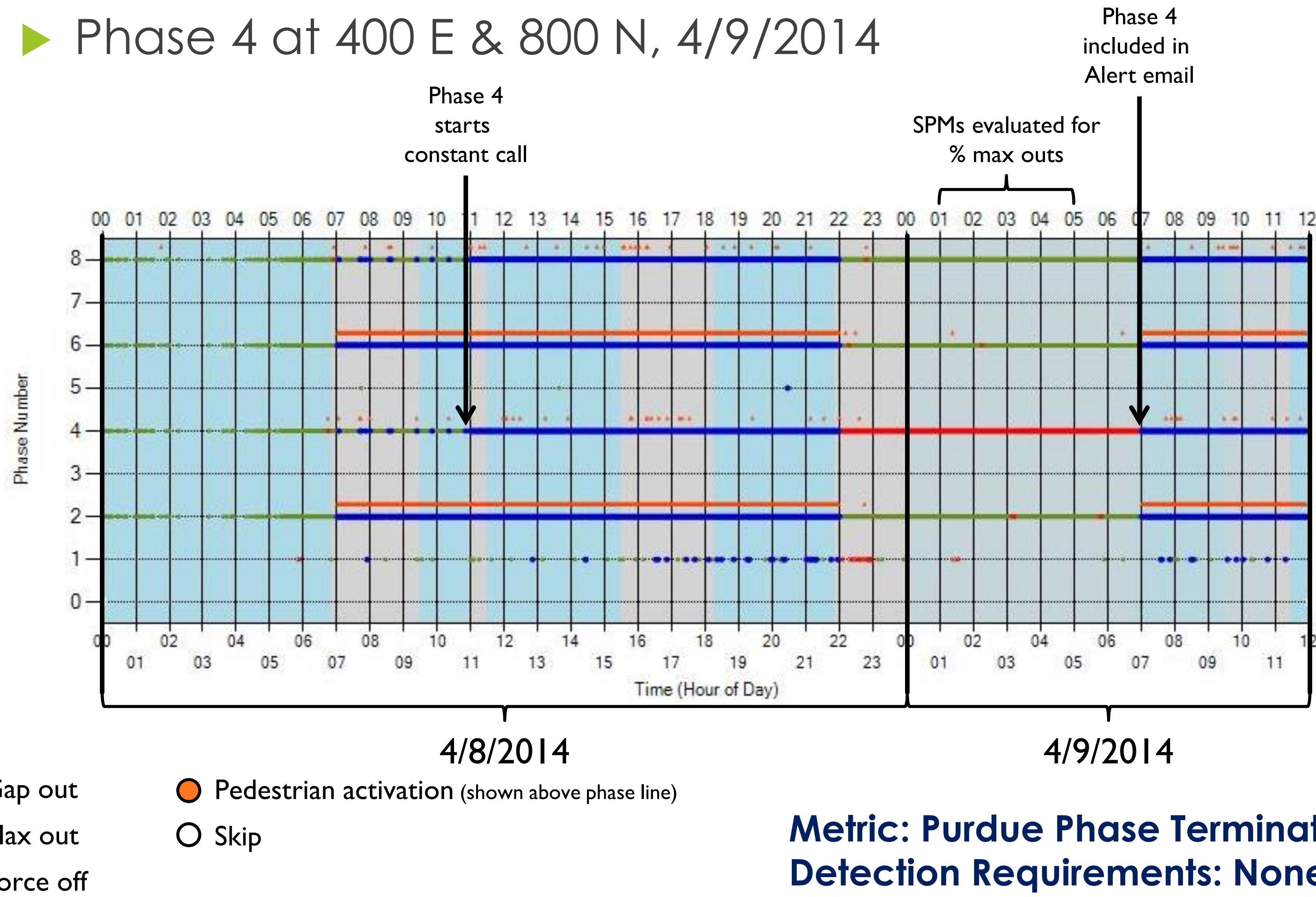
5092 - SR-126 (1900 W) & Riverdale (5300 S) (Roy) - Phase: 1
5105 - Antelope (SR-108/2000 N) & I-15 NB (Layton) - Phase: 4
6022 - US-89 & Pacific Dr (American Fork) - Phase: 3
6305 - 400 East & 800 North - Phase: 4 ← Example
6310 - Center Street (Orem) & I-15 SPUI - Phase: 8
7055 - Bangerter Hwy (SR-154) & SR-201 DDI - Phase: 5
7062 - Bangerter Hwy (SR-154) & 4700 South - Phase: 11
7613 - 10600 South & 700 West - Phase: 8
8114 - Bluff Street & I-15 NB Ramps - Phase: 4

- Daily email at 7 a.m.
- Uses Purdue Phase Termination chart data
- Flags phases with >90% max-outs on each phase between 1 a.m. and 5 a.m.
- Compare to previous day's list. Only phases with new flags are sent in the email.

**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Alert Example: 100% Max Out

- Phase 4 at 400 E & 800 N, 4/9/2014

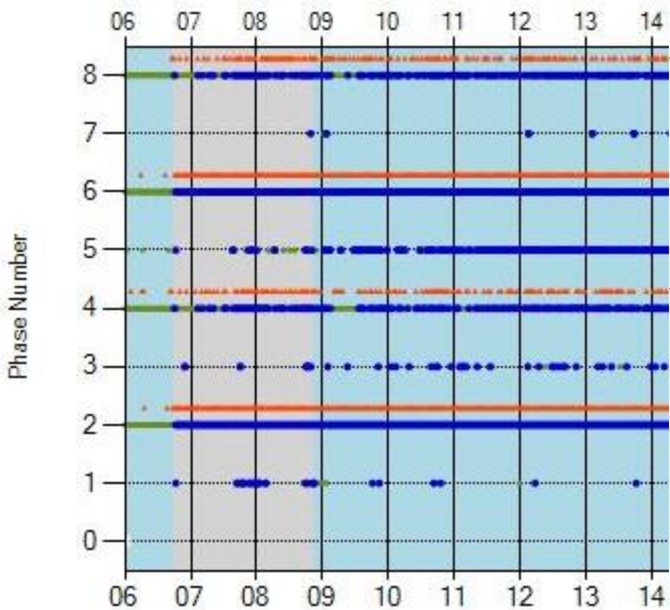



**Metric: Purdue Phase Termination**
**Detection Requirements: None**

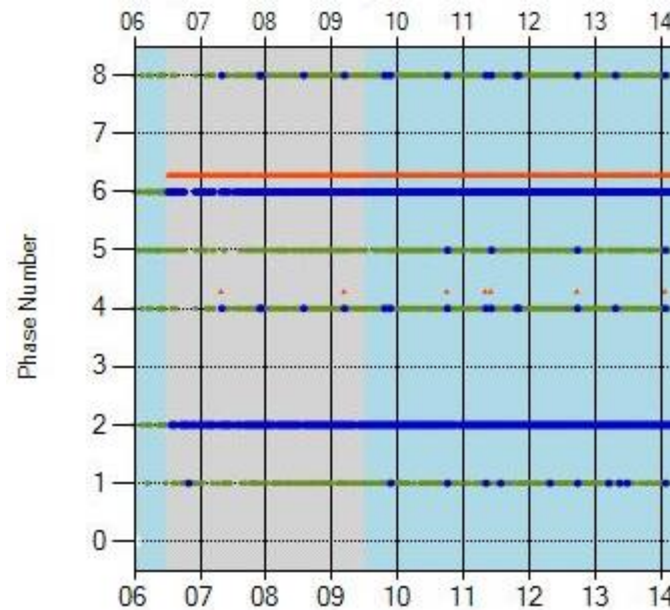
# Optimization Example: Oversize Peds

- Check frequency of ped calls

Peds for Phases 4 & 8 are called **frequently**
Recommendation: Do not oversize peds



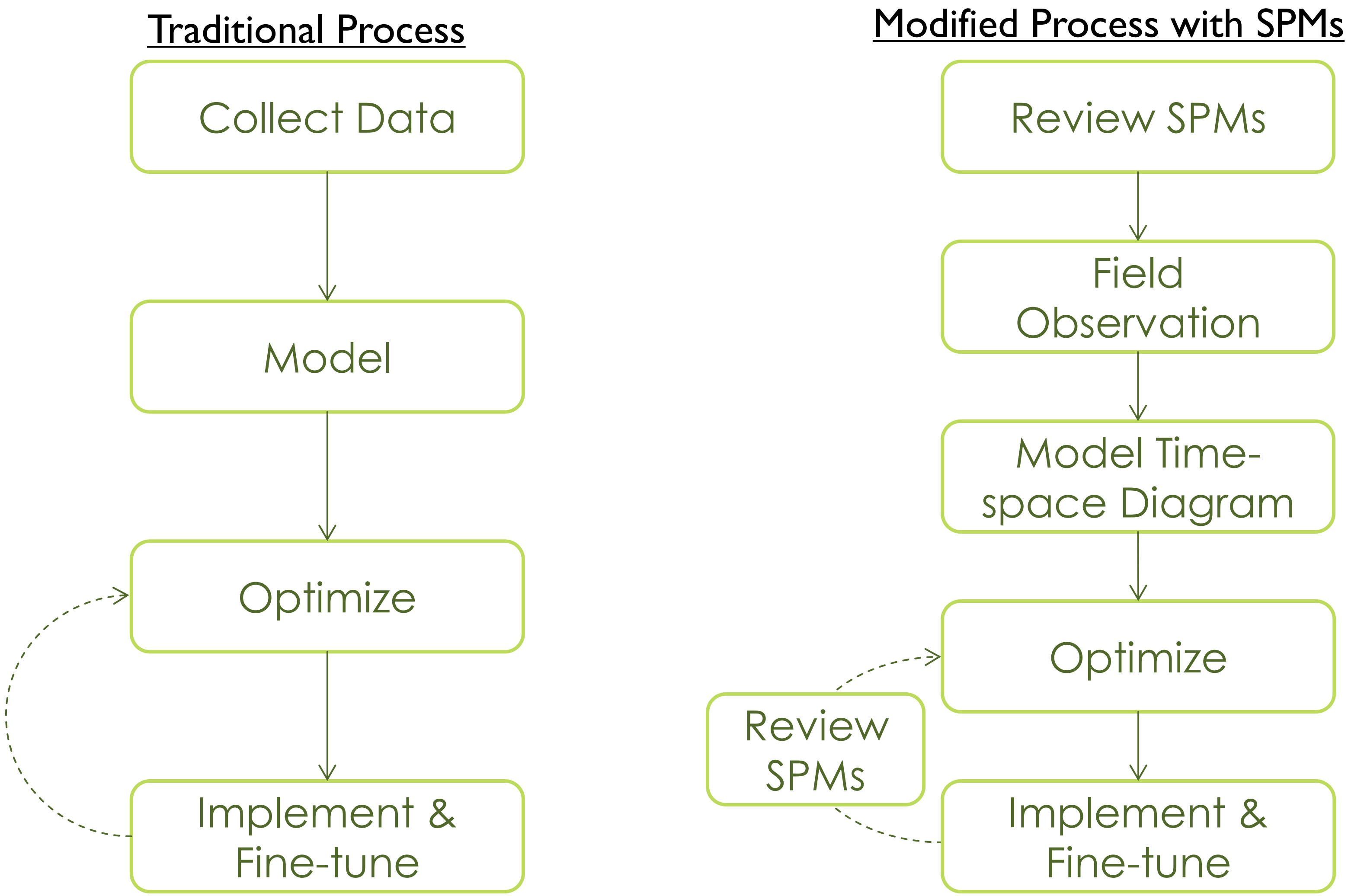

Peds for Phases 4 & 8 are **rarely** called
Recommendation: Oversize peds, if needed




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

**Metric: Purdue Phase Termination**
**Detection Requirements: None**

# Optimization with SPMs



# Before and After Coordination Results

Corridor: Bangerter Hwy, SLC

To/From: SR-201 - 6200 South

Date: March 2013

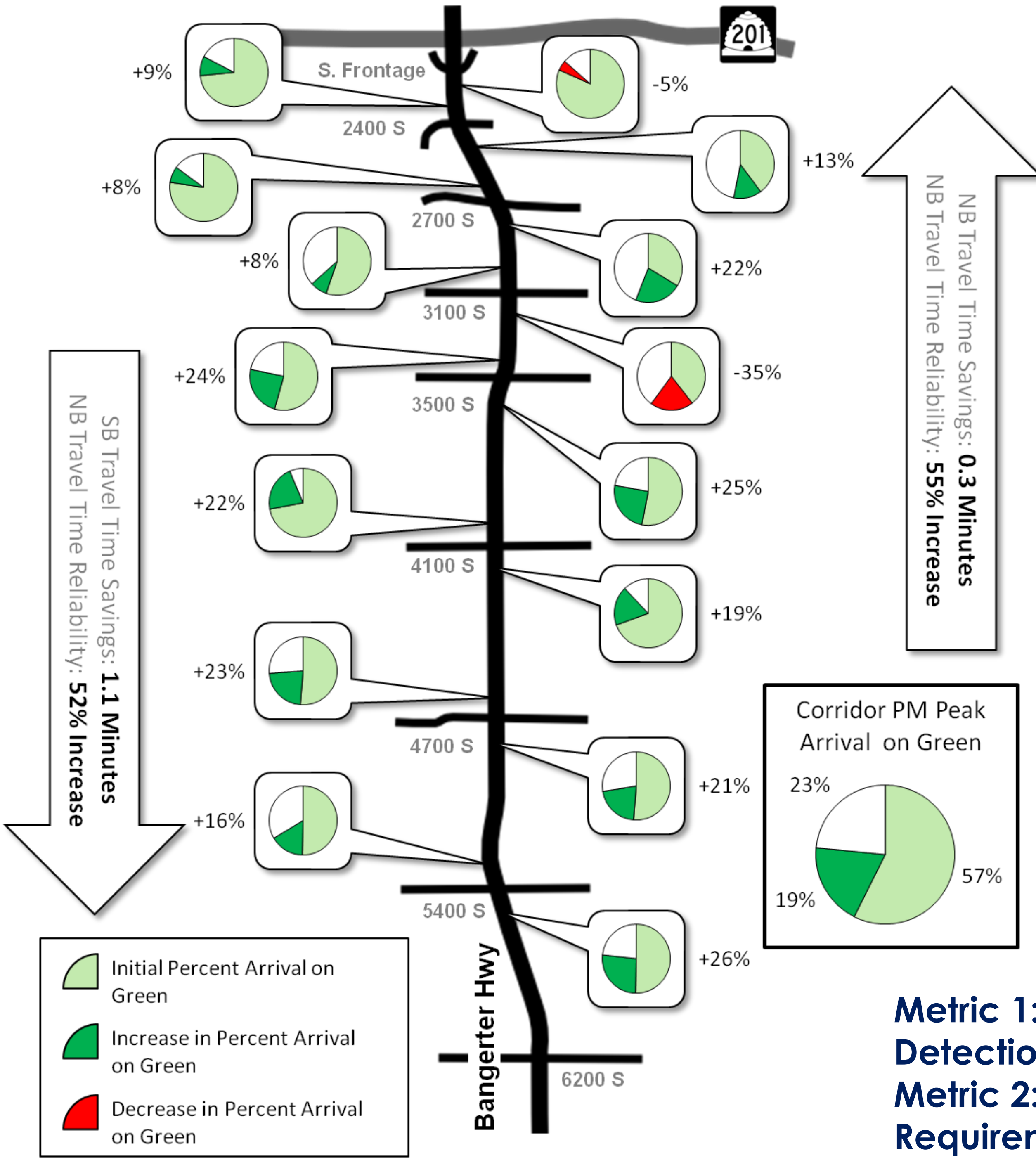
Time Period: PM Peak

**Results:**

- Arrivals on Green: 19% ⇧

- NB TT Savings: 0.3 Minutes
- NB Reliability: 55% ⇧

- SB TT Savings: 1.1 Minute
- SB Reliability: 52% ⇧




**Metric 1: Purdue Coordination Diagram**
**Detection Requirements: Advance**
**Metric 2: Purdue Travel Time Diagram**
**Requirements: Probe data set**

# AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES CASE STUDIES: INDOT

**INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – MAY 7, 2014**

PRESENTED BY AMANDA STEVENS, INDOT AND ALEX HAINEN, PURDUE

**Active Phase Events:**

| | |
|---|---|
| 0 | Phase On |
| 1 | Phase Begin Green |
| 2 | Phase Check |
| 3 | Phase Min Complete |
| 4 | Phase Gap Out |
| 5 | Phase Max Out |
| 6 | Phase Force Off |
| 7 | Phase Green Termination |
| 8 | Phase Begin Yellow Clearance |
| 9 | Phase End Yellow Clearance |
| 10 | Phase Begin Red Clearance |
| 11 | Phase End Red Clearance |

**Detector Events:**

| | |
|---|---|
| 81 | Detector Off |
| 82 | Detector On |
| 83 | Detector Restored |
| 84 | Detector Fault- Other |
| 85 | Detector Fault- Watchdog Fault |
| 86 | Detector Fault- Open Loop Fault |

**Preemption Events:**

| | |
|---|---|
| 101 | Preempt Advance Warning Input |
| 102 | Preempt (Call) Input On |
| 103 | Preempt Gate Down Input Received |
| 104 | Preempt (Call) Input Off |
| 105 | Preempt Entry Started |

# Controller Enumerations

## Event Code, Event Description, Parameter

Detector 5 ON

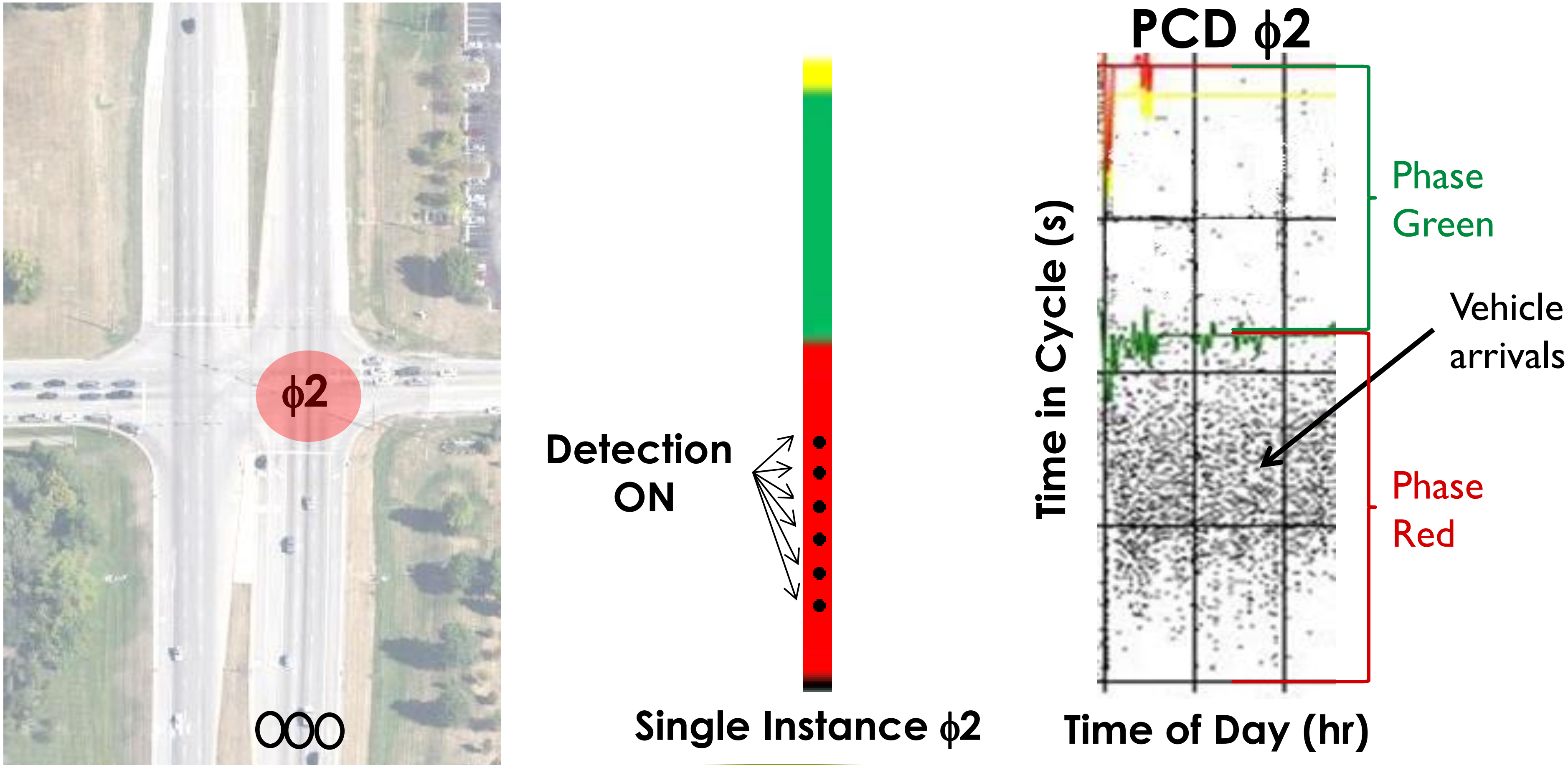
Phase 8 GREEN

Detector 5 OFF

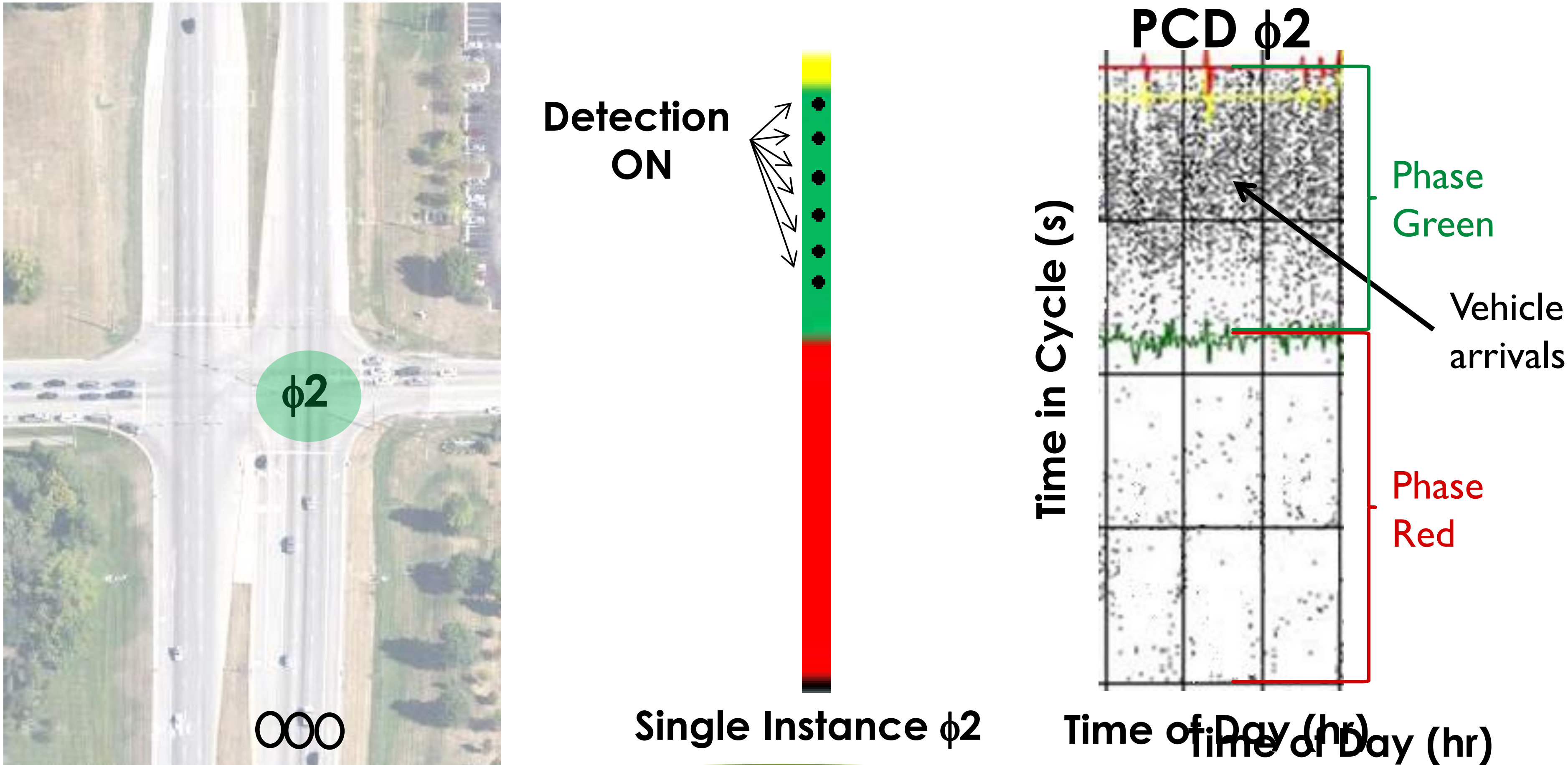
| | | |
|---|---|---|
| 06/27/2013 01:29:51.1 | 10 | 8 |
| 06/27/2013 01:29:51.1 | 82 | 5 |
| 06/27/2013 01:29:52.2 | 1 | 2 |
| 06/27/2013 01:29:52.2 | 1 | 6 |
| 06/27/2013 01:29:52.3 | 82 | 2 |
| 06/27/2013 01:29:52.8 | 82 | 4 |
| 06/27/2013 01:29:52.9 | 81 | 4 |
| 06/27/2013 01:29:53.3 | 81 | 6 |
| 06/27/2013 01:29:54.5 | 81 | 2 |
| 06/27/2013 01:30:02.2 | 8 | 2 |
| 06/27/2013 01:30:02.2 | 8 | 6 |
| 06/27/2013 01:30:02.2 | 33 | 2 |
| 06/27/2013 01:30:02.2 | 33 | 6 |
| 06/27/2013 01:30:02.2 | 32 | 2 |
| 06/27/2013 01:30:02.2 | 32 | 6 |
| 06/27/2013 01:30:06.1 | 10 | 2 |
| 06/27/2013 01:30:06.1 | 10 | 6 |
| 06/27/2013 01:30:08.1 | 1 | 8 |
| 06/27/2013 01:30:13.1 | 32 | 8 |
| 06/27/2013 01:30:15.8 | 81 | 5 |
| 06/27/2013 01:30:18.5 | 82 | 6 |
| 06/27/2013 01:30:27.5 | 81 | 6 |
| 06/27/2013 01:30:30.4 | 8 | 8 |

# High-resolution Data

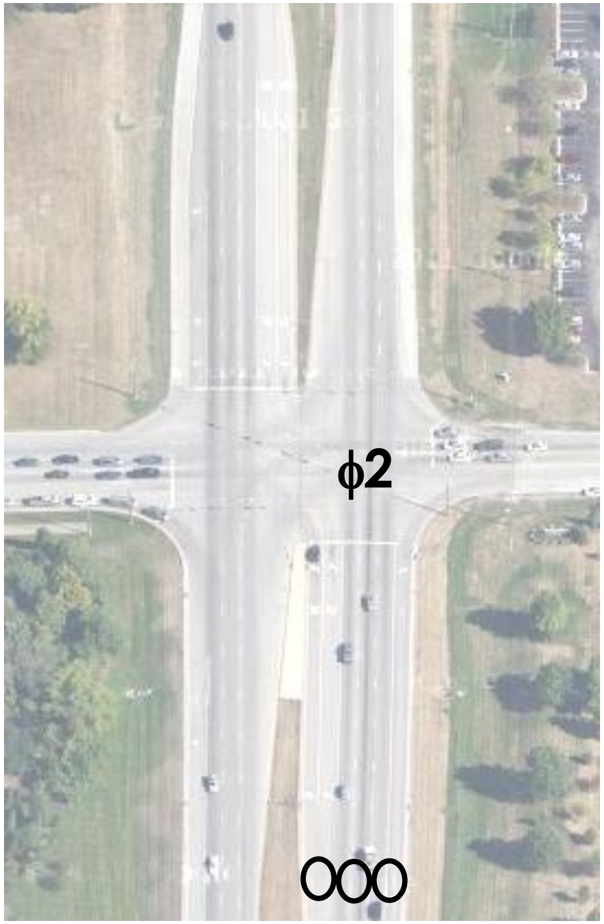
## Timestamp, Enumeration Code, Parameter

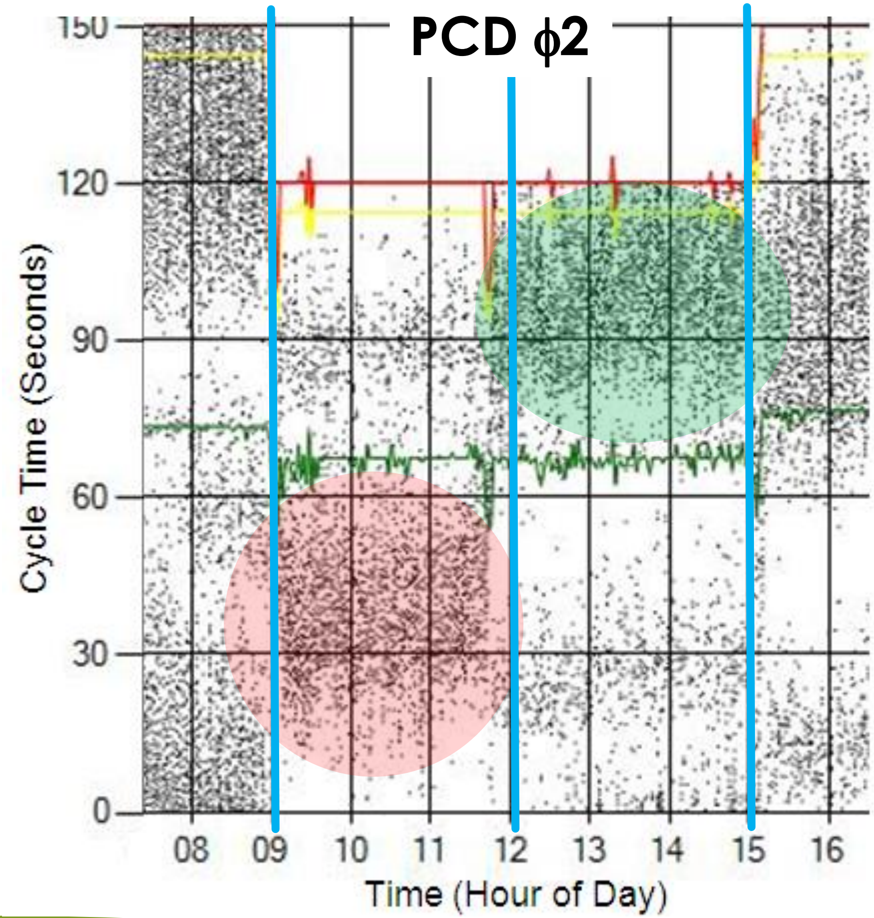



# Purdue Coordination Diagram: Red Arrival

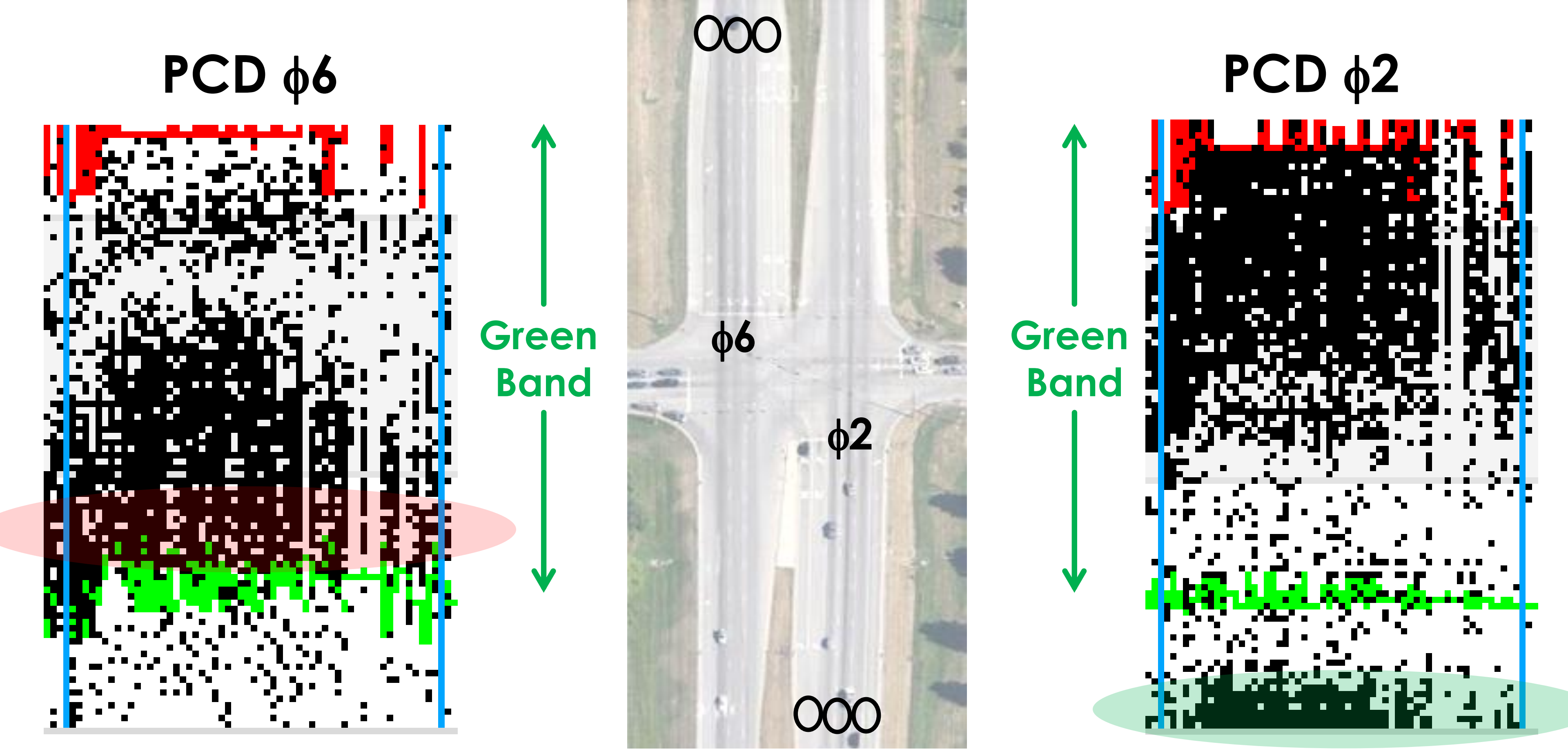



# Purdue Coordination Diagram: Green Arrival




# PCD: Platoon Arrival by TOD




# PCD: Adjust Offsets

# INDOT System

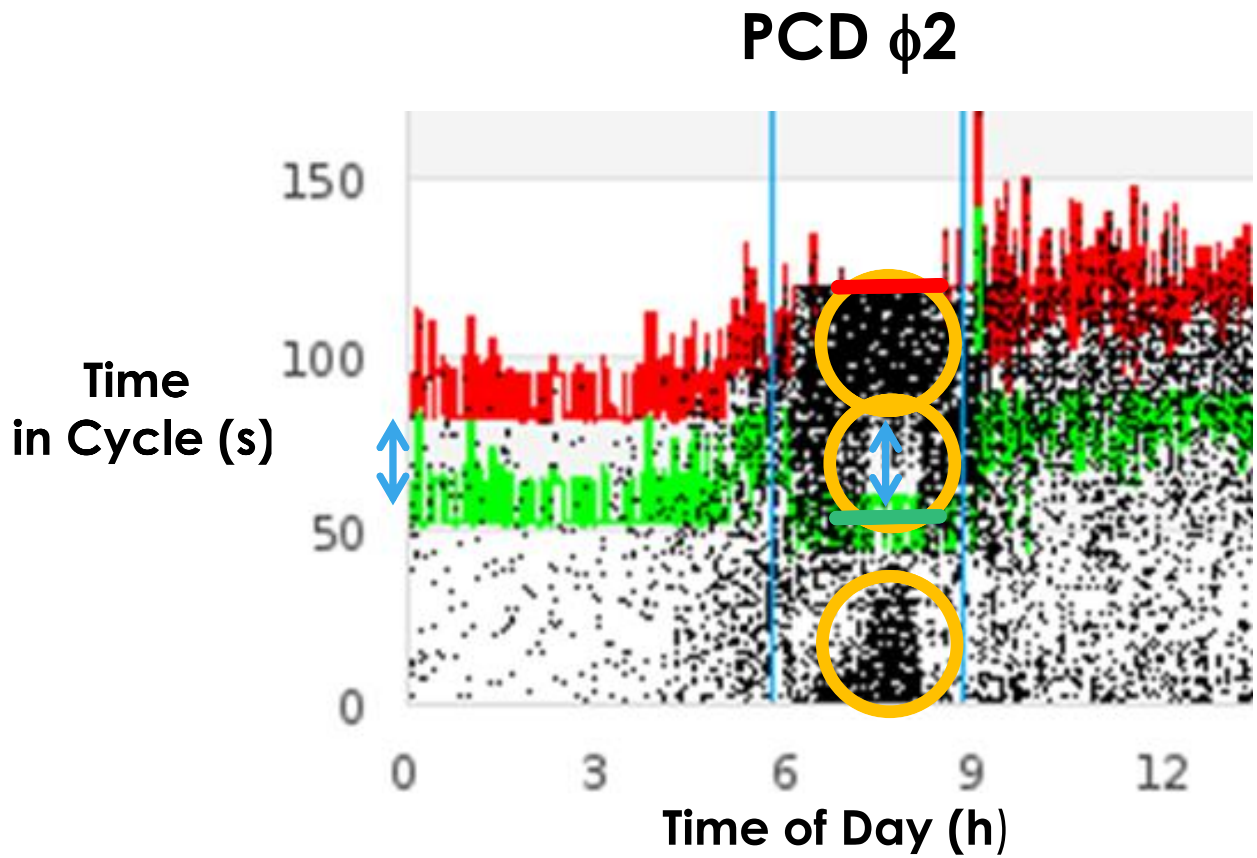
- # SIGNALS TOTAL
- # SIGNALS ONLINE, AUTOMATICALLY STORING DATA & GENERATING PERFORMANCE MEASURE GRAPHS
- PEEK ATC, ECONOLITE ASC/3, SIEMENS M50 SERIES…

# "Human-in-the-Loop-Adaptive"

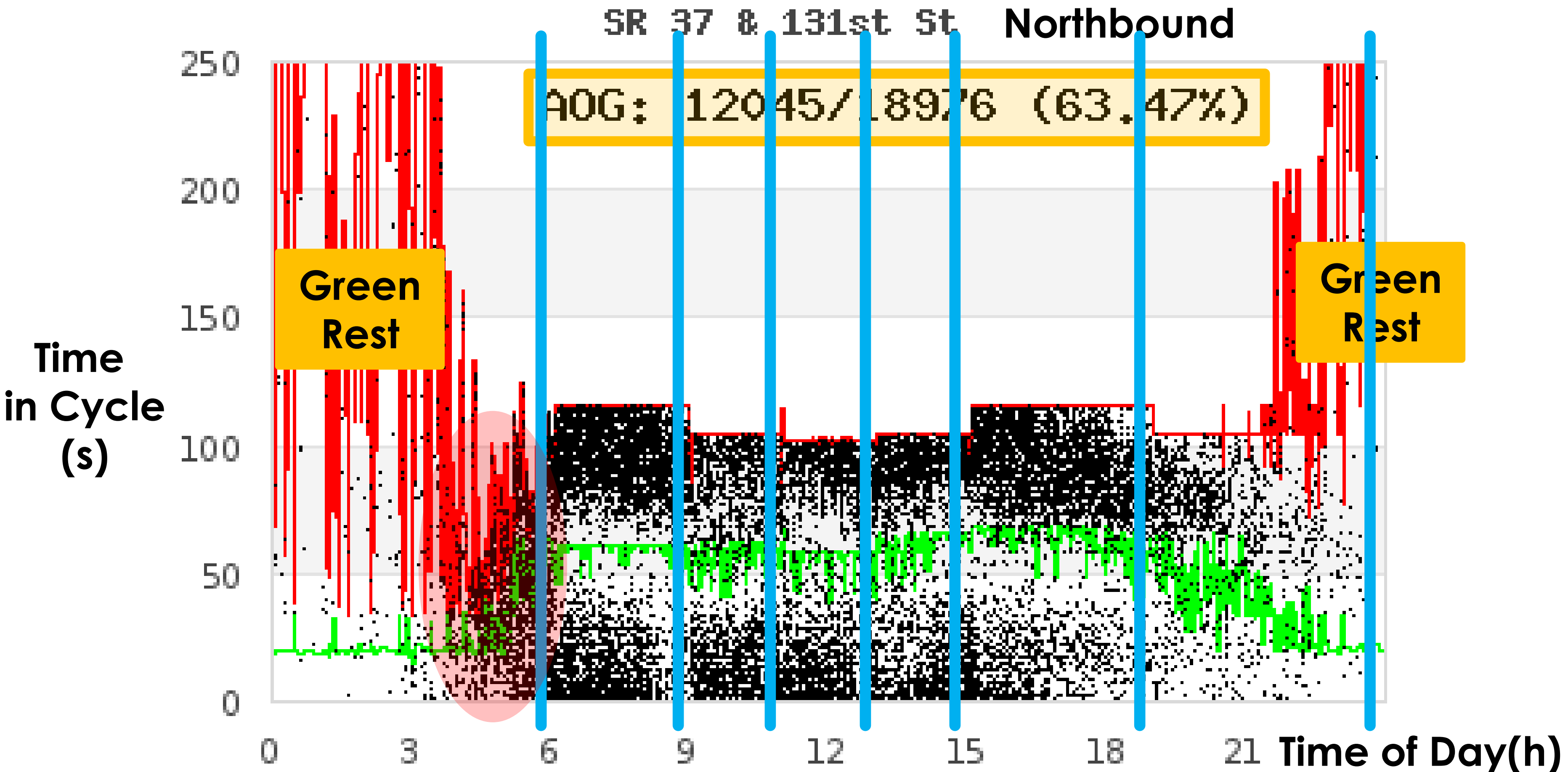
- **WEEKENDS & OFF-PEAKS**
- **ROUTINE RETIMINGS**
- **CONSTRUCTION SEASON:**
  - You cannot be everywhere at once!
  - Could take Months for traffic to settle
  - Project in Flux:
    - Detection
    - Phases
    - Approaches / Lanes
    - Adjacent construction detours

# Moving Forward:

- CLOSELY-SPACED SIGNALS ALSO NEED ADVANCED DETECTION ON LEFT TURNS
- SEPARATE DETECTION CHANNELS FOR EACH LANE


# PCD: Cycle Failure



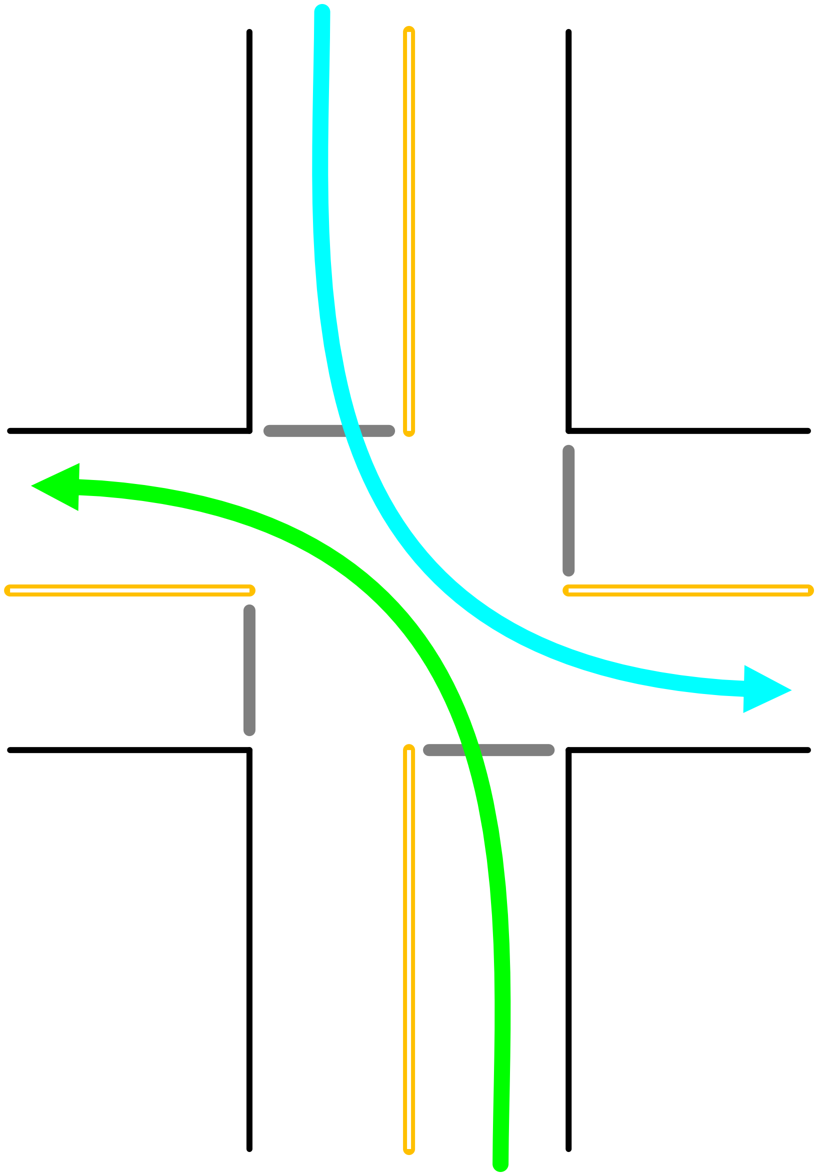

# PCD: Pattern Start & End Times

# Hi-resolution Event-based Data for Diamond Interchange Operations

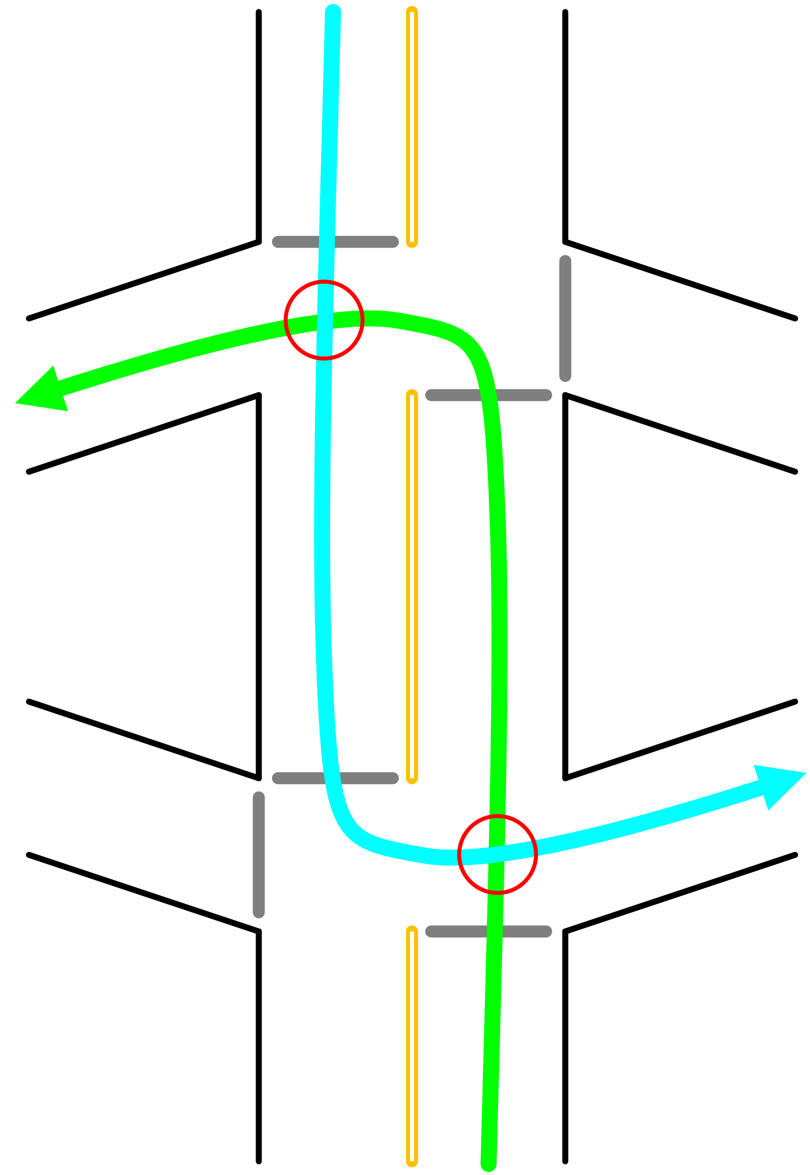
ALEX HAINEN
AMANDA STEVENS
CHRIS DAY
RICK FREIJE
JIM STURDEVANT
DARCY BULLOCK
HOWELL LI

# Diamond Interchanges

*What are they and why do they matter?*



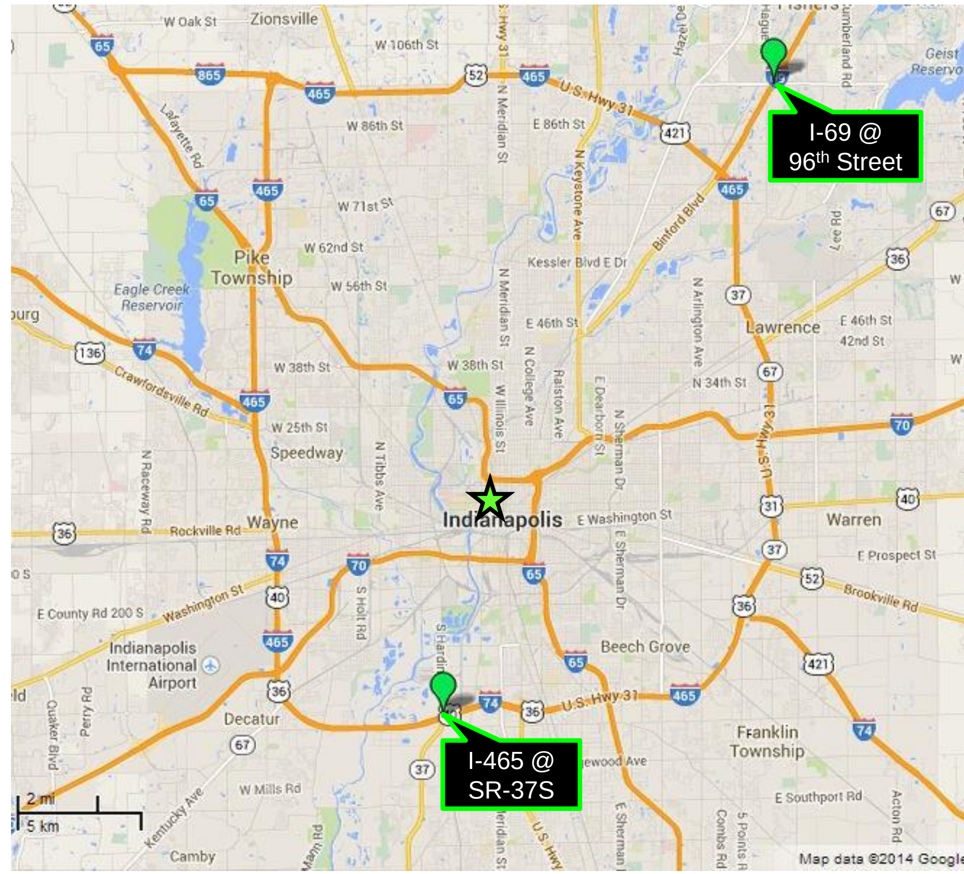
Normal Intersection



Diamond Interchange

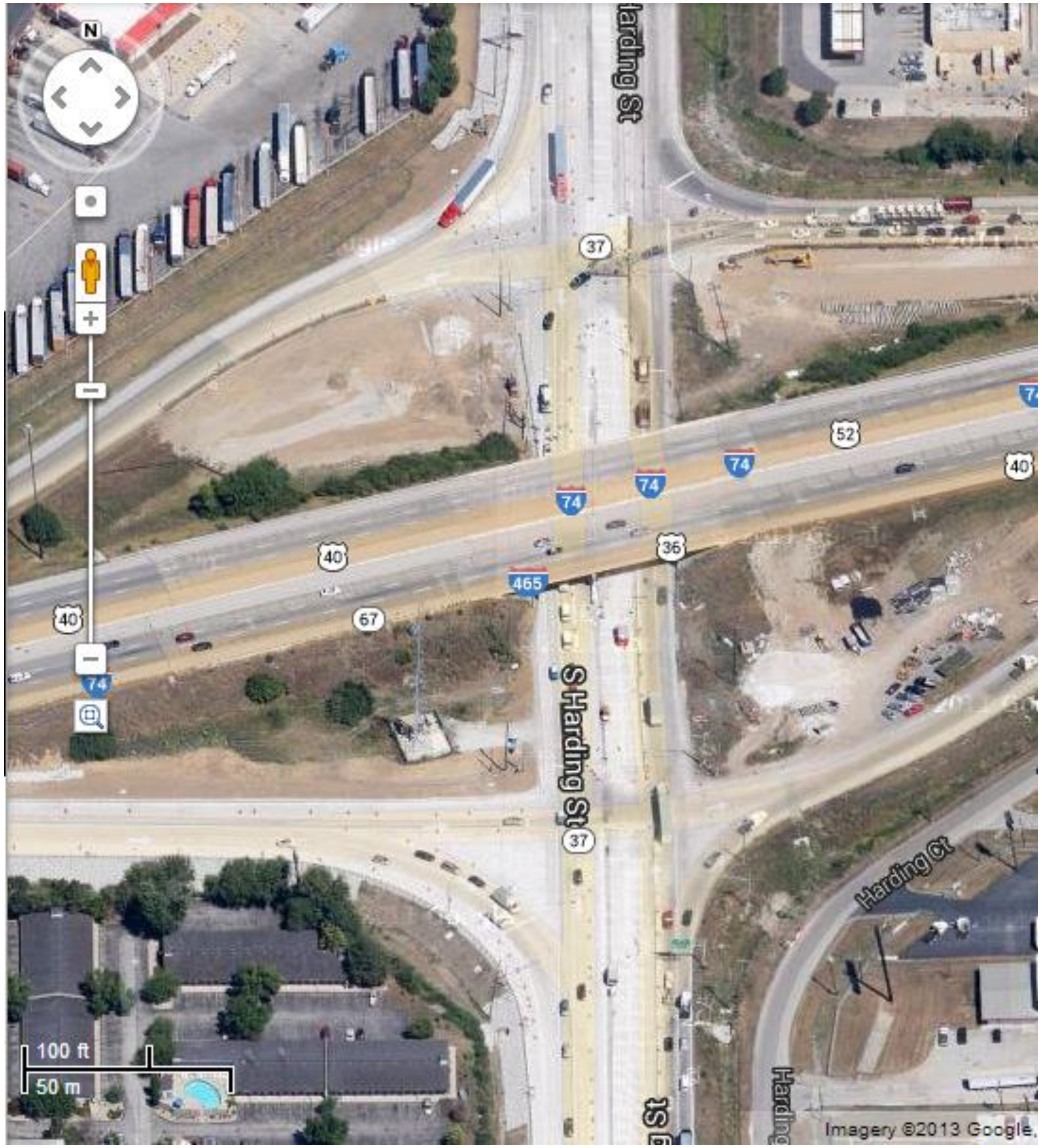
# Diamond Interchanges

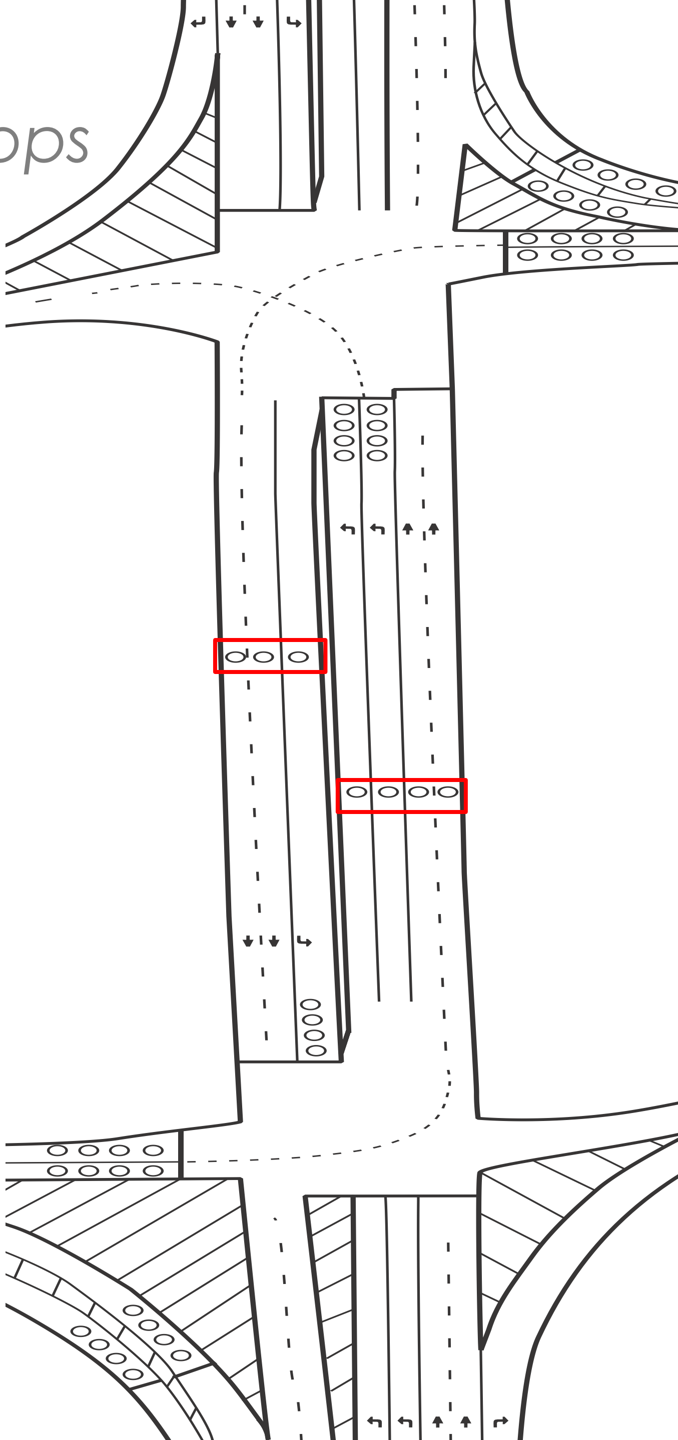
*Indiana = 161 Interchanges*  *Nationally >= 10,000*



# I-465 @ SR-37

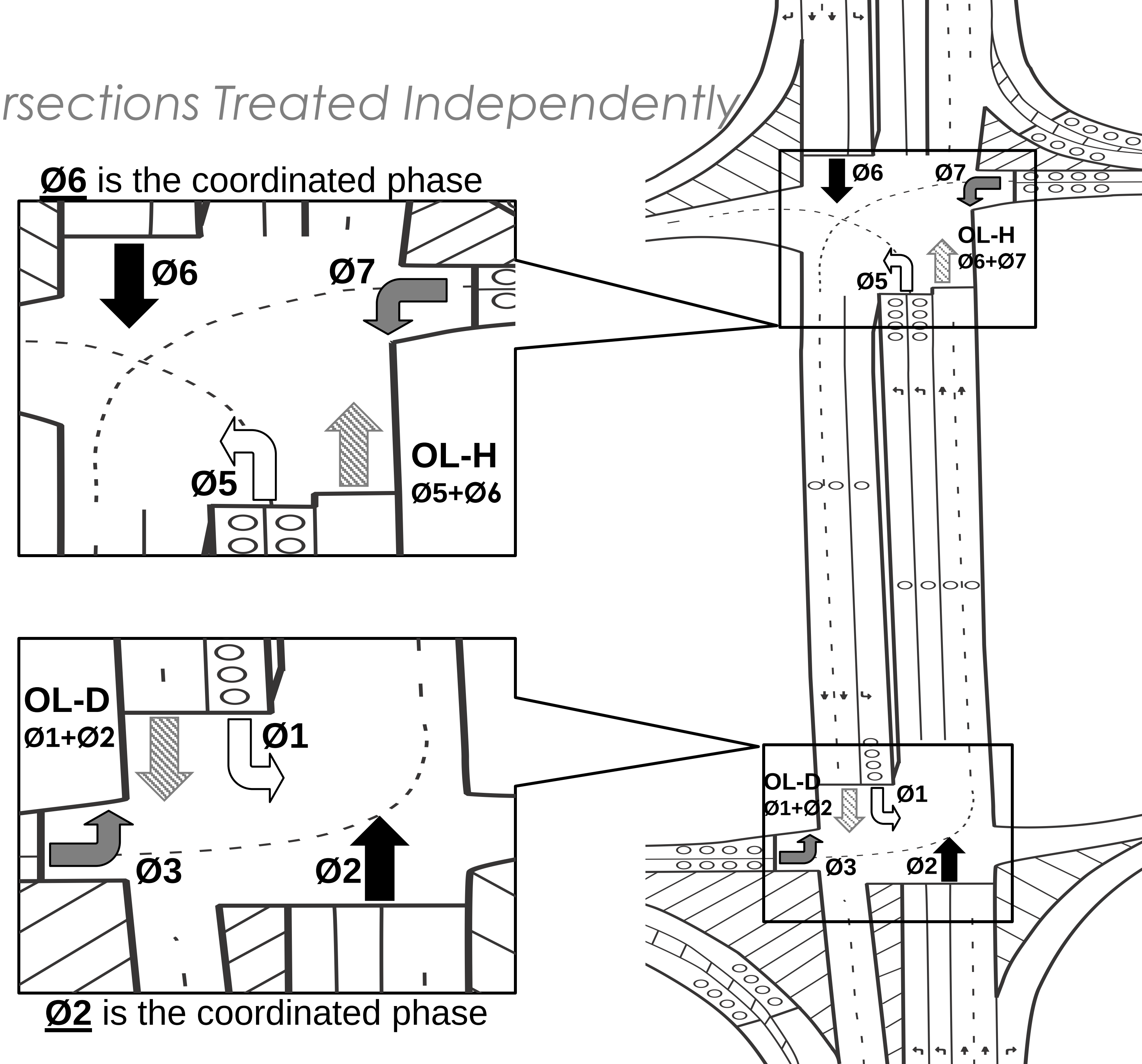
*Diamond Interchange w/Advanced Loops*



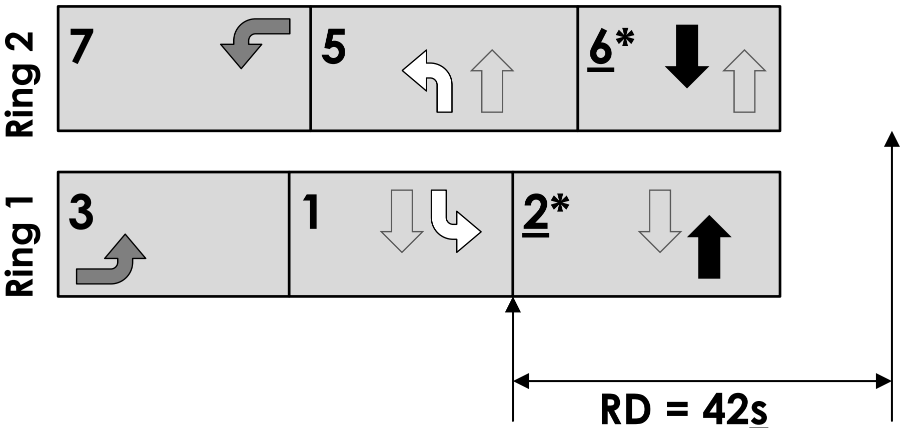
# Phasing

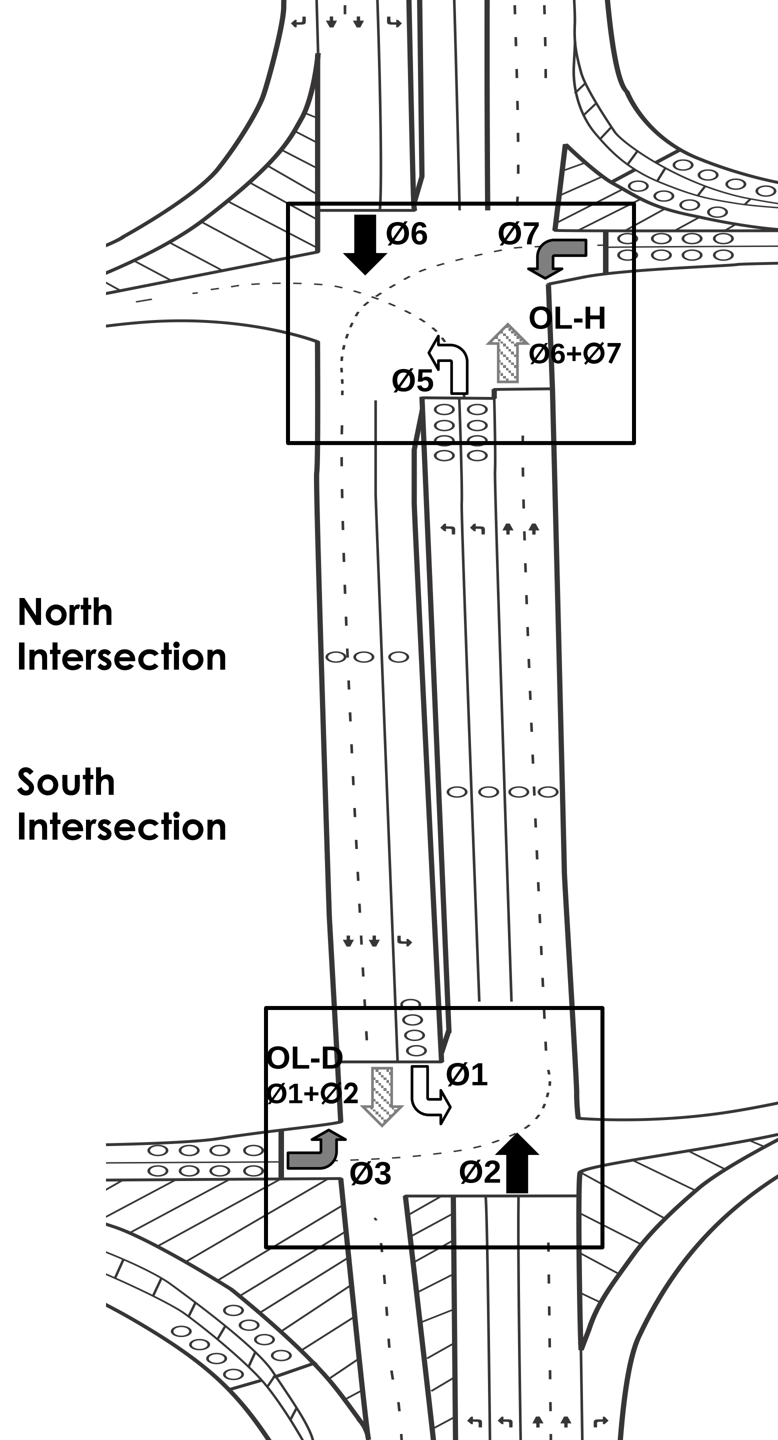
*Two "T"-Intersections Treated Independently*



# Ring Displacement

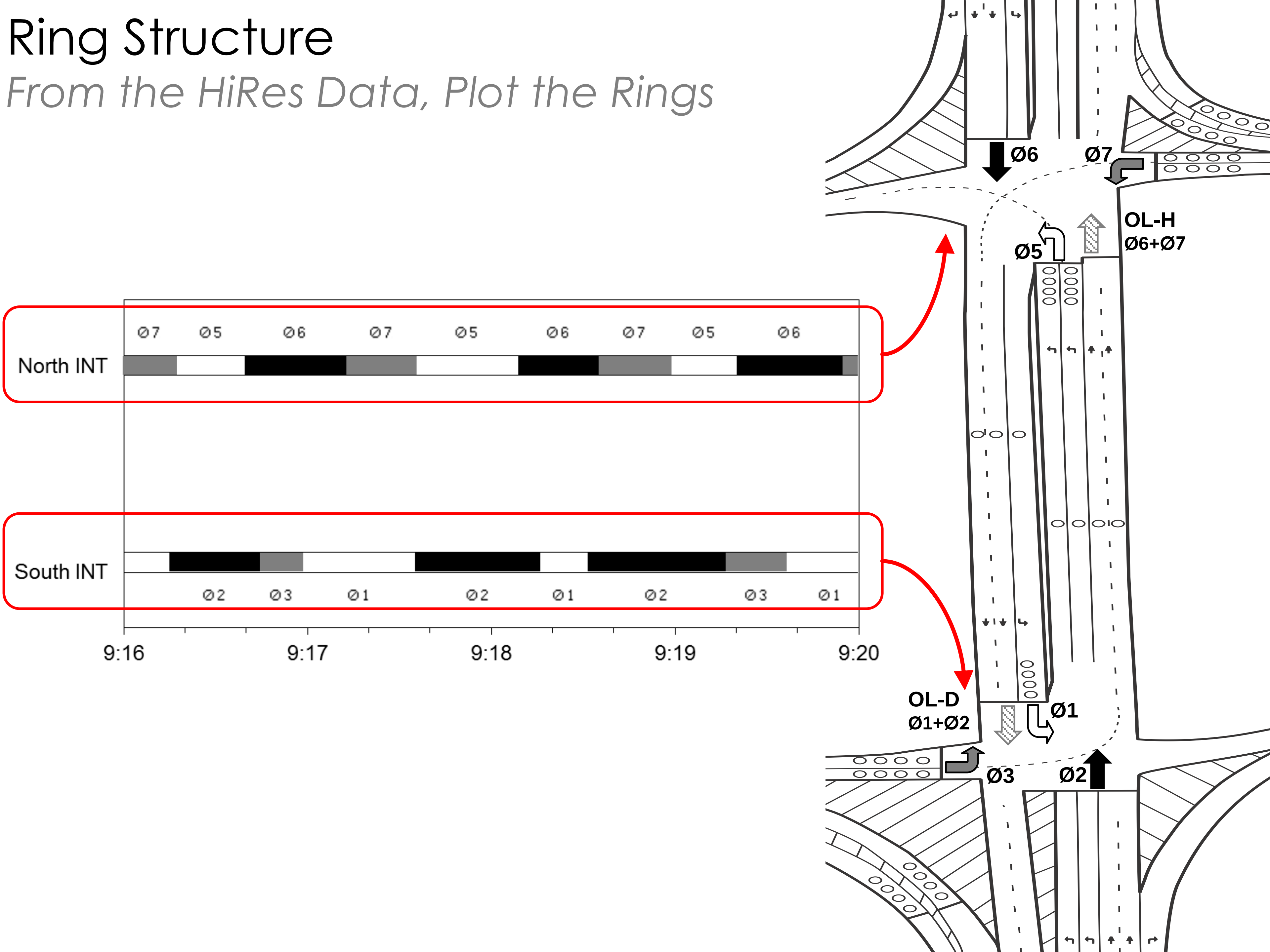
*Offset Between Coordinated Phases*



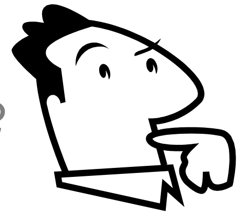
# Ring Structure

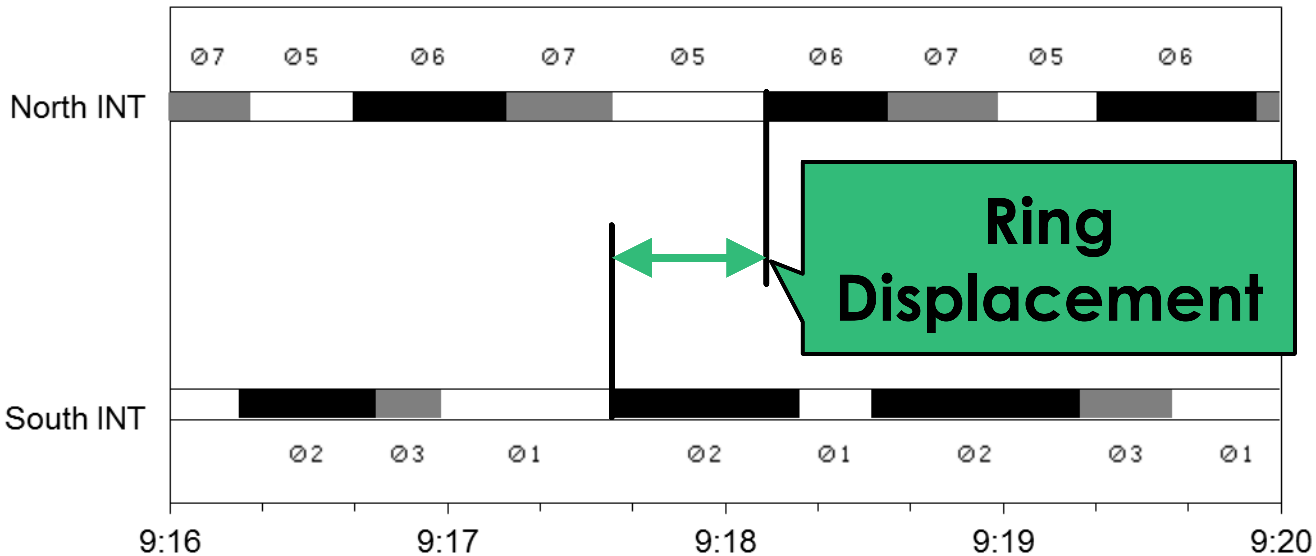
*From the HiRes Data, Plot the Rings*

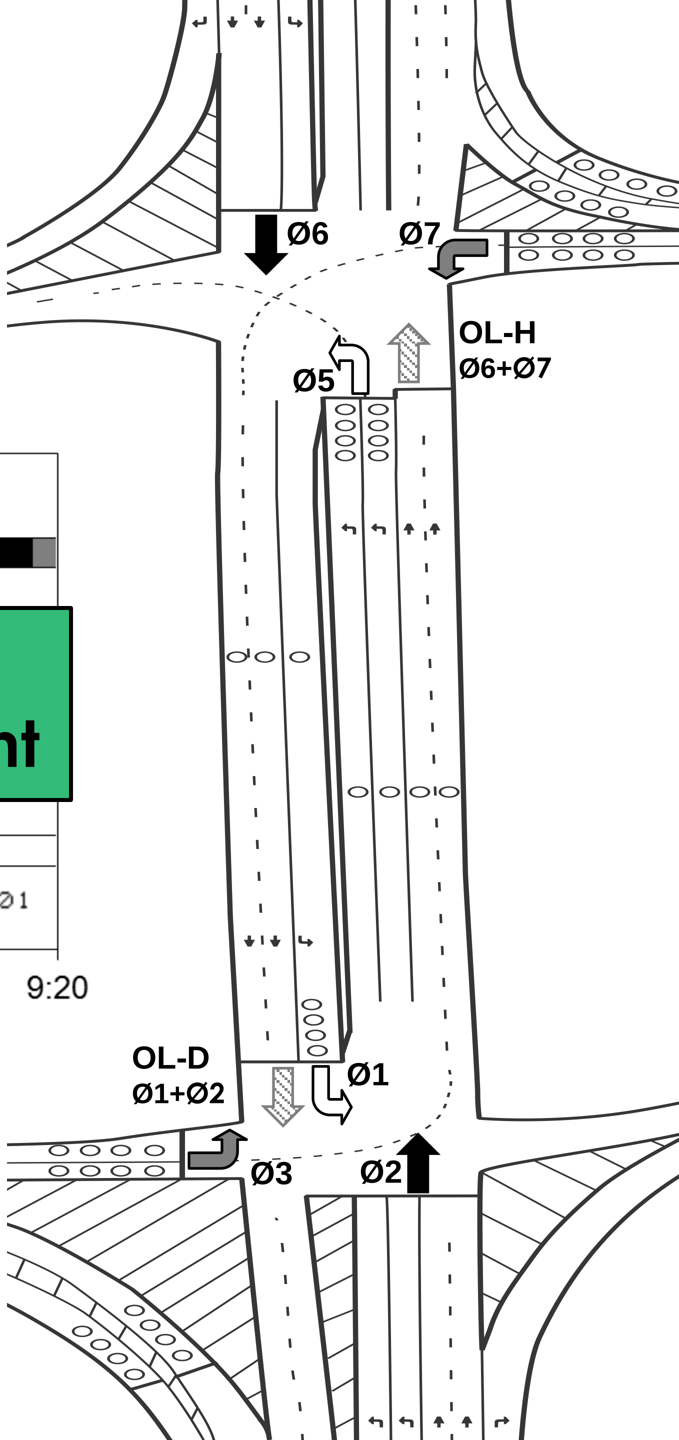


# Ring Displacement

*How is this parameter set?*





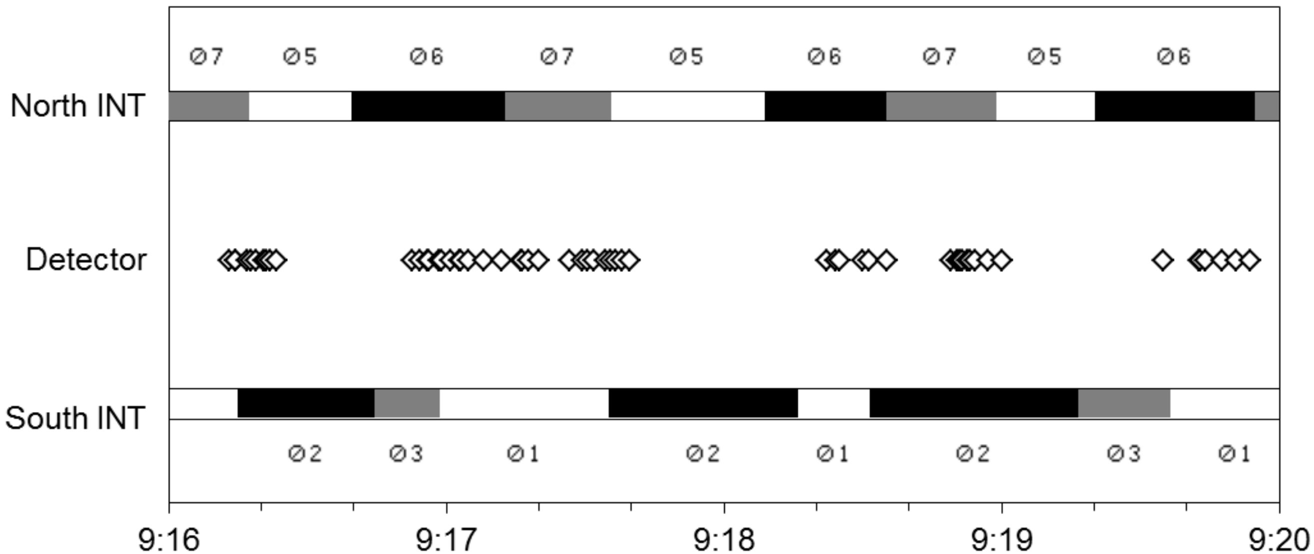



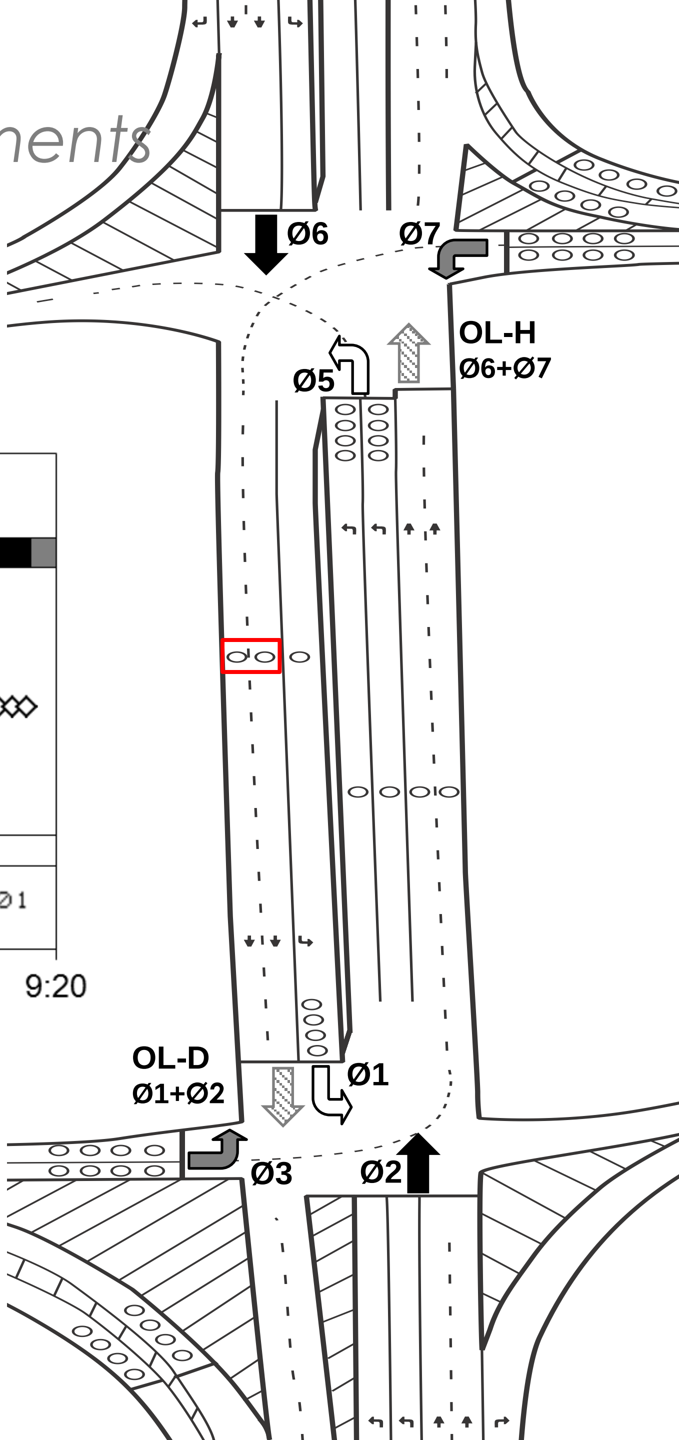

```
COORDINATOR PATTERN [  1]                    ^v
TS2 (PAT-OFF)..    0-1
CYCLE..........     0s STD (COS)......111
OFFSET VAL......    0s DWELL/ADD TIME.  0
ACTUATED COORD...   NO TIMING PLAN....  X
ACT WALK REST....   NO SEQUENCE........ X
PHASE RESRVCE....   NO ACTION PLAN.... X
MAX SELECT.....   NONE FORCE OFF....  NONE
SPLIT PREFERENCE PHASES
 PHASE[s]   1    2    3    4    5    6    7    8
SPT[  1]    0    0    0    0    0    0    0    0
PREF 1...   0    0    0    0    0    0    0    0
PREF 2...   0    0    0    0    0    0    0    0
SPLT EXT...0s.  0s   0s   0s
VEH PERM.   0s   0s   0s   DISP
RING DISP  -    0s   0s   0s (RING 2-4)
```

```
DIAL 1 SPLIT 1 PARAMETERS
 OFFSET TIME  ALT   PATN   R2   R3   R4
    #     SEC  SEQ   MODE  LAG  LAG  LAG
    1       0    0      0
    2       0    0      0
    3       0    0      0
MODE (0-6): NRM/PRM/YLD/PYL/POM/SOM/FAC
A-UP B-DN C-LT D-RT E-ENTER F-PRIOR MENU
```

# SB Thru Detectors

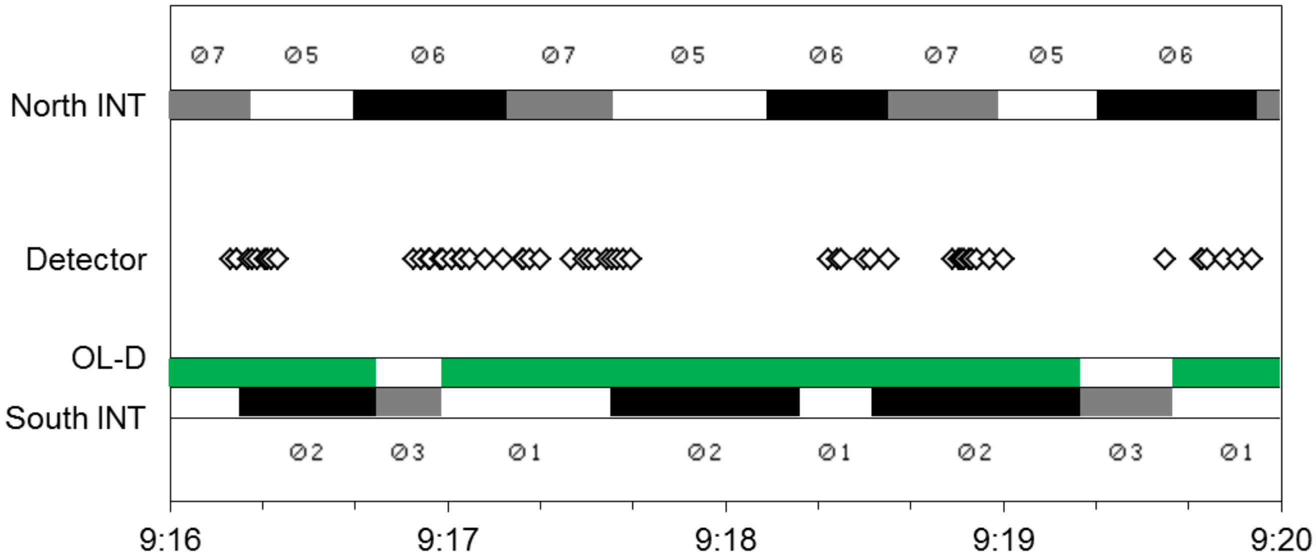
*Consider one of the four internal movements*

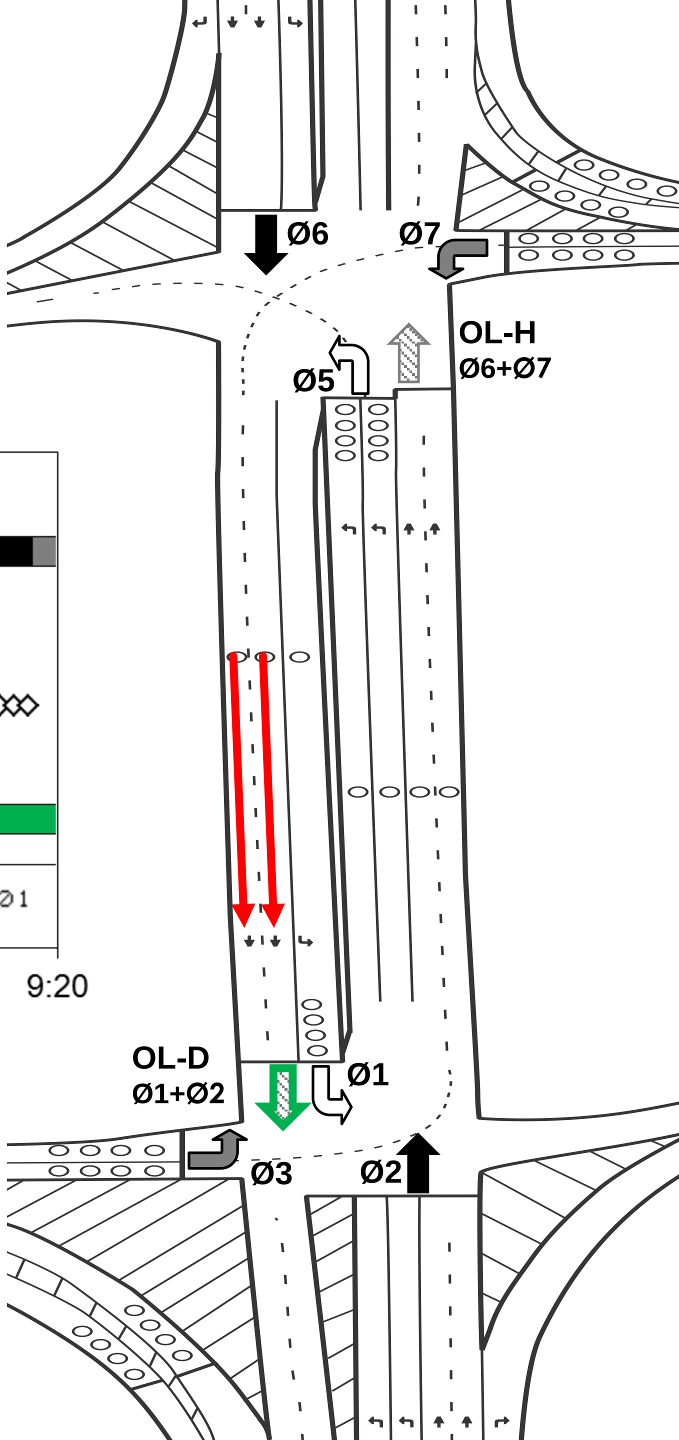


# Arrival on Green?

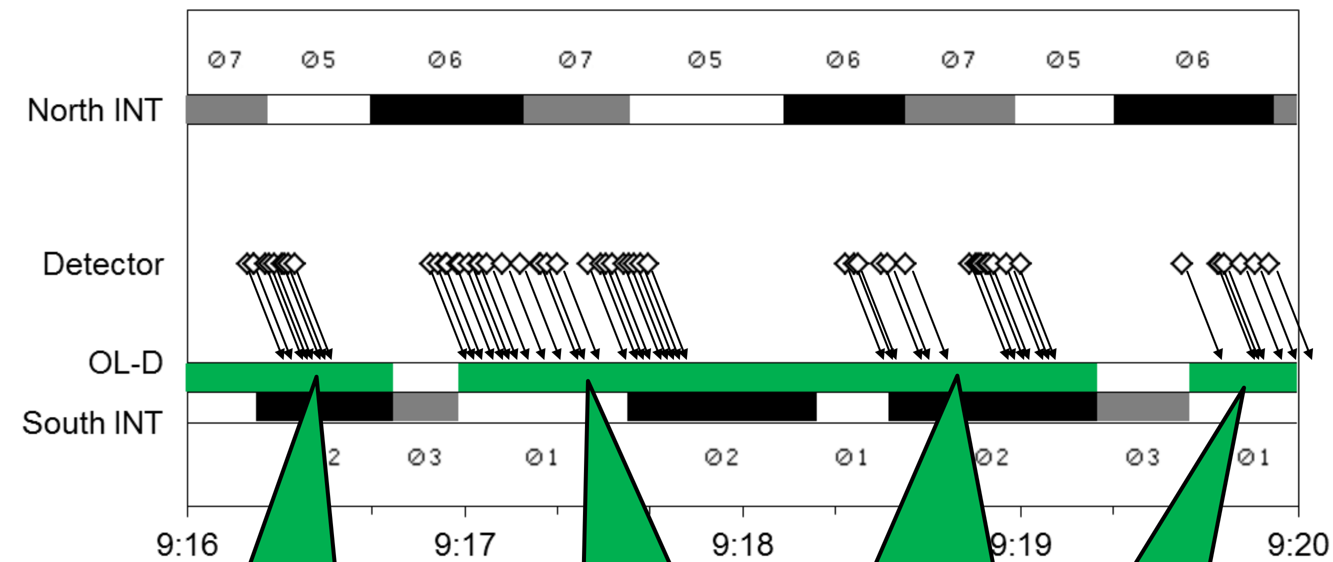
*Plot the green status of the overlap*

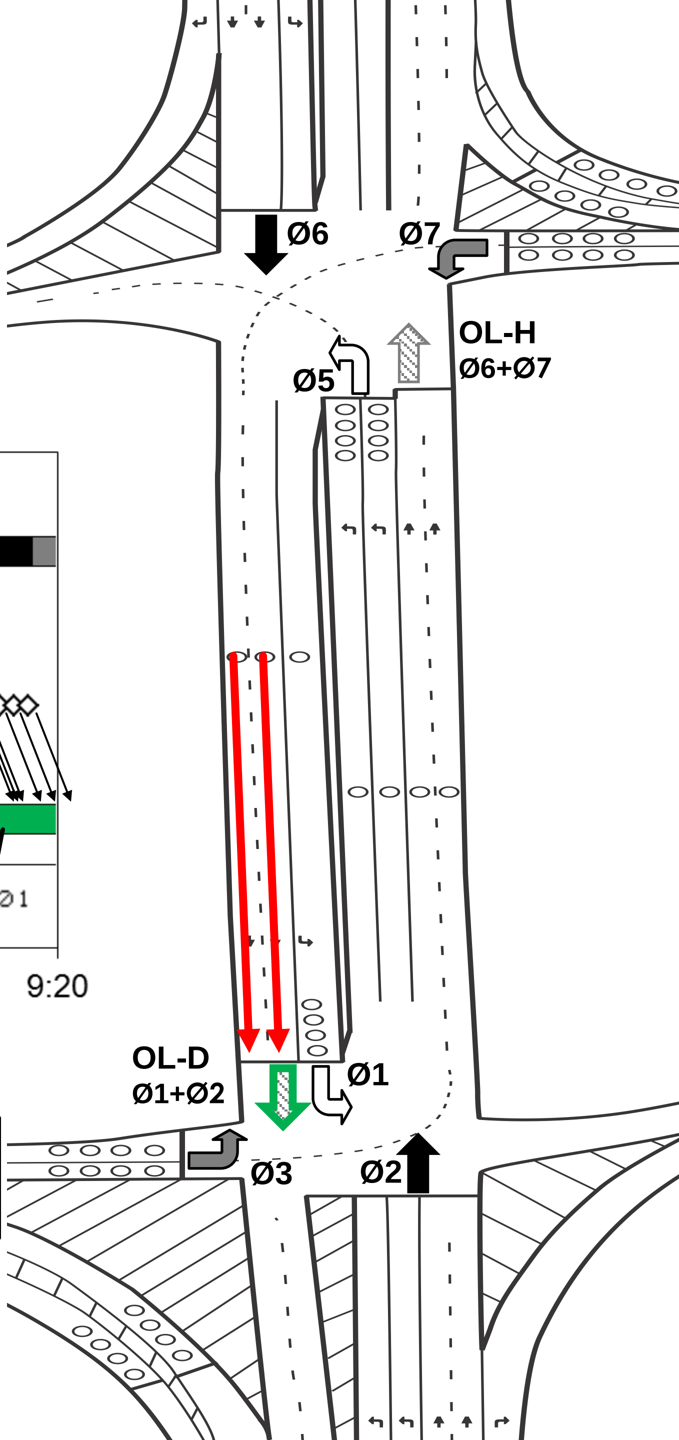


# Project the Detector Data

*295' upstream ≈ 5 seconds @ 40 MPH*

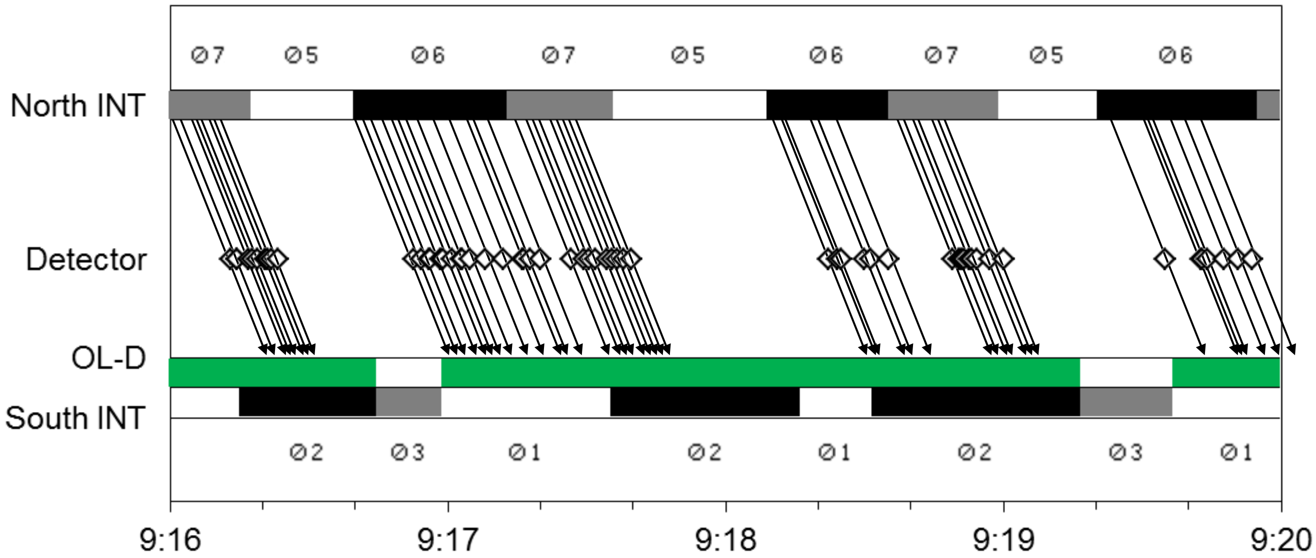


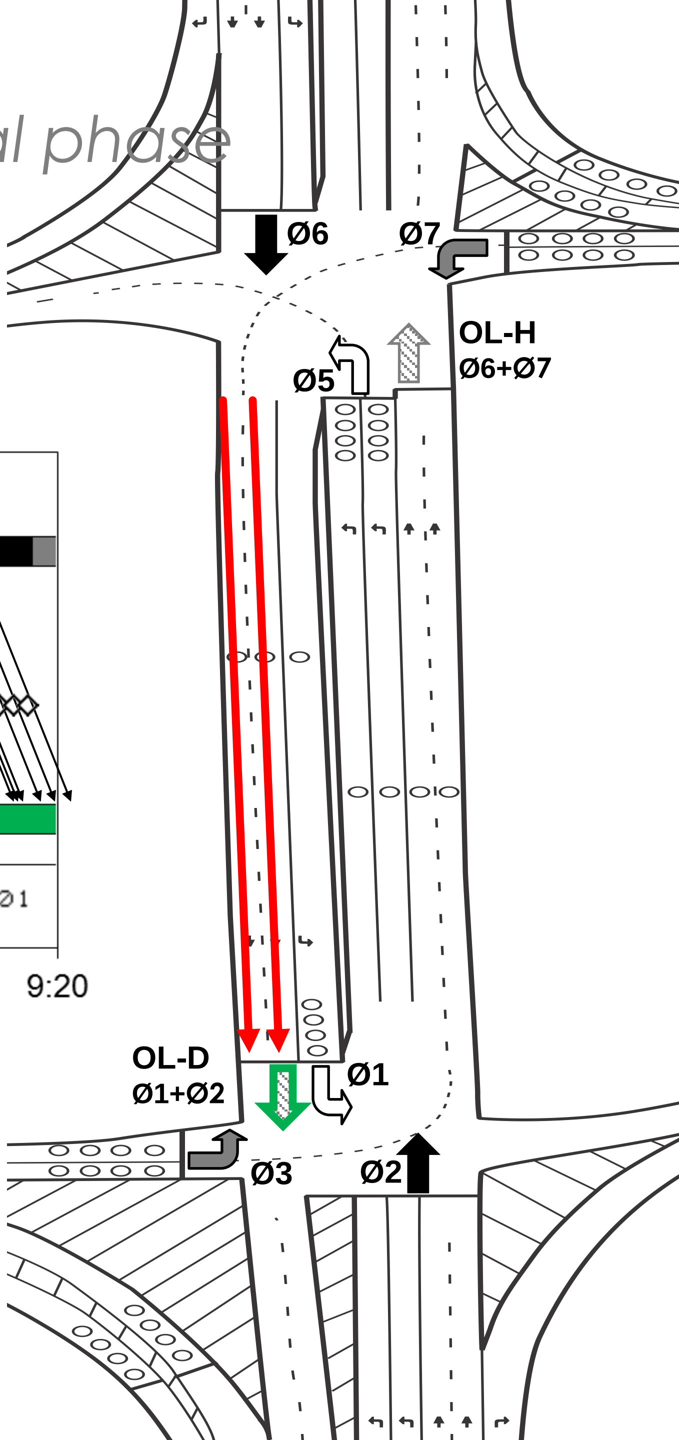




**The engineer who set the ring displacement did a fantastic job at arrivals on green for this movement!**

# Upstream Source Phase?

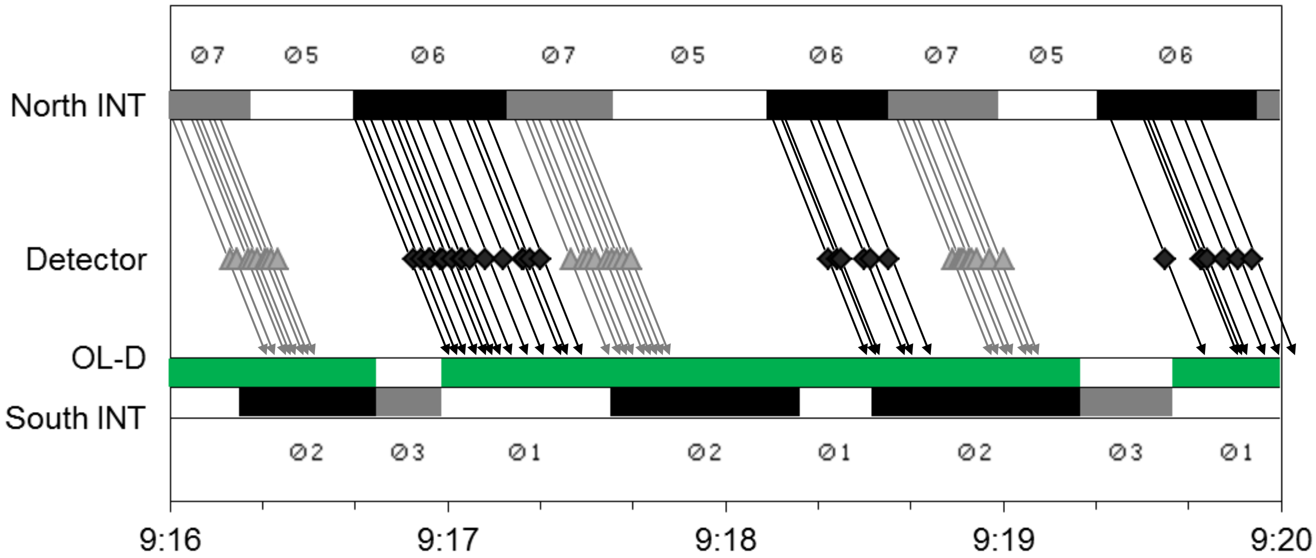
*Look upstream ~10 seconds at the signal phase*

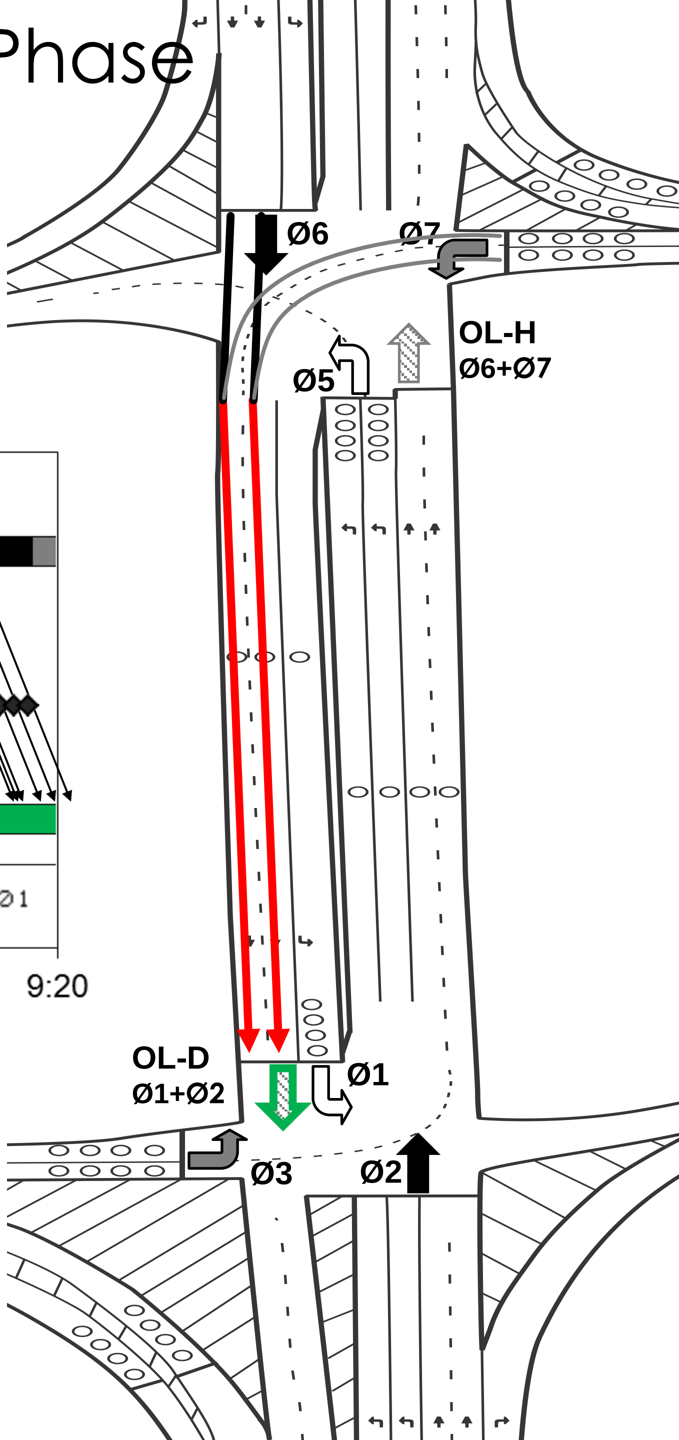


# Now Platoons are Attributed to a Phase

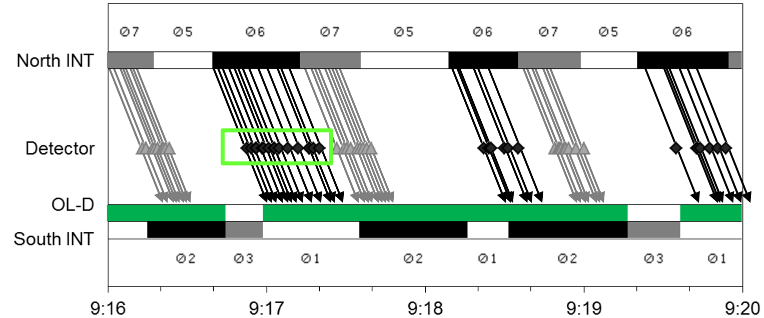
*The vehicles' sources are known*

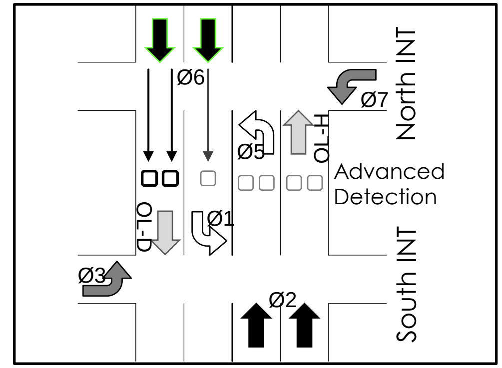


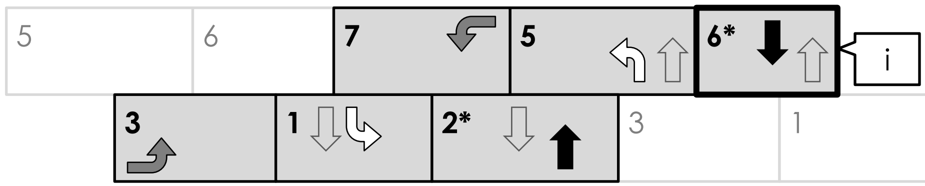



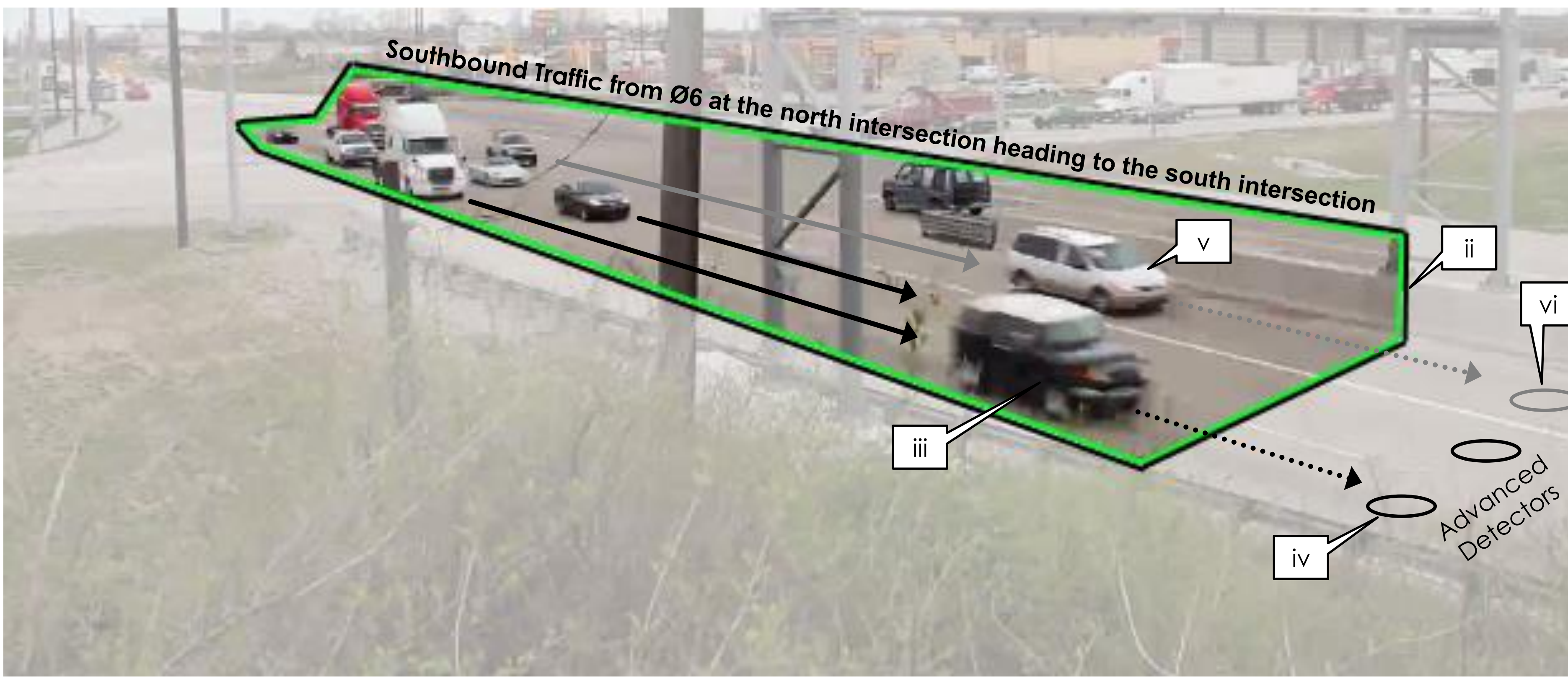
# Traffic from SBT

*Vehicles from Ø6*



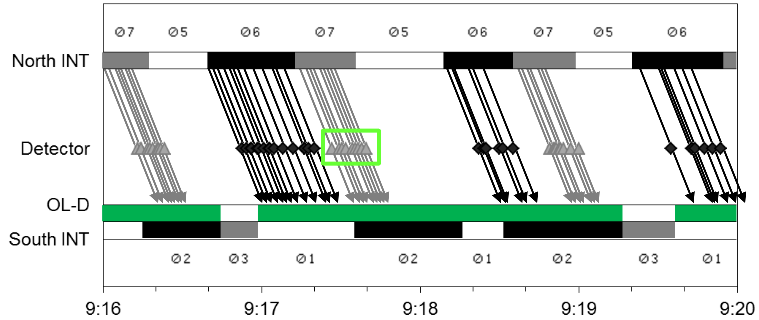



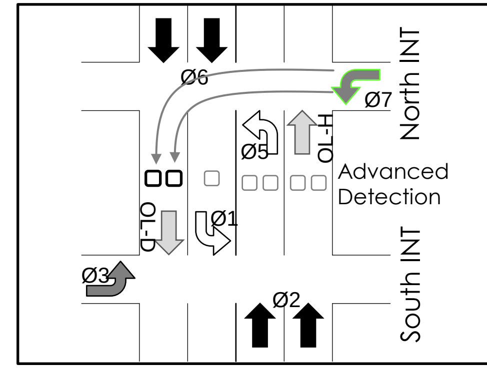



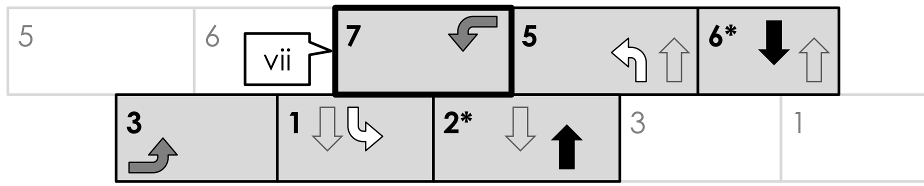



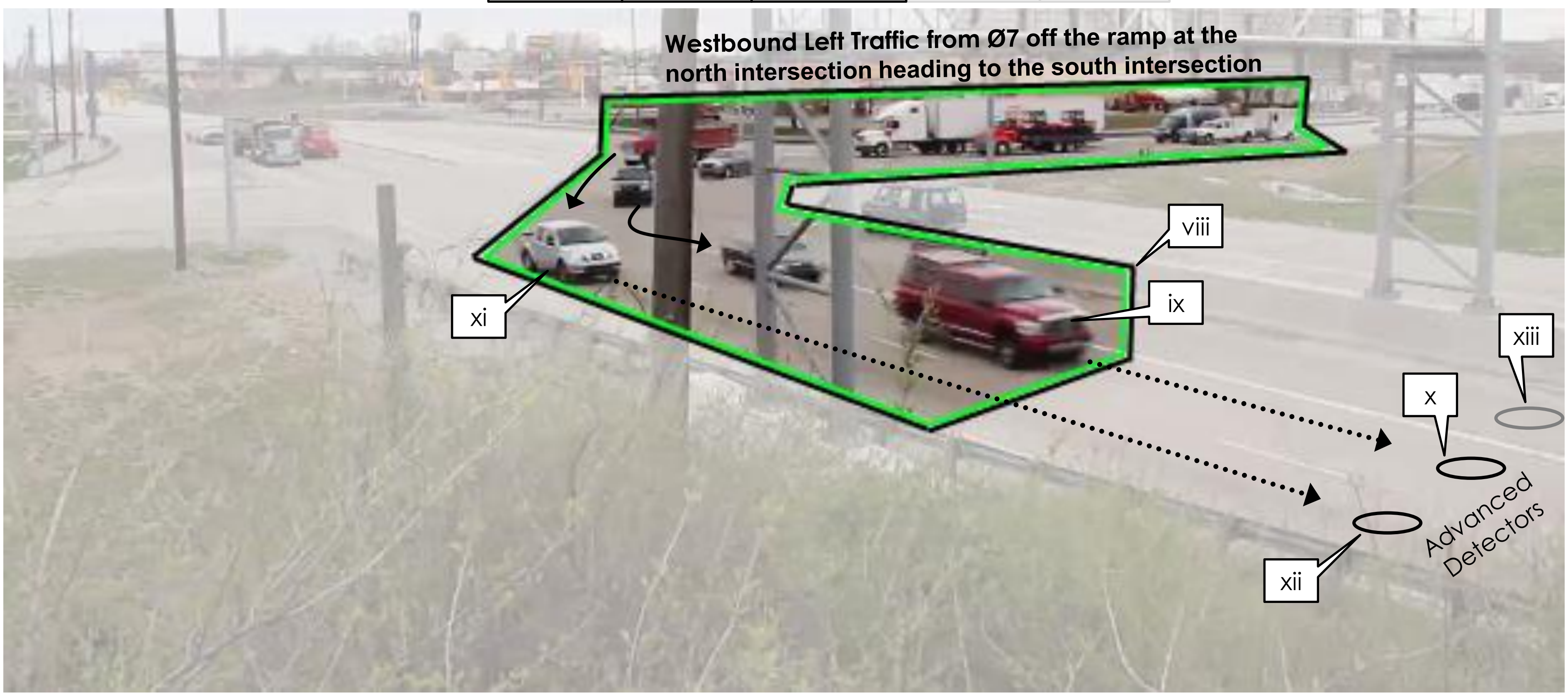
# Traffic from WBL

*Vehicles from Ø7*



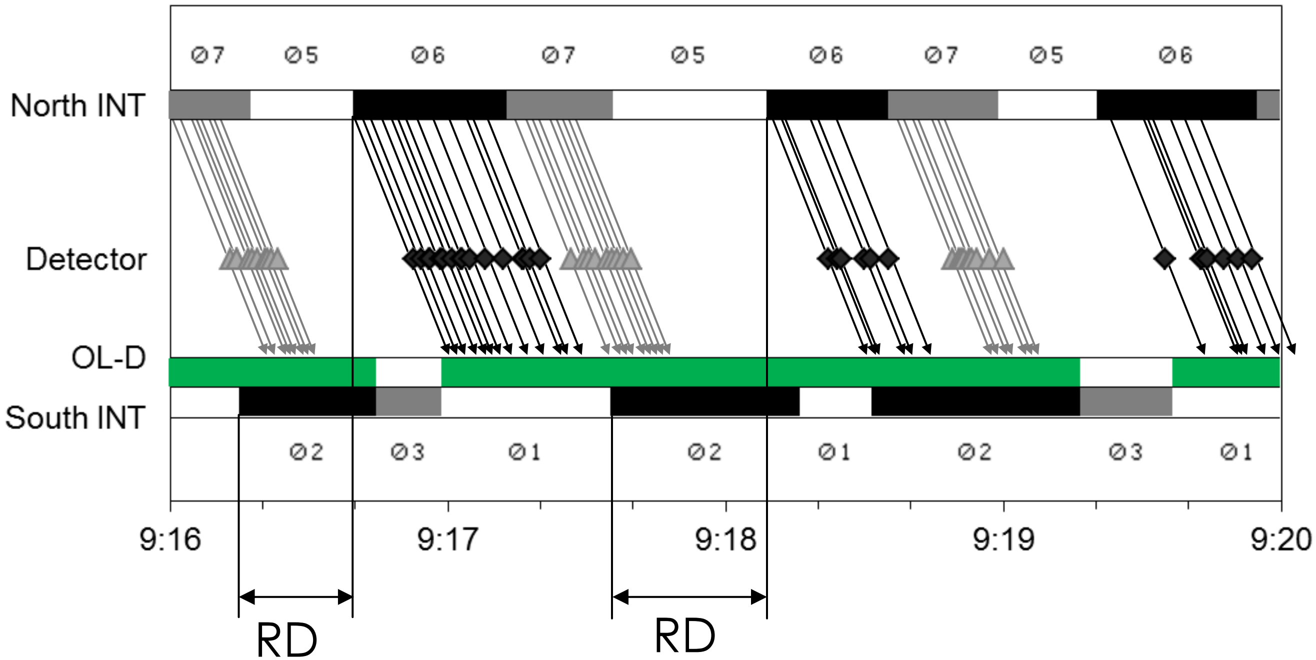



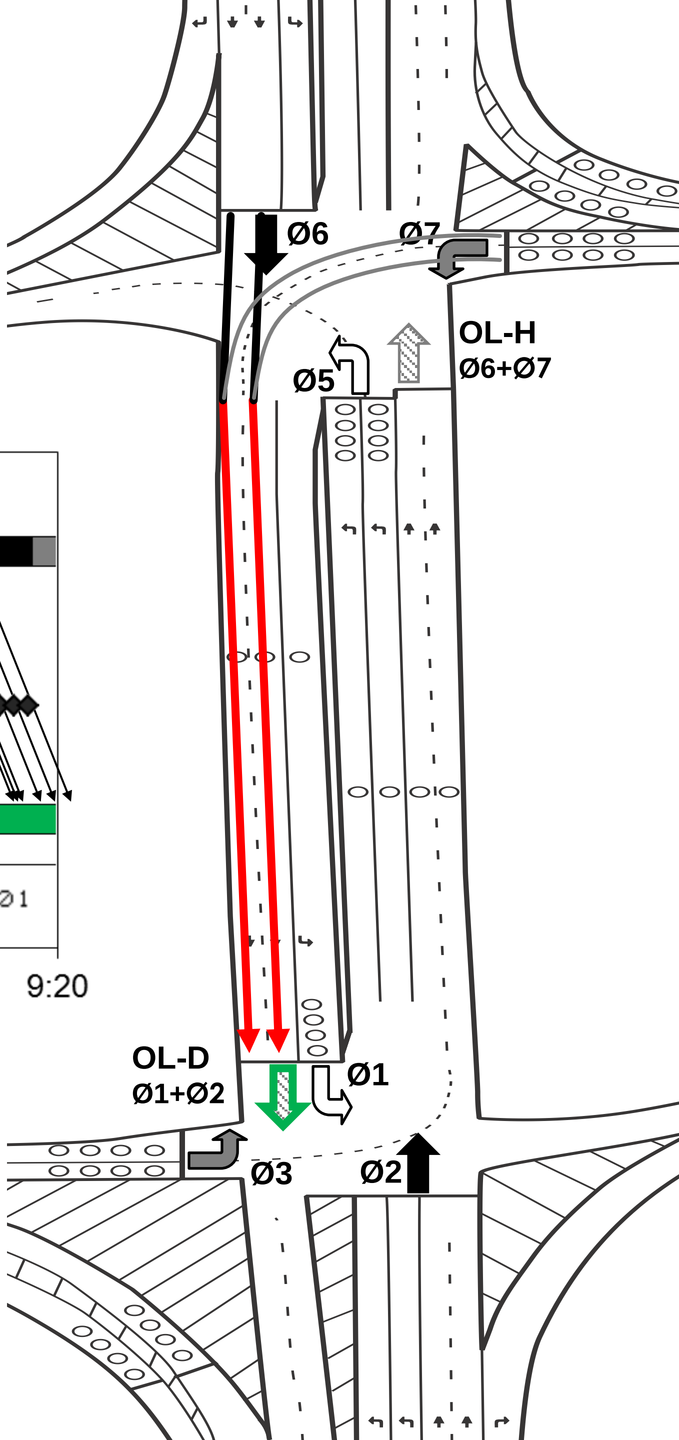



# Adjusting the ring displacement

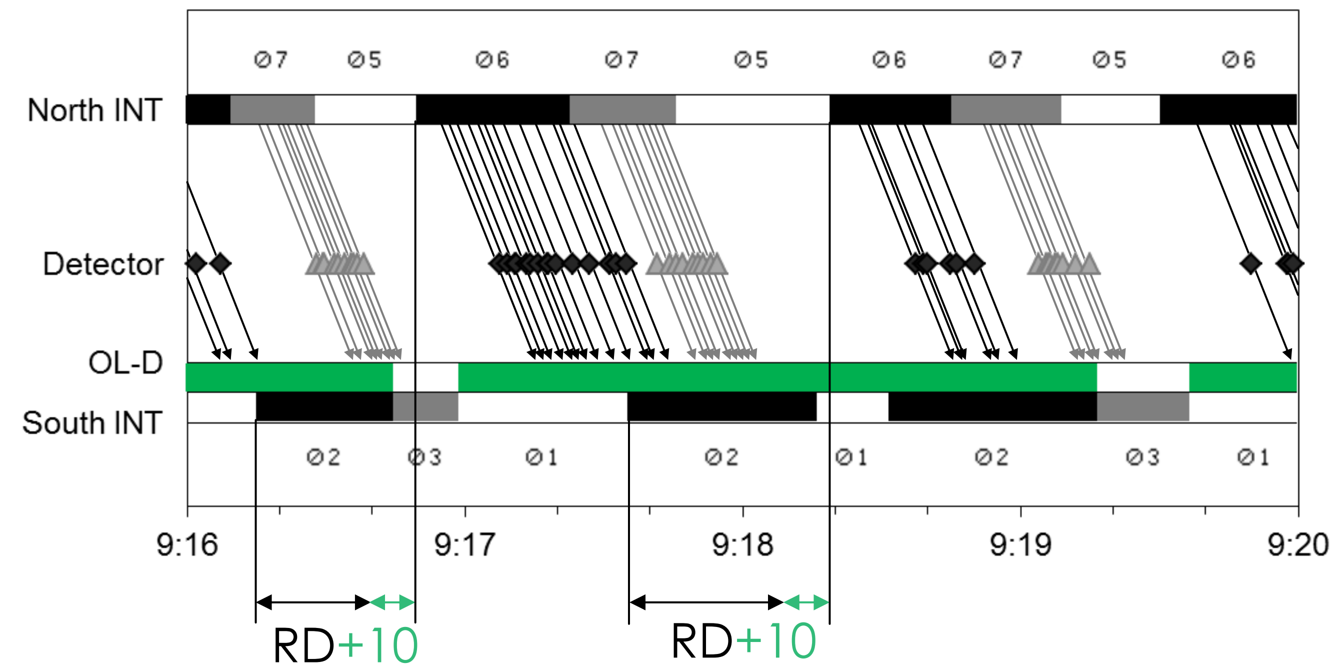
*What effect would it have?*

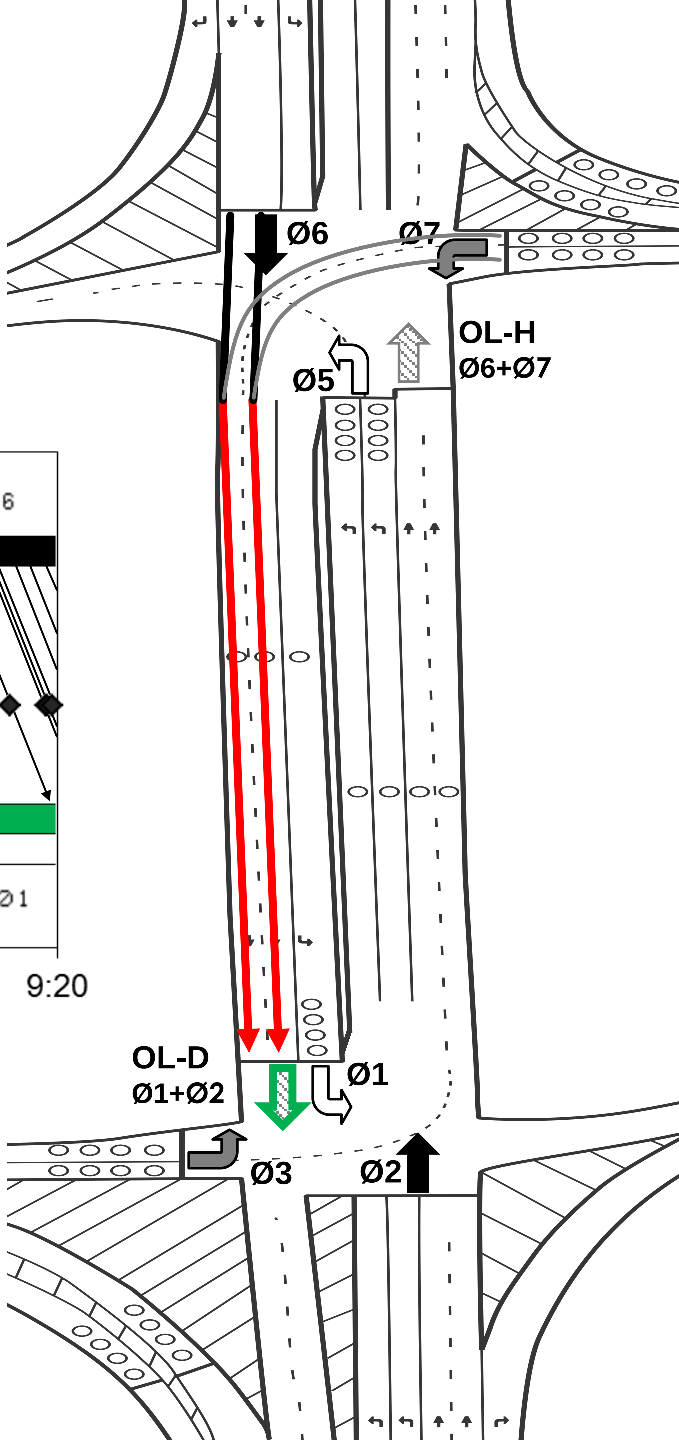


# Ring Displacement **+10 Seconds**

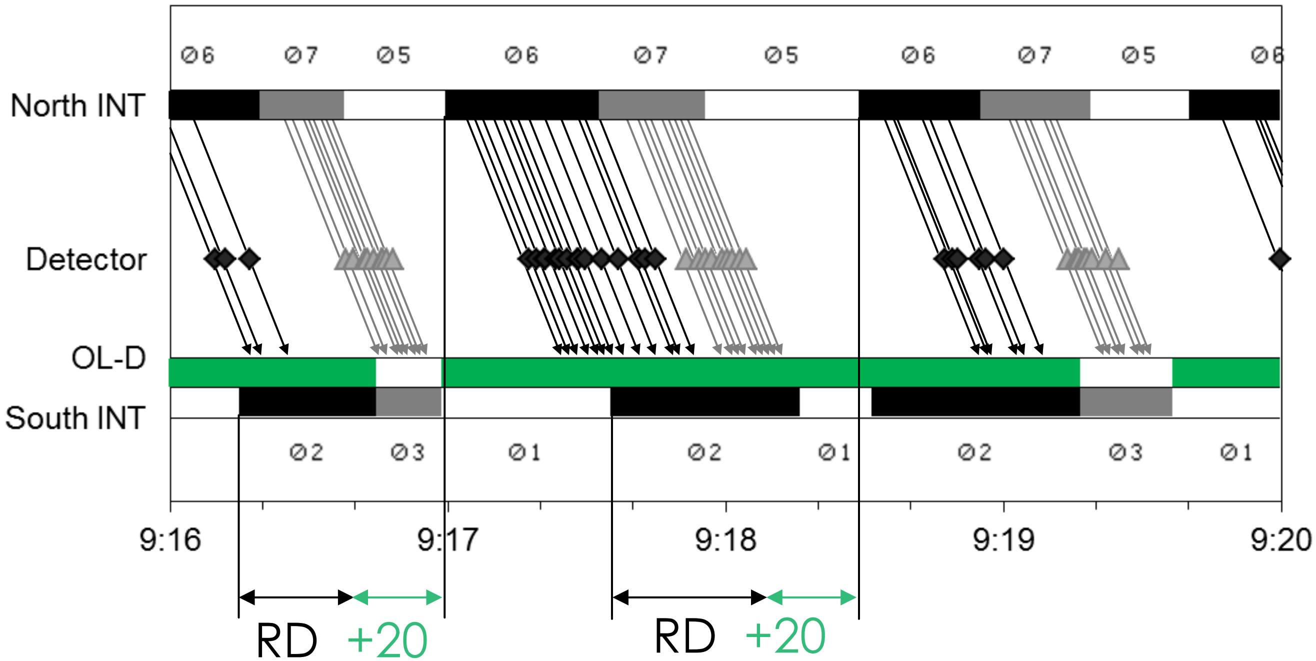
*What effect would it have?*

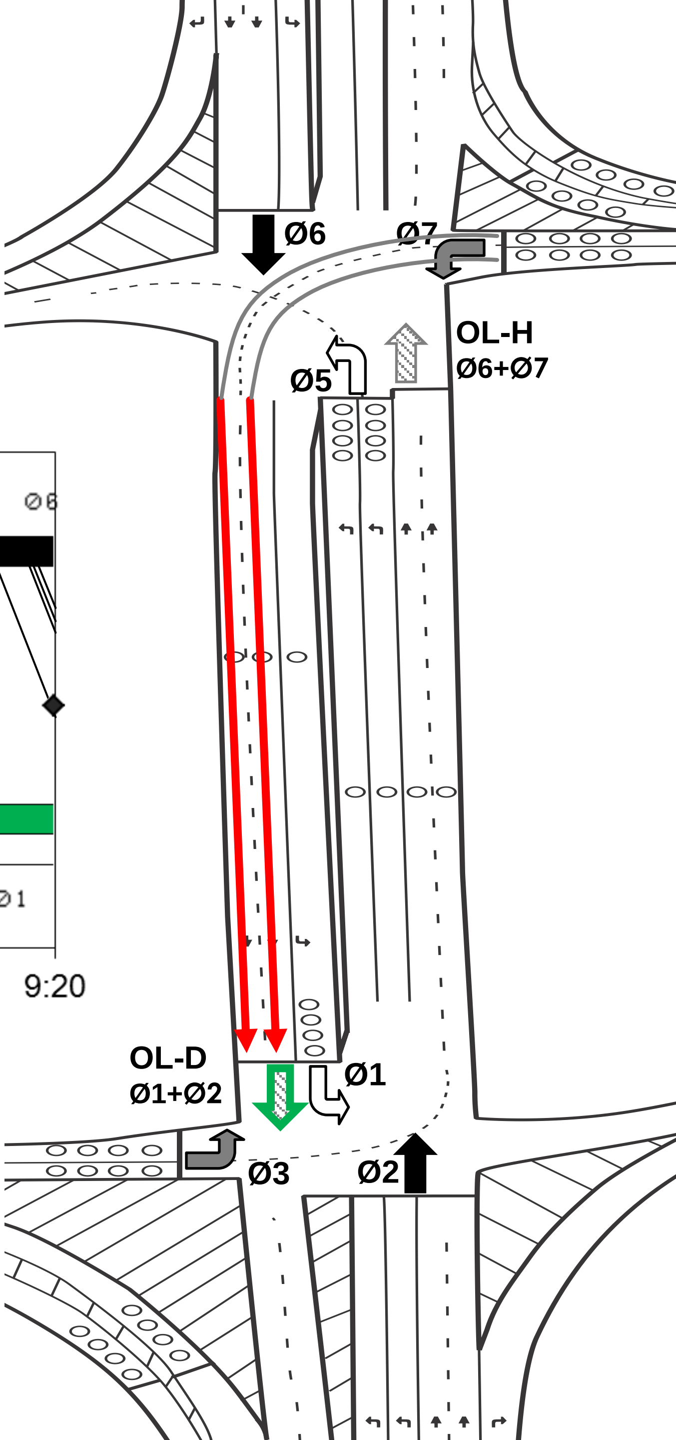


# Ring Displacement **+20 Seconds**

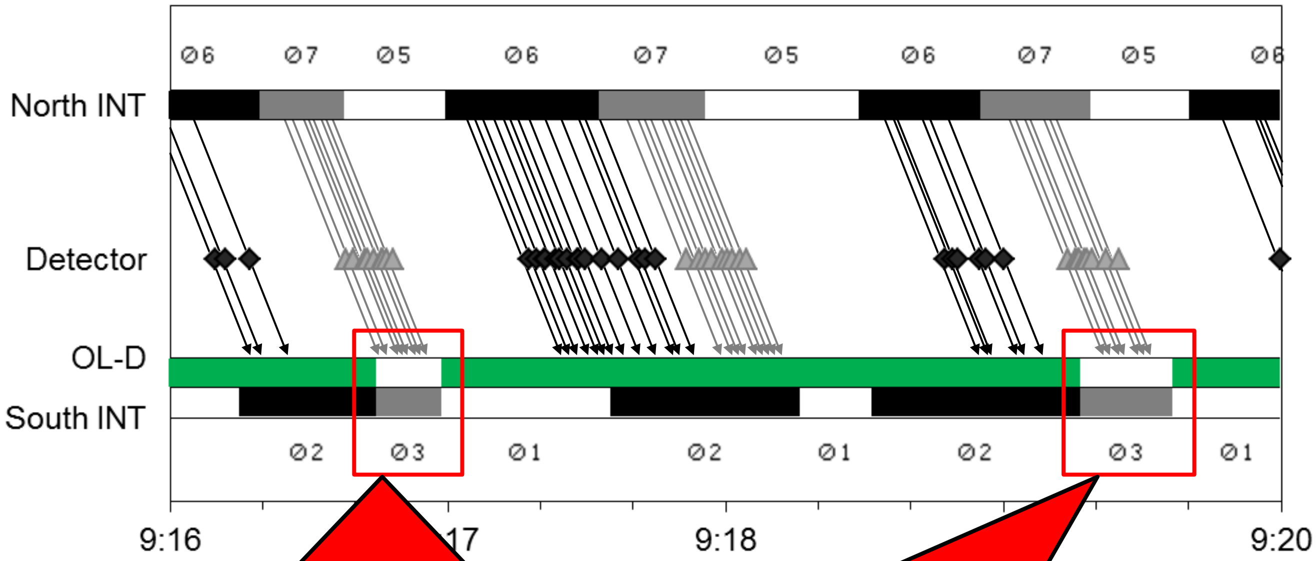
*Vehicles from upstream arrive later*

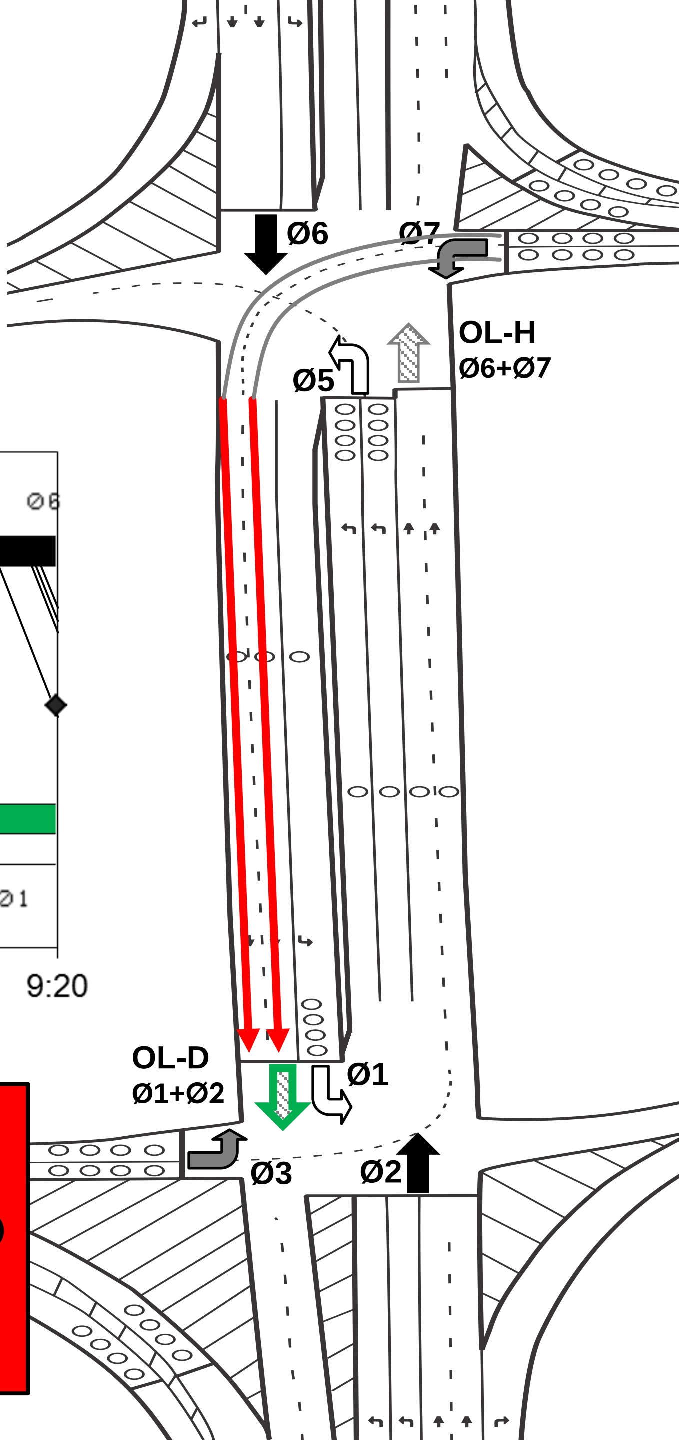


# Ring Displacement **+20 Seconds**

*Vehicles from upstream arrive later*



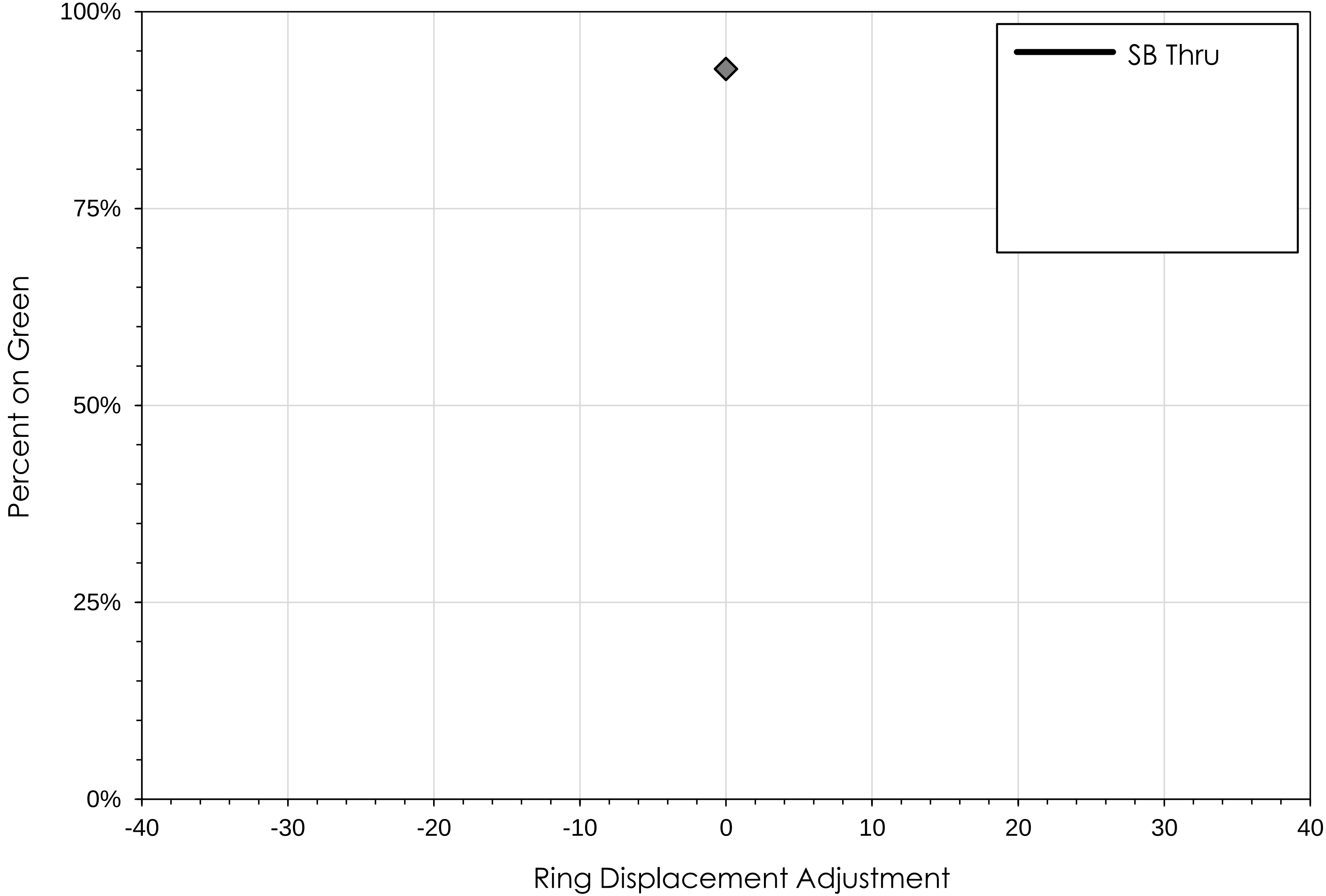




**By moving the ring displacement 20 seconds forward, the lagging WBL from the north ramp movement arrives at the south intersection on OL-D red while the EBL at the south ramp is served…**

**<u>Not Good!</u>**

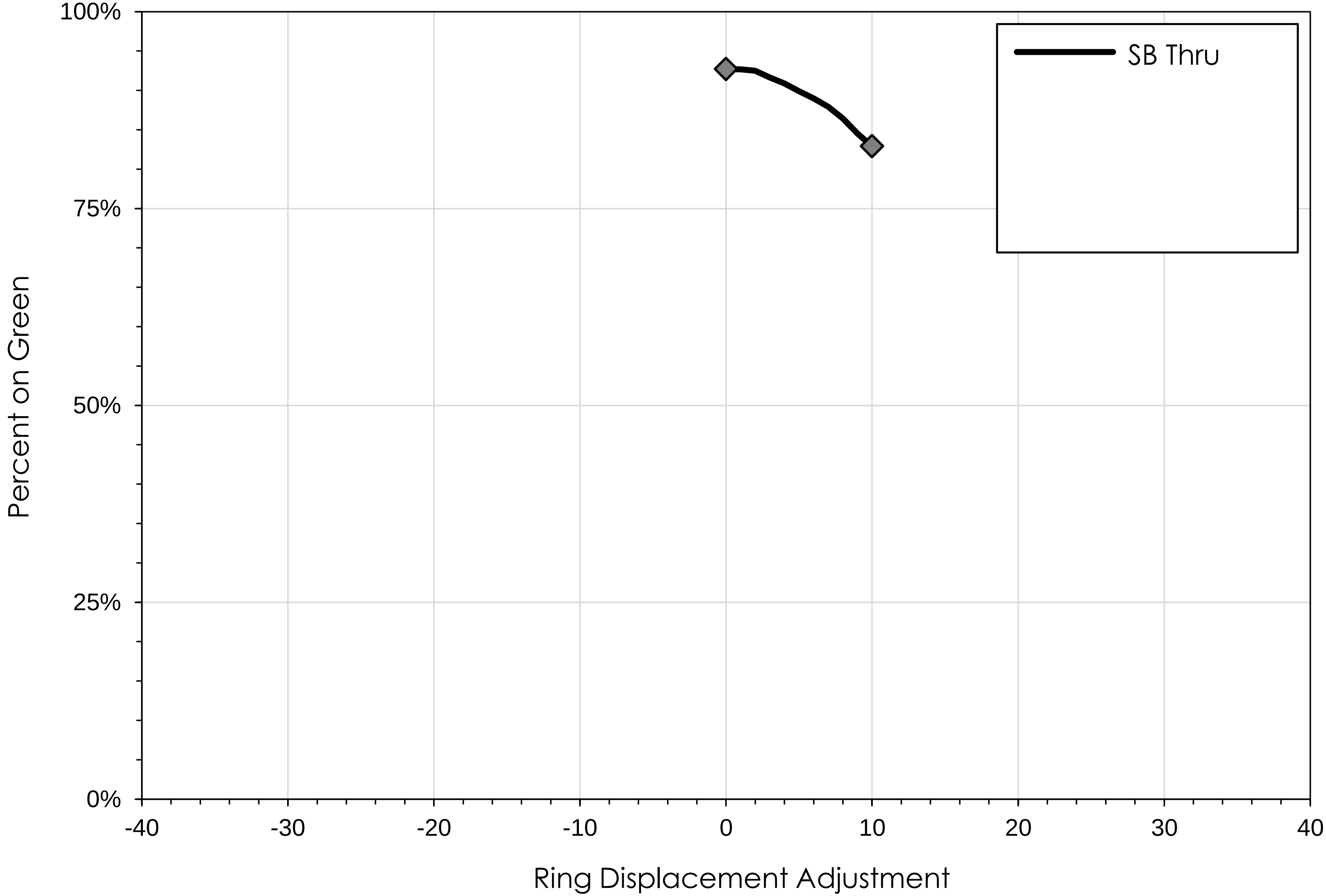
# Optimization Curves

*Let's Look at the Southbound Thru (Our +0, +10, +20 example)*



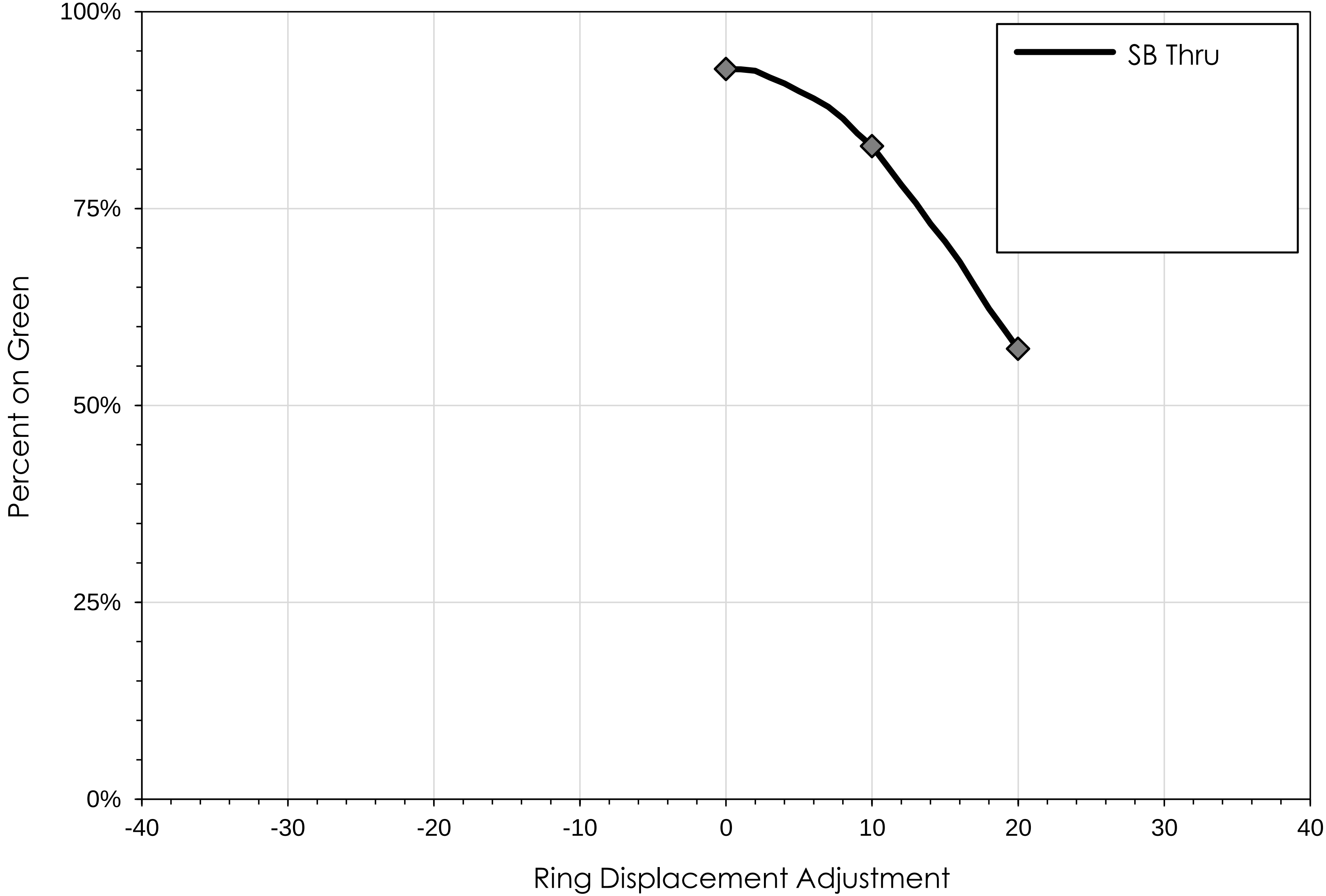
# Optimization Curves

*Southbound Thru +10*



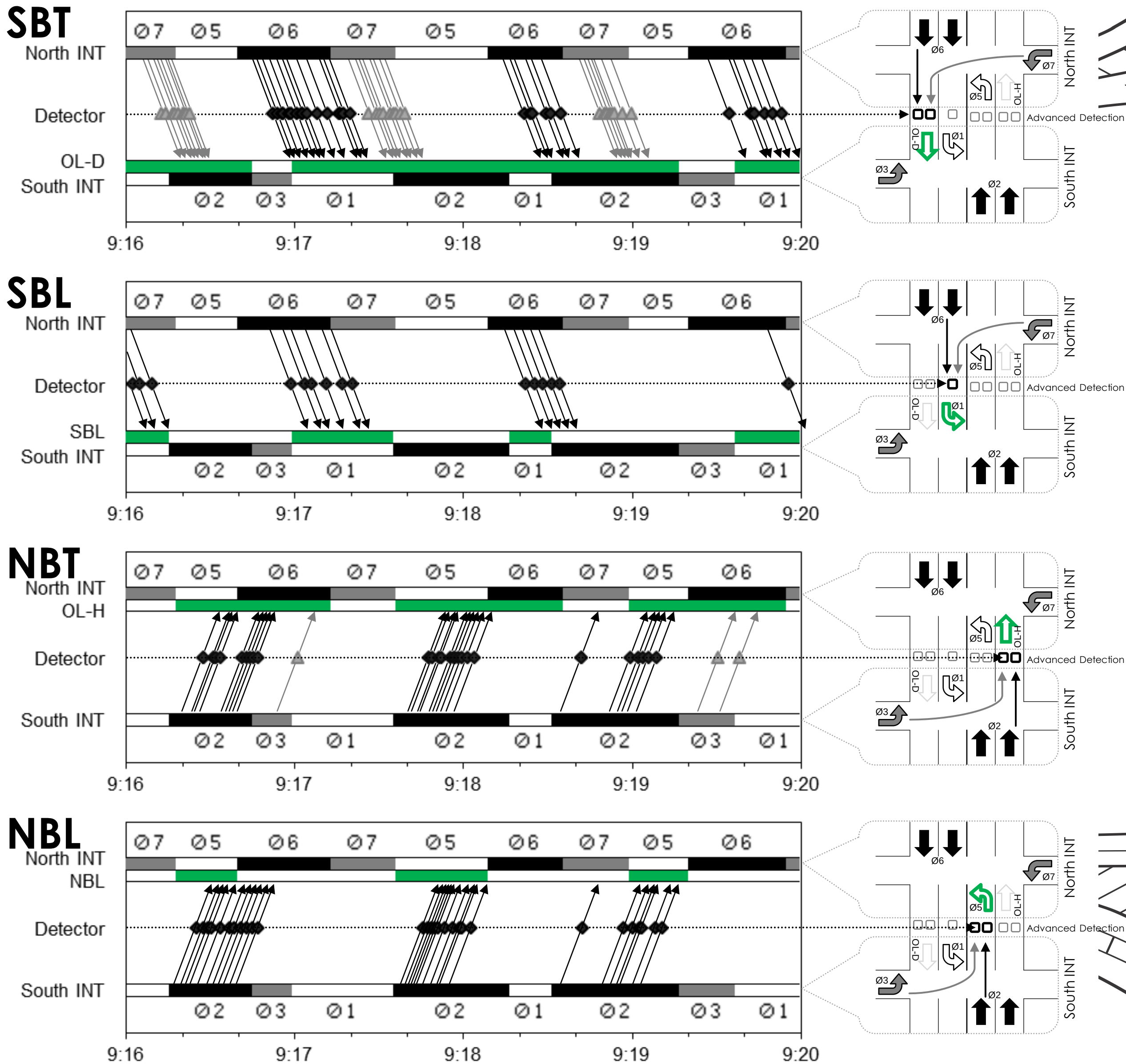
# Optimization Curves

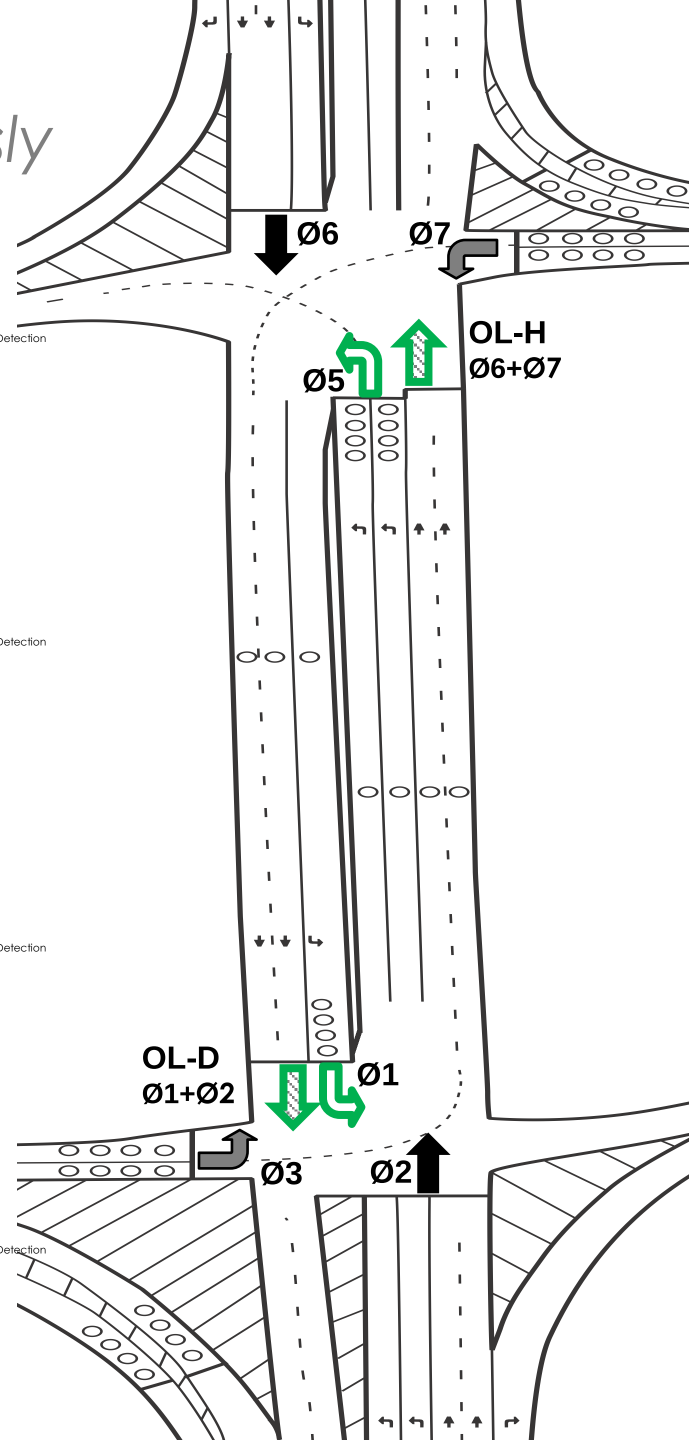
*Southbound Thru +20*



# Optimization Consideration

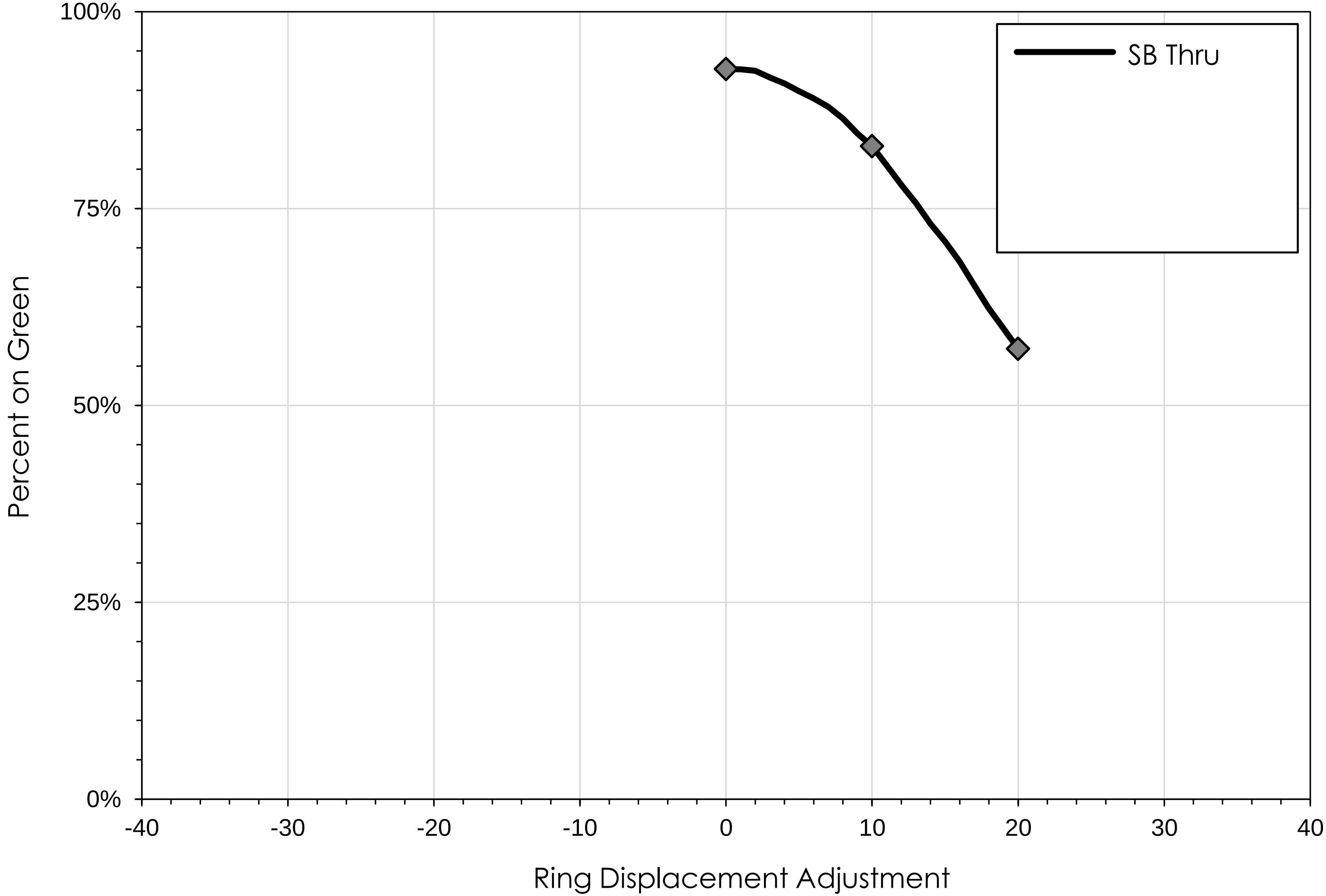
## *Consider All 4 Movements Simultaneously*



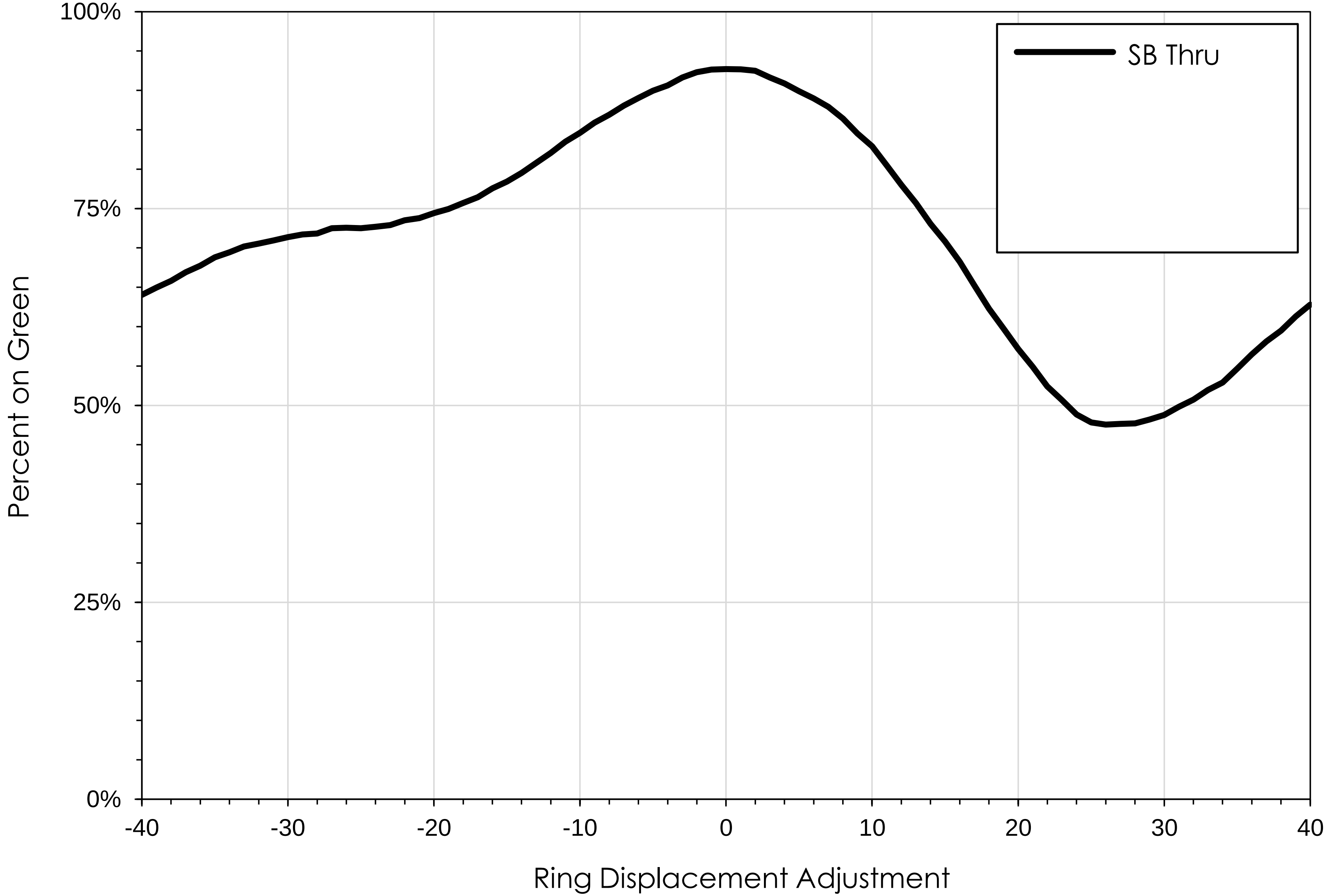
# Optimization Curves

*Southbound Thru +20*



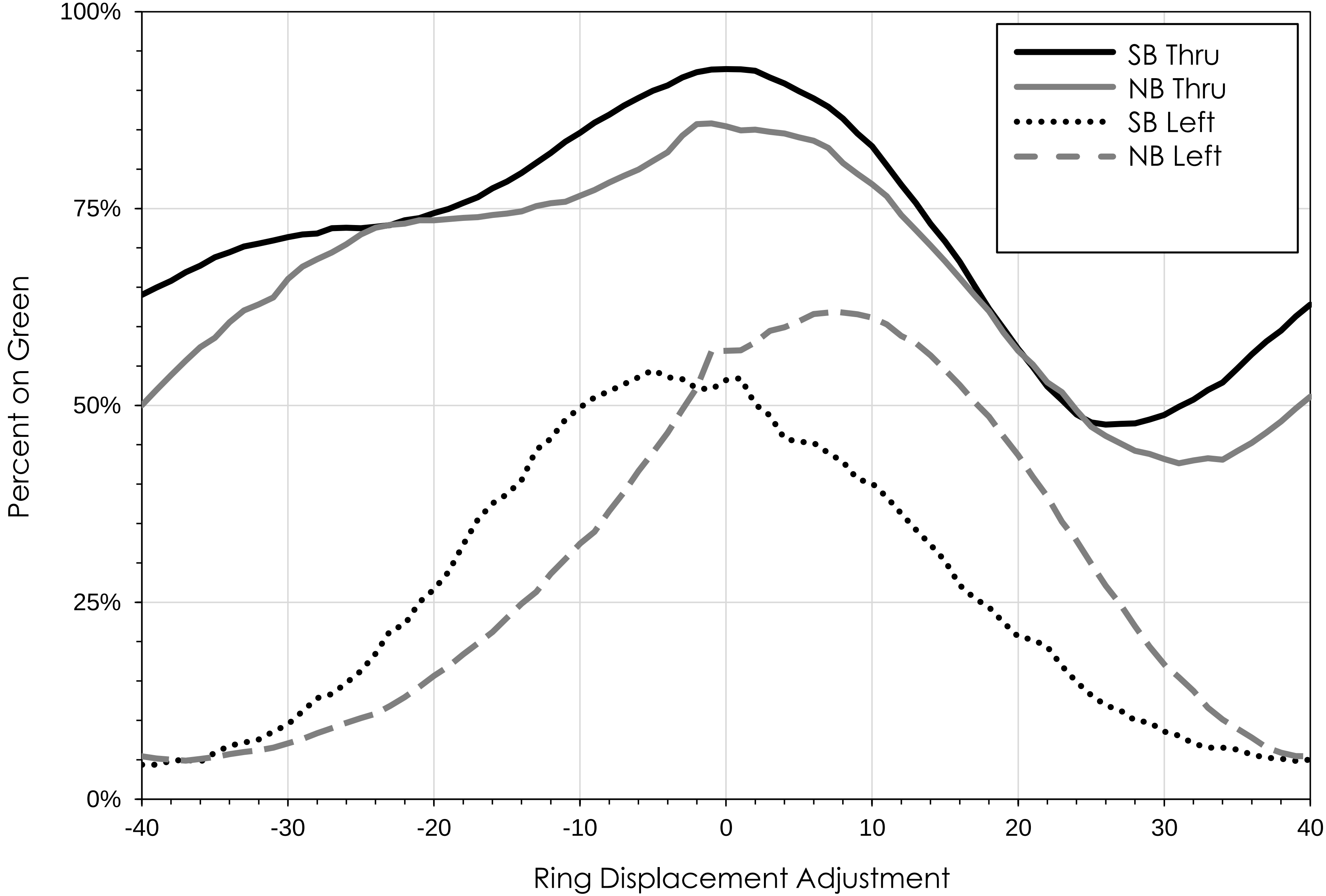
# Optimization Curves

*Southbound Thru for the Full Sweep*



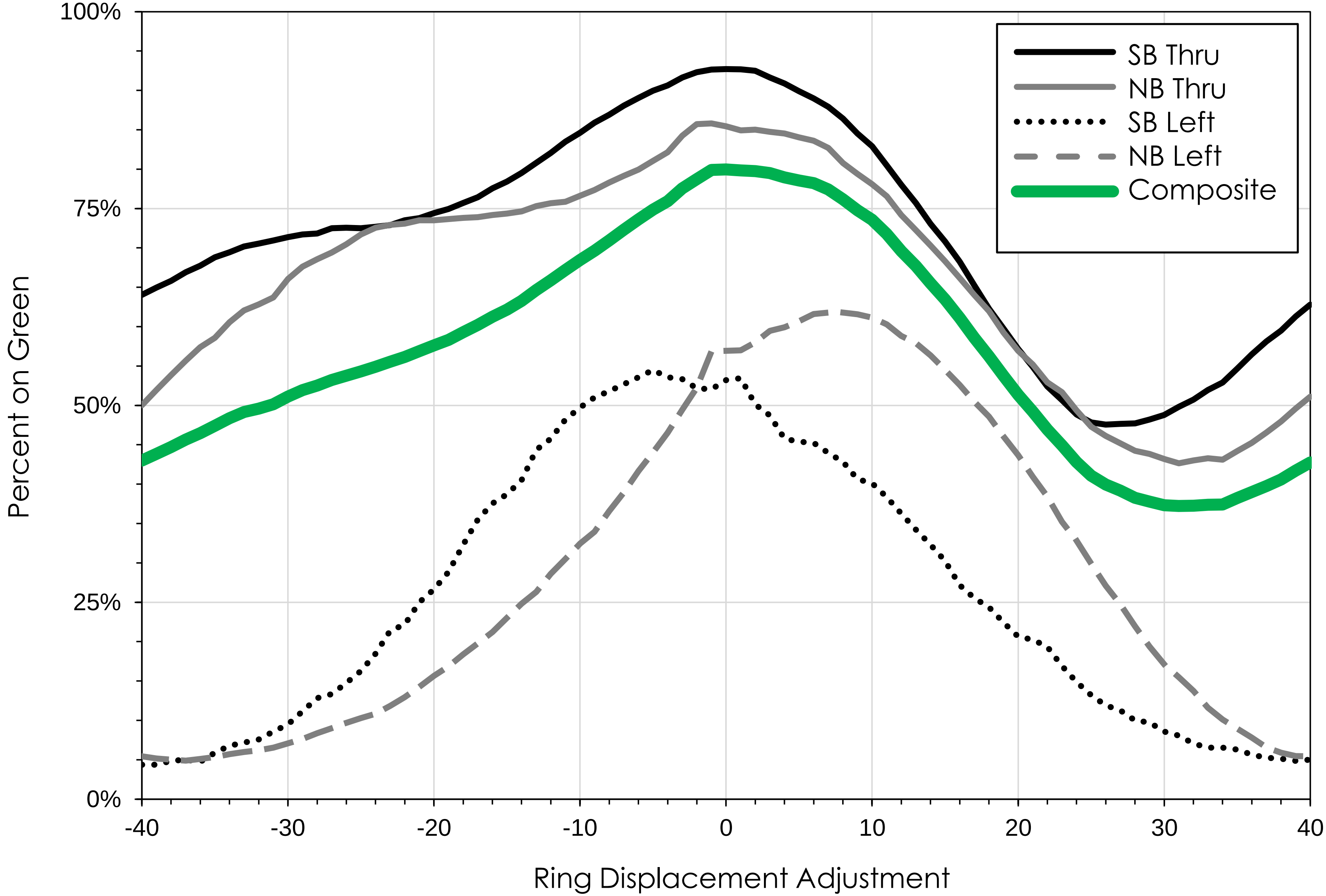
# Optimization Curves

*Northbound Left*



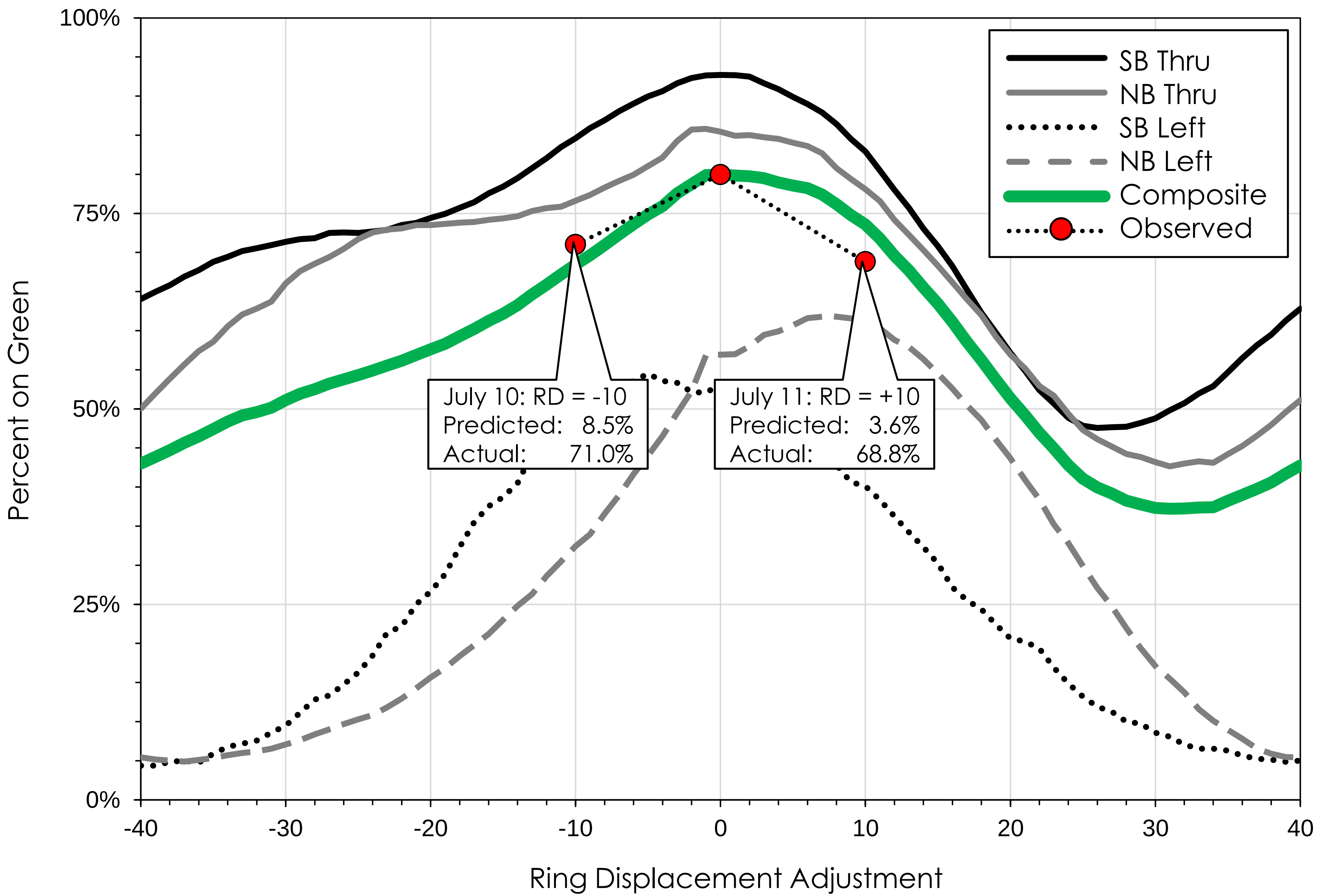
# Composite Interchange Sweep

*This is where all four movements are considered simultaneously*



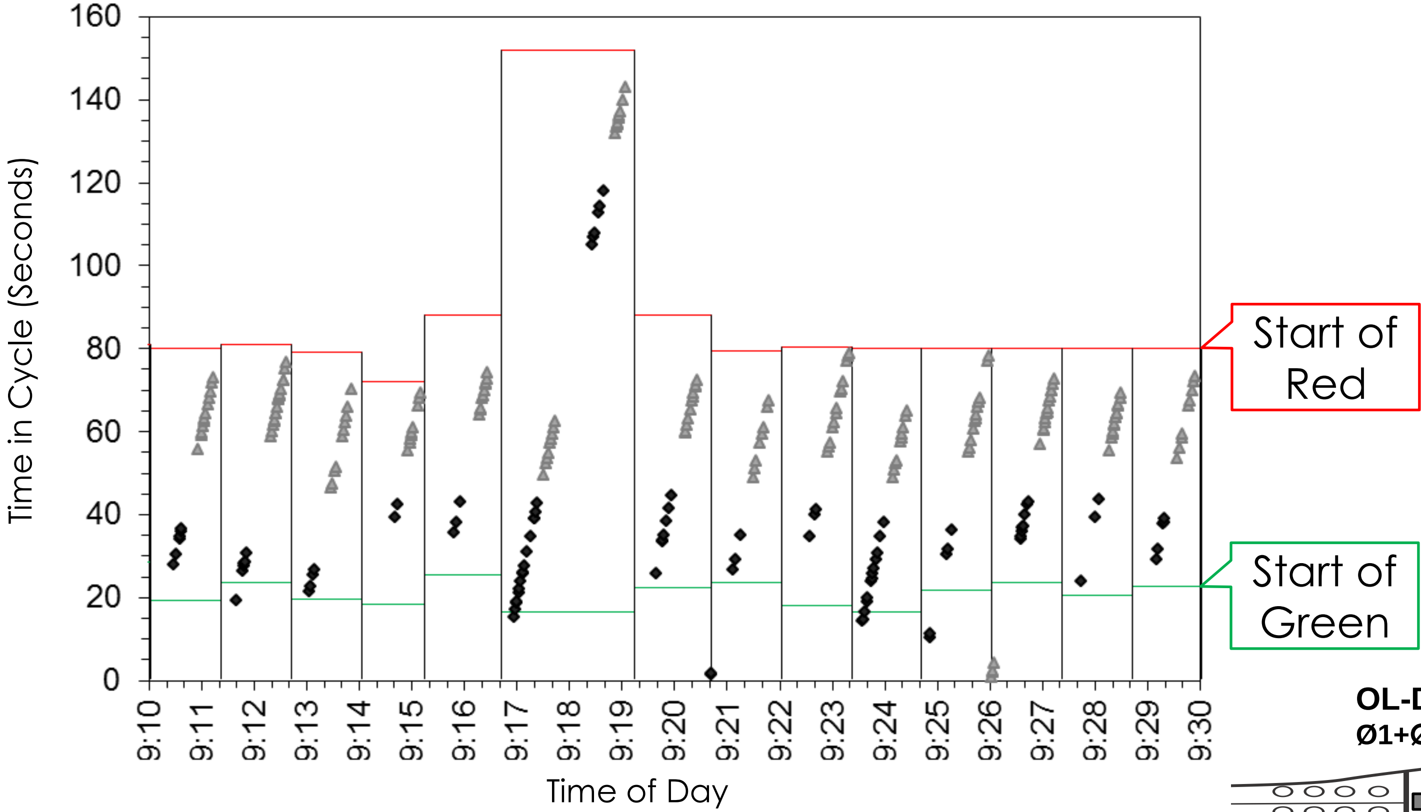
# Field Evaluation

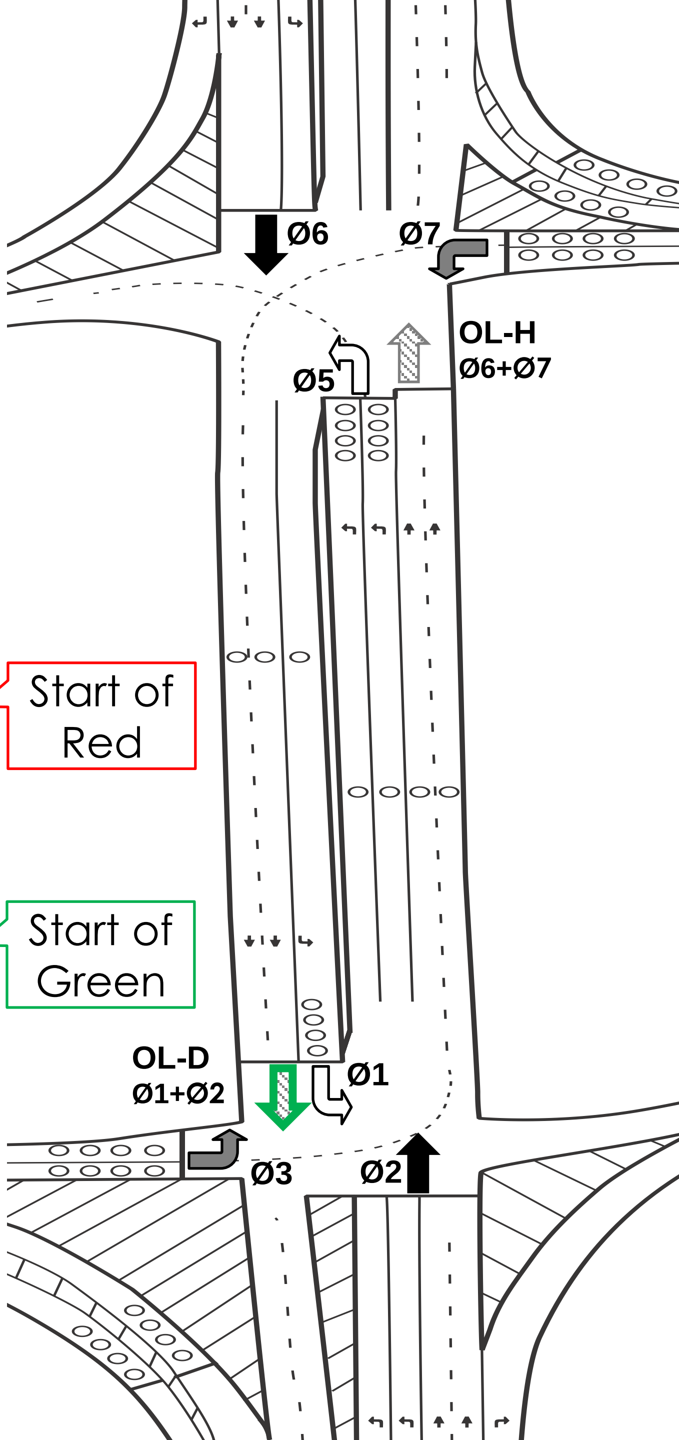
*Adjust +/- 10 to see how it worked in the field*



# Purdue Coordination Diagram

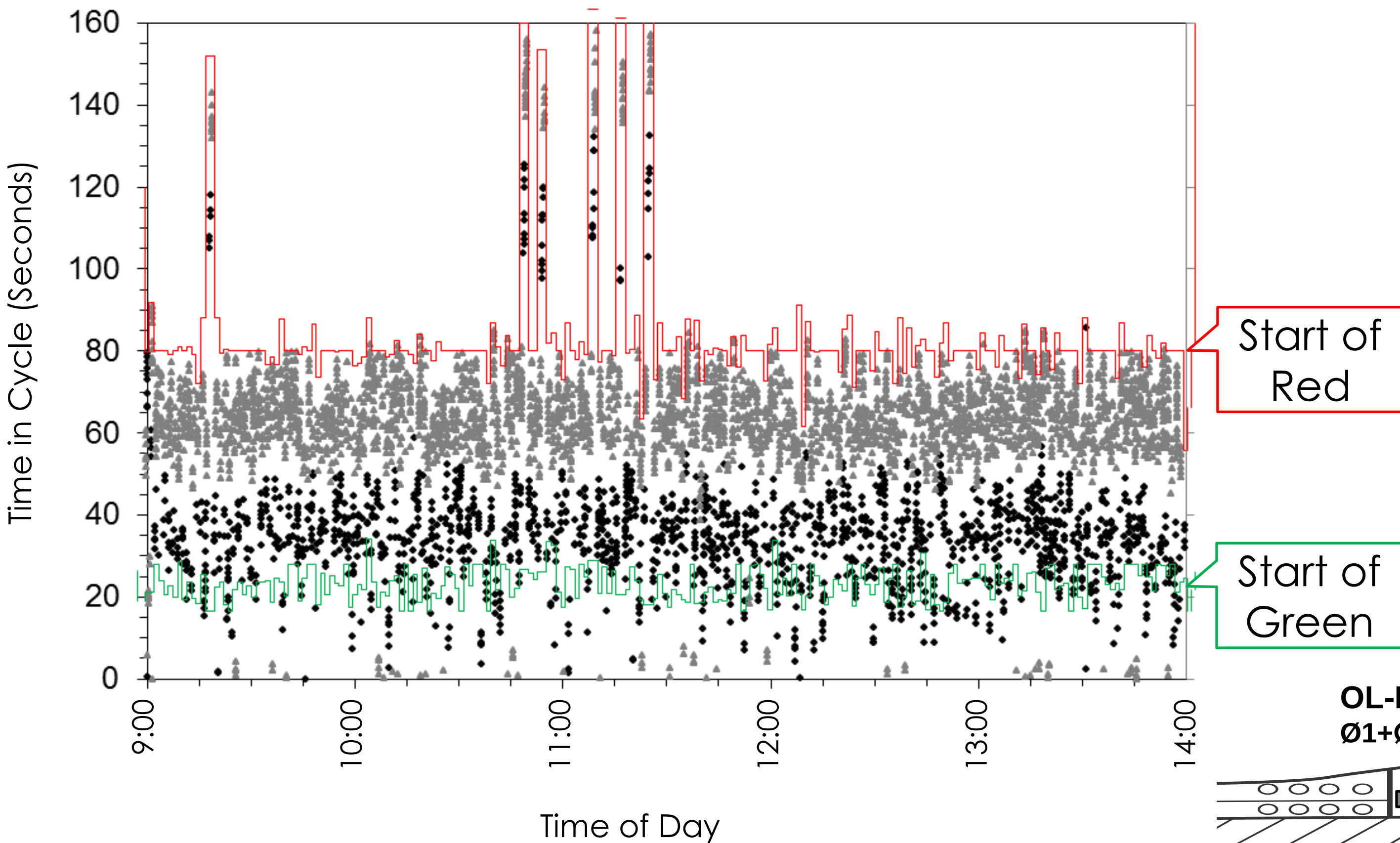
*Also Useful to Visualize Arrivals on Green*

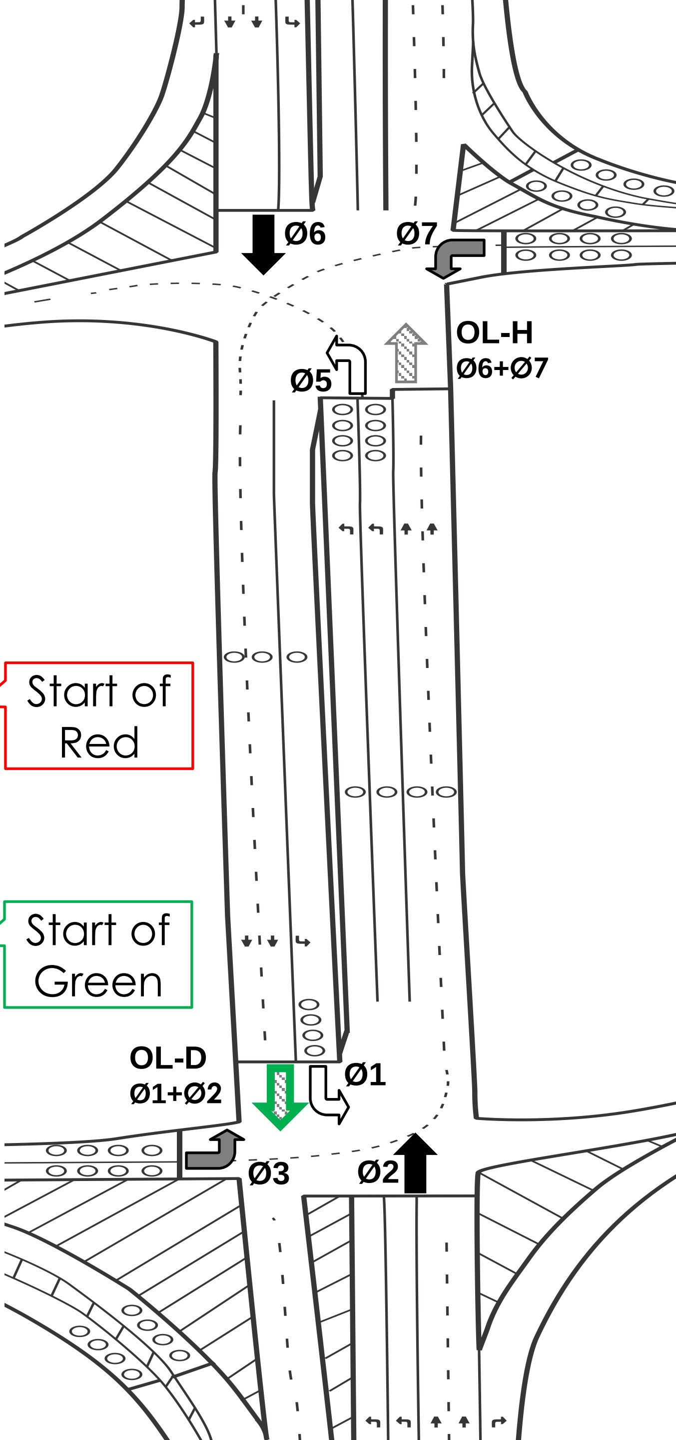


# Purdue Coordination Diagram

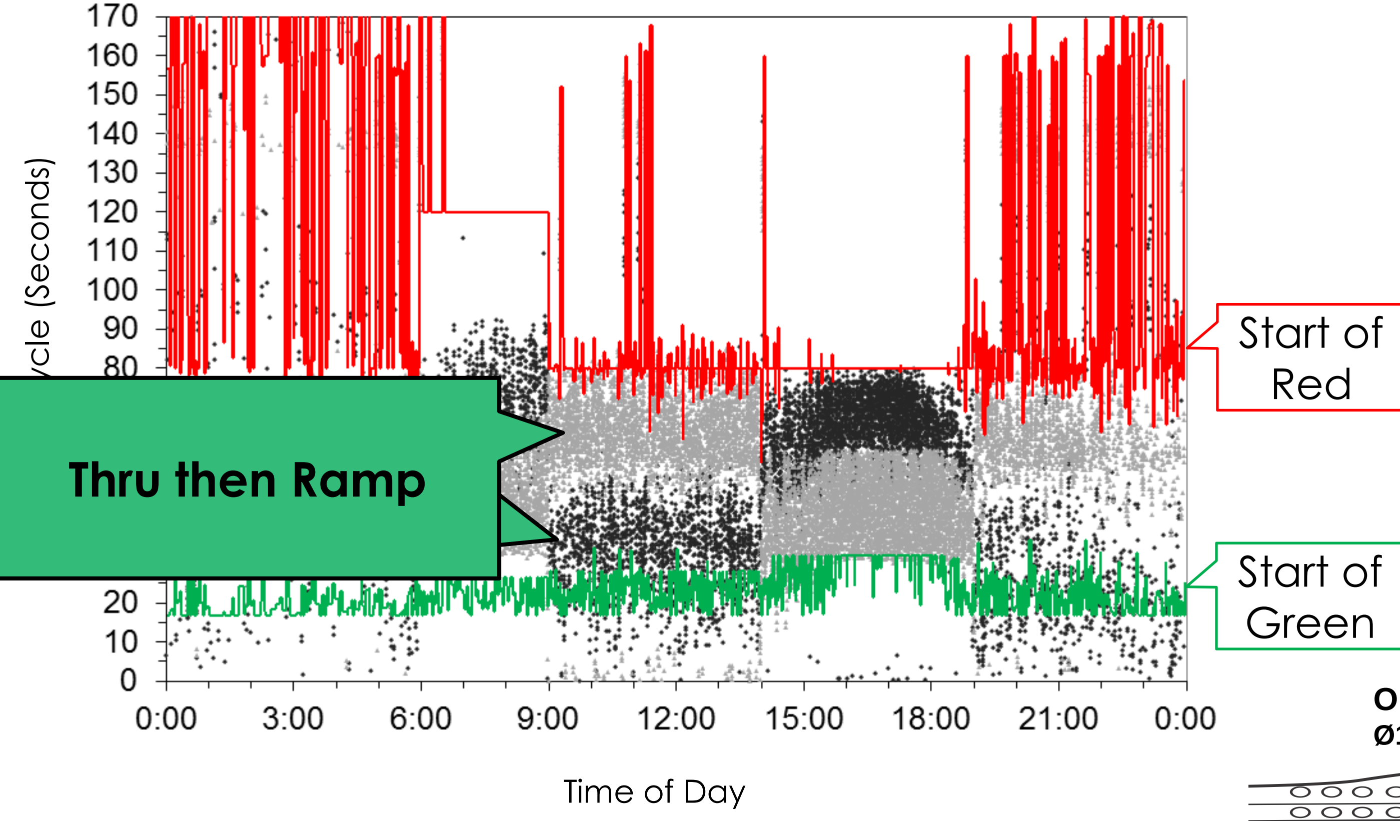
*Looking at an entire plan (0900-1400)*

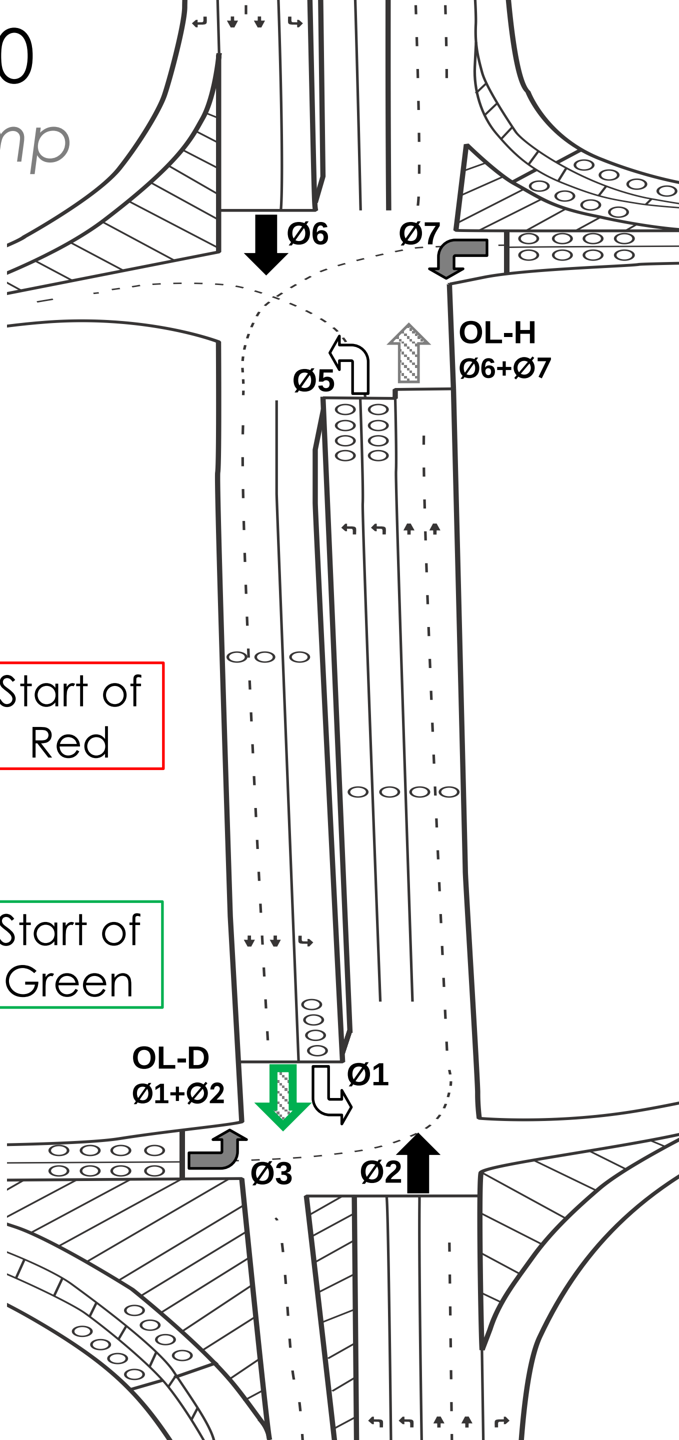


# 24HR PCD: Sequence for 0900-1400

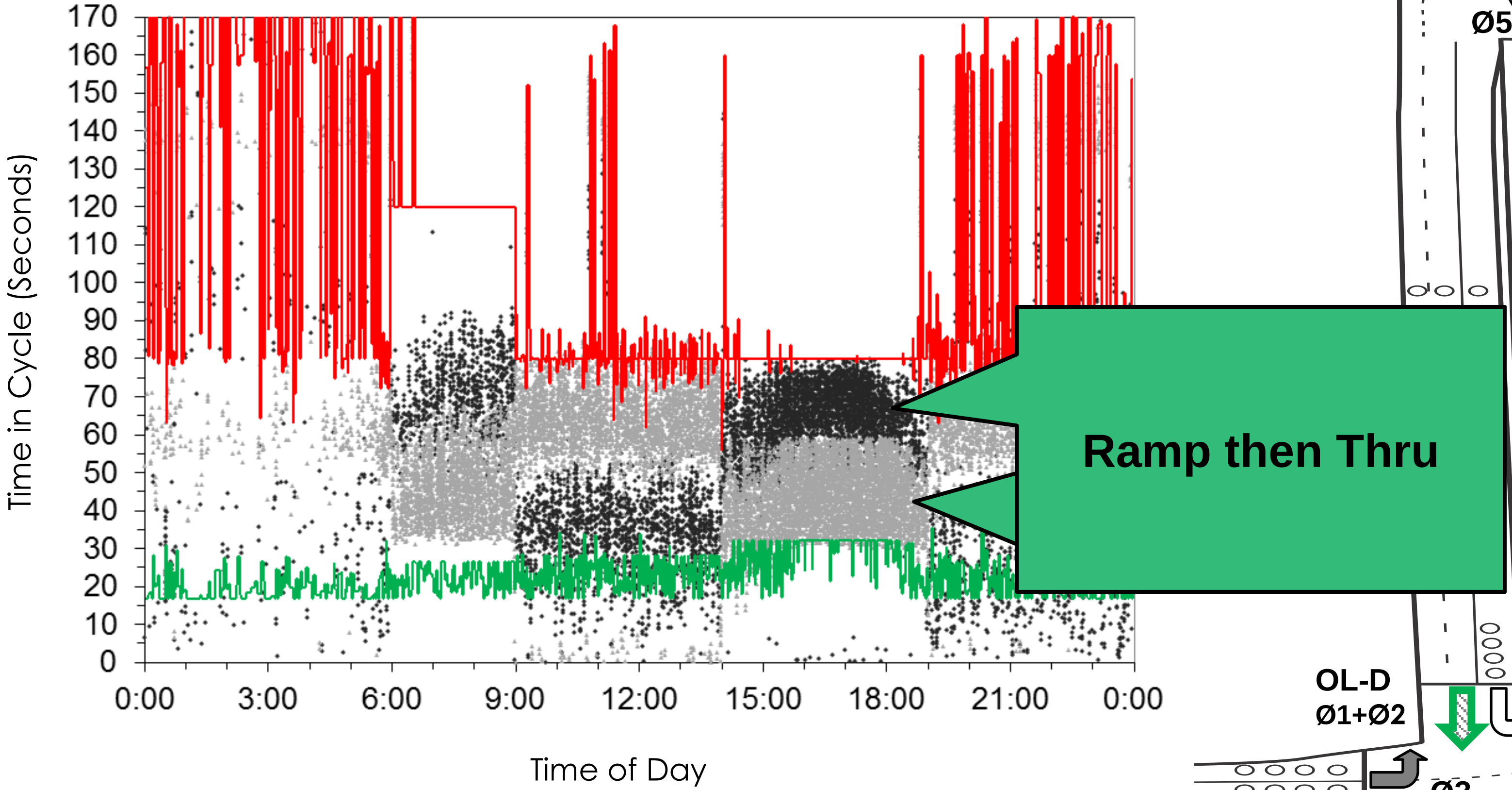
*First is Ø6 SBT, then Ø7 WBL from the ramp*

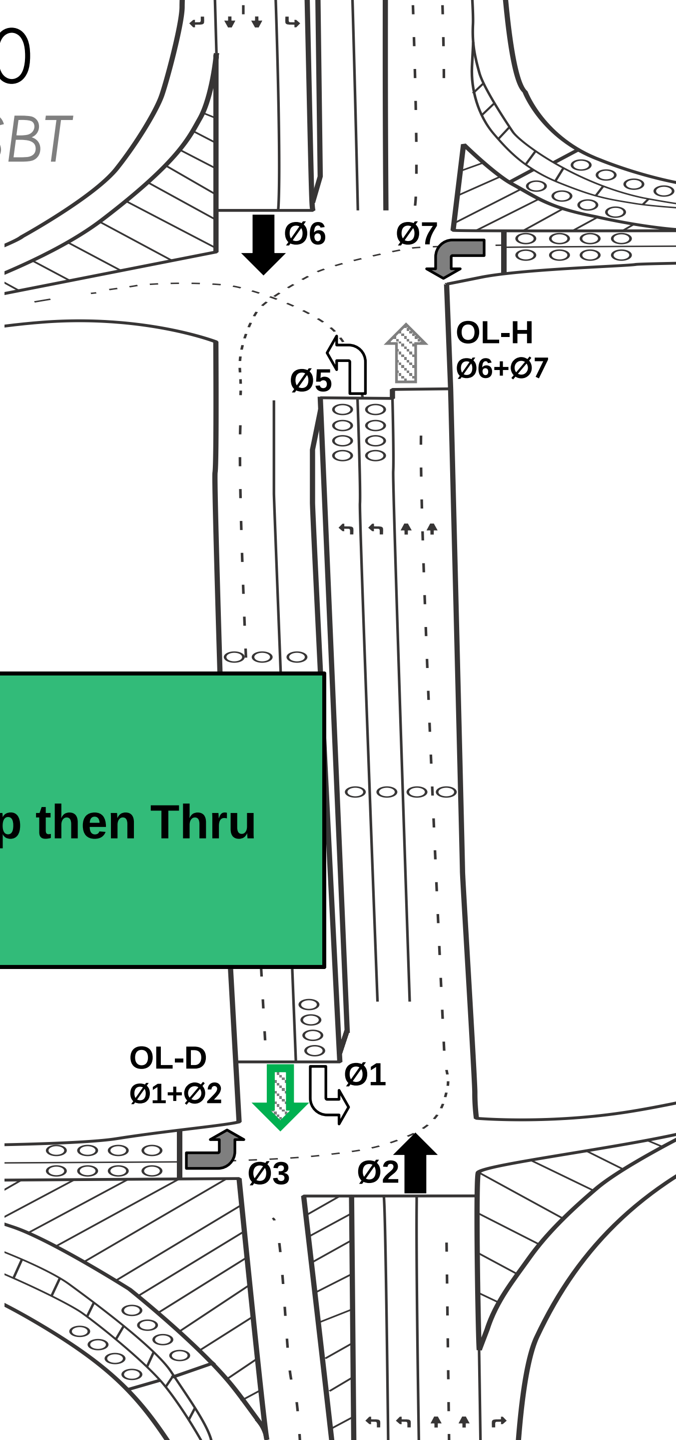


# 24HR PCD: Sequence for 1400-1900

*First is Ø7 WBL from the ramp, then Ø6 SBT*



# Conclusion: These Graphics are Useful!

*Can they be included on newer generation traffic controllers?*


# Conclusion: These Graphics are Useful!

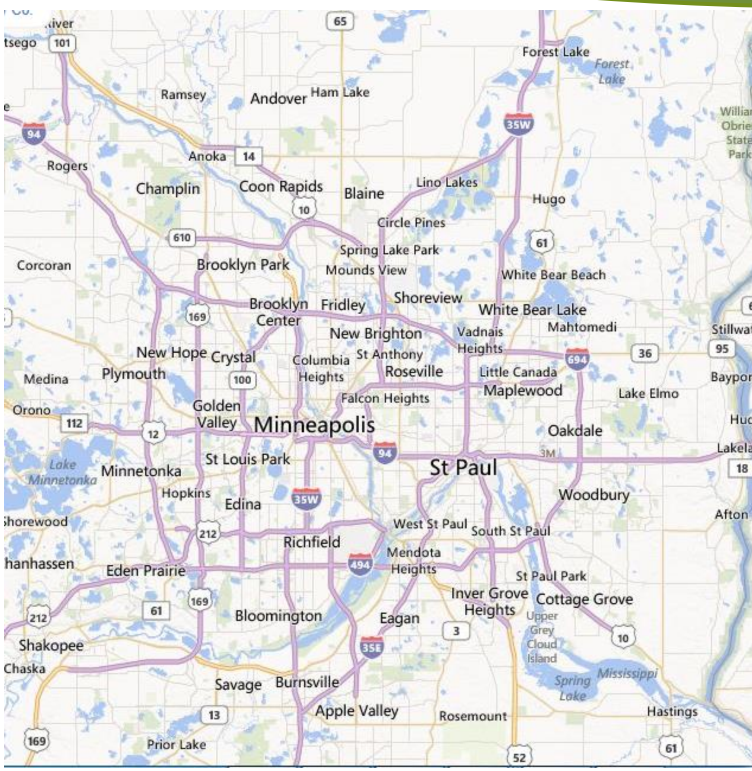
*Can they be included on newer generation traffic controllers?*


# AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES CASE STUDIES: MnDOT

**INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – MAY 7, 2014**

PRESENTED BY STEVE MISGEN, MNDOT

# MnDOT - Metro District Background

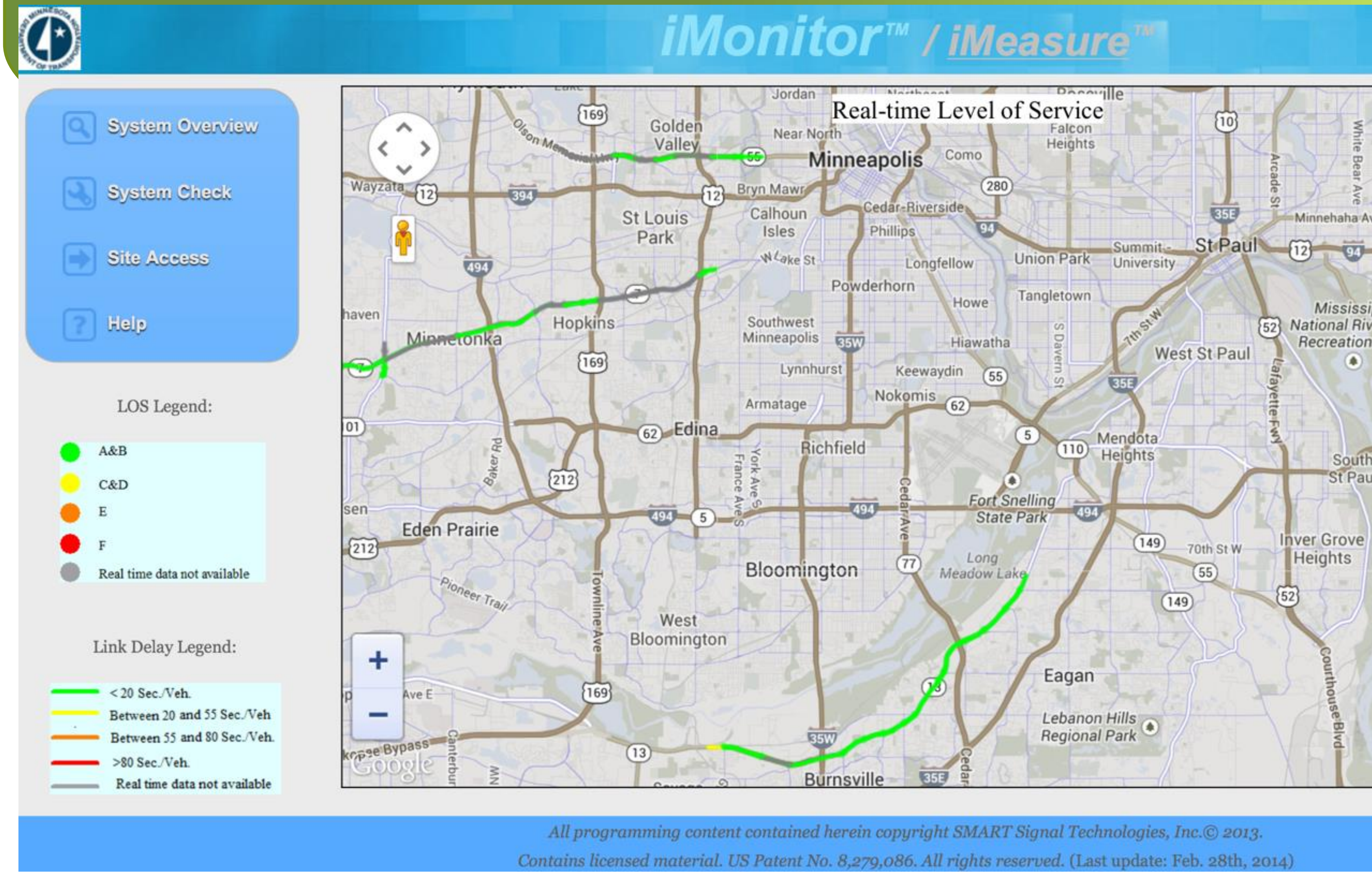



- Operates about 700 signals (Mpls/St. Paul Metro area)
  - 250 signal on i2 central system
  - 450 on ARIES dial-up
- Econolite ASC2/ASC2S or ASC3 controllers
- Signal Performance Measure
  - 83 on Smart Signal
  - 21 on Utah SPM

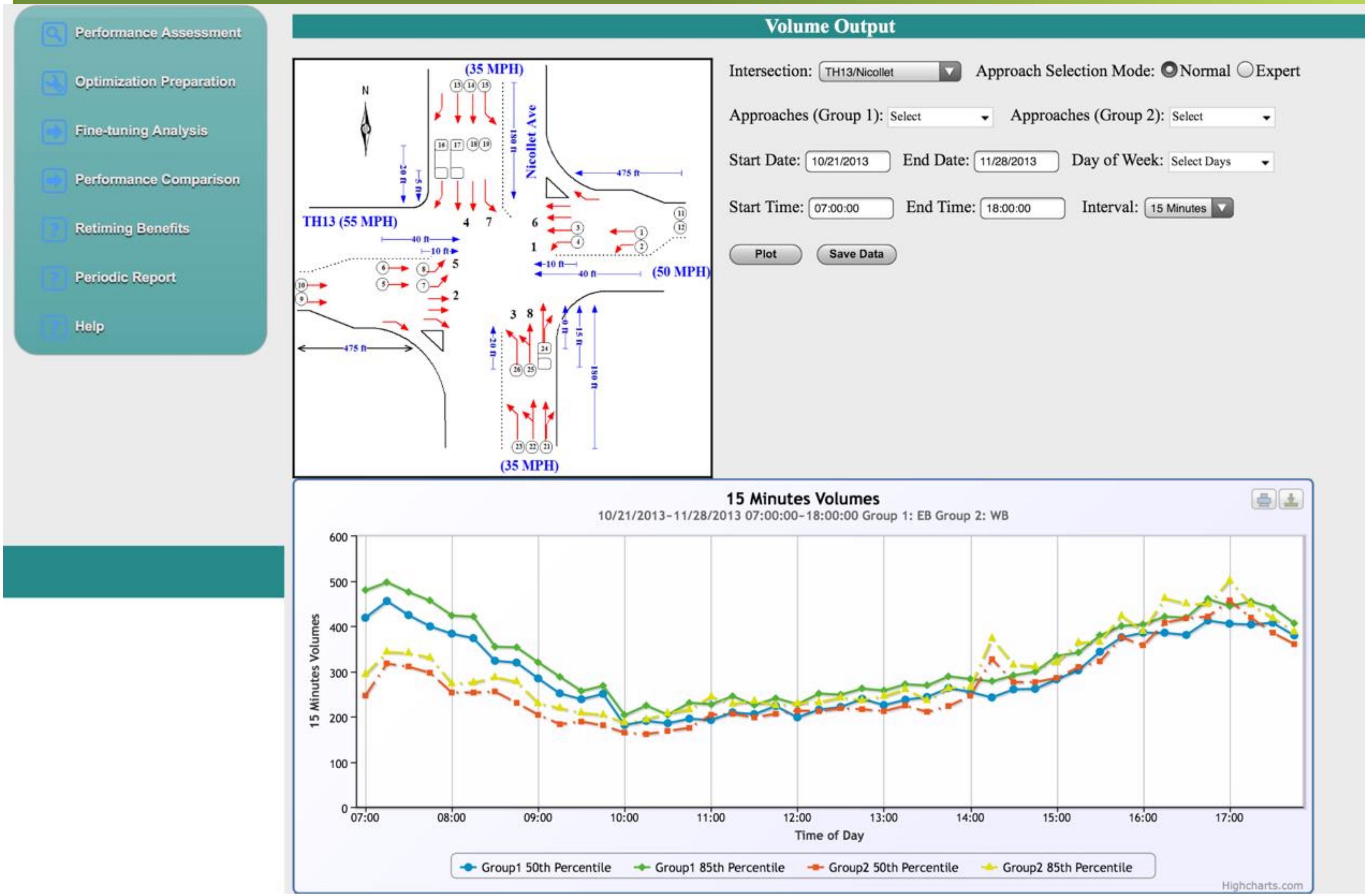
# Smart Signal

- University of Minnesota
  - Henry Liu
- Minnesota Department of Transportation
- http://dotapp7.dot.state.mn.us/smartsignal
  - iMonitor – "Real-time" Level of Service
  - iMeasure – Data extraction tool

# Smart Signal

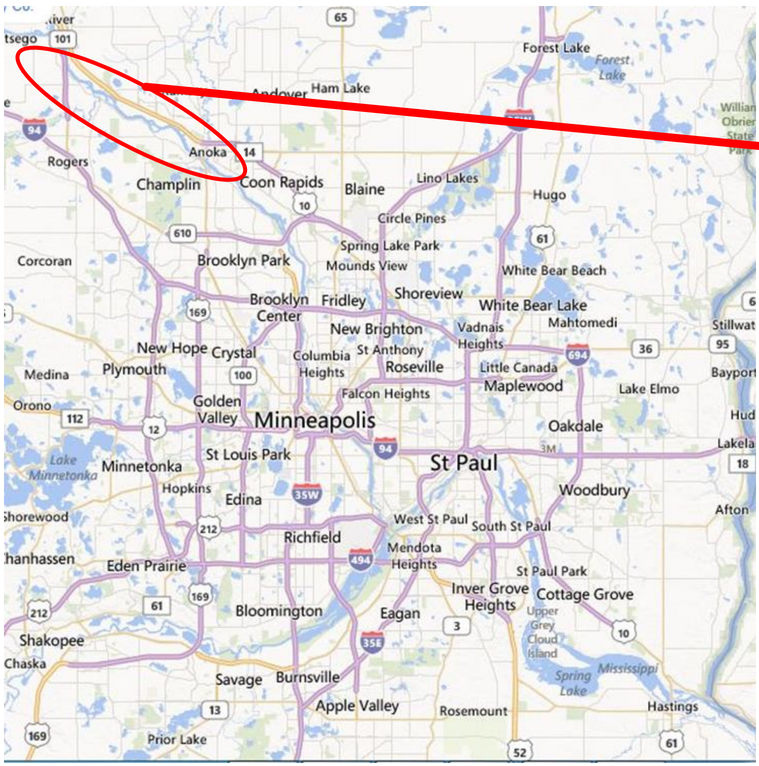


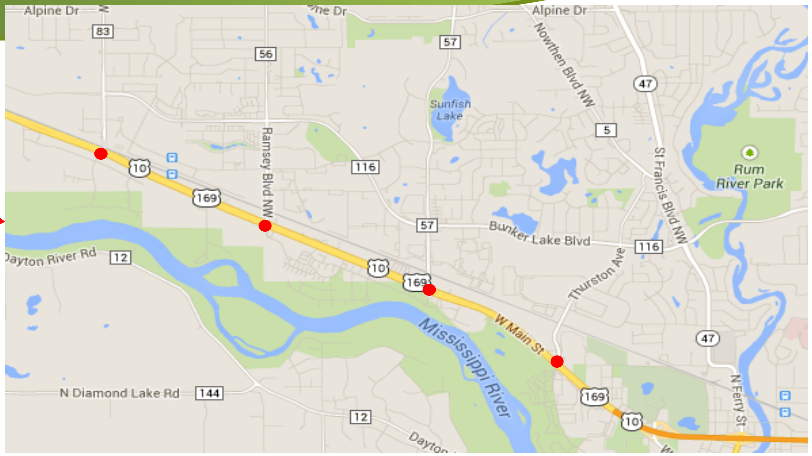
# Smart Signal



# The Project

## Develop New Timing Using High Resolution Data collected from SmartSignal




- 4 fully-actuated signals
- High speed 60-65 mph posted
- 33,000-68,000 AADT
- 7 TOD plans
- Last retimed 2009

# Signal Timing Development

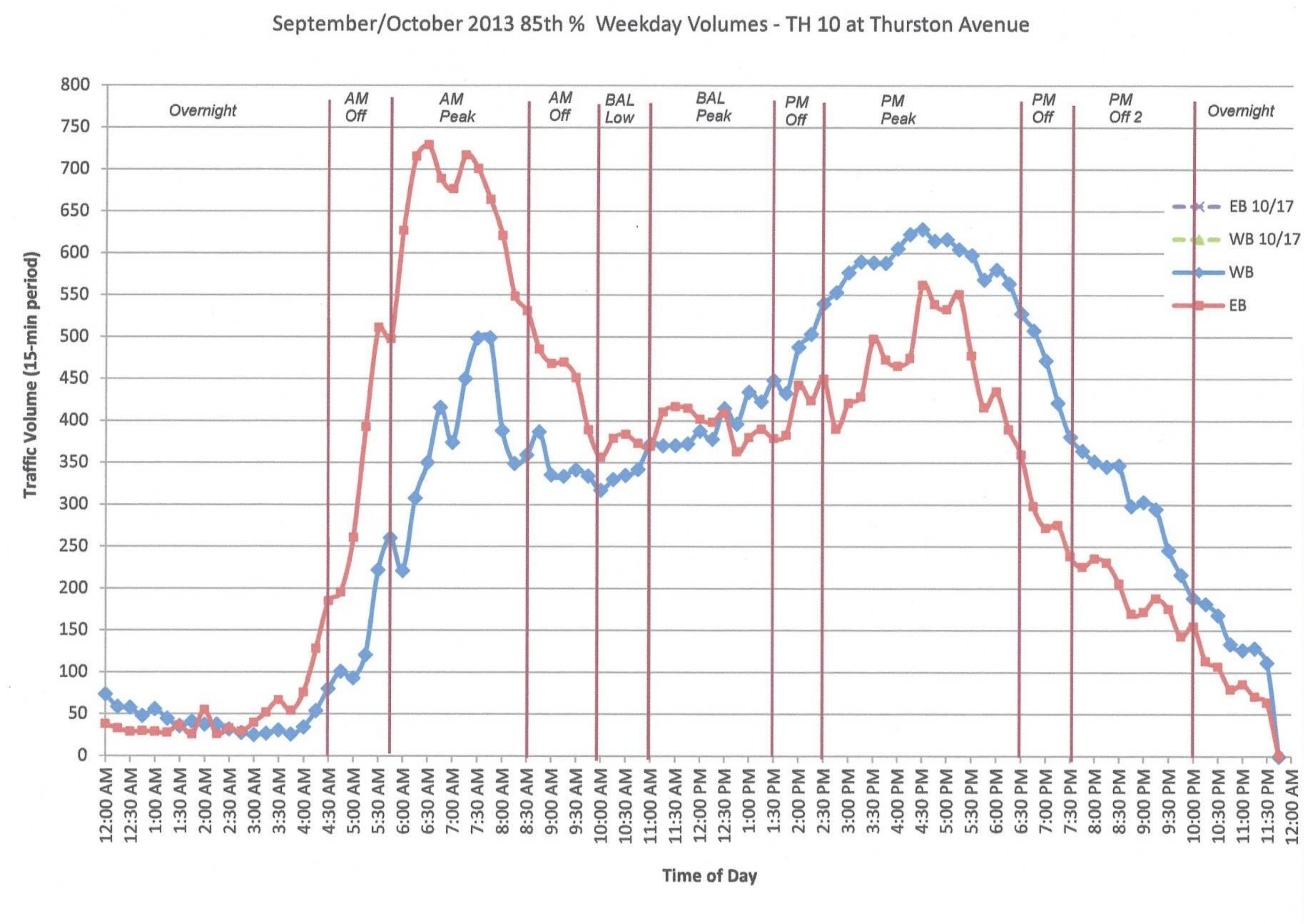
<u>Standard Method</u>

- Data Collection
  - Manual Turning Movement Count – 12 hour
  - System Detectors
- Synchro – approximation of splits & cycle lengths
- Implementation  & fine turning completed by time space diagram and field observations
- Before/After Comparison using Travel Time Studies

<u>Improved Method</u>

- Data Collection
  - Automated collection averaged over Sept-Oct for each movement (M-Th, F, S & S)
- Synchro - Time-space diagram for best two-way progression
- Implementation & fine turning completed by time-space diagram and field observations
- Smart Signal – monitor and make adjustments to insure efficiency
- Before/After Comparison using signal performance metrics

# Volumes



September/October 2013 85th % Weekday Volumes - TH 10 at Thurston Avenue
Traffic Volume (15-min period)
Time of Day
Overnight
AM Off
AM Peak
AM Off
BAL Low
BAL Peak
PM Off
PM Peak
PM Off
PM Off 2
Overnight
EB 10/17
WB 10/17
WB
EB
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
12:00 AM
12:30 AM
1:00 AM
1:30 AM
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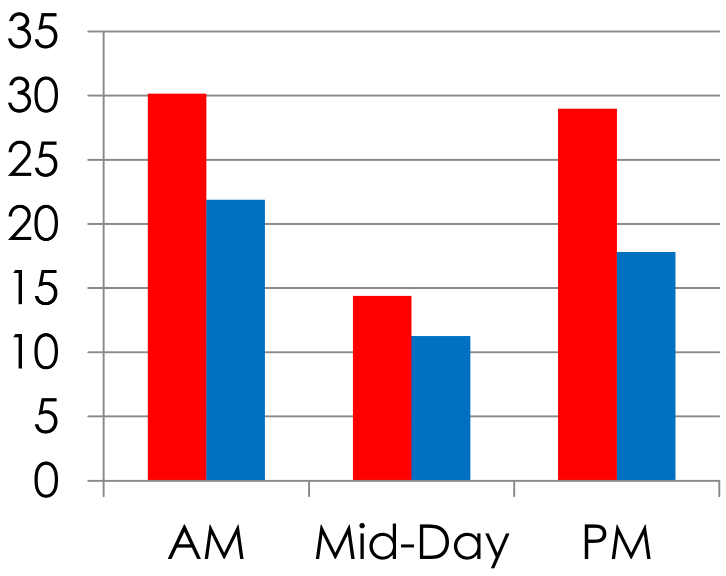
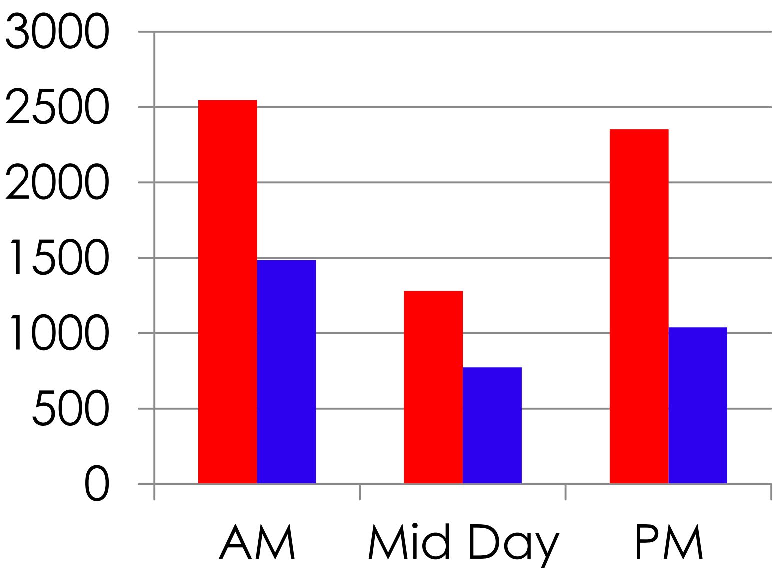
9:30 PM
10:00 PM
10:30 PM
11:00 PM
11:30 PM
12:00 AM

# Peak Periods Before/After Performance Comparison

Total Delay (Hours)

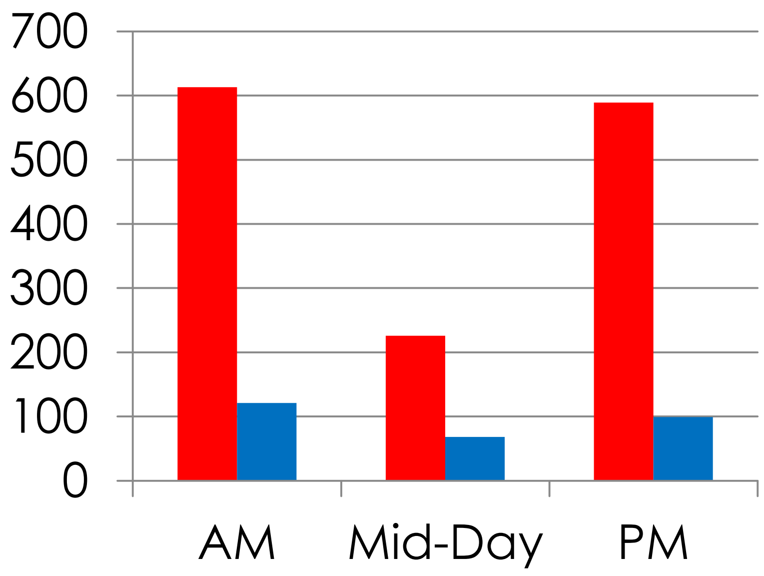



Number of Stops

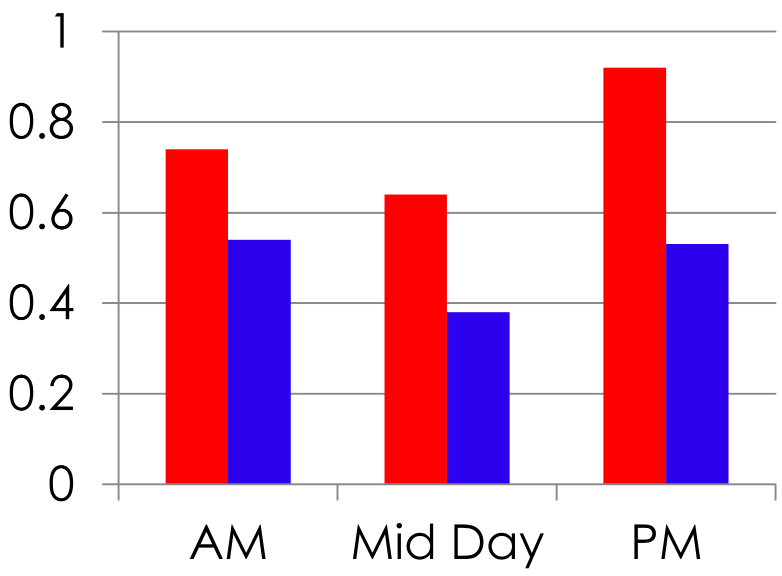


# Peak Periods Before/After Performance Comparison

## Max Queue Length (Ft)




## Saturation Level



# Future Plans

- Performance Index
  - based on volume, delay, number of stops, max queue length, saturation level & percent of vehicles arriving on Green
  - Calculate the PI for a given period on time (PM Peak) over a period of time (every Wednesday for the past year)
  - Track the change on performance over time
    - **When do you need to retime!**
- Time-space Diagram
  - Real-time TSD based on detector actuations
- Performance Metrics
  - Emissions – $CO_2$ fuel consumed

# MnDOT Signal Performance Measures

Steve Misgen, PE, PTOE

MnDOT – Metro District

Traffic Engineer

Steve.misgen@state.mn.us

# Find out more: http://tig.transportation.org

**AASHTO TIG**

- TIG Home
- About TIG
- Focus Technologies
- Executive Committee
- Feedback
- Additionally Selected Technologies
- TIG-Solicitation
- Lead States Team Guidance

**TIG Home**

AASHTO > AASHTO Technology Implementation Group > TIG Home

AASHTO's Technology Implementation Group — or TIG — scans the horizon for outstanding ad technology and invests time and money to accelerate their adoption by agencies nationwide.

Each year, TIG selects a highly valuable, but largely unrecognized procedure, process, software that has been adopted by at least one agency, is market ready and is available for use by othe

Guided by the vision of "a culture where rapid advancement and implementation of high payoff, expectation of the transportation community," TIG's objective is to share information with AAS agencies, and their industry partners to improve the Nation's transportation system.

Recently selected technologies with links to additional information are listed below. Also, you m and Additionally Selected Technologies categorized by AASHTO subcommittee interest area.

## Lead States Team Focus Technologies

### 2013 Focus Technologies

- Automated Traffic Signal Performance Measures
- UPlan Phase II

### Prior Four Years Focus Technologies

- Embedded Data Collector
- Environmental Planning GIS Tools

## Additionally Selected T

### 2013 ASTs

- Double Crossover Dia

### Prior Four Years ASTs

- Anonymous Wireless Time Data Collection
- Curvature Extension f

# ITE Webinar Series on Automated Traffic Signal Performance Measures (SPMs)

- Achieve Your Agency's Objectives Using SPMs

  April 9, 2014, 12:00 pm to 1:30 pm. Eastern

- SPM Case Studies

  May 7, 2014, 12:00 pm to 1:30 pm. Eastern

- **Critical Infrastructure Elements for SPMs**

  **June 11, 2014, 12:00 pm to 1:30 pm. Eastern**

Jamie Mackey
UDOT

Amanda Stevens
INDOT

Alex Hainen
Purdue

Steve Misgen
MnDOT

# Thank you.

## QUESTIONS?

**http://tig.transportation.org**

# TIG SPM TEAM CONTACTS

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