

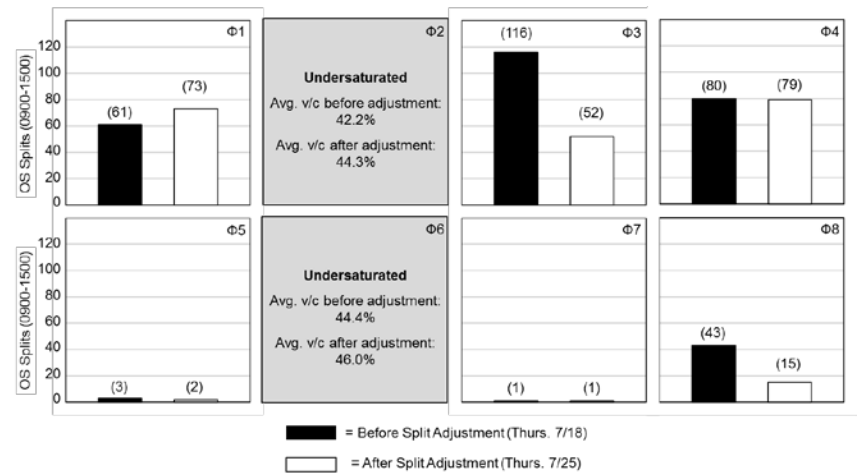
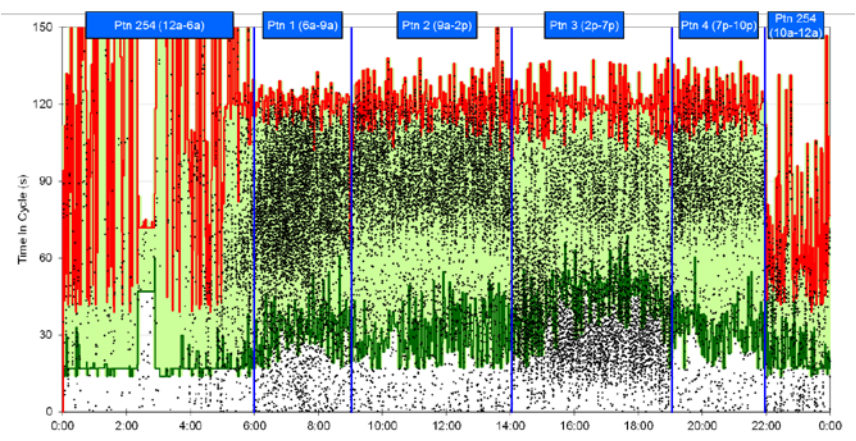


Corridor Ranking with Automated Traffic Signal Performance Measures

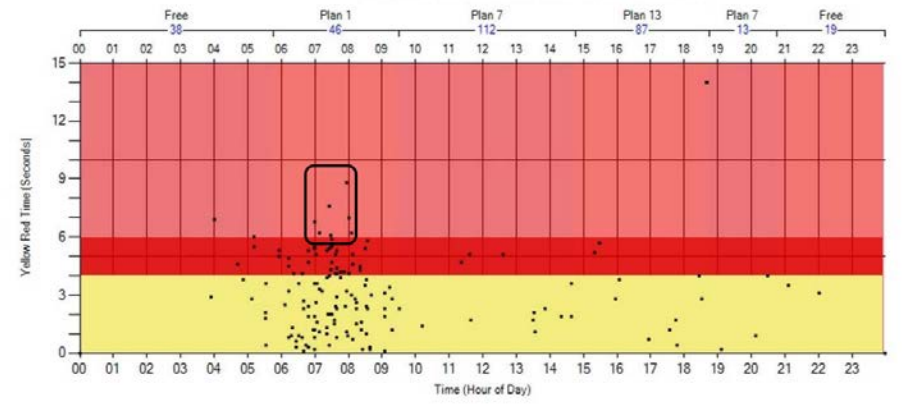
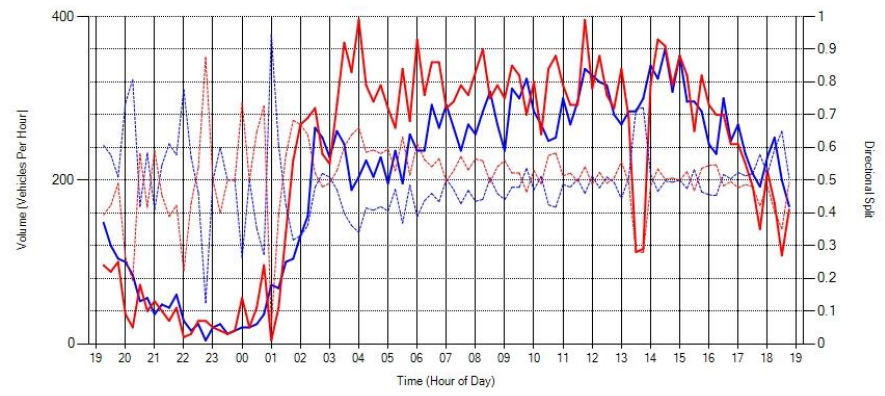
Chris Day, P.E., Ph.D.
Tuesday, March 6, 2018

Research Motivation

- Automated Traffic Signal Performance Measures (ATSPMs)



Volume report for Southwest Glade on the Westbound and Eastbound approaches.
4/11/2016 7:00:00 PM - 4/12/2016 6:59:00 PM
Approach count accuracy: undercounts by 5-25%



Research Motivation ... at the ITE Annual Meeting in Toronto, last August

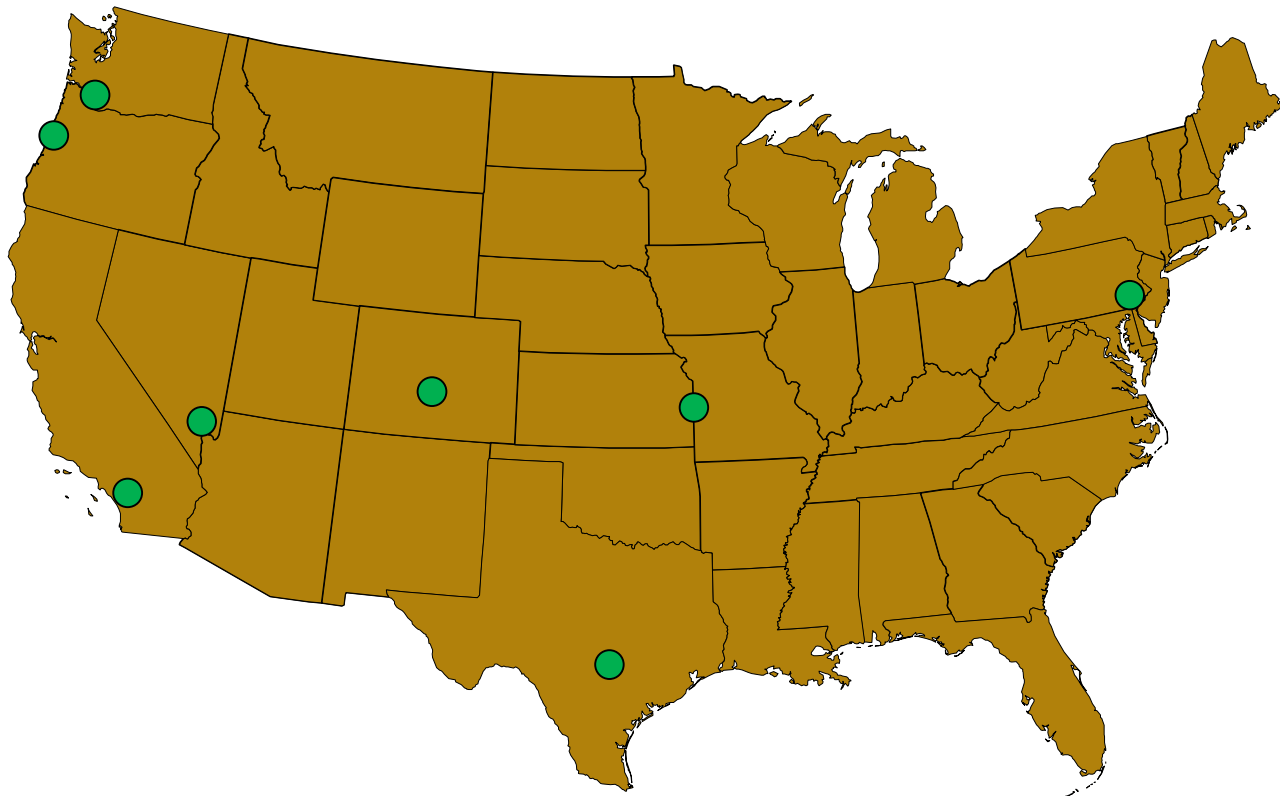


ATSPM background

- Existing Data Sets
 - Volume/occupancy
 - Real-time status
 - Some performance measures in some adaptive systems
- High-Resolution Data
 - State changes (phases, detectors) at nearest 0.1 seconds
 - Pattern changes, etc.
- Travel Time Data
 - Individual vehicles
 - Average speeds
- Integration into a system

Research Motivation

- NCHRP 3-122
 - Production of Guidance for Implementation of ATSPMs
- Interviews with Early Adopters



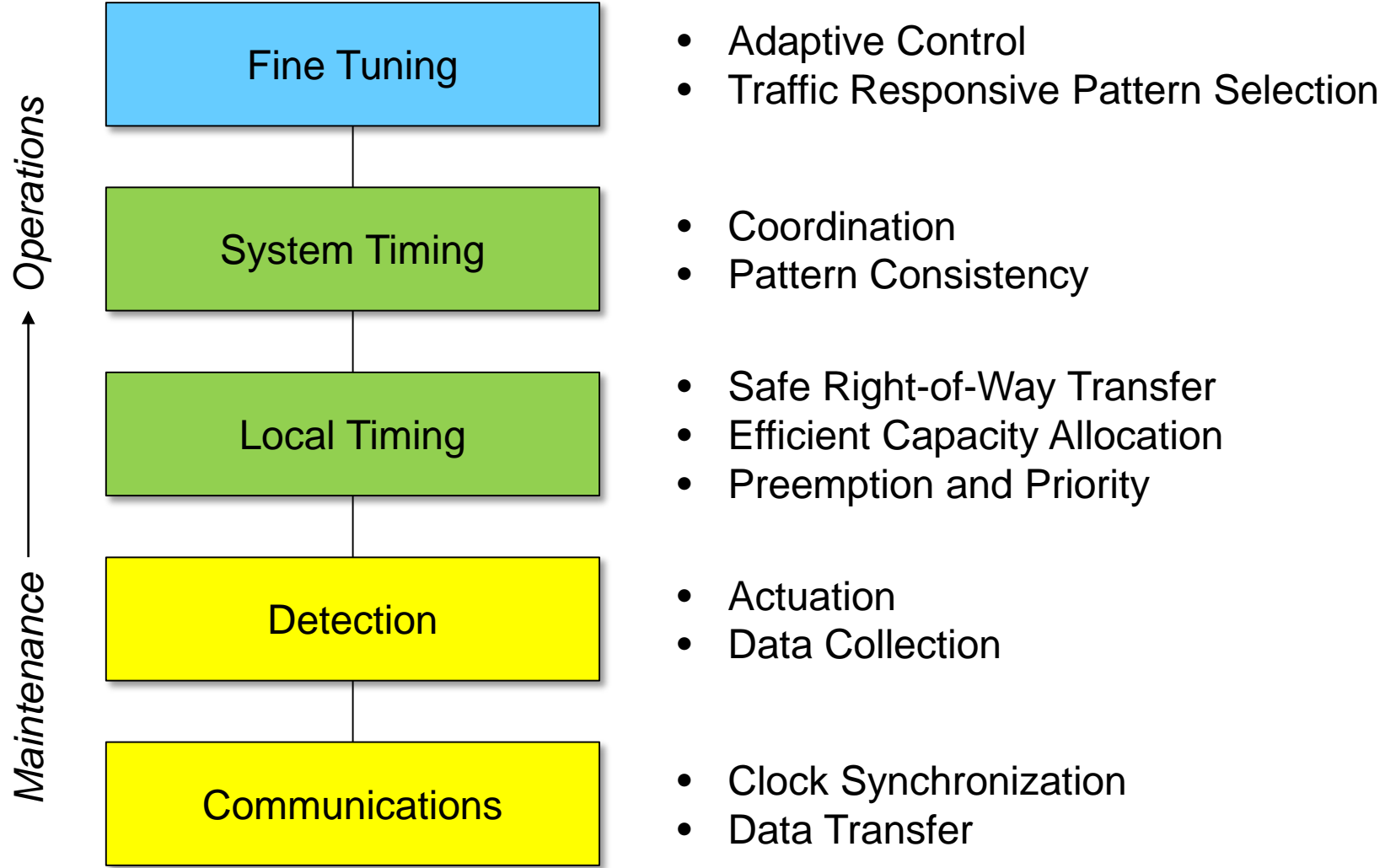
Some Comments Received (Paraphrased)

- “The metrics need to be higher level...”
- “We need higher level reports for managers...”
- “We need something more digestible...”
- “Data Overload”
- “It’s not feasible to go through [###] signals one-by-one...”

Getting Started

- What should we measure to know that traffic signal systems are working?
- What does “working” mean?

Hierarchical Approach



Study Background

- We have a huge amount of ATSPM data
- How can we roll this up into something that is...
 - **Digestible**
 - Not much time needed
 - **Easy to Understand**
 - “Letter Grade” rather than numerical value
 - **“Contextual”**
 - The same quantitative result may be “good” in some circumstances, but “bad” in others

ATSPM Data in Indiana

Map Satellite

Chicago

South Bend

Elkhart

Fort Wayne

Lafayette

Kokomo

Indianapolis

Terre Haute

Bloomington

Columbus

Cincinnati

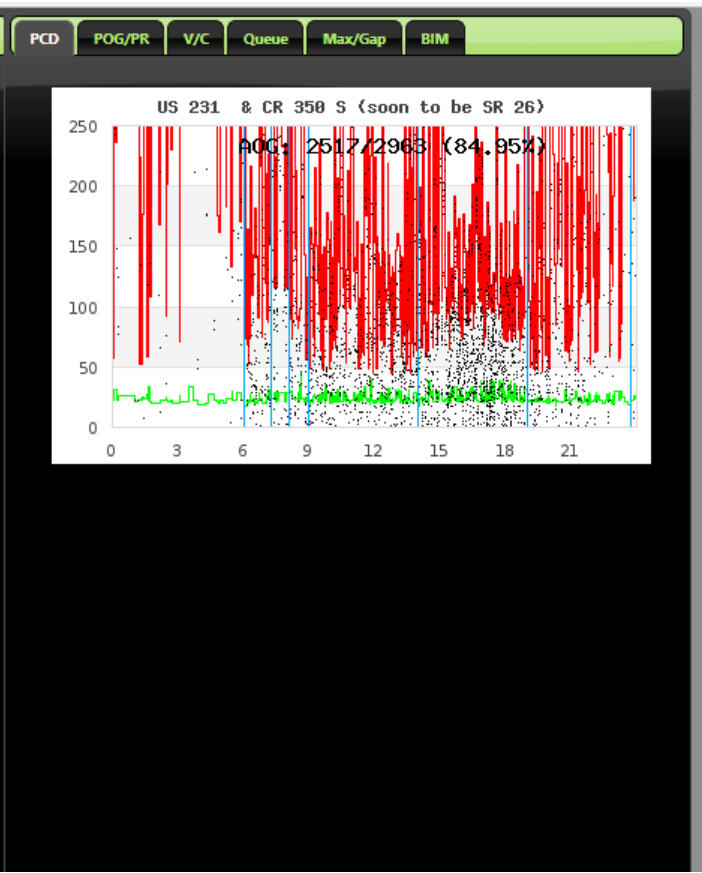
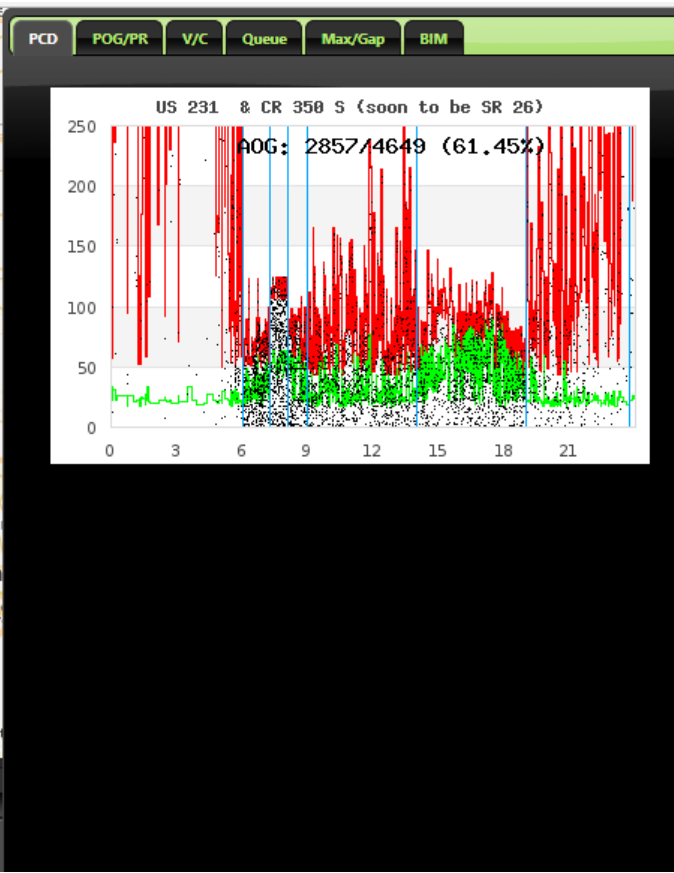
PURDUE UNIVERSITY

ITAP

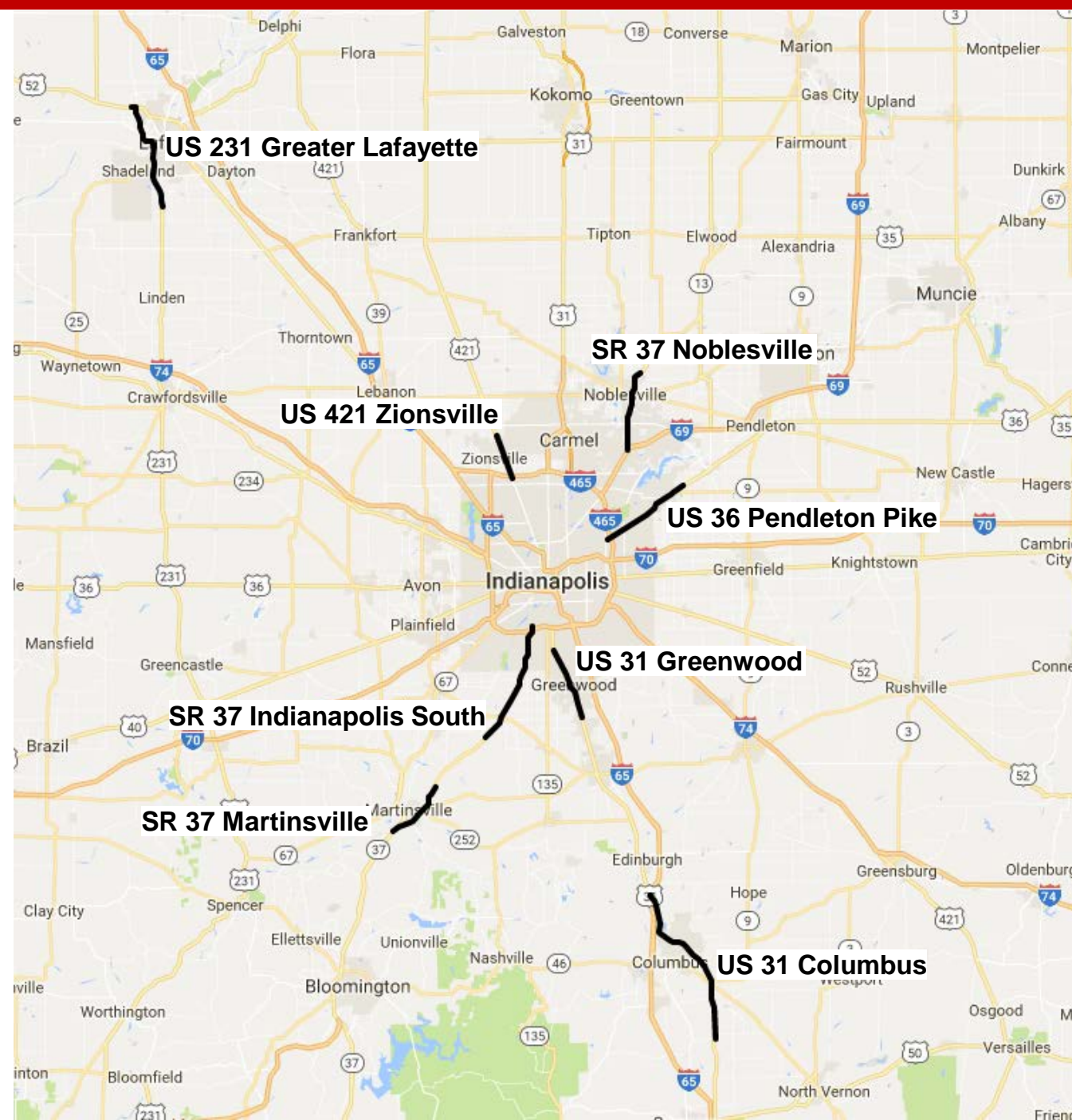
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Indiana Study Corridors



Focus Areas of Individual Metrics

- Maintenance
 - **Communication Systems**
 - **Detection Systems**

- Operations
 - **Safety**
 - **Capacity Allocation**
 - **Progression**

1. Communication Concept

- Communication systems should work
- How to measure it?
 - Failure to “ping” the controller
 - Data missing in the database

1. Communication Thresholds

- Relatively “strict” thresholds
- Without comm, we have no data

- “A” = 100% of intersections online
- “B” = More than 90% of intersections online
- “C” = More than 80% of intersections online
- “D” = More than 70% of intersections online
- “F” = Less than 70% of intersections online

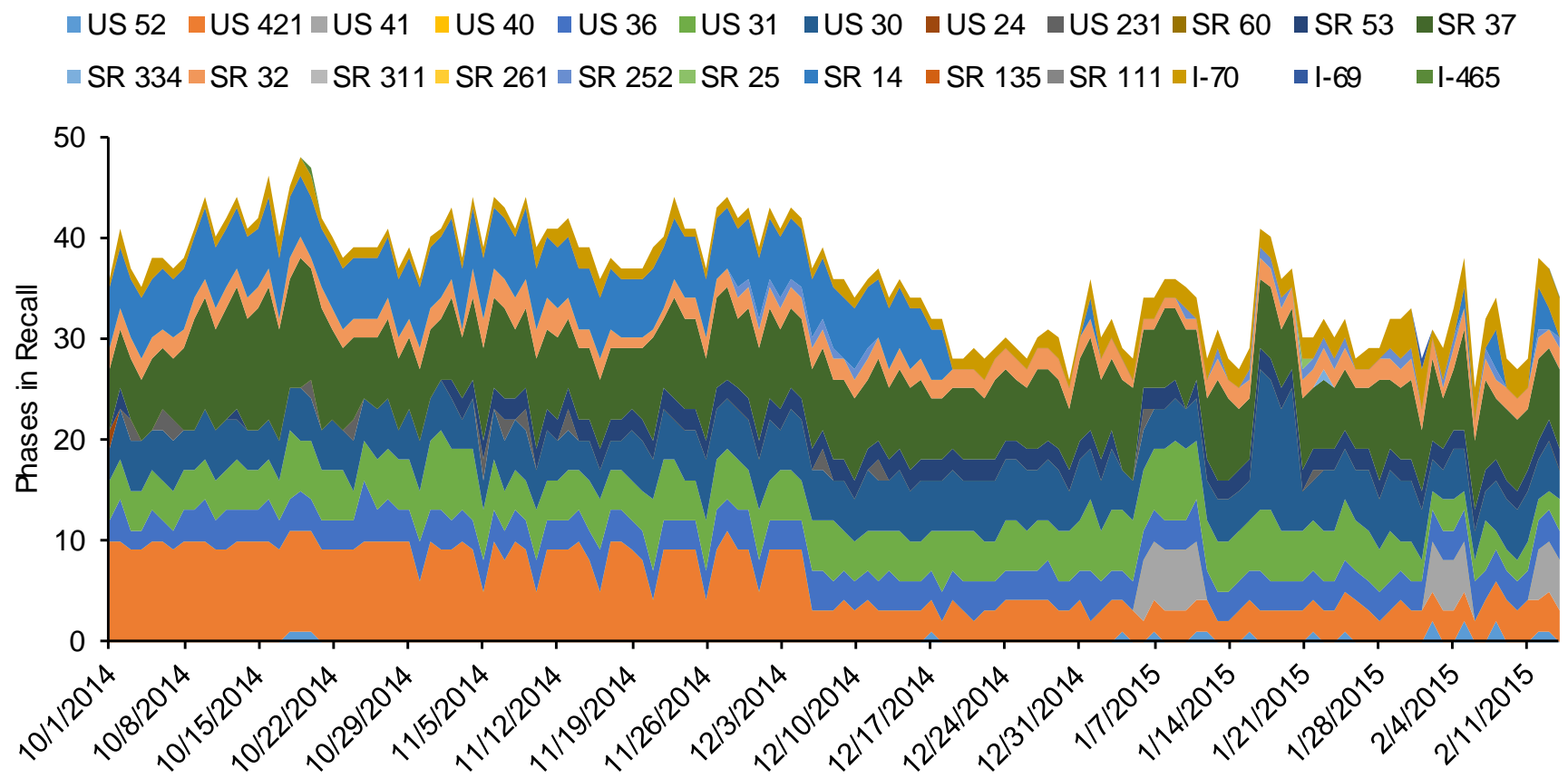
1. Communication Outcomes

Corridor	Number of Intersections	Number Online	Percent Online	Score
Pendleton Pike	15	14	93%	B
SR 37 Indianapolis South	12	10	83%	C
SR 37 Martinsville	5	5	100%	A
SR 37 Noblesville	9	5	56%	F
US 231 Greater Lafayette	10	10	100%	A
US 31 Columbus	13	11	85%	C
US 31 Greenwood	8	7	88%	C
US 421 Zionsville	7	7	100%	A

2. Detection Concept

- Detection systems should work
- How do detection systems fail? (Four Heuristics)
 - Detection channels stop reporting data
 - Missing data – H1
 - Detection channels overcount
 - Too many detections – H2
 - Phases effectively are in max recall when detectors fail
 - Unintended late night max recall – H3
 - Ped buttons become stuck
 - Unintended ped recall – H4

Number of failed detectors over time...



2. Detection Details

Corridor	Number of Detectors	H1 Detectors	H2 Detectors	Number of Phases	H3 Phases	H4 Ped Phases
Pendleton Pike	185	19	1	382	42	0
SR-37 Indianapolis South	138	11	0	242	31	0
SR-37 Martinsville	75	42	0	129	123	0
SR-37 Noblesville	85	9	0	183	2	0
US-231 Greater Lafayette	142	4	4	199	12	0
US-31 Columbus	133	3	0	253	3	0
US-31 Greenwood	100	6	0	209	31	0
US-421 Zionsville	97	8	6	148	42	0

2. Detection Thresholds

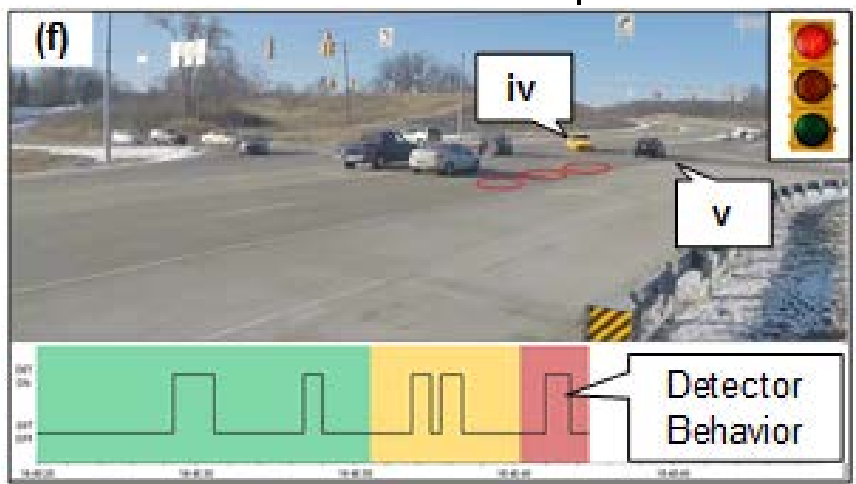
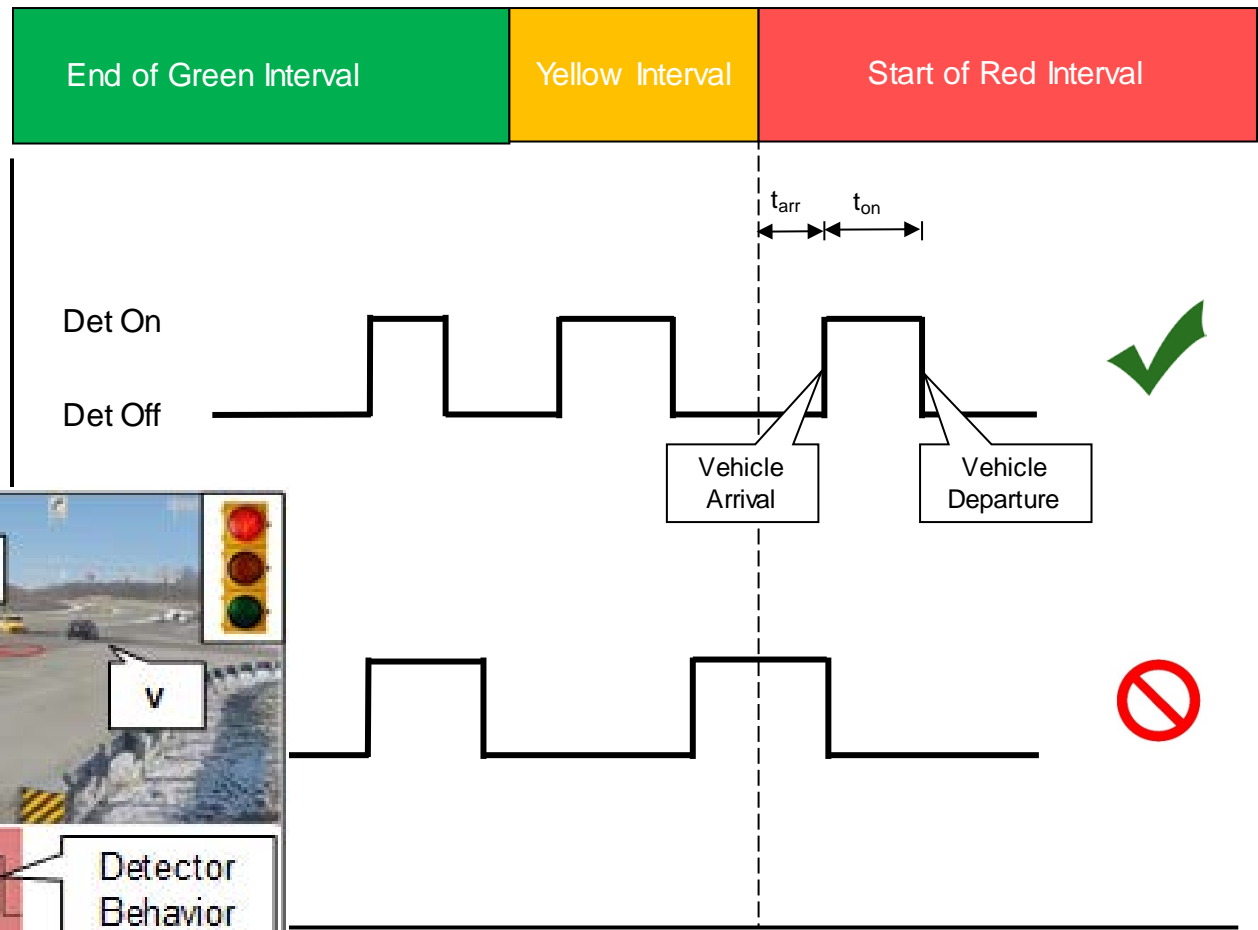
- Metric = number of detectors/phases/ped phases in the corridor affected by each heuristic
- “A” = Less than 5% affected
- “B” = Less than 15% affected
- “C” = Less than 35% affected
- “D” = Less than 50% affected
- “F” = More than 50% affected

2. Detection Outcomes

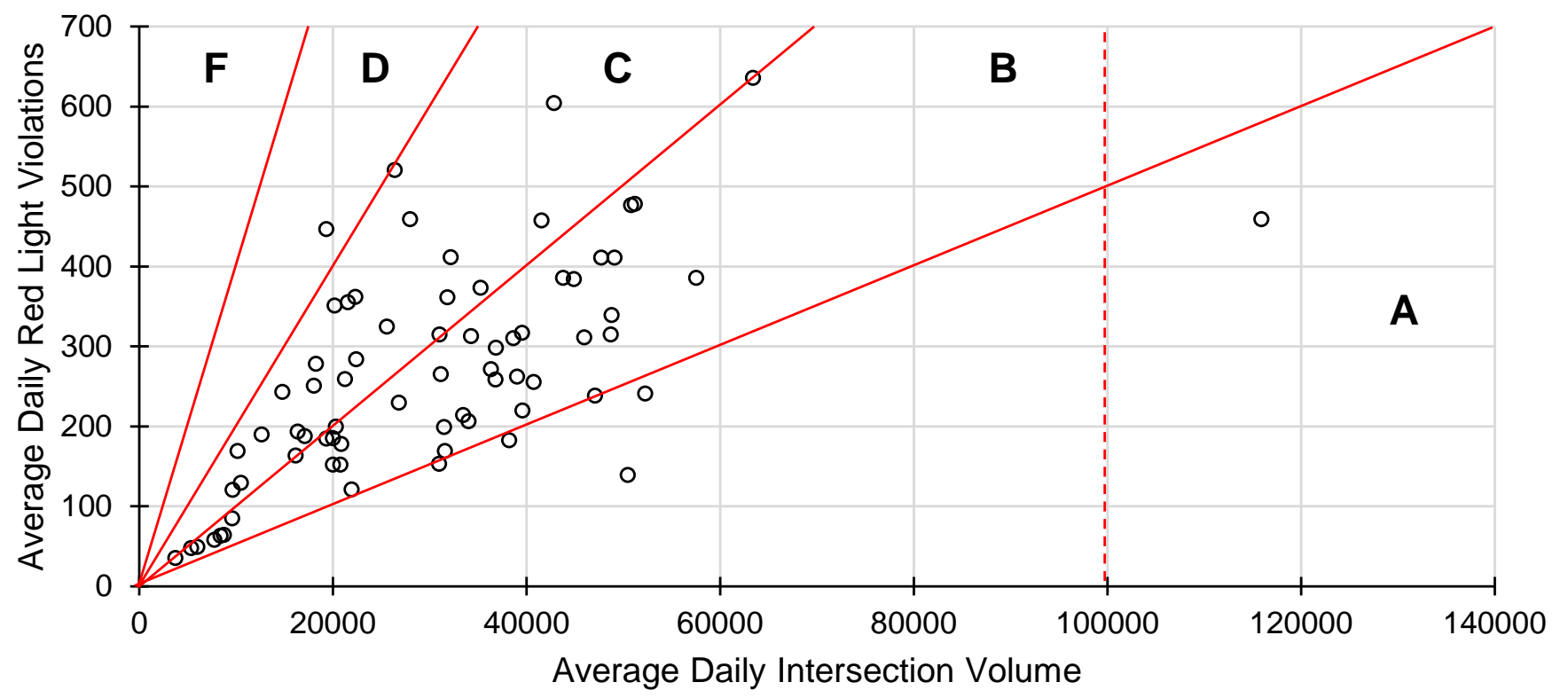
Corridor	Rates				Subscores				Score
	H1	H2	H3	H4	H1	H2	H3	H4	
Pendleton Pike	10%	1%	11%	0%	B	A	B	A	B
SR-37 Indianapolis South	8%	0%	13%	0%	B	A	B	A	B
SR-37 Martinsville	56%	0%	95%	0%	F	A	F	A	F
SR-37 Noblesville	11%	0%	1%	0%	B	A	A	A	B
US-231 Greater Lafayette	3%	3%	6%	0%	A	A	B	A	B
US-31 Columbus	2%	0%	1%	0%	A	A	A	A	A
US-31 Greenwood	6%	0%	15%	0%	B	A	B	A	B
US-421 Zionsville	8%	6%	28%	0%	B	B	C	A	C

3. Safety Concept

- Signal timing should be safe
- In this study, we looked at red light running
- Method of detection



3. Safety Details



3. Safety Thresholds

- These are what seemed to make sense based on possible ranges in our data and in other studies
- Number of red light violations per 1000 vehicles (at the intersection)
 - “A” = less than 5
 - “B” = less than 10
 - “C” = less than 20
 - “D” = less than 40
 - “F” = more than 40

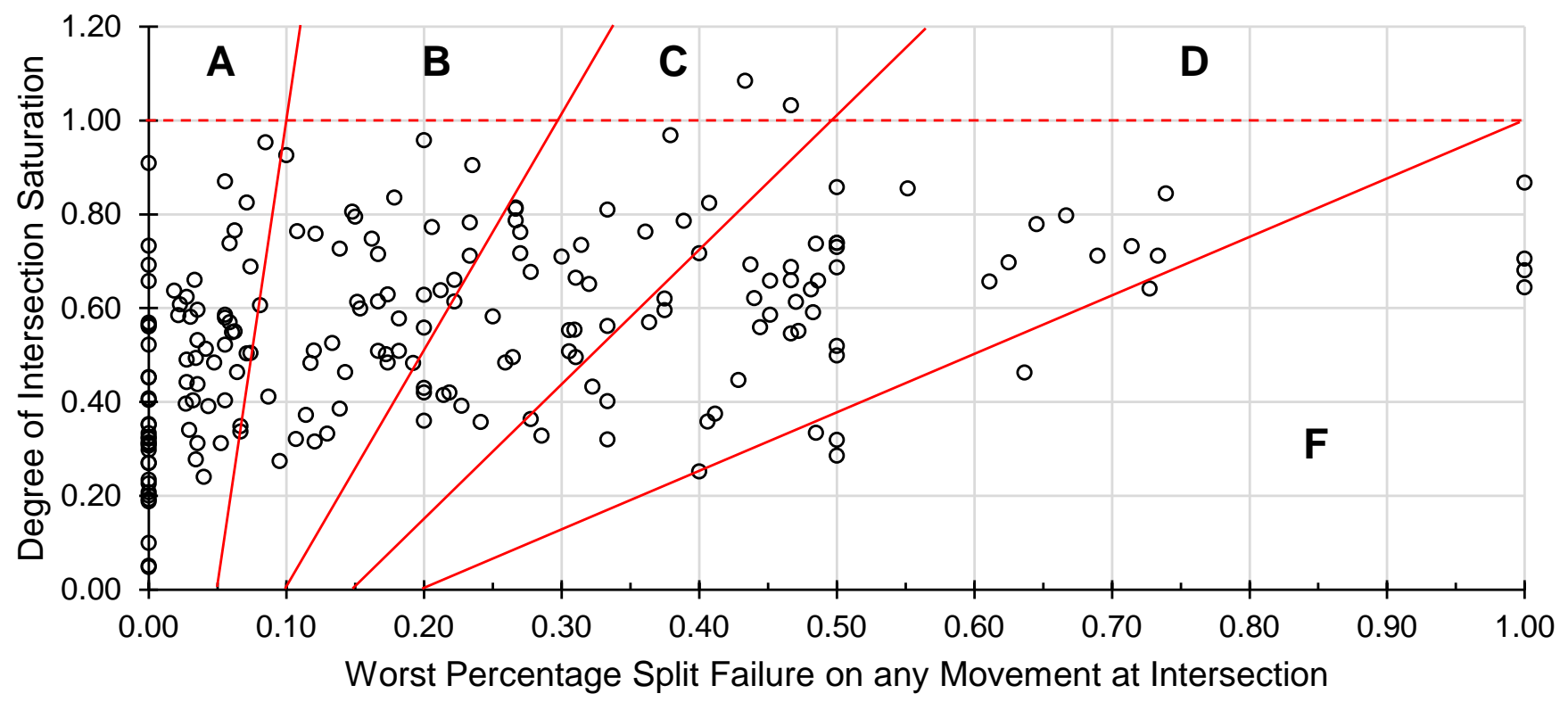
3. Safety Outcomes

Corridor	Worst Intersection Rate (violations/1000 vehicles)	Score
Pendleton Pike	15.2	C
SR-37 Indianapolis South	8.6	B
SR-37 Martinsville	-	-
SR-37 Noblesville	12.8	C
US-231 Greater Lafayette	17.3	C
US-31 Columbus	23.1	D
US-31 Greenwood	8.8	B
US-421 Zionsville	16.4	C

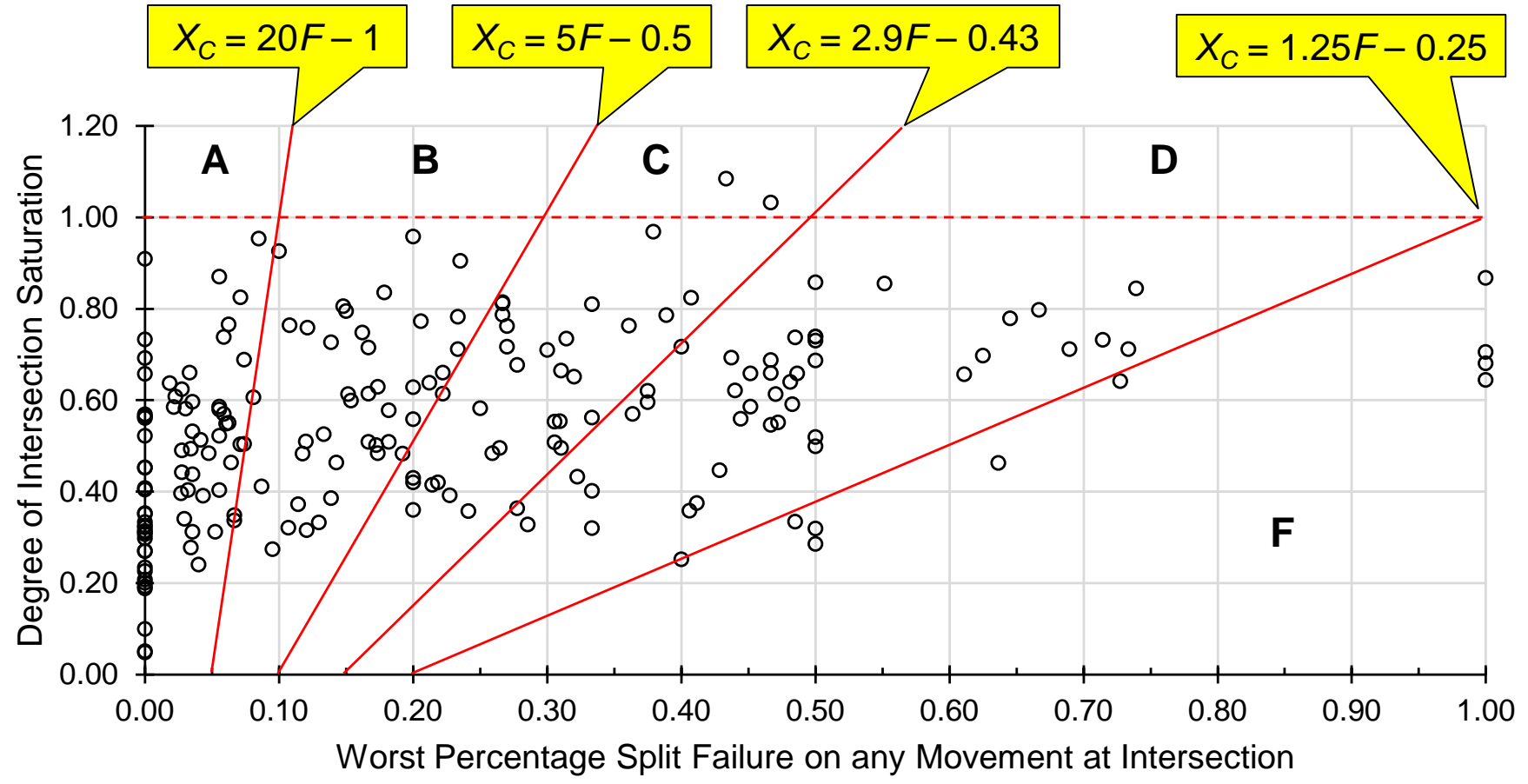
4. Capacity Allocation Concept

- It is desirable to avoid **split failures**
- It is harder to avoid or correct split failures when the overall intersection utilization is reduced
- Measurement:
 - Split failure detection using red and green occupancy ratios
 - Intersection saturation measured using volumes for each movement

4. Capacity Allocation Details



4. Capacity Allocation Thresholds

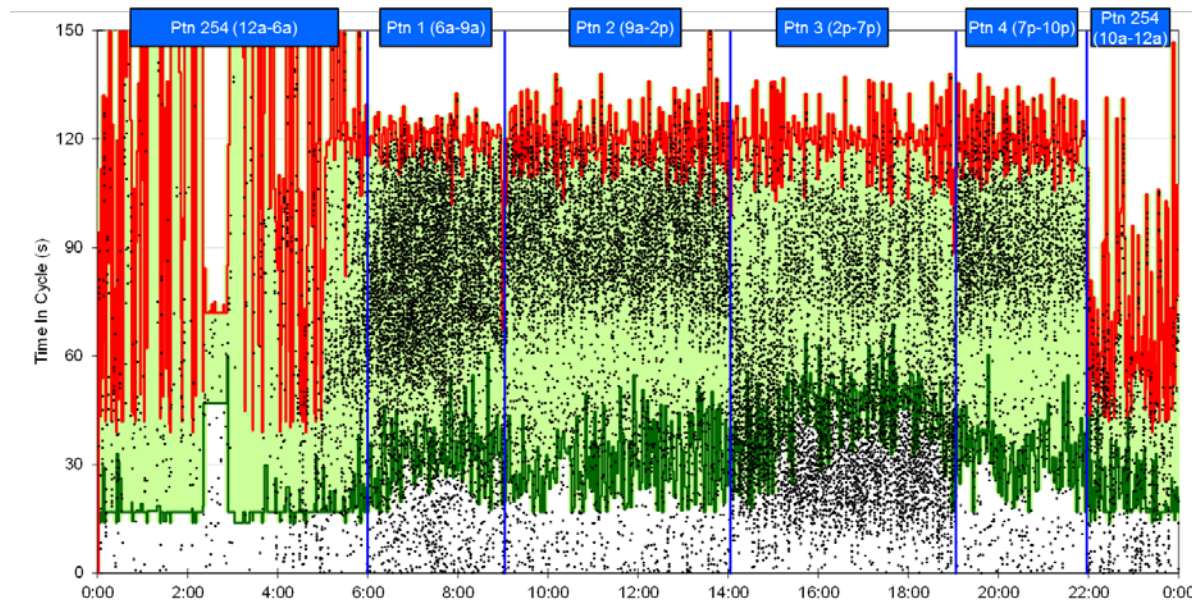


4. Capacity Allocation Outcomes

Corridor	AM	Midday	PM	Score
Pendleton Pike	B	B	C	C
SR-37 Indianapolis South	B	B	B	B
SR-37 Martinsville	-	-	-	-
SR-37 Noblesville	C	C	C	C
US-231 Greater Lafayette	A	A	B	B
US-31 Columbus	B	C	C	C
US-31 Greenwood	C	C	C	C
US-421 Zionsville	C	C	D	D

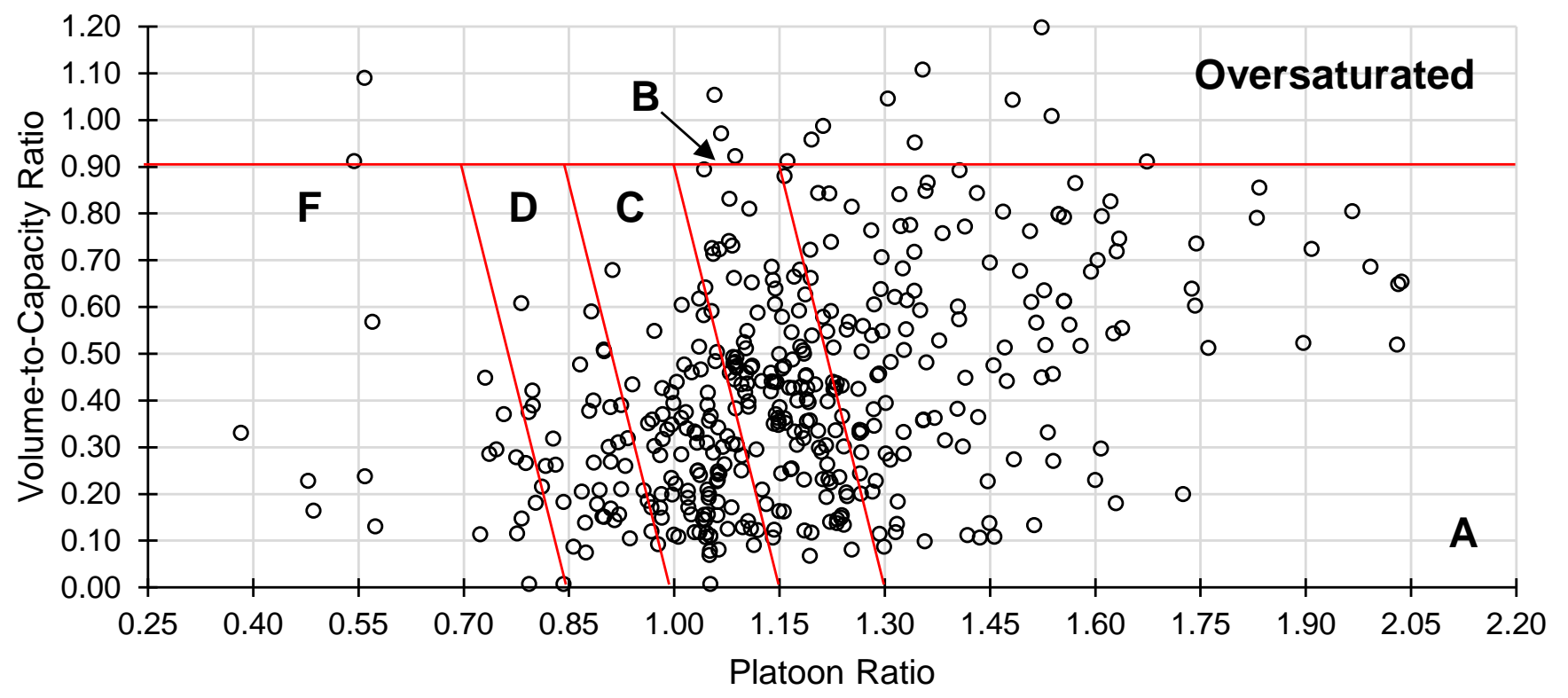
5. Progression Concept

- It is desirable to avoid stopping traffic, whenever possible
- Arrivals on Green is a useful metric to tell if vehicles are being stopped

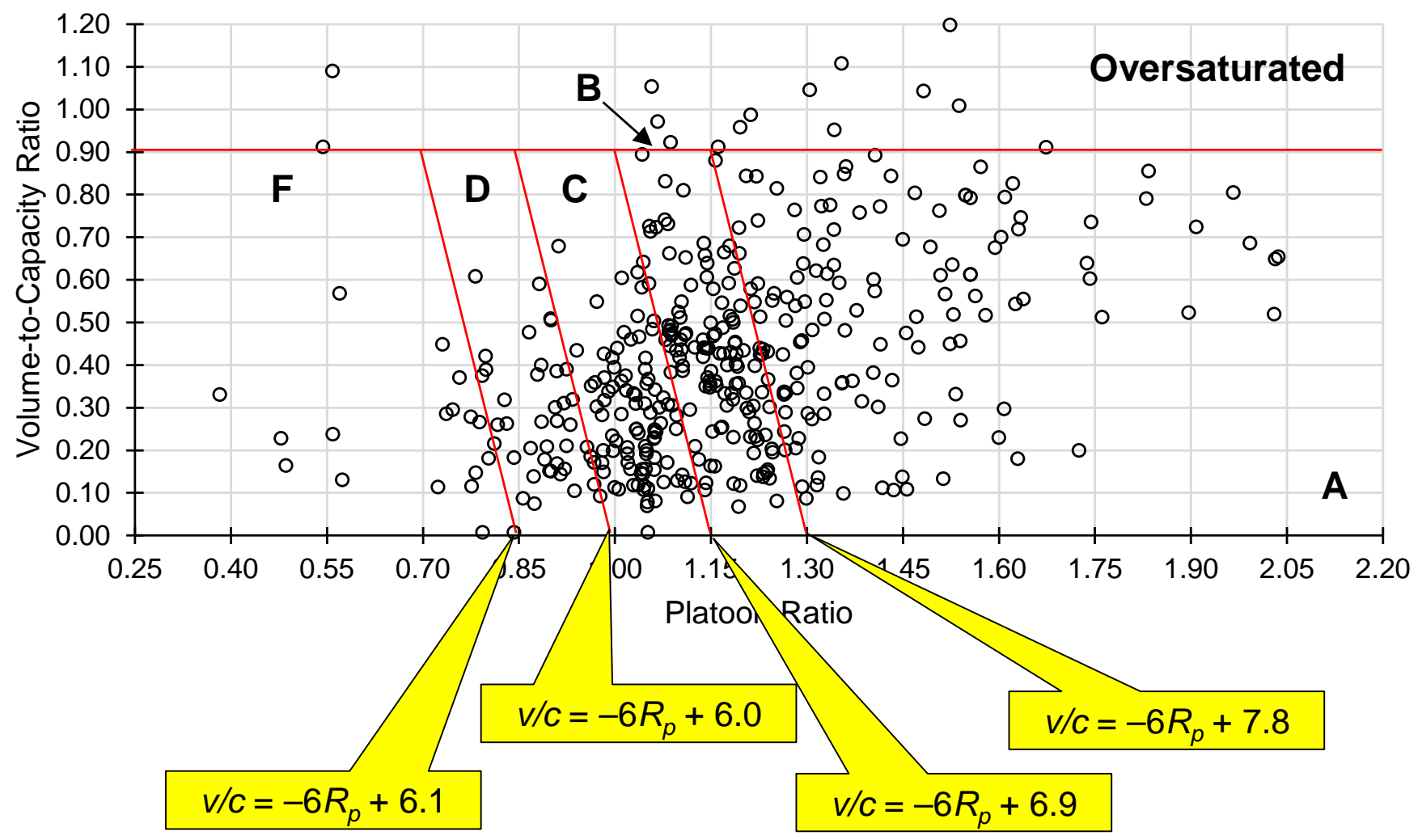


- Platoon Ratio accounts for the fact that long green times lead to increased arrivals on green

5. Progression Details



5. Progression Thresholds



5. Progression Outcomes

Corridor	AM	Midday	PM	Overall Score
Pendleton Pike	C	B	B	C
SR 37 Indianapolis South	B	B	B	B
SR 37 Martinsville	-	-	-	-
SR 37 Noblesville	C	B	B	C
US 231 Greater Lafayette	C	C	C	C
US 31 Columbus	-	-	-	-
US 31 Greenwood	B	A	A	B
US 421 Zionsville	C	C	C	C

“Score Sheet”

Performance Information	Corridor Number							
	1	2	3	4	5	6	7	8
Number of Intersections Total	15	12	5	9	10	13	8	7
Number of Intersections Online	14	10	5	5	10	11	7	7
Percent Online	93%	83%	100%	56%	100%	85%	88%	100%
Communication Subscore	B	C	A	F	A	C	C	A
Number of Detectors	185	138	75	85	142	133	100	97
H1 Detectors	19	11	42	9	4	3	6	8
H1 Rate (% of detectors affected)	10	8	56	11	3	2	6	8
H1 Subscore	B	B	F	B	A	A	B	B
H2 Detectors	1	0	0	0	4	0	0	6
H2 Rate (% of detectors affected)	1	0	0	0	3	0	0	6
H2 Subscore	A	A	A	A	A	A	A	B
Number of Phases	382	242	129	183	199	253	209	148
H3 Phases	42	31	123	2	12	3	31	42
H3 Rate (% of phases affected)	11	13	95	1	6	1	15	28
H3 Subscore	B	B	F	A	B	A	B	C
H4 Ped Phases	0	0	0	0	0	0	0	0
H4 Rate (% of pedestrian phases affected)	0	0	0	0	0	0	0	0
H4 Subscore	A	A	A	A	A	A	A	A
Detection Subscore	B	B	F	B	B	A	B	C
Highest red light violation rate per 1000 vehicles	15.2	8.6	(a)	12.8	17.3	23.1	8.8	16.4
Safety Subscore	C	B	(a)	C	C	D	B	C
AM Peak capacity subscore	B	B	(a)	C	A	B	C	C
Midday capacity subscore	B	B	(a)	C	A	C	C	C
PM capacity subscore	C	B	(a)	C	B	C	C	D
Capacity Allocation Category Subscore	C	B	(a)	C	B	C	C	D
AM Peak progression subscore	C	B	(a)	C	C	(b)	B	C
Midday progression subscore	B	B	(a)	B	C	(b)	A	C
PM Peak progression subscore	B	B	(a)	B	C	(b)	A	C
Progression Category Subscore	C	B	(a)	C	C	(b)	B	C
Overall Corridor Score	C	C	F	F	C	D	C	D

Overall Results

Corridor	Maintenance		Operation			Overall Score
	Comm	Detection	Safety	Capacity	Progression	
Pendleton Pike	B	B	C	C	C	C
SR 37 Indianapolis South	C	B	B	B	B	C
SR 37 Martinsville	A	F	-	-	-	F
SR 37 Noblesville	F	B	C	C	C	F
US 231 Greater Lafayette	A	B	C	B	C	C
US 31 Columbus	C	A	D	C	-	D
US 31 Greenwood	C	B	B	C	B	C
US 421 Zionsville	A	C	C	D	C	D

Summary

- A method of aggregating ATSPMs to deliver a score for corridors was demonstrated for eight arterials in Indiana
- A hierarchical system of scoring was developed for five areas
 - Communication
 - Detection
 - Safety
 - Capacity Allocation
 - Progression
- “Strawman” thresholds were used to convert individual metrics for these areas into a letter-grade score
- Values for each corridor were given using the lowest area score

Questions



Chris Day
cmday@iastate.edu

Howell Li, Purdue
Darcy Bullock, Purdue

Jim Sturdevant, Indiana DOT