Scaling Detailed High-Resolution Data Split Performance Measures to Statewide System Level Management

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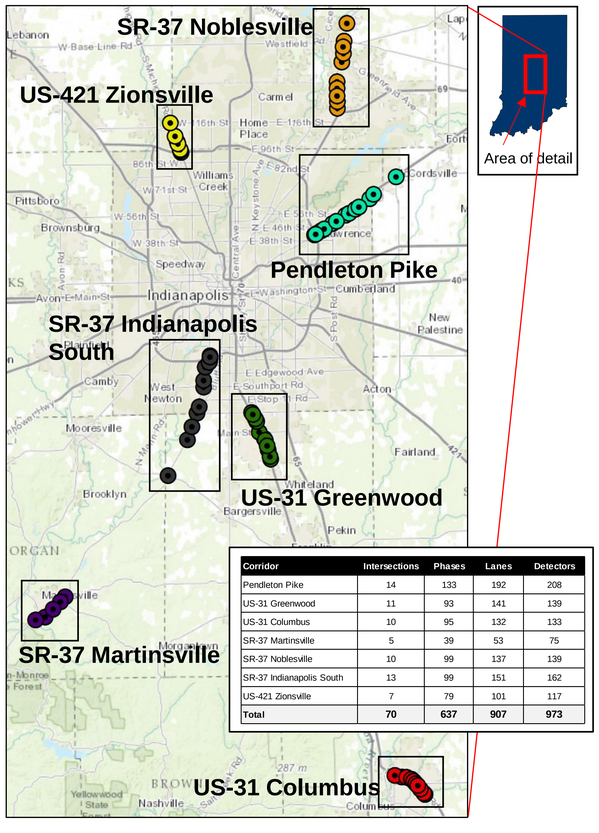
Abstract

Recent advancements in high-resolution signal controller data logging and acquisition technologies have enabled development of fundamental performance measures that are effective at identifying split failures and rebalancing green times. However, from a system operator perspective it is important to scale these metrics system-wide for monitoring, triaging, and decision-making uses. This paper articulates the questions that concern a typical system operator, and the associated performance measures and tools that can be used to actively manage such systems macroscopically. To illustrate this methodology, the paper examines 70 signals across seven corridors over a six-month period. Approximately three billion high-resolution signal events including 217 million phase occurrences are analyzed, with 126 million of those phases occurring during the 0600–1900 time period. This paper proposes a scalable method to identify phase occurrences with insufficient green. Applying a previously-developed split failure performance measure for this purpose, over 106,000 split failures (0.08% percent) of the phase occurrences are estimated to have failures for the time of day period. These are displayed using a graphical visualization we called the Purdue Split Failure Ticker (PSFT). Subsequent sections of the paper recommend Pareto ranking, drill-down analysis by movement and hour, and corridor movement split summaries to identify where to prioritize resources for signal re-timing activities and geometric improvements.

Study Location



Corridor	Intersections	Phases	Lanes	Detectors
Pendleton Pike	14	133	192	208
US-31 Greenwood	11	93	141	139
US-31 Columbus	10	95	132	133
SR-37 Martinsville	5	39	53	75
SR-37 Noblesville	10	99	137	139
SR-37 Indianapolis South	13	99	151	162
US-421 Zionsville	7	79	101	117
Total	**70**	**637**	**907**	**973**

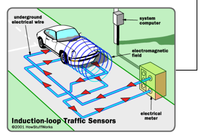
Indianapolis, Indiana Area

Scaling Data – Reduction and Aggregation

Level 1 - Stateless Events

Output, Phase Events

Signal Controller



Detector Events

There is considerable overhead in storing data with this format

High-Resolution Data

Timestamp	Event	Phase or Channel
2015-12-09 12:00:43.0	ON	10
2015-12-09 12:02:09.0	GRN	3
2015-12-09 12:02:20.3	OFF	10
2015-12-09 12:02:20.7	ON	10
2015-12-09 12:02:24.6	YEL	3
2015-12-09 12:02:24.8	OFF	10
2015-12-09 12:02:26.5	ON	10
2015-12-09 12:02:28.2	RED	3
2015-12-09 12:03:17.9	GRN	3
2015-12-09 12:03:24.2	OFF	10

Level 2 - Intervals

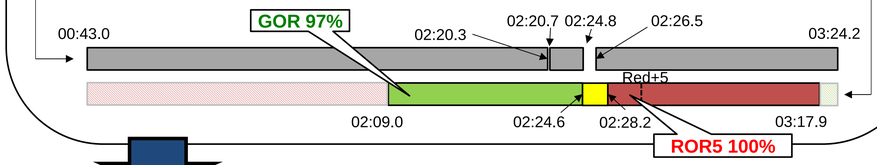
Phase and detector event pairs are combined into interval records, and non-essential records are removed to reduce the number of rows indexed.

Phase Intervals

Time on	Time off	Indication	Phase
2015-12-09 12:02:09.0	2015-12-09 12:02:24.6	Green	3
2015-12-09 12:02:24.6	2015-12-09 12:02:28.2	Yellow	3
2015-12-09 12:02:28.2	2015-12-09 12:03:17.9	Red	3

Detector Intervals

Time on	Time off	Channel
2015-12-09 12:00:43.0	2015-12-09 12:02:20.3	10
2015-12-09 12:02:20.7	2015-12-09 12:02:24.8	10
2015-12-09 12:02:26.5	2015-12-09 12:03:24.2	10



Level 3 – 15-Minute Aggregates

Once the intervals are produced, occupancy ratios and split failures can be aggregated into single 15-minute binned records for faster queries.

Phase Aggregate Record

Bin	Output	Split Failures	Green Time	Yellow time	Red time	Occ. Green	Occ. Yellow	Occ. Red
2015-12-09 12:00:00.0	3	**1**	191.8s	39.6s	654.8s	149.8s	6.1s	273.5s

Detector Aggregate Record

Bin	Channel	Split Failures	% Occ. Green	% Occ. Yellow	% Occ. Red
2015-12-09 12:00:00.0	10	**1**	70.4%	37.5%	50.1%

What Constitutes a *Split Failure*?

A *split failure* is when the duration of green for a movement at a signalized intersection is *insufficient* to service the amount of demand present. This study uses an occupancy-based metric that looks at the green interval and the beginning (first five seconds) of the red interval, i.e. if both are over **80%** occupied.

Queue builds during first red interval.

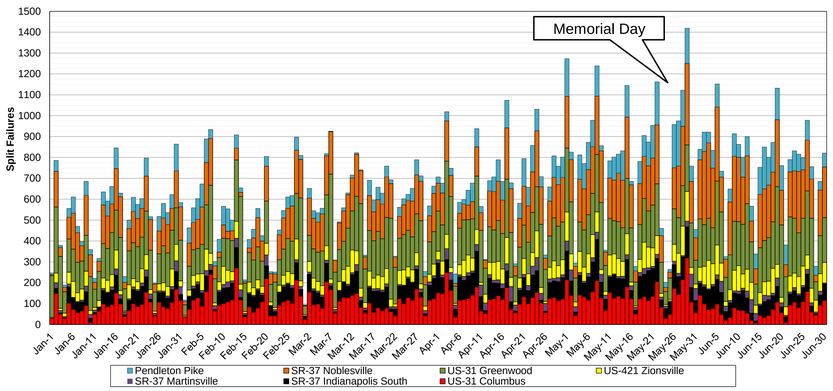
Vehicles start to depart at the beginning of the green interval.

Vehicles finish departing during the yellow interval.

New queue forms at the beginning of the second red interval.

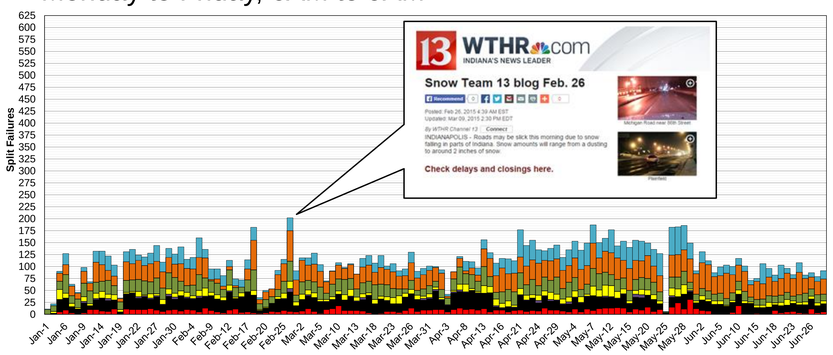
Total Split Failures, January to June 2015

All days of the week, 24 hours per day



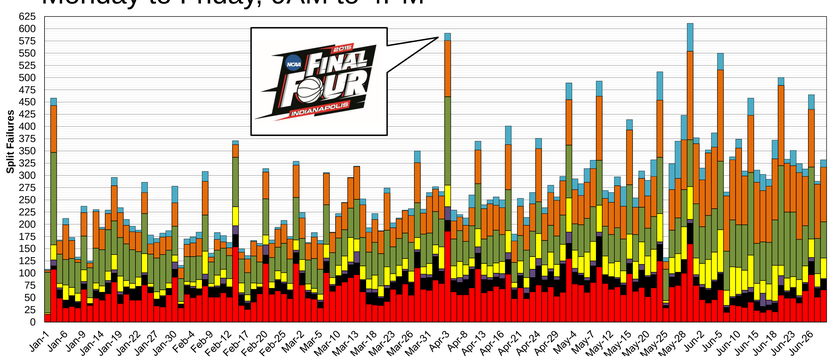
General trend from winter to summer is increasing split failures. Weekly trends show peaking characteristics for most Fridays, and Saturdays for some systems.

Monday to Friday, 6AM to 9AM



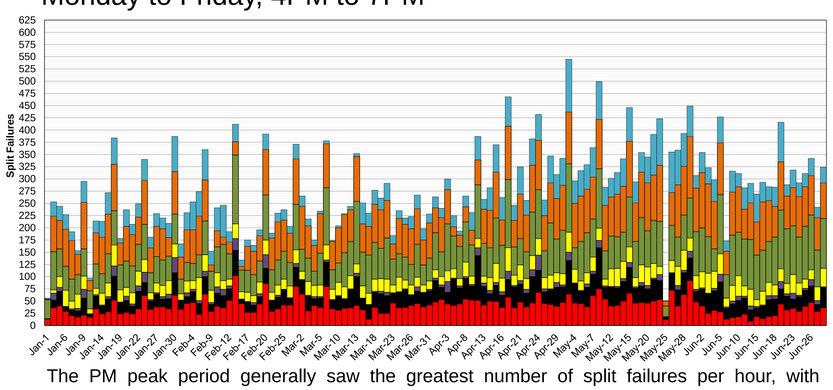
Most systems spiked during two snow events in February with the exception of US-31 Columbus (the southernmost system).

Monday to Friday, 9AM to 4PM



The first Friday of April broke seasonal trends as the NCAA Final Four tournament was in town.

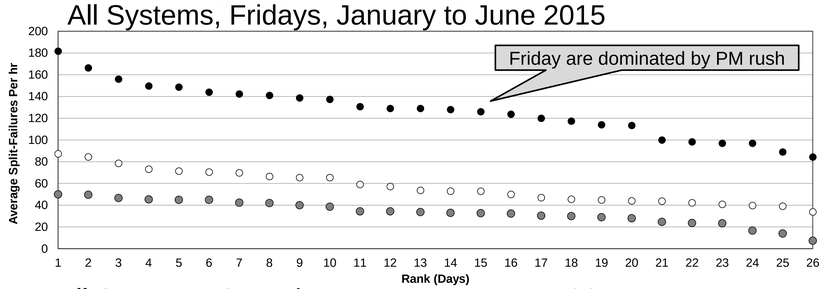
Monday to Friday, 4PM to 7PM



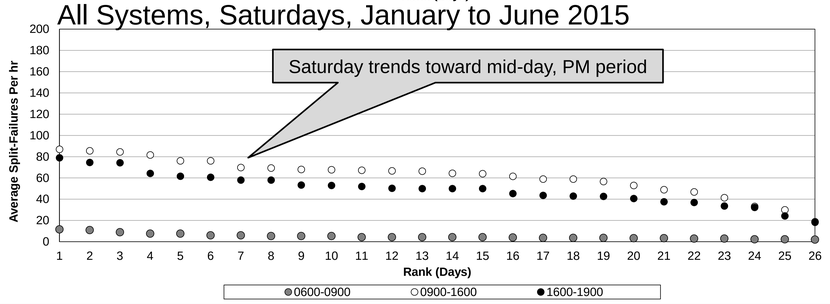
The PM peak period generally saw the greatest number of split failures per hour, with significant increases after the beginning of April.

Time-of-Day Performance

All Systems, Fridays, January to June 2015

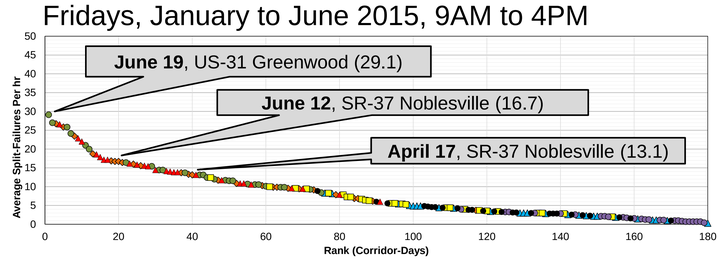


All Systems, Saturdays, January to June 2015

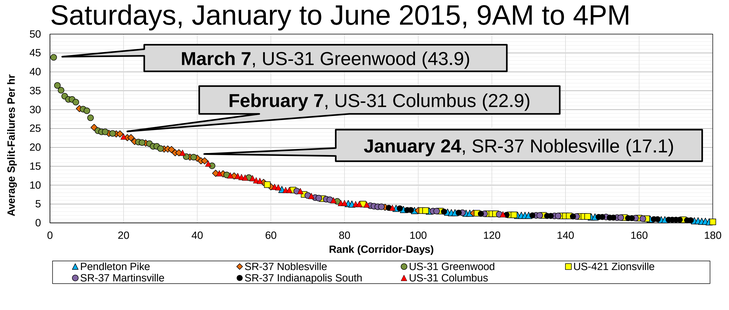


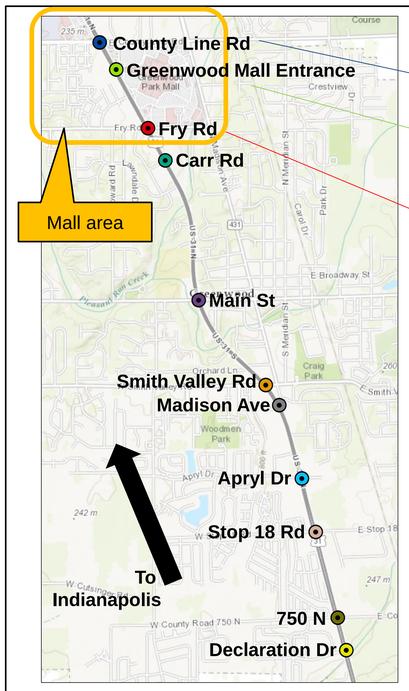
Corridor Performance

Fridays, January to June 2015, 9AM to 4PM



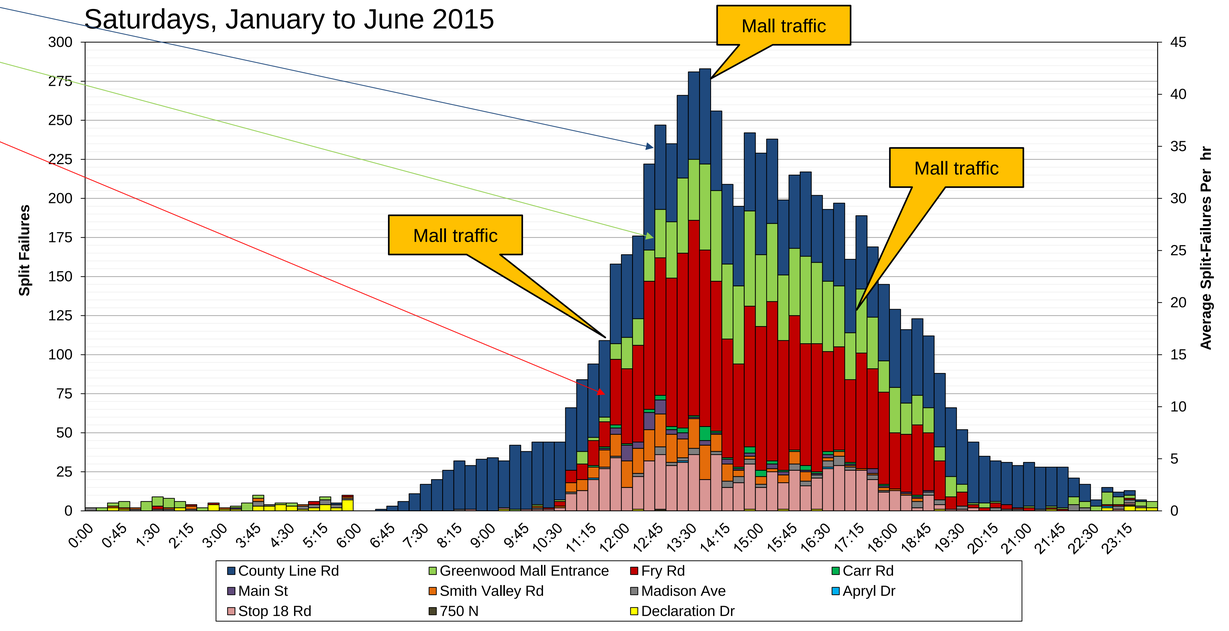
Saturdays, January to June 2015, 9AM to 4PM





Intersection Performance at US-31 Greenwood

Saturdays, January to June 2015



System Summary

Avg. split failures per intersection per hour

January to June 2015

Corridor	Time of Day	Mon-Thur	Fri	Sat	Sun
Pendleton Pike	0600-0900	0.52	0.44	0.04	0.06
	0900-1600	0.65	0.23	0.17	0.08
	1600-1900	1.49	1.17	0.12	0.08
US-31 Greenwood	0600-0900	0.67	0.60	0.21	0.08
	0900-1600	0.83	1.35	2.22	0.89
	1600-1900	1.89	2.99	2.28	0.70
US-31 Columbus	0600-0900	0.25	0.26	0.04	0.02
	0900-1600	0.76	1.43	0.94	0.39
	1600-1900	1.21	1.86	0.73	0.33
SR-37 Martinsville	0600-0900	0.06	0.07	0.02	0.01
	0900-1600	0.12	0.34	0.69	0.40
	1600-1900	0.28	1.05	0.26	0.12
SR-37 Noblesville	0600-0900	1.08	0.93	0.06	0.03
	0900-1600	0.83	1.33	1.72	0.47
	1600-1900	2.21	2.98	0.83	0.21
SR-37 Indianapolis South	0600-0900	0.58	0.48	0.04	0.05
	0900-1600	0.22	0.28	0.14	0.07
	1600-1900	0.70	1.12	0.32	0.07
US-421 Zionsville	0600-0900	0.42	0.33	0.06	0.05
	0900-1600	0.52	0.84	0.44	0.16
	1600-1900	1.14	1.35	0.25	0.16

Movement Performance at US-31 Greenwood

Saturdays, January to June 2015, 11AM to 7PM