

Enhancing Traffic Safety and Mobility by Leveraging Big Data and Analytics

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Smart Infrastructure: Opportunities

- As network data becomes faster, cheaper, and more integrated, we will face a brave new world in traffic management, an incredible opportunity
- The cloud offers even greater opportunities for integration, big data, and analytics
- The convergence of recent technology developments portend a revolution
 - Big data analytics and visualization
 - High resolution data capture
 - ATC controller hardware with more processing, network, and UI capabilities

Data Driven Traffic Management Systems

- New approaches are changing how we manage and optimize signals
 - Hi-resolution data
 - Data fusion
 - Data analytics
- New algorithms and processing capabilities are changing arterial traffic control with alternatives to traditional adaptive approaches
 - Signal performance measures
 - Purdue algorithms (Link pivot and GOR/ROR)
 - New optimization approaches



Raw High-Resolution Event Data

● SignalID	Timestamp	EventCodeID	Param
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	7	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	8	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	2	4
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	63	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	83	9
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	43	4
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.600	4	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.700	81	9
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.700	43	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:00.700	44	4
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:02.300	82	1
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:02.800	22	2
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:02.800	81	1
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:04.100	10	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:04.100	9	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:04.100	64	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:05.100	0	4
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:05.100	11	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:05.100	1	4
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:05.100	2	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:05.100	12	6
● A51C66F2-DB15-4CB3-A42D-D8BA36CF9F5B	2016-09-30 00:15:05.100	61	4

High-Resolution Event Data – Why It Is Important?

Traditional

- 15-minute bins
- Volume
- Occupancy

Hi-Resolution Data

Logs virtually every signal state 10x per second

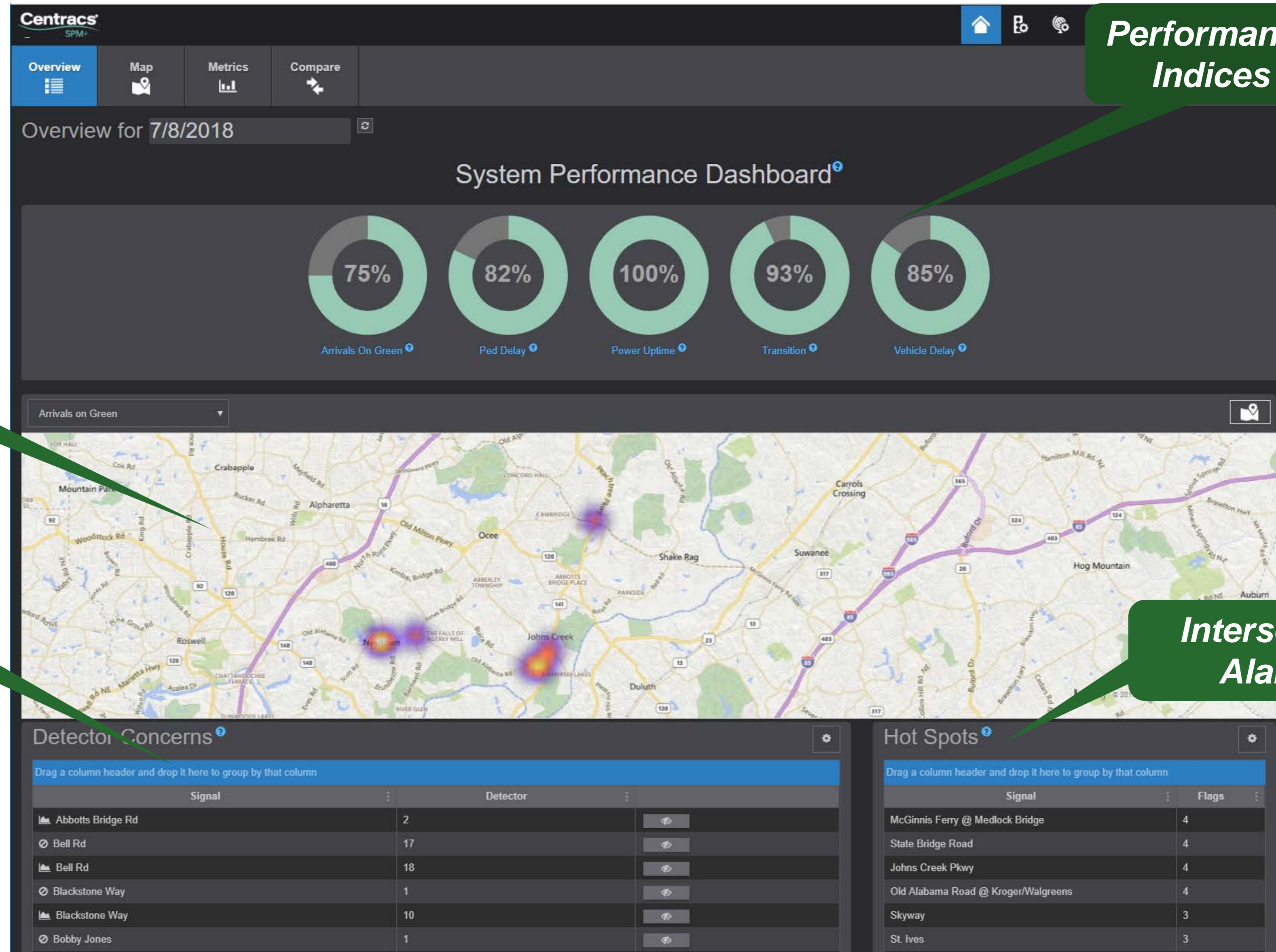
- Phase color change
- Arrivals On Green (AOG)
- Occupancy ratio
- Detector on/off
- ROR/GOR
- Transition
- Preemption
- Vehicle delay
- Purdue Coordination Diagram
- Pedestrian delay
- Ped actuations
- Phase color change
- Power failures
- Split monitoring
- Split failures
- Longitudinal split failures
- Flow rate
- Volume/Capacity
- More

What is Automated Traffic Signal Performance Measures?

ATSPM is a suite of *performance measures*, *High Resolution Data* collection tools, and *data analysis* tools to support an objectives- and performance-based approach to managing a traffic signal program.

FHWA Every Day Counts

A Cloud-Based SPM Solution



Performance Indices

Heat Map

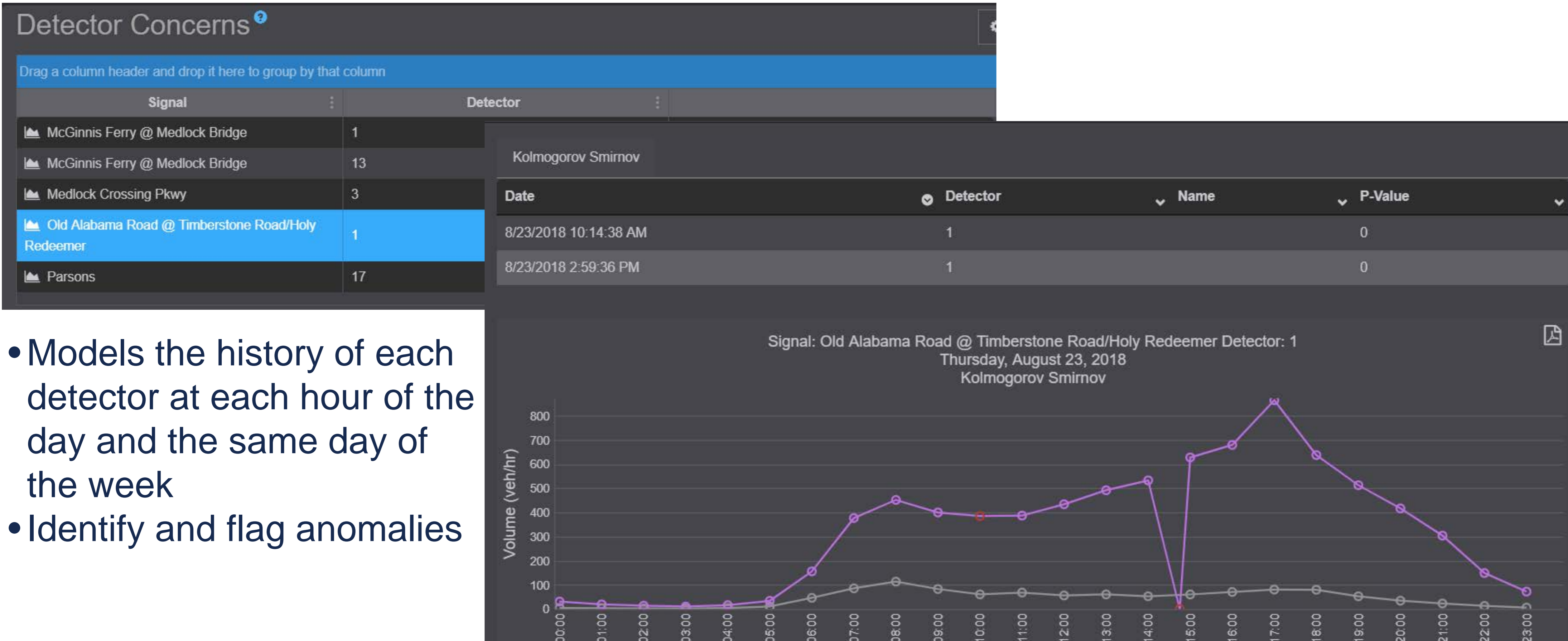
Detector Issues

Intersection Alarms

Addressing Operational Needs

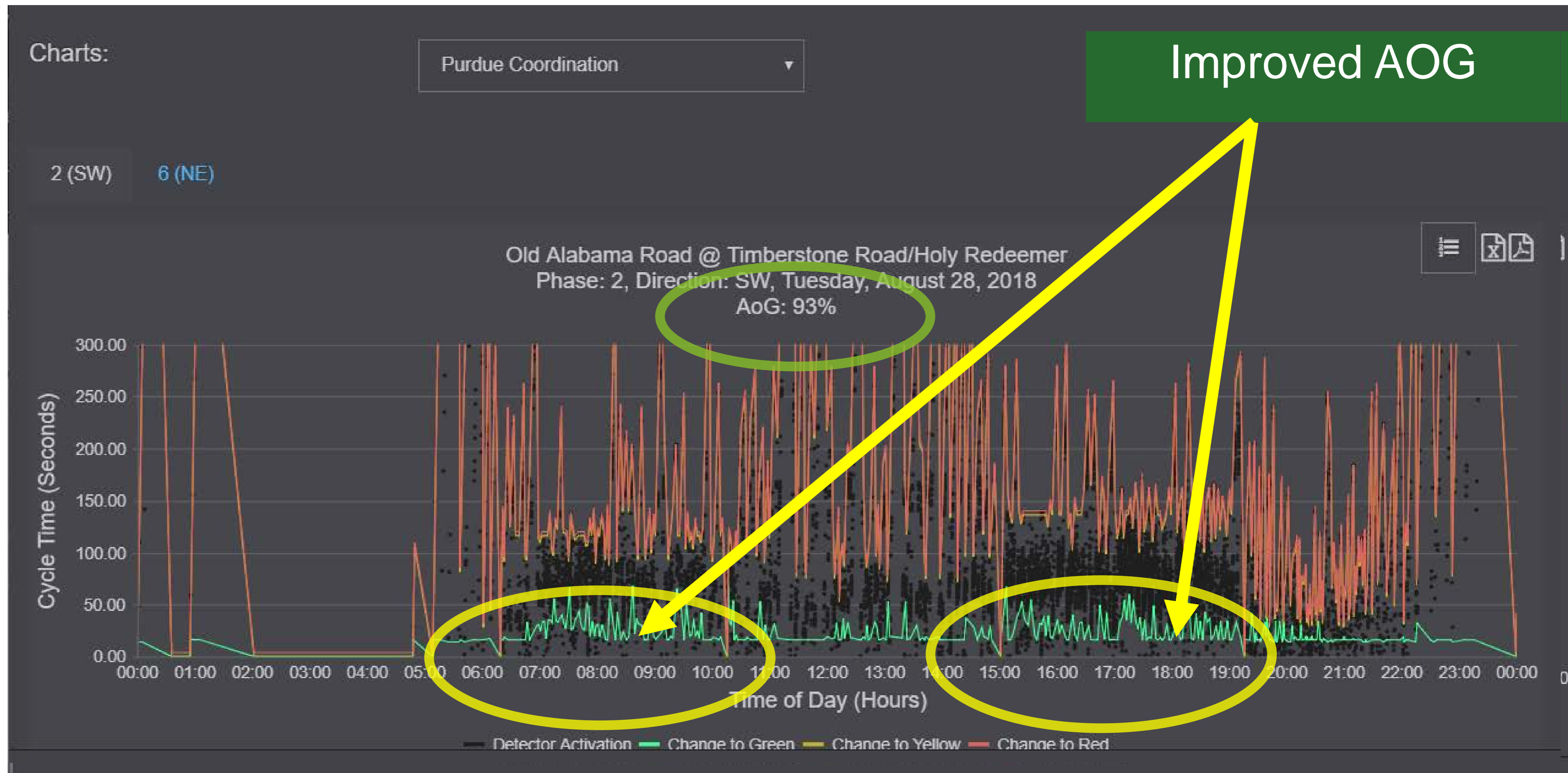
- Enhanced monitoring capability to more deeply assess operational performance of traffic signals
- A high-level view of the health and performance of the system
- Data analytics and system intelligence to pinpoint problem areas on a daily basis (addressing resource constraints)
- Proactive operations & maintenance of traffic network
- Capability to optimize signal timings

Detector Fault Analysis



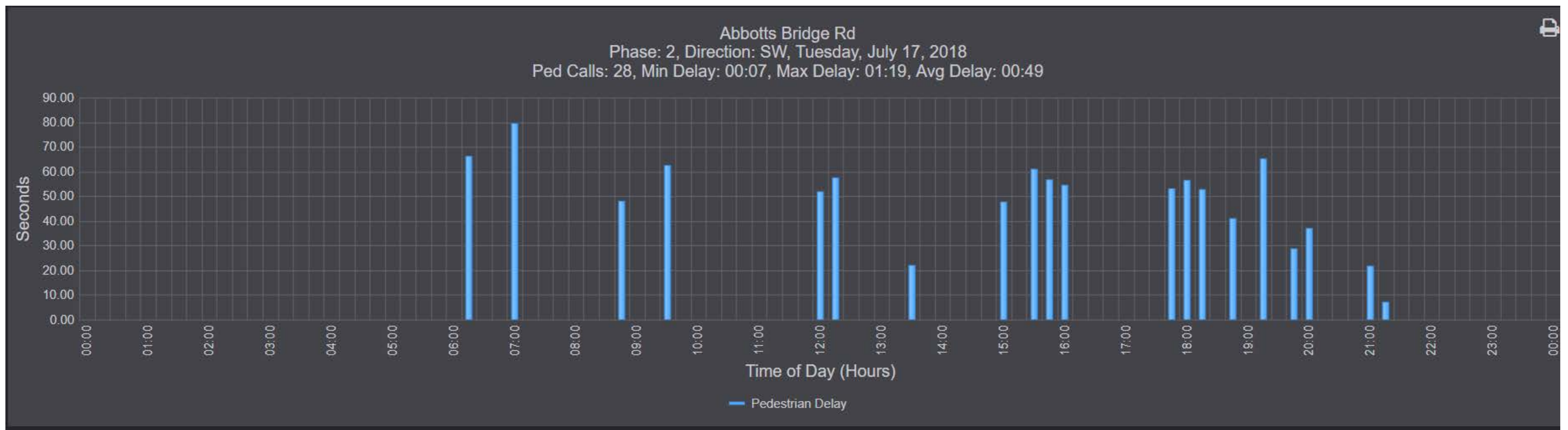
- Models the history of each detector at each hour of the day and the same day of the week
- Identify and flag anomalies

Purdue Coordination Diagram



Pedestrian Safety - Ped Delays Chart

- Duration of time from ped call to phase walk activation
- Used for:
 - Multi-modal prioritization
 - Ensure pedestrians are receiving equitable service



Pedestrian Safety: Ped Actuations

- Allowing “Oversized Ped”
 - Ped Crossings used very infrequently
- Heavily used Ped crossing should fit Ped timing into splits

Metrics

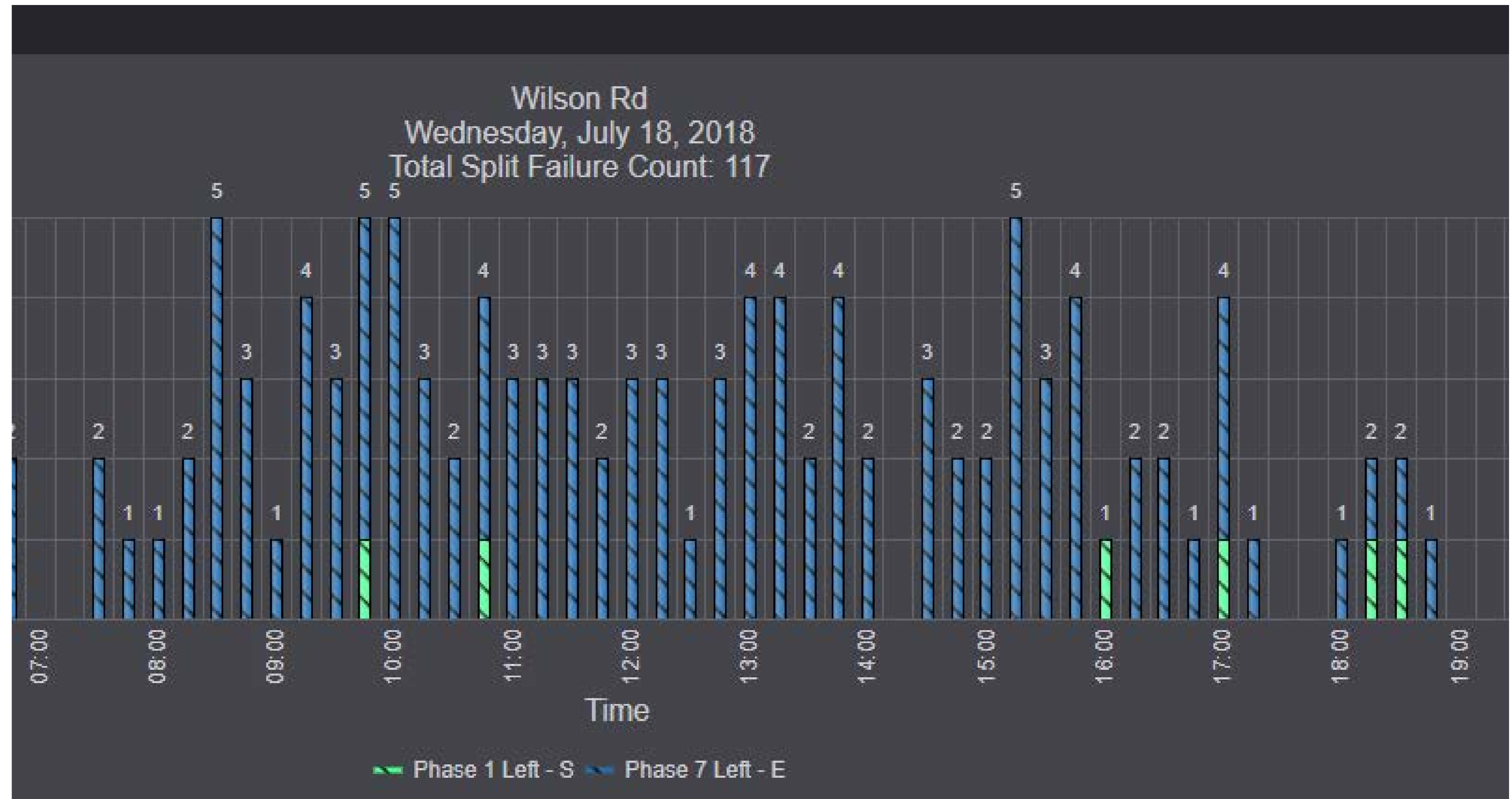
SPM Transition Preempt Missing Data

Date 07/24/2018

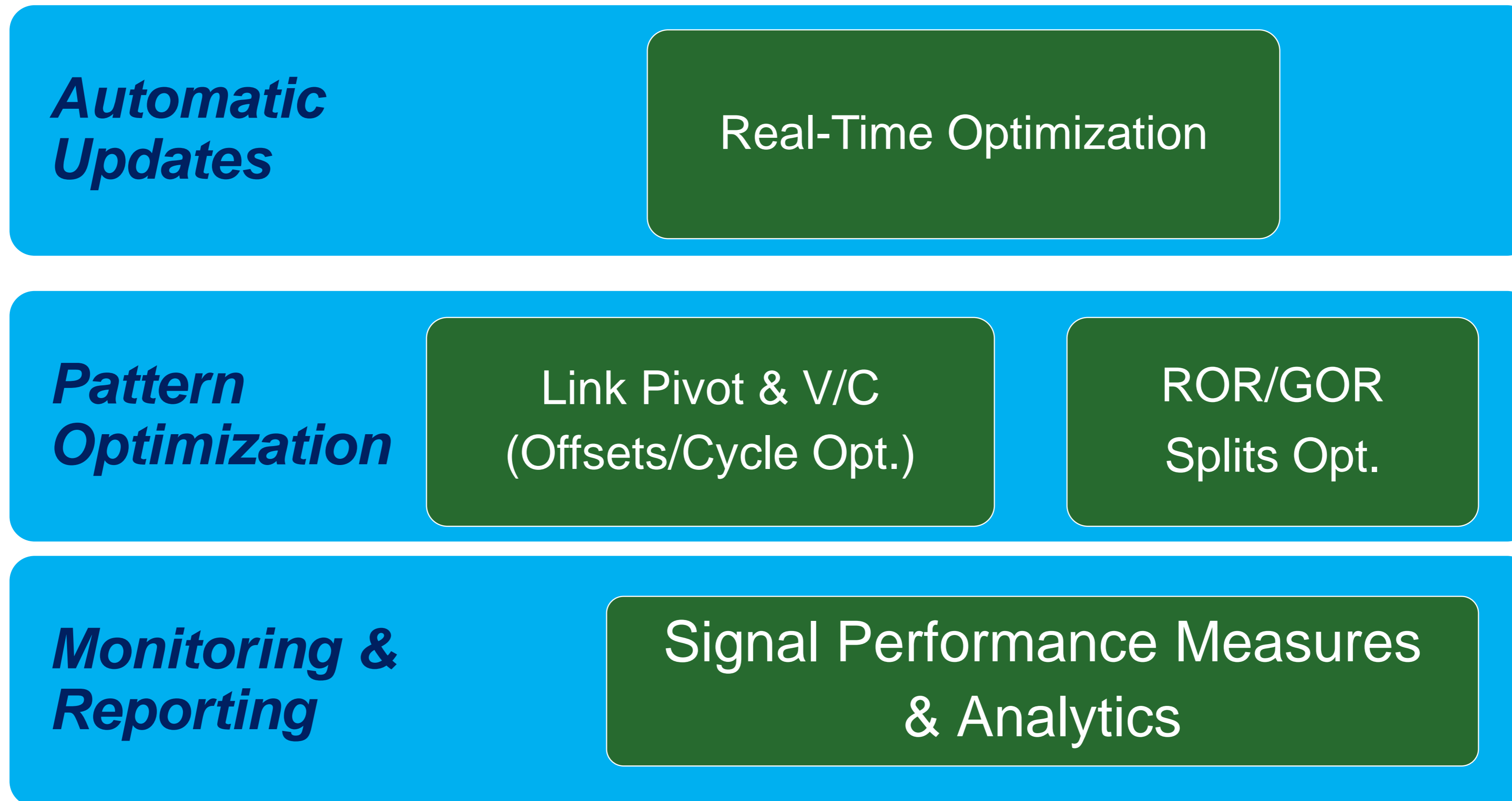
Corridors > Signals > Details

Transition Start	Duration	Cause	Occurred	Parameter
7/24/2018 6:19 AM	0:00:26	Ped Begin Walk	7/24/2018 6:18 AM	Phase 6
7/24/2018 6:20 AM	0:00:07	Coord Pattern Change	7/24/2018 6:20 AM	Pattern 25
7/24/2018 6:39 AM	0:00:19	Ped Begin Walk	7/24/2018 6:39 AM	Phase 6
7/24/2018 6:50 AM	0:00:19	Ped Begin Walk	7/24/2018 6:48 AM	Phase 6
7/24/2018 6:59 AM	0:00:13	Ped Begin Walk	7/24/2018 6:59 AM	Phase 6
7/24/2018 7:10 AM	0:00:08	Ped Begin Walk	7/24/2018 7:09 AM	Phase 6
7/24/2018 7:19 AM	0:00:20	Ped Begin Walk	7/24/2018 7:18 AM	Phase 6
7/24/2018 7:29 AM	0:00:29	Ped Begin Walk	7/24/2018 7:28 AM	Phase 6
7/24/2018 7:40 AM	0:00:16	Coord Pattern Change	7/24/2018 7:40 AM	Pattern 25
7/24/2018 7:49 AM	0:00:44	Ped Begin Walk	7/24/2018 7:49 AM	Phase 4

Longitudinal Split Failure



Continuous Signal Timing Optimization



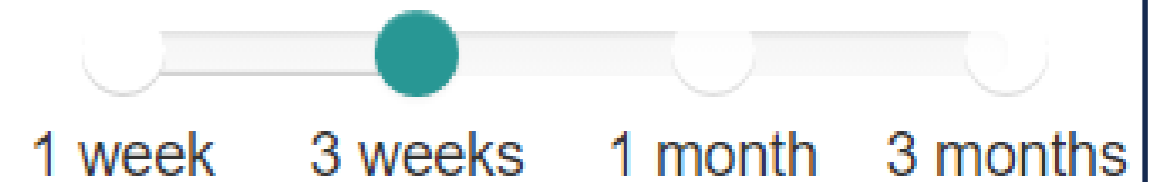
Plan Optimizer

- Plan Optimizer produces an optimized **set** of patterns based on actual data, tailored by day of the week, special events, holidays, weather conditions, etc.
- Configurable frequency: from 1 week to 3 months
- User selectable S/C/O optimization
- User chooses the changes to be applied

Enabled



Frequency



What settings would you like to optimize?

Offset



Phase Sequence



Cycle Length



Splits



Optimized Timing Plans

SPM+ - Medlock Bridge Optimization Beta [?]

Optimization > Plans > Jun 12, 2018 11:47 AM

Plan Generated On: Jun 12, 2018 11:47 AM

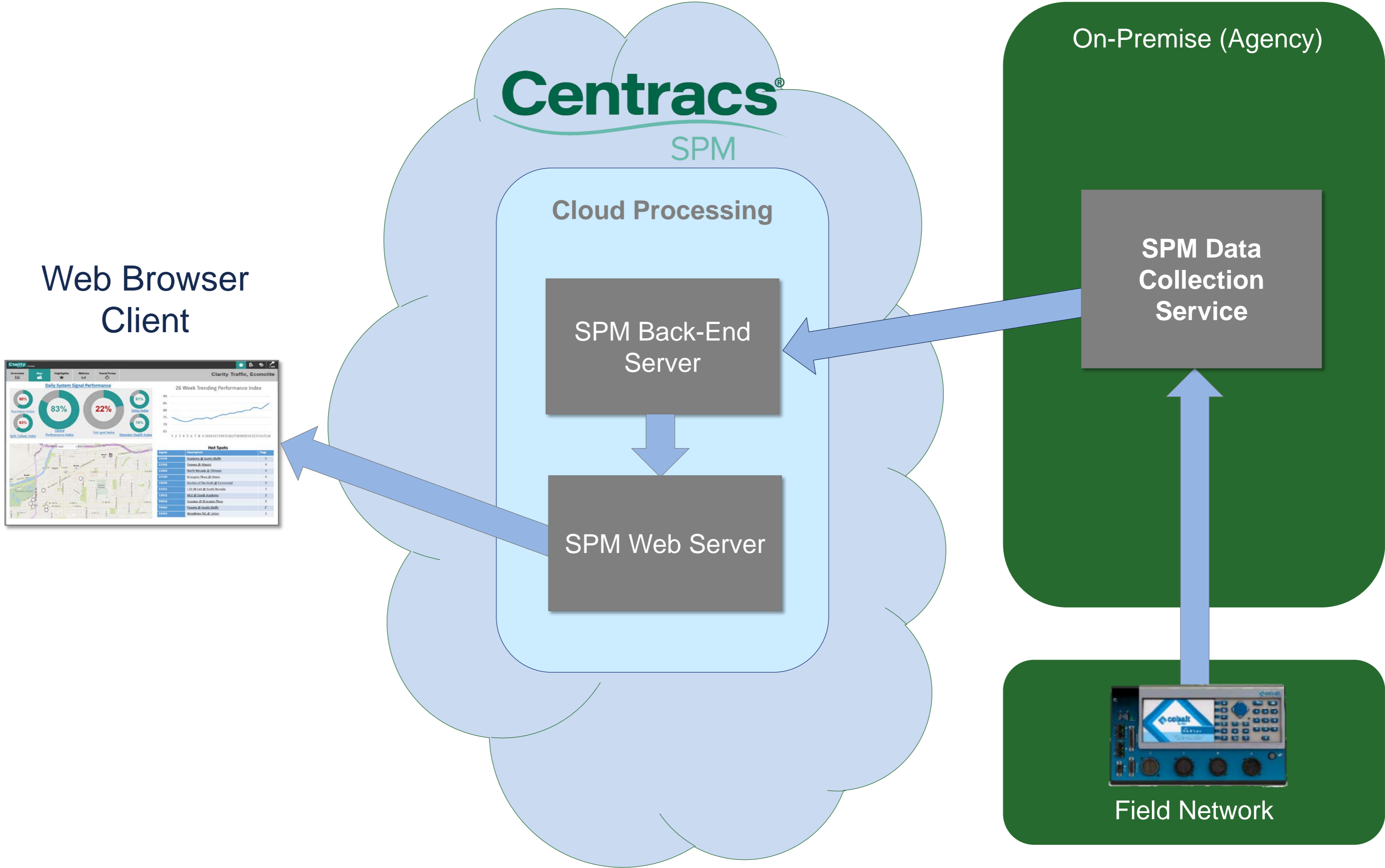
Analysis Period: Jun 11, 2018 - Jun 12, 2018

Configured: O, C, S [View Details](#)

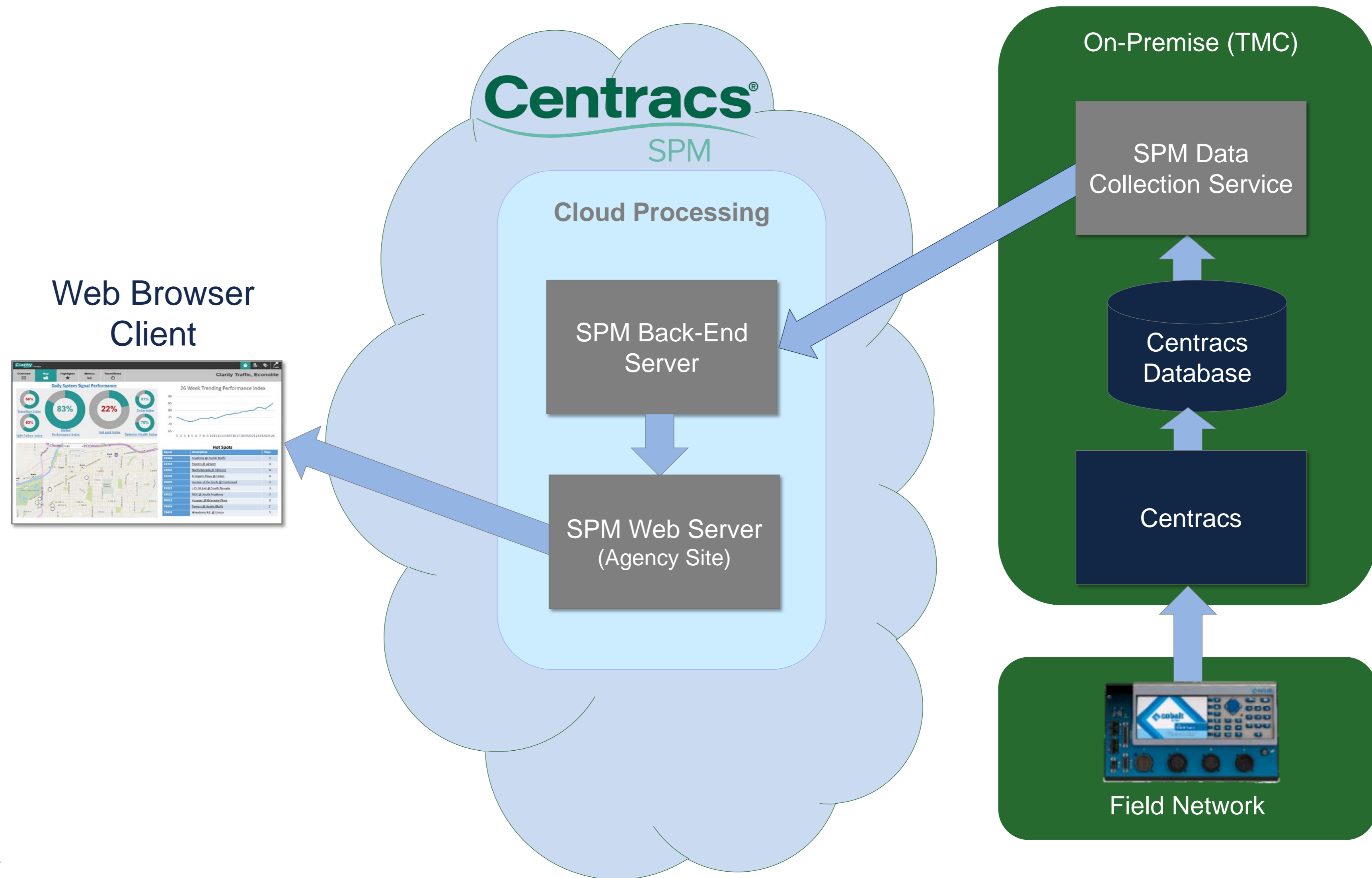
All Patterns

			Delay		
Pattern	Latest Action	Green Time / Direction	Initial	Predicted	Outcome
Pattern 22	Jun 12, 2018 11:47 AM	Programmed / Southbound	8:36:02	7:56:35 ↓ 8%	--
		Programmed / Northbound	9:19:15	5:20:57 ↓ 43%	--
Pattern 25	Jun 12, 2018 11:47 AM	Programmed / Southbound	55:30:12	45:42:24 ↓ 18%	--
		Programmed / Northbound	61:18:40	52:23:36 ↓ 15%	--
Pattern 27	Jun 12, 2018 11:47 AM	Programmed / Southbound	50:15:51	36:32:25 ↓ 27%	--
		Programmed / Northbound	25:03:12	22:24:22 ↓ 11%	--
Pattern 28	Jun 12, 2018 11:47 AM	Programmed / Southbound	9:40:37	4:21:26 ↓ 55%	--
		Programmed / Northbound	4:10:59	6:39:07 ↑ 59%	--
Pattern 29	Jun 12, 2018 11:47 AM	Programmed / Southbound	54:04:36	43:58:16 ↓ 19%	--
		Programmed / Northbound	24:37:30	30:05:01 ↑ 22%	--

Deployment Architecture - Standalone

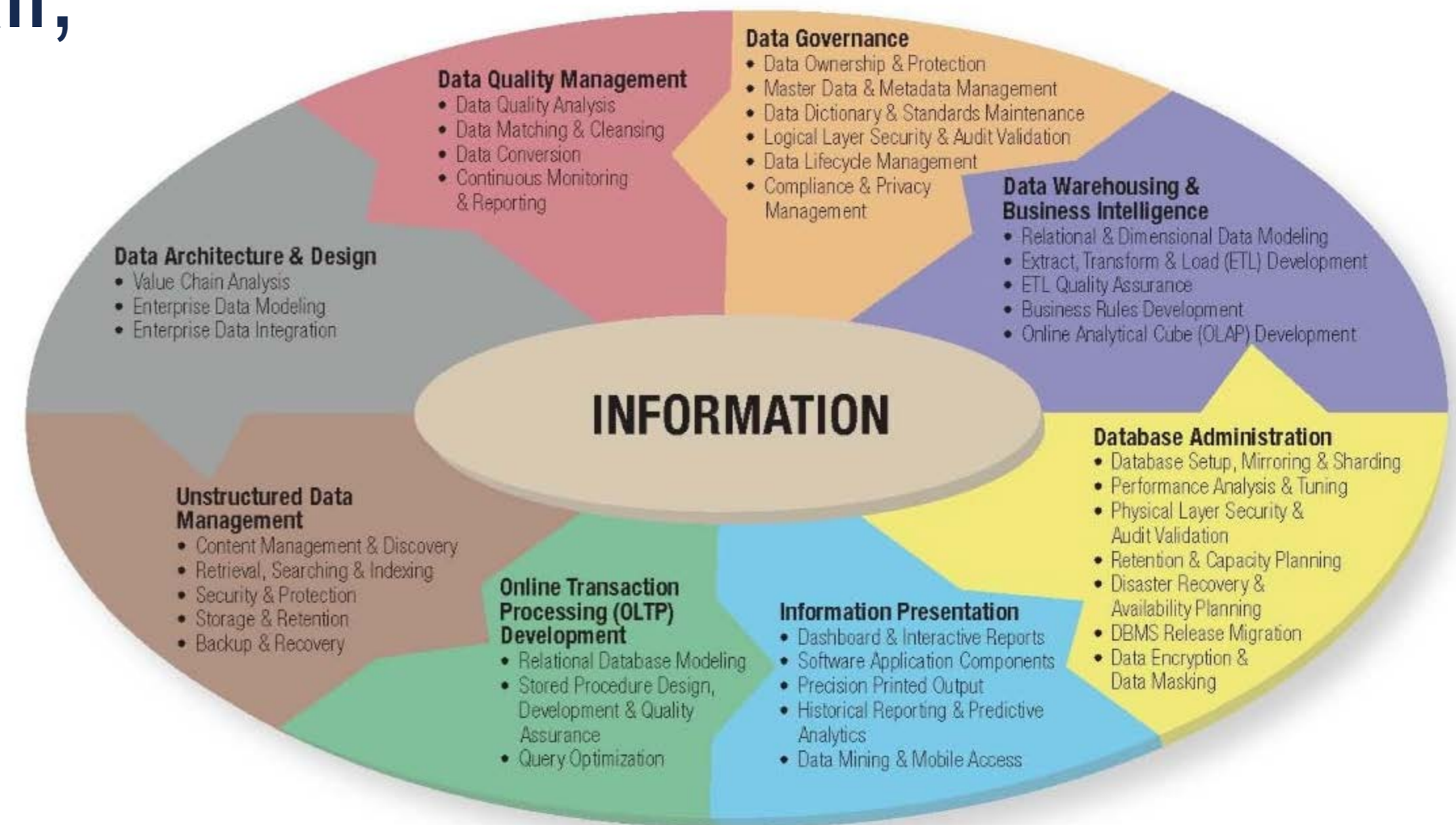


Deployment Architecture – with ATMS in the Loop

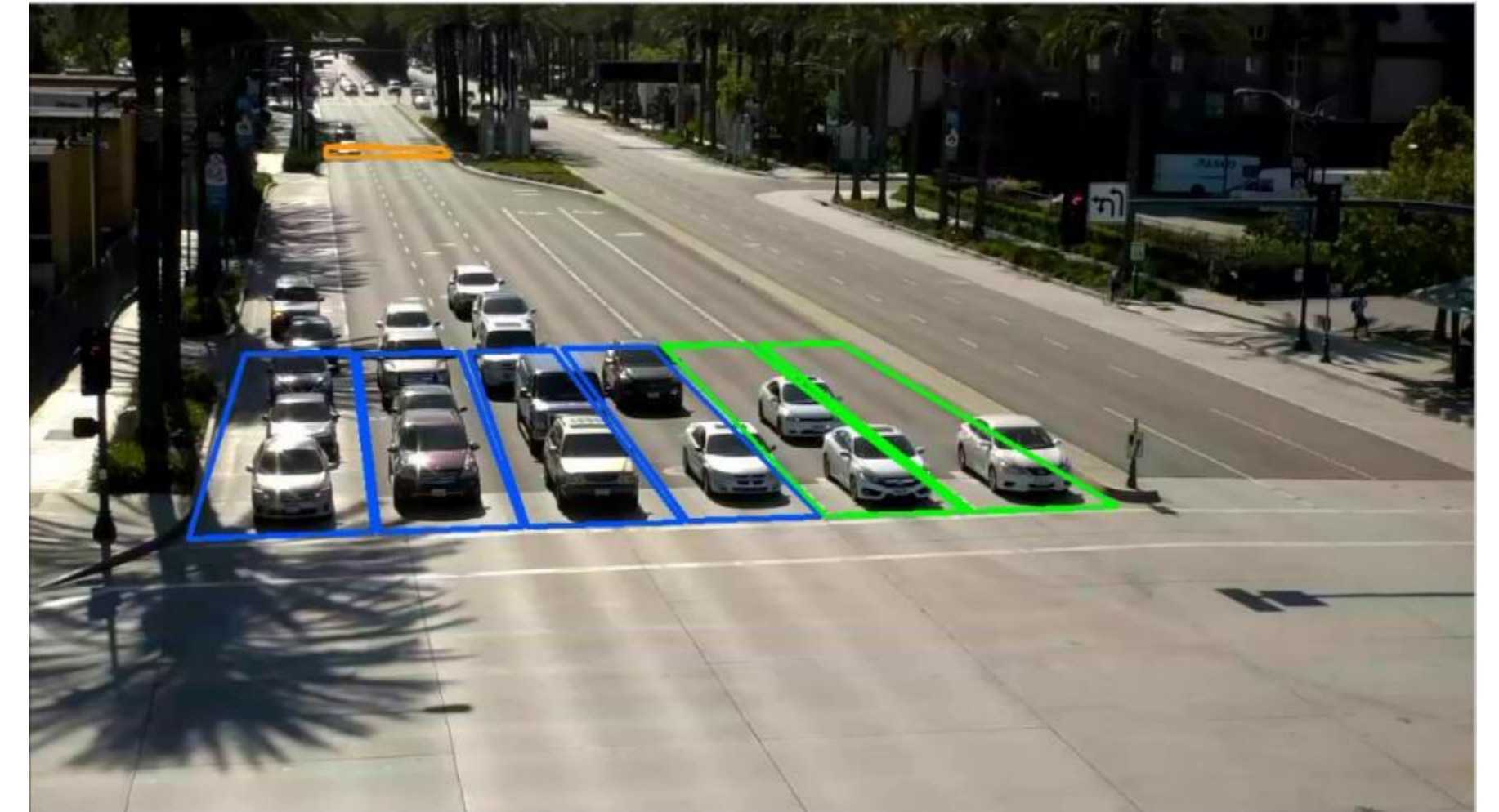
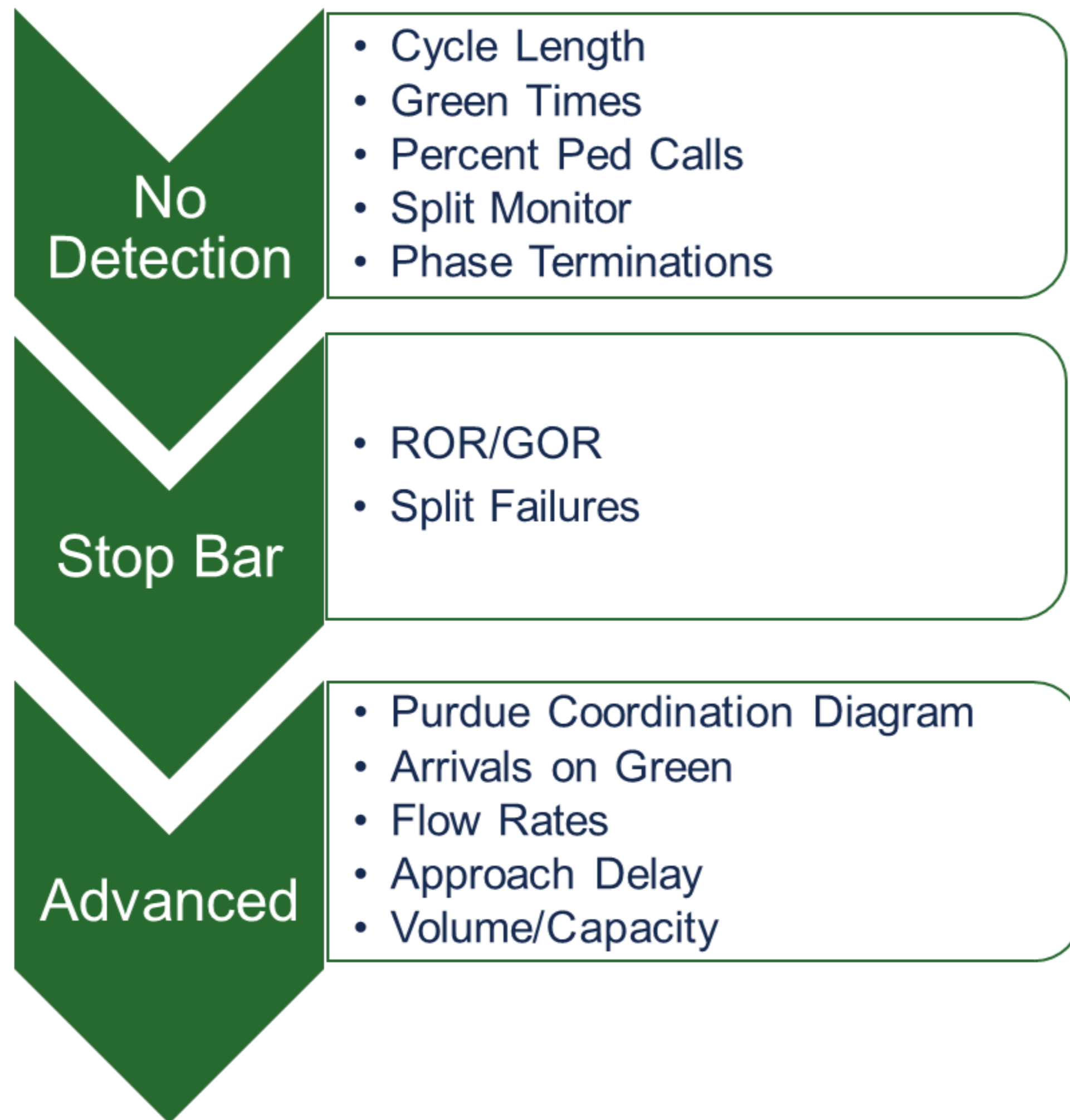


Why “the Cloud”?

- Eliminates need to purchase, install, maintain and upgrade on premise hardware
- No-hassle software upgrades and support
 - All done remotely in the cloud
- Store large datasets
 - As much as 1000 terabytes
- Ideal dissemination point for all stakeholders/systems



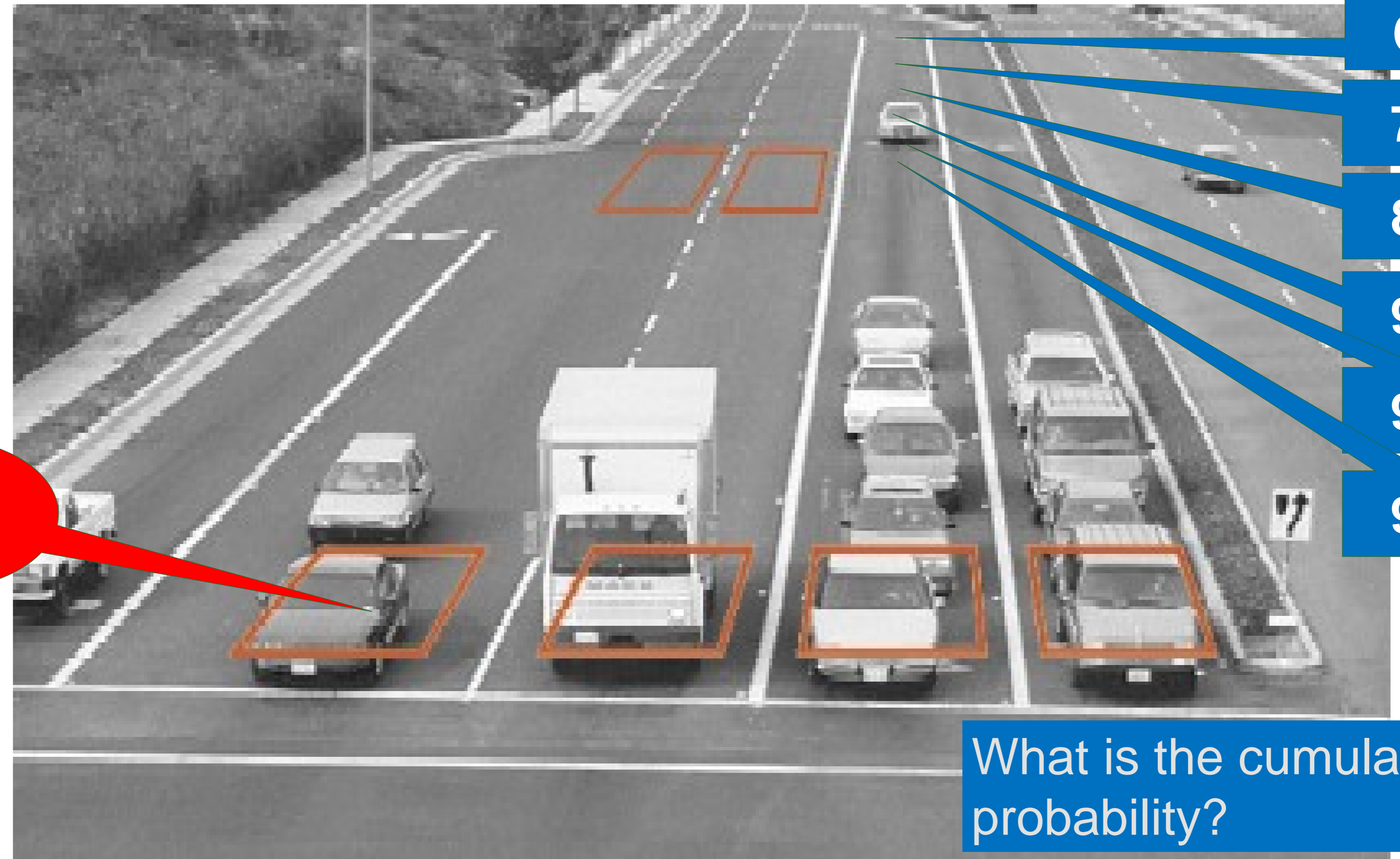
Detection Requirements



Going Forward: Trajectory-Based detection

What we need to know:

- ...how many need service
- ...how fast are they arriving
- ...what kind of vehicle is it
- ...is it accelerating
- ...decelerating



98%

- 60%
- 70%
- 80%
- 90%
- 91%
- 92%

What is the cumulative probability?

Trajectory-Based Detection

- Control decisions can “peek ahead” into the future:
 - Safer phase termination
 - Better phase utilization (demand optimization)
 - Desirable data for Connected Vehicle applications
- Vehicle instantaneous speed data allows for safety applications:
 - Red light running, prediction
 - Gap termination based upon speed profiles.

Future Direction

- **Data** centric: collection and analysis of numerous new data sources
- **Proactive** management: finding and fixing problems before they become issues
- **Automation** of signal retiming
- Better **Trajectory based detection**
- Highly efficient and flexible controller decision algorithms, e.g. objective function, geometric awareness, practices and policies
- Connected Vehicle readiness

Thank You!

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