VASITE 2025 Annual Meeting

VDOT Signal Operations Initiatives

June 17, 2025

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Salem District

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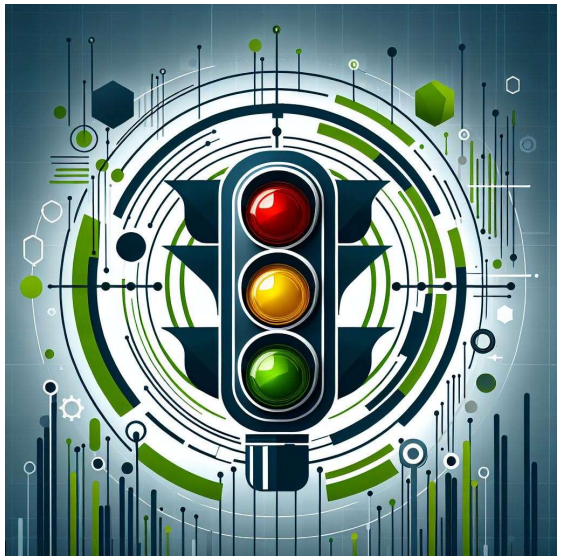
Practice Leader - TSMO: Arterial Management

Agenda



- **Traffic Signal Initiatives**
  - Detection
  - Control
  - Management
- **SPM Projects & Benefits**
  - VDOT
  - Minnesota DOT
  - Anne Arundel Co, MD

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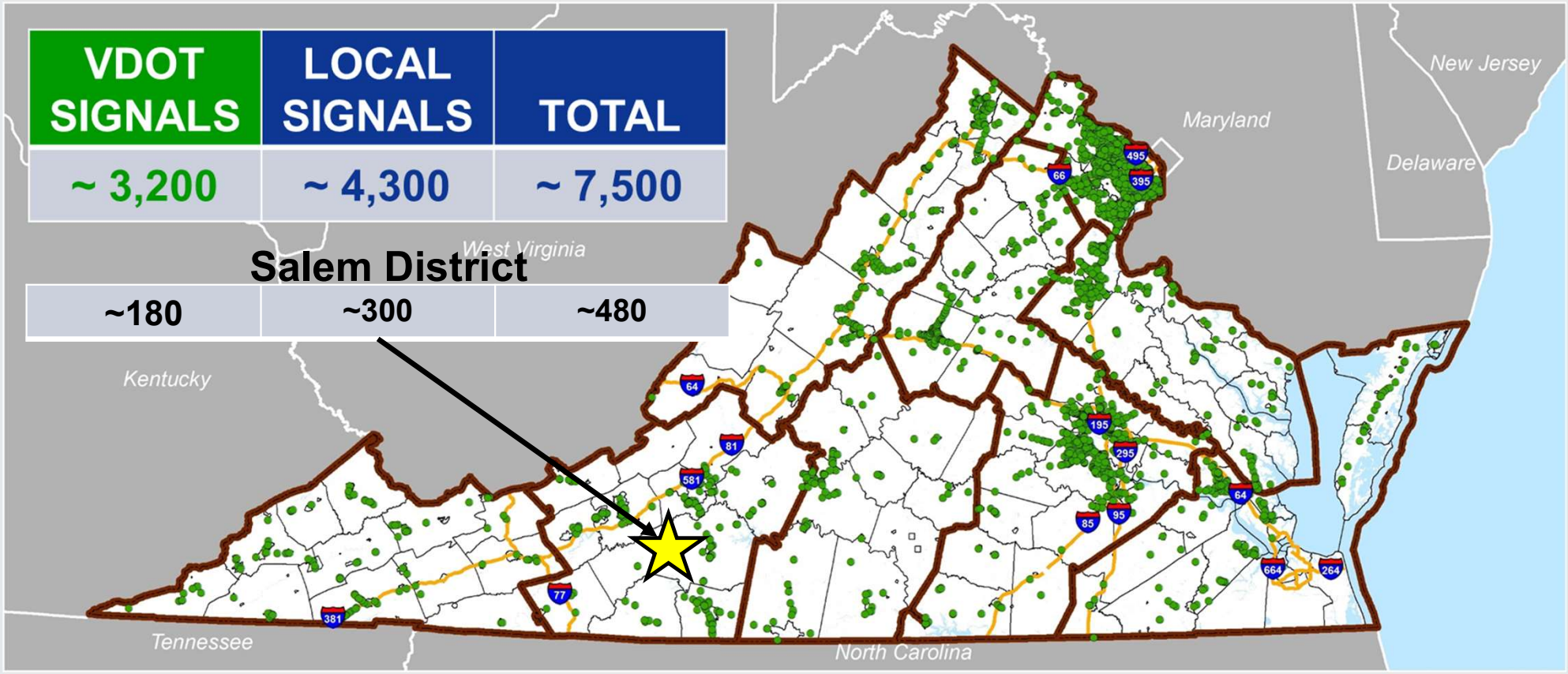
Salem District Traffic Signals



Note: Map contains only VDOT owned and maintained signals.

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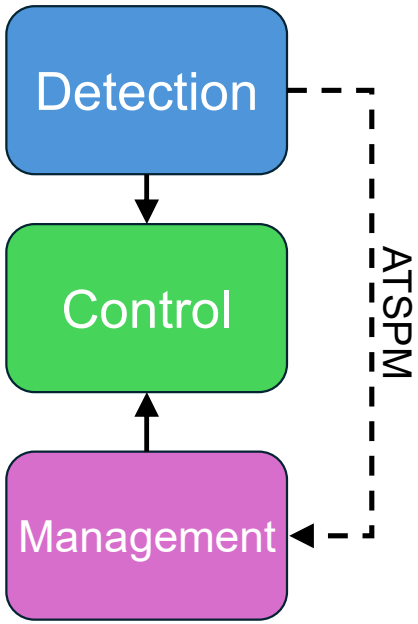
Traffic Signal Operations Components

- Detection (optional)
  - Vehicles, peds, and bikes; Emergency vehicles and transit
  - ON/OFF signal to the controller by phase
- Control
  - Logic that changes signal indications
  - Timing thresholds that limit green time
  - Parameters to provide progression along arterials
- Management
  - Monitoring performance and addressing problems
  - Engineering analysis to determine signal timings
  - Prioritization of retiming efforts
- *Maintenance*



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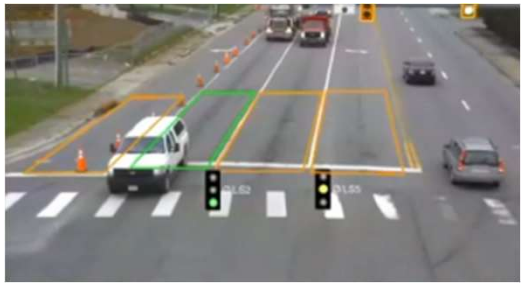
Detection Initiatives

Detection

- Single detection technology that serves multiple purposes
  - Reliable lane-by-lane presence detection (stop bar and advanced)
  - Continuous vehicle and ped counts
  - Trajectories of all approaching/departing vehicles
  - Reliable pedestrian presence detection
  - Video archive of notable safety and operation events
  - Remotely accessible from VDOT network
  - No/minimal traffic control for installation/maintenance



- Reliable probe data to see an entire corridor in real-time
  - Continuous queue length and delay data
  - Corridor-level trajectories

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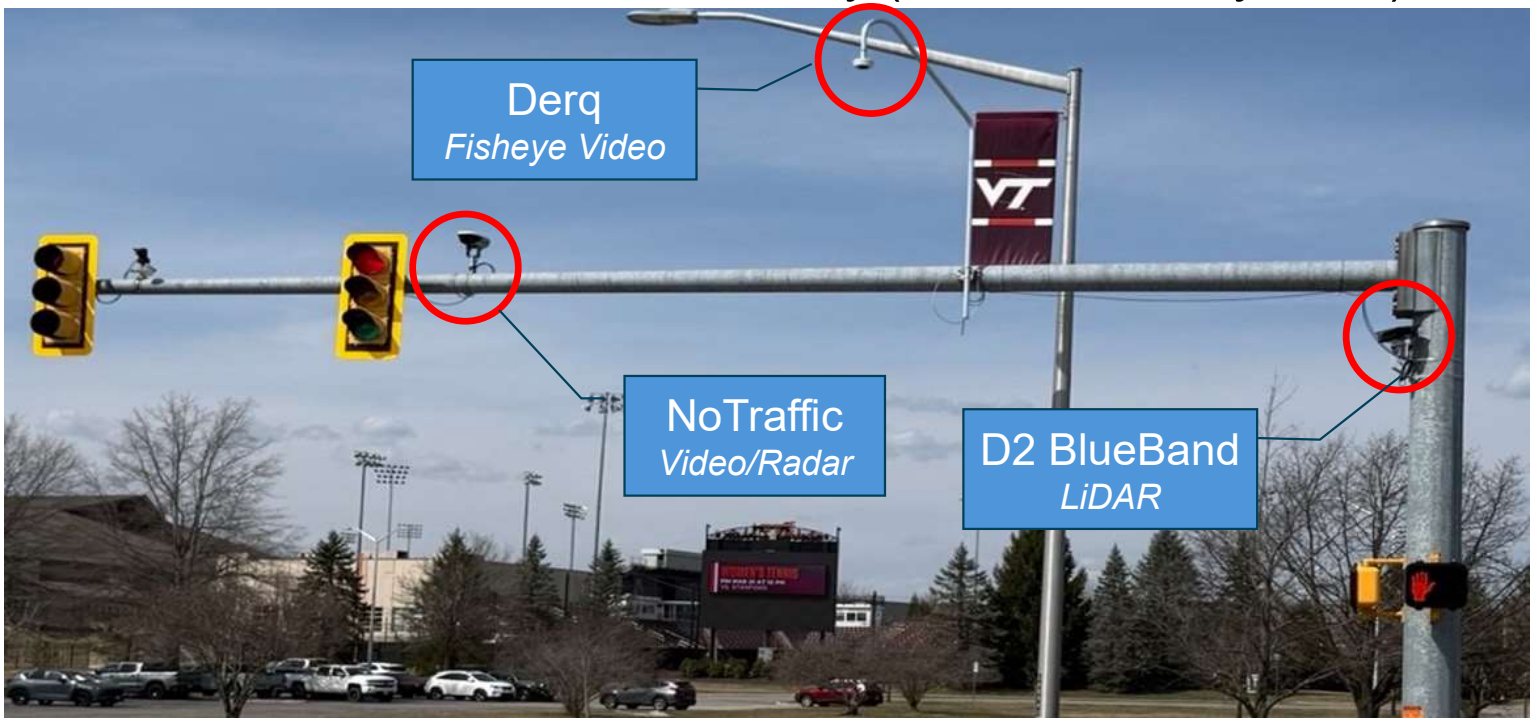
Detection Evaluations

Detection

- 2 intersections in Salem District with multiple detection systems to evaluate presence detection and other functionality (ITTF funded by VTTI)



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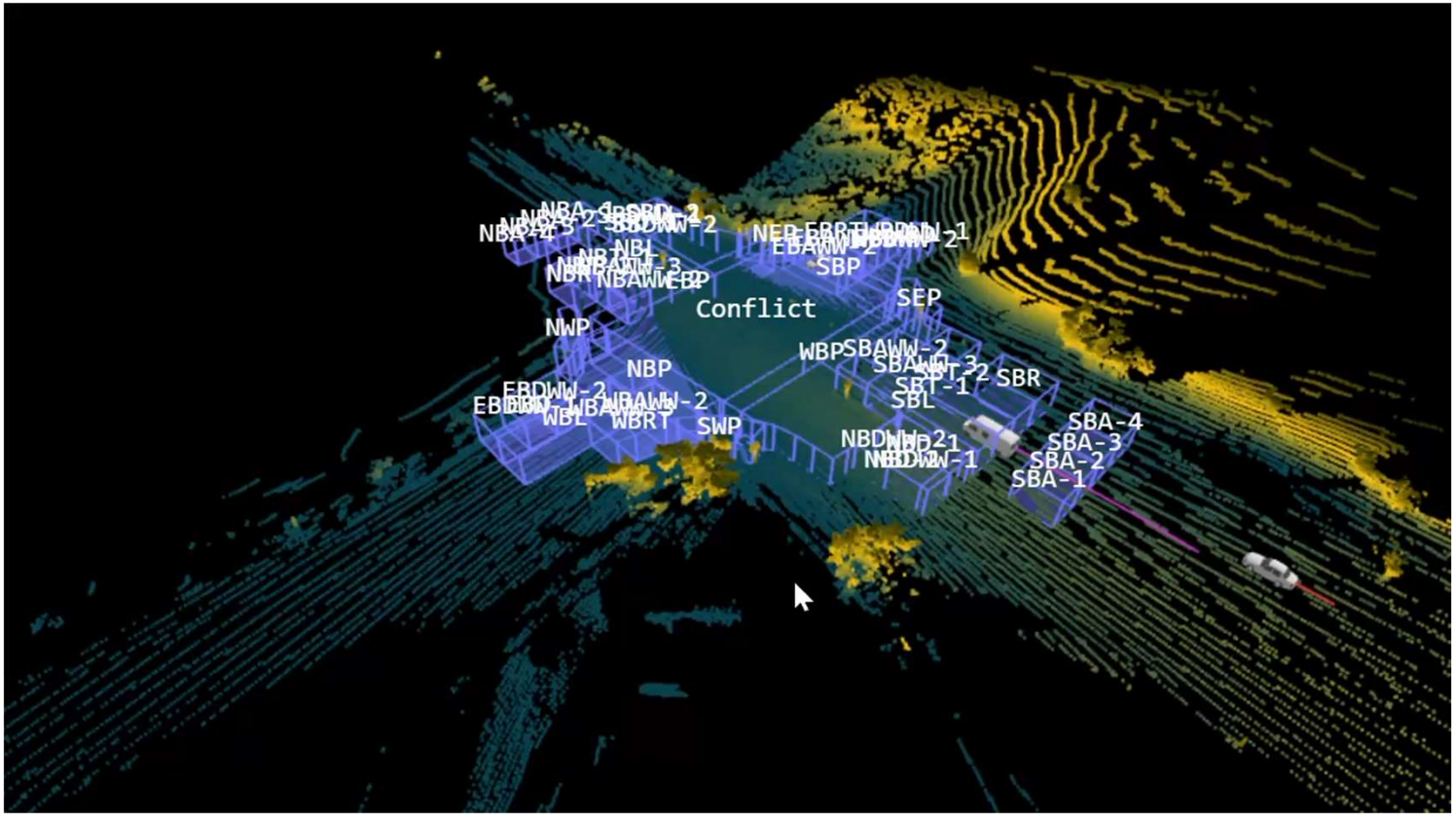
LiDAR Detection

Detection



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Control Initiatives

Control

- Mechanisms that allow the intersection/corridor to automatically react to observed traffic conditions

1. Trajectory-based control (free optimization)
   - Prioritize platoons of vehicles on the mainline without a coordination plan
   - VDOT joined Pooled Fund Study and has identified a test corridor
2. Traffic Responsive (KITS Congestion Manager)
   - Selects predefined signal timing plans based on detector-based thresholds
   - Upcoming ITTF project for Rte 220 corridor in Roanoke
3. Adaptive (KITS Kadence)
   - Continuously adjusts cycle/offset/split parameters based on detection observations
   - Upcoming ITTF project for 17 intersections on Rte 460B in Christiansburg

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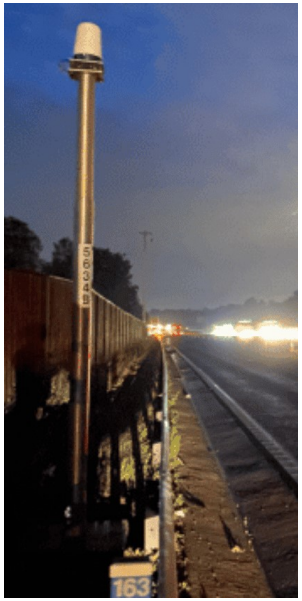
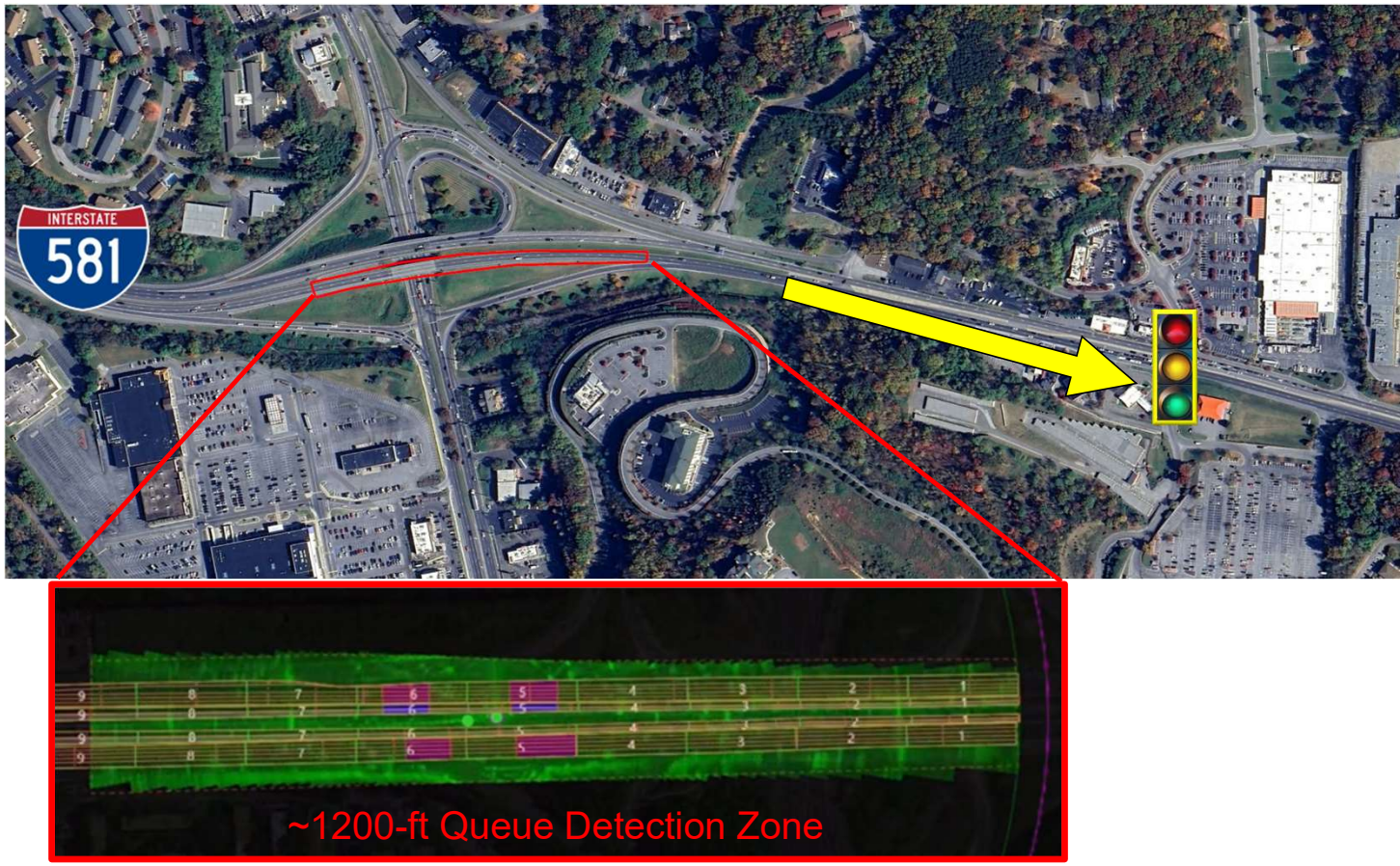
Traffic Responsive: Rte 220 Corridor in Roanoke

Control

- Trigger “flush” timing plan when queue reaches interchange
- NavTech radar detection





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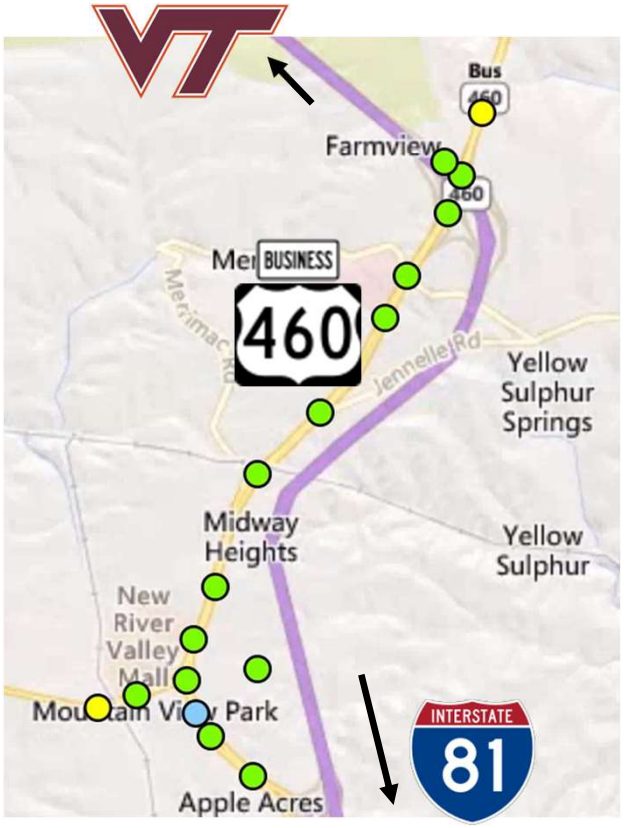
Adaptive: 460B Corridor in Christiansburg

Control

- Detection: lane-by-lane stopbar and advanced
- KITS Kadence Adaptive control
- Adjusts cycle, offset, and splits based on traffic
- Evaluate adaptive performance with ATSPM and probe data



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Management Initiatives

Management

- Notification of potential problems and remotely observe/troubleshoot
  - Flash conditions
  - Detector malfunction
  - Split/cycle failures and abnormally long queue lengths
- Streamline signal timing development and updates
  - Eliminate traffic data collection and reliance on Synchro “snapshot” optimization
  - Continuously update traffic signal timings based on ATSPM and probe data
- Continuously and uniformly measure signal performance
  - Signal timing modifications during incidents
  - Prioritize intersections based on public experience
  - Quantify the impact of improvements

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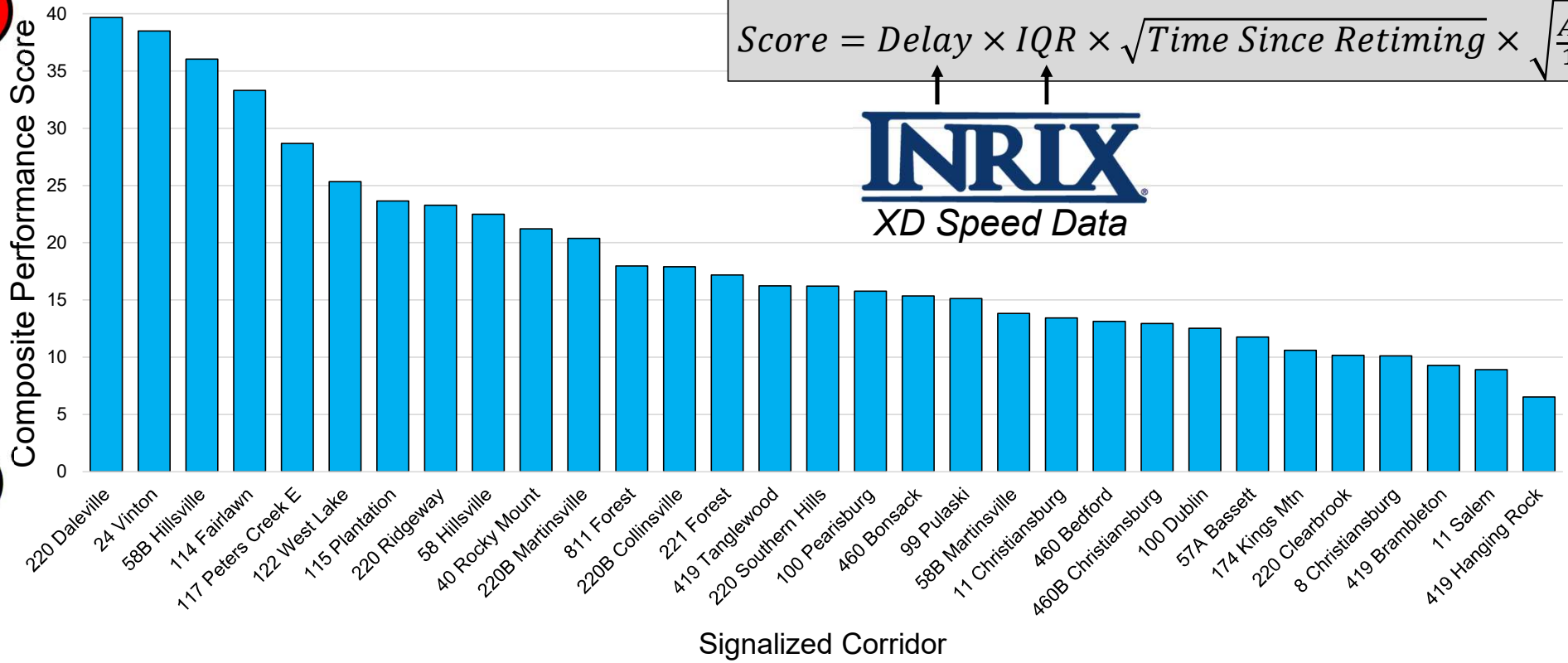
2024 Salem District Corridor Ranking

Management

$$Score = Delay \times IQR \times \sqrt{Time\ Since\ Retiming} \times \sqrt{\frac{AADT}{1000}}$$

INRIX

XD Speed Data



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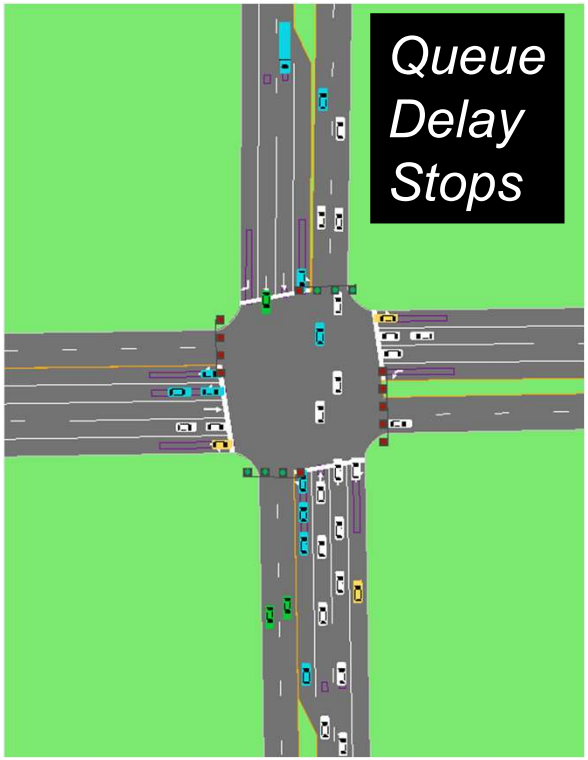
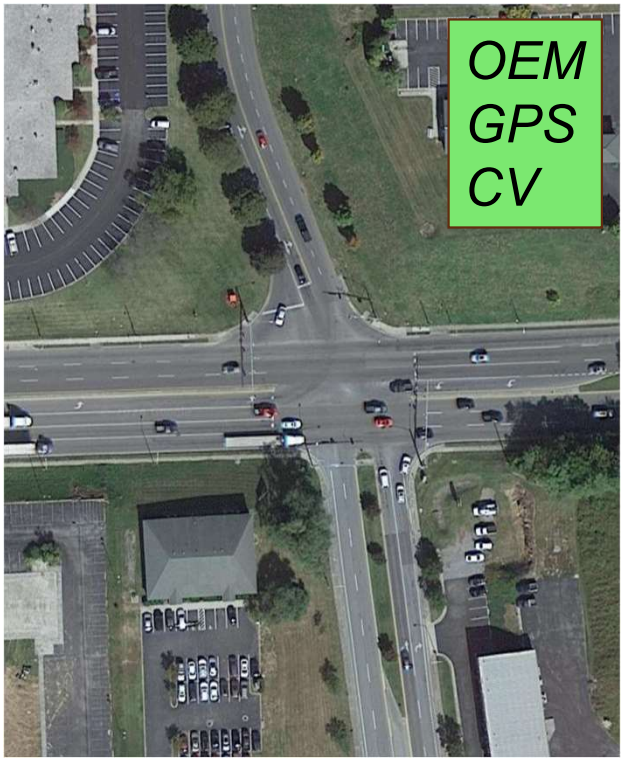
Probe-based Signal Performance Measures (SPM)

- SimTraffic = 100% Probes



=?

- Real World = 5-20% Probes



SPM Projects & Benefits

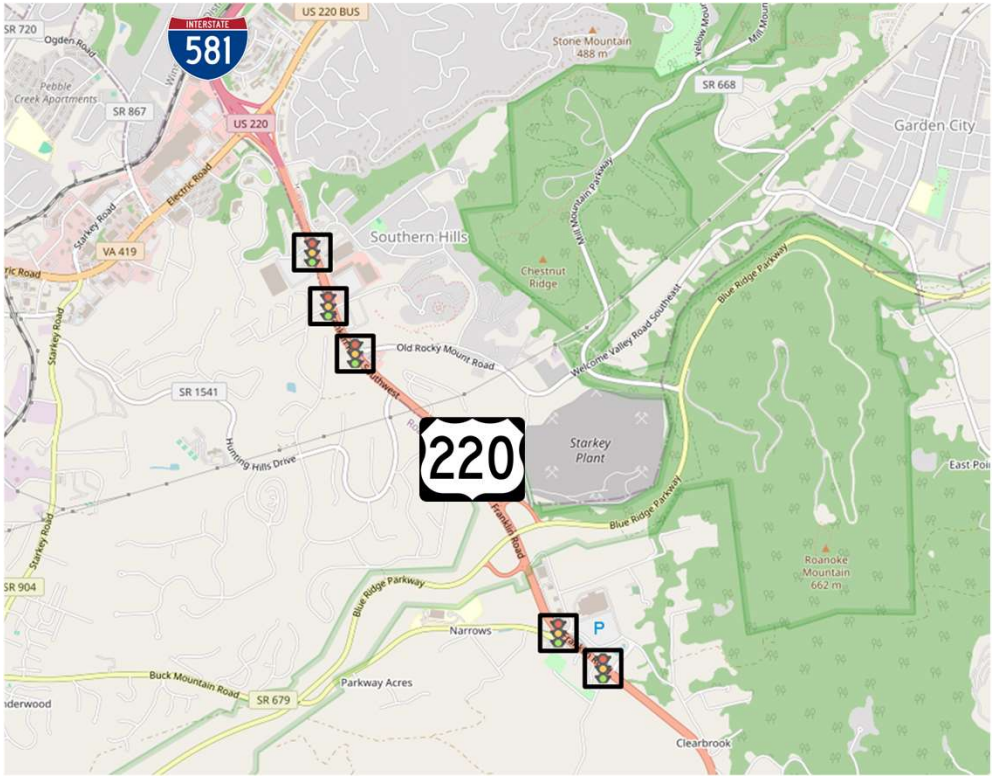
- Virginia DOT
  - Current: Use of KITS historical data and Flow Labs probe-based data to evaluate intersection performance
  - Upcoming: Use of KITS and Flow Labs data to retime corridors

- Minnesota DOT
  - Completed: Use of Flow Labs data to evaluate and retiming 16 intersections in South Metro area (Minneapolis, MN)

- Anne Arundel County, MD
  - Completed: Use of High-Resolution Data (Miovision) to evaluate and retime two corridors in Annapolis, MD

Integrating KITS and Probe-Based SPMs

- Analysis focused on 5 intersections along Rte 220 south of Roanoke
- Investigate data from KITS and Flow Labs that could be used to improve traffic signal operations
- Group the data in a more beneficial format that combines the data sources and enhances what the open-sourced ATSPM software can do
- Identify challenges, gaps and lessons learned that will help in the data architecture/dashboard task



Integrating KITS and Probe-Based SPMs

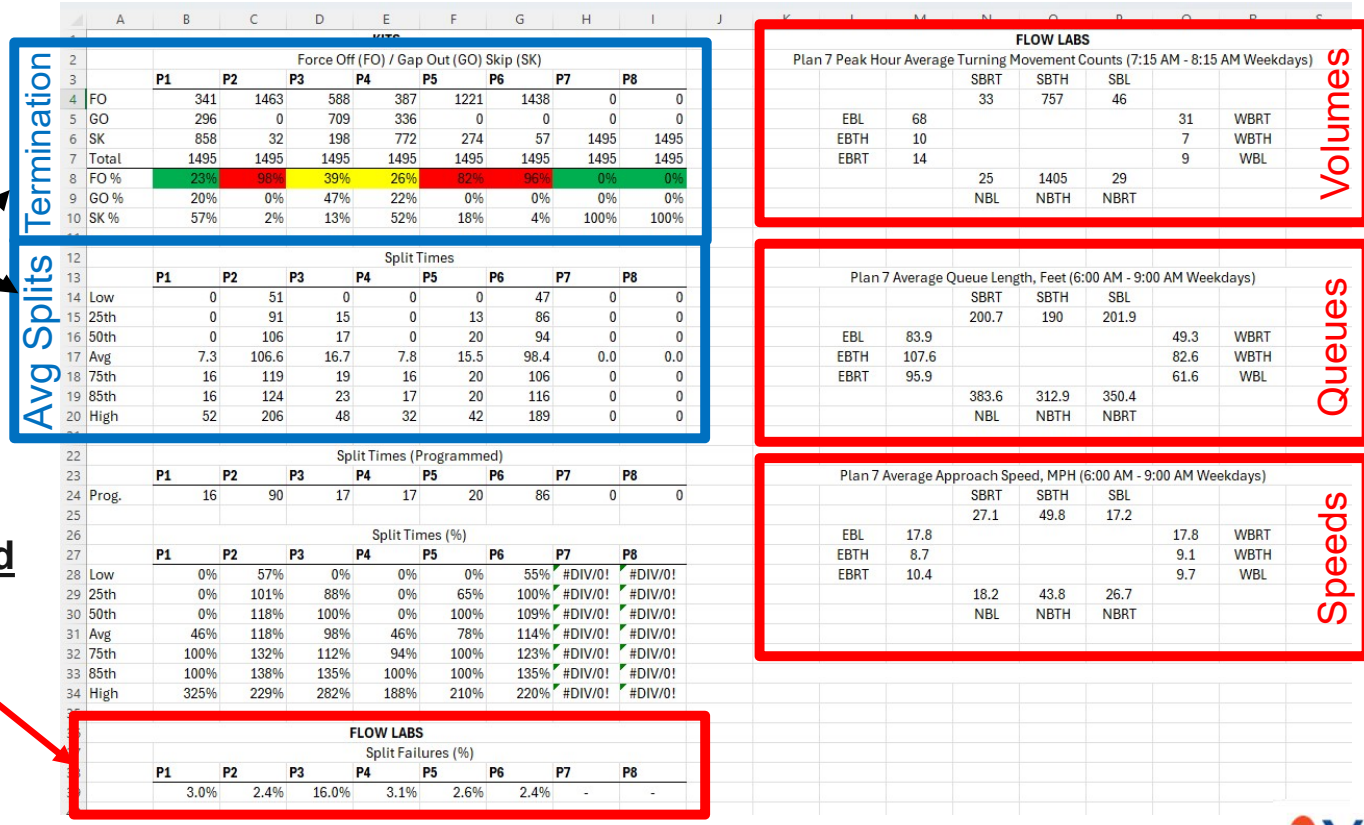
KITS Data

Flow Labs

Similar to ATSPMs but over a long duration

Lesson Learned
Needed to be converted from movement to phase

Good for Synchro analysis & Calibration



Termination

Force Off (FO) / Gap Out (GO) Skip (SK)

	P1	P2	P3	P4	P5	P6	P7	P8
FO	341	1463	588	387	1221	1438	0	0
GO	296	0	709	336	0	0	0	0
SK	858	32	198	772	274	57	1495	1495
Total	1495	1495	1495	1495	1495	1495	1495	1495
FO %	23%	98%	39%	26%	82%	96%	0%	0%
GO %	20%	0%	47%	22%	0%	0%	0%	0%
SK %	57%	2%	13%	52%	18%	4%	100%	100%

Avg Splits

Split Times

	P1	P2	P3	P4	P5	P6	P7	P8
Low	0	51	0	0	0	47	0	0
25th	0	91	15	0	13	86	0	0
50th	0	106	17	0	20	94	0	0
Avg	7.3	106.6	16.7	7.8	15.5	98.4	0.0	0.0
75th	16	119	19	16	20	106	0	0
85th	16	124	23	17	20	116	0	0
High	52	206	48	32	42	189	0	0

Split Times (Programmed)

	P1	P2	P3	P4	P5	P6	P7	P8
Prog.	16	90	17	17	20	86	0	0

Split Times (%)

	P1	P2	P3	P4	P5	P6	P7	P8
Low	0%	57%	0%	0%	0%	55%	#DIV/0!	#DIV/0!
25th	0%	101%	88%	0%	65%	100%	#DIV/0!	#DIV/0!
50th	0%	118%	100%	0%	100%	109%	#DIV/0!	#DIV/0!
Avg	46%	118%	98%	46%	78%	114%	#DIV/0!	#DIV/0!
75th	100%	132%	112%	94%	100%	123%	#DIV/0!	#DIV/0!
85th	100%	138%	135%	100%	100%	135%	#DIV/0!	#DIV/0!
High	325%	229%	282%	188%	210%	220%	#DIV/0!	#DIV/0!

FLOW LABS

Split Failures (%)

P1	P2	P3	P4	P5	P6	P7	P8
3.0%	2.4%	16.0%	3.1%	2.6%	2.4%	-	-

Volumes

FLOW LABS

Plan 7 Peak Hour Average Turning Movement Counts (7:15 AM - 8:15 AM Weekdays)

		SBRT	SBTH	SBL		
		33	757	46		
EBL	68				31	WBRT
EBTH	10				7	WBTH
EBRT	14				9	WBL
		25	1405	29		
		NBL	NBTH	NBRT		

Queues

Plan 7 Average Queue Length, Feet (6:00 AM - 9:00 AM Weekdays)

		SBRT	SBTH	SBL		
		200.7	190	201.9		
EBL	83.9				49.3	WBRT
EBTH	107.6				82.6	WBTH
EBRT	95.9				61.6	WBL
		383.6	312.9	350.4		
		NBL	NBTH	NBRT		

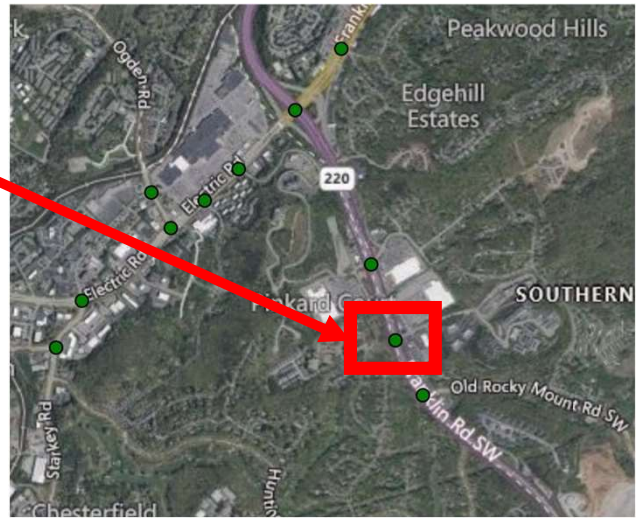
Speeds

Plan 7 Average Approach Speed, MPH (6:00 AM - 9:00 AM Weekdays)

		SBRT	SBTH	SBL		
		27.1	49.8	17.2		
EBL	17.8				17.8	WBRT
EBTH	8.7				9.1	WBTH
EBRT	10.4				9.7	WBL
		18.2	43.8	26.7		
		NBL	NBTH	NBRT		

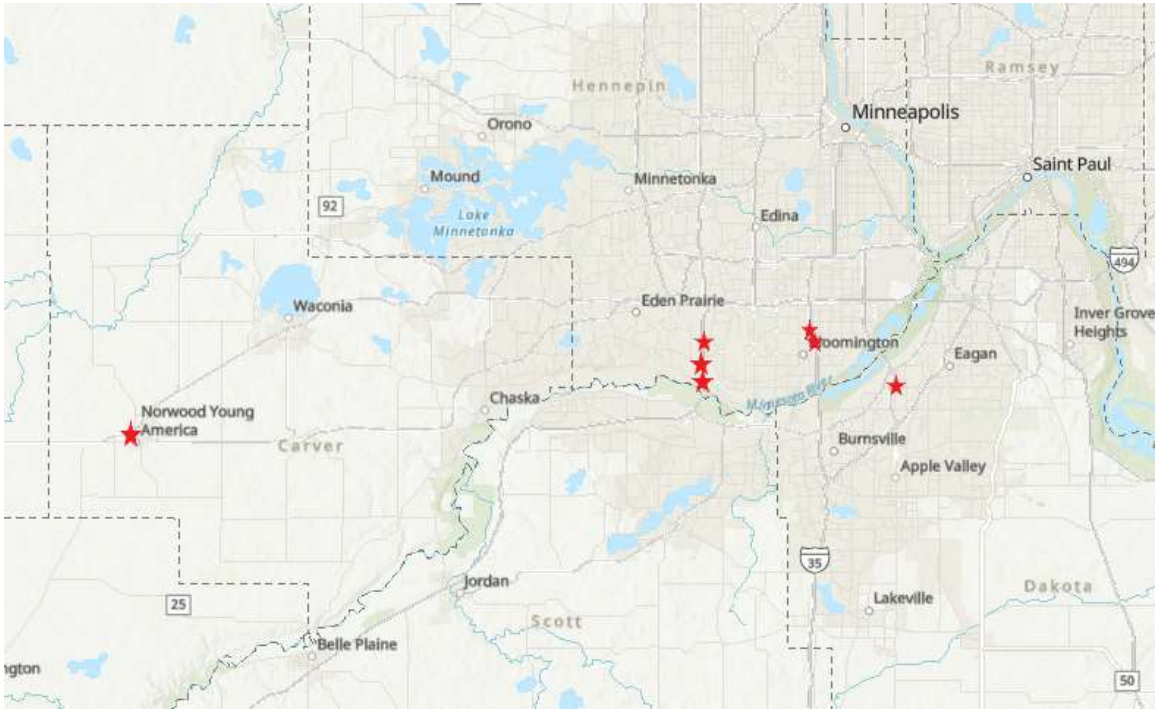
Actionable Outcomes – Rte 220 Corridor

- Weekend has total volumes comparable to the weekday PM Peak
- Phase 3 is more prone to split failures, especially during Plan 8 & Plan 11
  - Switch side-street split phasing order?
  - Utilize PCD to determine if any mainline time is unused by platoons and could be given to the side streets
- EVP significantly impacts corridor operations
  - Multiple EVP instances over a short duration
  - Modify EVP parameters
- Look into the post-COVID-19 travel patterns
  - Investigate whether number of timing plans should be changed
- *(Implementing upstream queue detection and Traffic Responsive)*



South Metro Signal Optimization Project

- 16 Signalized Intersections
- Turning Movement Counts
  - Flow Labs Probe-Based Data
- Analysis of Existing Intersections
- Optimization of Signal Timing
  - FYA Phasing Analysis
  - Cycles, Splits, Offsets, Sequence
  - Traffic Responsive
- Timing Plan Implementation
  - Kinetics Central Signal System
- Project Benefits Report

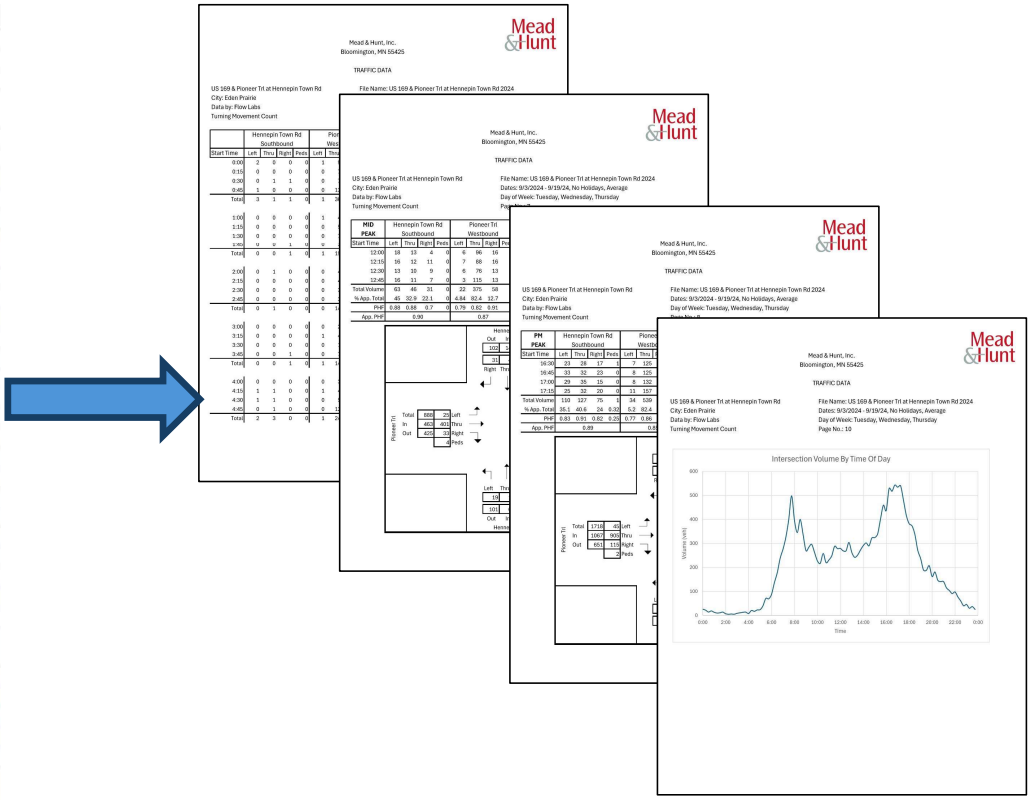


Note: This was a full signal optimization project, however, this presentation focuses only on some of the big data integration.

Flow Labs Turning Movement Count Data

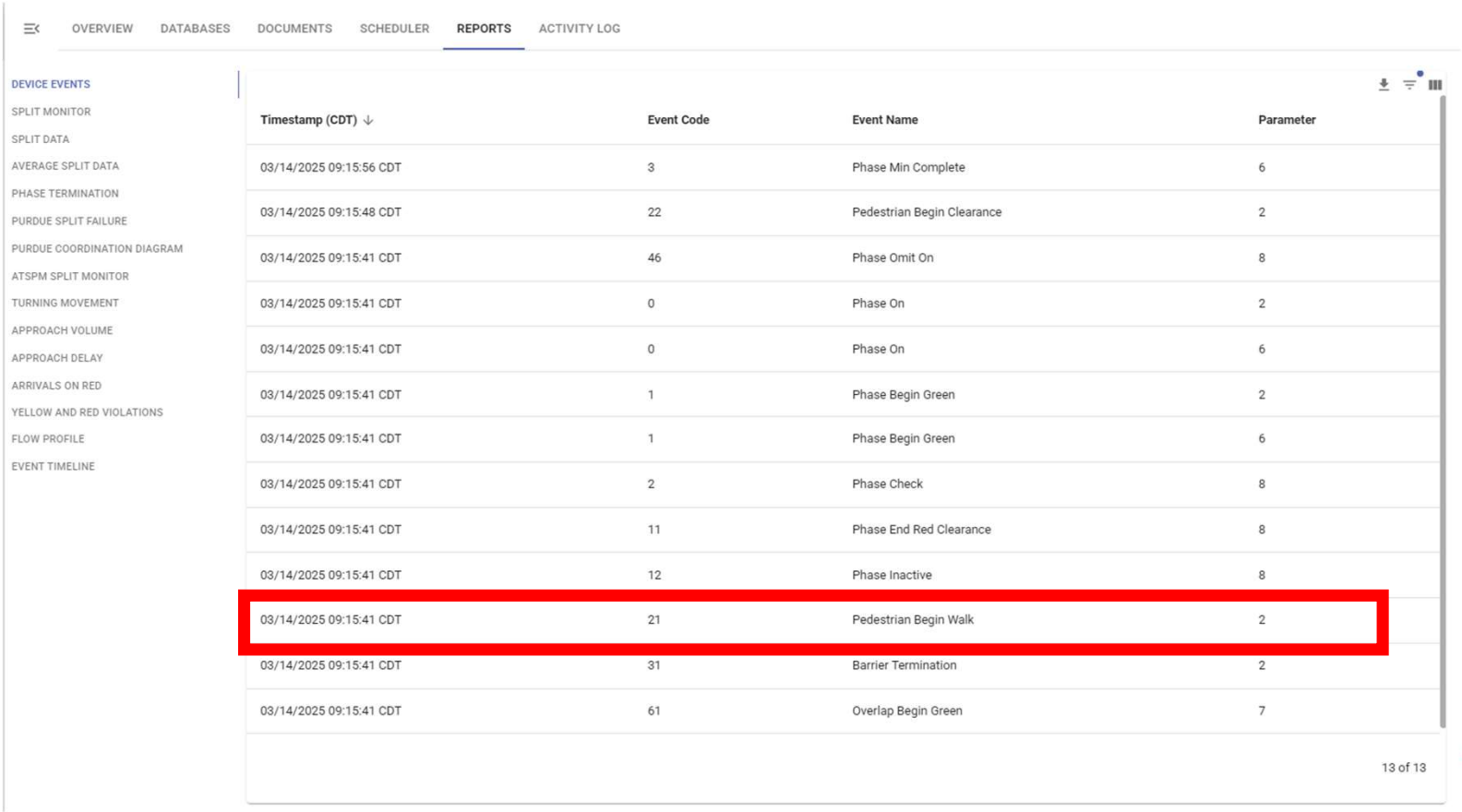
- Utilized multiple months of continuous TMC data (instead of 1-2 days)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Network	TH169 at Pioneer Trail											
2	Signal	TH 169 & Pioneer Trl at Hennepin Town Rd											
3	Date Rang	09/03/2024 - 09/20/2024 Excluding Holidays											
4	Time	TuWTh 12am - 11:59pm											
5													
6	Approach	SB - Left	SB - Throu	SB - Right	WB - Left	WB - Throi	WB - Right	NB - Left	NB - Throu	NB - Right	EB - Left	EB - Throu	EB - Right
7	Hour												
8	12:00 AM	1.7	0	0	0.6	8.8	0.6	0	0	0.6	0	11	0.6
9	12:15 AM	0	0	0	0	6.6	0	0	0.6	0.6	1.1	11.6	0
10	12:30 AM	0	0.6	0.6	0	6.6	0	0	0	0	0.6	3.9	0
11	12:45 AM	0.6	0	0	0	13.2	0.6	0	0	0	0.6	2.2	1.1
12	1:00 AM	0	0	0	1.1	4.4	0	0	0	0	0	7.7	0
13	1:15 AM	0	0	0	0	5	0.6	1.1	0	0	0.6	2.2	0
14	1:30 AM	0	0	0	0	7.2	0	0	0	0	0.6	2.8	0
15	1:45 AM	0	0	0.6	0	3.3	0.6	0.6	0	0	0.6	6.6	0
16	2:00 AM	0	0.6	0	0	3.9	0	0	0	0	0	1.7	0
17	2:15 AM	0	0	0	0	3.9	0	0	0	0	0	0.6	0
18	2:30 AM	0	0	0	0	3.3	0	0.6	0	0	0	1.7	0
19	2:45 AM	0	0	0	0	2.8	1.1	0	0	0	0	1.1	0
20	3:00 AM	0	0	0	0	1.7	1.7	0	0	2.2	0	2.8	0
21	3:15 AM	0	0	0	1.1	3.9	0.6	0	0	0.6	1.1	3.3	0
22	3:30 AM	0	0	0	0	0.6	0	0	0	0	0	11.6	0
23	3:45 AM	0	0	0.6	0	6.6	0.6	0	0	0	0	5	0
24	4:00 AM	0	0	0	0	3.3	0.6	0	0	0	0	4.4	0
25	4:15 AM	0.6	0.6	0	0.6	3.9	6.1	0	0	1.7	0	6.1	0
26	4:30 AM	1.1	0.6	0	0	5	1.7	0	0	1.7	0	5	0.6
27	4:45 AM	0	0.6	0	0	11.6	0	0	1.1	1.7	0	7.2	0
28	5:00 AM	0	1.7	0	0	5.5	0	0	0	0.6	0	14.3	0.6
29	5:15 AM	0	0.6	0.6	0	9.9	5	0	0.6	3.9	1.1	15.5	0.6
30	5:30 AM	0.6	0	0	0.6	28.7	2.2	0.6	0.6	0.6	0.6	33.7	0
31	5:45 AM	2.2	0.6	0.6	1.7	28.7	3.9	0	1.7	1.1	1.7	23.7	0.6
32	6:00 AM	9.4	1.1	1.7	3.9	32.6	6.6	1.7	0	3.9	0	22.6	2.2
33	6:15 AM	16	1.7	3.3	2.8	33.7	5.5	0.6	0.6	8.8	5.5	55.2	0.6
34	6:30 AM	4.4	0.6	0.6	2.8	64	13.2	2.8	3.3	8.8	2.8	69.5	3.9
35	6:45 AM	20.4	2.2	5	2.8	88.8	14.9	1.1	3.9	5	7.2	86.1	1.1
36	7:00 AM	9.4	2.8	7.2	2.8	105.4	12.1	2.2	9.4	16	6.1	96.6	6.6
37	7:15 AM	12.7	2.8	6.1	5	113.7	18.8	11.6	10.5	11.6	11.6	114.2	5
38	7:30 AM	15.5	3.9	13.8	3.9	136.9	18.8	6.6	11.6	12.7	10.5	151.2	11
39	7:45 AM	22.6	5	16	7.7	179.4	23.7	14.3	13.2	11.6	9.4	183.2	12.1
40	8:00 AM	16.6	6.6	7.2	5.5	144.6	20.4	13.2	6.1	10.5	11.6	140.7	9.4



Flow Labs Turning Movement Count Data

- Where can we get pedestrian data without observations?



Timestamp (CDT)	Event Code	Event Name	Parameter
03/14/2025 09:15:56 CDT	3	Phase Min Complete	6
03/14/2025 09:15:48 CDT	22	Pedestrian Begin Clearance	2
03/14/2025 09:15:41 CDT	46	Phase Omit On	8
03/14/2025 09:15:41 CDT	0	Phase On	2
03/14/2025 09:15:41 CDT	0	Phase On	6
03/14/2025 09:15:41 CDT	1	Phase Begin Green	2
03/14/2025 09:15:41 CDT	1	Phase Begin Green	6
03/14/2025 09:15:41 CDT	2	Phase Check	8
03/14/2025 09:15:41 CDT	11	Phase End Red Clearance	8
03/14/2025 09:15:41 CDT	12	Phase Inactive	8
03/14/2025 09:15:41 CDT	21	Pedestrian Begin Walk	2
03/14/2025 09:15:41 CDT	31	Barrier Termination	2
03/14/2025 09:15:41 CDT	61	Overlap Begin Green	7

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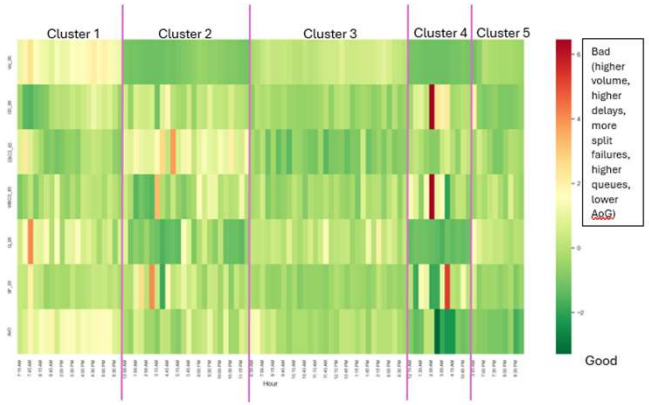
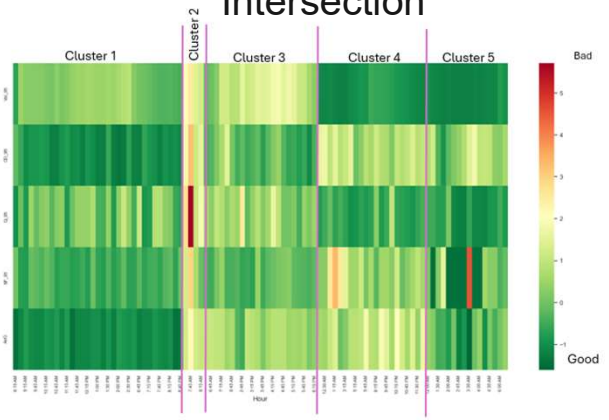
Big Data Analysis of Probe Data

- Cluster Analysis performed to identify actionable insights

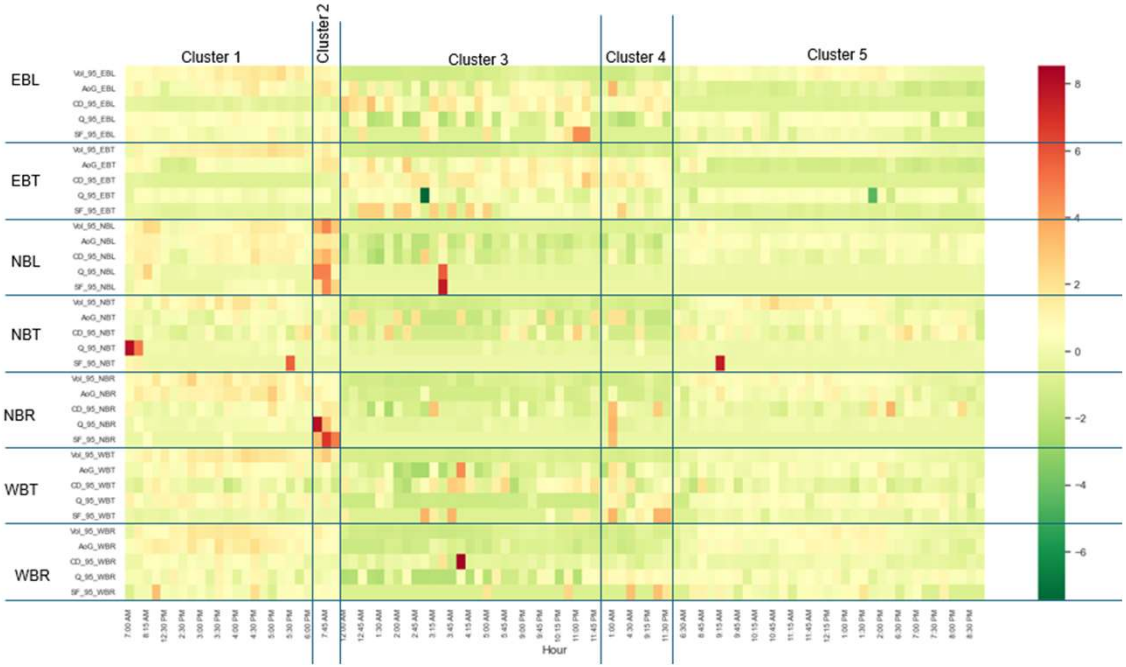
Corridor



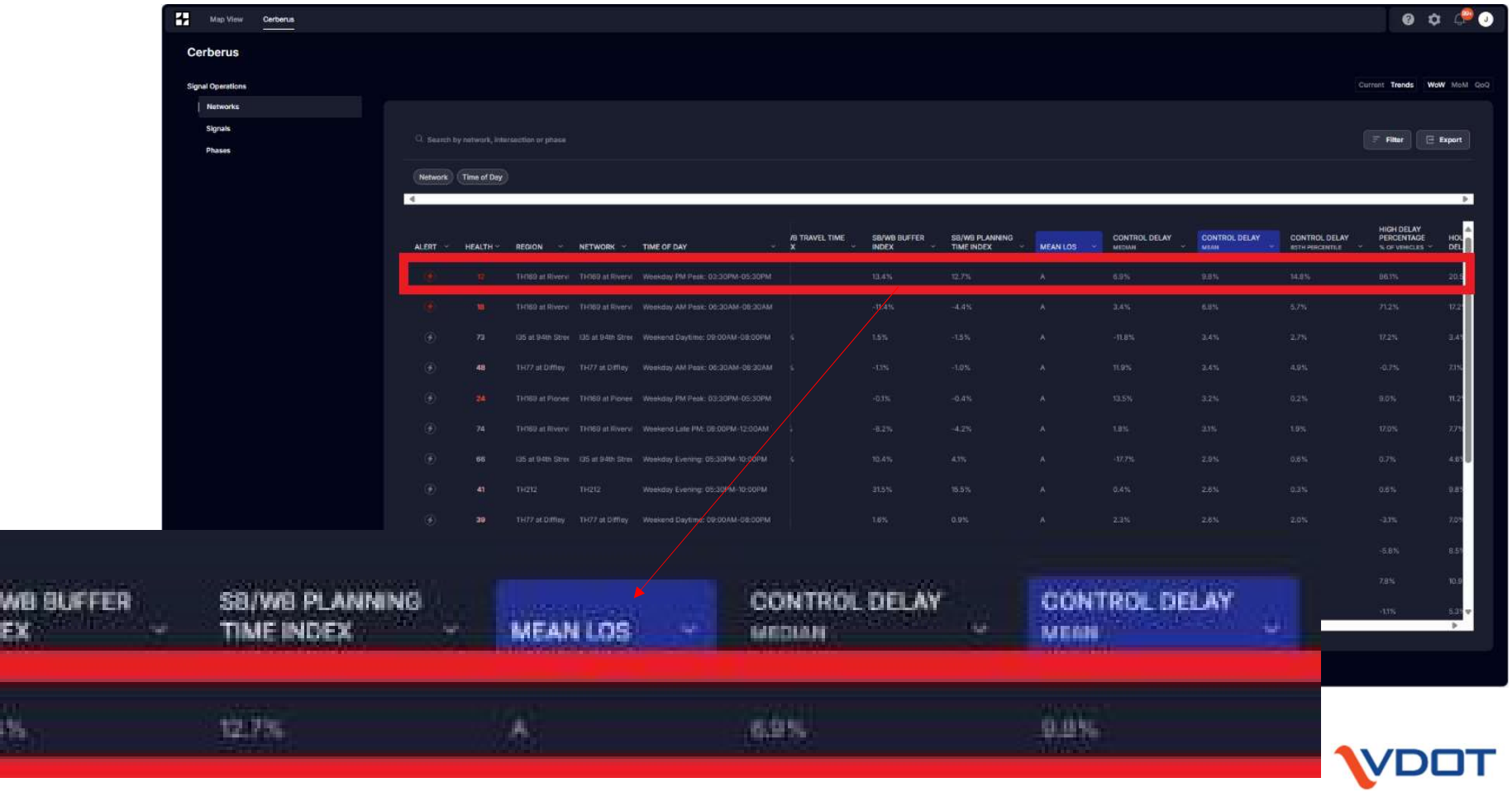
Intersection



Movement



Flow Labs – Week-over-Week Trend Analysis



DEPARTMENT OF TRANSPORTATION

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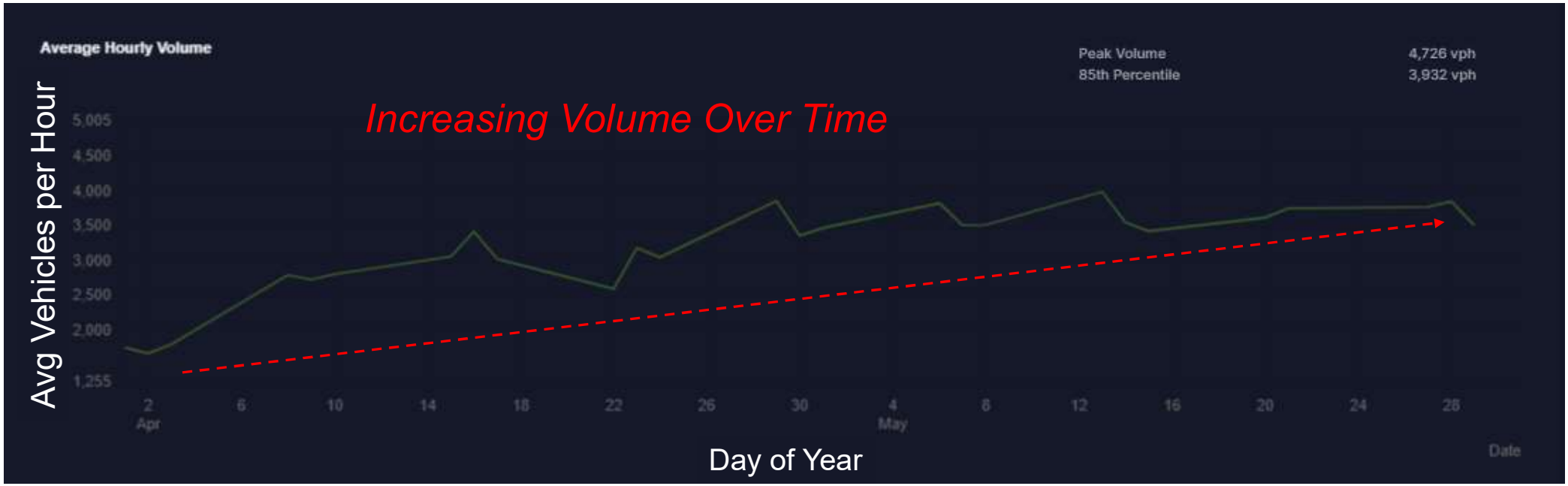
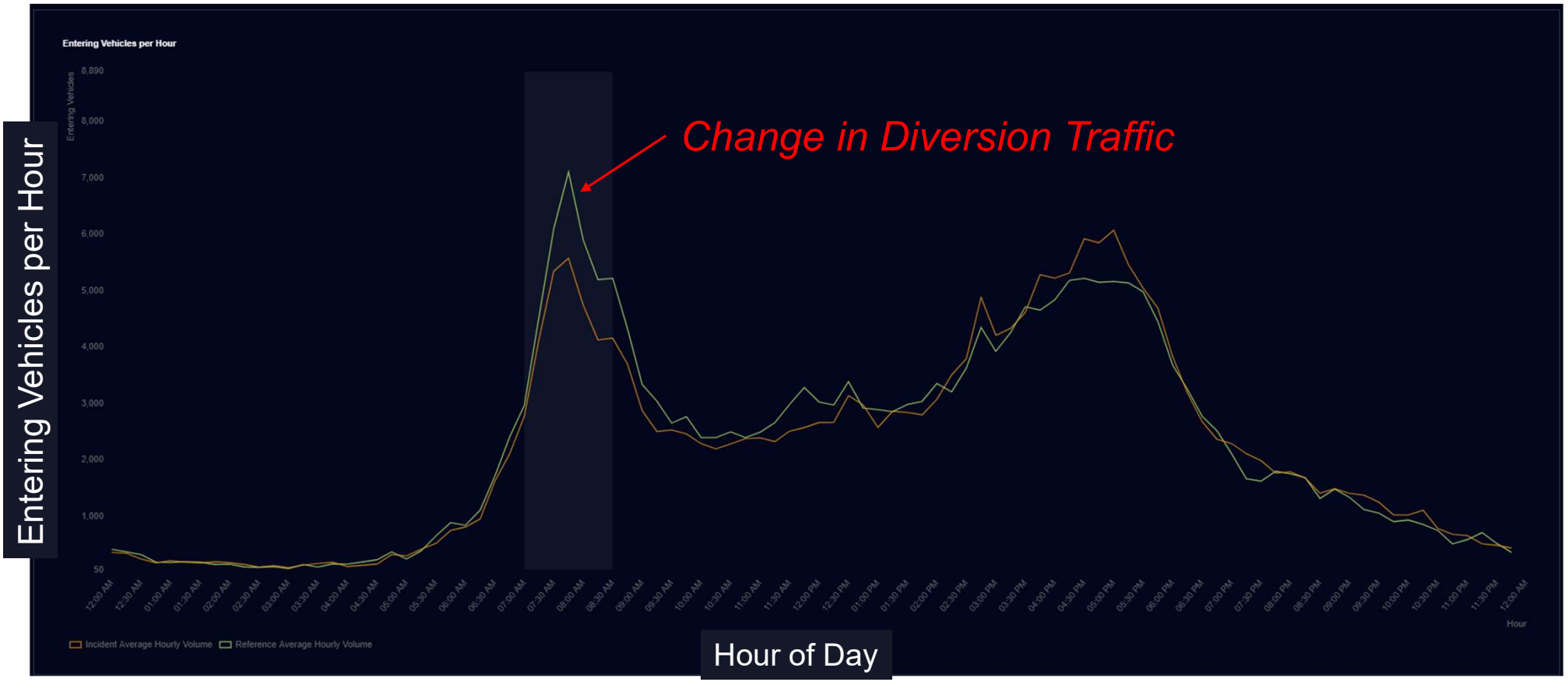
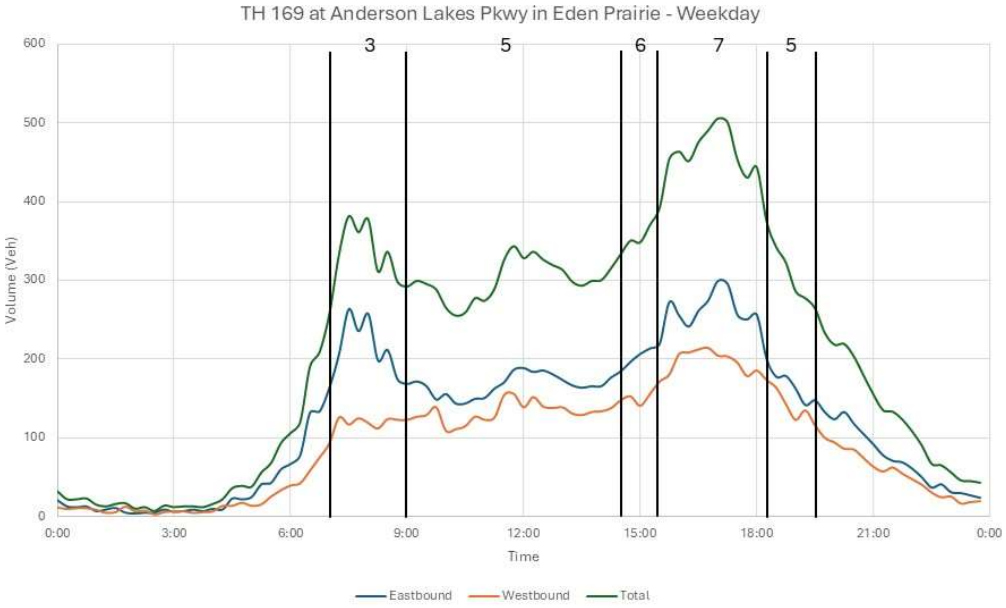
Flow Labs – Volume Trend Analysis

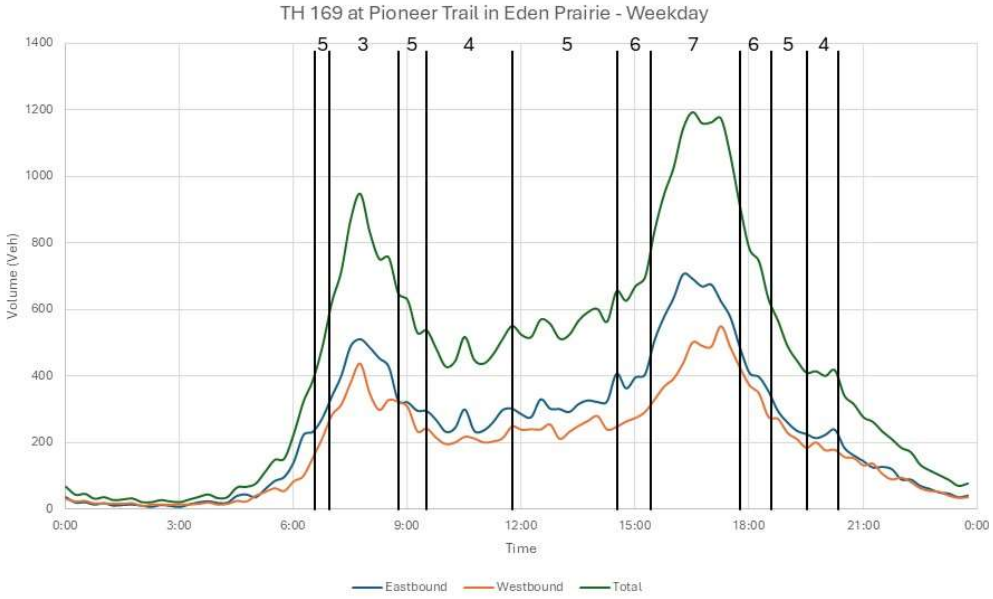


Flow Labs – Volume Trend Analysis



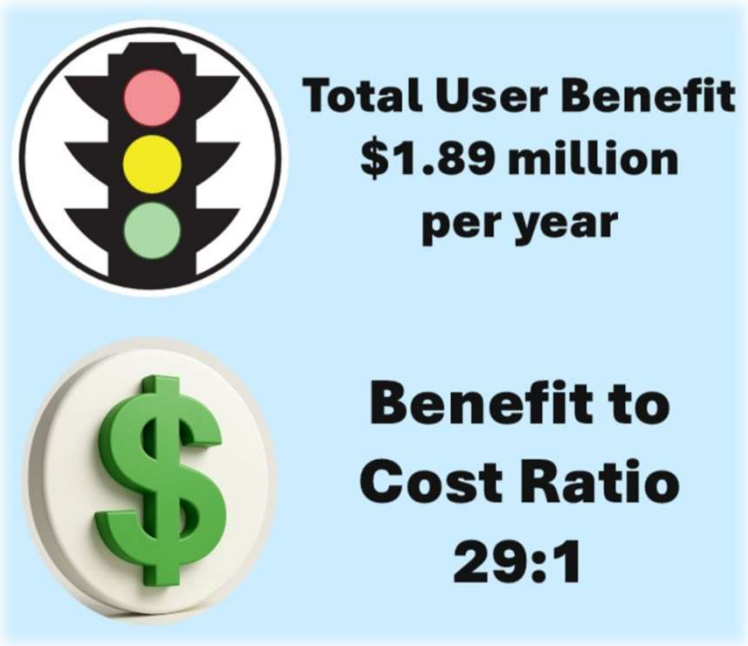
Time-of-Day (TOD) Plan Analysis

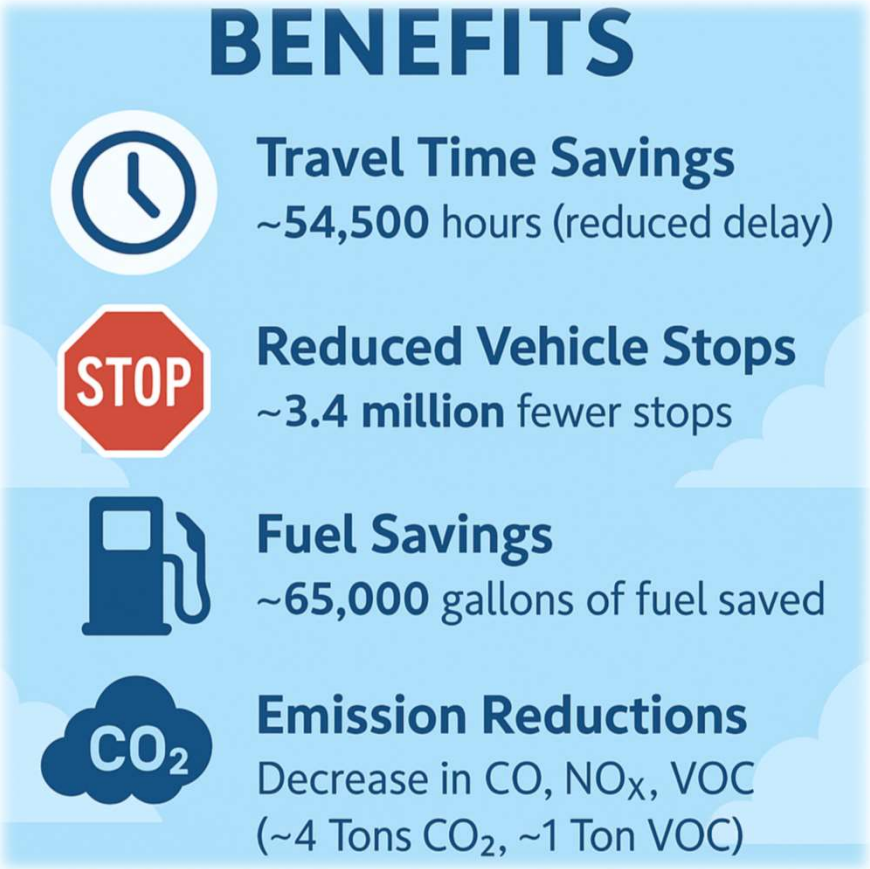




South Metro Project Benefits

DEPARTMENT OF TRANSPORTATION





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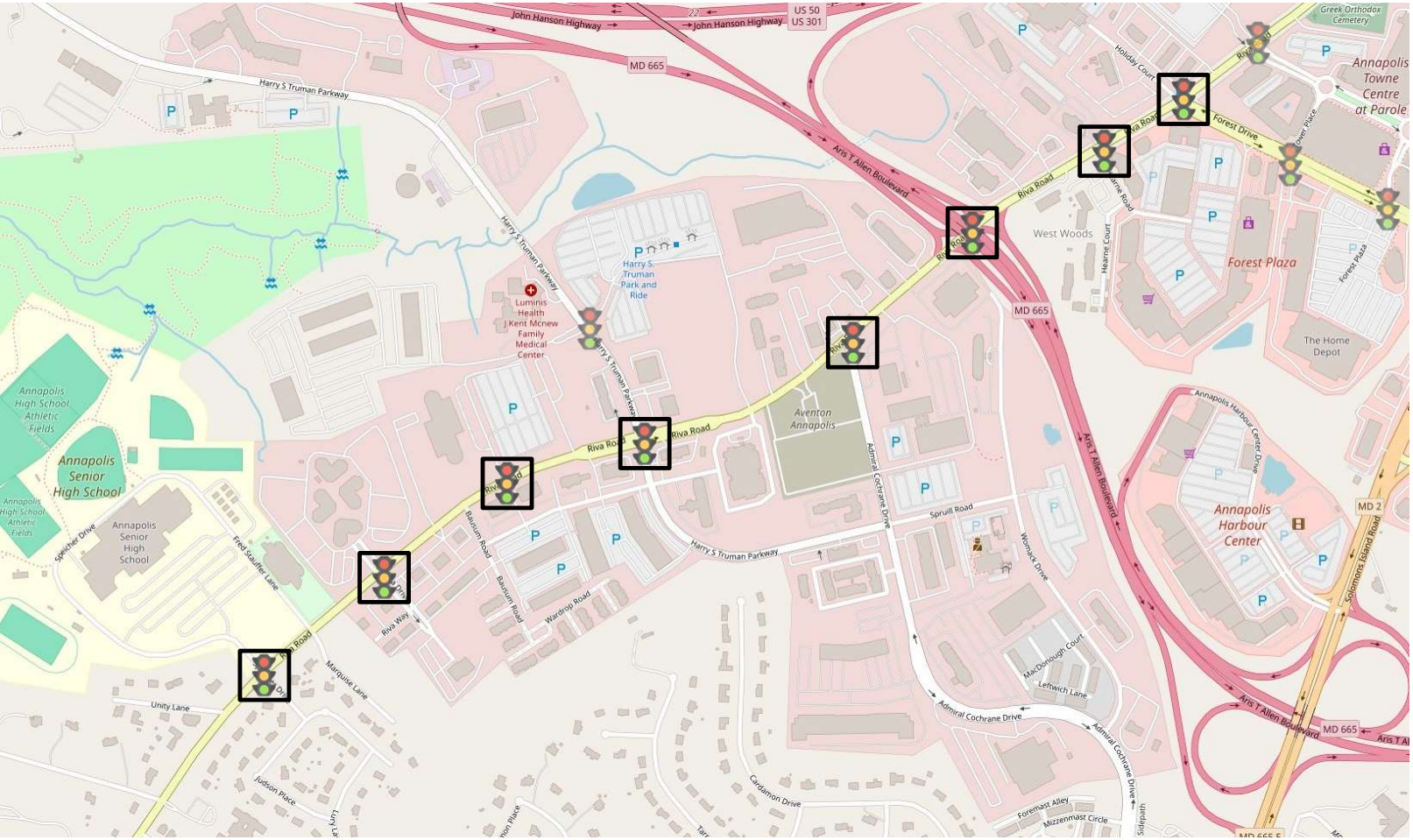
Riva Road Corridor Retiming Project



- High School
  - ~2160 Students
- Office Complexes
- Hotels
- Shopping Centers
- Large Retail Stores
- Car Dealership
- Interchange (MD 665)
  - To US 50/I-97
- Park & Ride Lot
  - Transit & Greyhound
- Residential

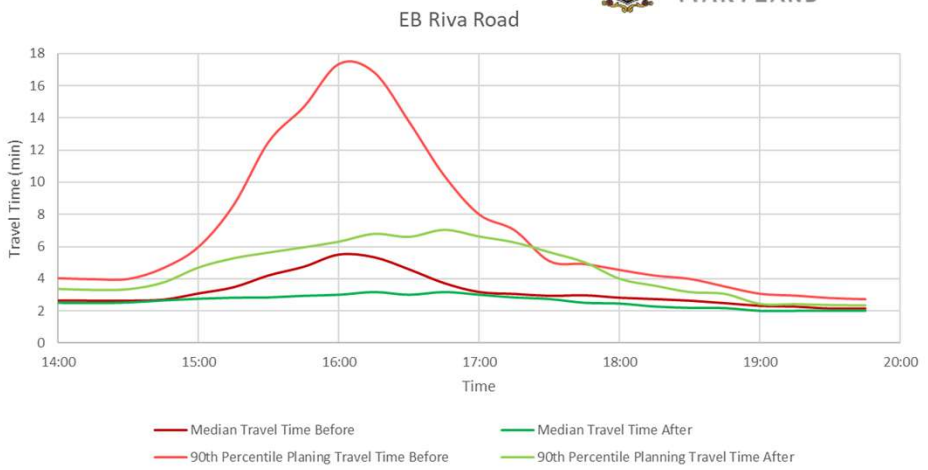
ATSPM Projects & Benefits

User cost: $324,000
(17,200 hours of delay)

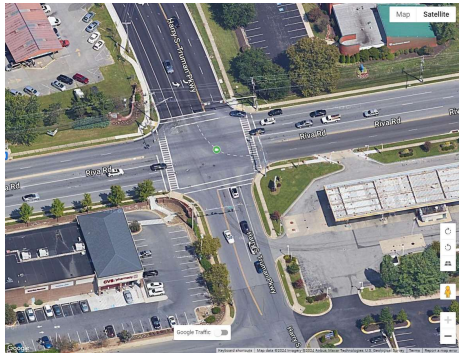
Fuel cost: $48,000
(15,000 gallons of fuel)

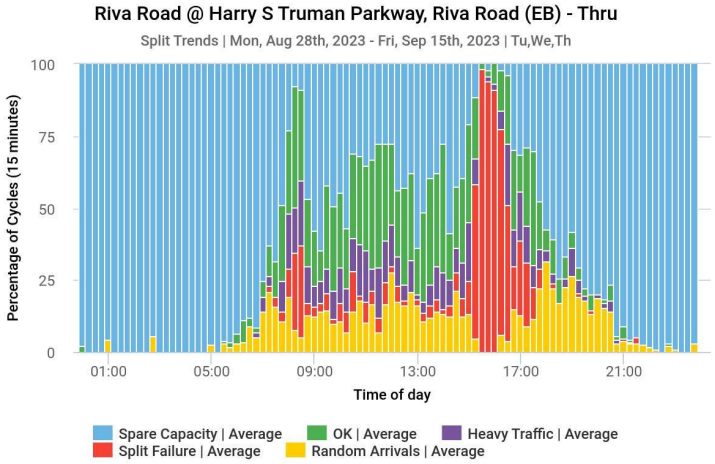
CO2 cost: $7,000
(145 tons of CO2)

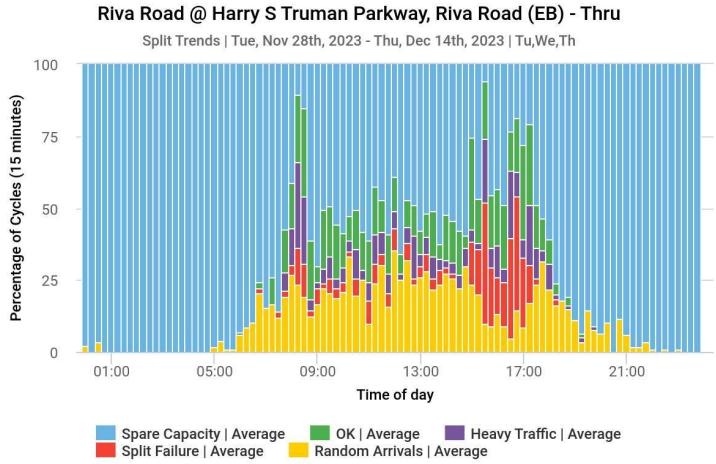
Benefit to Cost* Ratio: **14:1**



Split Failures

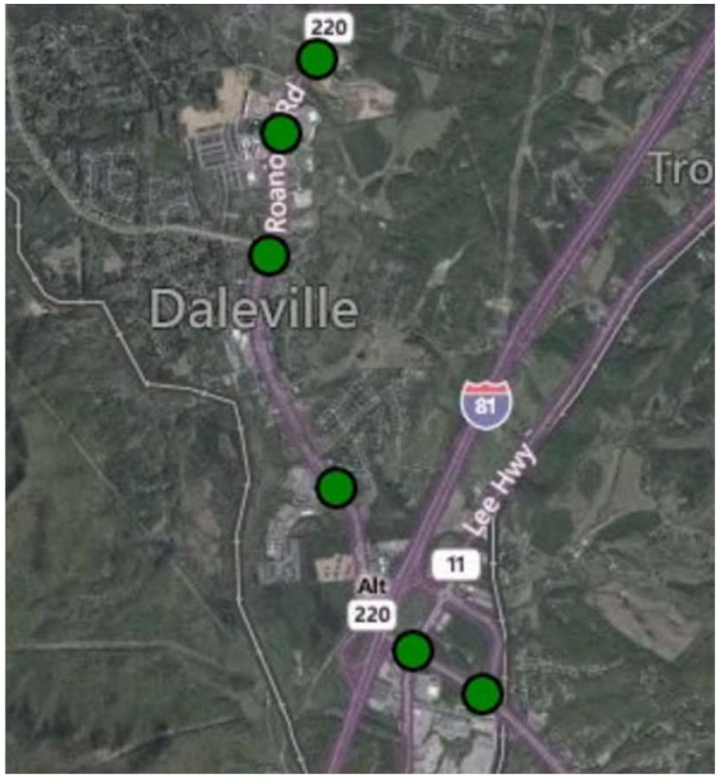




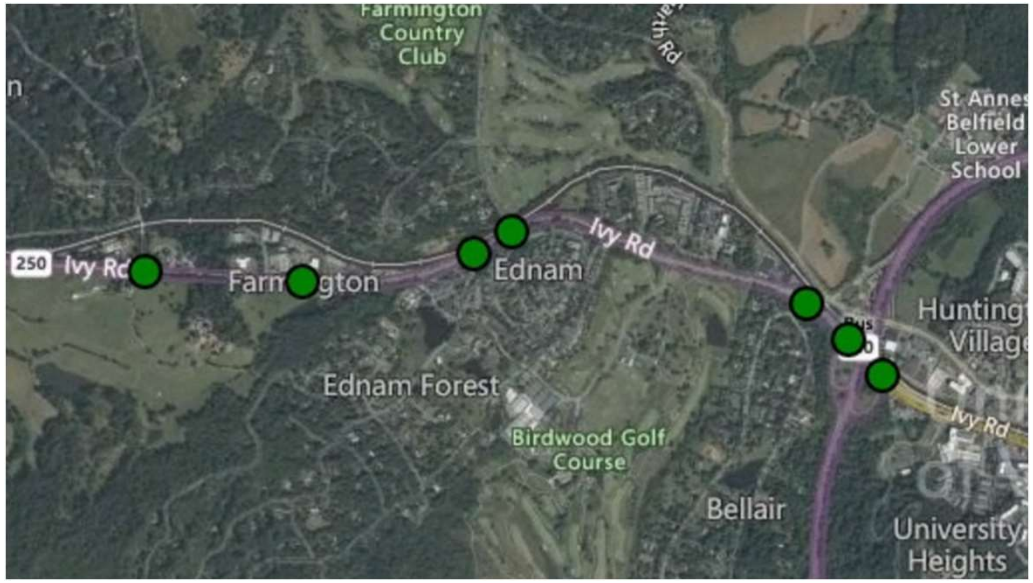


Upcoming VDOT Retiming Projects

Probe-Based Signal Performance Measures
Rte 220 Daleville, VA



Traditional ATSPMs
Rte 250 Charlottesville, VA



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Probe-Based SPM Evaluation

- DDOT funding Probe-Based SPM Study that will evaluate INRIX Signal Analytics, Flow Labs, and Iteris Signal Trends
  - Data collection
  - Penetration rate study
  - Turning movement count accuracy
  - Integration into existing DDOT processes
    - Network optimization
    - Signal system operational support
- VDOT funding extension of that project for Virginia needs

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Summary

- There are plenty of opportunities to improve VDOT signal operations as the industry continues to advance with emerging technologies

- ATSPM will be operational soon and VDOT will begin integration of this tool into operations and maintenance workflows

- Share your agency's efforts on advancing detection, control, and management

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Thank You!

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