Signalized Intersection Performance Measures WITHOUT Hardware

Data-driven mobility insights from CATT Lab and INRIX

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Today's Presentation

- Background to probe-based signal analytics
- Source of data
- Fundamentals of intersection analysis
- Use case
- Time for questions

Improving Operations with Traffic Signal Performance Measures

Benefits

- Issues can be identified quickly
- Proactive instead of reactive response
- More efficient traffic signal operations
- Data to communicate outcomes

Improving Safety and Sustainability Measures

Reduction of Fuel Consumption and GHG Emissions

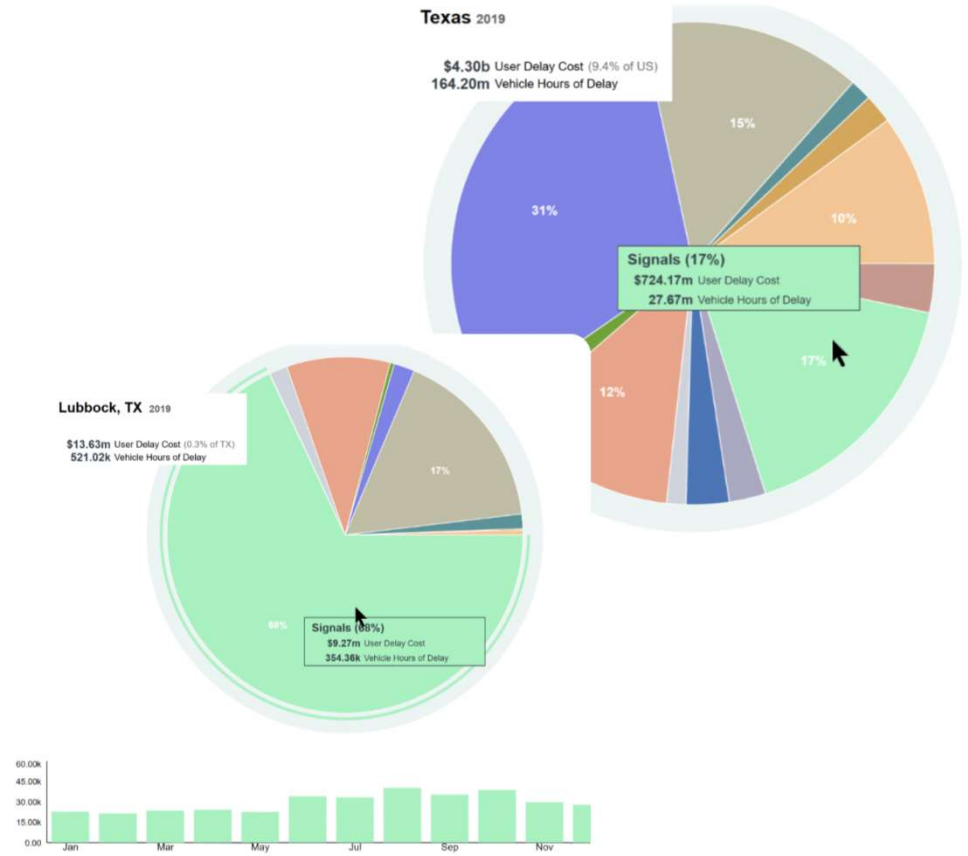
- Inst. of Transportation Engineers (ITE) estimates that properly timed signals decreases fuel consumption by 6% to 9%
- Aligns your with IIJA SMART program

Improve Safety

- Where queues exist, correlation to safety issues
- Reducing split failures, reduces more aggressive driving behaviors

Reduce Delay in Texas

- Recent estimates indicate that traffic signals account for roughly **164 million vehicle hours of delay** per year
- ITE reports,signal retiming projects reduce motorist delay by between 15% to 37%.



SOURCE: *HRG Report on Traffic Signal Retiming Cost Benefits*

Visit: https://go.umd.edu/congestion

Traditional Traffic Signal Timing Processes

Trigger

- Complaint
- 3-5 Year Retiming

Design

- Hire a consultant
- Collect data and build models

Implement

- Program
- Fine-Tune
- Evaluate

Done?

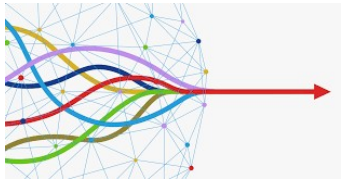
Move on to the next corridor or signal when triggered by complaint or next retiming cycle

Performance-Based Traffic Signal Timing

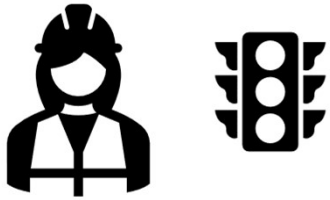
Monitor Signals

Identify Issues

Data Suggests Solutions



Deploy Fix



Rinse and Repeat!

Improving Operations with Traffic Signal Performance Measures

Barriers

- Roadside detection infrastructure
- Signal controller upgrades
- Data storage and servers
- Software expertise

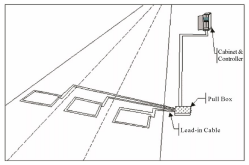
Traffic Signal Performance Measurement

Bottom-Up Approach

Derive traffic performance metrics

ATSPM
Automated Traffic Signal Performance Measures

Start with high-resolution detector data…



Top-Down Approach

Start with high-resolution CV data…

Signal Analytics

Derive intersection performance metrics

No roadside infrastructure needed
Rapidly scalable anywhere in the nation

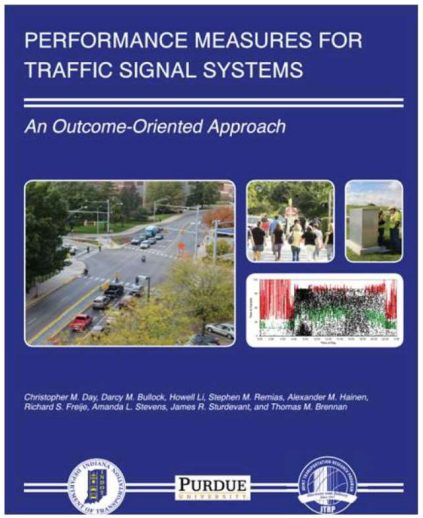
Sensor/Detector Derived Performance Measures

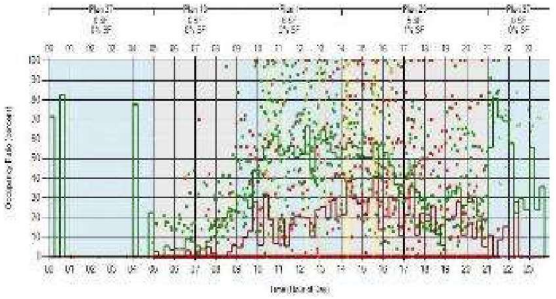
Strengths

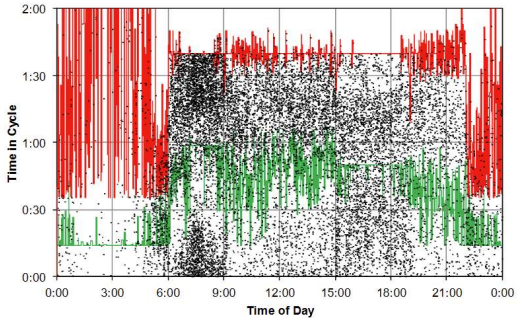
- 100% of traffic
- Includes signal timing information
- Includes phase termination
- Visualize detector actuations

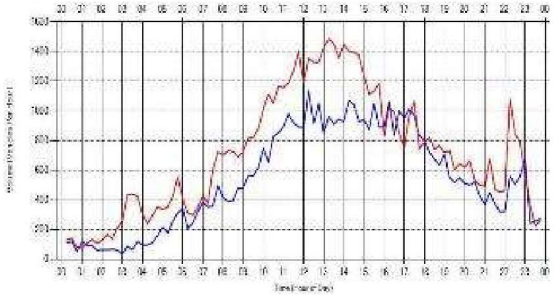
Limitations

- Complex detector layout
- System-wide comparison difficult
- Many points of failure
- Some metrics are approximated



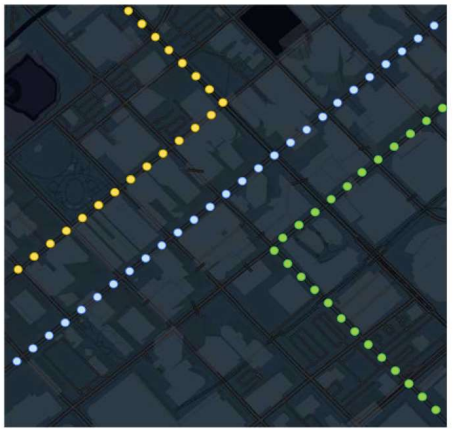


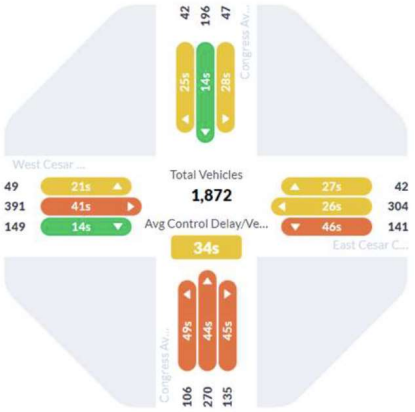


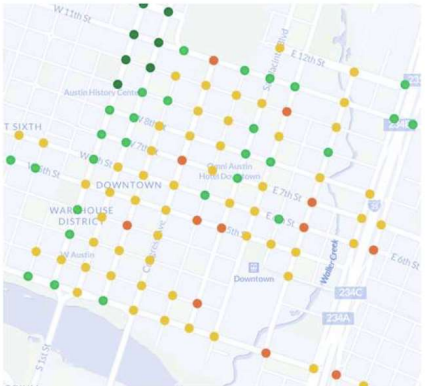


Connected Vehicle (CV)/GPS Derived Performance Measures

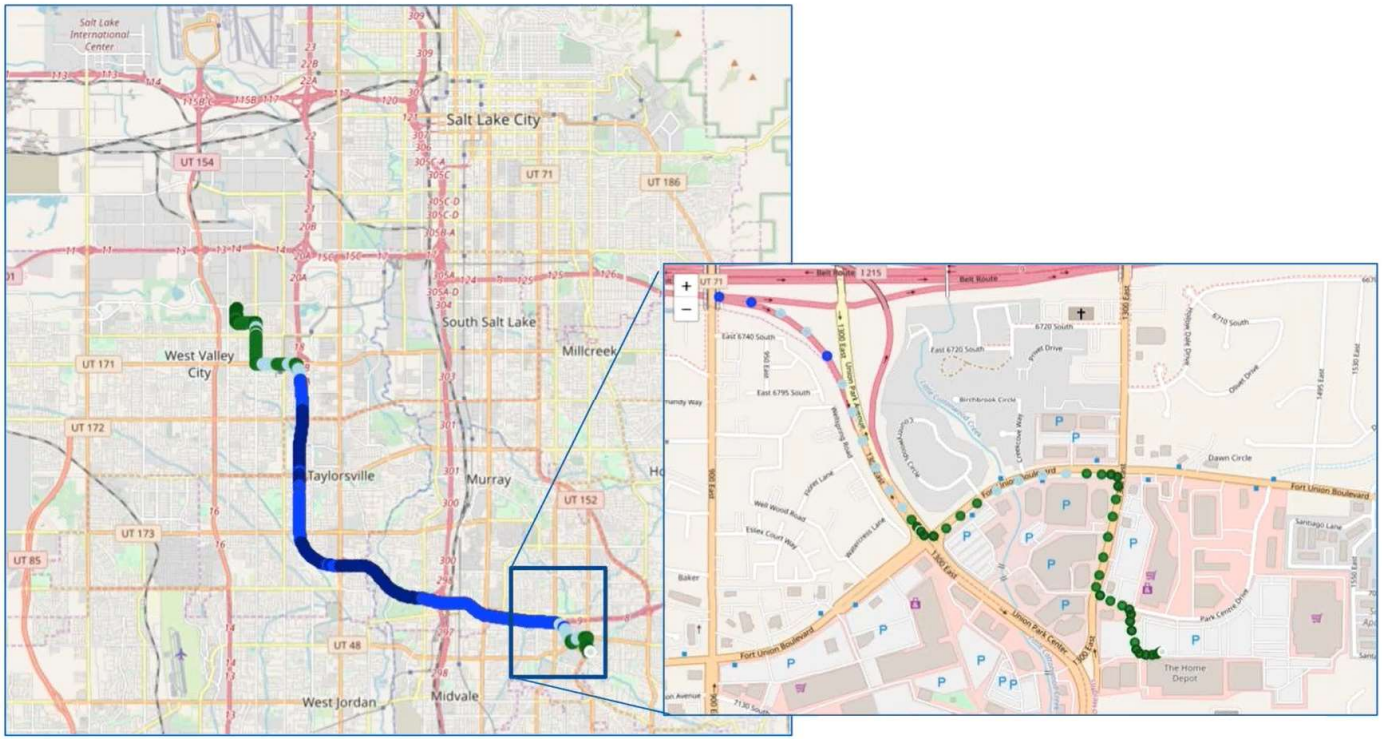
Strengths	Limitations
Real 'observed' vehicles	Only a sample of vehicles
No added infrastructure	No direct signal/phasing measurement
Scale & Consistency	Vehicle only
Integrated Software	Not in real time





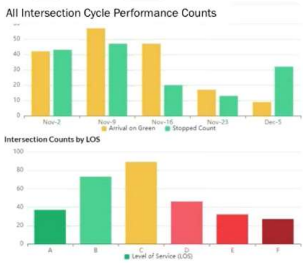


BASED ON HIGH-TEMPORAL DENSITY PROBE DATA



Source: INRIX

WHAT IS SIGNAL ANALYTICS



The Data

- 1 to 5 second frequency waypoints collected from connected vehicles
- Snapped to a free, open, and global map

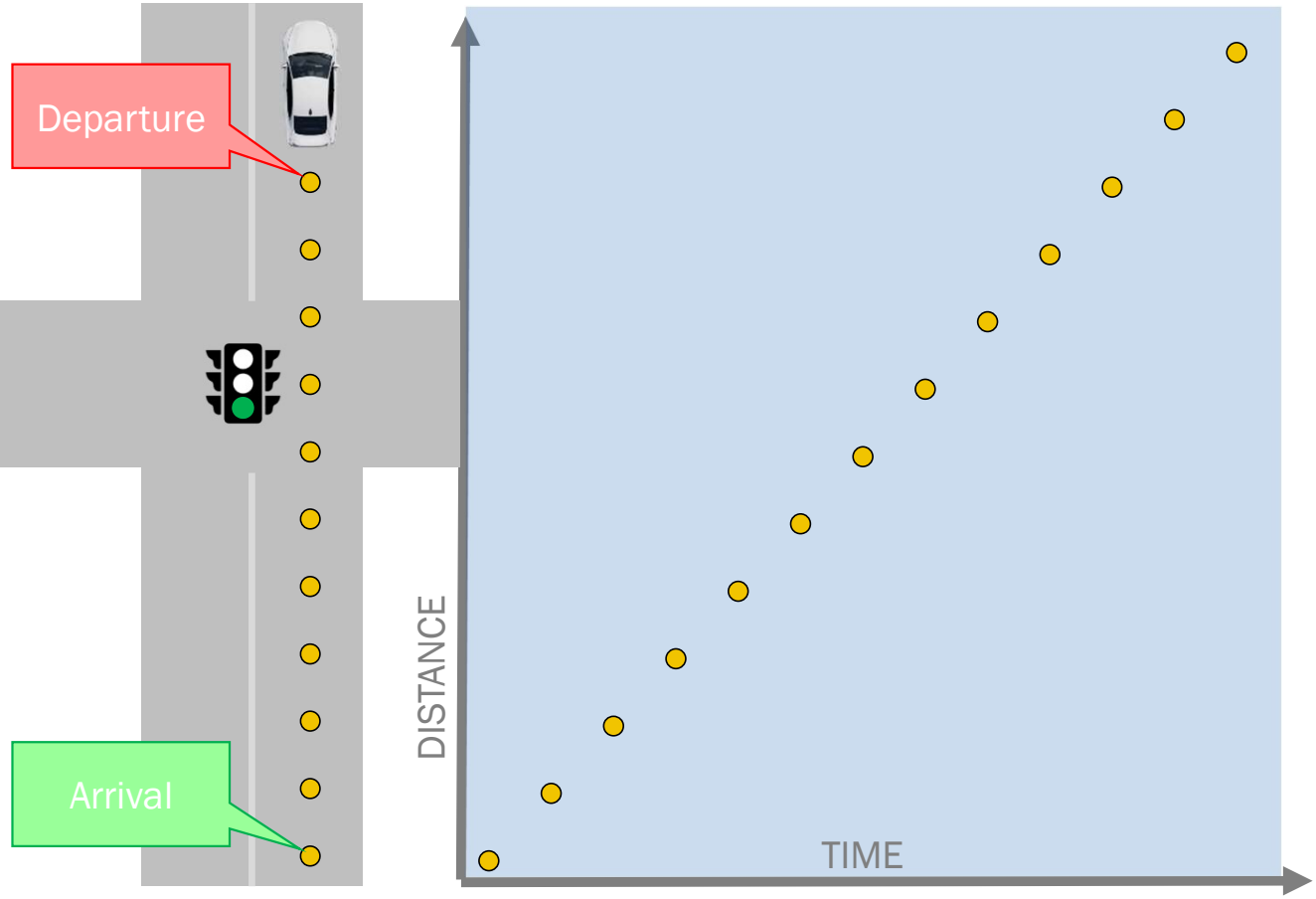
The Metrics

- Individual vehicle waypoints are used to determine the travel time of a vehicle moving through an intersection
- Other vehicle attributes include turning movement, vehicle stop, approach speed, or vehicle split failure and volume

The Tools – Cloud-based Solution as a Service

- Agency defines number of intersections to license
- Collaboration between CATT Lab and INRIX
- Aggregate the performance measures by intersection
- Report summary metrics over various time periods

THE METRICS – FROM EACH VEHICLE



Metrics for each vehicle

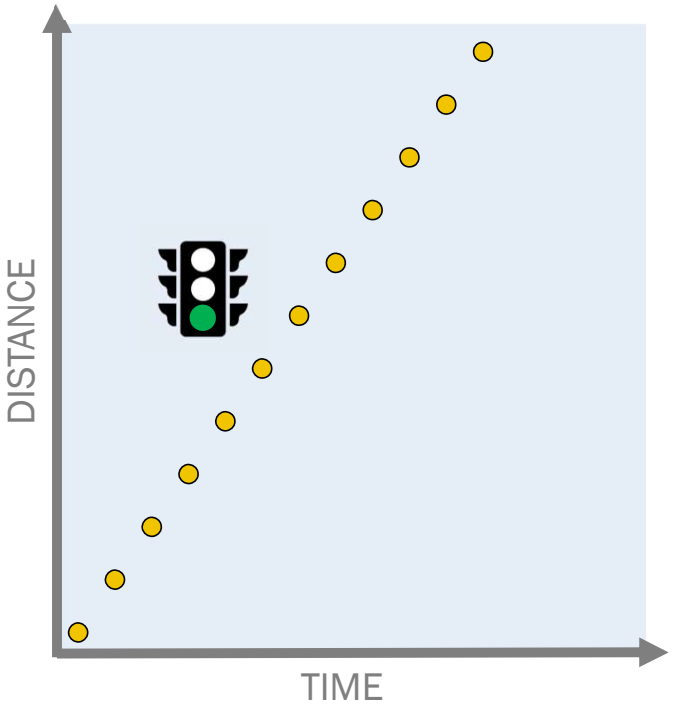
- Travel Time
- Approach Speed
- Vehicle Stop
- Vehicle Double Stop
- Movement (Left, Thru, Right)
- Volume

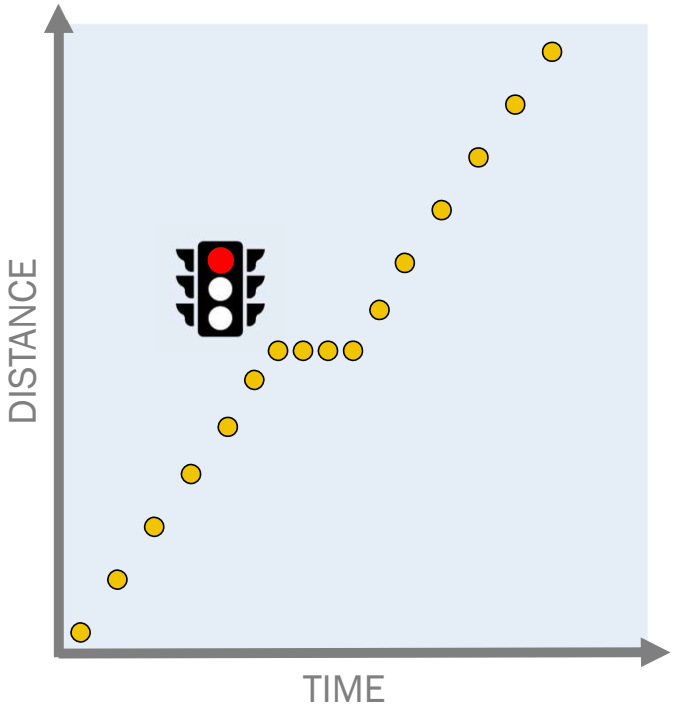
THE METRICS – INTERSECTION BUSINESS LOGIC

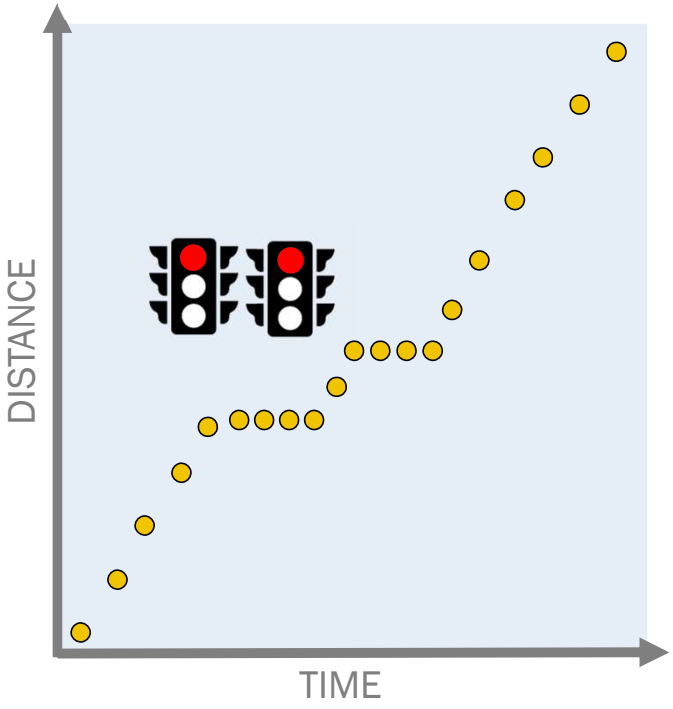
42 sec
ARRIVAL ON GREEN

61 sec
ARRIVAL ON RED

100 sec
SPLIT FAILURE

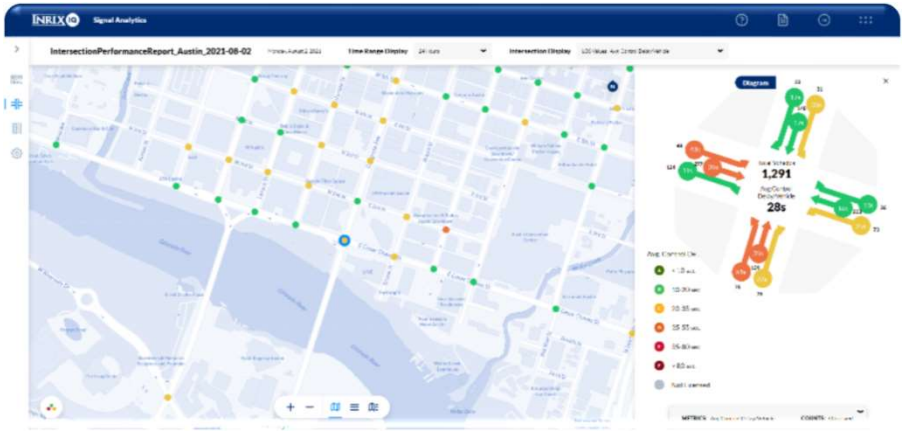


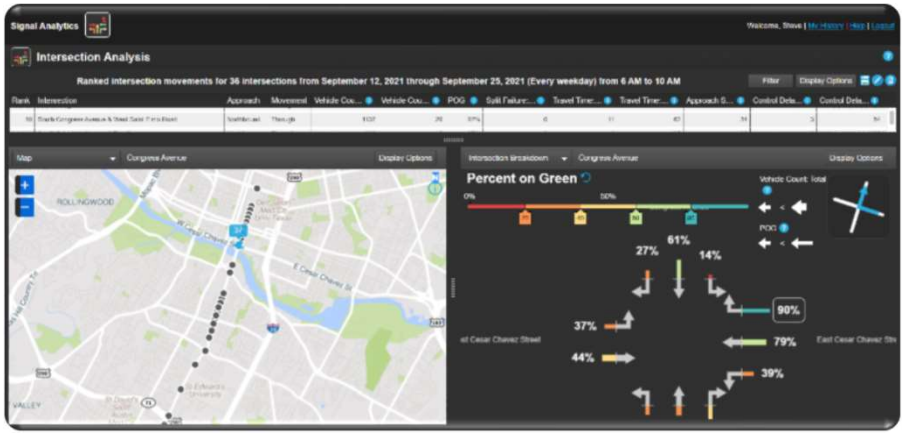




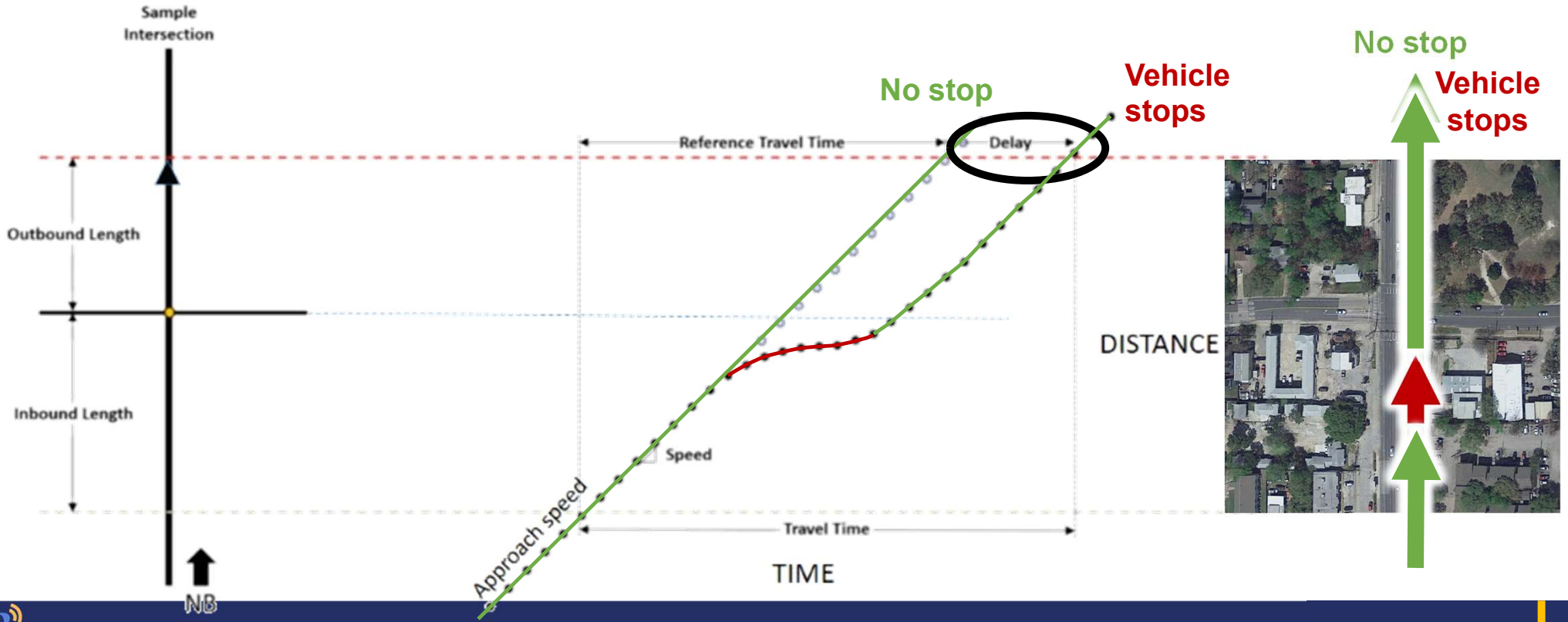
CORE USE CASES – SIGNAL ANALYTICS

- Safety and Emissions
  - Reducing split failures, reduces idling
  - Where queues exist, safety issues arise
- Project prioritization
  - Scan the entire traffic signal network to focus on problem intersections
- Performance
  - Identify underperforming intersections
  - Discover and measure iterative changes to signal timings
- Before and After studies
  - Did the retiming have a positive outcome
- Traffic Models
  - Validate the results of traffic modeling or simulation software

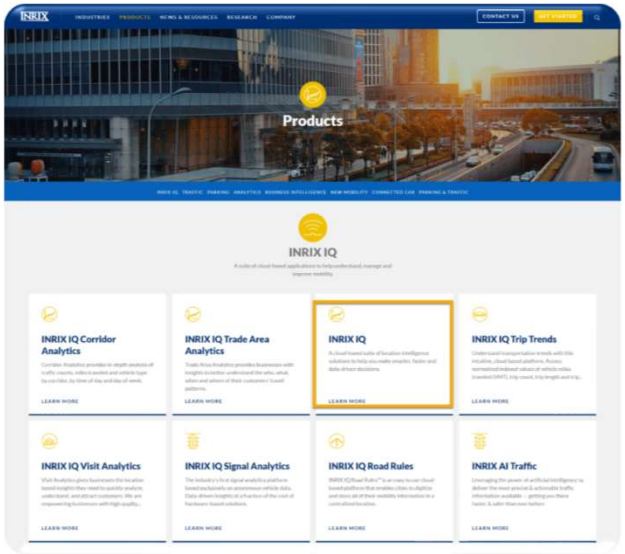




Intersection Metrics Using Trajectory Data

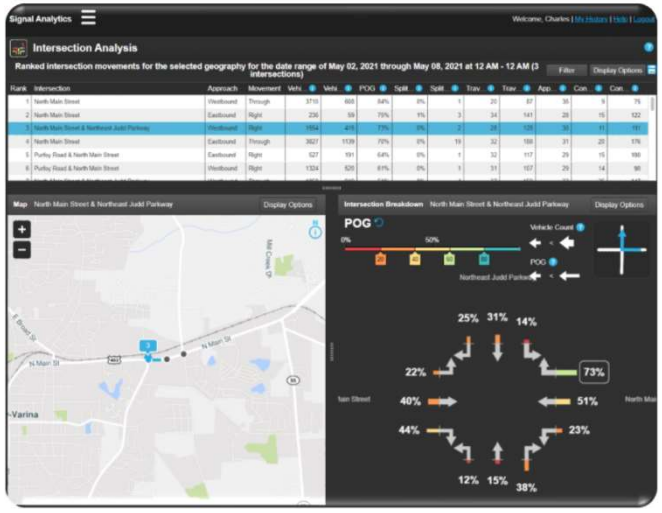


Two Complimentary Tools



INRIX IQ

Daily System Dashboard

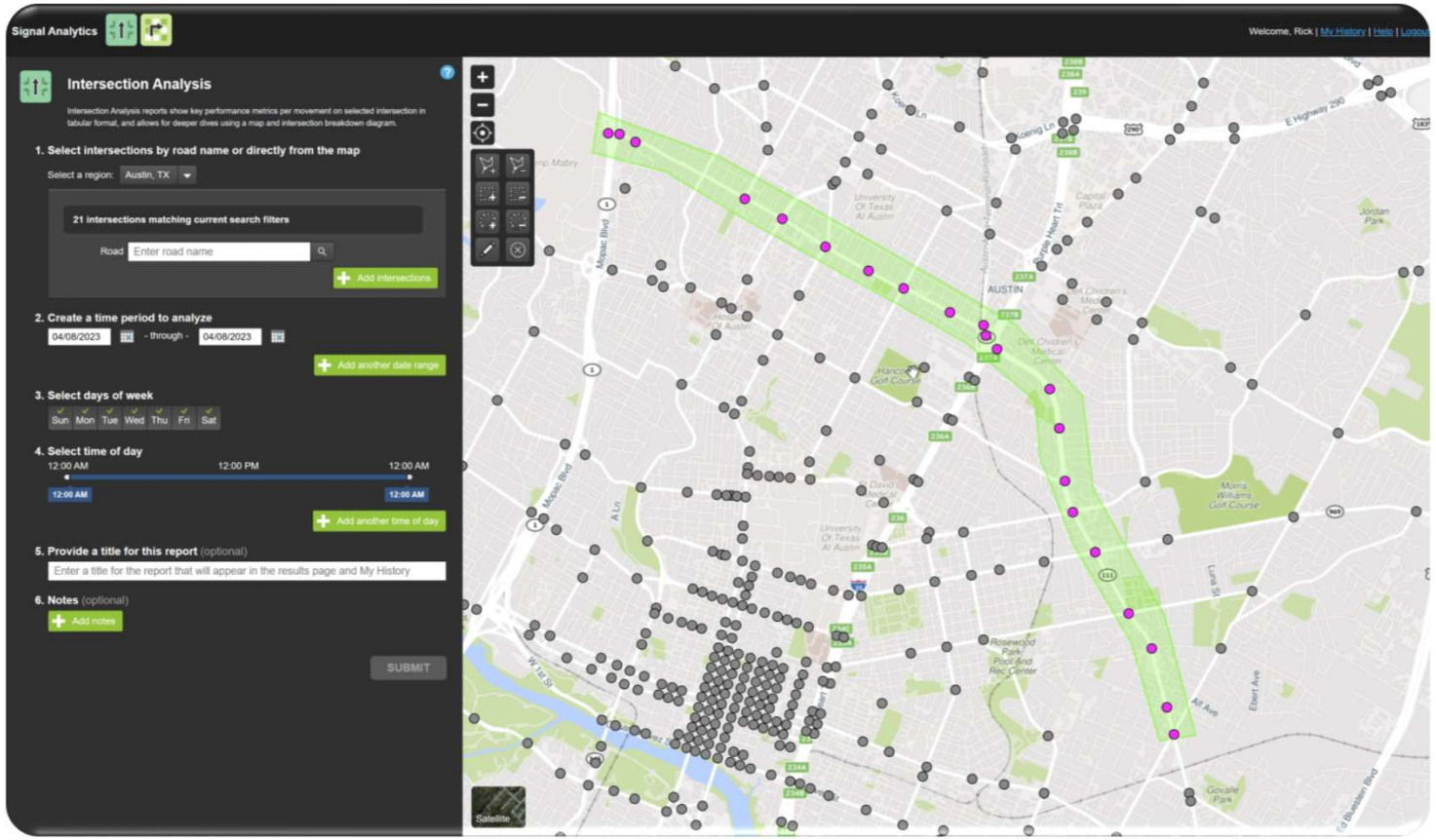


CATT Lab Signal Analytics

Deep Dive Analytics

signals.ritis.org

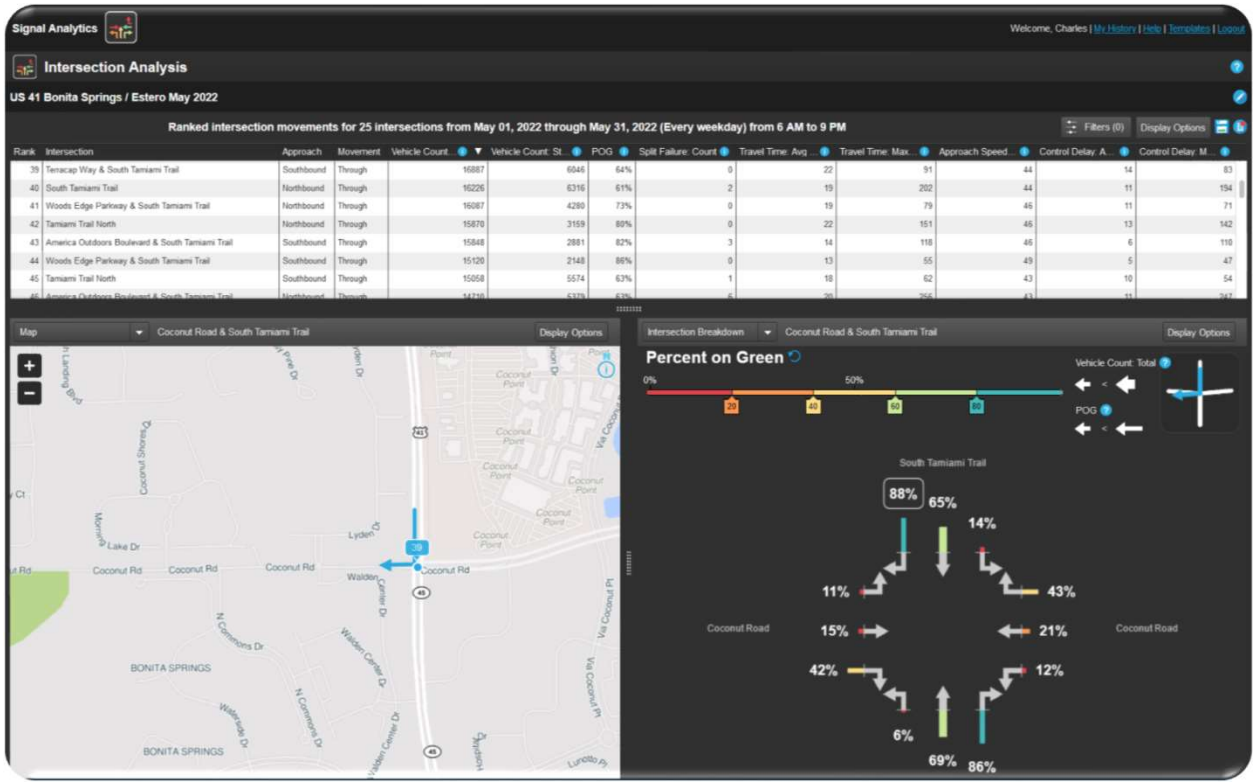
Signal Analytics Intersection Analysis Tool



User defines:

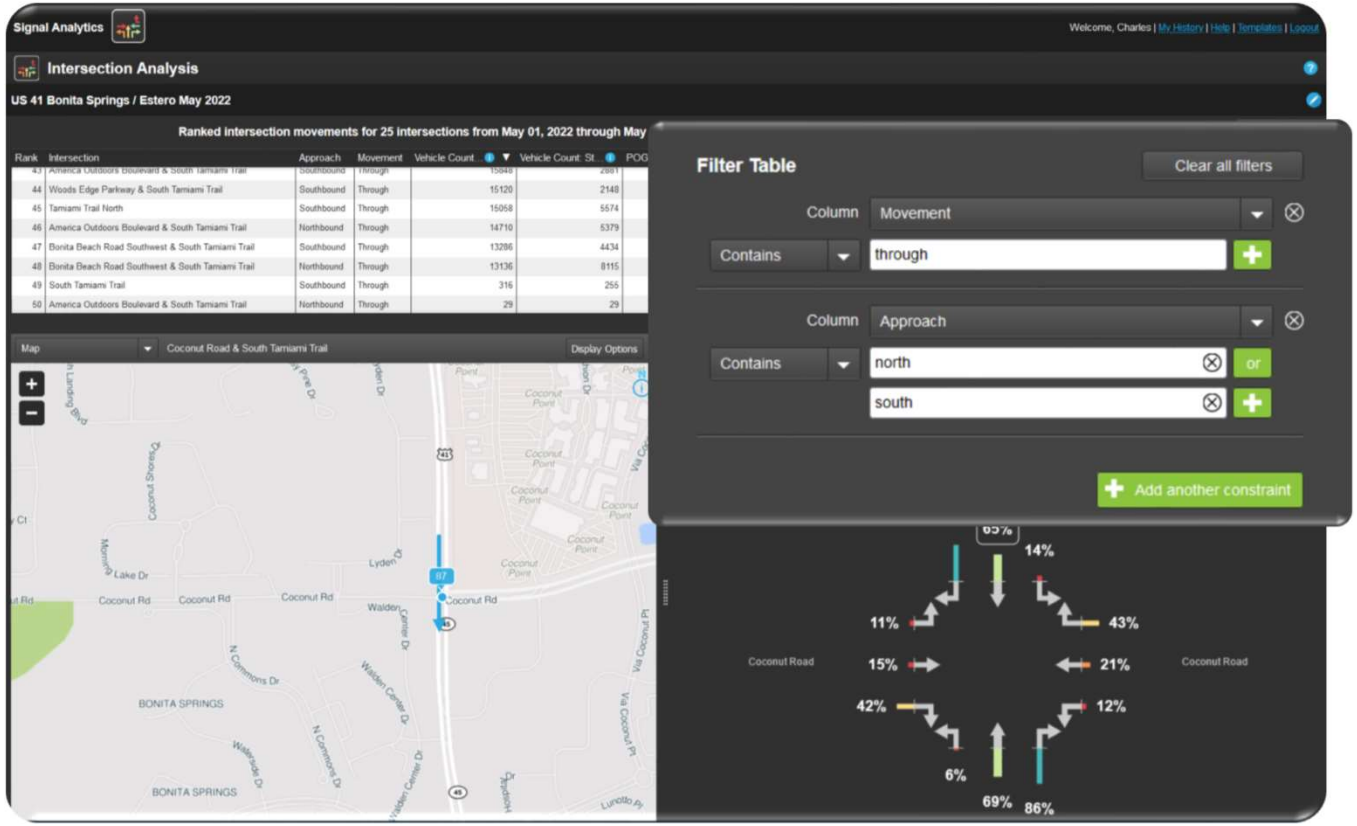
- Intersections or corridors
- Date range(s)
- Time(s) of day

Signal Analytics Intersection Analysis Tool



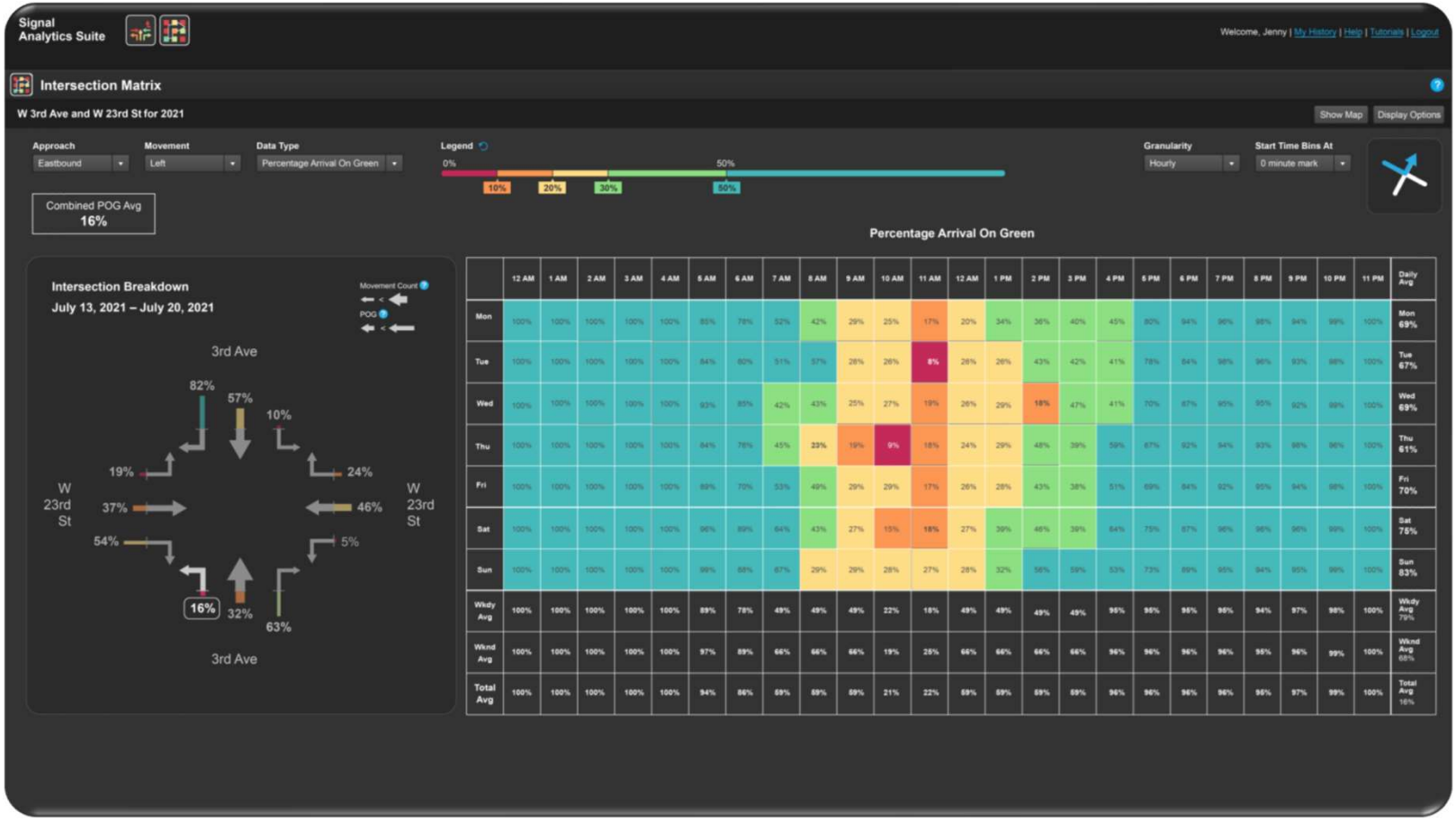
- Table shows intersection performance ranked by metric
- Map shows location and orientation of each intersection movement
- Diagram visualizes performance of each metric by movement

Signal Analytics Intersection Analysis Tool

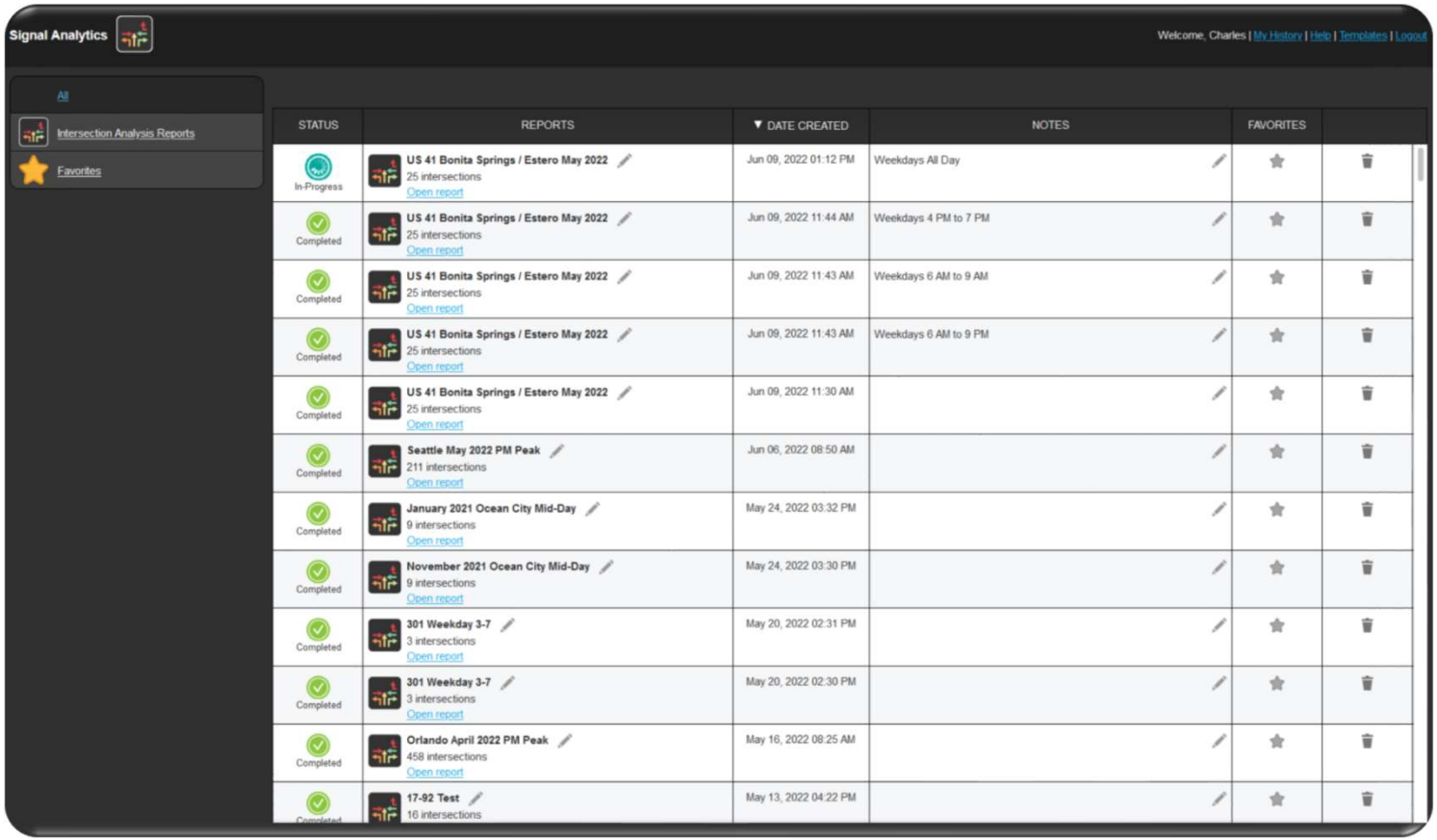


- Advanced table filtering allows ranking by approach, movement, and value
- Download table as CSV

Intersection Matrix Tool



My History Page Lists Previous Reports



Use Case 1: How are the signals in my county performing?

Washington County, OR

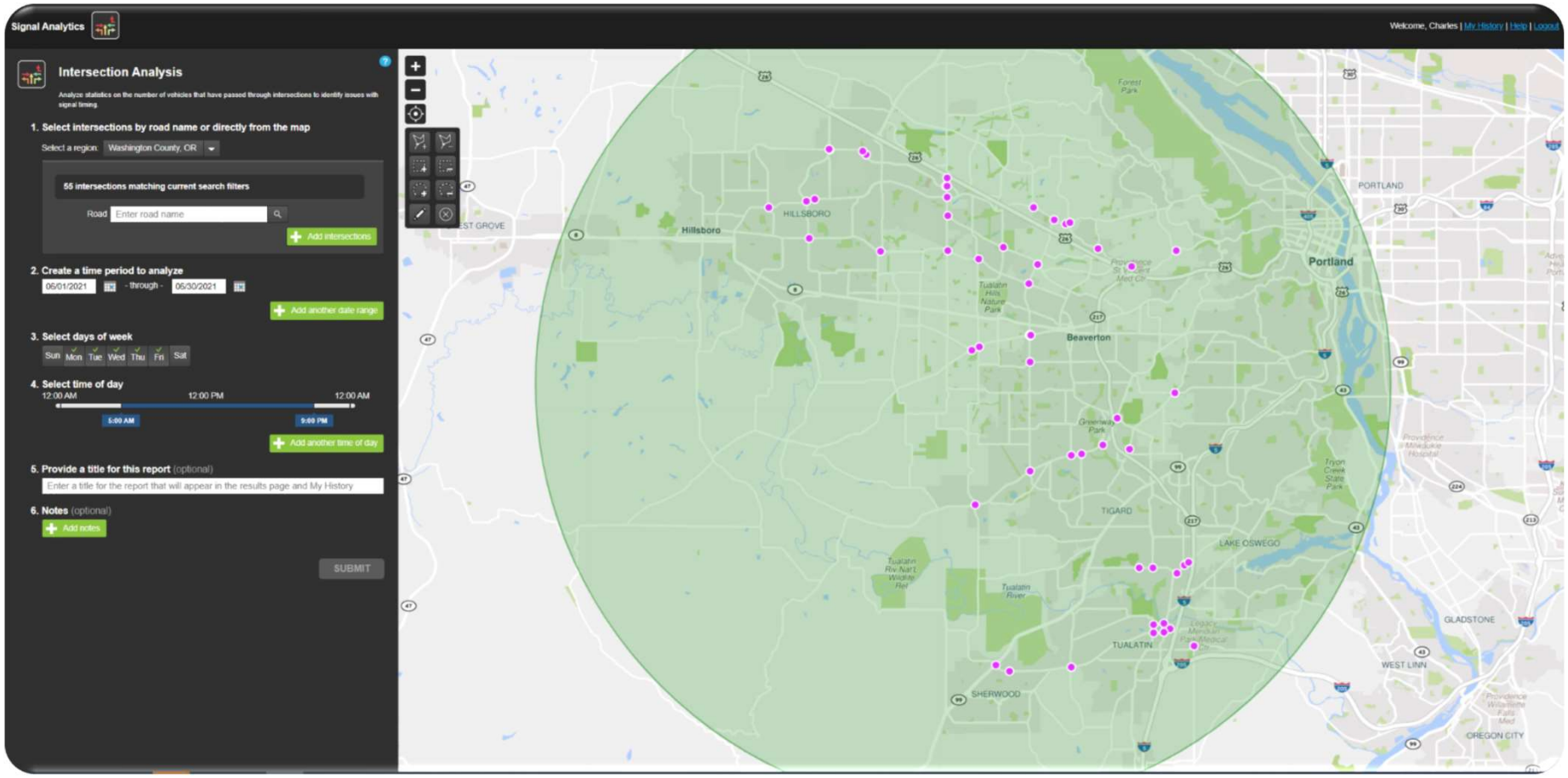
“Is there a way that I can rank the performance of my traffic signals across my entire county?”

“Can I see how much conditions change month by month?

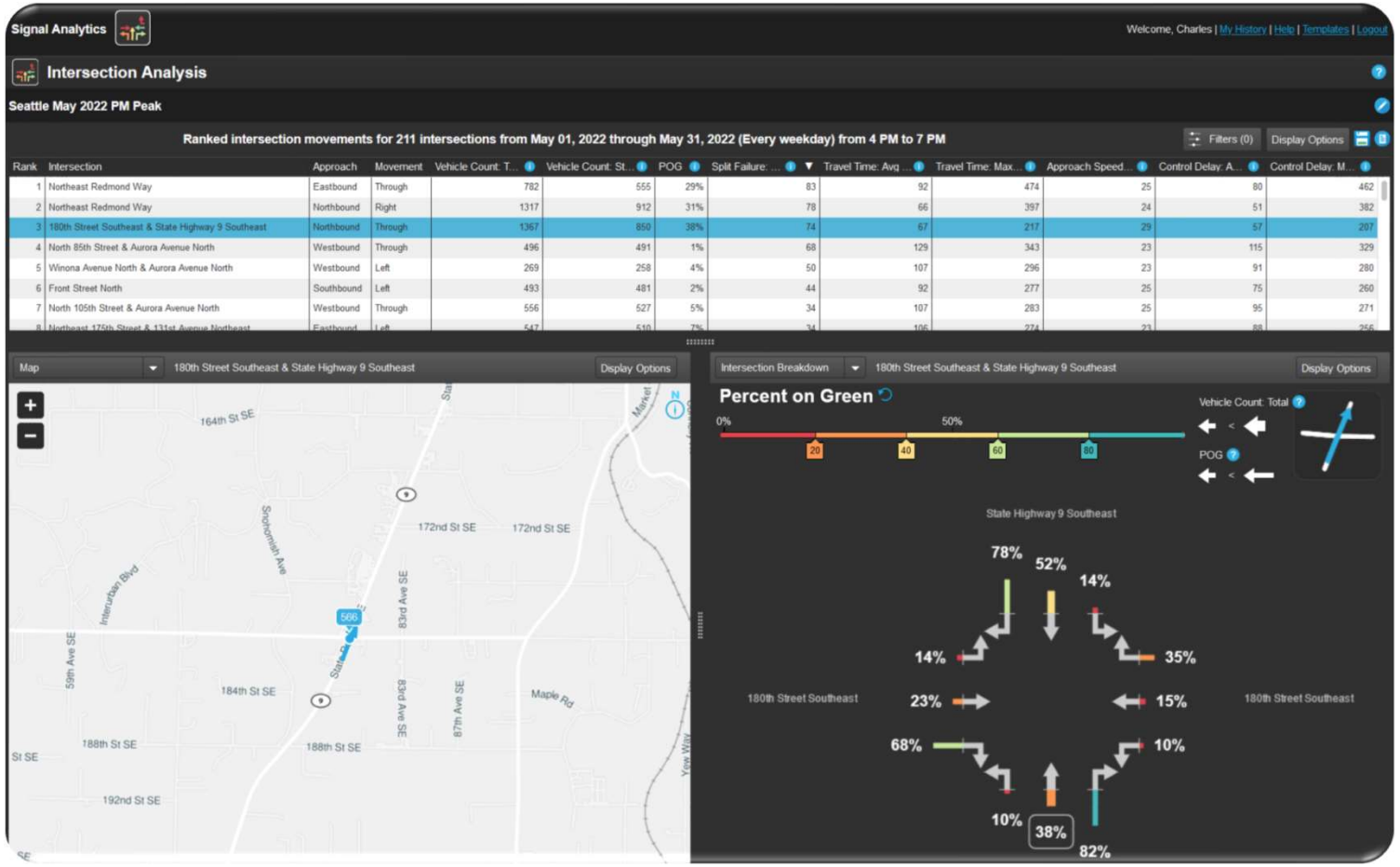
Solution: Use the Signal Analytics Ranked Intersection Table

Consider ranking by weekday split failures

Selecting the intersections in my county…



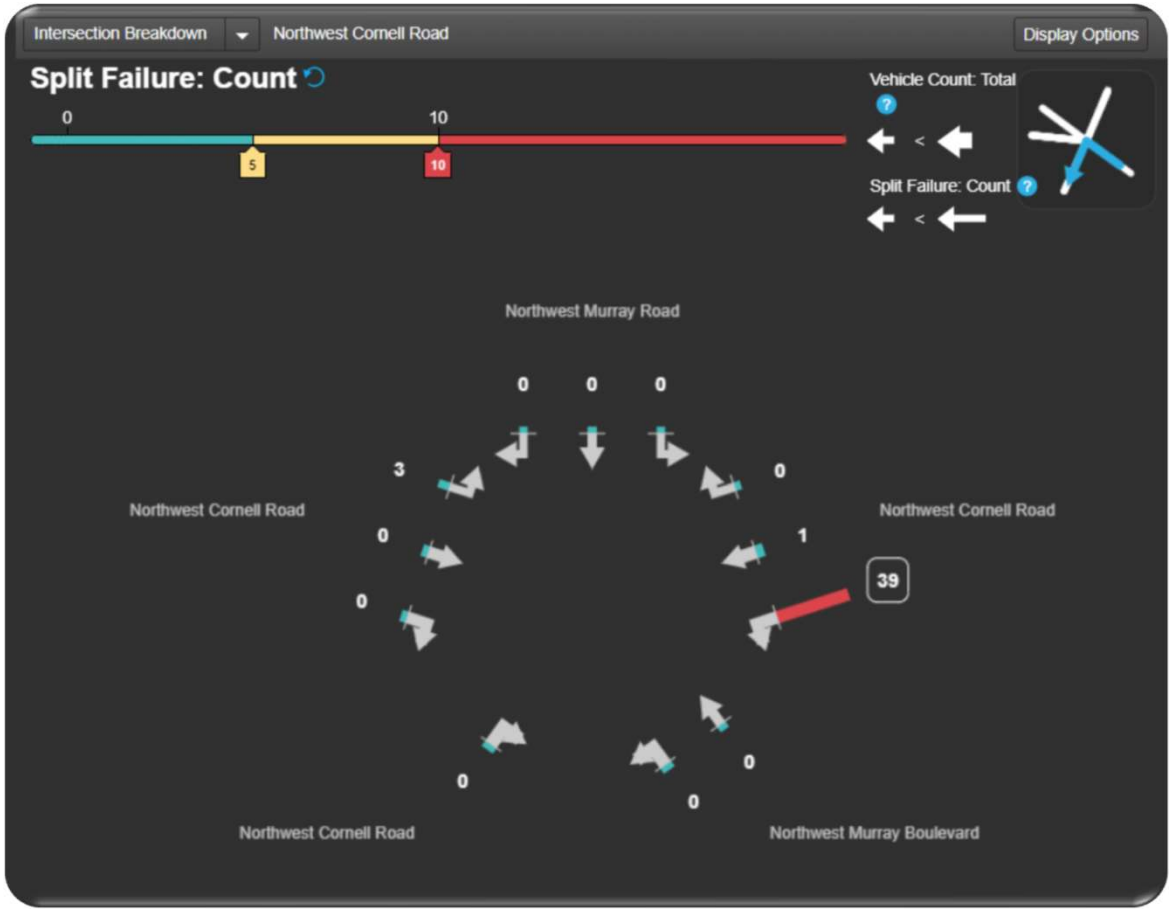
Sort the ranked intersection movement table by split failures



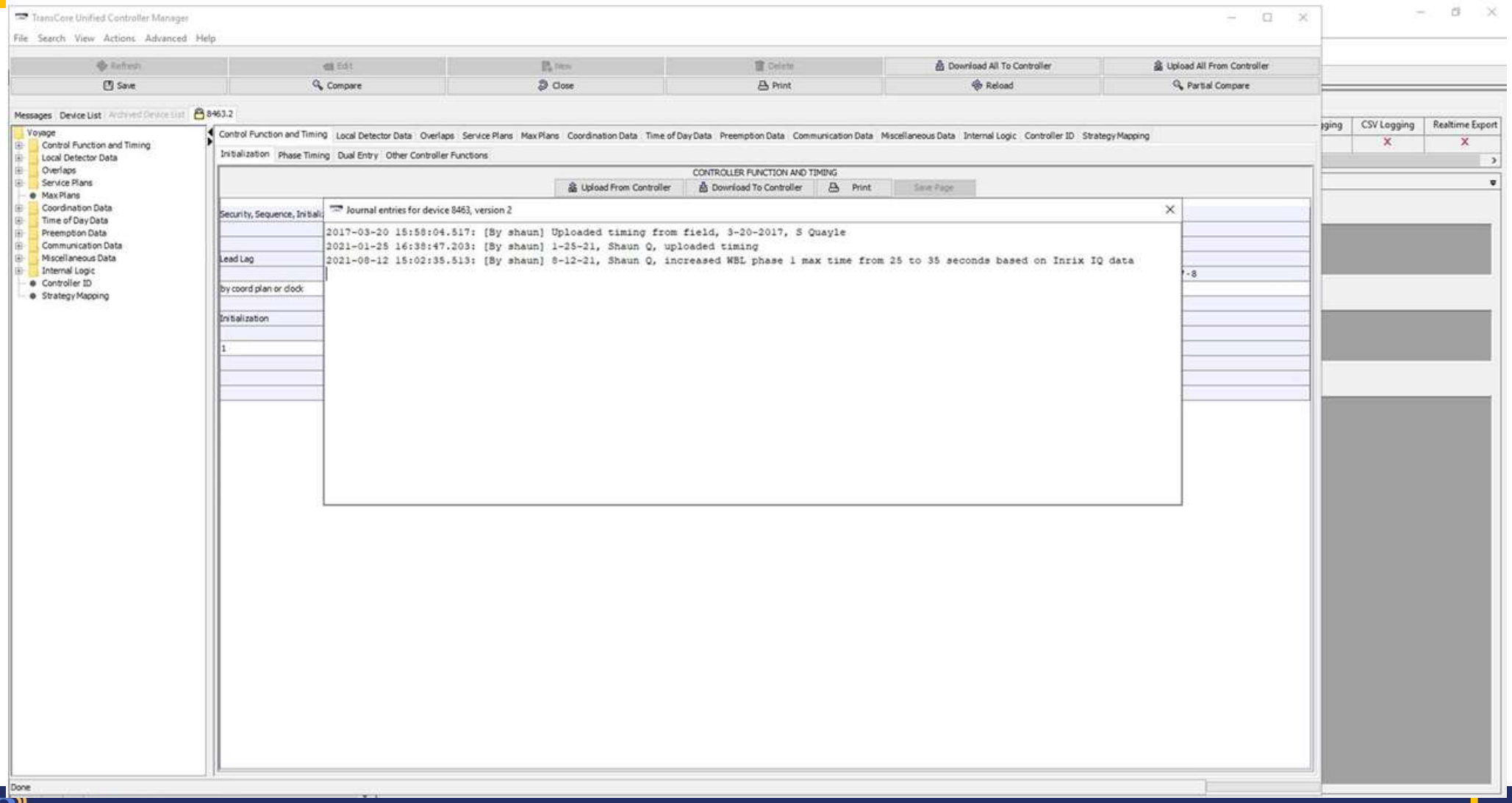
Countywide Analysis

Frequency in Top 10 for Total # of Weekday Split Failures, 5am-9pm								
Intersection	**Approach**	**Maneuver**	**June**	**May**	**April**	**March**	**February**	**% in Top 10**
Southwest Pacific Highway & TSR	Southbound	Through	1	2	5	3	6	100%
Southwest 124th Avenue & Southwest Tualatin Sherwood Road	Westbound	Through	2					20%
Northwest 185th Avenue & Northeast Evergreen Parkway	Eastbound	Left	3	3				40%
Southwest Durham Road & Southwest Upper Boones Ferry Road	Eastbound	Left	4	7	3, 7		9	60%
Northwest Cornell Road & Murray Road	Westbound	Left	5	4	1	4	10	100%
Southwest Durham Road & Southwest Upper Boones Ferry Road	Northbound	Through	6	10	4	9		80%
Southwest Pacific Highway & TSR	Northbound	Through	7	6	2	2	1	100%
Northeast Brookwood Parkway & Northeast Cornell Road	Eastbound	Left	8		10			40%
Southwest Tualatin Sherwood Road & Southwest Boones Ferry Road	Westbound	Left	9		8	5	8	80%
Northwest 185th Avenue & Northeast Evergreen Parkway	Southbound	Left	10					20%
Southwest Baseline Road & 185th Avenue	Northbound	Through				7	2	40%
Southwest Martinazzi Avenue & Southwest Tualatin Sherwood Road	Eastbound	Through		1			3	40%
Southwest Baseline Road & 185th Avenue	Northbound	Left					4	20%
Southwest 92nd Avenue & Southwest Durham Road	Northbound	Left				1	5	40%
Southwest Baseline Road & 185th Avenue	Southbound	Through		9	6	6	7	80%
Southwest Tualatin Sherwood Road & Southwest Boones Ferry Road	Eastbound	Through		5				20%
Northwest Cornell Road & 48th Avenue	Eastbound	Left		8				20%
Southwest Nyberg Street & Fred Meyer Entrance	Southbound	Left				8		20%
Southwest Tualatin Sherwood Road & Southwest Boones Ferry Road	Southbound	Through				10		20%
Southwest Pacific Highway & TSR	Southbound	Right			9			20%

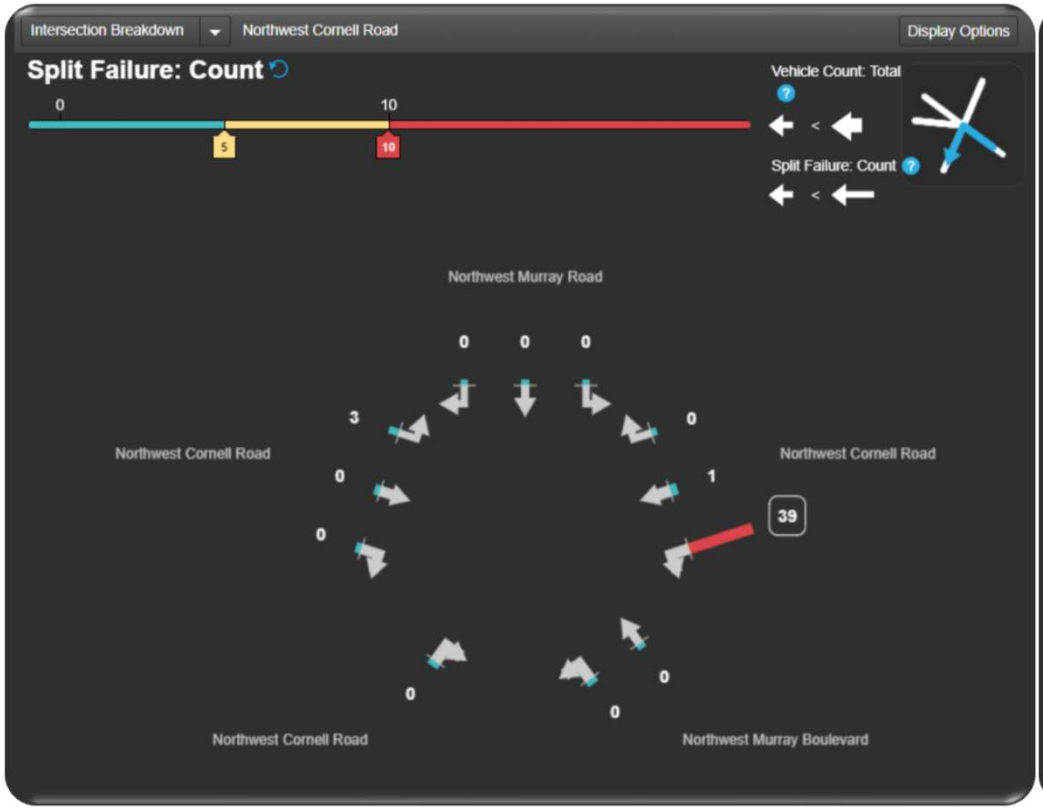
Let's take a look at the intersection diagram…



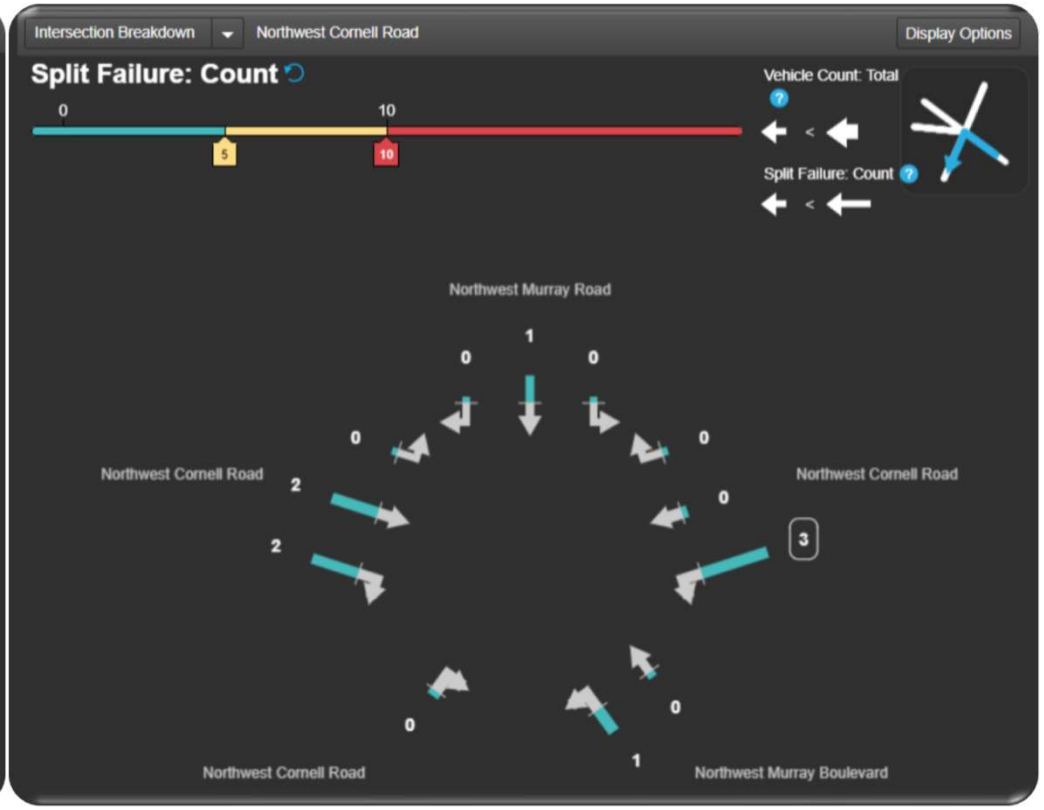
There are a lot more split failures on that left turn movement. **What would happen if I extended the max time for that movement?**


TransCore Unified Controller Manager
File Search View Actions Advanced Help
Refresh
Edit
New
Delete
Download All To Controller
Upload All From Controller
Save
Compare
Close
Print
Reload
Partial Compare
Messages
Device List
Archived Device List
8463.2
Voyage
Control Function and Timing
Local Detector Data
Overlaps
Service Plans
Max Plans
Coordination Data
Time of Day Data
Preemption Data
Communication Data
Miscellaneous Data
Internal Logic
Controller ID
Strategy Mapping
Initialization
Phase Timing
Dual Entry
Other Controller Functions
CONTROLLER FUNCTION AND TIMING
Upload From Controller
Download To Controller
Print
Save Page
Security, Sequence, Initiali
Lead Lag
by coord plan or clock
Initialization
Journal entries for device 8463, version 2
2017-03-20 15:58:04.517: [By shaun] Uploaded timing from field, 3-20-2017, S Quayle
2021-01-25 16:38:47.203: [By shaun] 1-25-21, Shaun Q, uploaded timing
2021-08-12 15:02:35.513: [By shaun] 8-12-21, Shaun Q, increased WBL phase 1 max time from 25 to 35 seconds based on Inrix IQ data
Done
CSV Logging
Realtime Export

Before
(Jul. 22 – Aug. 11)



After
(Aug. 13 – Sep. 2)



Use Case: How do I compare conditions before and after a signal timing change?

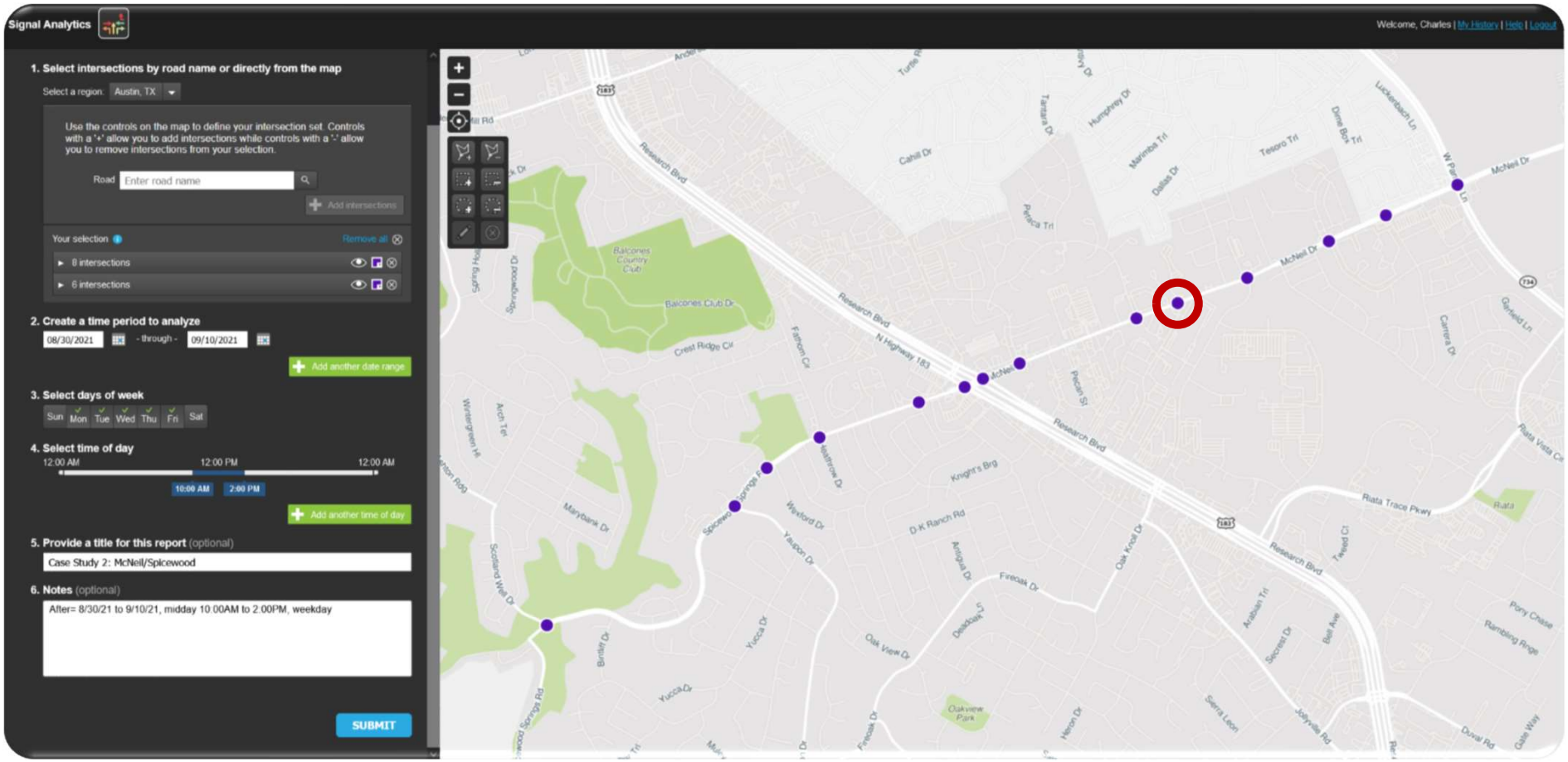
City of Austin, TX

“How can I measure changes to intersection performance if I don’t have detection on all my approaches?”

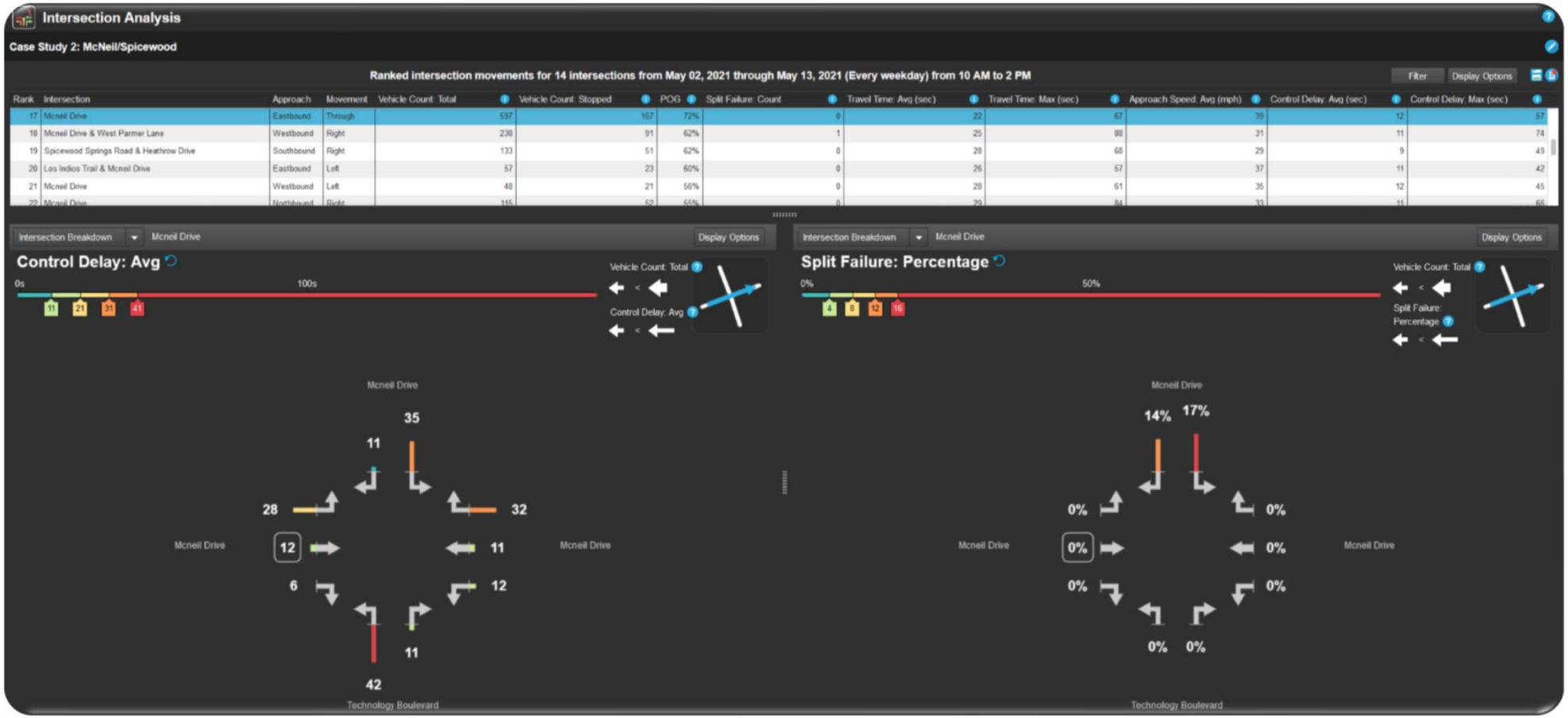
“Using corridor travel times to measure signal timing improvement can be good, but sometimes it seems they don’t tell the whole story. Are there additional measures I can use?”

Solution: Use the Signal Analytics to compare split failures, control delay, and percent on green over time

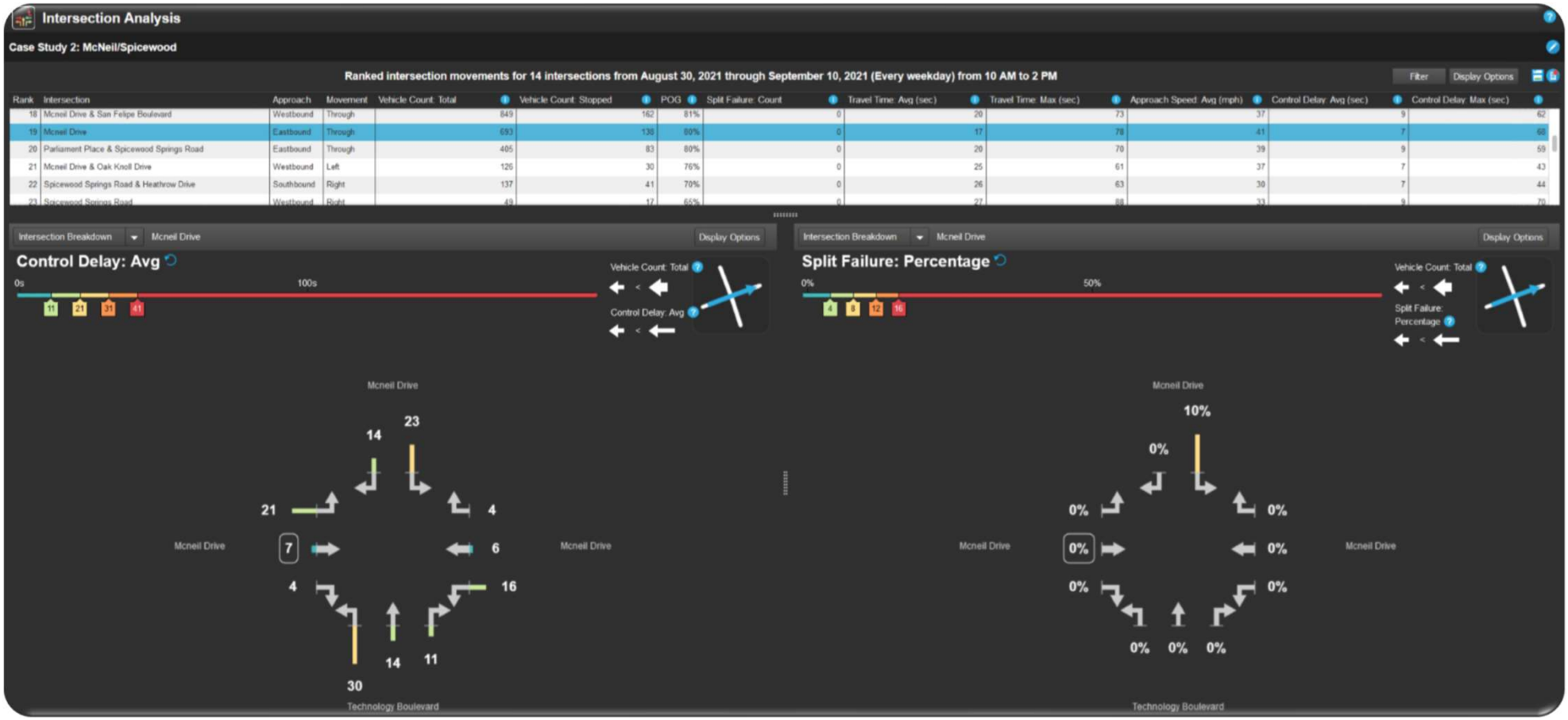
Selecting intersections on McNeil Dr.…



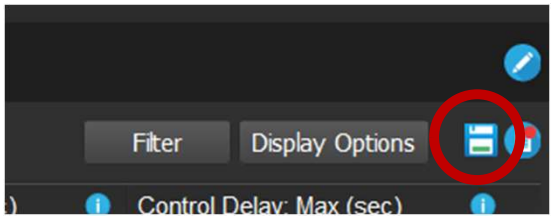
Before retiming



After retiming



Downloading Data



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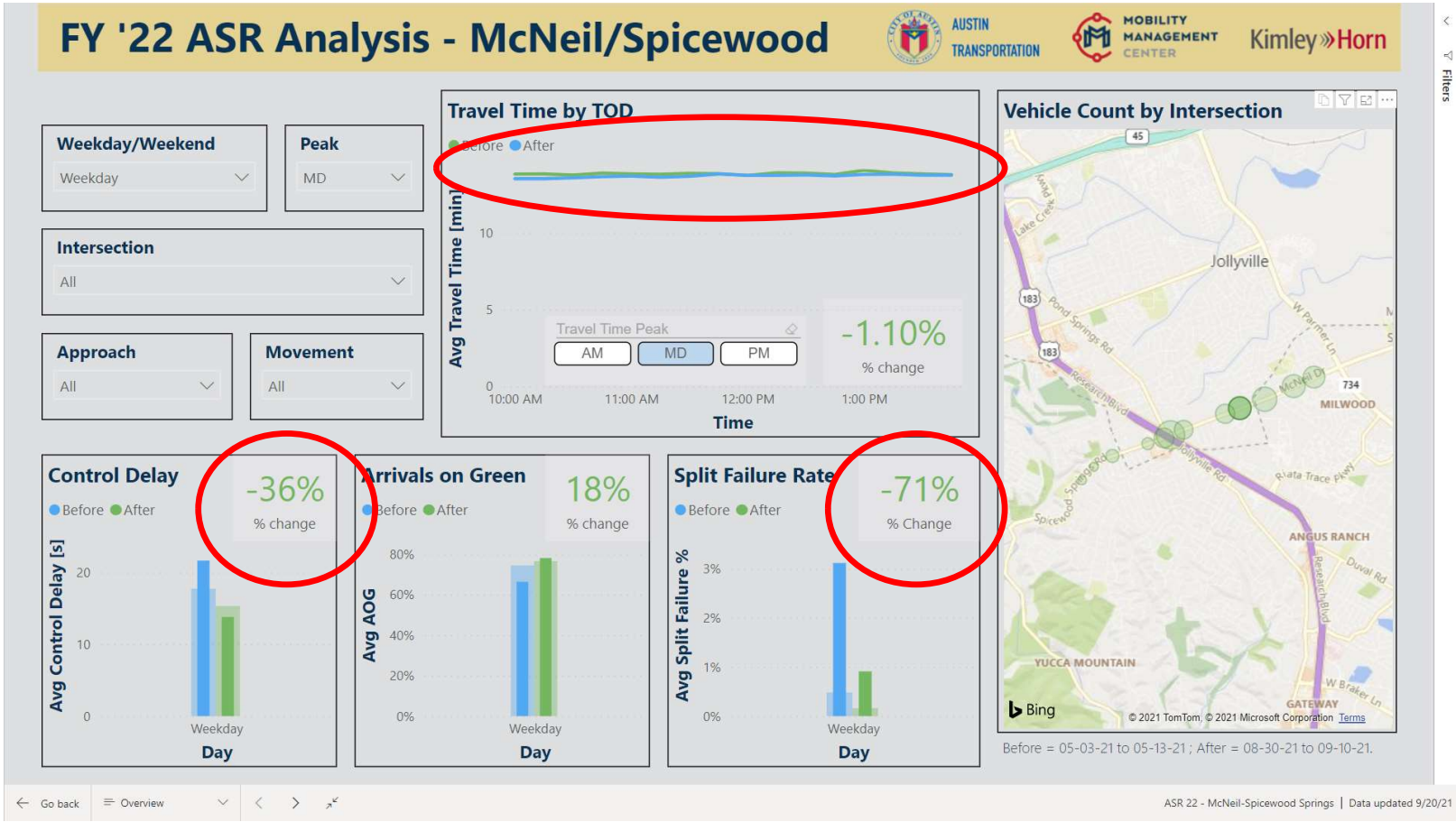
Rank	Intersection	Intersection ID	Latitude	Longitude	Approach	Approach ID	Movement	Movement ID	Vehicle Count: Total	Vehicle Count: Stopped	Vehicle Count: Through	Estimated Volume: Total	Estimated Volume: Stopped	Estimated Vol
1	Mcneil Drive & Oak Knoll Drive	30.4394_-97.7542	30.4393591	-97.7542284	Westbound	30.4394_-97.7542-30.4394_-97.7542_3	Through	30.4394_-97.7542_X3Y2Z	852	15	837	25403	447	
2	Rustic Rock Drive & Spicewood Springs Road	30.4301_-97.7812	30.43014345	-97.78122745	Eastbound	30.4301_-97.7812-30.4301_-97.7812_1	Through	30.4301_-97.7812_DE3F	342	10	332	12838	375	
3	Rustic Rock Drive & Spicewood Springs Road	30.4301_-97.7812	30.43014345	-97.78122745	Westbound	30.4301_-97.7812-30.4301_-97.7812_3	Through	30.4302_-97.7813_2XW	317	10	307	11899	375	
4	Mcneil Drive & Oak Knoll Drive	30.4394_-97.7542	30.4393591	-97.7542284	Eastbound	30.4394_-97.7542-30.4394_-97.7542_2	Through	30.4394_-97.7542_3H3G	808	42	766	24091	1252	
5	Los Indios Trail & Mcneil Drive	30.4374_-97.7605	30.4373716	-97.7604817	Westbound	30.4374_-97.7605-30.4374_-97.7605_3	Through	30.4374_-97.7605_3Y	845	74	771	28414	2488	
6	Mcneil Drive & Heinemann Drive	30.4424_-97.7464	30.4423753	-97.7464263	Westbound	30.4424_-97.7464-30.4424_-97.7464_2	Through	30.4424_-97.7465_3Y	787	72	715	25773	2358	
7	Corpus Christi Drive & Mcneil Drive	30.4411_-97.7496	30.4411412	-97.74964205	Eastbound	30.4411_-97.7496-30.4411_-97.7496_1	Through	30.4411_-97.7496_4G	828	77	751	26539	2468	
8	Mcneil Drive & West Parmer Lane	30.4438_-97.7424	30.44384835	-97.74239143	Southbound	30.4438_-97.7424-30.4438_-97.7424_2	Right	30.4439_-97.7425_4P2Y	185	19	166	6449	662	
9	Corpus Christi Drive & Mcneil Drive	30.4411_-97.7496	30.4411412	-97.74964205	Westbound	30.4411_-97.7496-30.4411_-97.7496_3	Through	30.4412_-97.7497_5Y	853	89	764	27340	2853	
10	Spicewood Springs Road & Heathrow Drive	30.4316_-97.7783	30.43162835	-97.77829435	Westbound	30.4316_-97.7783-30.4316_-97.7783_3	Through	30.4317_-97.7783_3Z	262	33	229	8993	1133	
11	Mcneil Drive	30.4381_-97.7582	30.4381404	-97.7581562	Westbound	30.4381_-97.7582-30.4381_-97.7582_3	Through	30.4381_-97.7582_3Z3Y	824	109	715	23762	3143	
12	Mcneil Drive & Heinemann Drive	30.4424_-97.7464	30.4423753	-97.7464263	Eastbound	30.4424_-97.7464-30.4424_-97.7464_1	Through	30.4423_-97.7464_4G	739	101	638	24201	3308	
13	Spicewood Springs Road & Scotland Well Drive	30.4225_-97.7936	30.422528	-97.793613	Eastbound	30.4225_-97.7936-30.4225_-97.7936_1	Through	30.4225_-97.7936_2FEI	96	14	82	3797	554	
14	Spicewood Springs Road & Scotland Well Drive	30.4225_-97.7936	30.422528	-97.793613	Westbound	30.4225_-97.7936-30.4225_-97.7936_3	Through	30.4225_-97.7936_aYWX	132	22	110	5220	870	
15	Los Indios Trail & Mcneil Drive	30.4374_-97.7605	30.4373716	-97.7604817	Eastbound	30.4374_-97.7605-30.4374_-97.7605_1	Through	30.4374_-97.7605_5G	497	83	414	16712	2791	
16	Spicewood Springs Road & Heathrow Drive	30.4316_-97.7783	30.43162835	-97.77829435	Eastbound	30.4316_-97.7783-30.4316_-97.7783_1	Through	30.4316_-97.7783_F2H	361	65	296	12391	2231	
17	Mcneil Drive & West Parmer Lane	30.4438_-97.7424	30.44384835	-97.74239143	Southbound	30.4438_-97.7424-30.4438_-97.7424_2	Through	30.4439_-97.7425_6P	1167	219	948	40683	7635	
18	Mcneil Drive & San Felipe Boulevard	30.4352_-97.7670	30.4352045	-97.7670345	Westbound	30.4352_-97.7670-30.4352_-97.7670_3	Through	30.4352_-97.7670_6Y	849	162	687	29480	5625	
19	Mcneil Drive	30.4381_-97.7582	30.4381404	-97.7581562	Eastbound	30.4381_-97.7582-30.4381_-97.7582_1	Through	30.4381_-97.7582_4G2H	693	138	555	19984	3979	
20	Parliament Place & Spicewood Springs Road	30.4333_-97.7727	30.4333065	-97.77269095	Eastbound	30.4333_-97.7727-30.4333_-97.7727_1	Through	30.4333_-97.7727_5H	405	83	322	15521	3181	
21	Mcneil Drive & Oak Knoll Drive	30.4394_-97.7542	30.4393591	-97.7542284	Westbound	30.4394_-97.7542-30.4394_-97.7542_3	Left	30.4394_-97.7542_X3YV	126	30	96	3757	894	
22	Spicewood Springs Road & Heathrow Drive	30.4316_-97.7783	30.43162835	-97.77829435	Southbound	30.4316_-97.7783-30.4316_-97.7783_2	Right	30.4317_-97.7783_2QRZ	137	41	96	4703	1407	
23	Spicewood Springs Road	30.4283_-97.7831	30.4283	-97.78306185	Westbound	30.4283_-97.7831-30.4283_-97.7831_4	Right	30.4283_-97.7830_eD	49	17	32	1806	626	
24	Mcneil Drive & West Parmer Lane	30.4438_-97.7424	30.44384835	-97.74239143	Northbound	30.4438_-97.7424-30.4438_-97.7424_4	Right	30.4438_-97.7422_4hG	89	32	57	3103	1116	
25	Mcneil Drive & West Parmer Lane	30.4438_-97.7424	30.44384835	-97.74239143	Northbound	30.4438_-97.7424-30.4438_-97.7424_4	Through	30.4438_-97.7422_6h	792	329	463	27610	11469	
26	Mcneil Drive	30.4381_-97.7582	30.4381404	-97.7581562	Northbound	30.4381_-97.7582-30.4381_-97.7582_4	Right	30.4381_-97.7582_2Cj2H	139	58	81	4008	1673	
27	Mcneil Drive & West Parmer Lane	30.4438_-97.7424	30.44384835	-97.74239143	Westbound	30.4438_-97.7424-30.4438_-97.7424_3	Right	30.4440_-97.7423_ZYh	300	128	172	10458	4462	
28	Los Indios Trail & Mcneil Drive	30.4374_-97.7605	30.4373716	-97.7604817	Eastbound	30.4374_-97.7605-30.4374_-97.7605_1	Left	30.4374_-97.7605_4G2i	51	23	28	1715	773	
29	Mcneil Drive	30.4381 -97.7582	30.4381404	-97.7581562	Westbound	30.4381 -97.7582-30.4381 -97.7582 3	Left	30.4381 -97.7582 3ZRU	52	24	28	1500	692	

Little improvement in travel time

Significant improvement in control delay and split failure rate



Source: Kimley-Horn

More Data Fields

Thanks!

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