From Performance Evaluation to Signal Timing Optimization: Leveraging Connected Vehicle Data

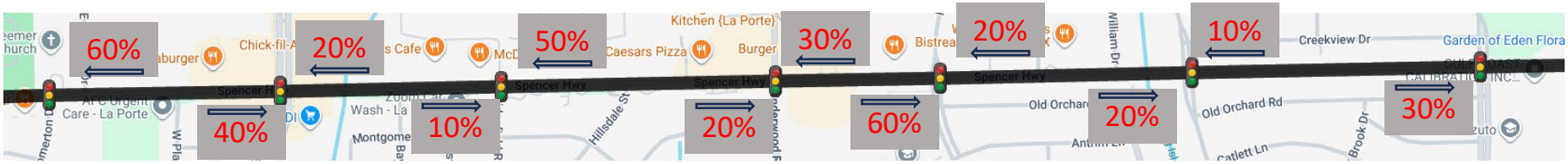
Zong Tian, PhD, PE
University of Nevada, Reno, NV

April 2026

SPACE CITY • 2026
HOUSTON
ite
TEXAS DISTRICT

Questions you may have been asking…

7 signals, 1.5 miles, Speed limit 45 mph

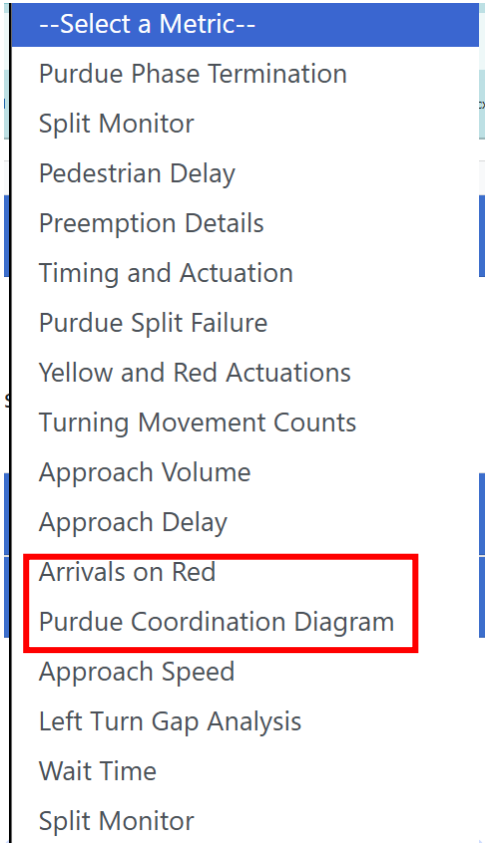


ATSPM: % Arrival on Red (AoR)

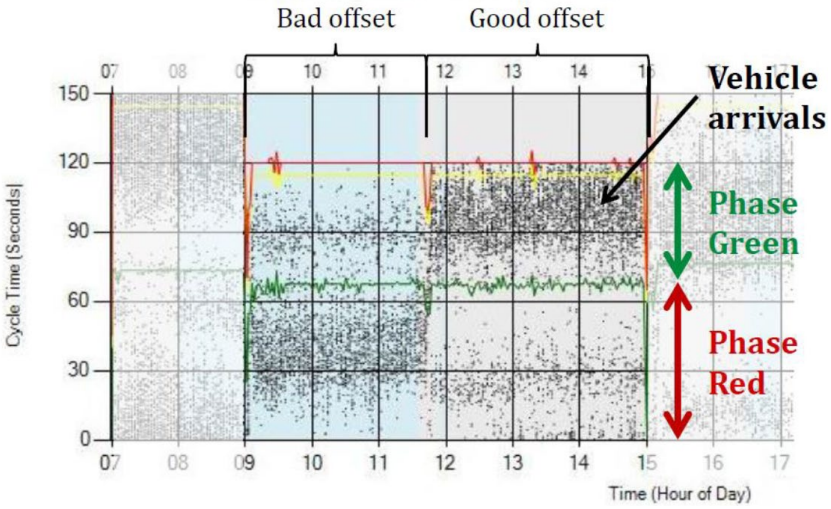
Floating Car: EB-Avg. Speed=35 mph; # Stops=2
WB-Avg. Speed=36 mph, #Stops=1

- **Given the %AoR, what is quality level (score)?**
- **Given the floating car runs, what is the quality (score)?**
- **Can we improve and how?**

Role of ATSPM



- **%AoR or %AoG**
- **Purdue Coordination Diagram**



Limitations:

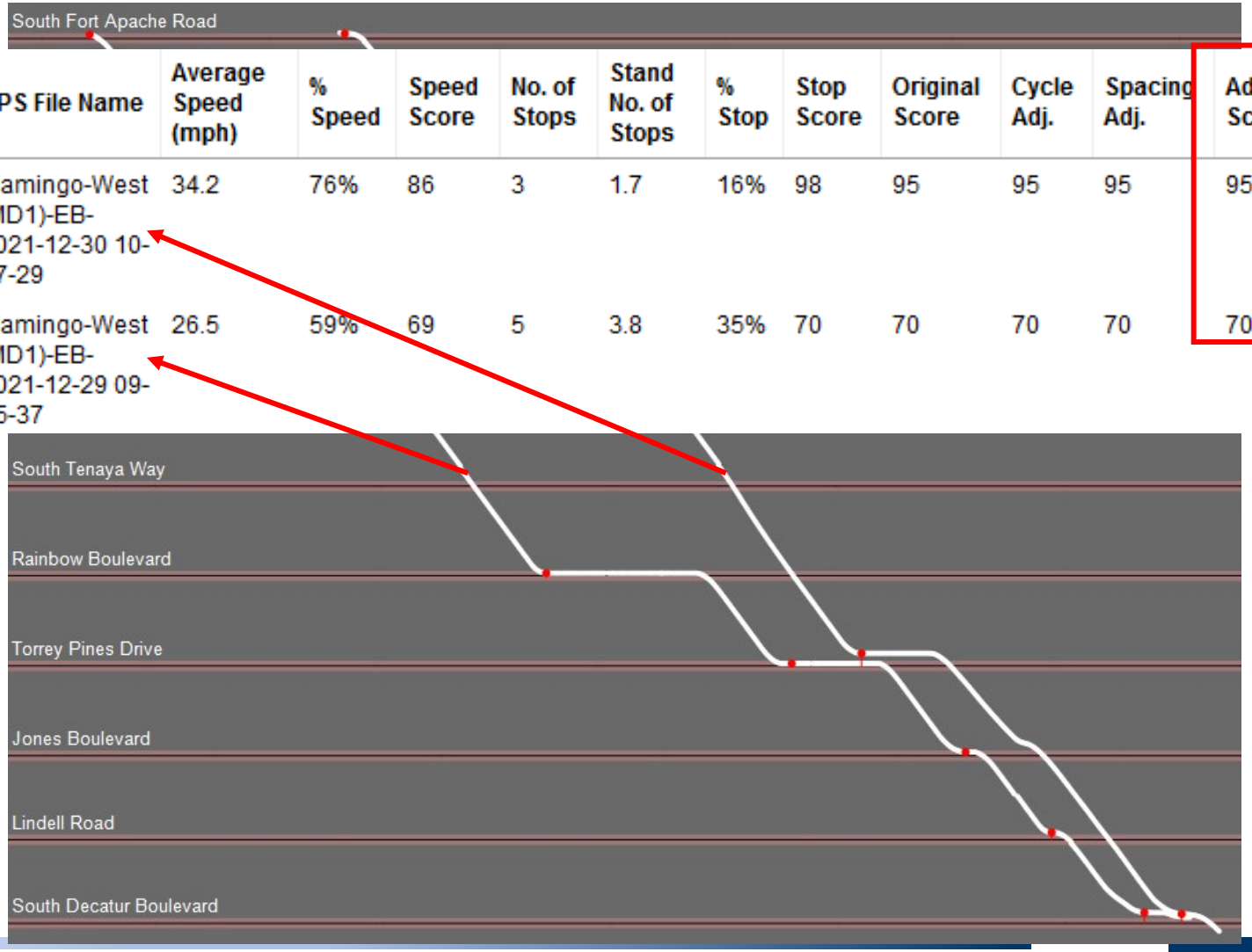
- **Link-based measure, not arterial-level performance**
- **No established criteria for corridor-level performance quality**
- **Unlikely to produce a timing recommendation**

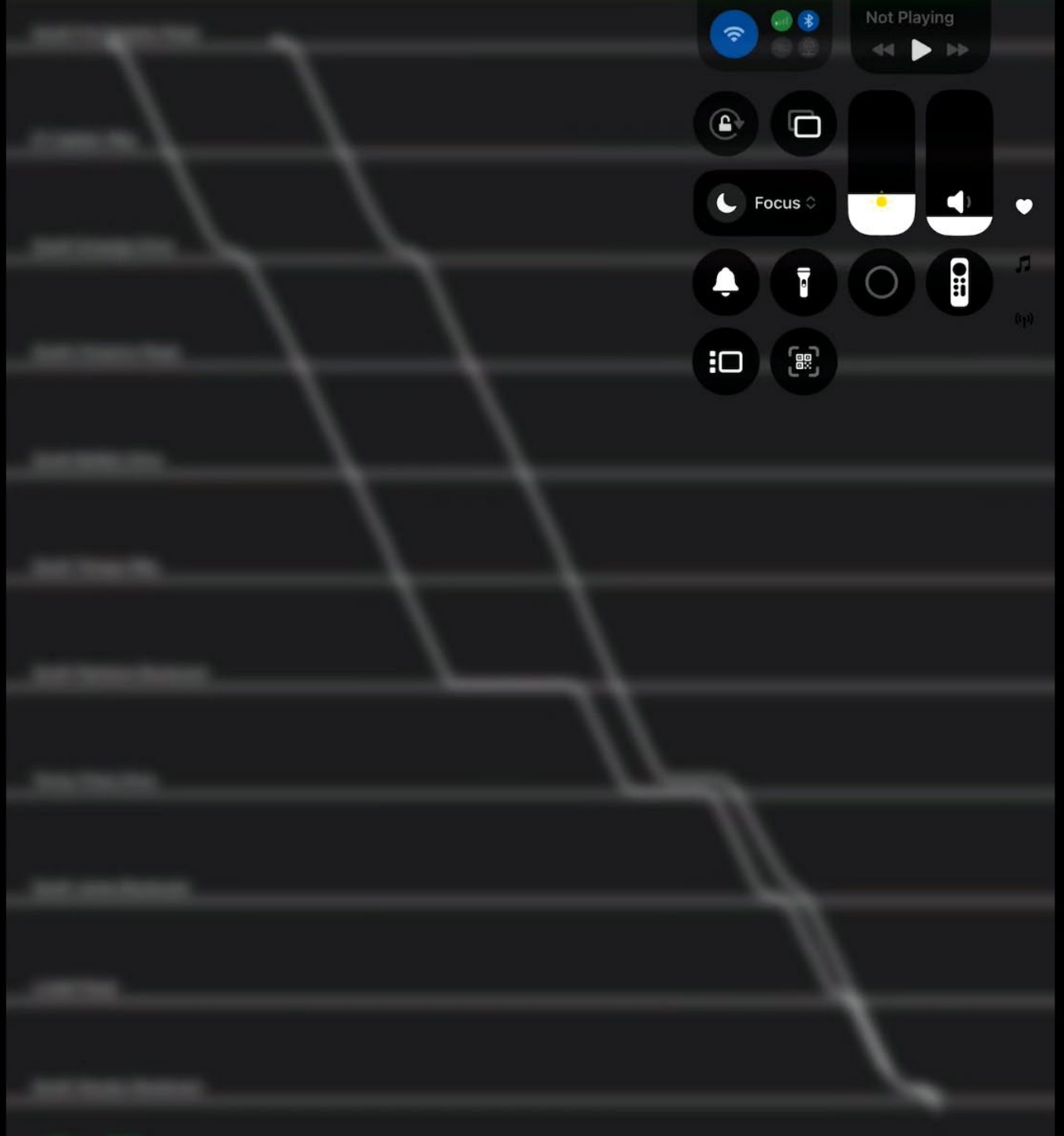
Trajectory-based Performance

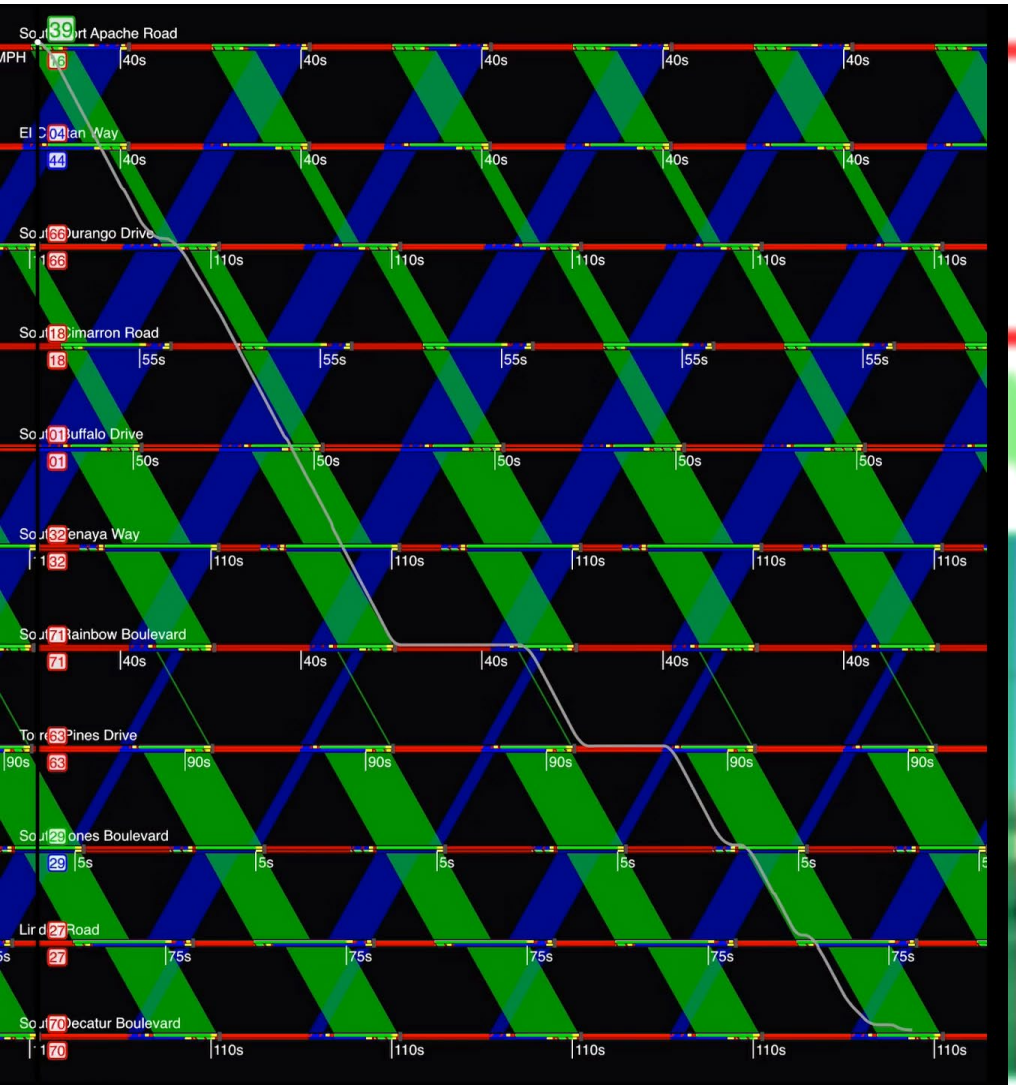
- **Manual floating-car travel runs are still the predominant method for before-after studies**
  - What is missing?
  - It does not tell if there is still room to improve.
  - Small sample size and data is not from independent source
- **Automated high-resolution vehicle trajectories from vehicle telematics**

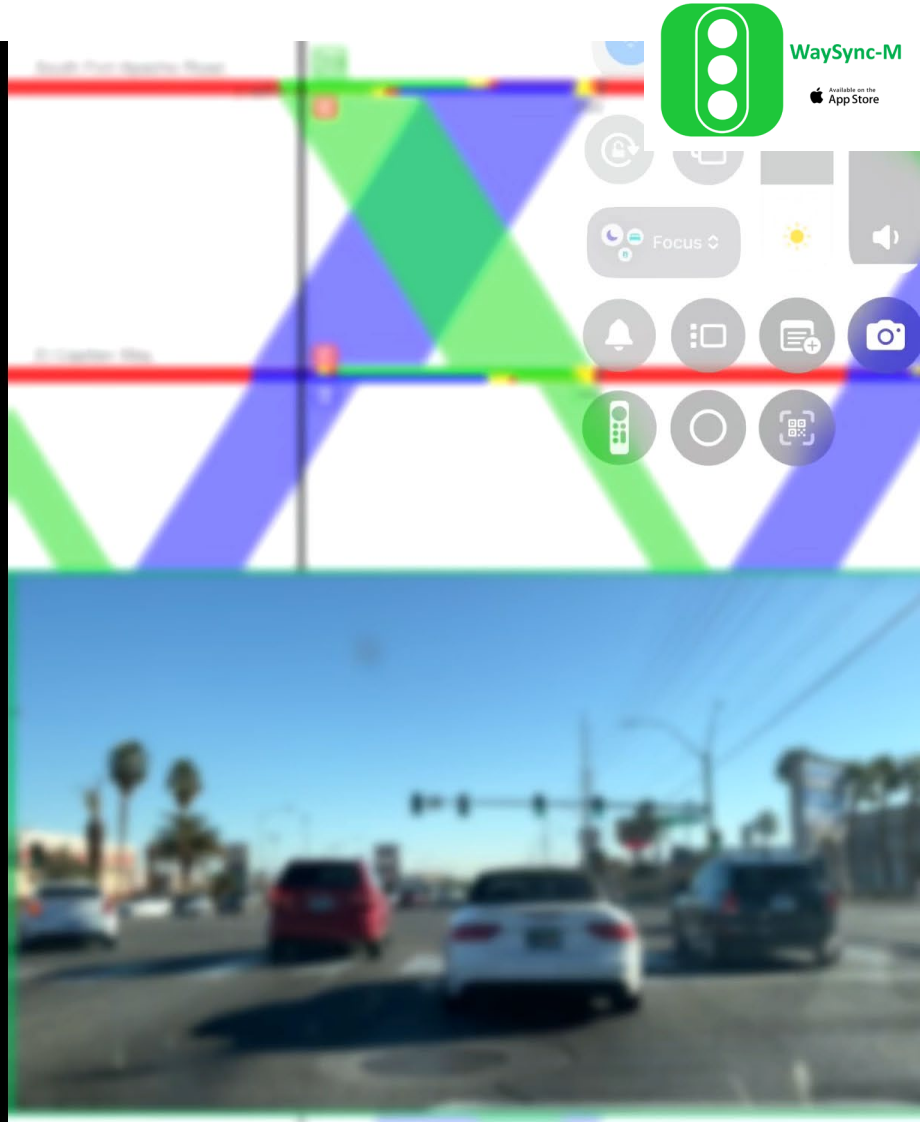
Trajectories and CSPI

Timing	GPS File Name	Average Speed (mph)	% Speed	Speed Score	No. of Stops	Stand No. of Stops	% Stop	Stop Score	Original Score	Cycle Adj.	Spacing Adj.	Adjusted Score	Quality of Signal Timing
MD1 (E)	Flamingo-West (MD1)-EB-2021-12-30 10-17-29	34.2	76%	86	3	1.7	16%	98	95	95	95	95	A
MD1 (E)	Flamingo-West (MD1)-EB-2021-12-29 09-35-37	26.5	59%	69	5	3.8	35%	70	70	70	70	70	C-

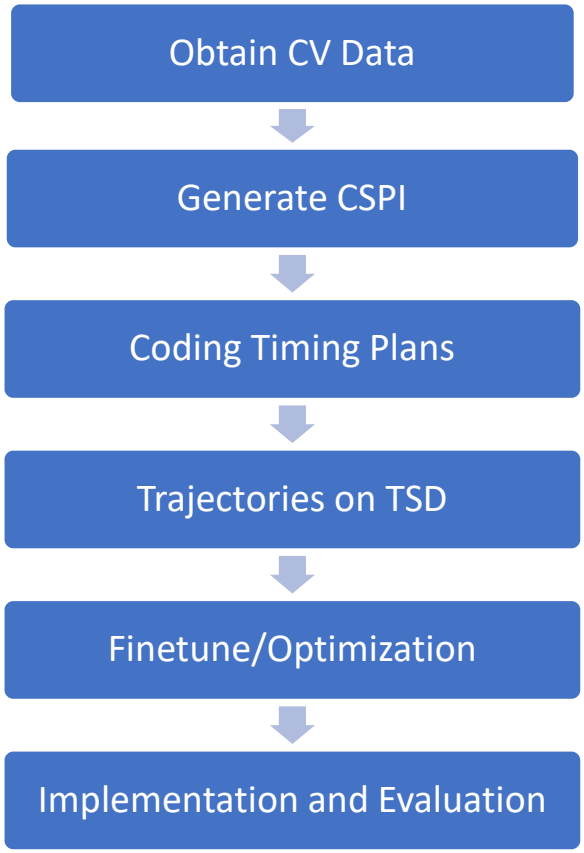



Not Playing
Focus


Apache Road
40s
Durango Drive
110s
Simarron Road
55s
Buffalo Drive
50s
Tenaya Way
110s
Rainbow Boulevard
40s
Pines Drive
90s
Jones Boulevard
5s
Road
75s
Decatur Boulevard
110s

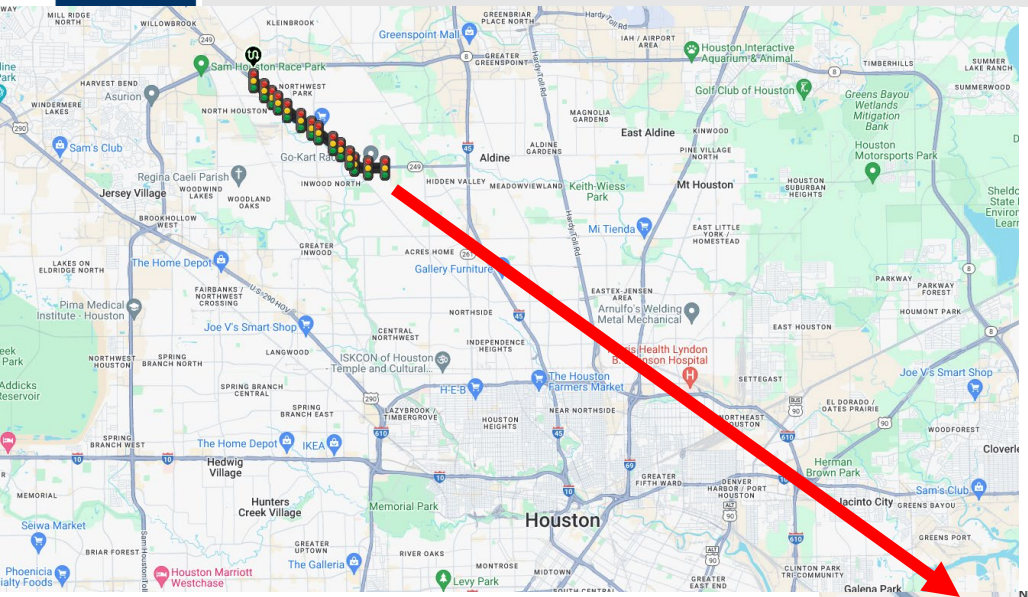

WaySync-M
Available on the App Store
Focus

The PM-Optimization Approach



CV - Connected Vehicle (telematics)
CSPI - Corridor Synchronization Performance Index
TSD - Time-space Diagram

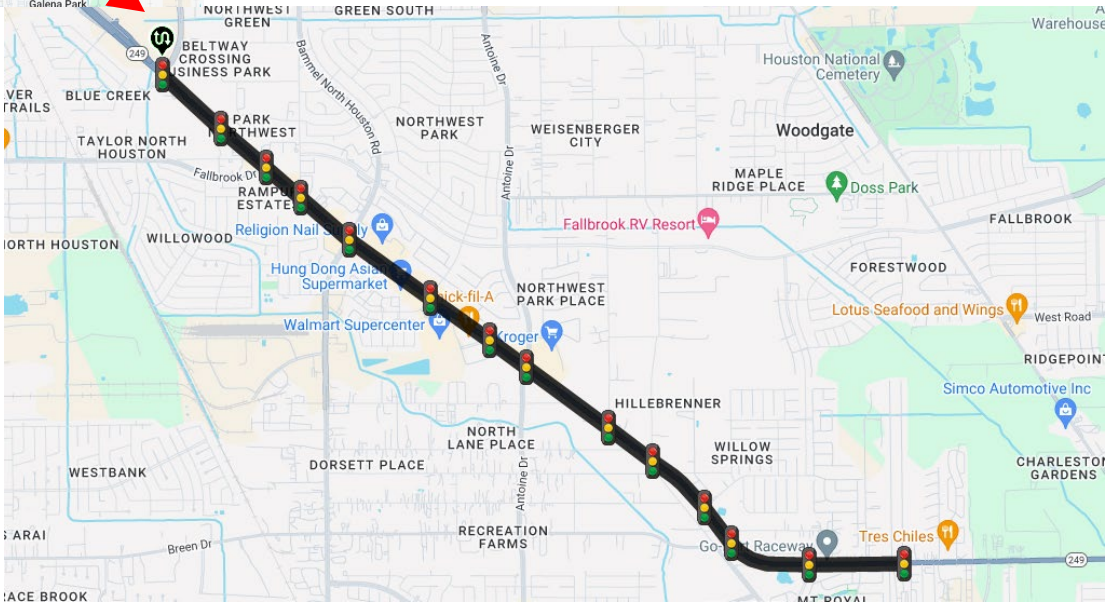
Case 2. SH 249, TxDOT Houston District



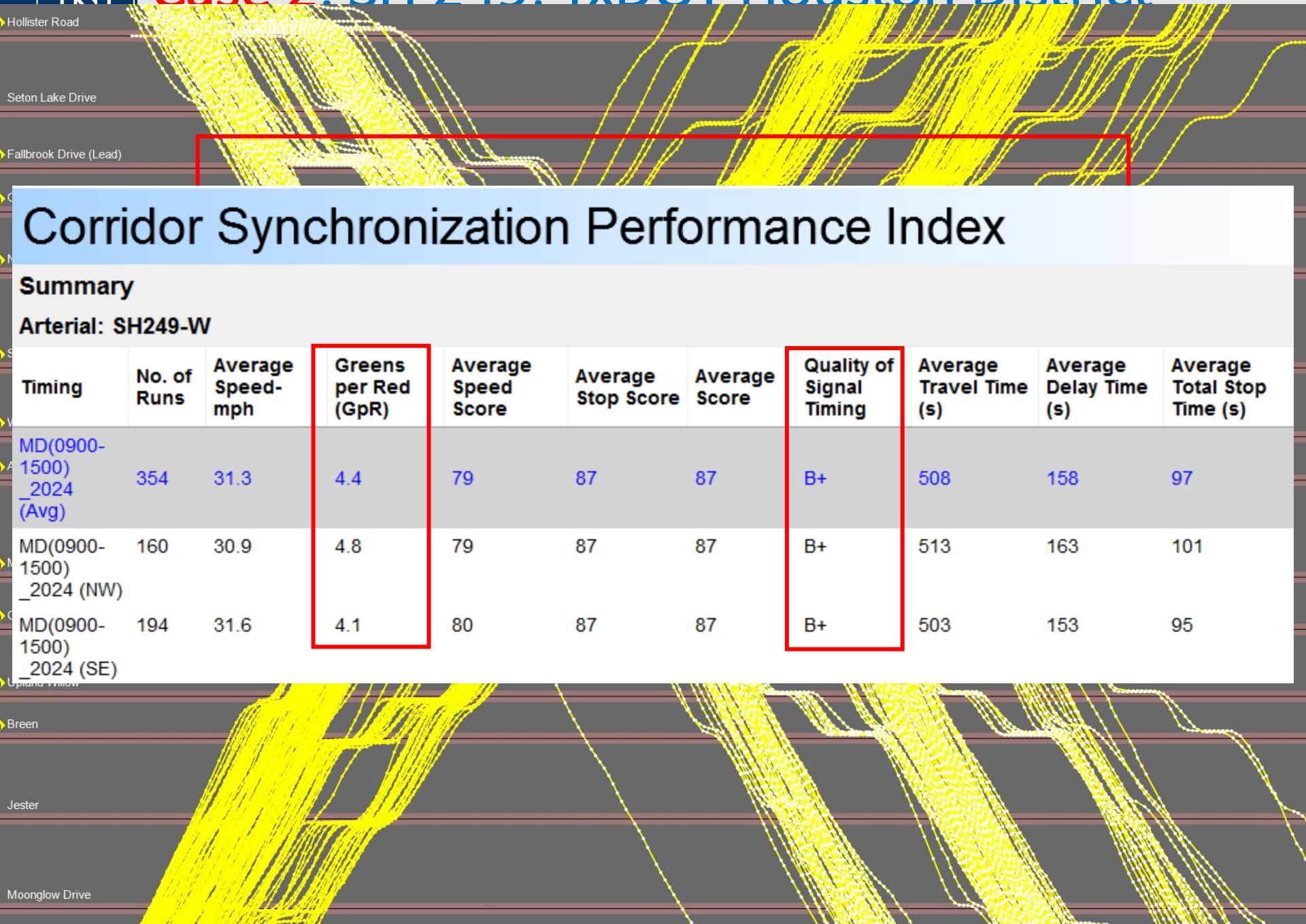
MD Peak

14 Signals

AADT=45,000



Case 2. SH 249. TxDOT Houston District



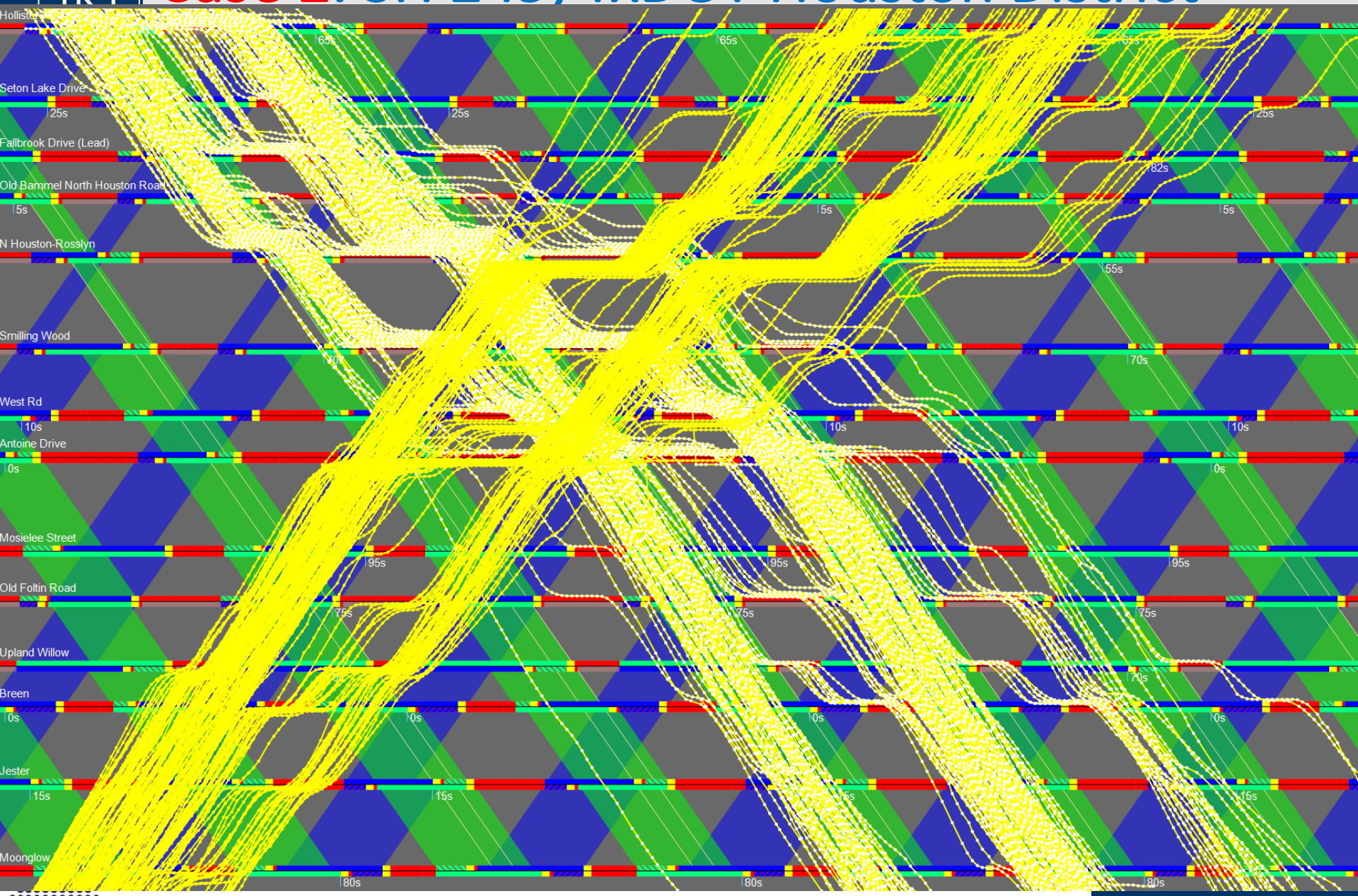
Corridor Synchronization Performance Index

Summary

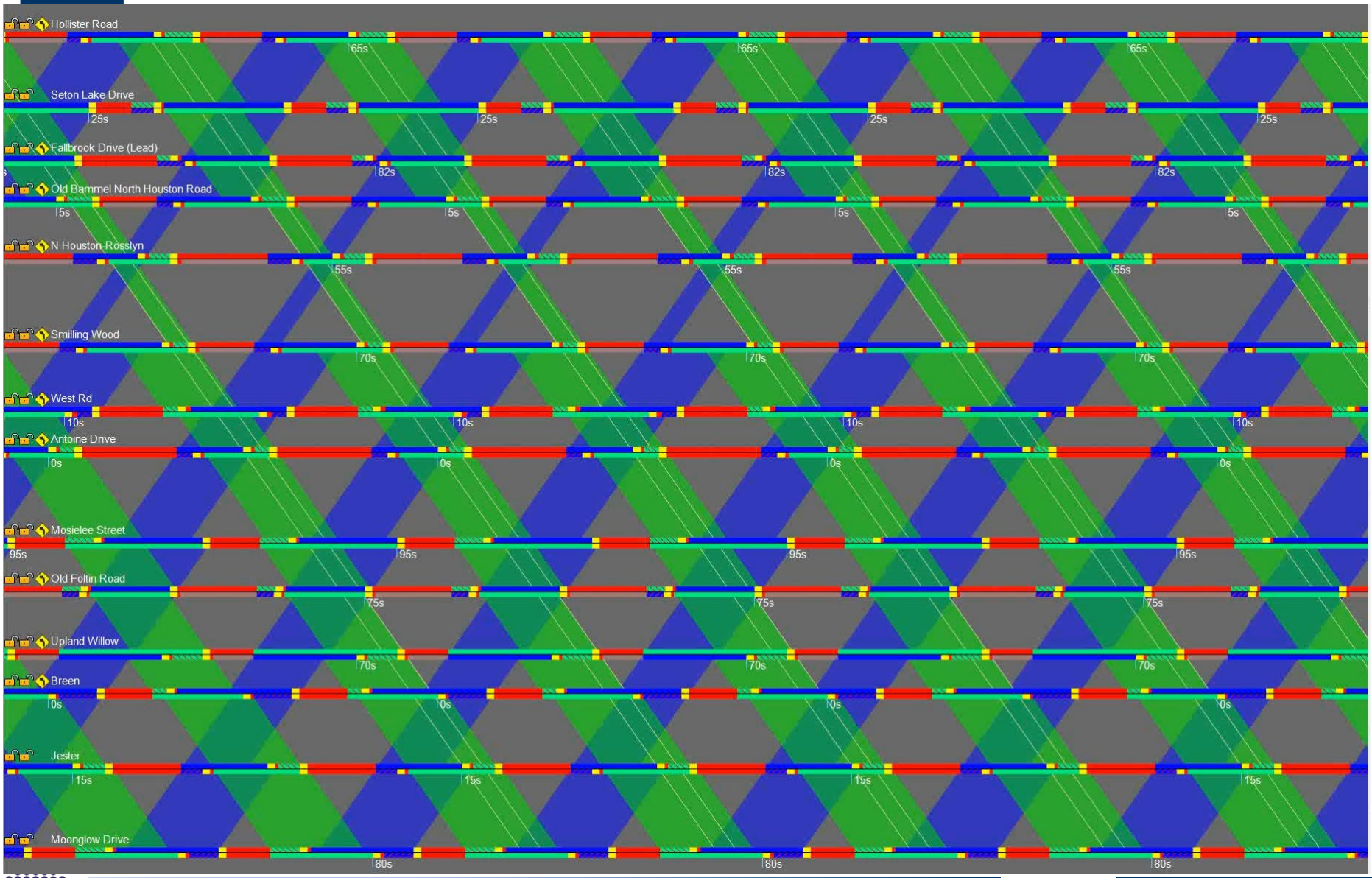
Arterial: SH249-W

Timing	No. of Runs	Average Speed-mph	Greens per Red (GpR)	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
MD(0900-1500)_2024 (Avg)	354	31.3	4.4	79	87	87	B+	508	158	97
MD(0900-1500)_2024 (NW)	160	30.9	4.8	79	87	87	B+	513	163	101
MD(0900-1500)_2024 (SE)	194	31.6	4.1	80	87	87	B+	503	153	95

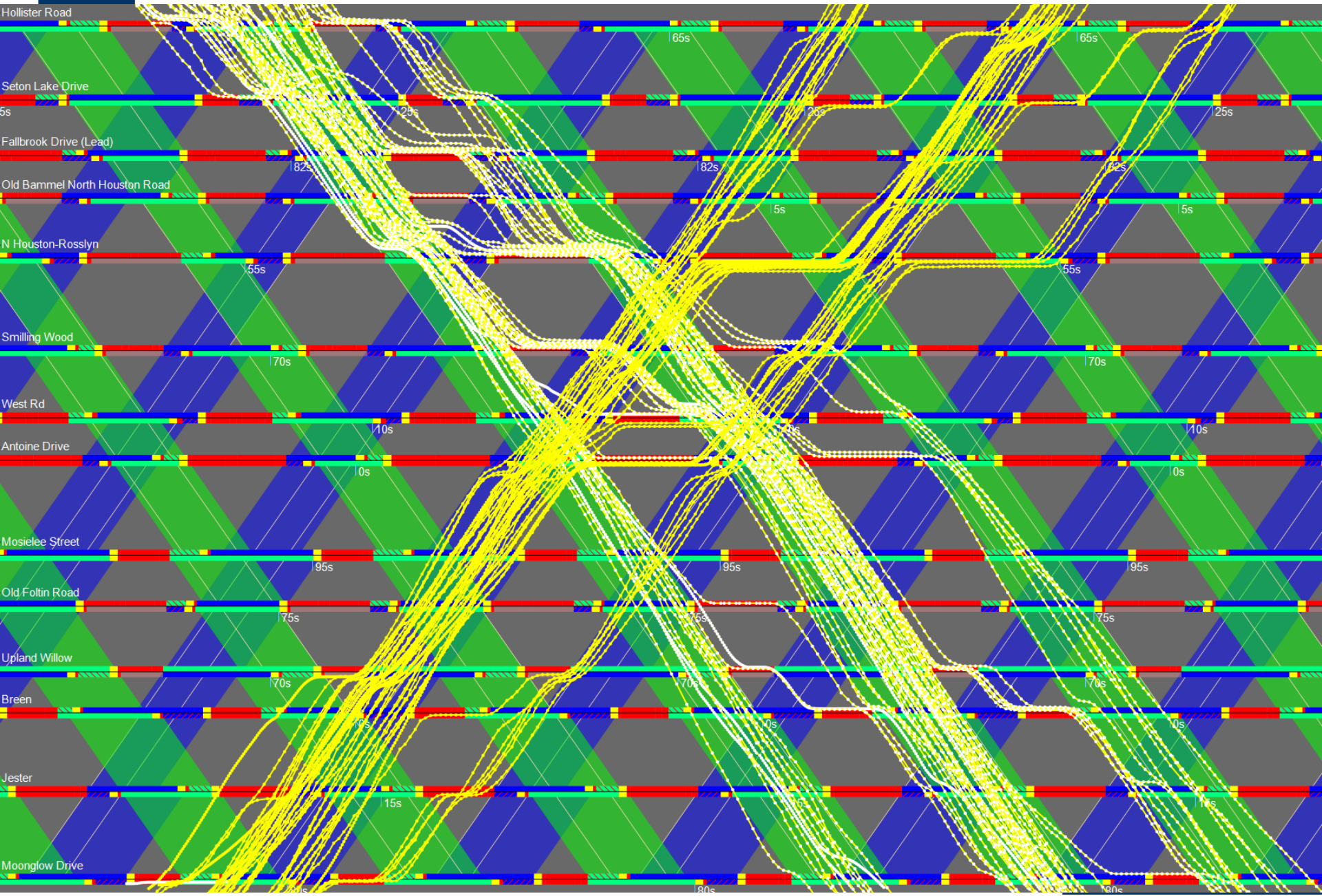
Case 2. SH 249, TxDOT Houston District



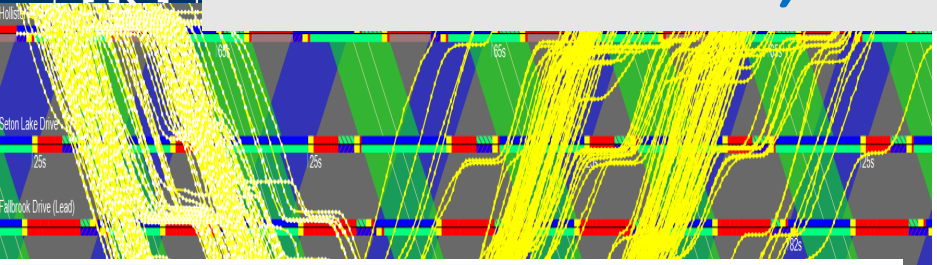
Case 2. SH 249, TxDOT Houston District



Case 2. SH 249, TxDOT Houston District



Case 2. SH 249, TxDOT Houston District

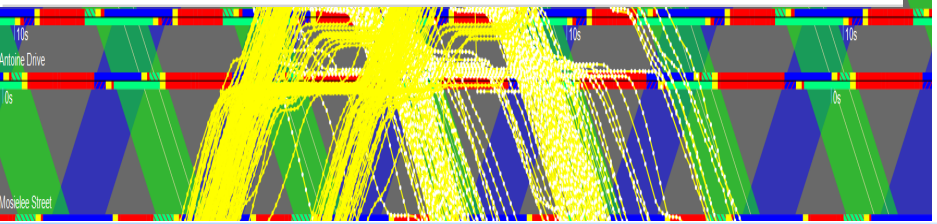


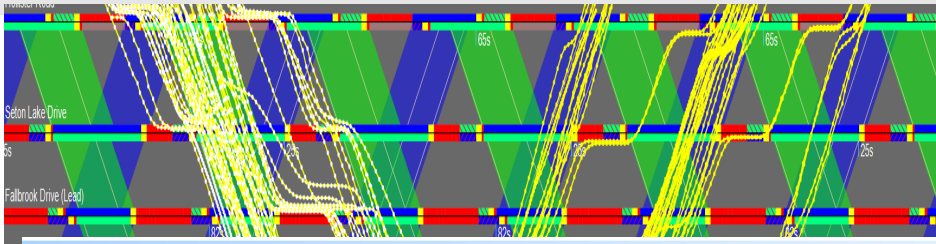
Corridor Synchronization Performance Index

Summary

Arterial: SH249-W

Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing
MD(0900-1500)_2024 (Avg)	354	31.3	79	87	87	B+
MD(0900-1500)_2024 (NW)	160	30.9	79	87	87	B+
MD(0900-1500)_2024 (SE)	194	31.6	80	87	87	B+



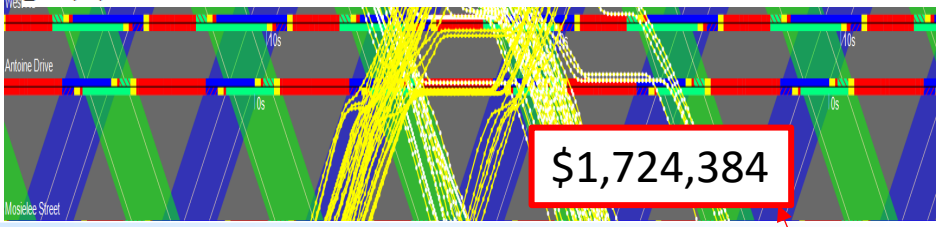


Corridor Synchronization Performance Index

Summary

Arterial: SH249-W

Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing
MD(0900-1500)_new (Avg)	96	35.8	88	96	95	A
MD(0900-1500)_new (NW)	39	36.8	90	97	97	A
MD(0900-1500)_new (SE)	57	35.1	86	95	94	A



$1,724,384

Corridor Before After Benefit Report

Summary of Annual Benefits

Subsystem Name	Travel Time Savings	Fuel Consumption Savings	ROG Emission Reduction	NOx Emission Reduction	PM10 Emission Reduction	CO Emission Reduction	CO2 Emission Reduction	Vehicle Maintenance Savings	Total Benefits
SH249-W	$1,128,472	$361,047	$690	$3,289	$13,285	$492	$28,263	$188,847	$1,724,384

Benefit by Direction

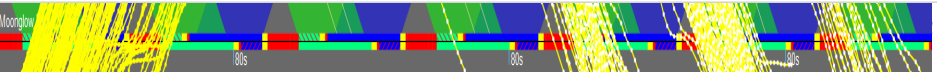
Before Timing Plan Name	After Timing Plan Name	Direction	Annual Affected VMT	Annual Travel Time Savings (hrs)	Annual Fuel Consumption Savings (gal)	Annual CO2 Emission Reduction (lbs)	Annual ROG Emission Reduction (lbs)	Annual NOx Emission Reduction (lbs)	Annual PM10 Emission Reduction (lbs)	Annual CO Emission Reduction (lbs)	Annual Benefit
MD(0900-1500)_2024	MD(0900-1500)_new	Southeast	10940814	31944 / $415,278	45951 / $137,854	938376 / $10,791	482 / $230	241 / $1,644	0 / $0	5784 / $174	$642,667
MD(0900-1500)_2024	MD(0900-1500)_new	Northwest	10940814	54861 / $713,194	74398 / $223,193	1519276 / $17,472	964 / $460	241 / $1,644	241 / $13,285	10603 / $318	$1,081,718

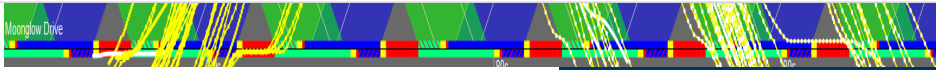
Calculation Parameters

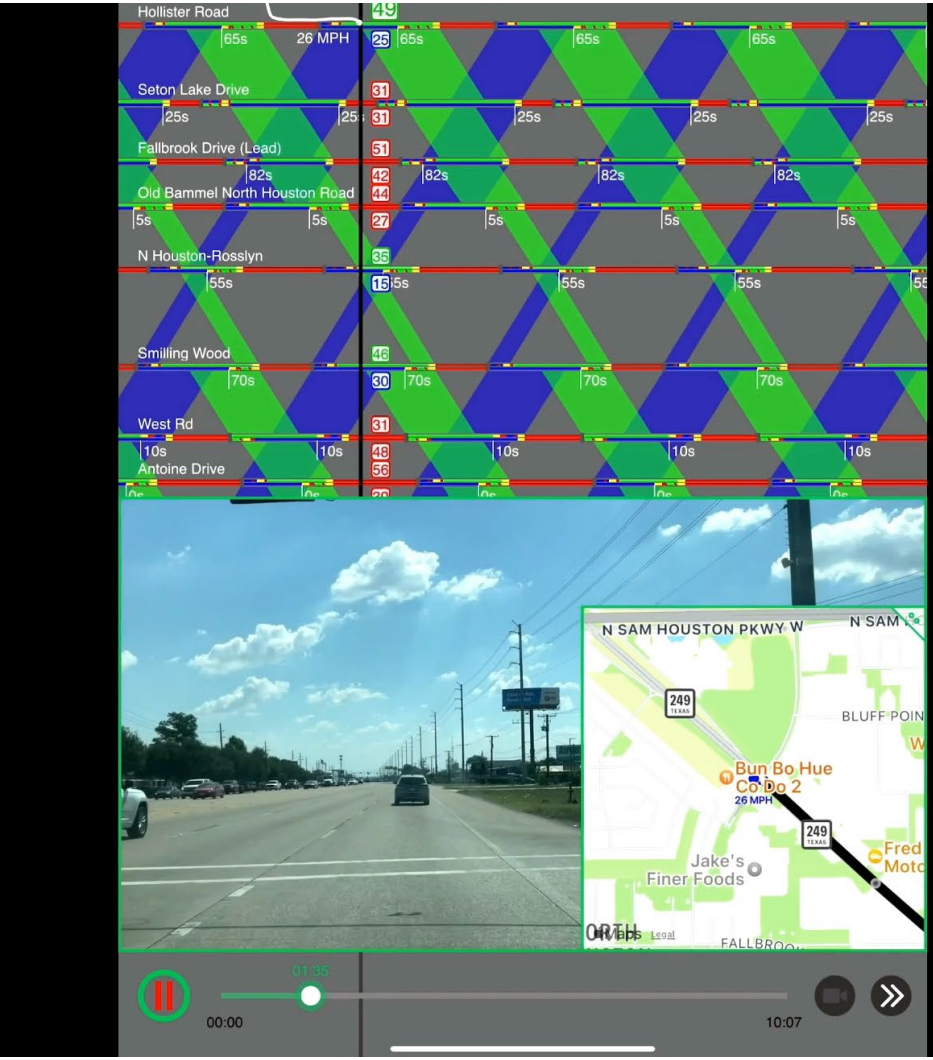
Before Timing Plan Name (No. of Runs)	After Timing Plan Name (No. of Runs)	Distance (feet)	Direction	Peak Hr VMT	Travel Time Before (s)	Travel Time After (s)	Speed Before (mph)	Speed After (mph)	Stop Before	Stop After
MD(0900-1500)_2024 (194)	MD(0900-1500)_new (57)	23107	Southeast	43763	504	458	32	35	3.1	2.1
MD(0900-1500)_2024 (160)	MD(0900-1500)_new (39)	23107	Northwest	43763	514	435	31	37	2.9	1.4

Assumptions

Time Value ($/hr)	Fuel Cost ($/gallon)	Operating Days	Maintenance Cost ($/stop)	CO Emission Cost ($/ton)	CO2 Emission Cost ($/ton)	NOX Emission Cost ($/ton)	PM10 EX Emission Cost ($/ton)	ROG Emission Cost ($/ton)
$13	$3	250	$0.03	$60.00	$23.00	$13,646.00	$110,258.00	$954.00

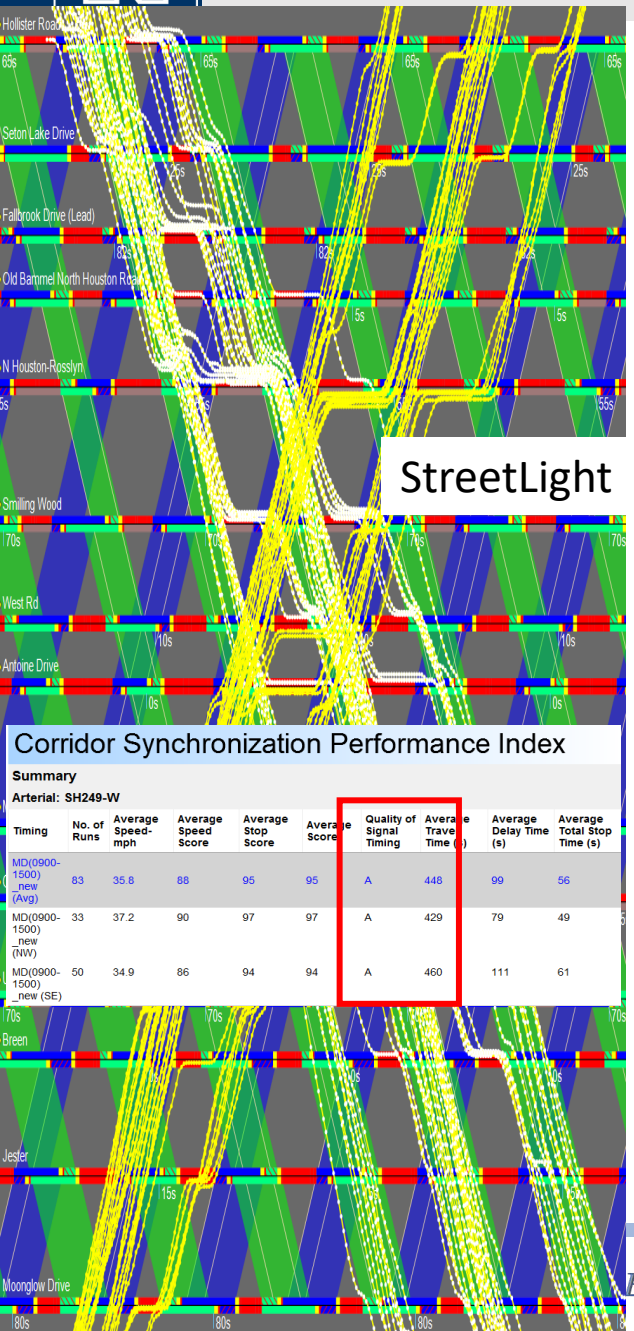





Hollister Road
65s
26 MPH
Seton Lake Drive
25s
Fallbrook Drive (Lead)
82s
Old Bammel North Houston Road
5s
N Houston-Rosslyn
55s
Smilling Wood
70s
West Rd
10s
Antoine Drive
N SAM HOUSTON PKWY W
249
Bun Bo Hue
Co Do 2
26 MPH
Jake's
Finer Foods
01:35
00:00
10:07


Hollister Road
65s
24 MPH
Seton Lake Drive
25s
Fallbrook Drive (Lead)
82s
Old Bammel North Houston Road
5s
N Houston-Rosslyn
55s
Smilling Wood
70s
West Rd
10s
Antoine Drive
N SAM HOUSTON PKWY W
GALENA CREEK DR
249
Bun Bo Hue
Co Do 2
Jake's
Finer Foods
00:44
00:00
07:28

Data Source Comparison: SH 249, TxDOT



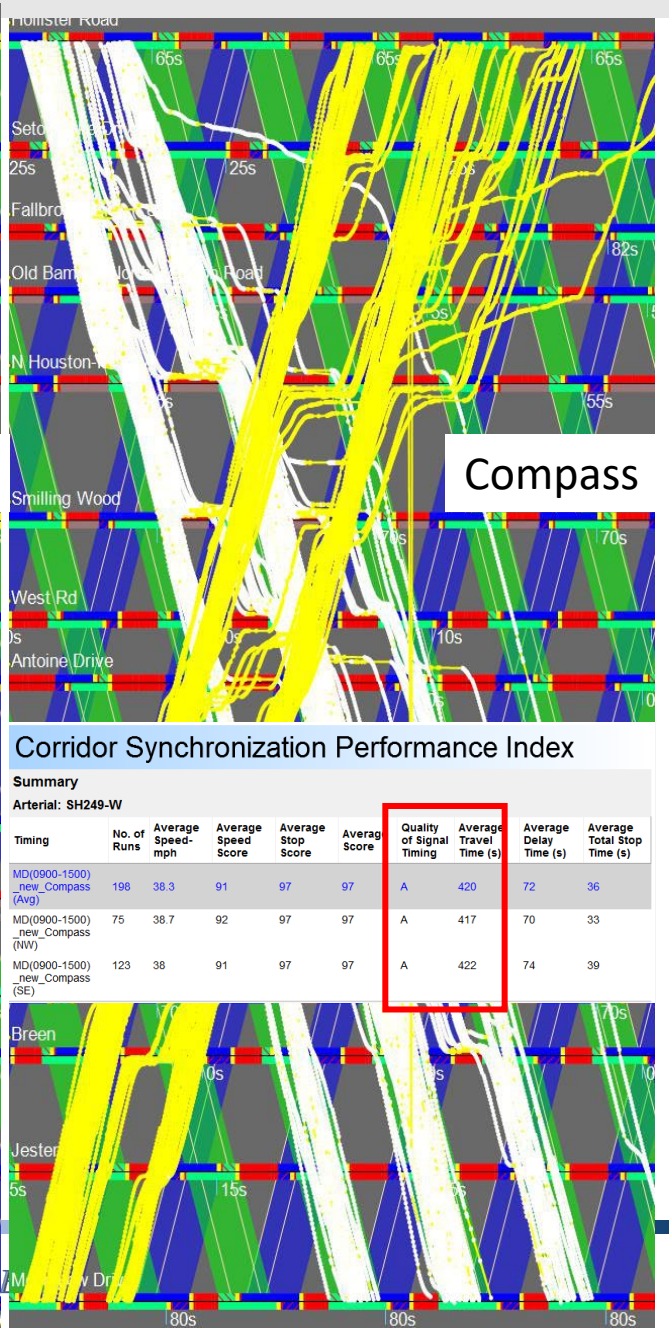
StreetLight

Corridor Synchronization Performance Index

Summary

Arterial: SH249-W

Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
MD(0900-1500)_new (Avg)	83	35.8	88	95	95	A	448	99	56
MD(0900-1500)_new (NW)	33	37.2	90	97	97	A	429	79	49
MD(0900-1500)_new (SE)	50	34.9	86	94	94	A	460	111	61



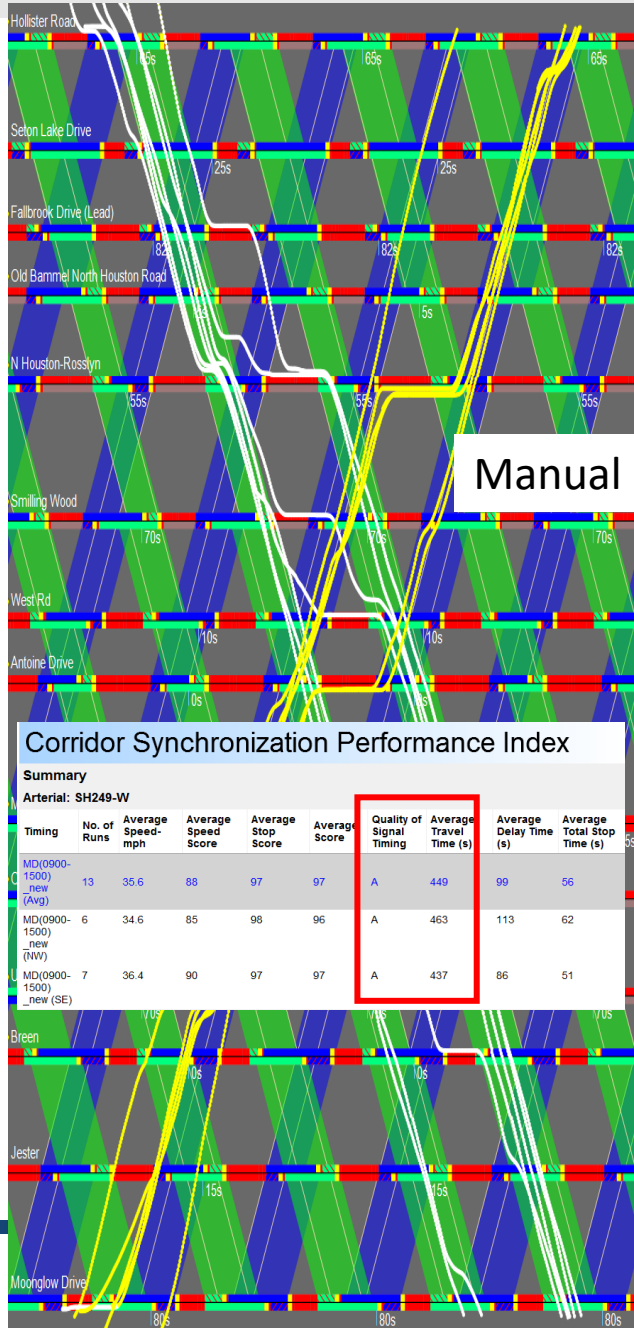
Compass

Corridor Synchronization Performance Index

Summary

Arterial: SH249-W

Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
MD(0900-1500)_new_Compass (Avg)	198	38.3	91	97	97	A	420	72	36
MD(0900-1500)_new_Compass (NW)	75	38.7	92	97	97	A	417	70	33
MD(0900-1500)_new_Compass (SE)	123	38	91	97	97	A	422	74	39



Manual

Corridor Synchronization Performance Index

Summary

Arterial: SH249-W

Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
MD(0900-1500)_new (Avg)	13	35.6	88	97	97	A	449	99	56
MD(0900-1500)_new (NW)	6	34.6	85	98	96	A	463	113	62
MD(0900-1500)_new (SE)	7	36.4	90	97	97	A	437	86	51

Questions?