



What Performance Measures are Needed for Signal Coordination Timing

Zong Tian, PhD, PE
zongt@unr.edu

March 27, 2024



Questions

- Is ATSPM (%AoG) sufficient for evaluating arterial signal coordination timing?
- What is missing in our current practice on conducting before-after signal timing evaluations?
- What is the purpose of signal performance measures (**Can they replace current signal timing process**)?



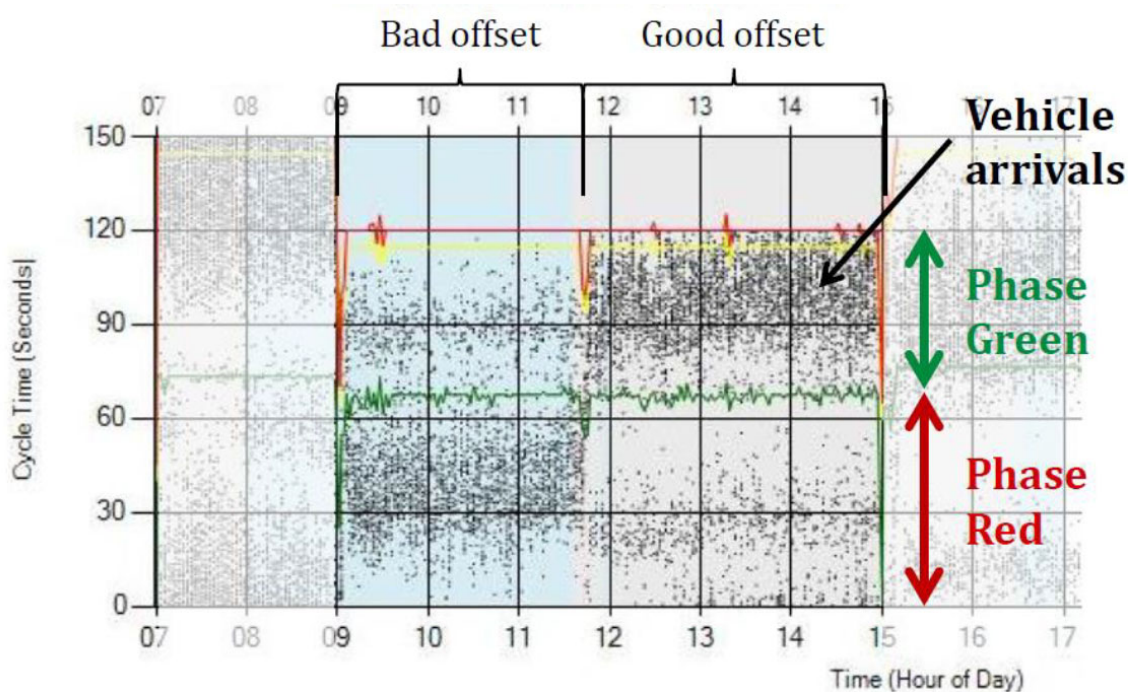
Outline

- **Two Types of ATSPM**
 - Detector/phase Events (FHWA/Purdue)
 - Automated Vehicle Trajectories
- **Trajectory-based Corridor Performance Measures**
 - Floating-car-based measures
 - Corridor Synchronization Performance Index or Quality of Signal Timing Index
 - Orange County and UNR Methods
- **Automated Vehicle Trajectories from CV Data Sources**



Detector/Phase Based ATSPM

- %AoR or %AoG
- Purdue Coordination Diagram



Limitations:

- Link-based measure, not arterial-level performance
- No established criteria for performance quality

Trajectory-based Performance

- **Conventional floating-car travel runs for before-after studies**
 - **What is missing?** Quality level, reflection of the timing, side street
- **Orange County's Corridor Synchronization Performance Index (CSPI)**
 - **A composite score based on average speed, greens per red, and stops per mile**
- **UNR enhanced CSPI or QOS**



What is the Purpose of ATSPM?

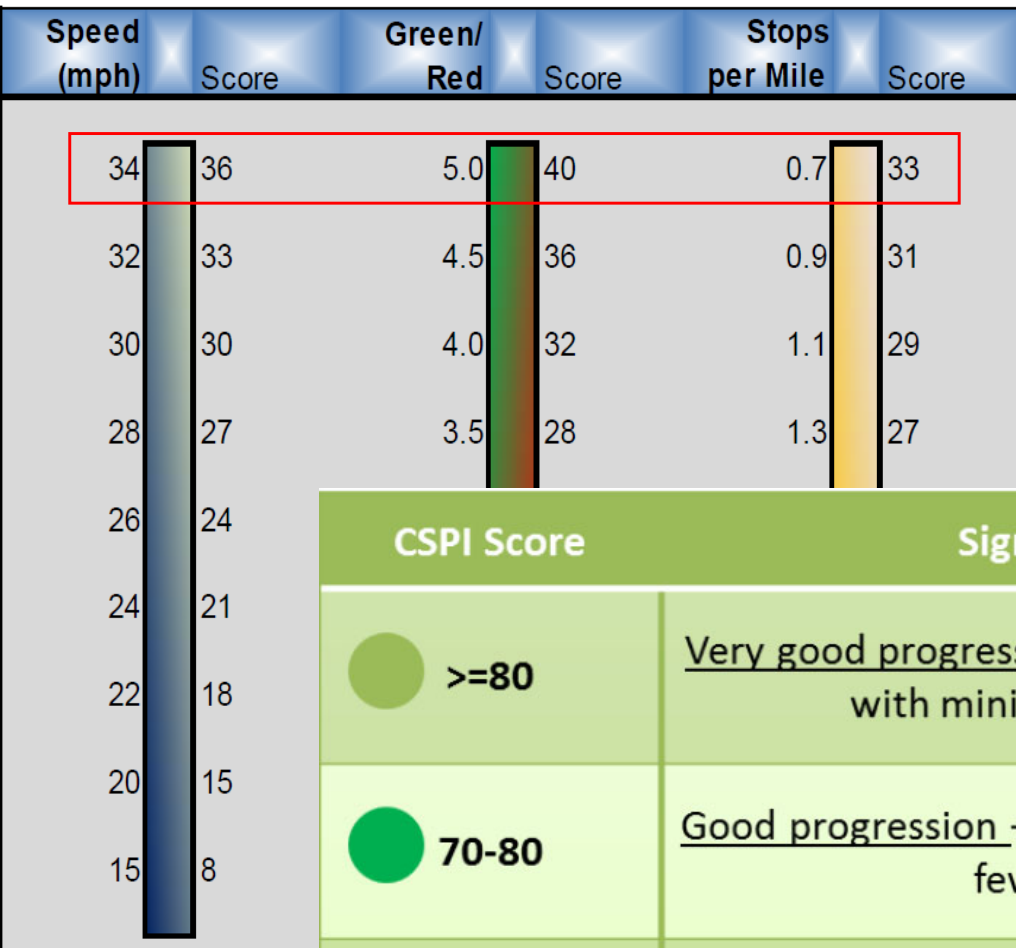
- A. Identify corridors where signal retiming would reduce drivers' complaints**

- B. Identify corridors where signal retiming would get the best bang for your buck (Quality of Signal Timing)**

- C. Automate the signal timing process like adaptive signal systems**



Orange County's CSPI



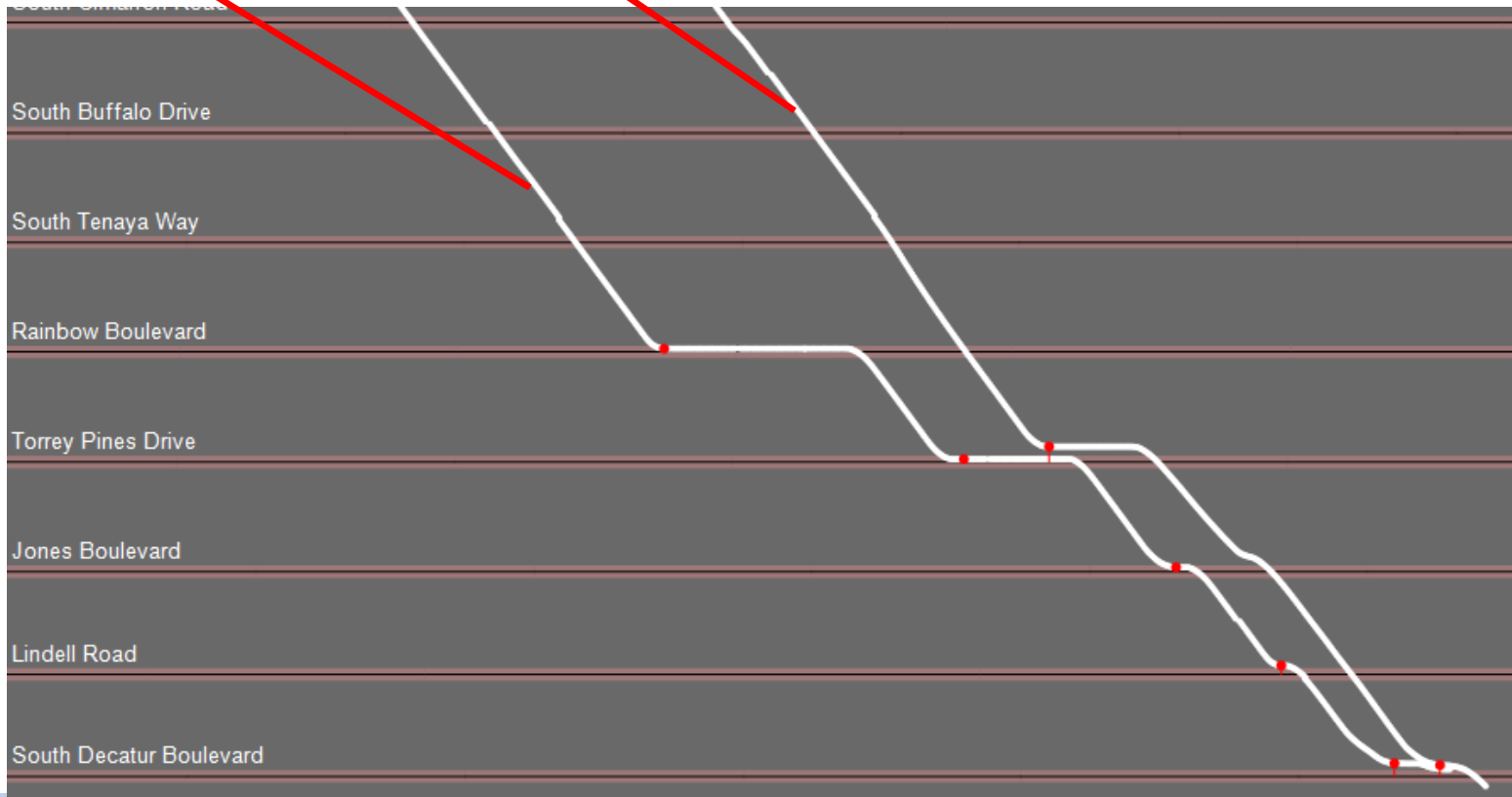
- Highest possible score = 109
- No information on speed limit or free-flow speed
- No differentiation between short stop and long stop
- Ignore the impact on side street

CSPI Score	Signal Synchronization Description	Level
>=80	<u>Very good progression</u> – traveling through signalized intersections with minimal stops and favorable travel speeds.	Tier 1
70-80	<u>Good progression</u> – traveling through signalized intersections with few stops and good travel speeds.	Tier 2
60-70	<u>Fair progression</u> – traveling through signalized intersections with moderate stops and fair travel speeds.	Tier 3
50-60	<u>Limited progression*</u> – traveling through signalized intersections with moderately high stops and slower travel speeds.	Tier 4

Orange County's CSPI

South Fort Apache Road

Timing	GPS File Name	Average Speed (mph)	Greens per Red	Stop per Mile	Speed Score	GpR Score	SpM Score	Total Score
MD1	Flamingo-West(MD1)-EB-2021-12-30 10-17-29	34.2	2.7	0.6	36	21	34	92
MD1	Flamingo-West(MD1)-EB-2021-12-29 09-35-37	26.5	1.2	1	25	10	30	65



UNR's CSPI or QOS

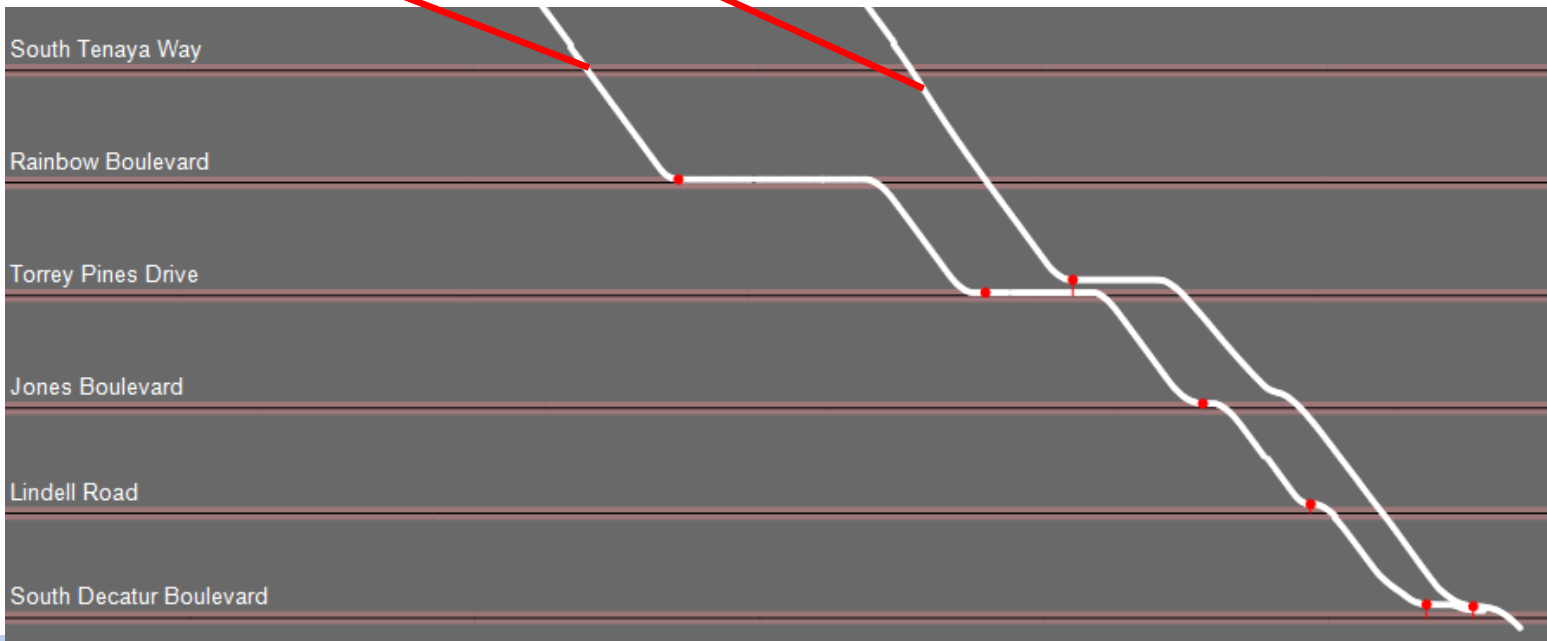
- Incorporate the following: **speed** limit (or free-flow speed), **cycle length**, and **stop duration**
- Different treatment on signal spacing
 - Quality of signal timing vs. driver's perception
- Score is on a 100 scale with corresponding letter grades (A, B, C, D, F)



UNR's Enhanced CSPI

South Fort Apache Road

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-



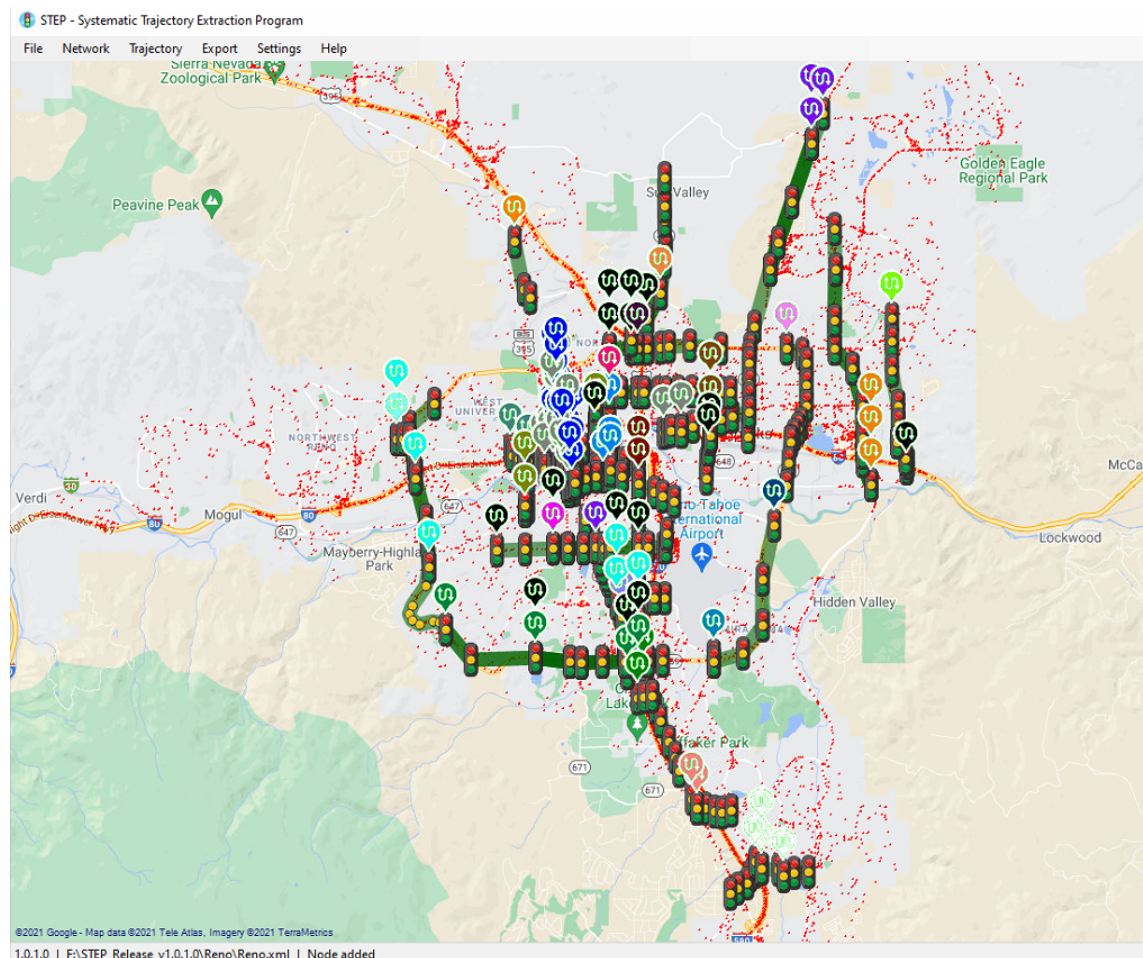
OCTA

Total Score
92
65



Automated Trajectory Data Sources

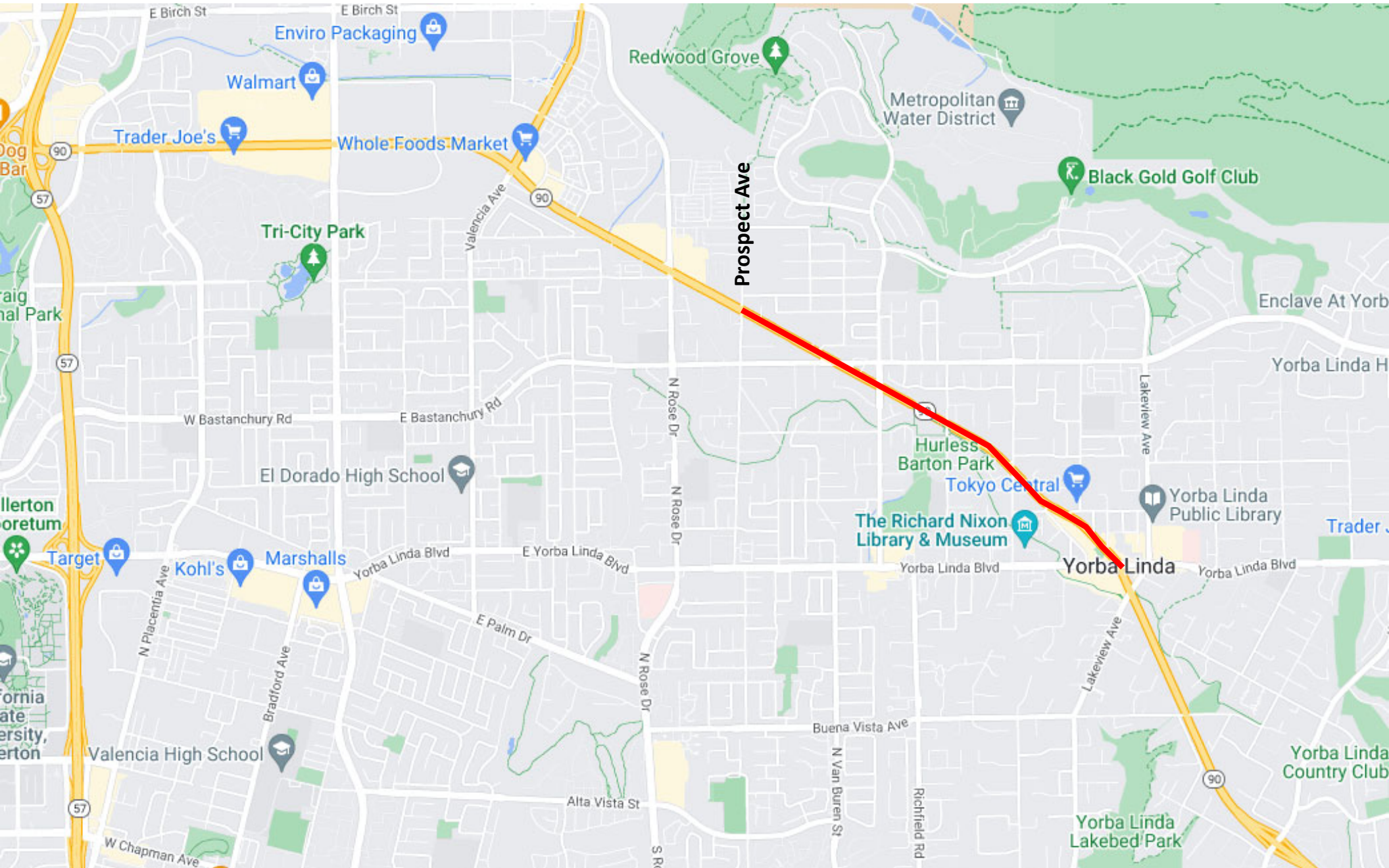
- Vehicle Telematics or Connected vehicles
- **S**ystematic **T**rajectory **E**xtraction **P**rogram (STEP)





Case Demo

– Imperial Highway, Yorba Linda

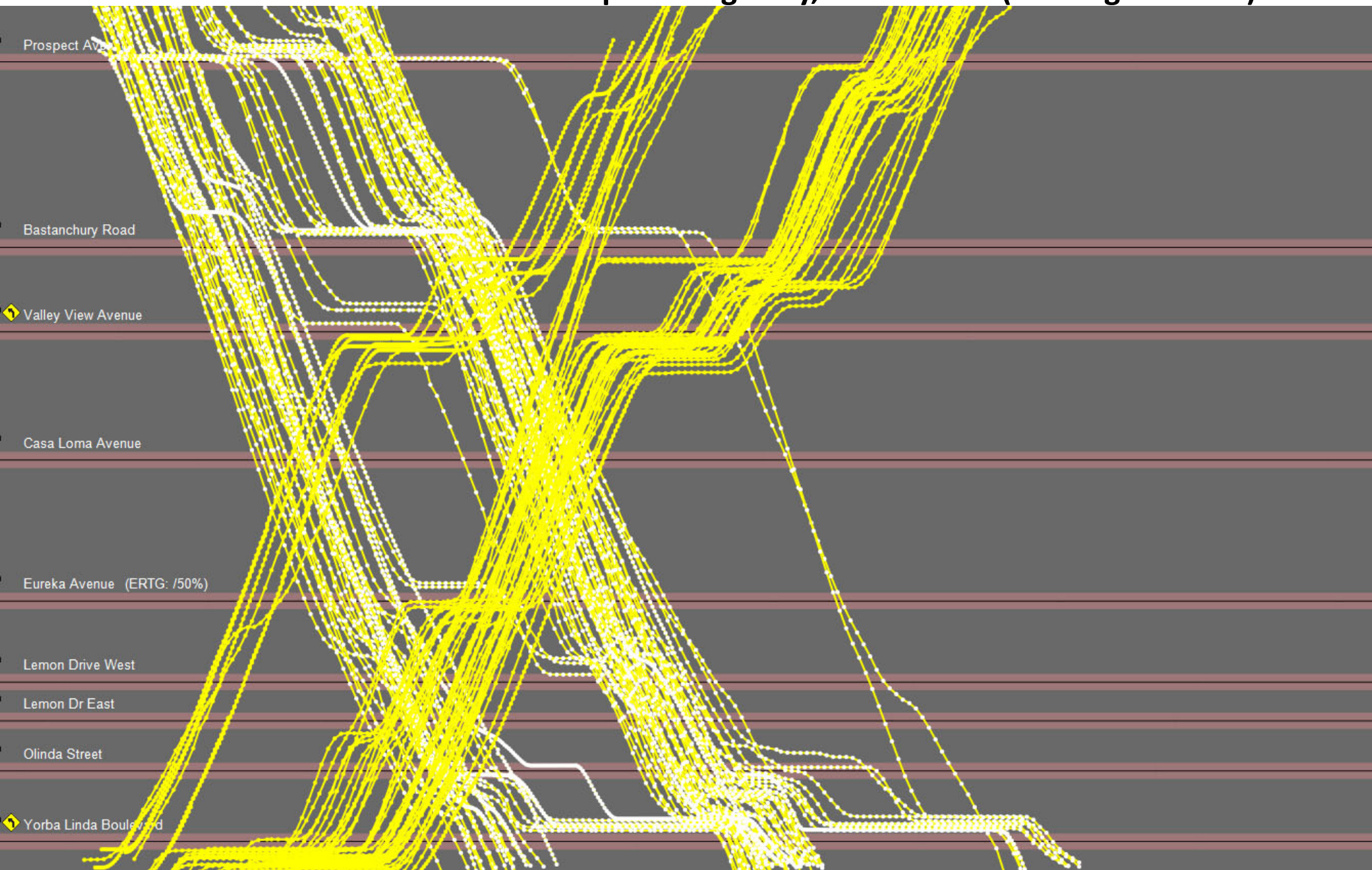




University of Nevada, Reno

Case Demo

– Imperial Highway, Yorba Linda (Existing PM Plan)



Case Demo

– Imperial Highway, Yorba Linda (Existing PM Plan)

Corridor Synchronization Performance Index

Summary

Arterial: Imperial Hwy

OCTA

Timing	No. of Runs	Average Speed (mph)	Greens per Red (GpR)	Stops per Mile (SpM)	Speed Score	GpR score	SpM score	Total Score	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
PM (Avg)	127	29.3	4.9	1	29	40	30	99	218	95	42
PM (NW)	47	28	4	1.1	27	32	29	88	226	103	49
PM (SE)	80	30.1	5.5	0.9	30	40	31	101	213	91	38

Corridor Synchronization Performance Index

Summary

Arterial: Imperial Hwy

UNR

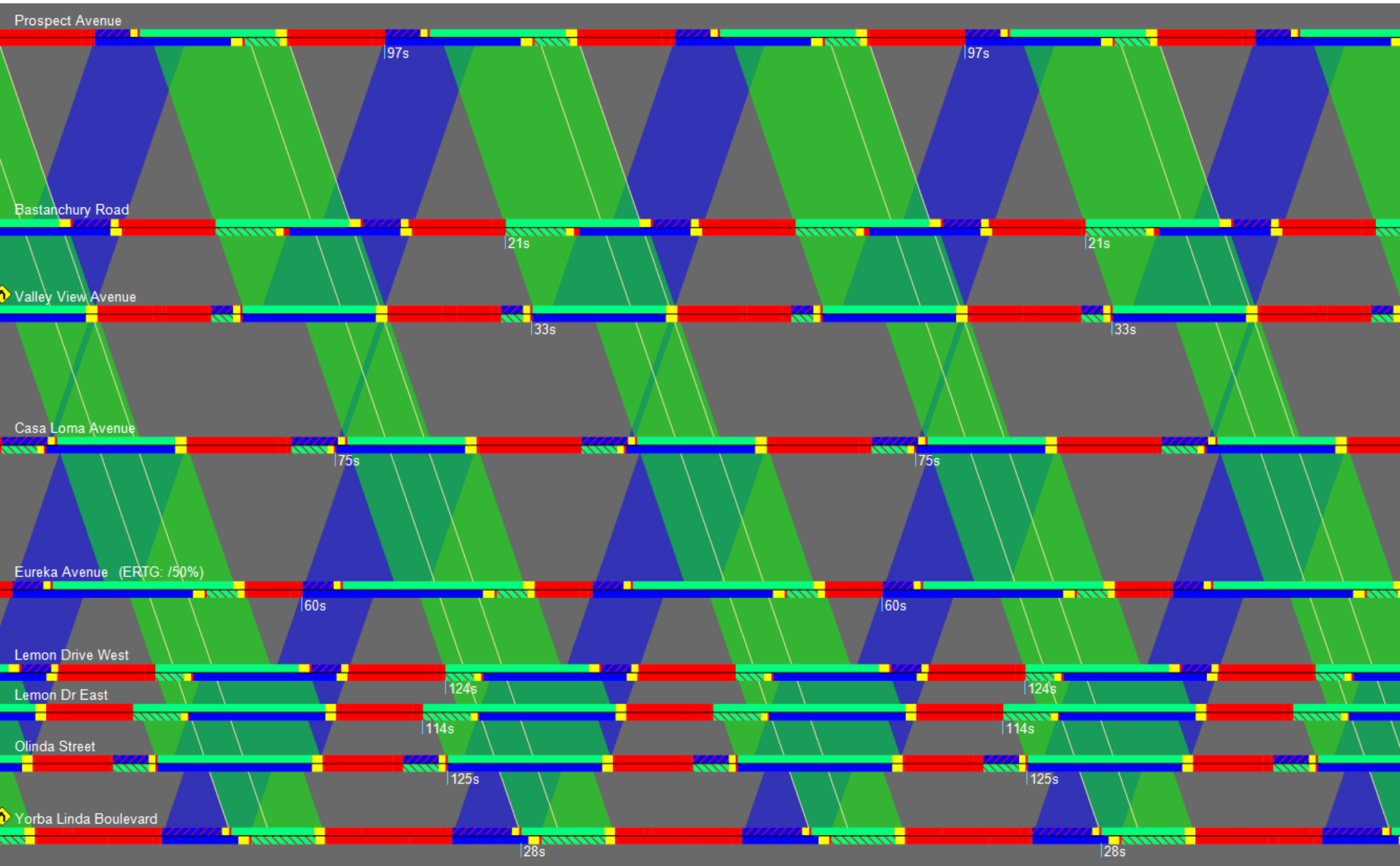
Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
PM (Avg)	127	29.3	69	93	87	B+	218	95	42
PM (NW)	47	28	66	92	85	B	226	103	49
PM (SE)	80	30.1	70	94	88	B+	213	91	38





Case Demo

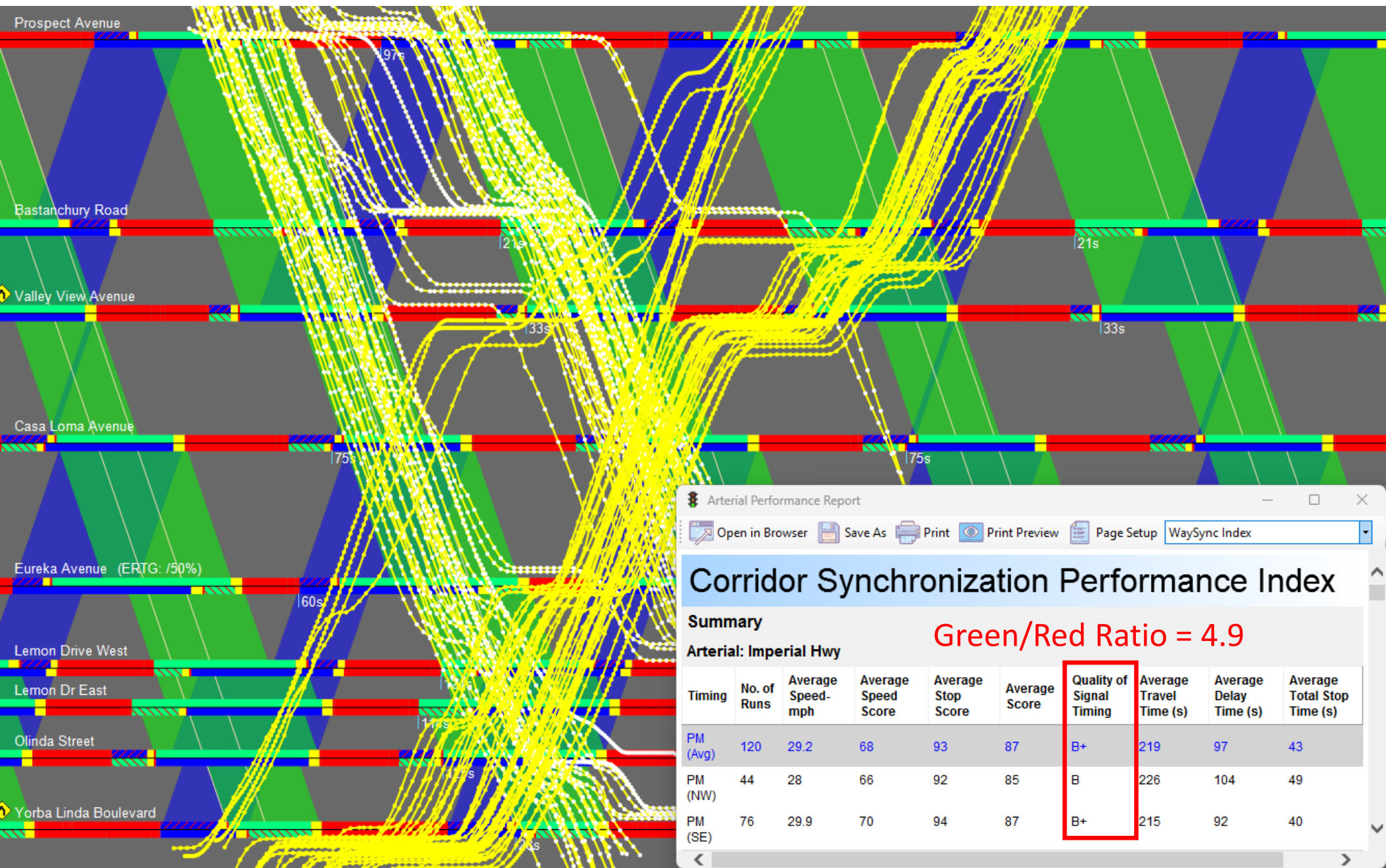
– Imperial Highway, Yorba Linda (Existing PM Plan)





Case Demo

– Imperial Highway, Yorba Linda (Existing PM Plan)



Arterial Performance Report

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Corridor Synchronization Performance Index

Summary

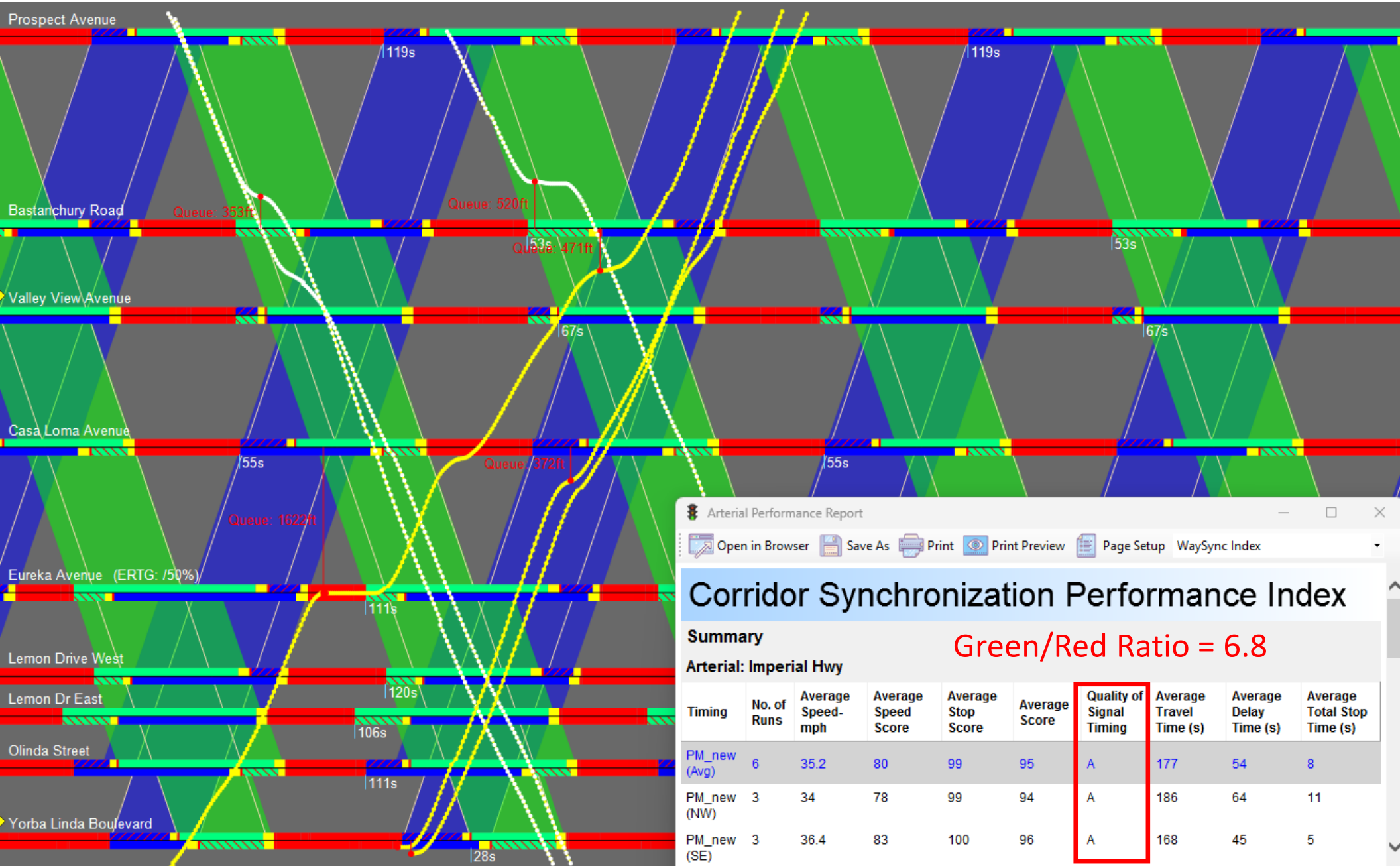
Arterial: Imperial Hwy Green/Red Ratio = 4.9

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)
PM (Avg)	120	29.2	68	93	87	B+	219	97	43
PM (NW)	44	28	66	92	85	B	226	104	49
PM (SE)	76	29.9	70	94	87	B+	215	92	40



Case Demo

– Imperial Highway, Yorba Linda (Optimized PM Plan)



Arterial Performance Report

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Corridor Synchronization Performance Index

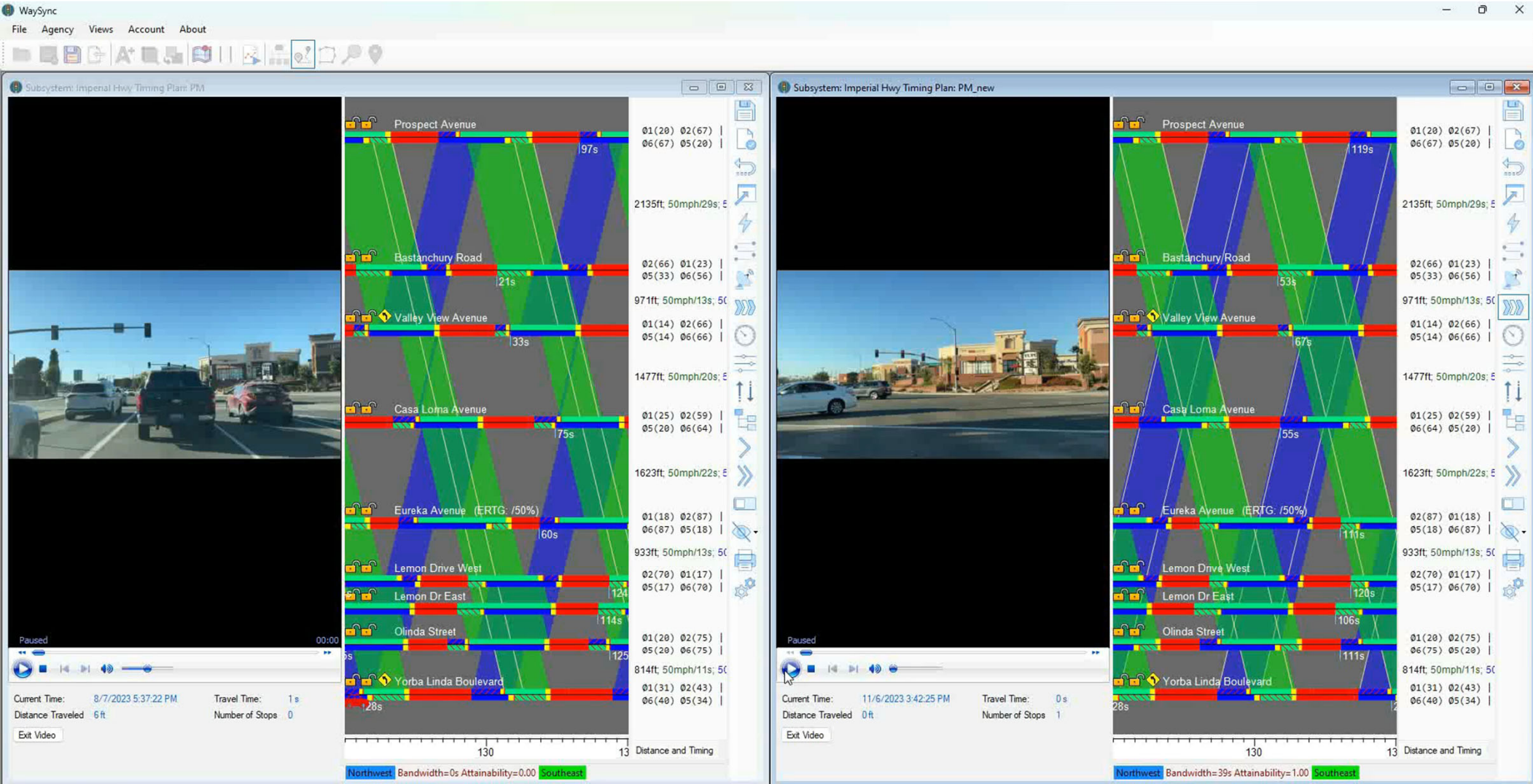
Summary Green/Red Ratio = 6.8

Arterial: Imperial Hwy

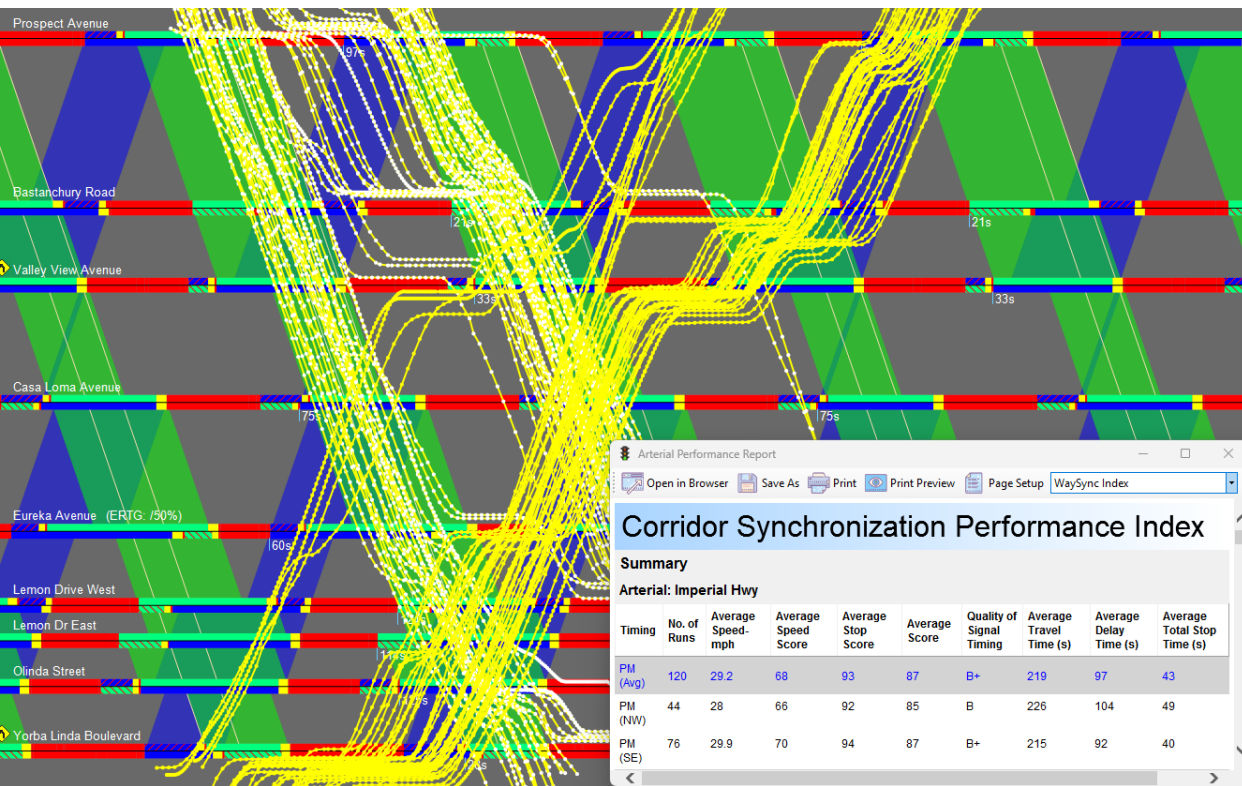
Timing	No. of Runs	Average Speed-mph	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing	Average Travel Time (s)	Average Delay Time (s)	Average Total Stop Time (s)
PM_new (Avg)	6	35.2	80	99	95	A	177	54	8
PM_new (NW)	3	34	78	99	94	A	186	64	11
PM_new (SE)	3	36.4	83	100	96	A	168	45	5

Applications

– Imperial Highway, Yorba Linda (PM Plan)



Can you trust the automated trajectory data?



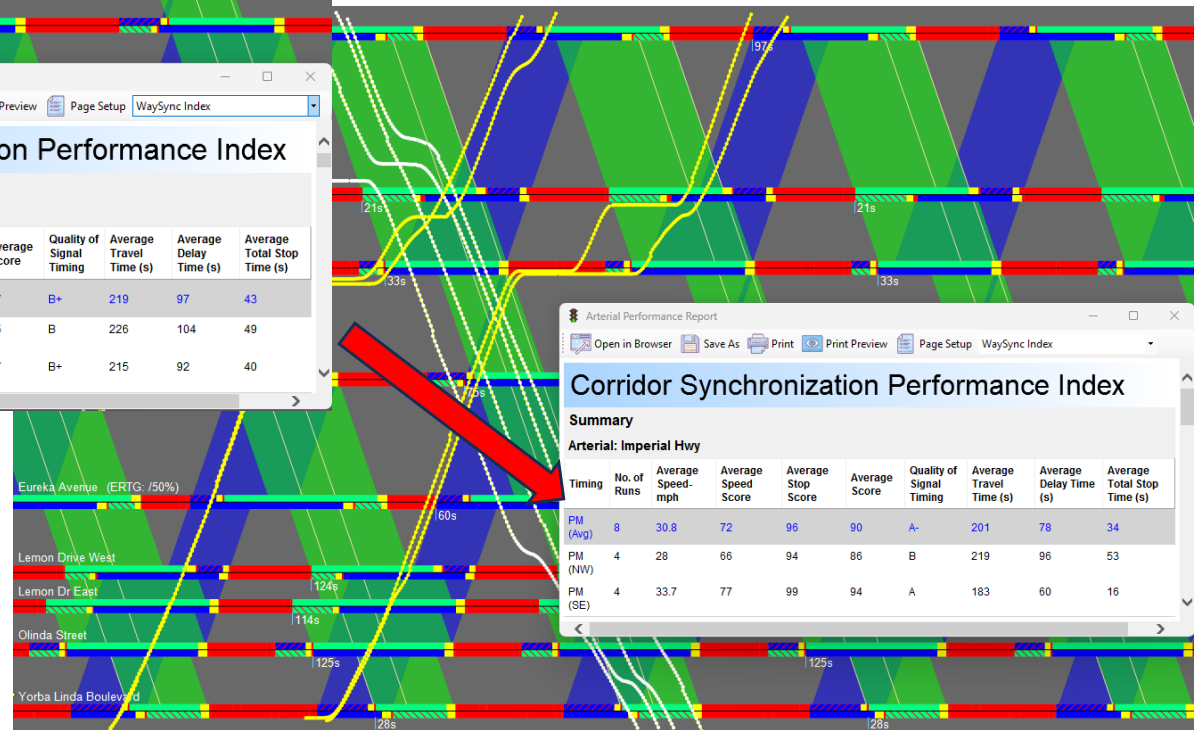
Arterial Performance Report

Corridor Synchronization Performance Index

Summary

Arterial: Imperial Hwy

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)
PM (Avg)	120	29.2	68	93	87	B+	219	97	43
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Arterial Performance Report

Corridor Synchronization Performance Index

Summary

Arterial: Imperial Hwy

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)
PM (Avg)	8	30.8	72	96	90	A-	201	78	34
PM (NW)	4	28	66	94	86	B	219	96	53
PM (SE)	4	33.7	77	99	94	A	183	60	16



Questions

- Is ATSPM (%AoG) sufficient for evaluating arterial signal coordination timing?
- What is missing in our current practice on conducting before-after signal timing evaluations?
- What is the purpose of signal performance measures?
- **Can ATSPM replace current signal timing optimization process?**



Summary

- Two types of ATSPM: detector/phase based and trajectory based.
- No widely accepted performance measures are available yet for evaluating corridor-level signal timing.
- A combination of %AoR, vehicle trajectories and time-space diagram can reveal a more complete picture of signal timing coordination.
- Trajectory-based %Stops are not the same as those reported by ATSPM.
- Keep in mind: The ultimate goal of ATSPM is to improve signal timing.

