



Technology Tools for Improving Signal Timing Practice

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About Myself

- Joined UNR in 2004
- Previous Employment
 - Texas Transportation Institute (2000-2004)
 - Kittelson & Associates Inc. (1995-1999)
- Education
 - Ph.D., Texas A&M (2004)
 - M.S., Univ. of Idaho (1996)
 - M.S. Beijing Jiaotong Univ. (1986)
 - B.S. Beijing Jiaotong Univ. (1983)


Student Awards

- International/National level
 - ITE Best Student Paper (2 times)
 - ITS America Student Paper Competition 1st Place (Hu)
- Regional Level
 - ITE District 6: Best Student Paper (6 times)
Van Wagoner Award
 - ITE Intermountain Section
 - Las Vegas Fall Conference



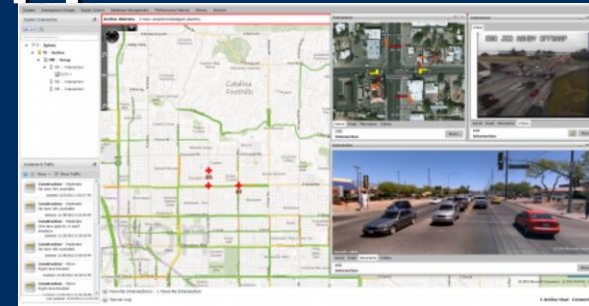
ITE District 6 and International Best Student Paper Awards

Year	Award Winner	Paper Title
2020	Sara Urbina, Portland State University	<u>Influence of Autonomous Vehicles on Travel Behavior of 50+ years Population</u>
2019	Rui Yue, University of Nevada, Reno	Microsimulation Analysis of Traffic Operations at Two Diamond Interchange Types
2018	Jianqing Wu, University of Nevada, Reno	An Automatic Procedure for Vehicle Tracking with a Roadside LiDAR Sensor
2017	Mohammadreza Hashemi	Exploratory Analysis of Roadway Departure Crashes Contributing Factors Based on Classification and Regression Trees
2016	Monirehalsadat Mohmoudi, Arizona State University	Toward a City with Fully Coordinated Vehicle Sharing System
2015	Nick Ferenchak, University of Colorado-Denver	Spontaneous Order of Pedestrian and Vehicle Interactions in Shared Spaces
2014	Britton Hammit, University of Wyoming	The Application of a Connected Vehicle Weather Data System
2013	Yue Zhao, University of Nevada, Reno	<u>A Multi-Criteria-Based Guideline for Marked and Unmarked Pedestrian Crosswalks at Unsignalized Intersections</u>
2012	Xiaoyue (Cathy) Liu, University of Washington	An Analytical Framework for Managed Lane Facility Performance Evaluation
2011	Runze Yu, University of Washington	Quantifying the Relationship between Near-Road Concentration of Black Carbon and Traffic Flow Observations
2010	PeiFeng Hu, University of Nevada, Reno	Traffic Counting Errors Due to Occlusion in Video Image Vehicle Detection Systems
2009	Cody Glasnappuan, Montana State University	Fuel Cost Parameter in Transportation Demand Models
2008	Xuan Wang, University of Nevada, Reno*	Evaluation of Lane-by-Lane Detection at Signalized Intersections using Simulation
2007	Xuan Wang, University of Nevada, Reno	An Economic Analysis Approach to Assessing Protected Only Versus Protected Permitted Left-turn Controls at Signalized Intersections

 Also won the international Dan B. Fambro Best Student Paper Awards

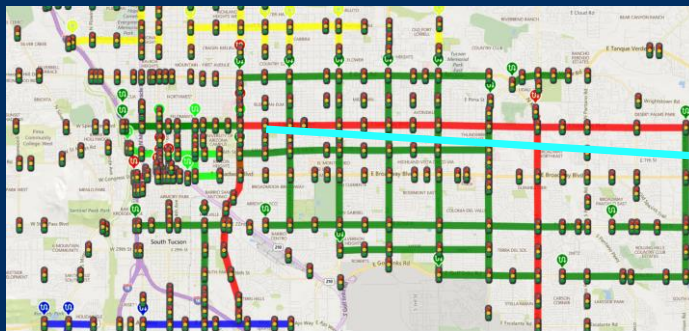
Outline

- **Critical Aspects in Signal Timing**
 - **M**anaging signal coordination timing data
 - **O**ptimizing timing plans with minimal data
 - **D**iagnosing timing errors in the field
 - **E**valuating signal coordination quality
- **Demo of Technology Tool Applications**



Managing Signal Timing Data

- Having all of your signal coordination timing data in a central place, so that you can easily:
 - ❖ View timing plans of any arterial
 - ❖ Assess the quality of timing plans
- Current state of practice
 - ❖ Synchro – usually many files, difficult to keep track
 - ❖ Central system – mainly for monitoring, no optimization



Can We **Optimize** Signal Timing without Traffic Volume Counts?

- ❑ Signal timing needs **cycle** and **splits** (*Volume and geometry are just interim variables*).
- ❑ 80%+ signal timing work is **re-timing**, so there already exist cycle and splits.
- ❑ Changing cycle length is not considered a common and prudent practice.
 - **Impact on crossing arterials**
 - **Constrained by pedestrian crossing**
- ❑ Most existing splits are good.
- ❑ Phase splits can be logged with advanced controllers or other tools.

Automated Traffic Signal Performance Measures (ATSPM)



Signal Performance Metrics



Charts Reports Links FAQ

->Signal Metrics

Selected Signal

3012 Sahara Ave & Fort Apache Rd

Signals

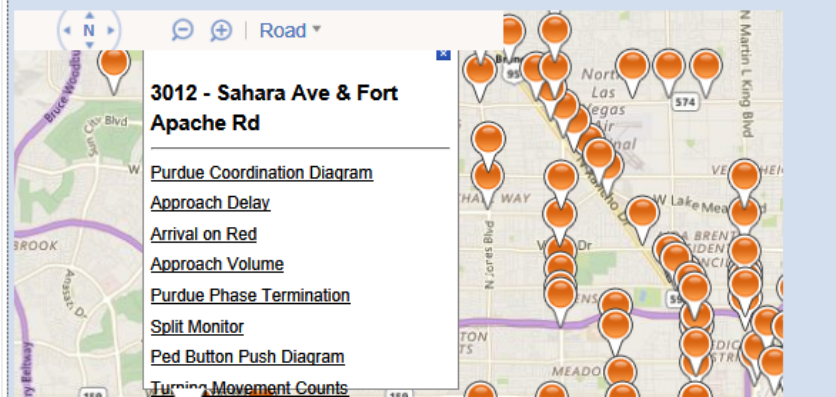
Region All

Metric Type All

Filter Signal Id Filter Clear Filter

Signal List

Map



Metric Settings

Metric Type

- Approach Delay
- Approach Volume
- Arrivals On Red
- Purdue Coordination Diagram
- Purdue Phase Termination
- Split Monitor
- Turning Movement Counts
- Ped Button Push Diagram

Y Axis Maximum

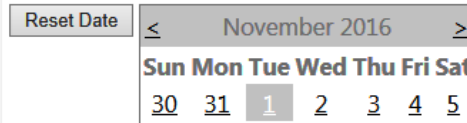
Percentile Split 85

- Show Plan Stripes
- Show % Max Out/ Force Off
- Show Ped Activity
- Show Percent Gap Outs
- Show Average Split
- Show Percent Skip

Dates

Start Date 11/1/2016 7 AM

End Date 11/1/2016 7 PM



Purdue's Split Monitor Report

Sahara Ave Fort Apache Rd SIG#3012 Phase 3 Westbound Left
Tuesday, November 1, 2016 7:00 AM - Tuesday, November 1, 2016 7:00 PM

Plan 11	Plan 15	Plan 16
19.0 - 85 Percentile...	23.4 - 85 Percentile Split	27.2 - 85 Percentile Split
16.1 Avg. Split	22.0 Avg. Split	28.9 Avg. Split
22.1% ForceOffs	1.9% ForceOffs	70.5% ForceOffs
67.6% GapOuts	36.9% GapOuts	29.5% GapOuts
4.4% Skips	0.6% Skips	0.0% Skips

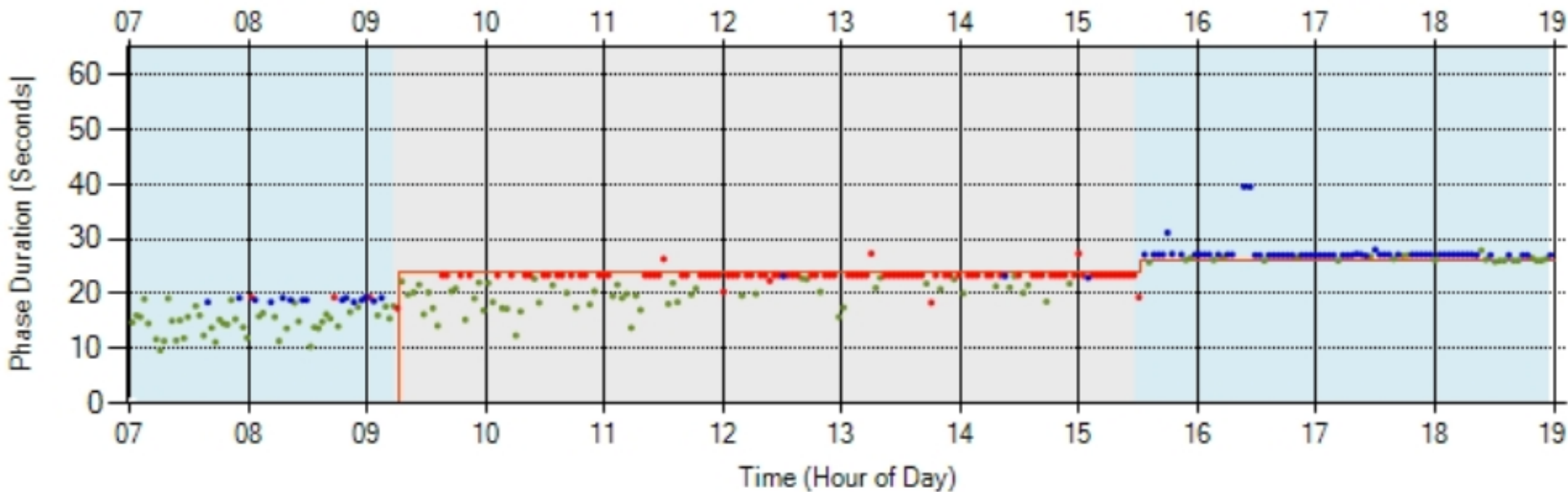


Chart Legend

- Programmed Split
- Gap Out
- Max Out
- Force Off
- Unknown Termination Cause
- Ped Activity

Split History from Controllers



Split History with Max(M), Gap(G), and Force-off(F)

Controller: 43 Elk Grove Blvd @ Laguna Springs Dr

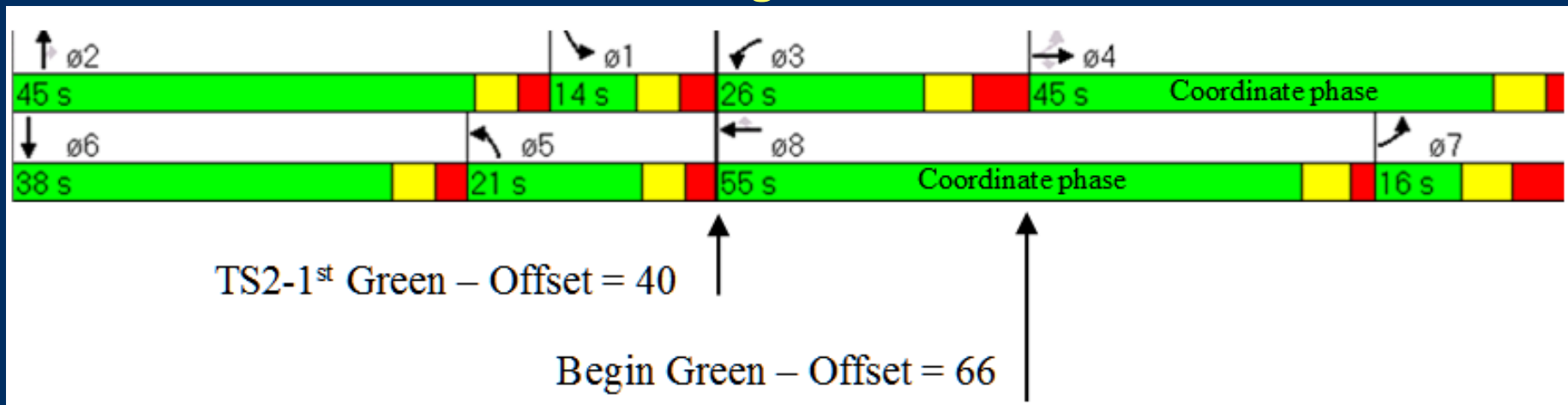
Time

Date/Time	Pattern	Cycle	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9
12/05/2019 09:00:05 AM	3	117	19/G	66/G	16/G	16/G	22/G	63/G	14/G	18/G	0
12/05/2019 09:02:04 AM	3	140	19/G	87/F	0	34/G	13/G	93/F	18/G	16/G	0
12/05/2019 09:04:25 AM	3	136	19/G	86/F	0	31/G	27/G	71/F	14/G	17/G	0
12/05/2019 09:06:43 AM	3	121	14/G	73/F	17/G	17/G	13/G	74/F	18/G	16/G	0
12/05/2019 09:08:45 AM	3	127	0	109/F	0	18/G	19/G	90/F	18/G	0	0
12/05/2019 09:10:53 AM	3	116	19/G	52/F	20/G	25/G	15/G	56/F	23/G	22/G	0

Real-world Challenges

Timing Error Diagnosis

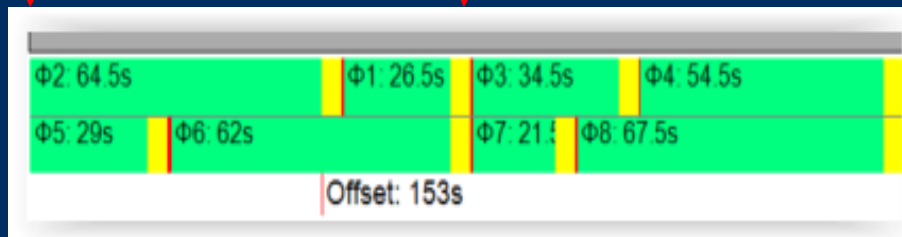
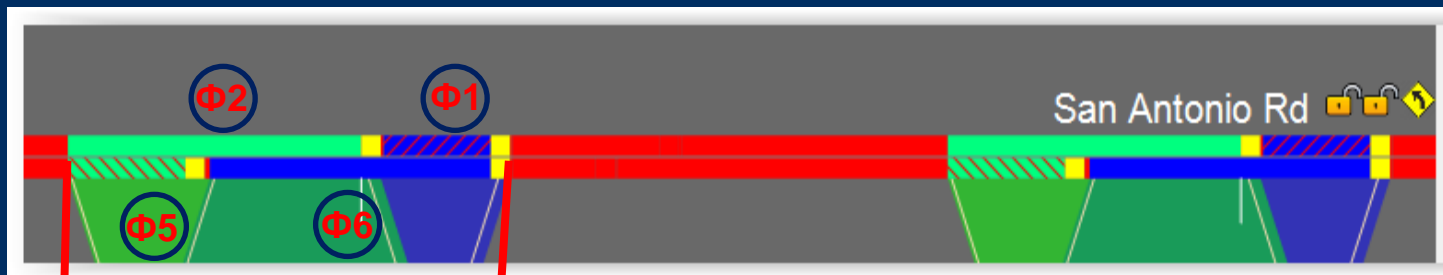
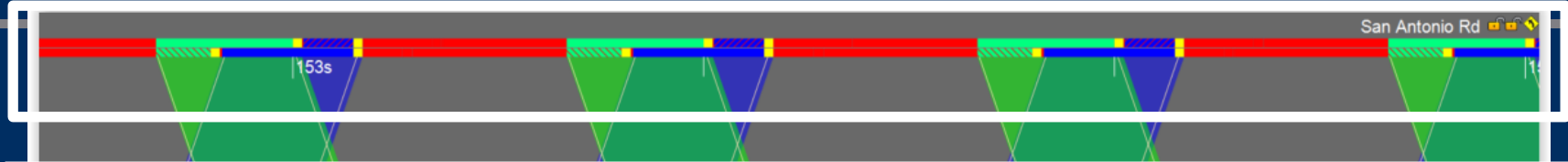
- ❑ Variable speeds affect progression
- ❑ Early return to main street causes extra stops
- ❑ Wrong offset reference
 - ❖ Start or end of coordinated phases
 - ❖ TS2-1st Green or First Ring



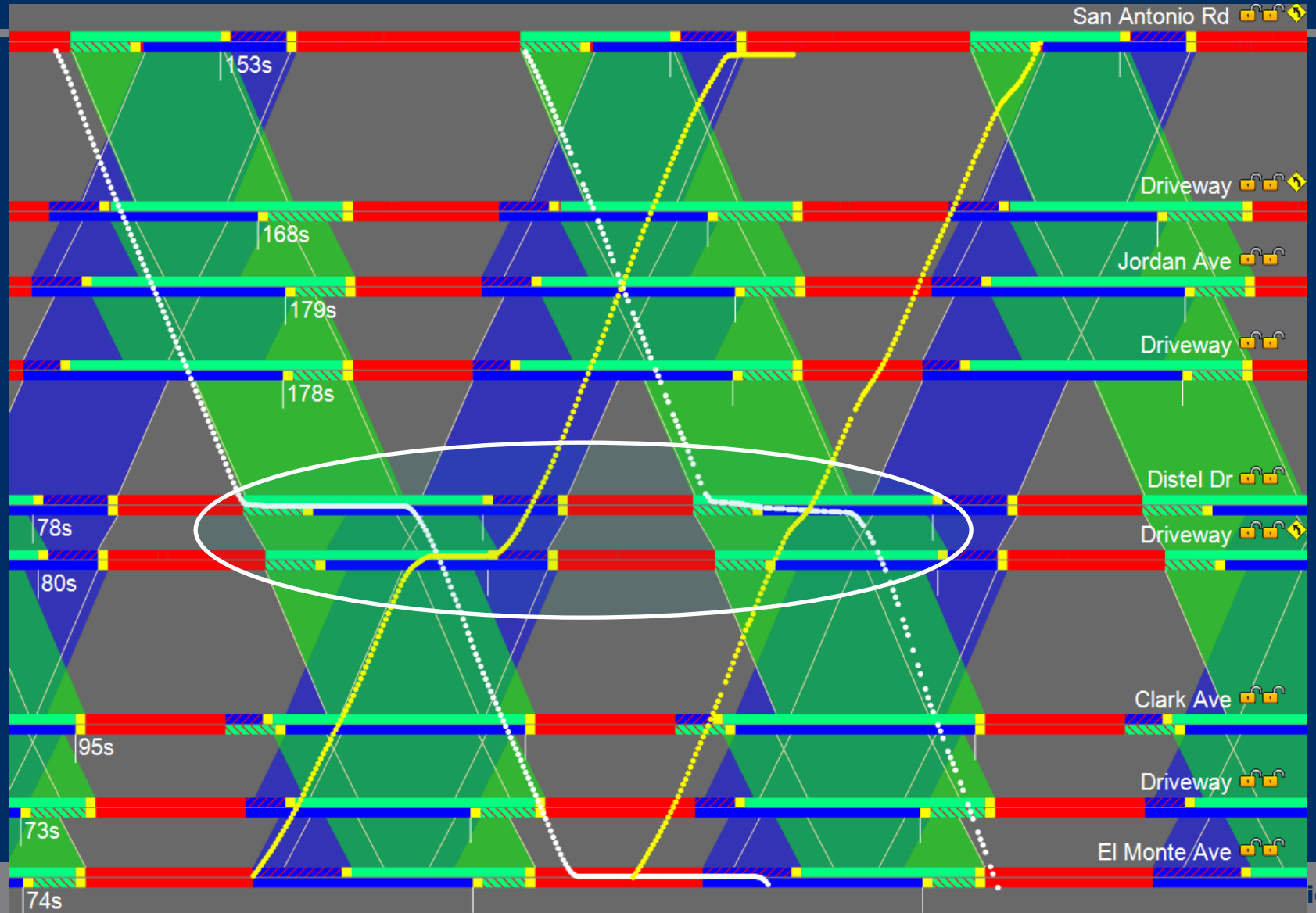
How Does Coordination Work?

- ❑ Key parameters: **cycle, split, offset, and sequence**
- ❑ Non-coordinated phases can gap out or skip due to lack of demand
- ❑ Green early return to the main street is normal
- ❑ Coordinated phase(s) cannot turn later nor terminate earlier

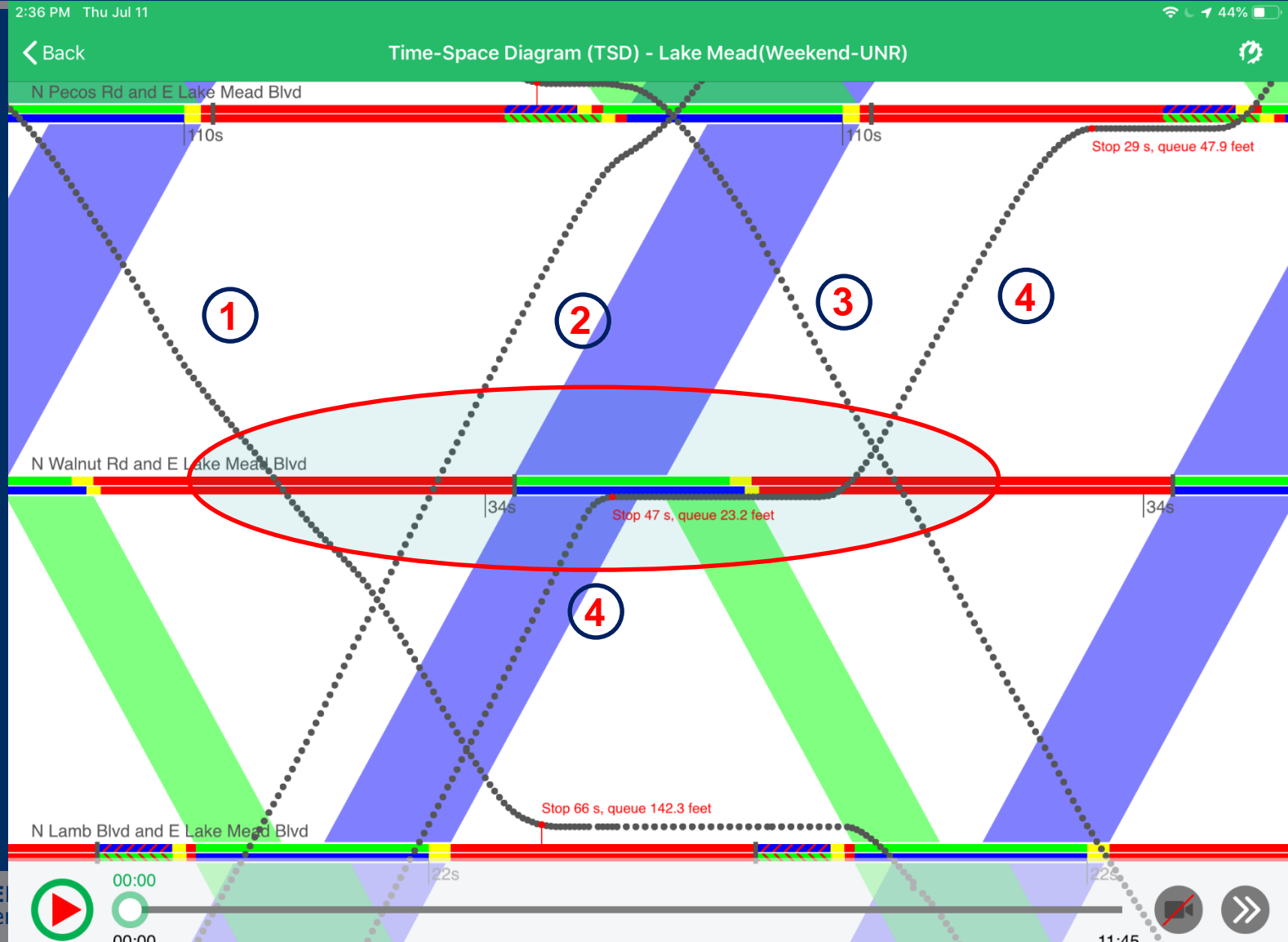
Timing **Diagnosis** based on Vehicle Trajectories



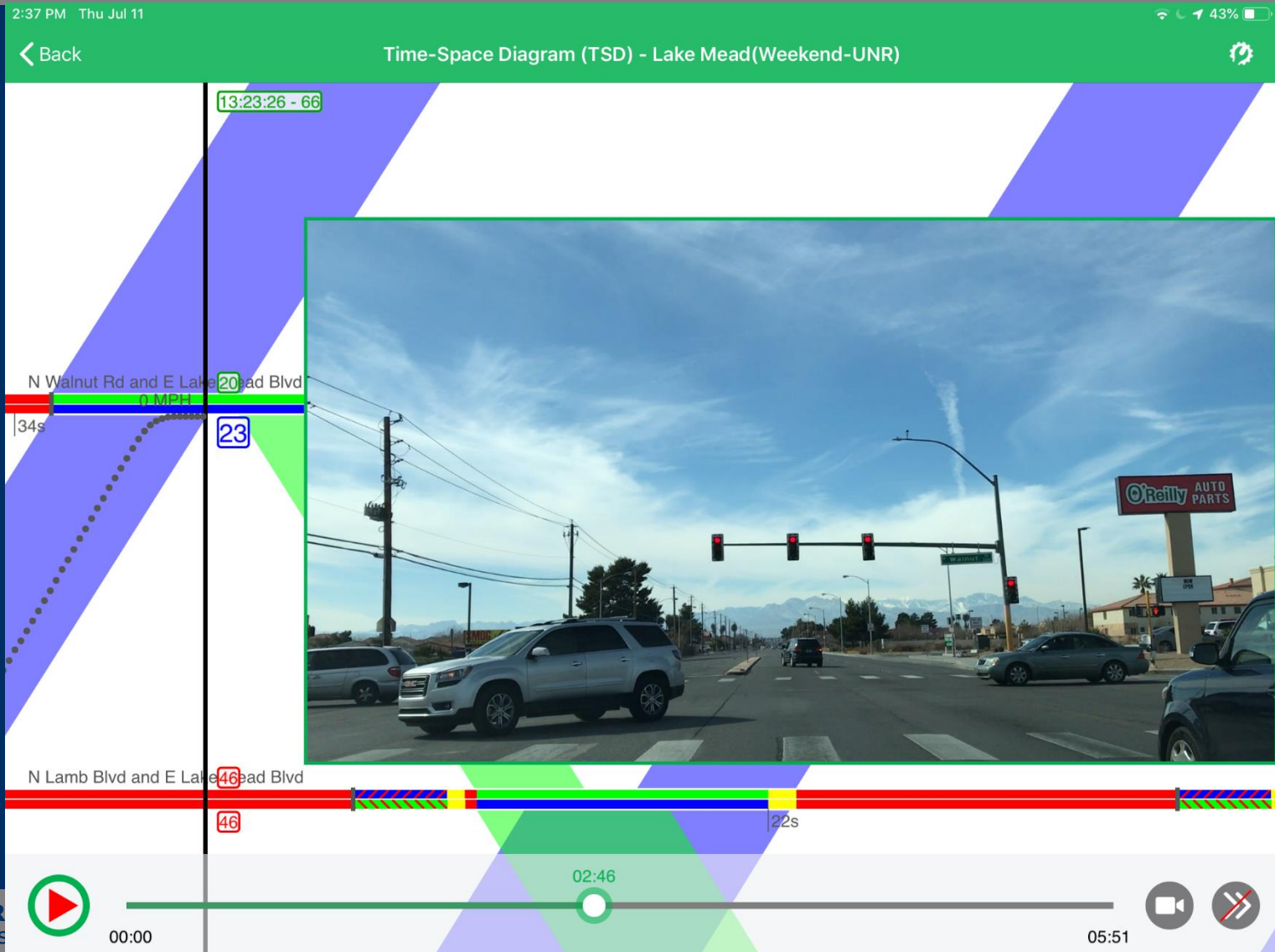
Timing Diagnosis Caltrans District 4



Timing Diagnosis Las Vegas

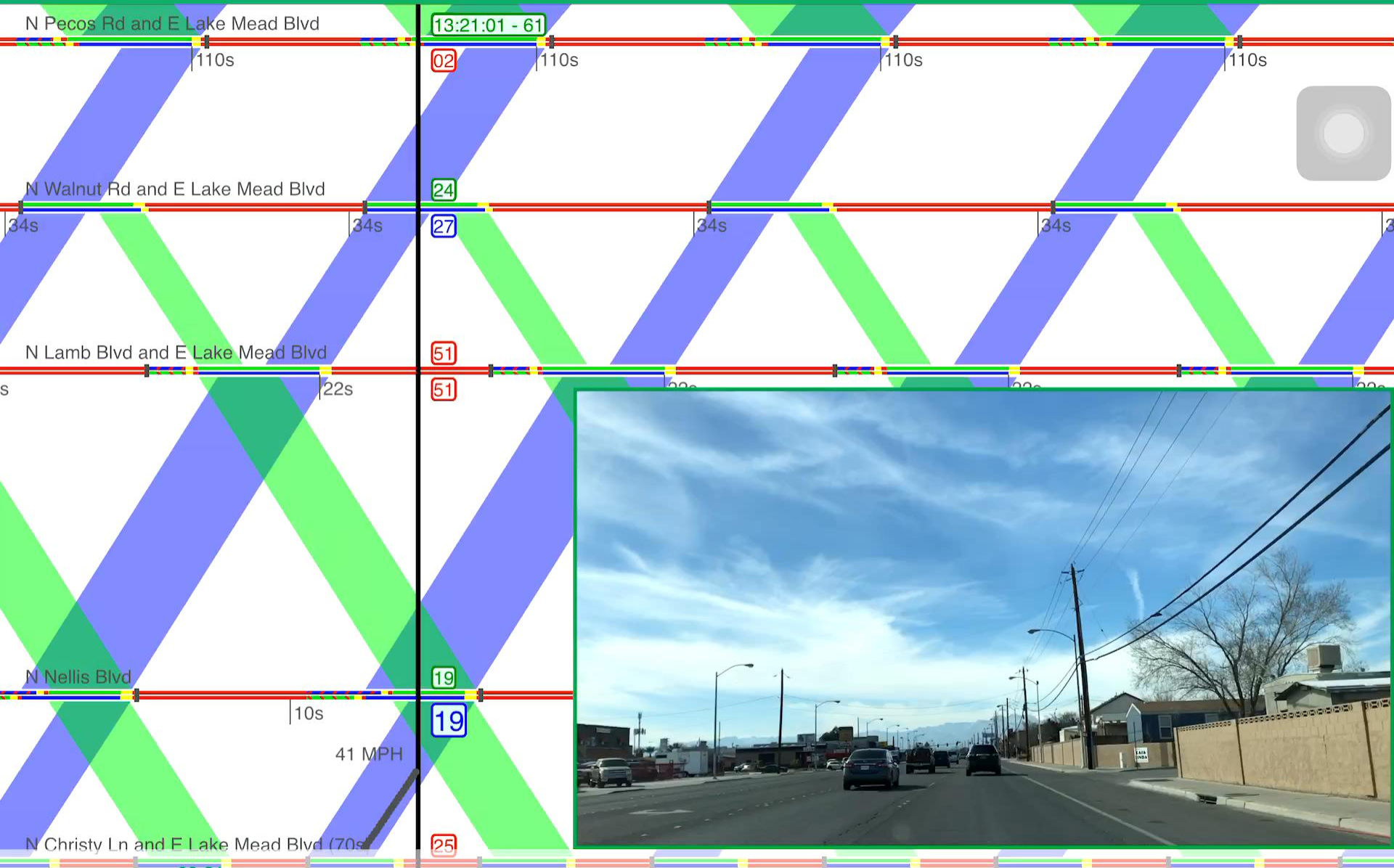


Timing Diagnosis





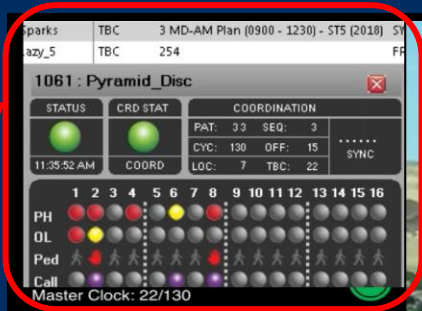
Time-Space Diagram (TSD) - Lake Mead(Weekend-UNR)



In-Field Calibration/Fine Tuning

Credit: Andrew Jayankura at RTC

ATMS



1061: Pyramid_Disc

STATUS	CRD STAT	COORDINATION	
		PAT: 33	SEQ: 3
		CYC: 130	OFF: 15
		LOC: 7	TBC: 22
			SYNC

11:35:52 AM

COORD	LOC	TBC
1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16		

PH

OL

Ped

Call

Master Clock: 22/130

Mobile App



Phase on map

Phase Diagram

2NBT	1SBL
6SBT	8WBL



Connected Signals

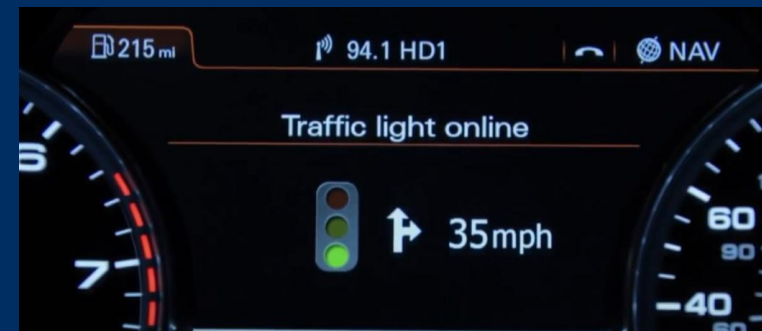
Enlighten App by Connected Signals

<https://www.youtube.com/watch?v=OF808vxLJp4&t=162s>



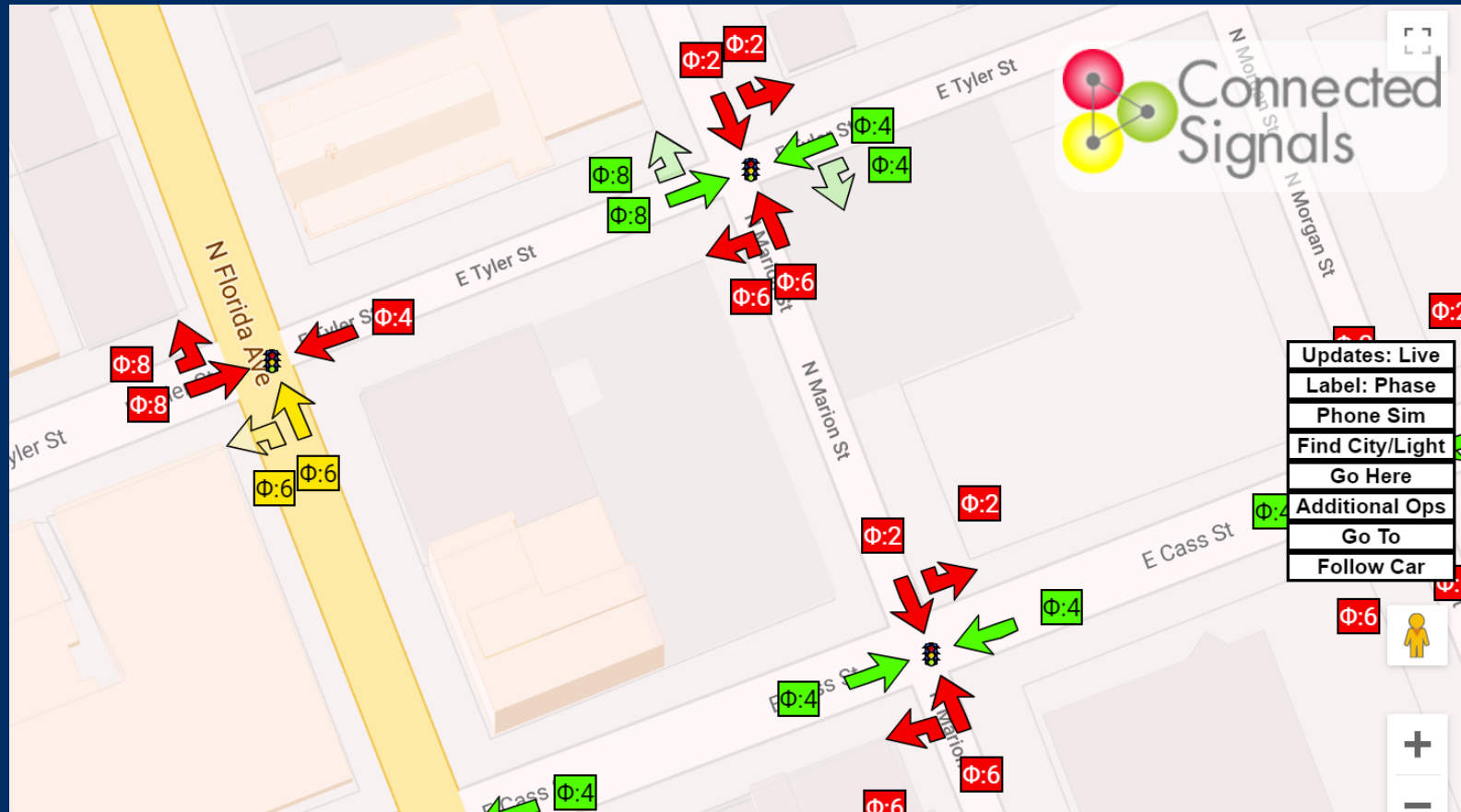
Audi's Traffic Light Info

<https://www.youtube.com/watch?v=rvTcc25Acfs>



Connected Signals

Tampa, FL

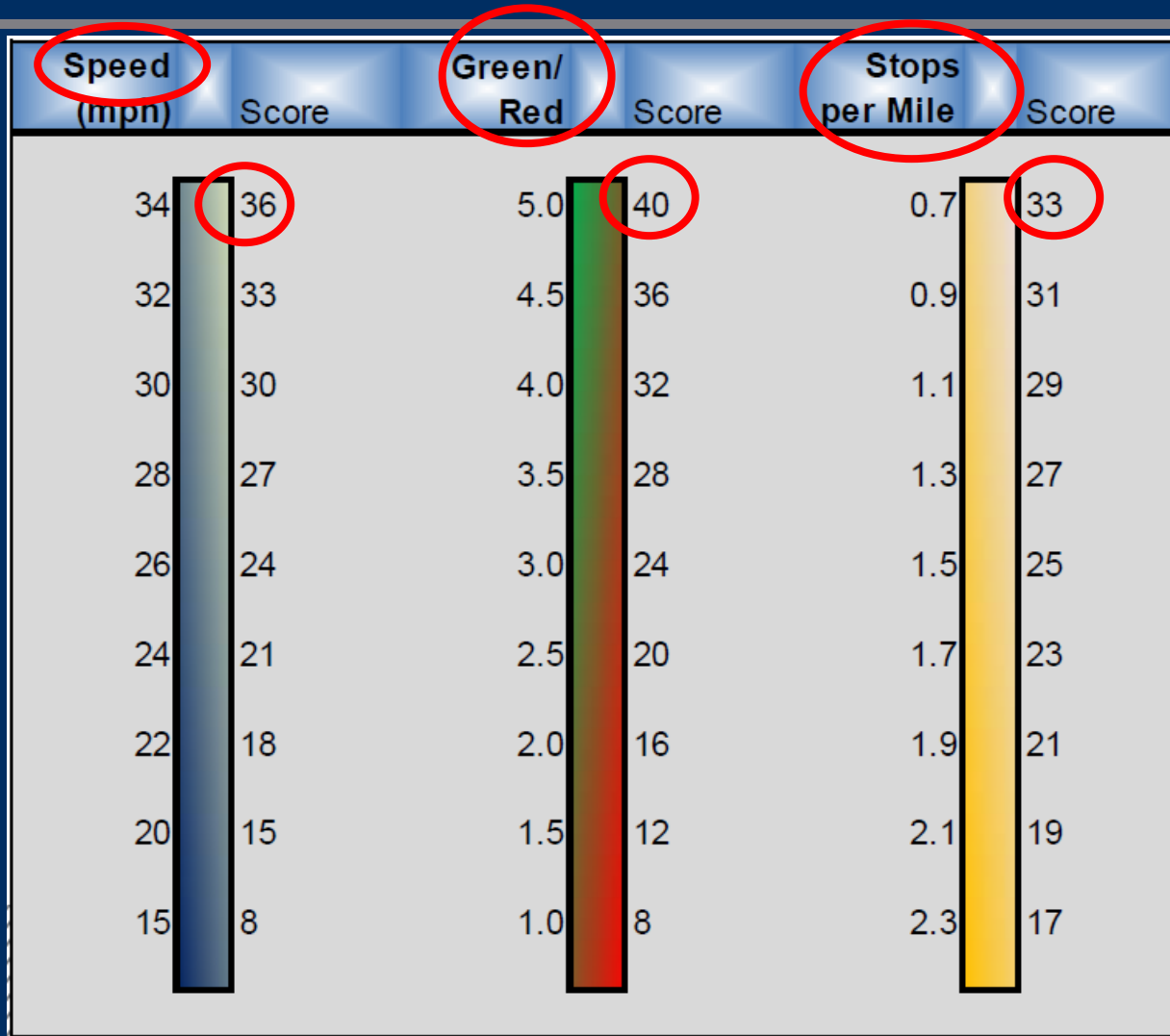


<https://www.youtube.com/watch?v=Jfp2sYu8SKE&t=9s>






State of the Practice on Signal Timing **Evaluation**

- ❑ Before-After travel runs – cannot tell if there is still room to improve.
- ❑ Only **Orange County**, CA has established a Corridor Synchronization Performance Index (**CSPI**) – a score based on average speed, number of stops and stops per mile.
- ❑ The **Purdue** System is a link-based performance and data acquisition requires ATC controllers.
- ❑ UNR developed a framework to enhance Orange County's CSPI.

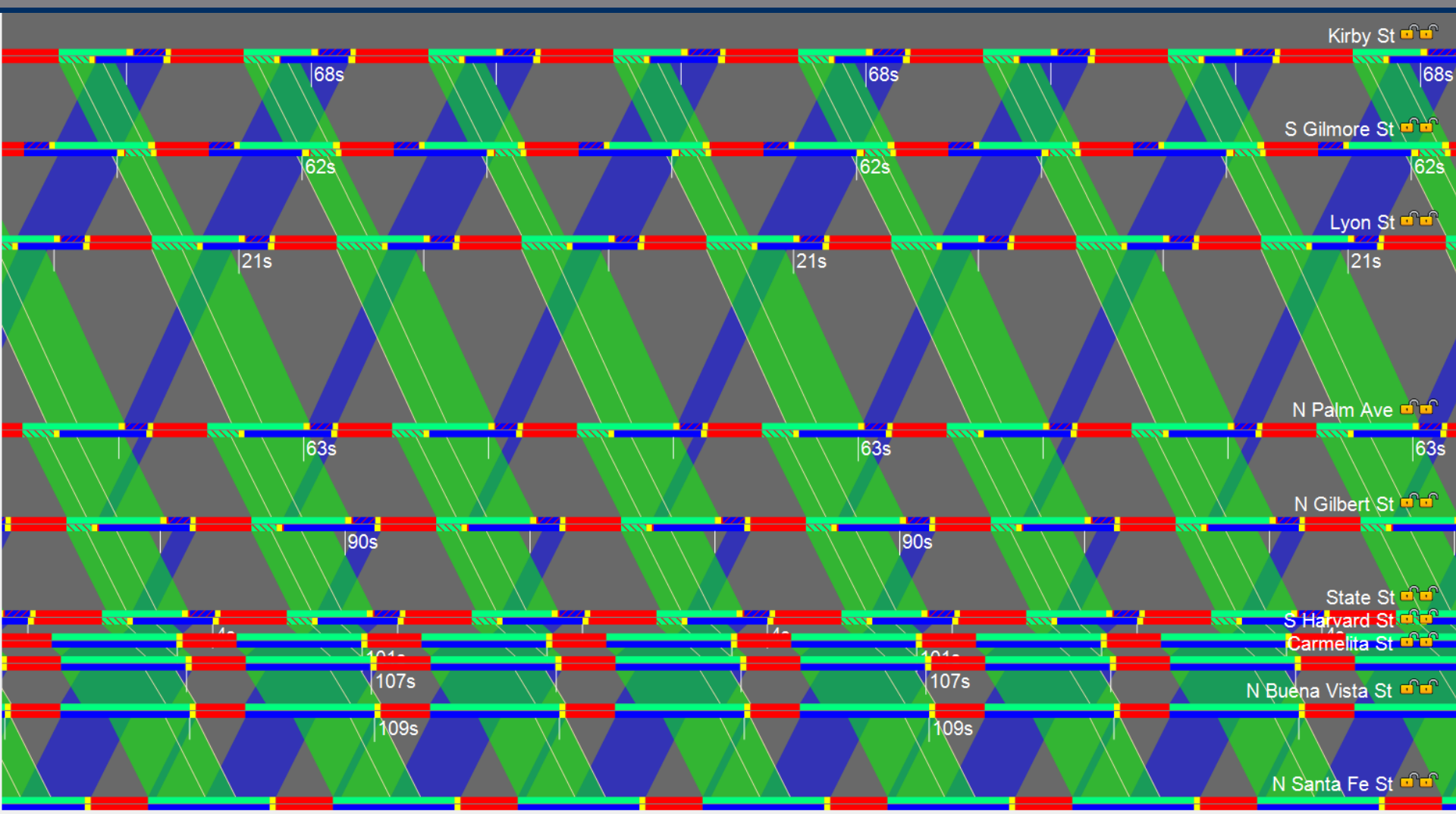
OCTA's CSPI



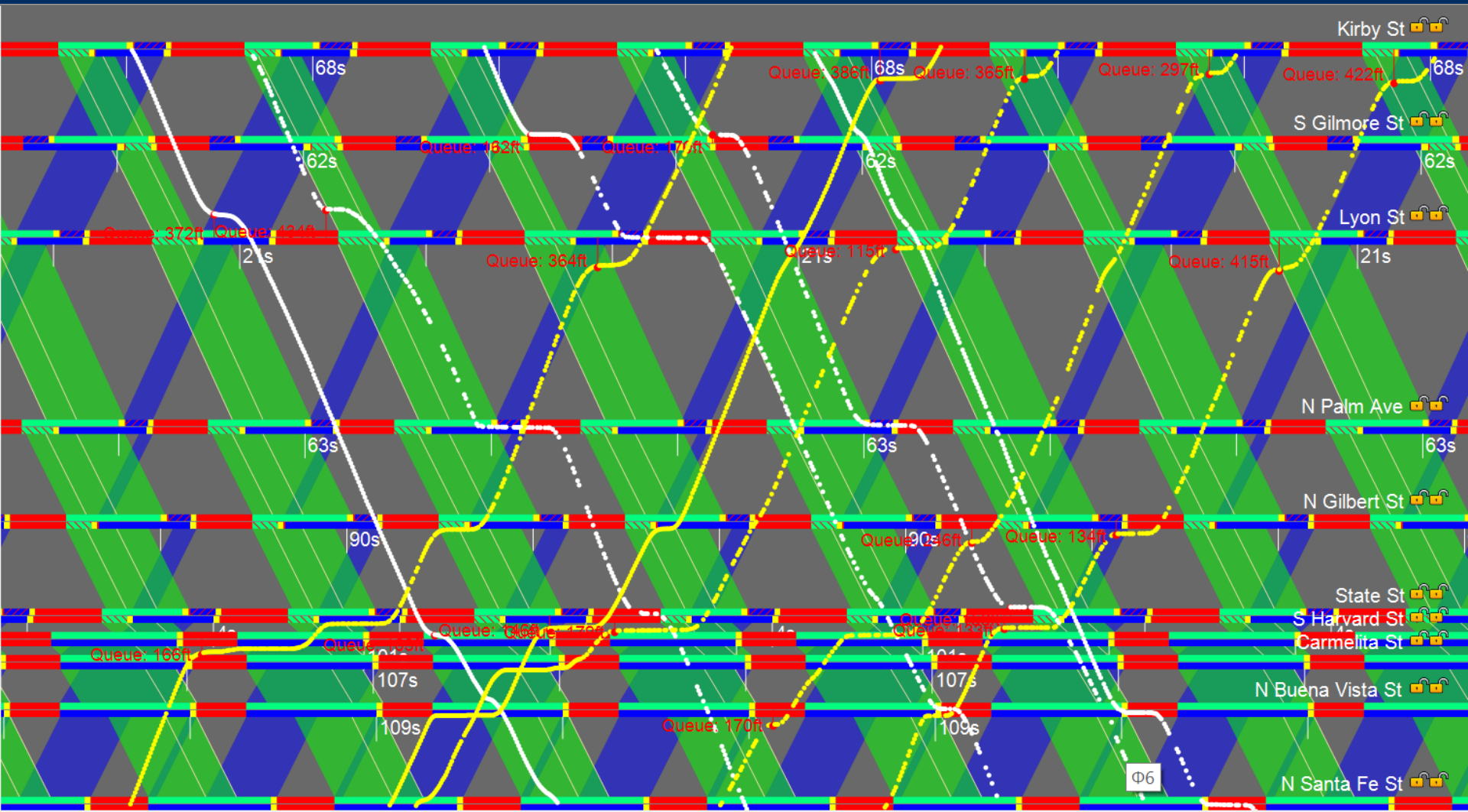
OCTA's CSPI

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
 < 50	<u>Very limited progression*</u> – traveling through signalized intersections with frequent stops and slow travel speeds.	Tier 5

Time-space Diagram - Before



GPS Trajectories on TSD - Before



Performance Index – Before (Orange County)

Corridor Synchronization Performance Index

Summary

Arterial: HWY-74

Timing	No. of Runs	Average Speed (mph)	Greens per Red (GpR)	Stops per Mile (SpM)	Speed Score	GpR score	SpM score	Total Score
MD-Before	10	21.8	2.2	1.7	18	18	23	59

Details

Arterial: HWY-74

Timing Plan: MD-Before

Timing	GPS File Name	Average Speed (mph)	Greens per Red	Stop per Mile	Speed Score	GpR Score	SpM Score	Total Score
MD-Before	City of Hemet-EB-2015-08-27-12_27_58	18.8	1.5	2	13	12	20	45
MD-Before	City of Hemet-NB-2015-08-27-11_59_52	20.3	1.5	2	16	12	20	48
MD-Before	1-WB-City of Hemet-2015-10-23-13_19_15	16.7	1.5	2	10	12	20	42
MD-Before	3-WB-City of Hemet-2015-10-23-13_35_07	21.8	1.5	2	18	12	20	50
MD-Before	5-WB-City of Hemet-2015-10-23-13_51_28	20.4	1	2.1	16	10	19	45
MD-Before	City of Hemet-NB-2015-08-27-12_19_48	26.2	4	1	24	32	30	86
MD-Before	0-EB-City of Hemet-2015-10-23-13_01_47	23	2.3	1.5	19	19	25	63
MD-Before	2-EB-City of Hemet-2015-10-23-13_26_49	21.2	2.3	1.5	17	19	25	60
MD-Before	4-EB-City of Hemet-2015-10-23-13_42_14	22.8	2.3	1.5	19	19	25	63
MD-Before	6-EB-City of Hemet-2015-10-23-13_57_33	26.2	4	1	24	32	30	86

Performance Index – Before (UNR)

Corridor Synchronization Performance Index

Summary

Arterial: HWY-74

Timing	No. of Runs	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing
MD-Before (Avg)	10	72	75	76	C
MD-Before (WB)	5	66	62	65	D
MD-Before (EB)	5	78	88	87	B+

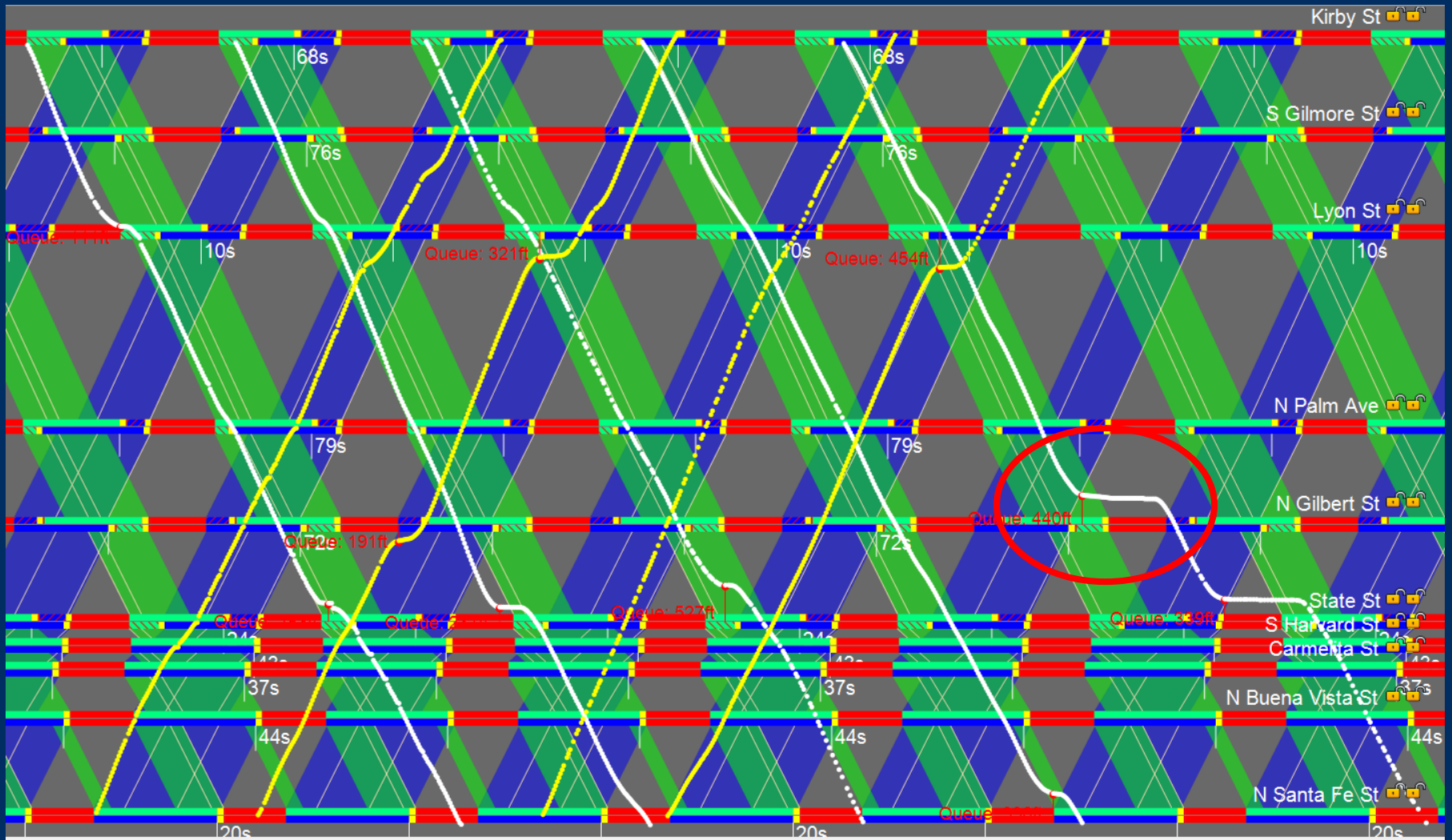
Details

Arterial: HWY-74

Timing Plan: MD-Before

Timing	GPS File Name	Average Speed (mph)	% Speed	Speed Score	No. of Stops	Standard No. of Stops	% Stop	Stop Score	Original Score	Cycle Length Adjustment	Spacing Adjustment	Adjusted Score	Quality of Signal Timing
MD-Before (WB)	City of Hemet-EB-2015-08-27-12_27_58	18.8	54%	64	4	4.6	46%	35	44	45.9(+2)	45.9(+0)	46	F
MD-Before (WB)	City of Hemet-NB-2015-08-27-11_59_52	20.3	58%	68	4	3.4	34%	64	65	67.1(+2)	67.1(+0)	67	D+
MD-Before (WB)	1-WB-City of Hemet-2015-10-23-13_19_15	16.7	48%	58	4	4.1	41%	48	51	53.2(+2)	53.2(+0)	53	F
MD-Before (WB)	3-WB-City of Hemet-2015-10-23-13_35_07	21.8	62%	72	4	1.8	18%	90	85	86.9(+2)	86.9(+0)	87	B
MD-Before (WB)	5-WB-City of Hemet-2015-10-23-13_51_28	20.4	58%	68	5	3.1	31%	72	71	72.7(+2)	72.7(+0)	73	C-
MD-Before (EB)	City of Hemet-NB-2015-08-27-12_19_48	26.2	75%	85	2	0.6	6%	97	93	95.2(+2)	95.2(+0)	95	A
MD-Before (EB)	0-EB-City of Hemet-2015-10-23-13_31_15	23	66%	76	3	2.3	23%	85	82	83.9(+2)	83.9(+0)	84	B

GPS Trajectories on TSD - After



Performance Index – After (Orange County)

Corridor Synchronization Performance Index

Summary

Arterial: HWY-74

Timing	No. of Runs	Average Speed (mph)	Greens per Red (GpR)	Stops per Mile (SpM)	Speed Score	GpR score	SpM score	Total Score
MD-UNR-NewSplits	9	27	5.3	0.7	26	40	33	99

Details

Arterial: HWY-74

Timing Plan: MD-UNR-NewSplits

Timing	GPS File Name	Average Speed (mph)	Greens per Red	Stop per Mile	Speed Score	GpR Score	SpM Score	Total Score
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-21 11-55-20	28.3	6	0.5	27	40	35	102
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-23 10-57-07wbGilbertwrong	27.6	4	1	26	32	30	88
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-23 13-13-23wb	32.8	6	0.5	34	40	35	109
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-23 13-31-21wb	27.6	6	0.5	26	40	35	101
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-21 11-46-52	26.6	4	1	25	32	30	87
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-21 11-40-58	28	6	0.5	27	40	35	102
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-23 13-21-03eb	25.9	6	0.5	24	40	35	99
MD-UNR-NewSplits	City of Hemet-Hwy74-EB-2016-03-23 13-55-20eb	26.1	6	0.5	24	40	35	99
MD-UNR-NewSplits	EB-PreEmption	20.2	4	1	15	32	30	77

Performance Index – After (UNR)

Corridor Synchronization Performance Index

Summary

Arterial: HWY-74

Timing	No. of Runs	Average Speed Score	Average Stop Score	Average Score	Quality of Signal Timing
MD-UNR-NewSplits (Avg)	9	87	95	94	A
MD-UNR-NewSplits (WB)	4	92	98	98	A
MD-UNR-NewSplits (EB)	5	82	92	91	A-

Details

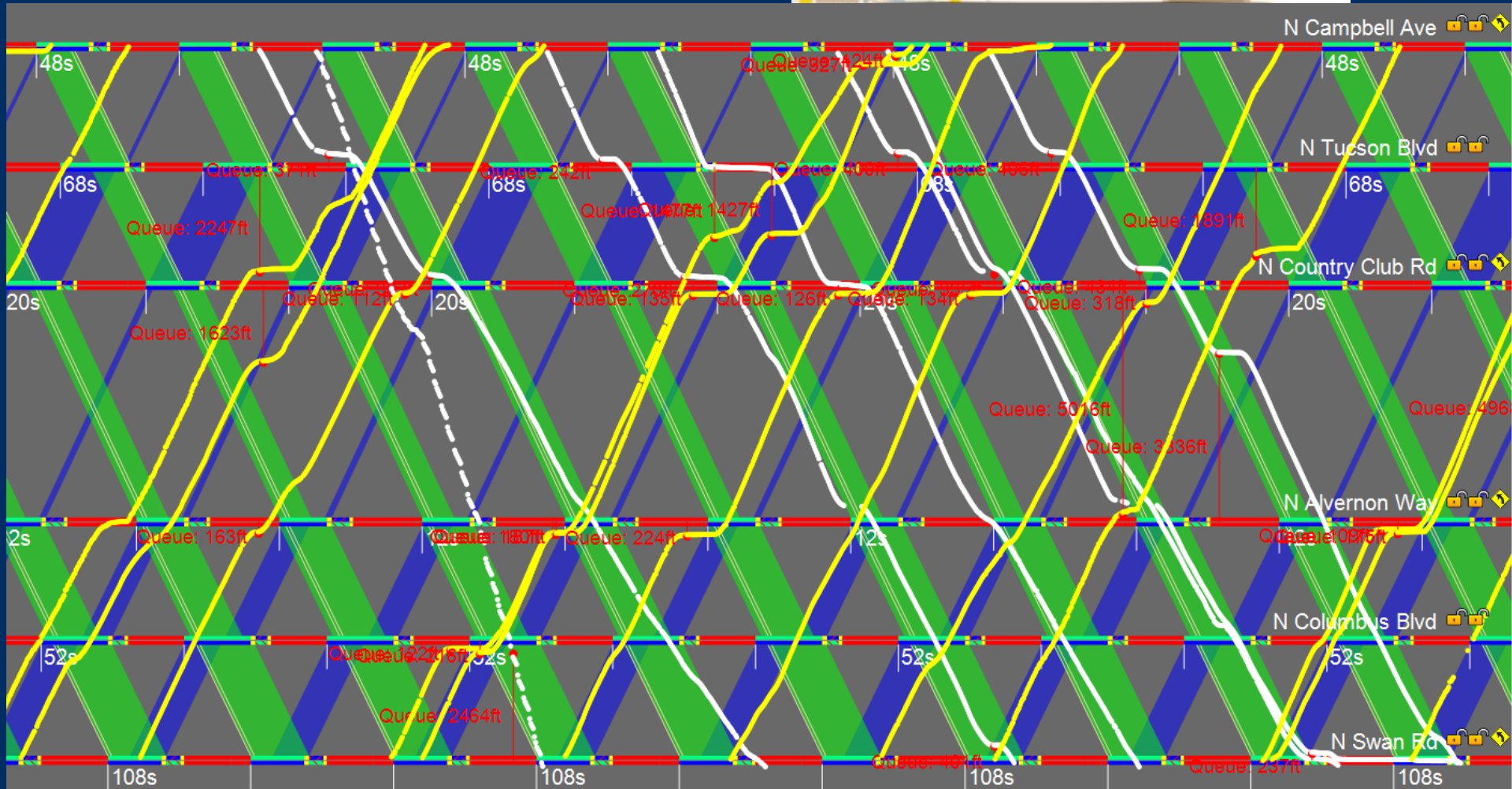
Arterial: HWY-74

Timing Plan: MD-UNR-NewSplits

Timing	GPS File Name	Average Speed (mph)	% Speed	Speed Score	No. of Stops	Standard No. of Stops	% Stop	Stop Score	Original Score	Cycle Length Adjustment	Spacing Adjustment	Adjusted Score	Quality of Signal Timing
MD-UNR-NewSplits (WB)	City of Hemet-Hwy74-EB-2016-03-21 11-55-20	28.3	81%	91	0	0	0%	100	97	99.3(+2)	99.3(+0)	99	A
MD-UNR-NewSplits (WB)	City of Hemet-Hwy74-EB-2016-03-23 10-57-07wbGilbertwrong	27.6	79%	89	2	0.8	8%	96	94	96(+2)	96(+0)	96	A
MD-UNR-NewSplits (WB)	City of Hemet-Hwy74-EB-2016-03-23 13-13-23wb	32.8	94%	100	0	0	0%	100	100	102(+2)	102(+0)	100	A
MD-UNR-NewSplits (WB)	City of Hemet-Hwy74-EB-2016-03-23 13-31-21wb	27.6	79%	89	1	0.4	4%	97	95	96.9(+2)	96.9(+0)	97	A
MD-UNR-NewSplits (EB)	City of Hemet-Hwy74-EB-2016-03-21 11-46-52	26.6	76%	86	2	0.4	4%	97	94	96(+2)	96(+0)	96	A
MD-UNR-NewSplits (EB)	City of Hemet-Hwy74-EB-2016-03-21 11-28	28	80%	90	1	0.5	5%	97	95	97(+2)	97(+0)	97	A

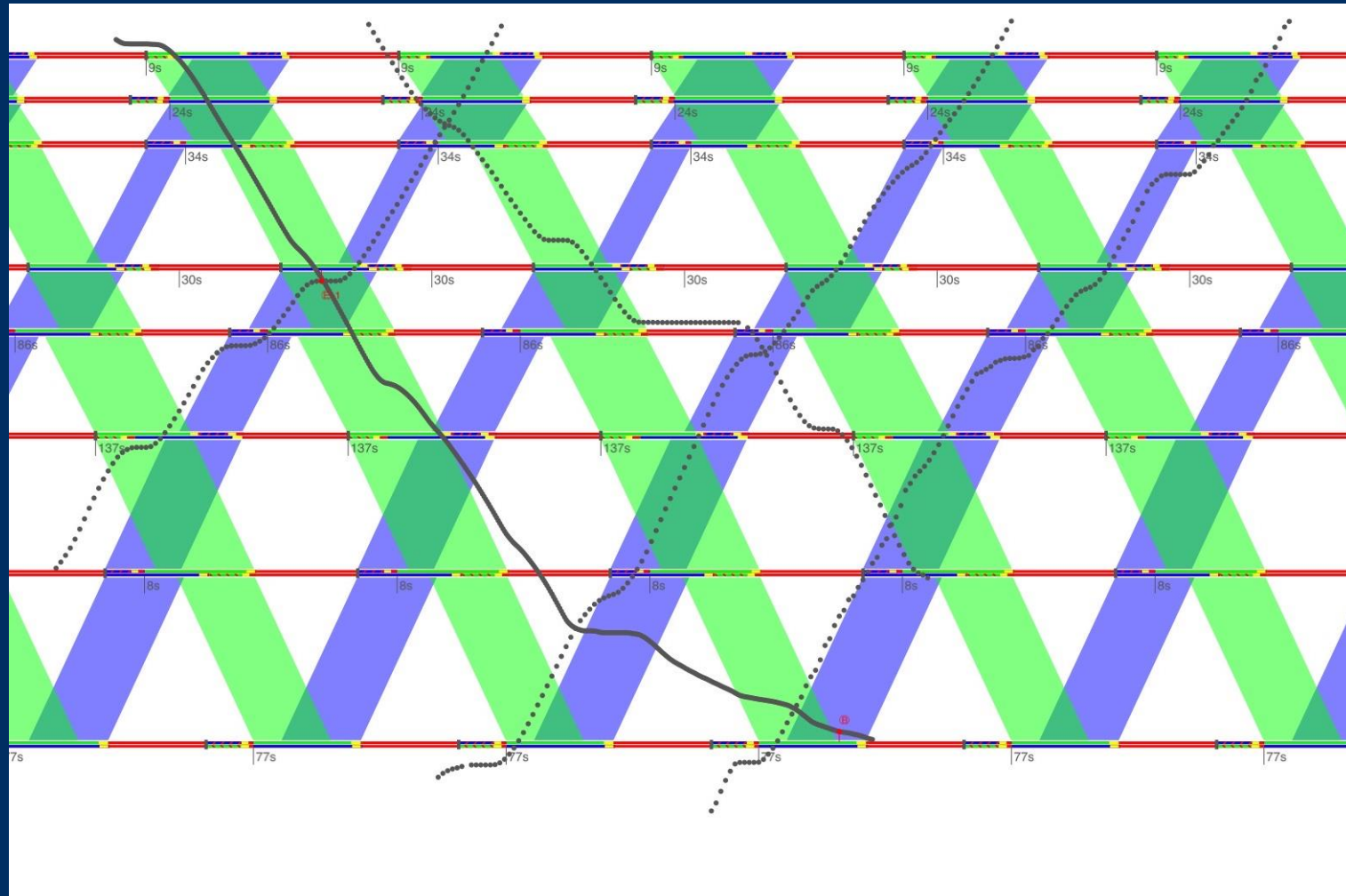
Automated Probe Vehicle Data

Metropia Inc



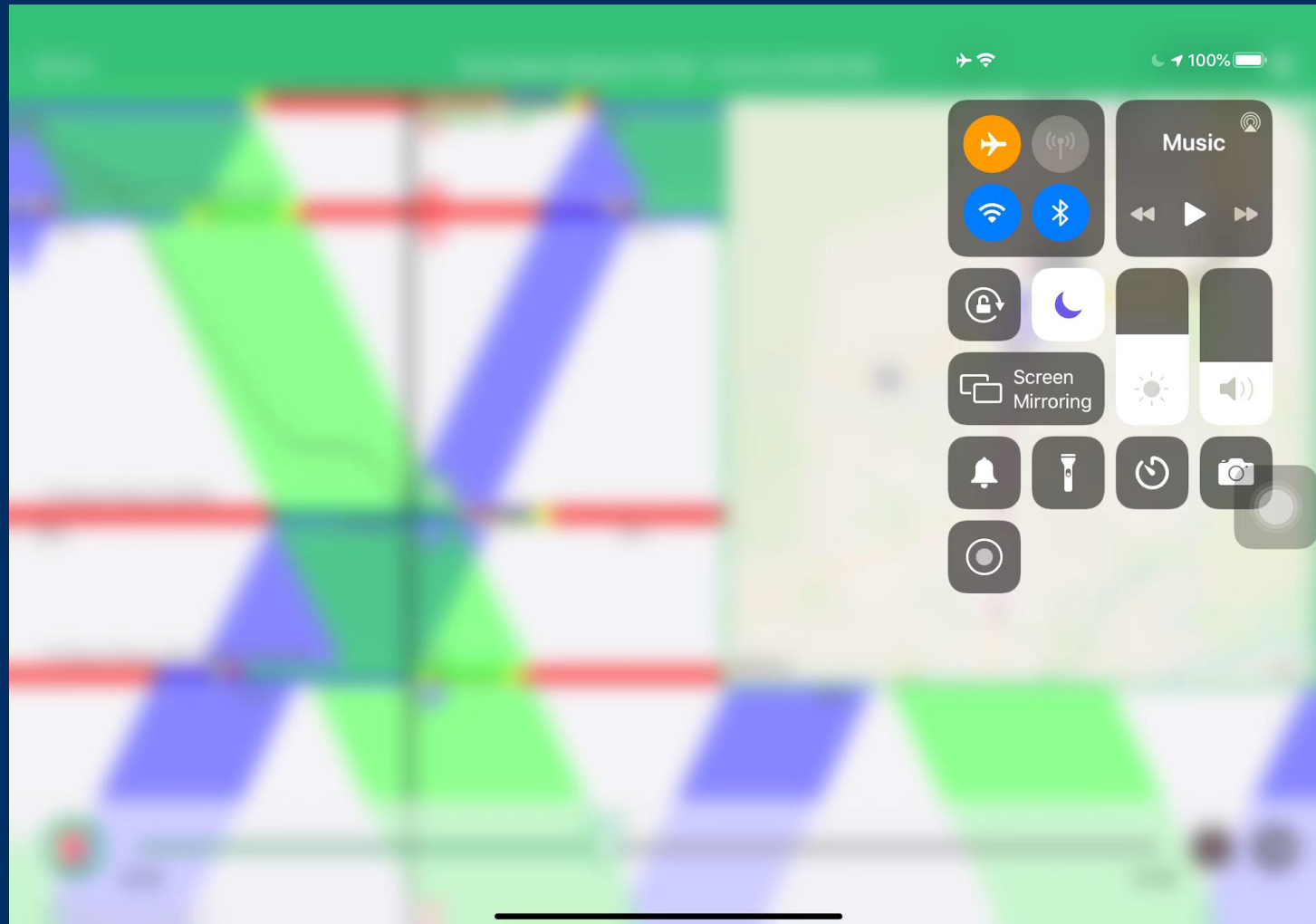
Automated Probe Vehicle Data

Ticon

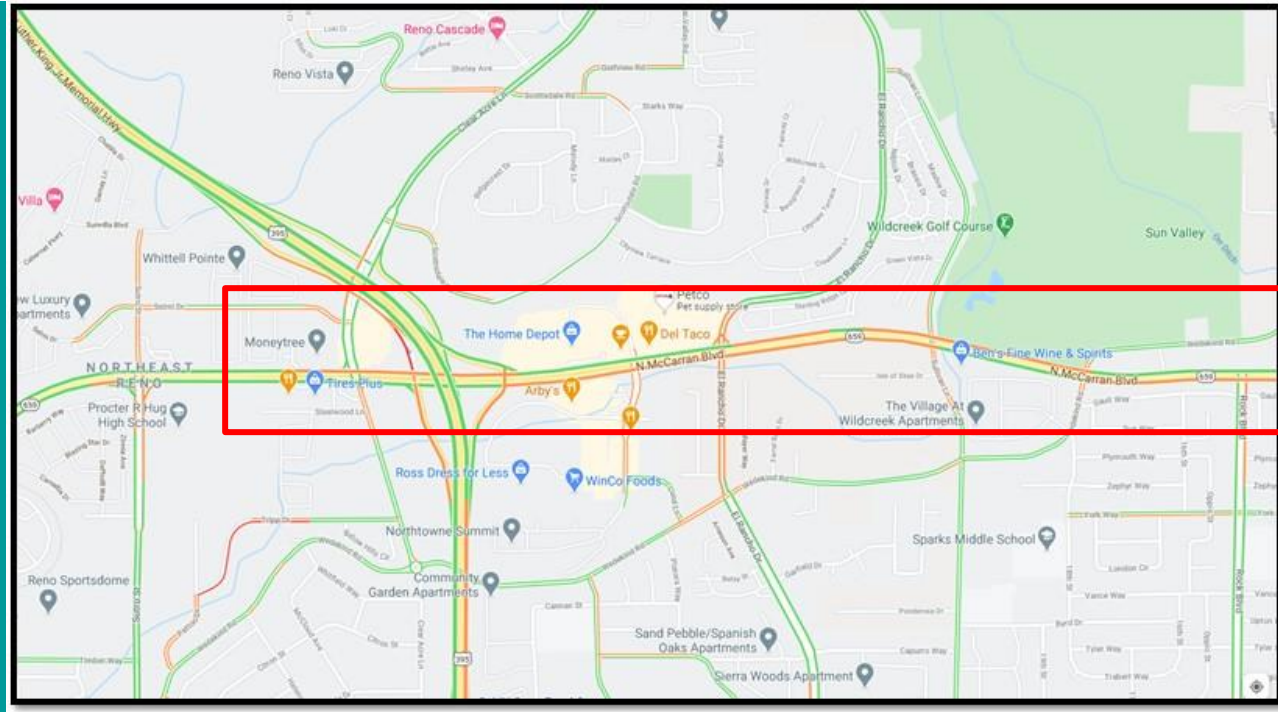


Automated Probe Vehicle Data

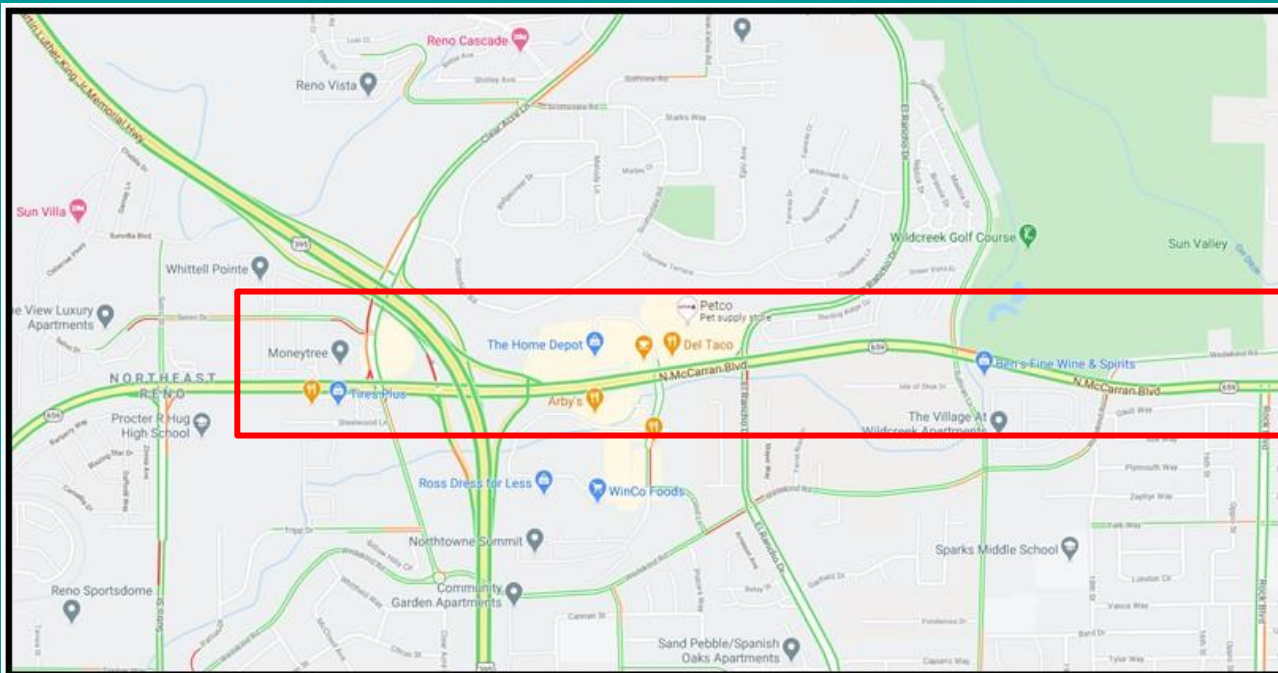
Ticon



Before



After



Summary

□ Four critical aspects: **MODE**

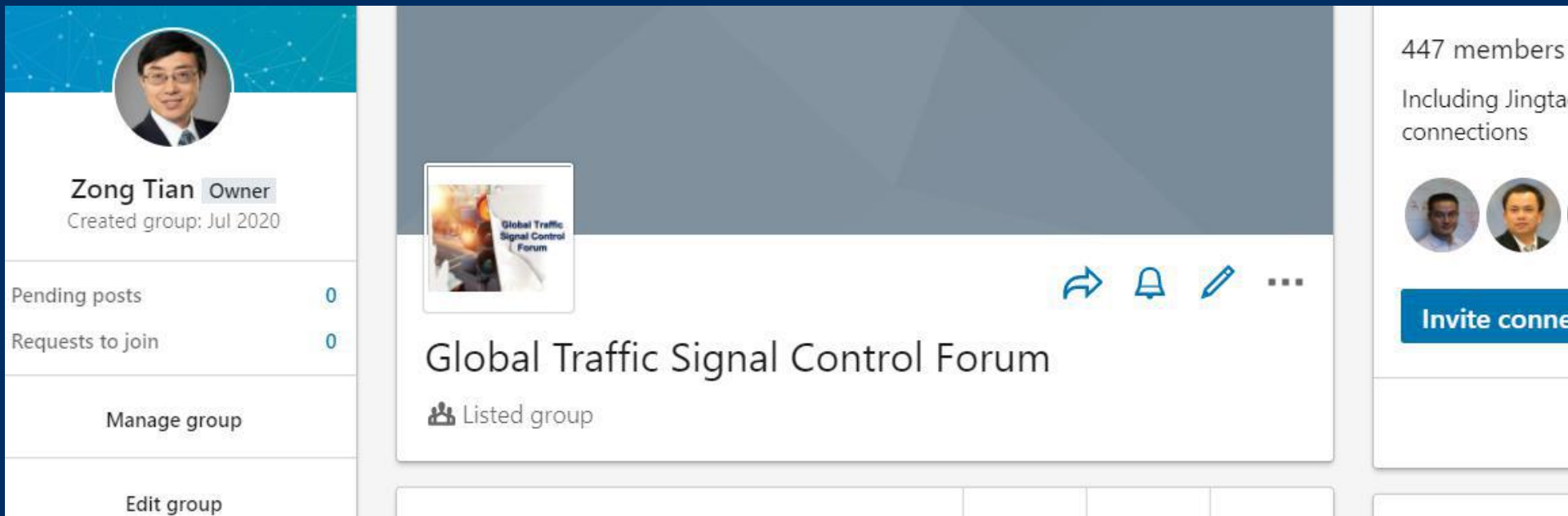
- ❖ **Managing data – store all of your signal timing data and associated performance data in a single file**
- ❖ **Optimizing signal timing – getting the right phase splits, not necessarily the volume counts**
- ❖ **Diagnosing signal timing – using a mobile tool that mimics real controller timing**
- ❖ **Evaluation of signal timing quality – a performance index to gauge and prioritize re-timing priorities**

□ Technology tools

- ❖ **Mobile Diagnosis App, ATSPM, Connected Signals, Crowdsourcing: Metropia, Ticon,**

Join LinkedIn Group

<https://www.linkedin.com/groups/13882507/>



The screenshot shows the LinkedIn profile of the group owner, Zong Tian, who created the group in July 2020. The group is titled 'Global Traffic Signal Control Forum' and is a listed group with 447 members. The page includes navigation options like 'Manage group' and 'Edit group', and a button to 'Invite connections'. The group's cover image features a traffic signal and the text 'Global Traffic Signal Control Forum'.

Zong Tian Owner
Created group: Jul 2020

Pending posts 0
Requests to join 0

Manage group
Edit group

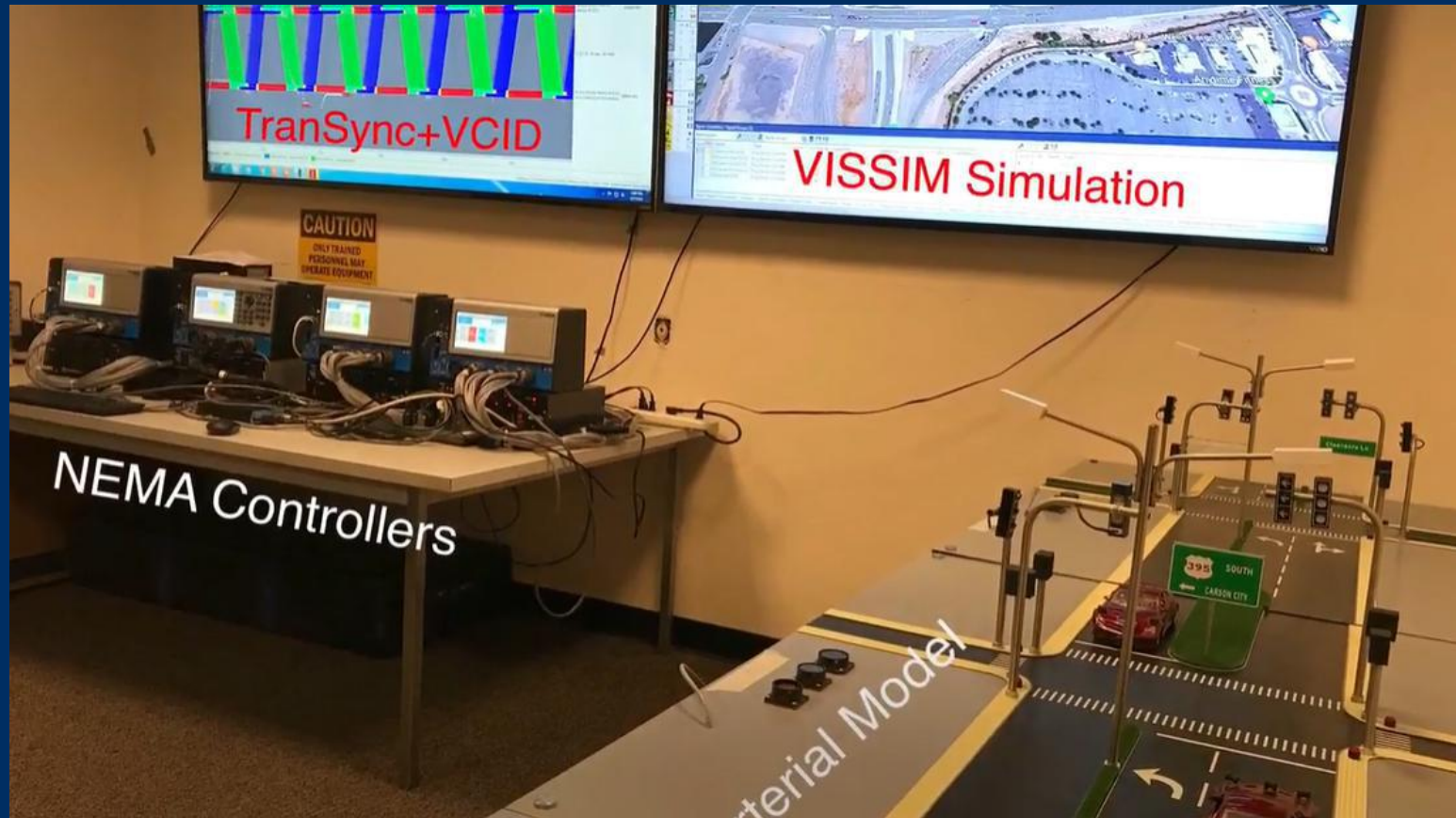
Global Traffic Signal Control Forum
Listed group

447 members
Including Jingtai connections

Invite connections

PASS-Physical Arterial Signal Simulation

<https://www.youtube.com/watch?v=qkpKII0HP1w>





U.S. Department of Transportation
Office of the Secretary of Transportation

UTC Spotlight

University Transportation Centers Program

This month: University of Nevada, Reno | January 2015

New Signal Timing Tool Helps Engineers Save User Costs and the Environment



* Experiencing interruptions?

[Find out why](#) x

Are Adaptive Signal Control Systems a Solution to Urban Congestion?



US Department of Transportation Office of the Assis...

[Subscribe](#) 26

151 views

Questions?