TranSync Mobile Tool

Traffic Signal Management and Retiming Tool

Pilot Project in Auburn and San Francisco Bay Area (Caltrans Districts 3 and 4)

Improving Signal Timing and Coordination

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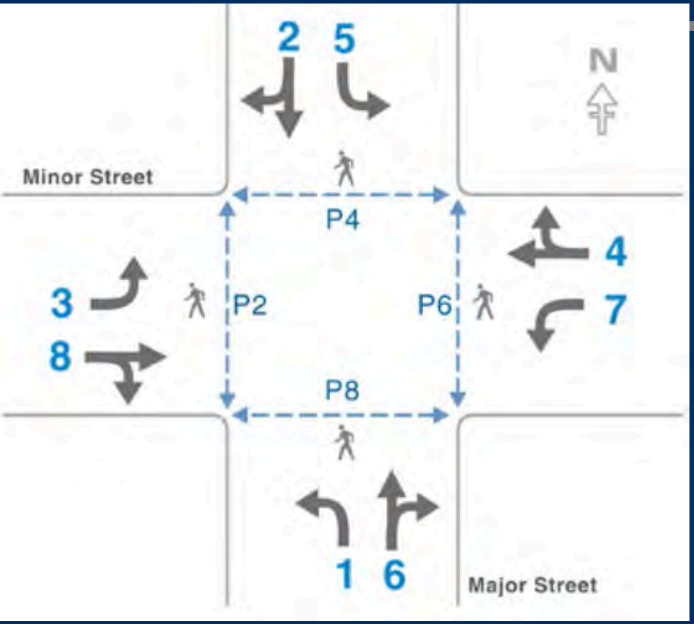
Caltrans

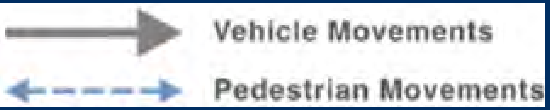
Outline

- Traffic Signal Timing Basics
- Time-Space Diagrams
- State of the practice on traffic signal timing and coordination
- Introducing the TranSync *Mobile Tool*
- Case demos: Auburn, Yuba City & Mt. View
- Q&A

Traffic Signal Timing Basics

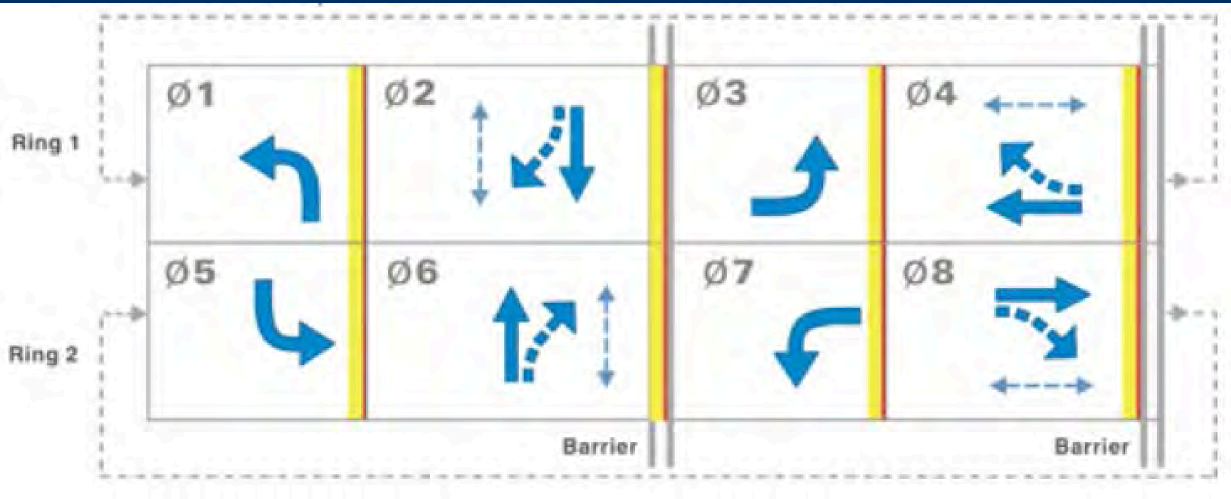


Typical vehicular and pedestrian movements (PHASES) at a 4-leg intersection



Standard ring-and-barrier diagram

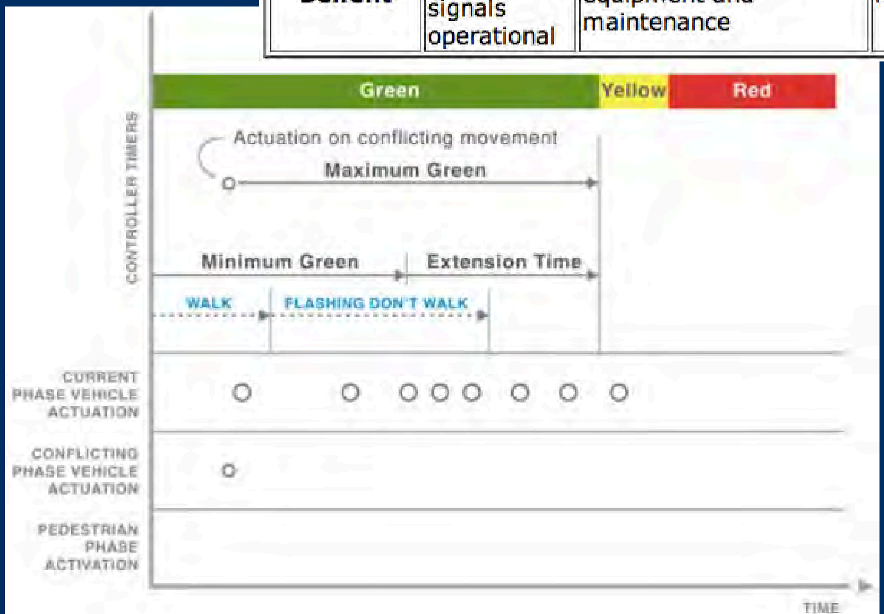
Major Street Phases *Minor Street Phases*



Traffic Signal Timing Basics -2

Relationship between intersection operation and control type

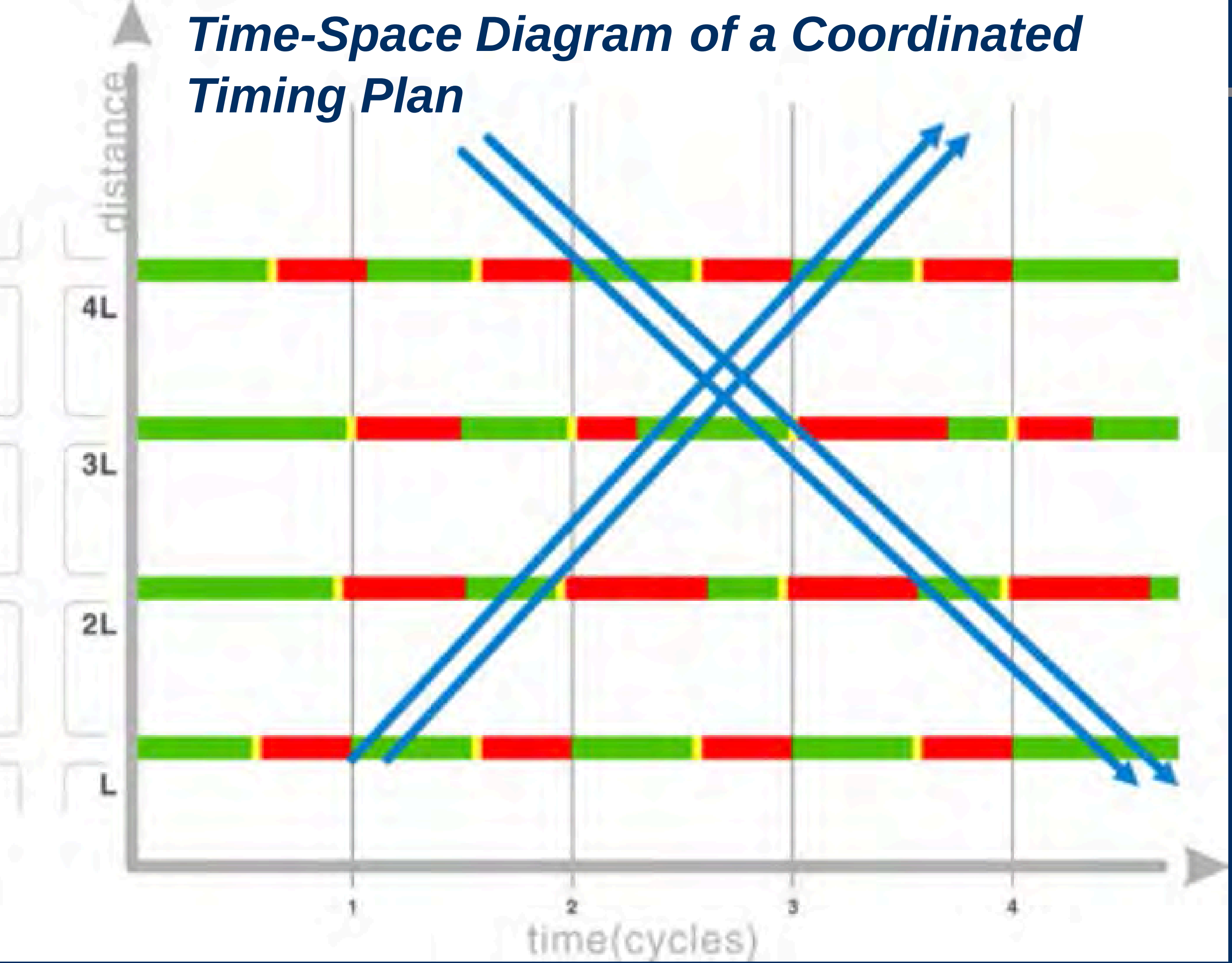
	Pre-timed		Actuated		
Type of Operation	**Isolated**	**Coordinated**	**Semi-Actuated**	**Fully-Actuated**	**Coordinated**
Fixed Cycle Length	Yes	Yes	No	No	Yes
Conditions Where Applicable	Where detection is not available	Where traffic is consistent, closely spaced intersections, and where cross street is consistent	Where defaulting to one movement is desirable, major road is posted <40 mph and cross road carries light traffic demand	Where detection is provided on all approaches, isolated locations where posted speed is >40 mph	Arterial where traffic is heavy and adjacent intersections are nearby
Example Application	Work Zones	Central business districts, interchanges	Highway operations	Locations without nearby signals; rural, high speed locations; intersection of two arterials	Suburban arterial
Key Benefit	Temporary application keeps signals operational	Predictable operations, lowest cost of equipment and maintenance	Lower cost for highway maintenance	Responsive to changing traffic patterns, efficient allocation of green time, reduced delay and improved safety	Lower arterial delay, potential reduction in delay for the system, depending on the settings



Settings that define the duration of a vehicle phase

Traffic Signal Timing Basics - 3

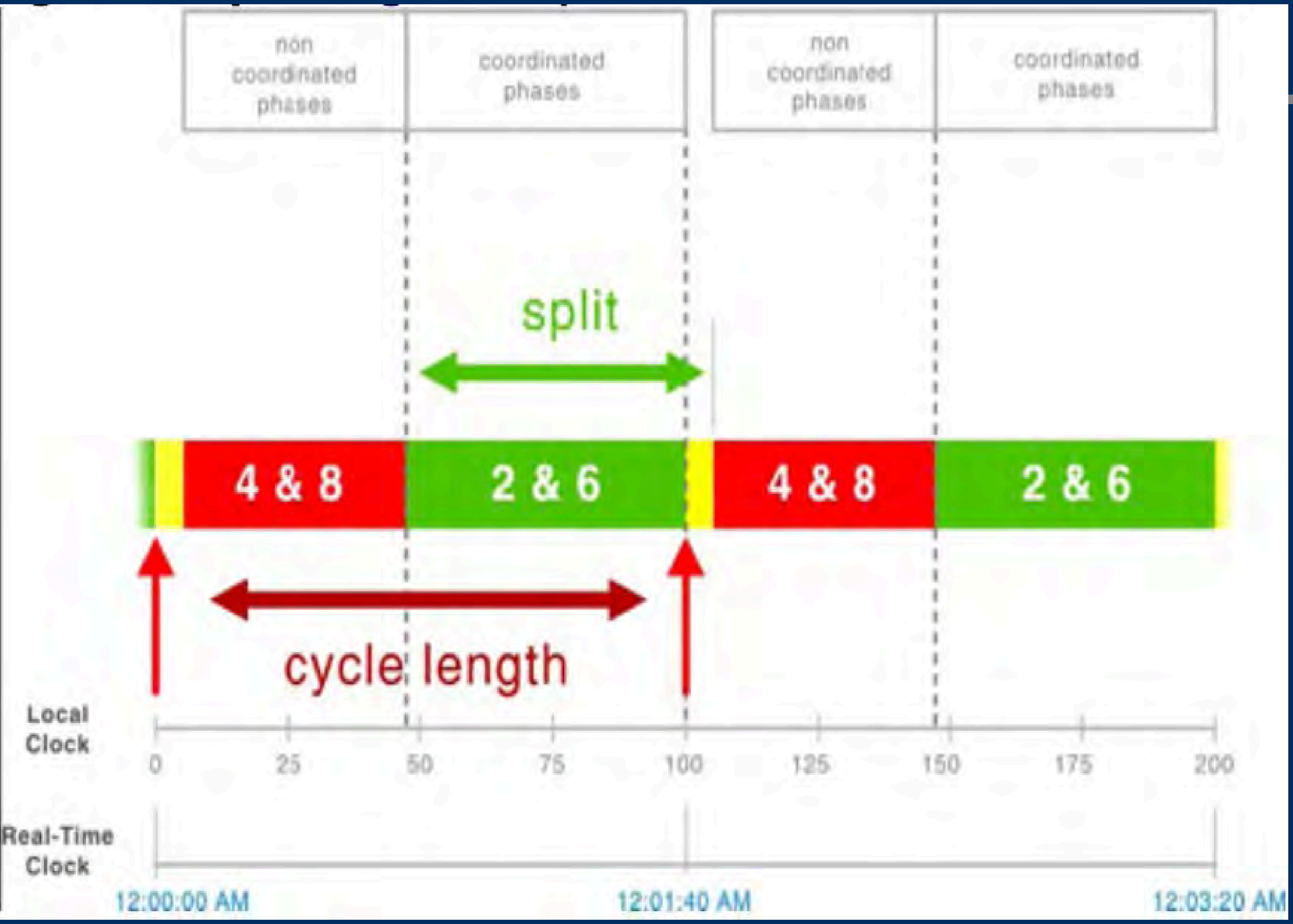
Time-Space Diagram of a Coordinated Timing Plan



A well-timed, coordinated system permits continuous movement along an arterial or throughout a network of major streets with minimum stops and delays, which, reduces fuel consumption and improves air quality.

The time-space diagram: Plots ideal vehicle platoon trajectories through a series of signalized intersections. The locations of intersections are shown on the distance axis (y), and time axis (x). Vehicles travel in both directions (in a two-way street).

Traffic Signal Timing Basics - 4

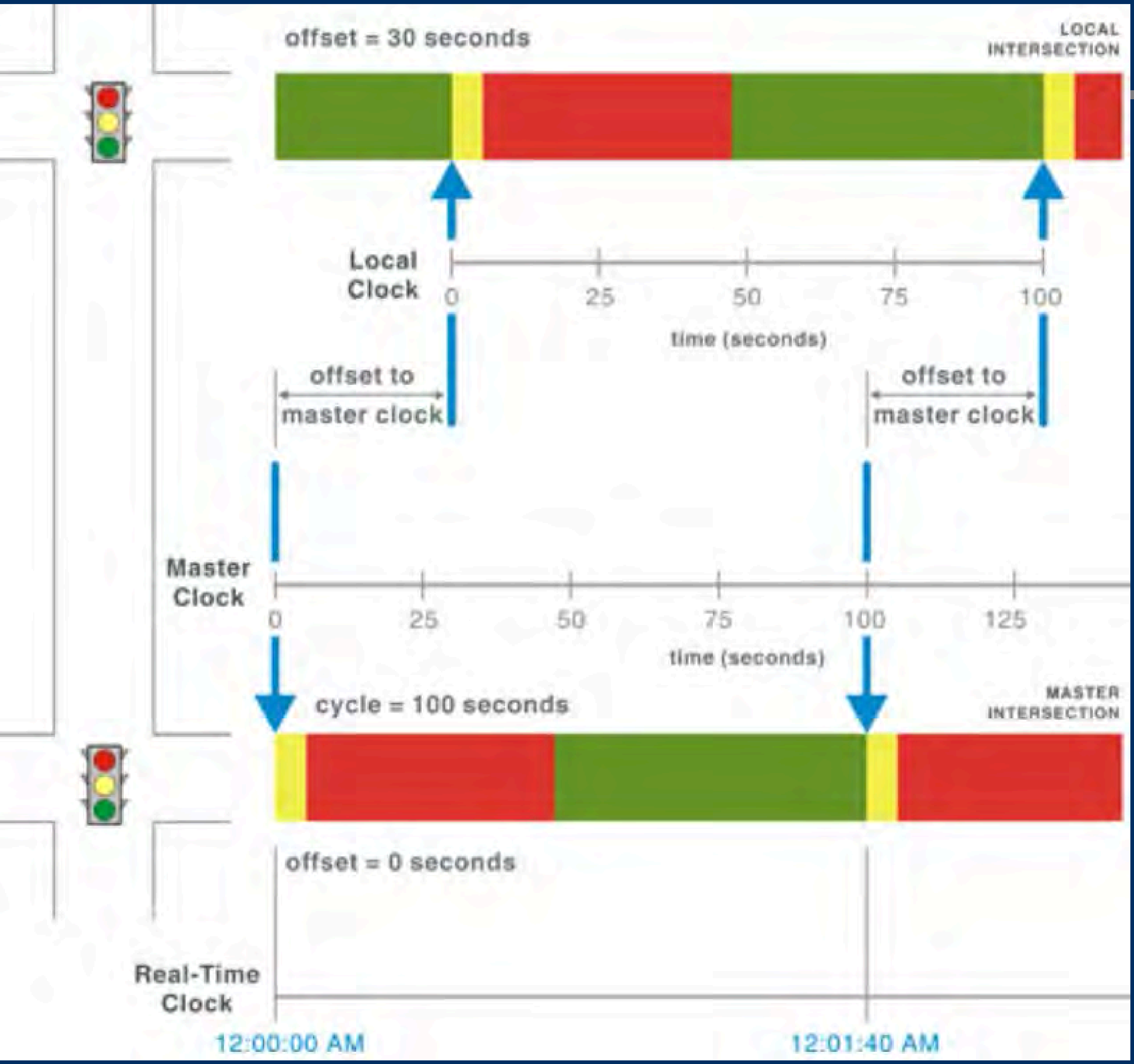


Within a *CYCLE*, SPLITS are the portion of time allocated to each phase at an intersection. These are calculated based on the intersection phasing and expected demand.

Splits can be expressed either in percentages of the cycle, or in seconds.

Split percentages typically include the yellow and all-red associated with the phase; as a result, the green percentage is less than total split for a phase.

Traffic Signal Timing Basics - 5

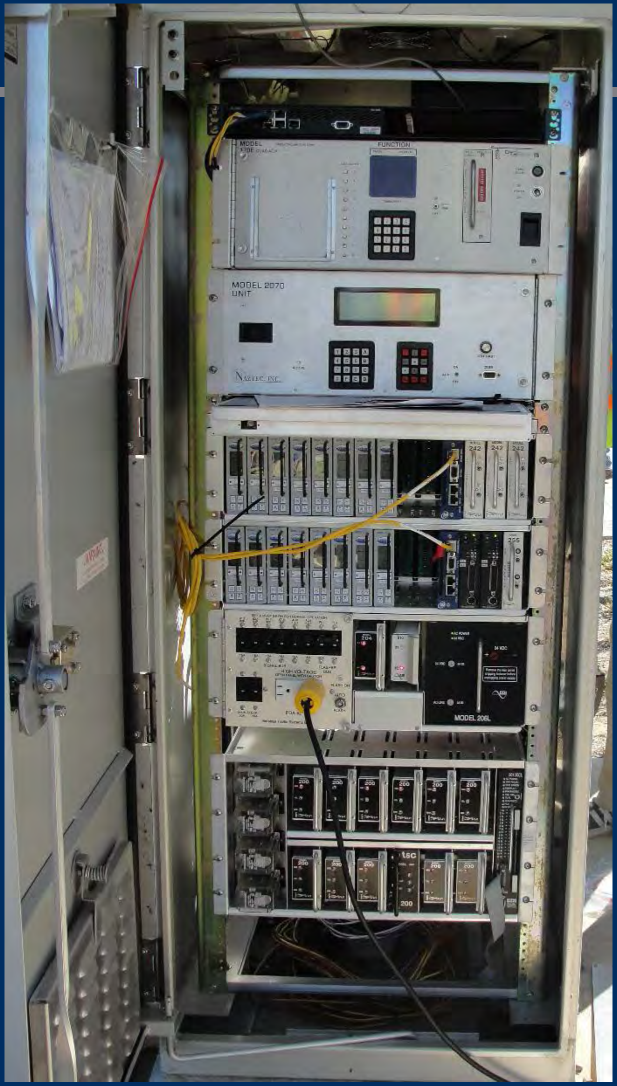


OFFSET: Defines the time relationship, expressed in either seconds or as a percent of the cycle length, between coordinated phases at subsequent traffic signals.

Offset: dependent on the ***offset reference point***, which is defined as the point within a cycle in which the local controller's offset is measured, relative to the master clock. *Reference point is different in NEMA and 2070 Models (next slide)*

The master clock is the background timing mechanism within the controller logic to which each controller is referenced, during coordinated operations.

Traffic Signal Timing Basics - 6



Type 332 Cabinet

Traffic Signal Controllers and Cabinets:

Model 170 & 2070

California 170/2070 Controller Standard: Defined by Caltrans. Including Model 170 and Model 2070. *Reference point at the start of the coordinated yellow*.

NEMA Standard: Defined by National Electrical Manufacturers Association. Including NEMA TS1 and TS2.. *Reference point at the start of the coordinated phase 2 and/or 6.*

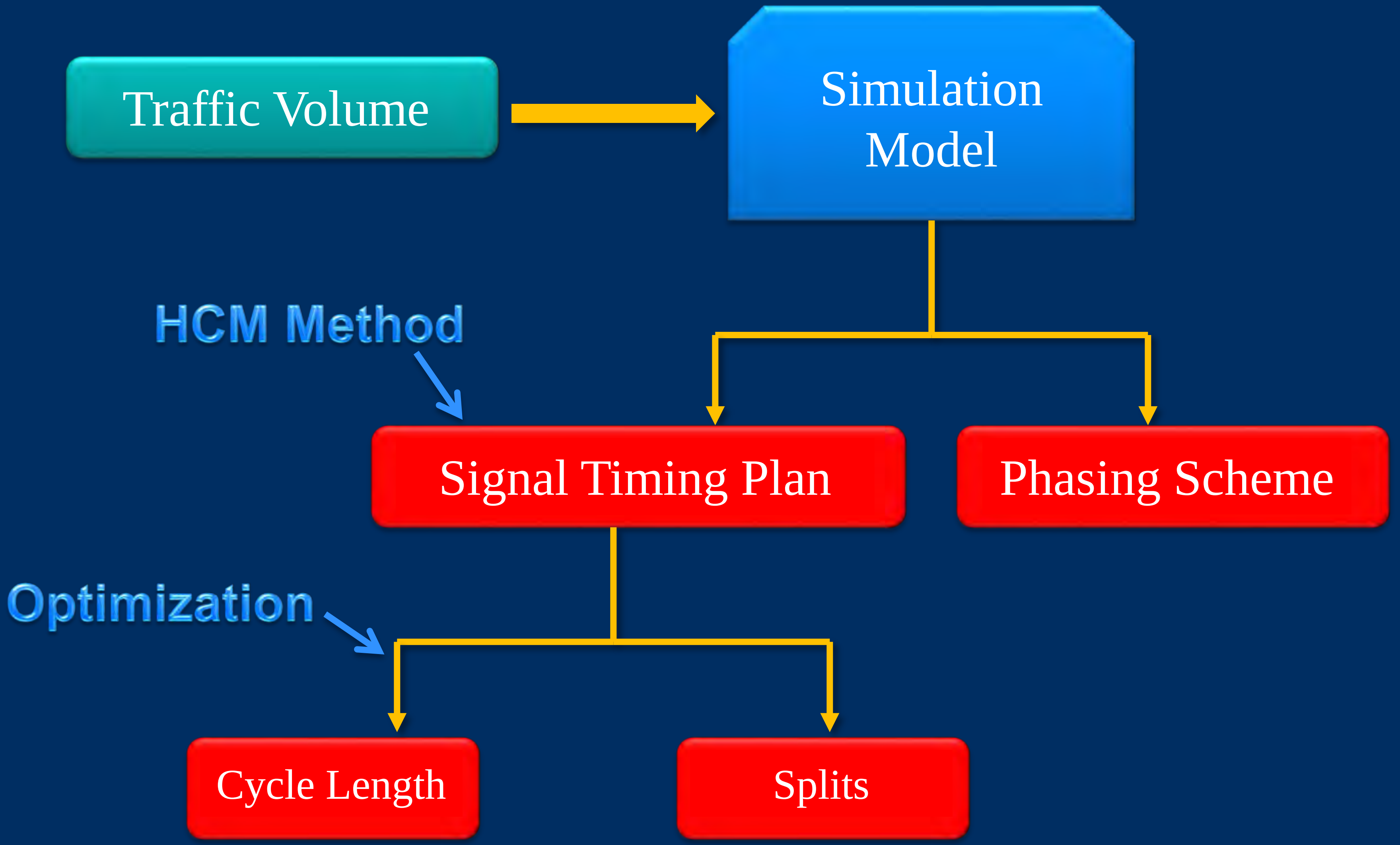
NEMA TS2

Traffic Signal Timing – State of the Practice

- **Data collection such as turning movement counts & vehicle speeds: not necessarily available or outdated.**
- **Need to determine when to run free mode vs. coordination mode (e.g., volume, distance).**
- **Two methods for signal timing development: empirical (manual/field) and software, e.g., off-line tool such as *Synchro* (**introduced in next slide**)**
- ***Empirical method* is time consuming and requires many years of field experience.**
- ***Software solutions* need careful reviews to meet operational objectives (e.g., bandwidth, delay).**
- **Limited field verification and fine-tuning.**

Synchro - *software application for optimizing traffic signal timing and performing capacity analysis*

Isolated Intersection

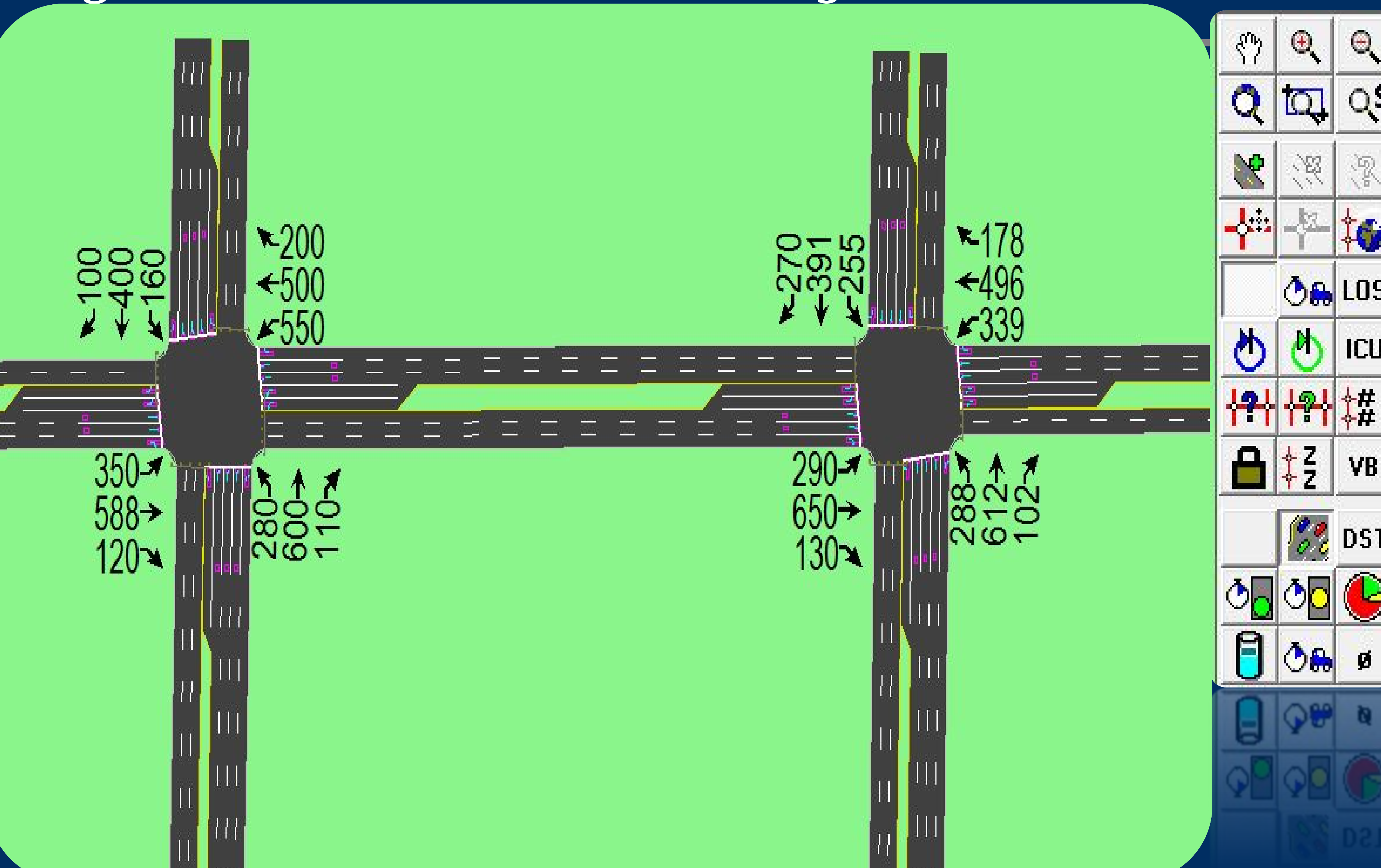


Synchro - *software application for optimizing traffic signal timing and performing capacity analysis*

Isolated Intersection

Synchro

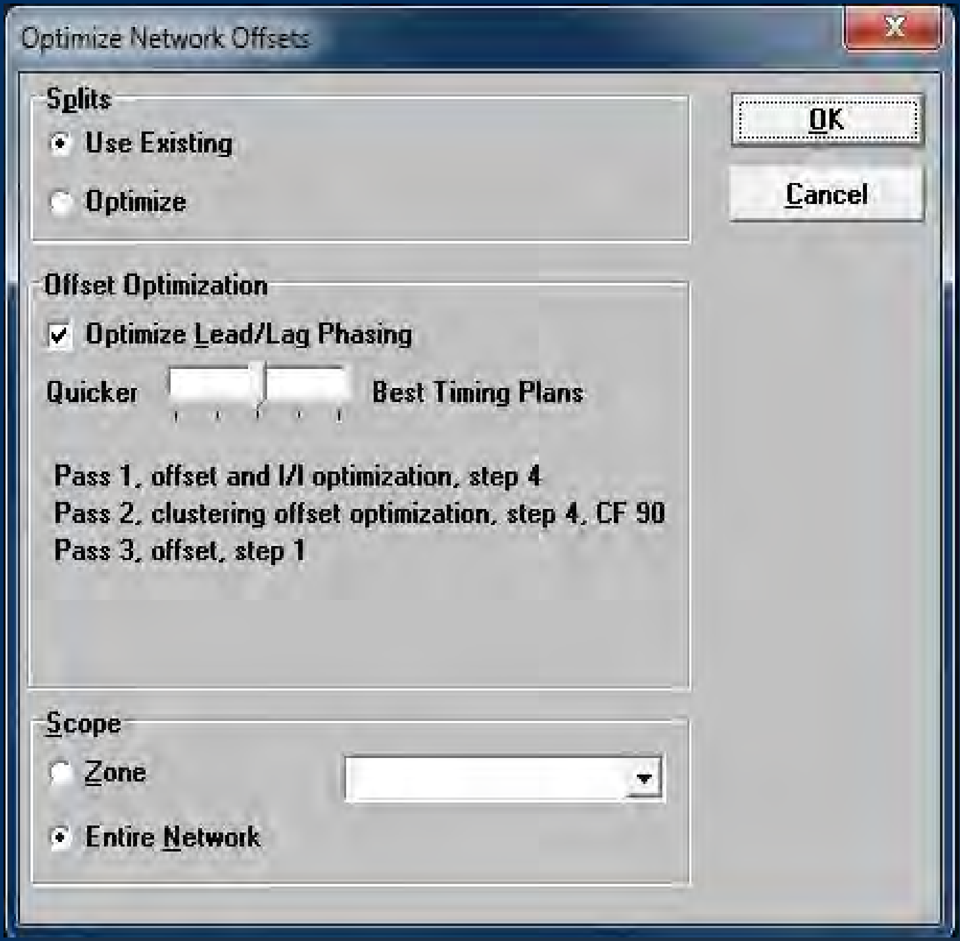
Signal Coordination – *2 or more signals*



Synchro

Signal Coordination Optimization

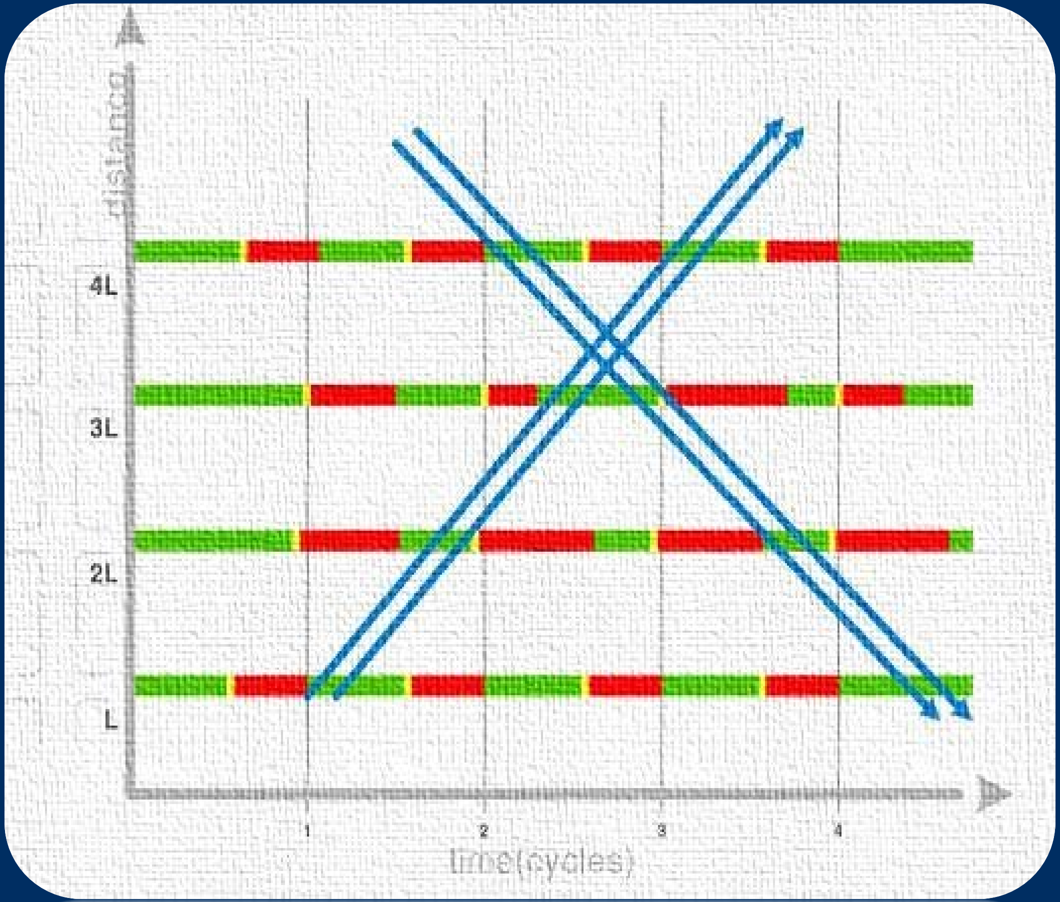
Performing Signal Timing Coordination By Optimizing Network Offset



Values Needed for Input:

Volumes, Fixed Timings, Cycle Lengths and Splits

Holy Grail *of efficiency and reduced driving stress is never (or at least seldom) stopping for a* ***traffic signal…***

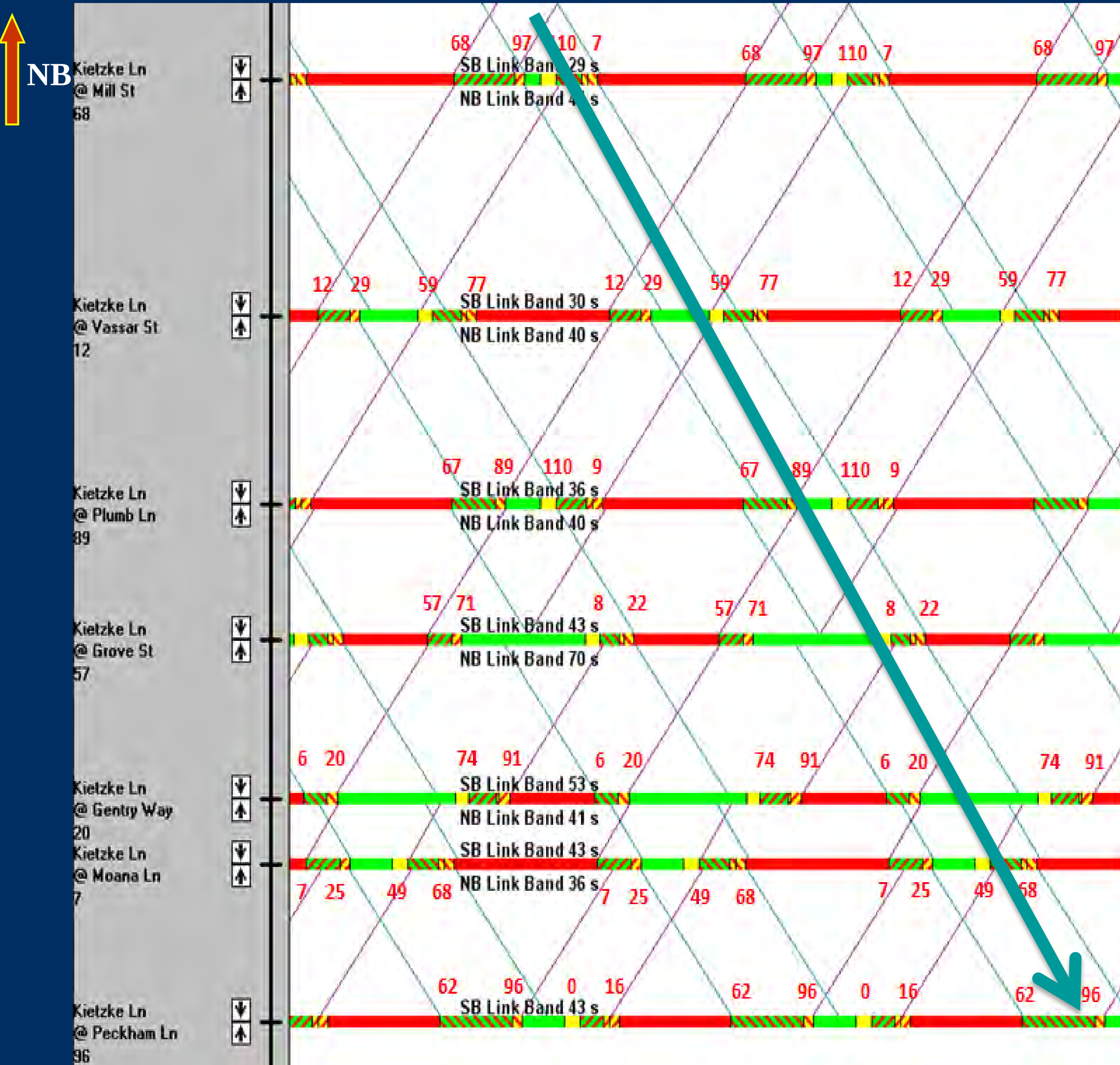


Truly Optimized ?

Offline tools

Limitations of Offline Signal Timing Tools

- Need extensive traffic volume data for optimization, every single update of a signal timing plan needs to update volume data
- Currently cannot easily perform real-time diagnosis and optimization/fine-tuning, *frequent field observation required*
- Cannot report ***performance measures*** tailored to agency needs (such as performance index-based: combination of: travel time, cycle length, number of stops, etc.)



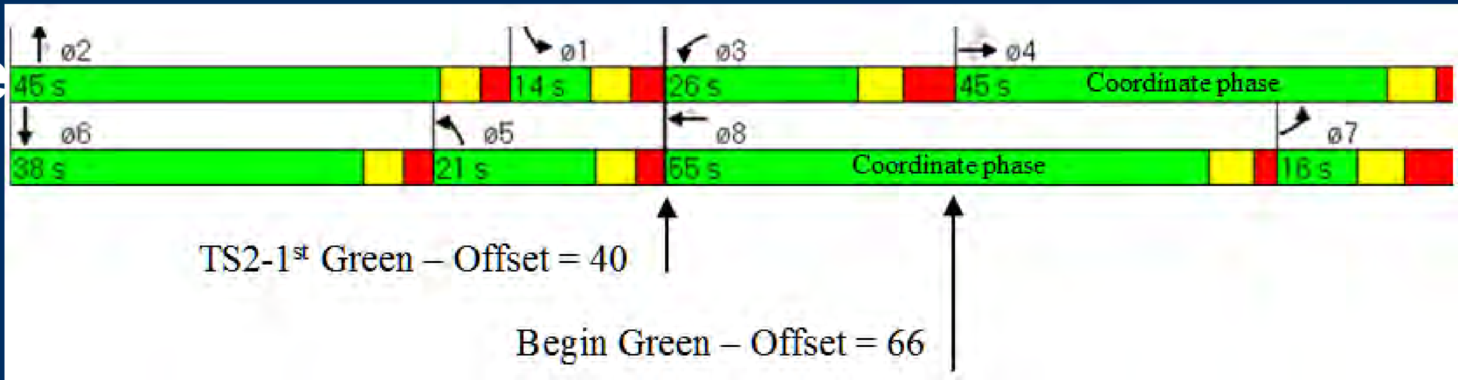
How to Achieve a Truly Optimized Timing Plan

*Vehicle remains inside **green** band – always gets green signal*

Real-world Challenges

- **Variable speeds**
- **Early releases** occurs when the side-street does not have enough traffic, and the green can terminate sooner, for main street green indication to begin earlier.
- **Wrong offset reference** (Offset Reference Point*:* defined point in a cycle that subsequent phases begin. For example, phases 1 and 5 terminate when clock time is 40 sec, for phases 3 and 8 to begin).
- **Signal out of coordination**
  - **Preemption**
  - **Pedestrians**
  - **Loss of Communication**
- **Clock time**

Drift or different controllers not on same clock time



The **TranSync** Mobile Tool

An easy-to-use iOS app for ***signal timing diagnosis*, *traffic progression evaluation*, *traffic signal timing verification*, and *bandwidth optimization*** functions

Bandwidth: the amount of green time available for vehicles to travel through a system at a determined progression speed. Each direction on the arterial street has its own bandwidth. Bandwidths in the same direction in a street can vary between adjacent signalized intersections.

finally a quantitative method to verify/validate improvement(s)

Diagnosis

- The tool functions as the *virtual signal controller* – it automatically reads existing signal timing plans into its database from a Traffic Management Center, or through manual input
- It runs exactly the same signal timing plan as that should be running in the field, thus diagnosis can be easily performed if inconsistency is found in the field.

The **TranSync** Mobile Tool

Progression Evaluation

- ***It utilizes the built-in GPS function of the mobile device to record vehicle's movement and develop movement trajectory (fix redundancy)*** **The *real-time* vehicle trajectory is automatically plotted onto the time-space diagram for real-time evaluation of traffic progression vehicle's GPS trajectory**

Signal Timing Verification

- **The validity and performance of a new signal timing plan can be easily examined in the field**

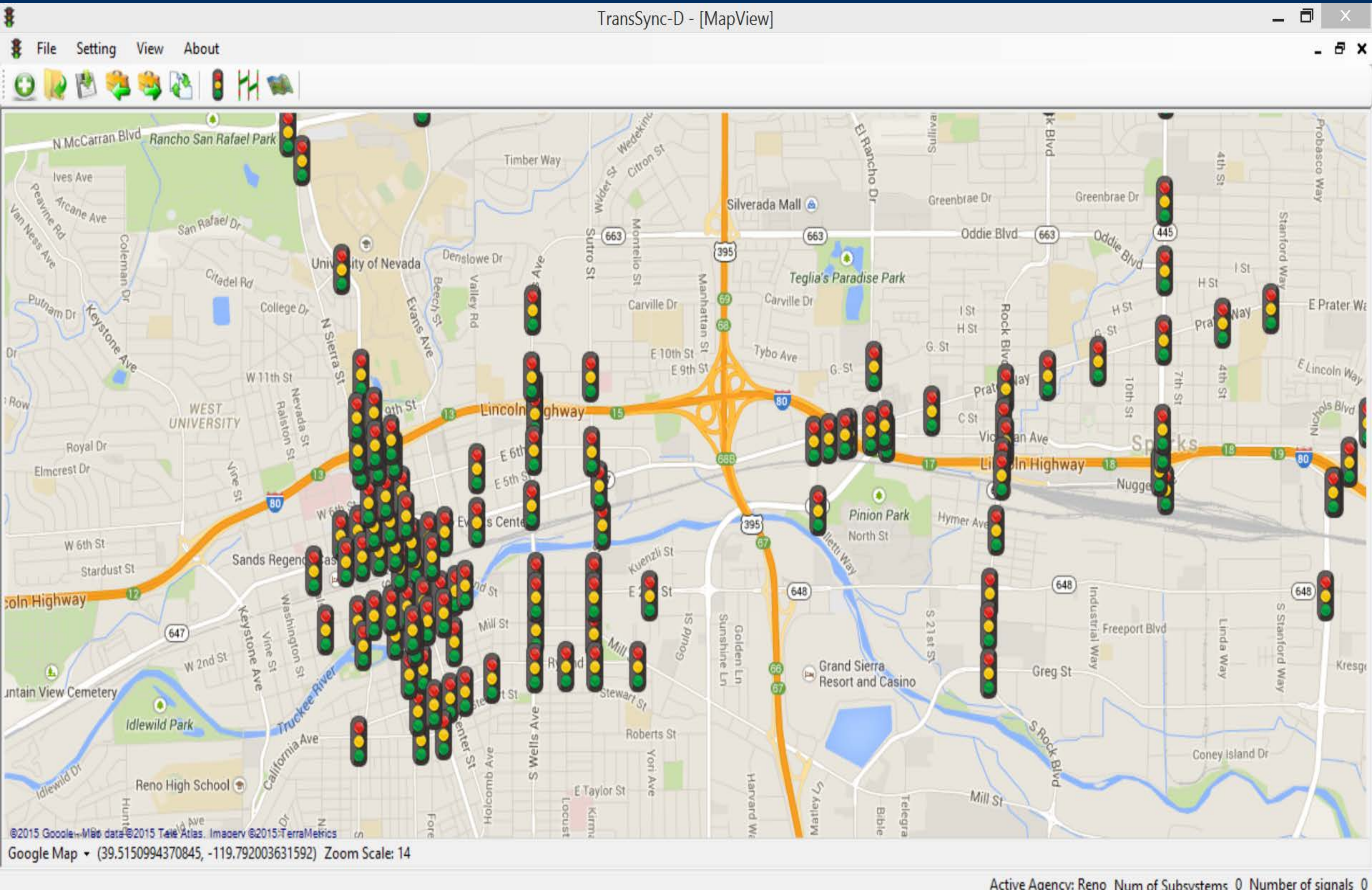
The **TranSync** Mobile Tool

Bandwidth Optimization

- **The bandwidth can be adjusted and optimized onsite directly through TranSync-M (mobile tool), or**
- **Can be optimized in TranSync-D, the tool's desktop version**
- **The Desktop version** *(next slide)* **is mainly for traffic signal management and optimization of large scale networks/corridors**

Notes

- NOT **intended for general public for navigational assistance**
- **Trans-Intelligence LLC is the developer and owns the software code (patent in process)**

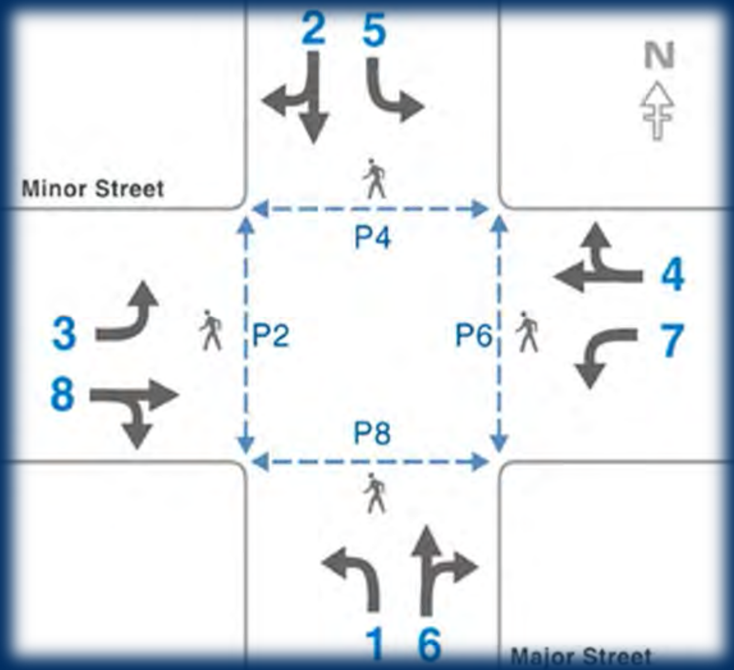


Map Display on iPad (Auburn, Calif.)

Virtual Real-time Signal Display

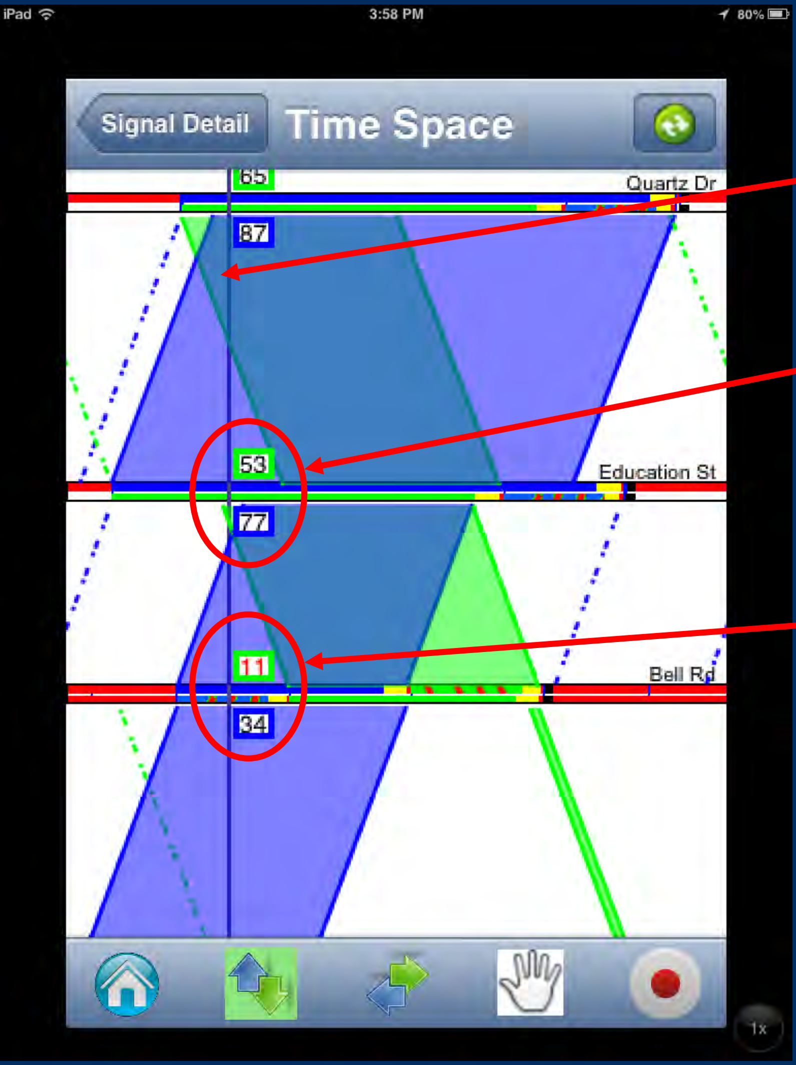
iPad display:

Phases 1 and 6 have 12 sec remaining in green



Basic phases for 4-leg intersection

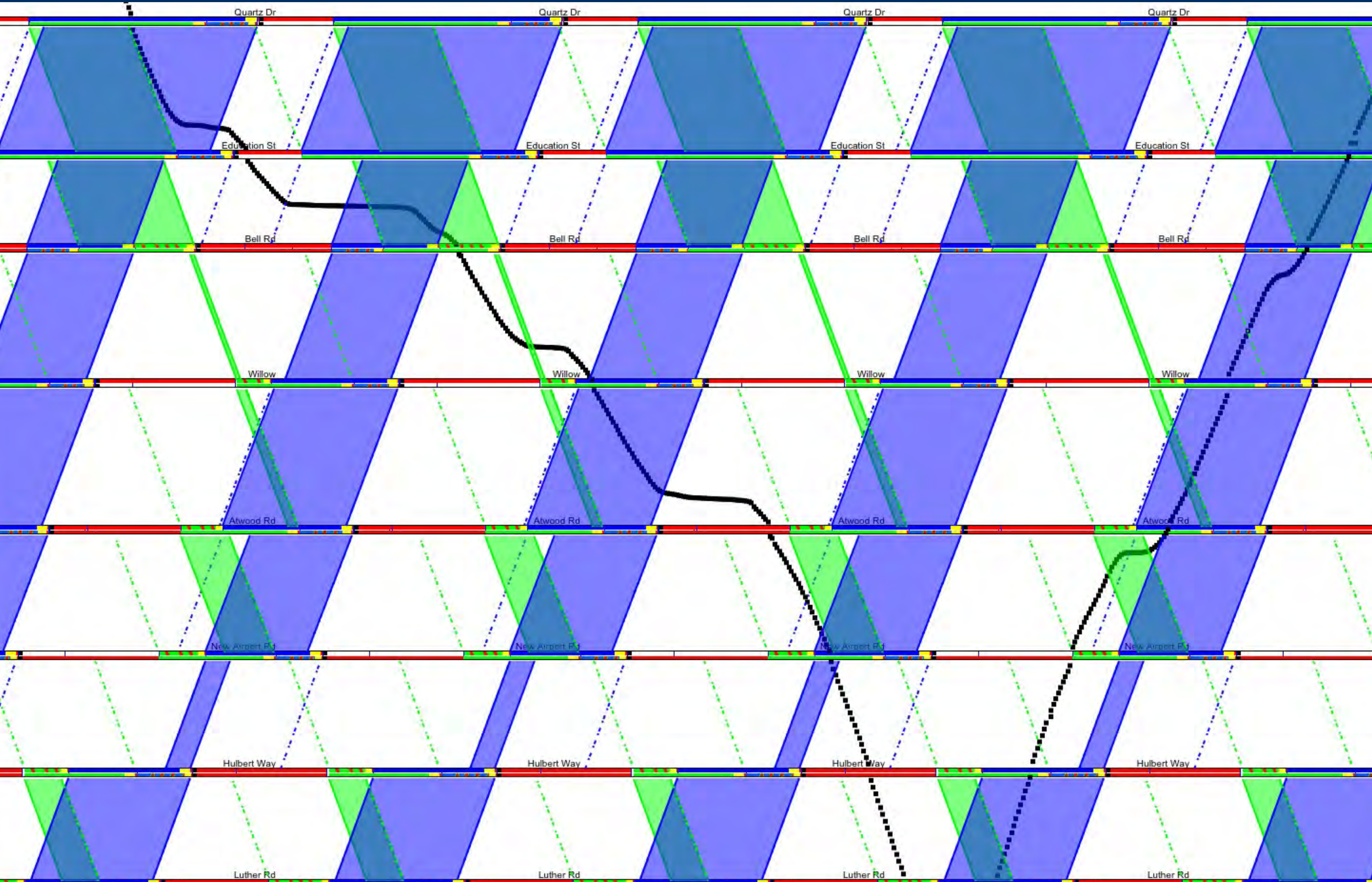
Real-time Dynamic Time-space Diagram



Current time in cycle

NB (blue band) has 77 sec remaining, and SB (green band) has 53 sec remaining

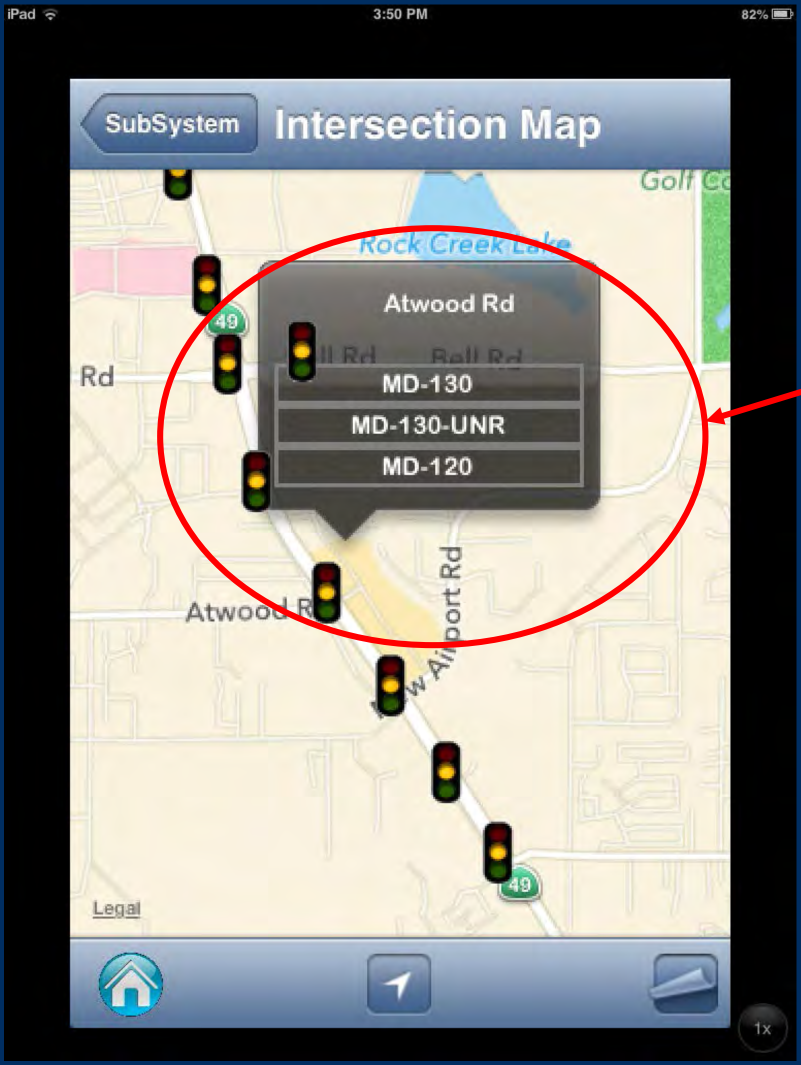
NB (blue band) has 34 sec remaining, and SB (green band) has no more than 11 sec to turn green



***Time** (x axis) **Space** (y axis) **Diagram**: Vehicle travels, shown in **black**, first SB (downward) then NB direction (upward).*
Ideal/Optimum : vehicle travels inside green (SB) and blue (NB) bands.

Horizontal portions reflect vehicle stops.

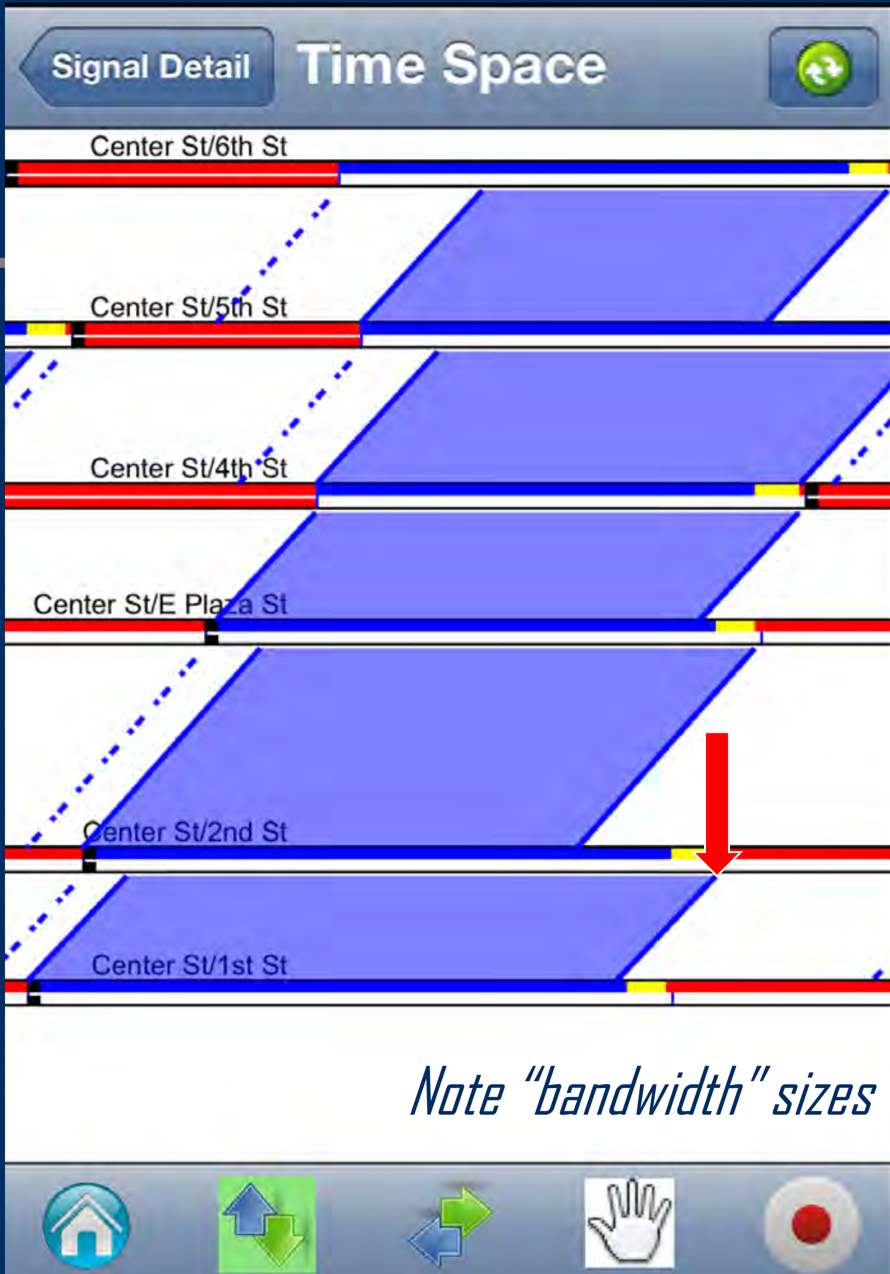
Map View

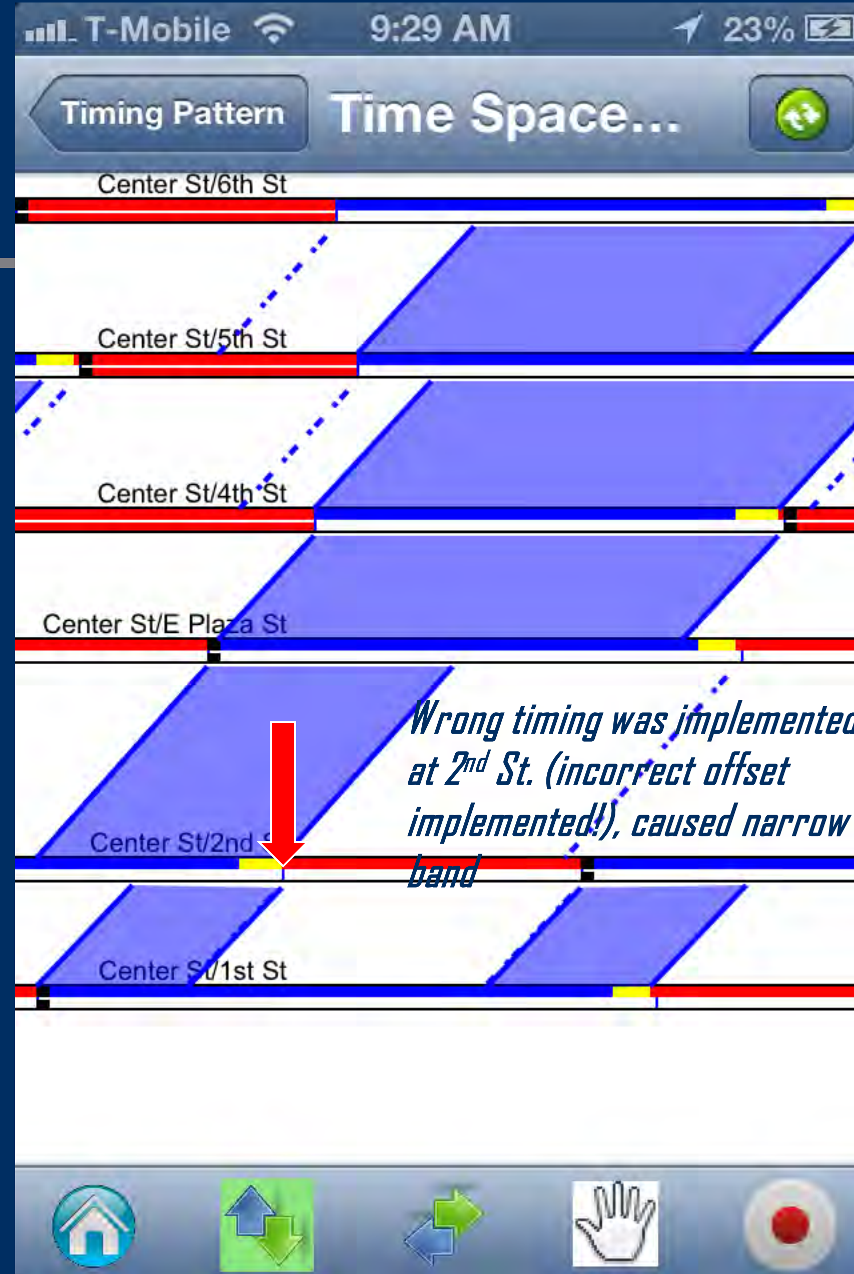


Map view

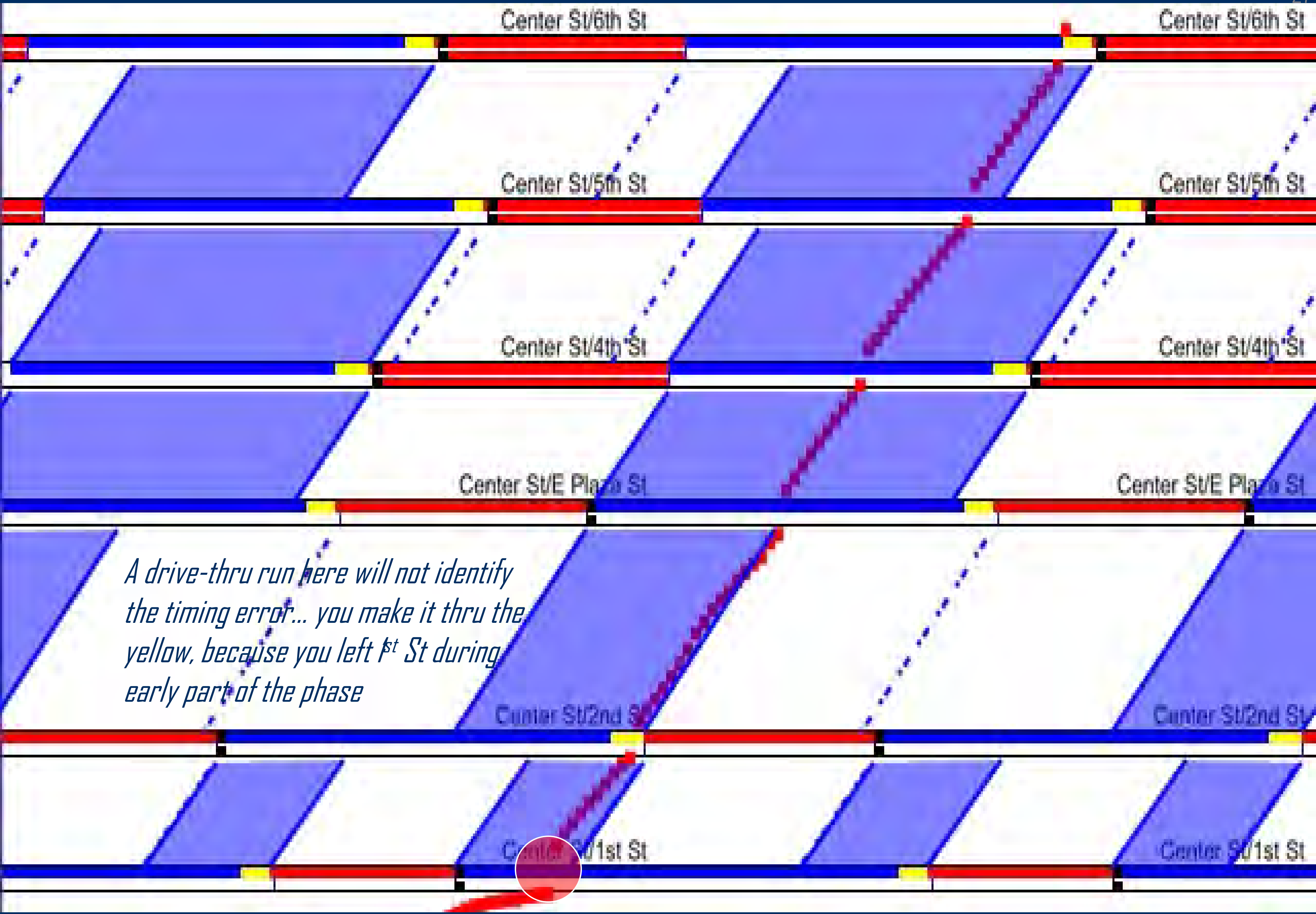
Auburn, California
Caltrans District 3, Hwy 49

Population: 13,410





Real-time iPAD display as vehicle travels through corridor.

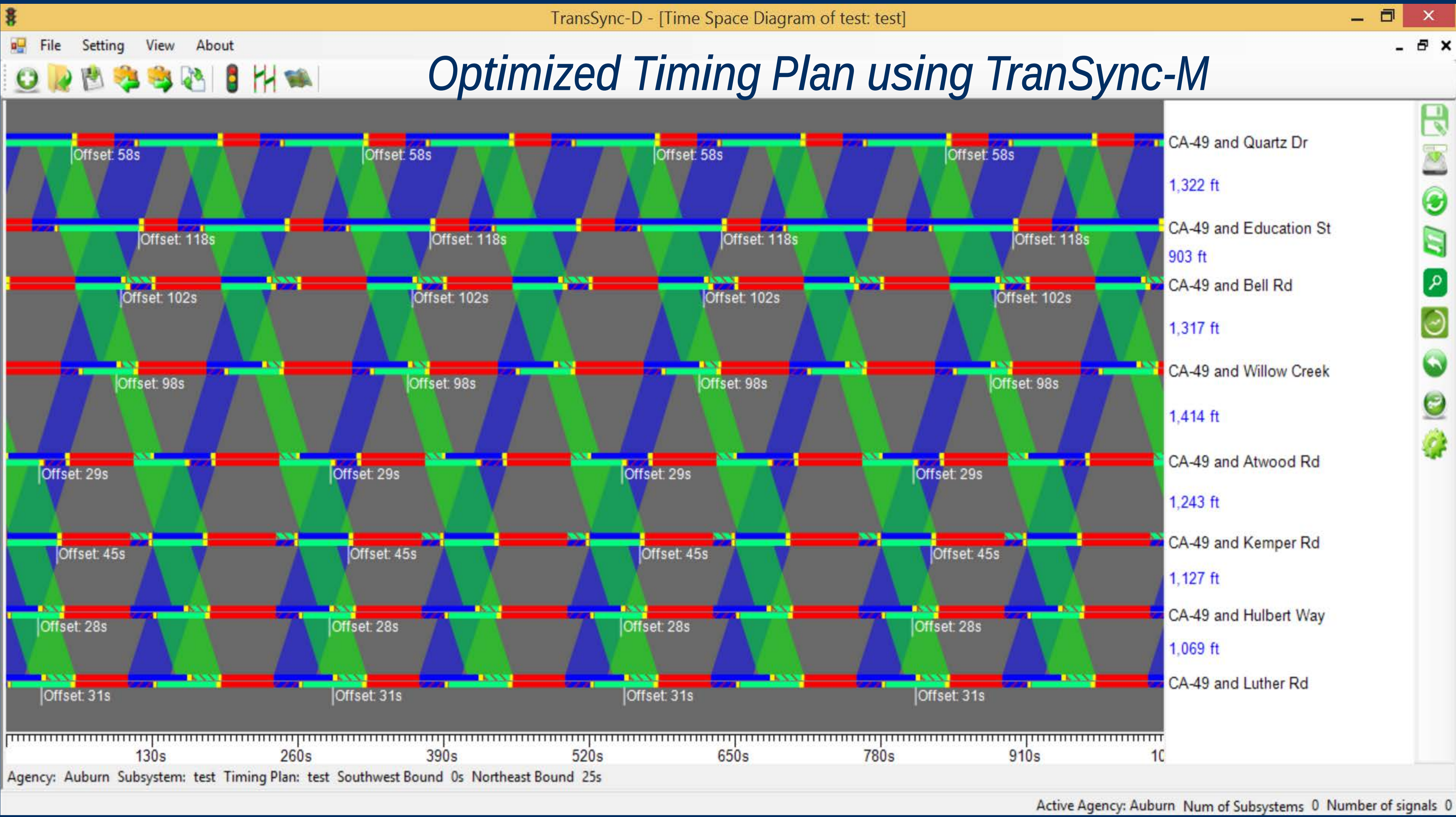


Time-Space diagram rich information: Has signal timing been set properly?

Case Demo – CA Hwy 49
BEFORE

Case Demo – CA Hwy 49
AFTER

Total Corridor Time-Space Diagram: Auburn (Hwy 49)



Cost Savings* – CA Hwy 49 Auburn, CA

- AADT = 40,000; SB direction = 17,000 between 6 am – 6 pm
- Segment = 1.7 miles
- ***Time savings:*** 2.0 min per trip; 2.0*17,000 ≈ 560 hrs ≈ $6,500/day
- ***Fuel savings:*** 600 gallons/day*$2.5/gal ≈ $1,500/day

  (Note: gas price in reference 2 adjusted to the current cost)
- ***Total annual savings:*** $2.92 million = $146/person/year
- ***Emission reductions:*** 22 tons
- **B/C ratio = $2,920,000/$25,000 = 117:1**

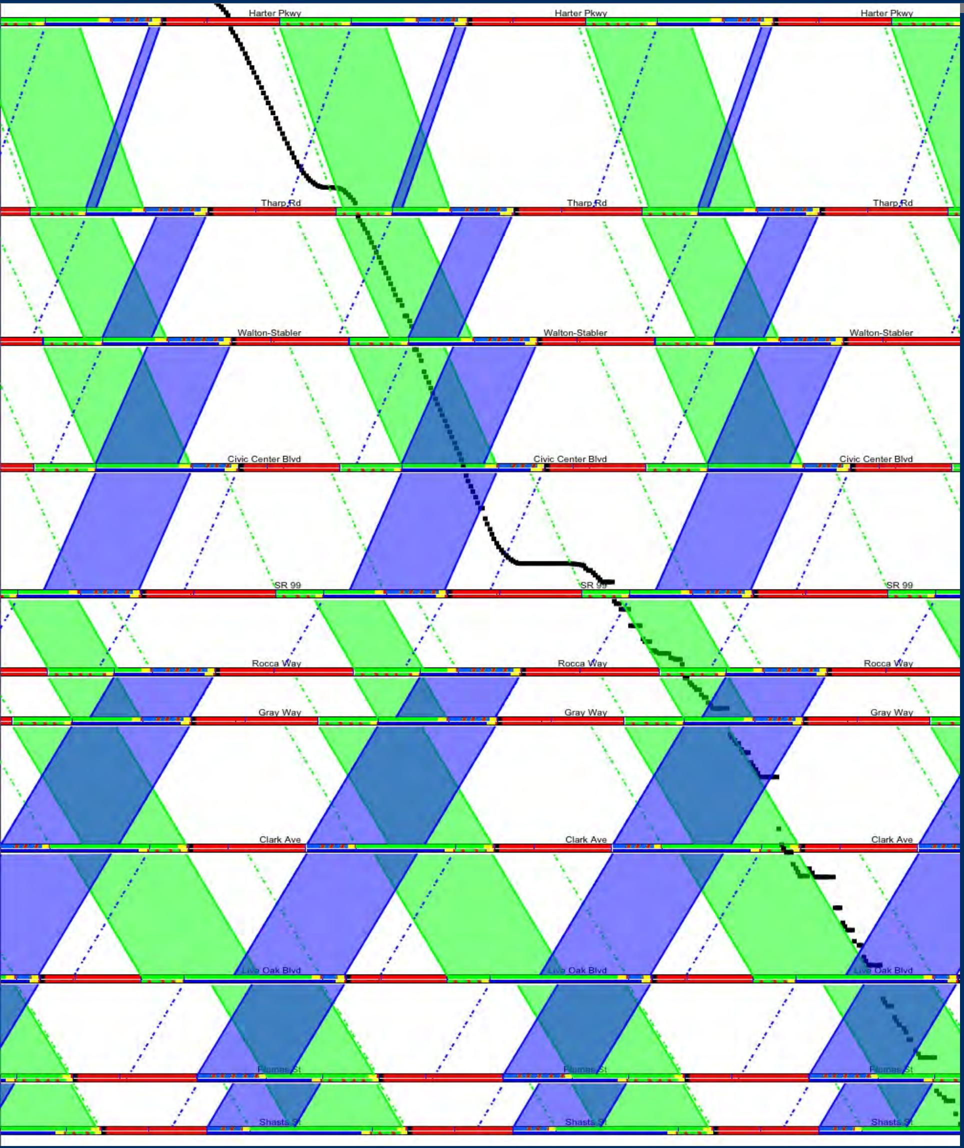
* 1) **US DOT: Revised Departmental Guidance for the Valuation of Travel Time in Economic Analysis, 2011** assuming all traffic are passenger cars, no commercial vehicles (for more conservative estimate), $2.50/gallon (vs. Caltrans 2012 standard of $3.70/gallon)

2) **Caltrans: Life-Cycle Benefit-Cost Analysis Economic Parameters 2012**

Cost Savings – McCarran Blvd Reno, NV

- **AADT = 40,000; SB direction = 15,000 between 7 am – 7 pm**
- **Segment = 1.0 miles**
- ***Time savings:* 1.0 min per trip; 1.0*15,000 ≈ 250 hrs ≈ $3,000/day**
- ***Fuel savings:* 350 gallons/day*$2.5/gal ≈ $875/day**
- ***Total annual savings:* $1.4 million = $70/person/year**
- ***Emission reductions:* 13 tons**
- **B/C ratio = $1,400,000/$15,000 = 93:1**

Yuba City – CA Hwy 20

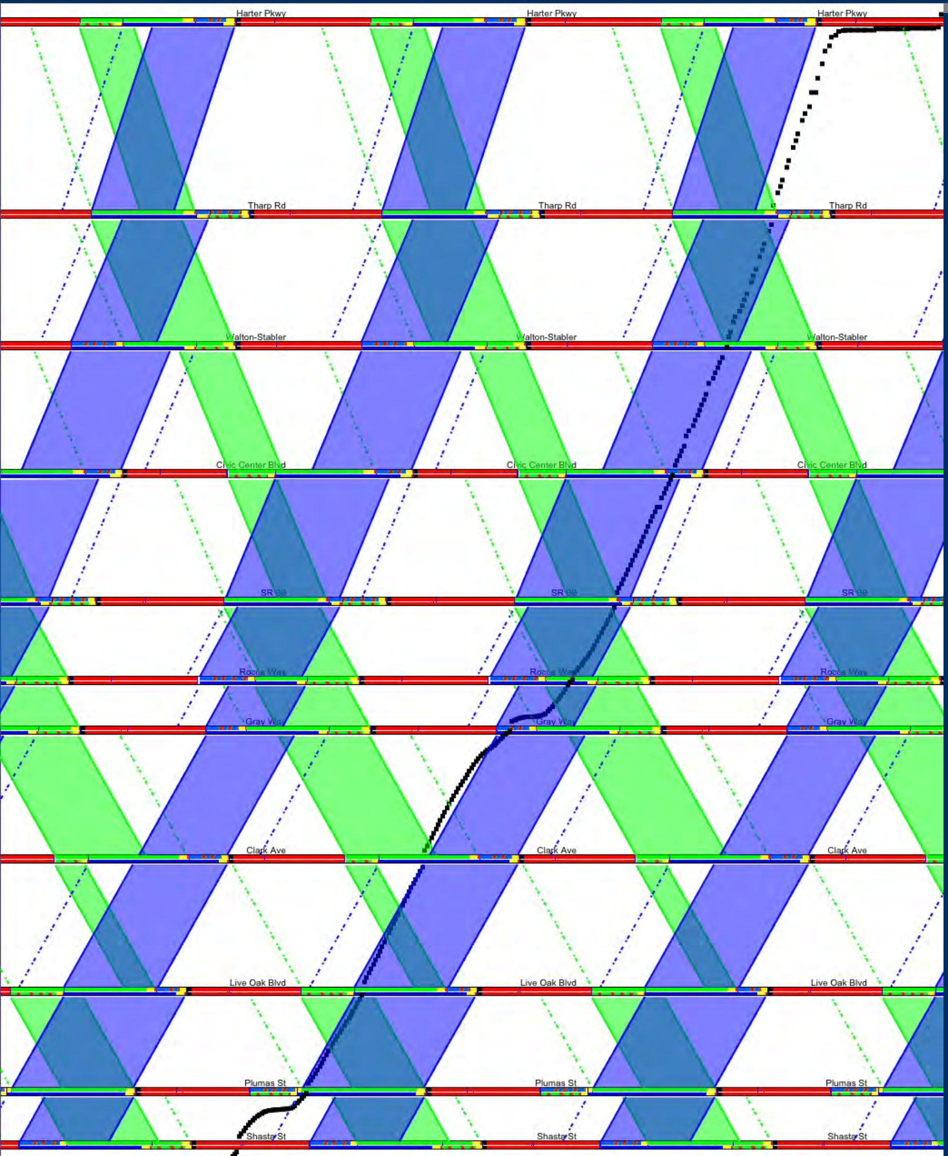


"Before" *130-sec cycle*: pretty good run with high volume and lower traffic speeds. Both directions need to stop at SR Hwy 99.

(green band: EB direction)

Population: 65,569

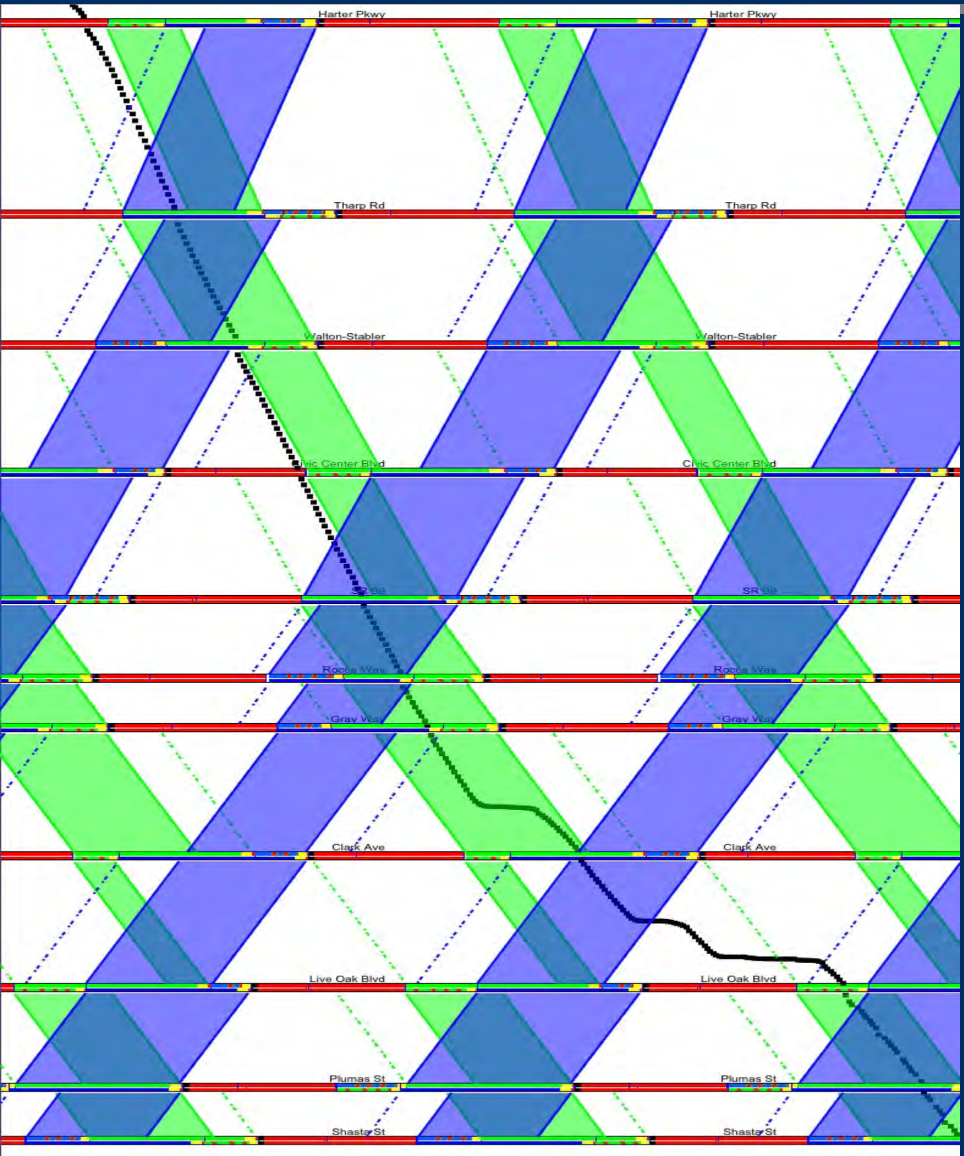
Yuba City – CA Hwy 20



"AFTER" with Trans-Sync
130-sec cycle:
Only one stop at the end

(blue band: WB direction)

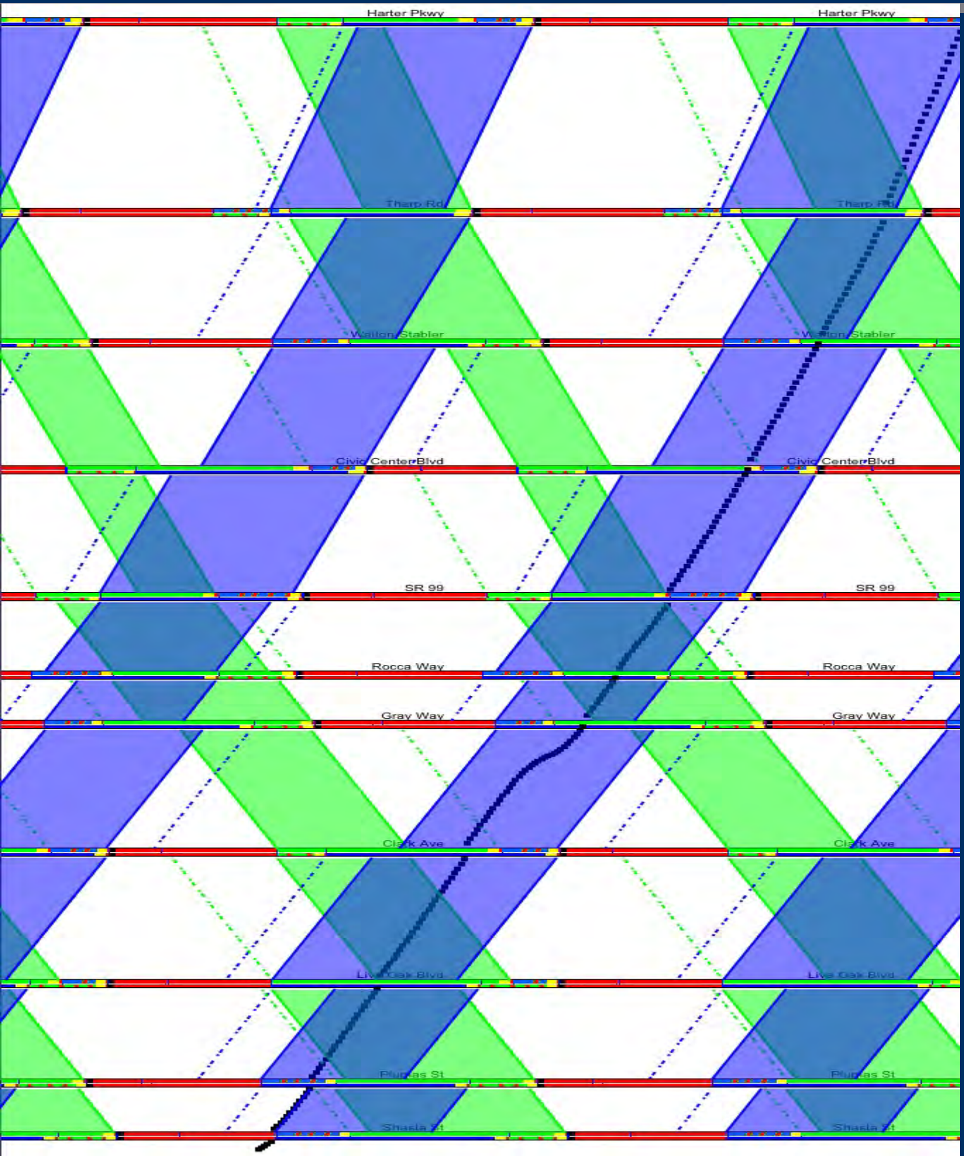
Yuba City – CA Hwy 20



"AFTER" with TranSync - *130 sec cycle*: Only one stop at Live Oak

(green band: EB direction)

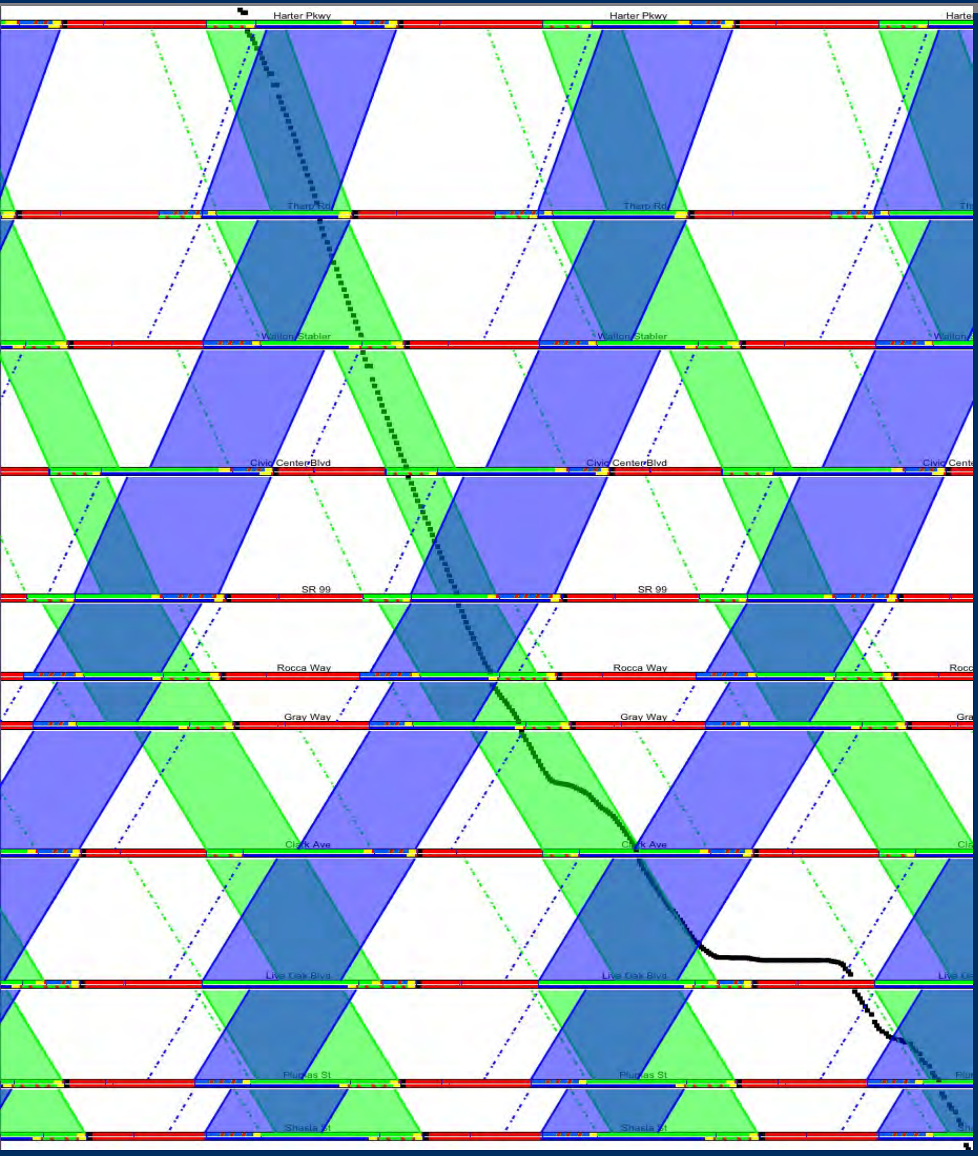
Yuba City – CA Hwy 20



"AFTER" with TranSync *140-sec cycle*: No stops when vehicle able to maintain close to speed limit

(blue band: WB direction)

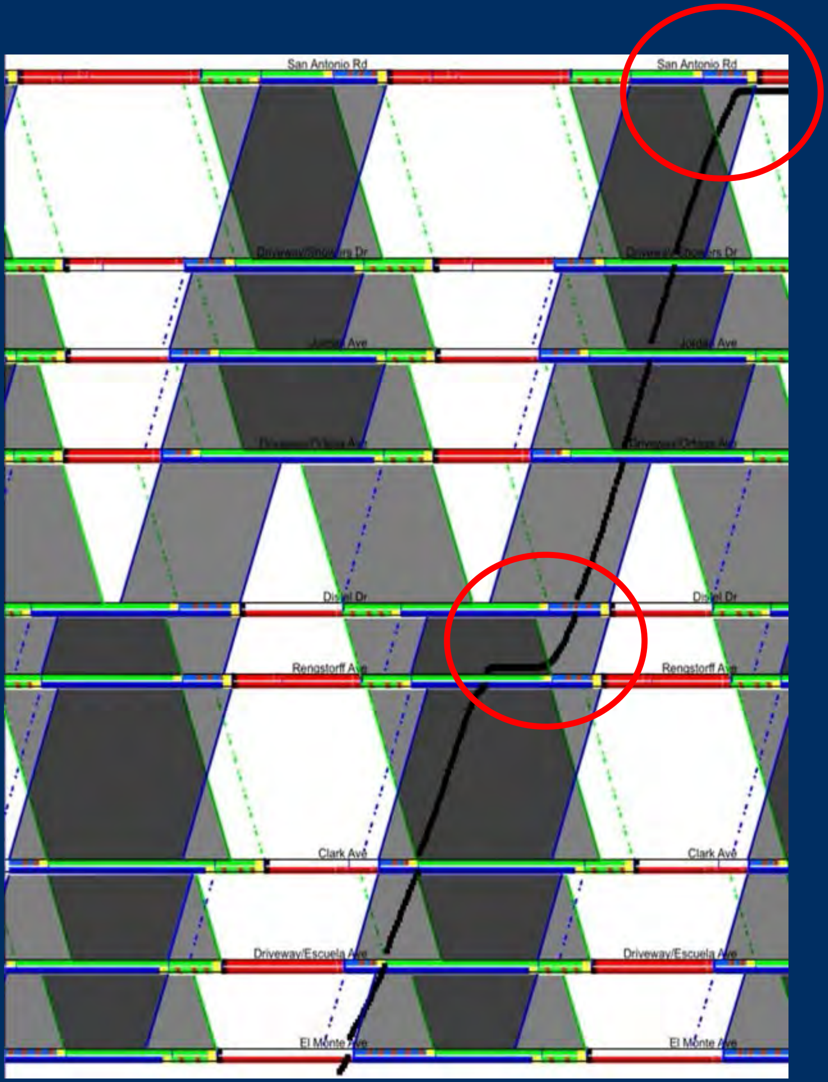
Yuba City – CA Hwy 20



"AFTER" with TranSync
140-sec cycle:
Typically one (1) stop either at Live Oak or Plums.
There is a possibility of going through, if speed can be maintained

(green band: EB direction)

CA Hwy 82: Mountain View *El Camino Real*



Mountain View population: 77,191

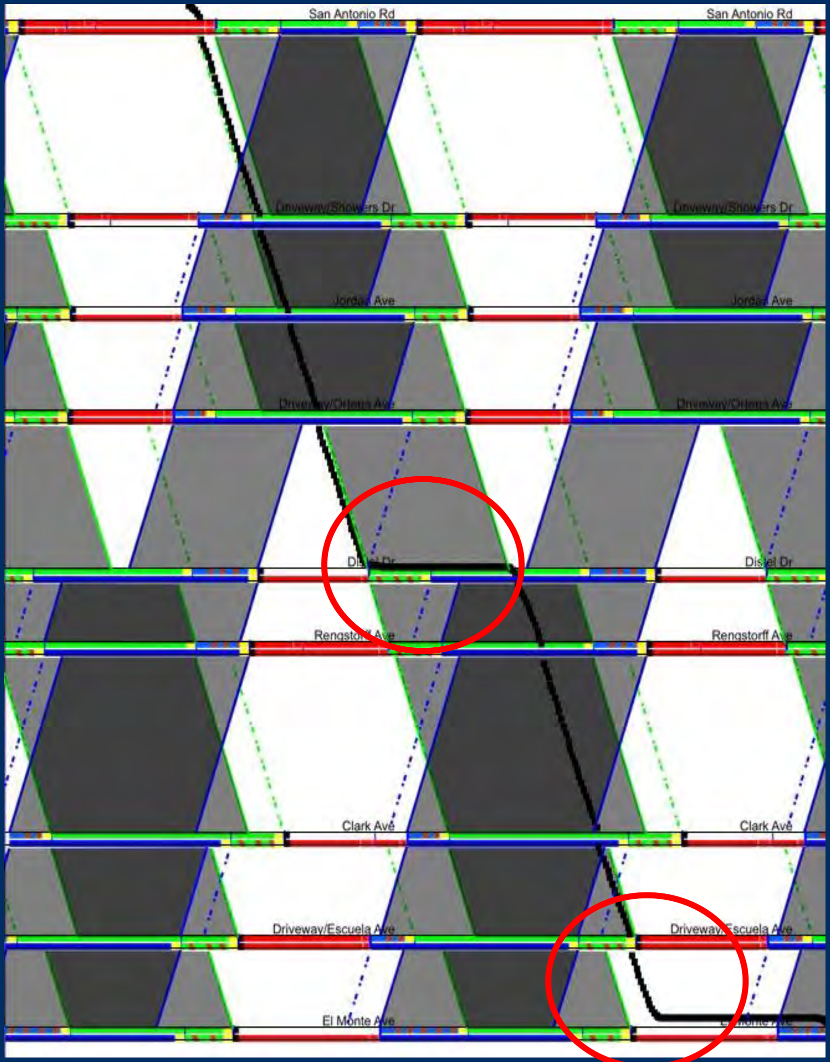
Timing error diagnosis

AM 180-sec cycle:

The diagram shows the optimized timing plan that is supposed to provide non-stop progression for both directions.

But, the timing error at Diesel Dr. caused stops at both Diesel Dr. & San Antonio Rd. (WB trajectory)

Mountain View – El Camino Real

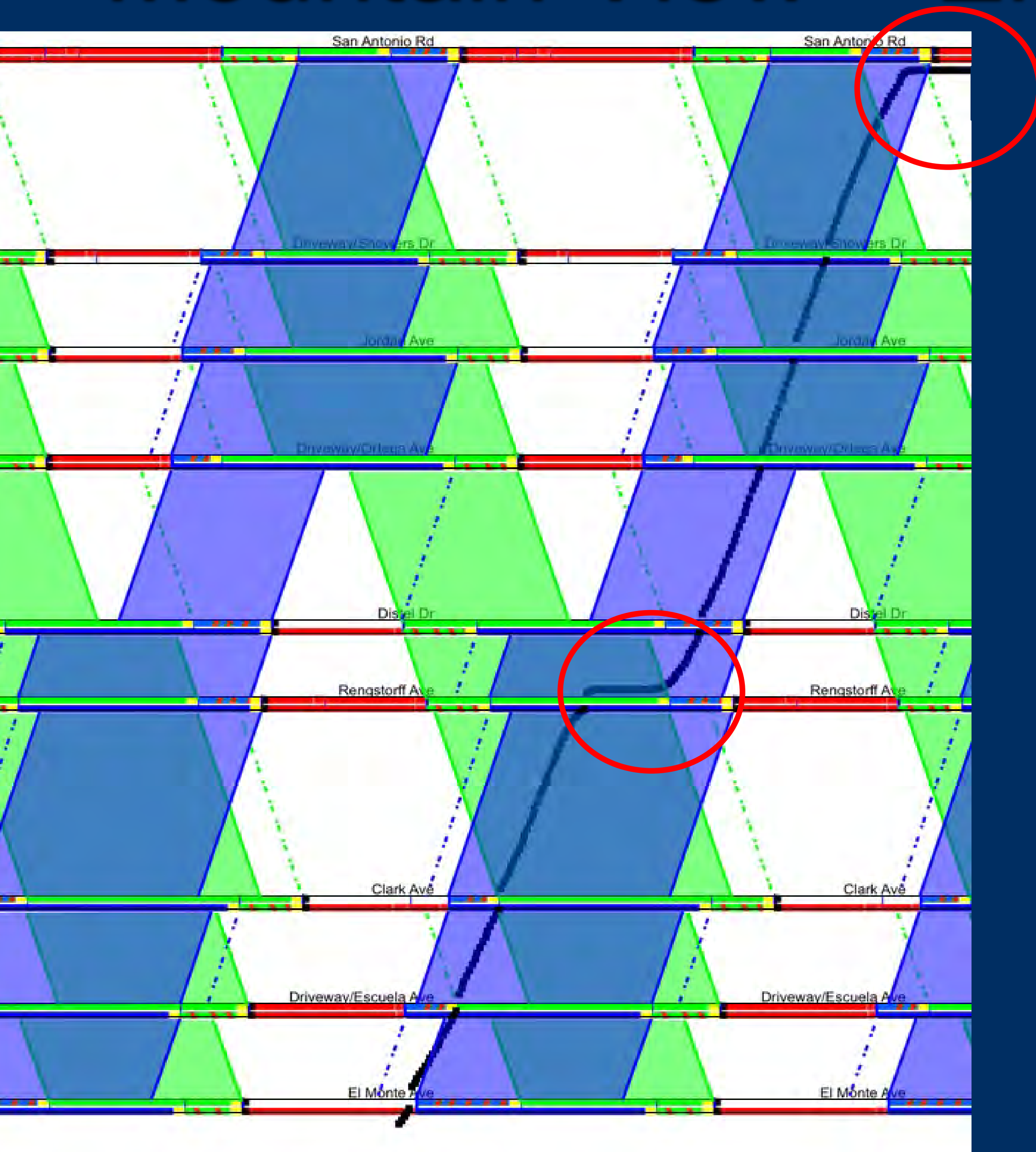


Timing error diagnosis

AM 180-sec cycle:

Timing error at Diesel Dr. causing stops at both Diesel Dr. & El Monte Ave. (EB trajectory)

Mountain View – El Camino Real

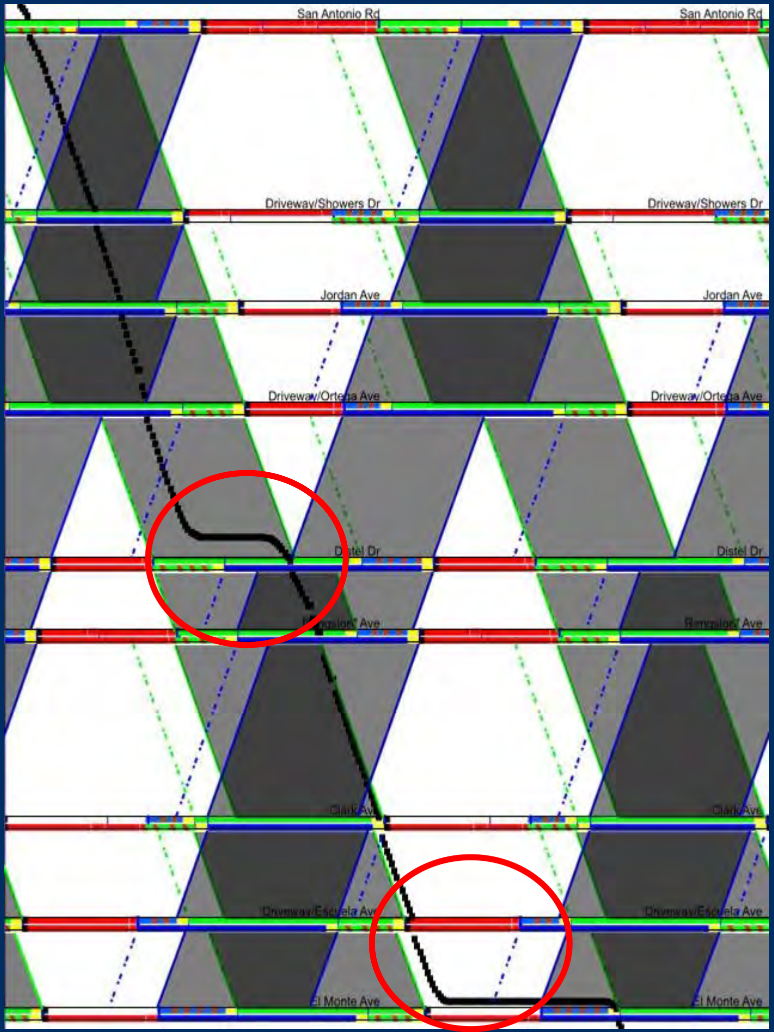


Timing error diagnosis

PM 150-sec cycle:

Timing error at Diesel Dr. causing stops at both Diesel Dr. & San Antonio Rd. (WB trajectory)

Mountain View – El Camino Real



Timing error diagnosis

PM 150-sec cycle:

Timing error at Diesel Dr. causing stops at both Diesel Dr. & El Monte Ave. (EB trajectory)

***Solution** (5/4/15):District operations staff reviewed whether defective signal interconnect or non-functioning GPS clock; offset timing was found to be OFF from Master location: 30sec ahead at 1 location, and 22 sec behind at another; 2 other locations 4 sec behind. District 4 grateful for useful tool.*

Who Did What

- Dr. Zong Tian (University of Nevada Reno, UNR) originally developed the idea of using mobile tools for signal timing diagnosis
- Dr. Hongchao Liu, VP of Trans-Intelligence (and Texas Tech University), and Dr. Zong Tian supervised the development of TranSync
- Dr. Hao Xu (UNR) and Dr. Dali Wei (Post-Doc UC Davis) are the lead software developers
- M. Styer saw presentation at ITS meeting and requested demo & pilot projects for Caltrans.
- *Tran-Intelligence owns TranSync (Patent Pending)*

Where we are

- TranSync-M and TranSync-D: Mobile and Desktop version
- Field tests conducted in cities in California, Texas, and Nevada
- US and China patents pending
- Commercially available on September 1st, 2015 (cost TBD)
- Android version will be developed in the future

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Questions?