Algorithms, AI and Signal Timing

ITS Texas Annual Meeting

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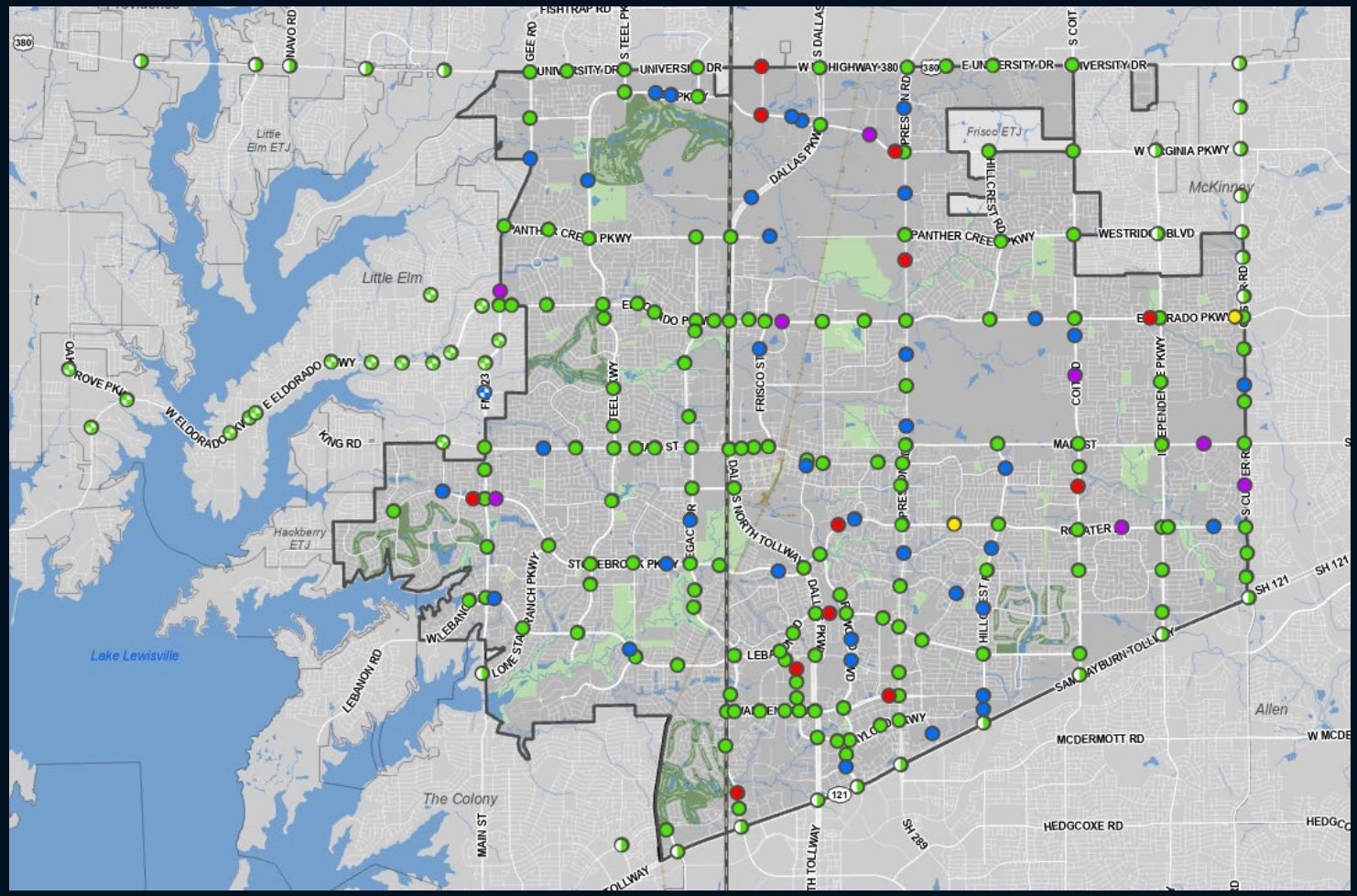
November 21, 2025

Frisco Signal System

- 2025 Pop Est – 242,000
  - Fast Growth
  - Best Place to Live
  - Sports City
- Operate 174+ traffic signals
- Controllers
  - 89% ATC – Cubic/Trafficware
- Cameras – PTZ & Fixed
  - 800+



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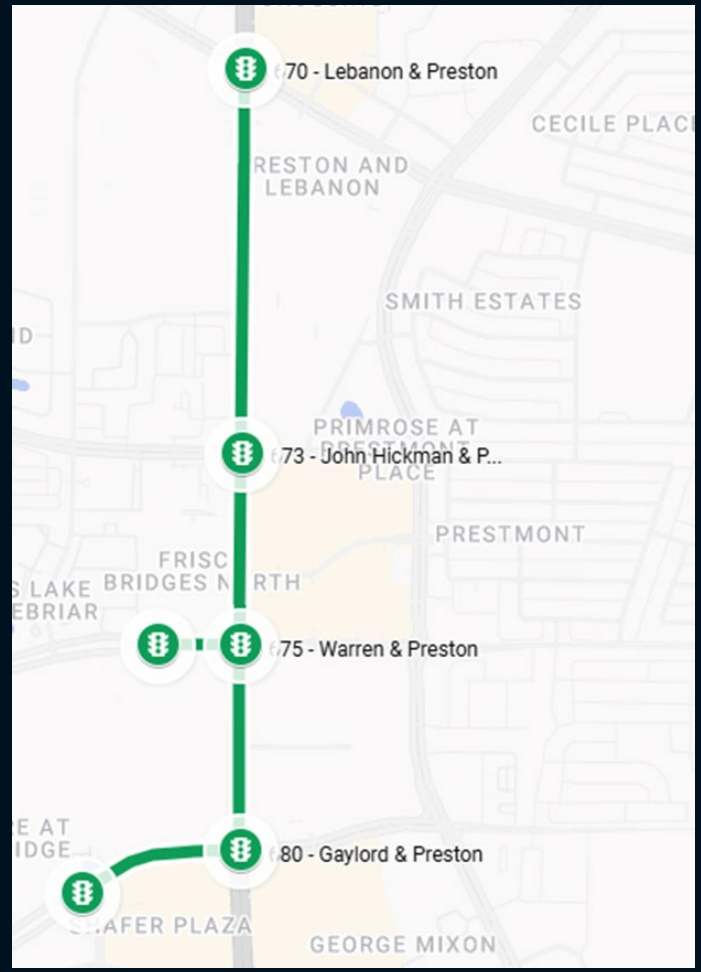
Preston Road Corridor

- 6 intersection study area
  - 4 on Preston
  - 2 on side streets
- Adjacent to Stonebriar Mall, Ikea, & large amount of retail & dining
- Running SynchroGreen since 2020



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Purpose of Study

Timing project with evaluation of 4 alternatives:

"Actual" Intelligence

- Neotraditional - tweak existing timings using Performance measures – no new counts

"Artificial" Intelligence - algorithms

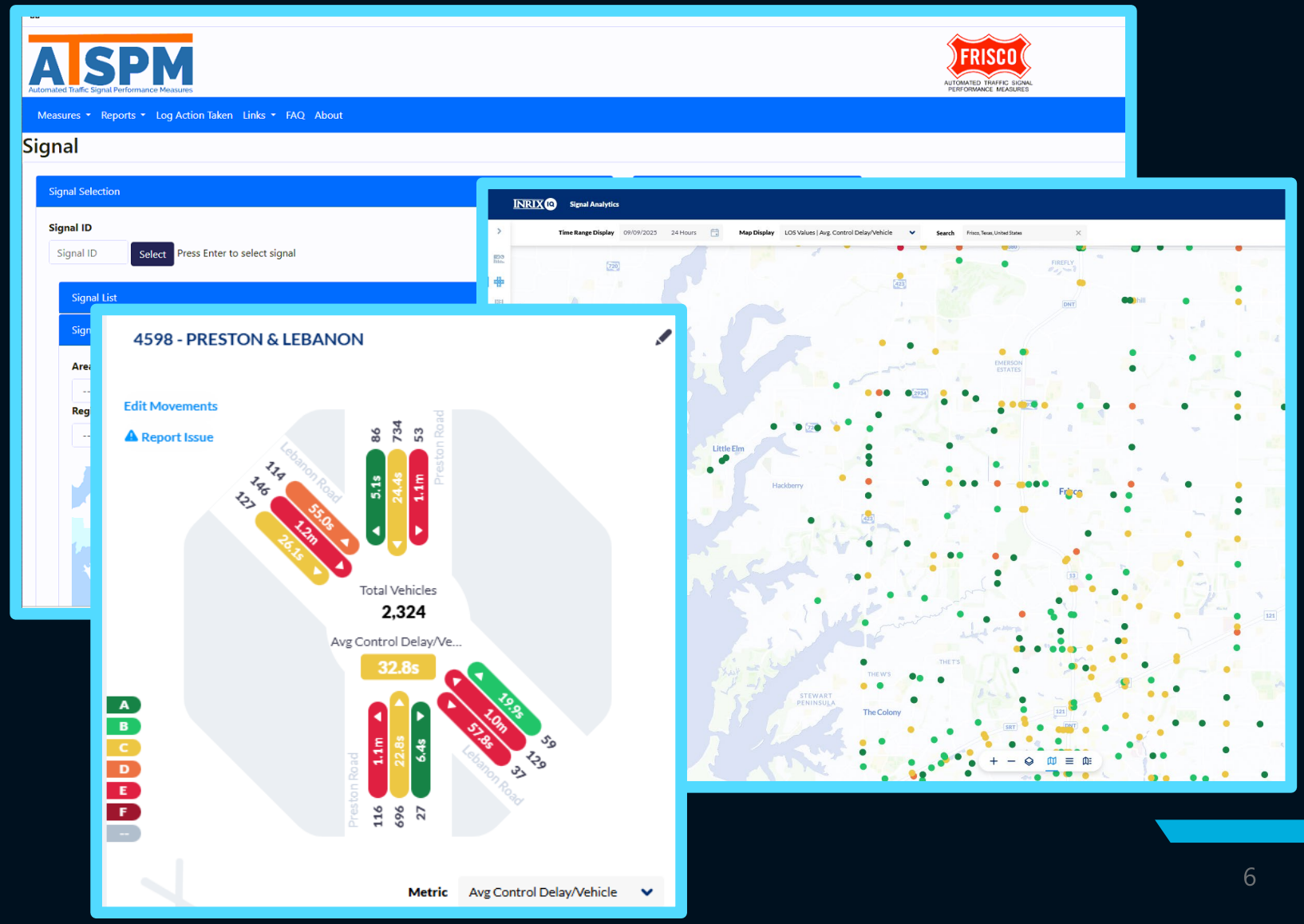
- SynchroGreen – full adaptive
- SynchroGreen – splits only mode
- ITC City Pilot – video analytics

Project Goals

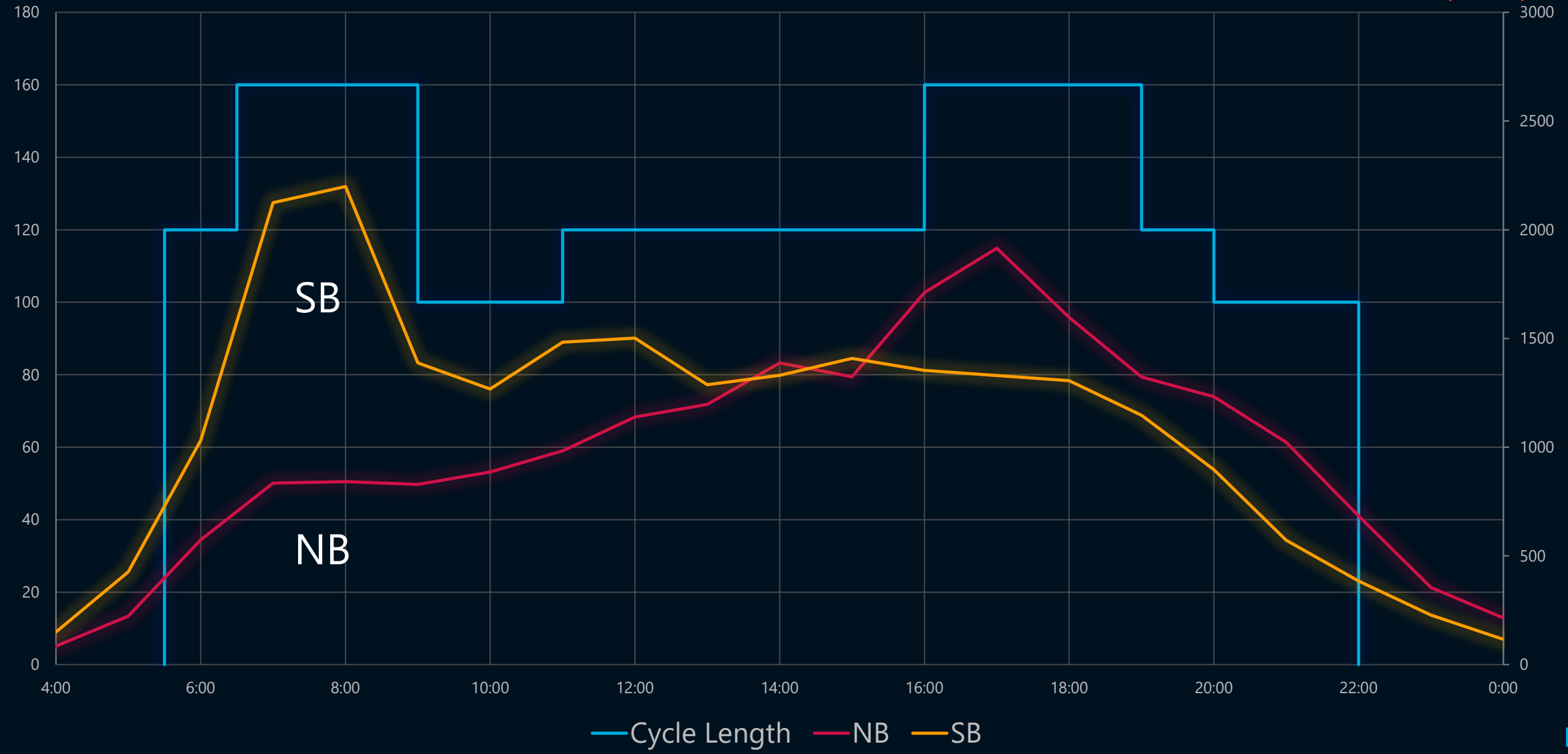
- What is the best strategy for this type of corridor?
- Can algorithm-based methods help minor movements without unduly harming progression?
- Are the advantages of frequent adaptive timing changes worth the downside of extra transitions?

Study Data Sources

- 1 PTZ and 4 fixed detection cameras per intersection
- Advanced Traffic Signal Performance Measures (ATSPM)
- Inrix Signal Analytics
  - Funded by NCTCOG
- Inrix Roadway Analytics
  - Funded by TxDOT



Frisco Time of Day Plan and Volume



Study Pre-stages

Develop Measures of Effectiveness (MOE) Toolbox

Report Name	Source	
	ATSPM	Inrix
Approach Volume	●	●
Turning Movement Count	●	●
Approach Delay/ Control Delay	●	●
Arrivals on Green	●	●
Split Failure	●	
Purdue Coordination Diagram	●	
Corridor Travel Times		●

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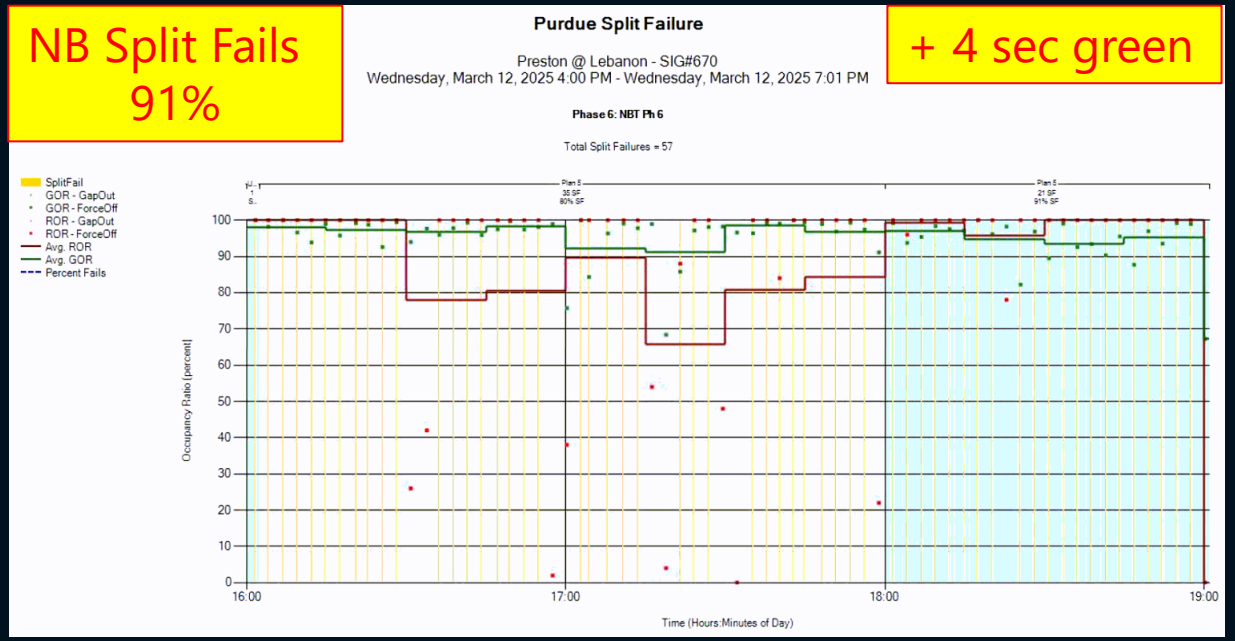
Study Pre-stages

Neotraditional

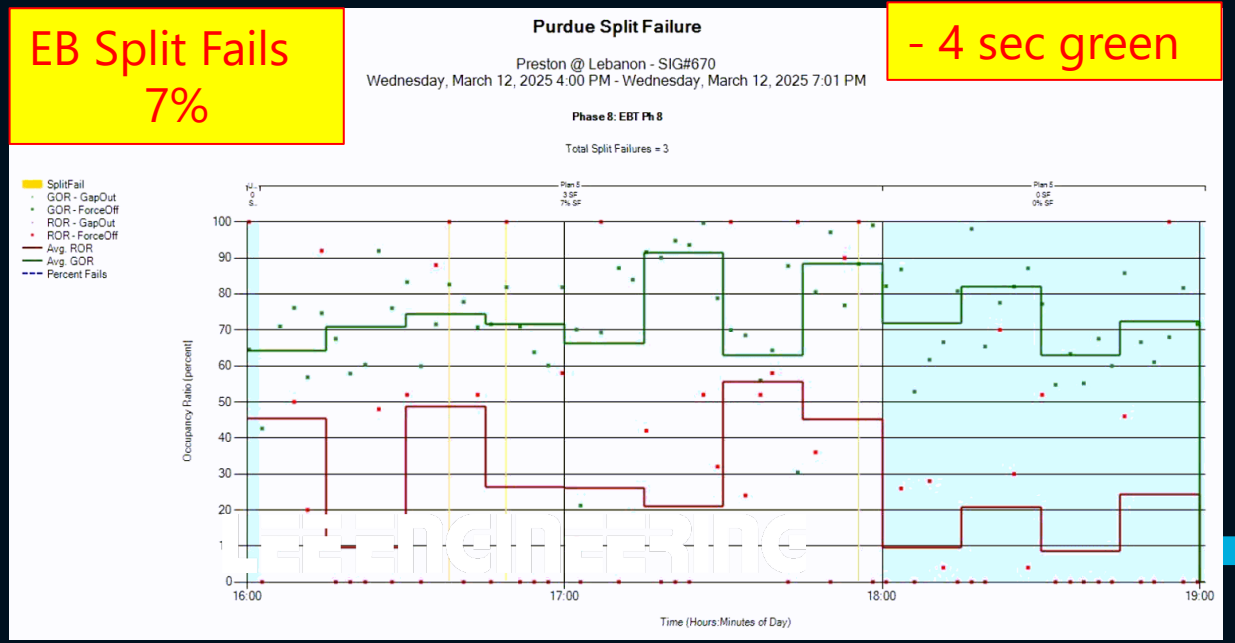
- SynchroGreen turned off
- No new counts
- Used camera observations, ATSPM, and Inrix Signal Analytics to fine-tune existing plans
  - Split Failures
  - Arrivals on Green

NB Split Fails 91%



+ 4 sec green

EB Split Fails 7%



- 4 sec green

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Study Pre-stages

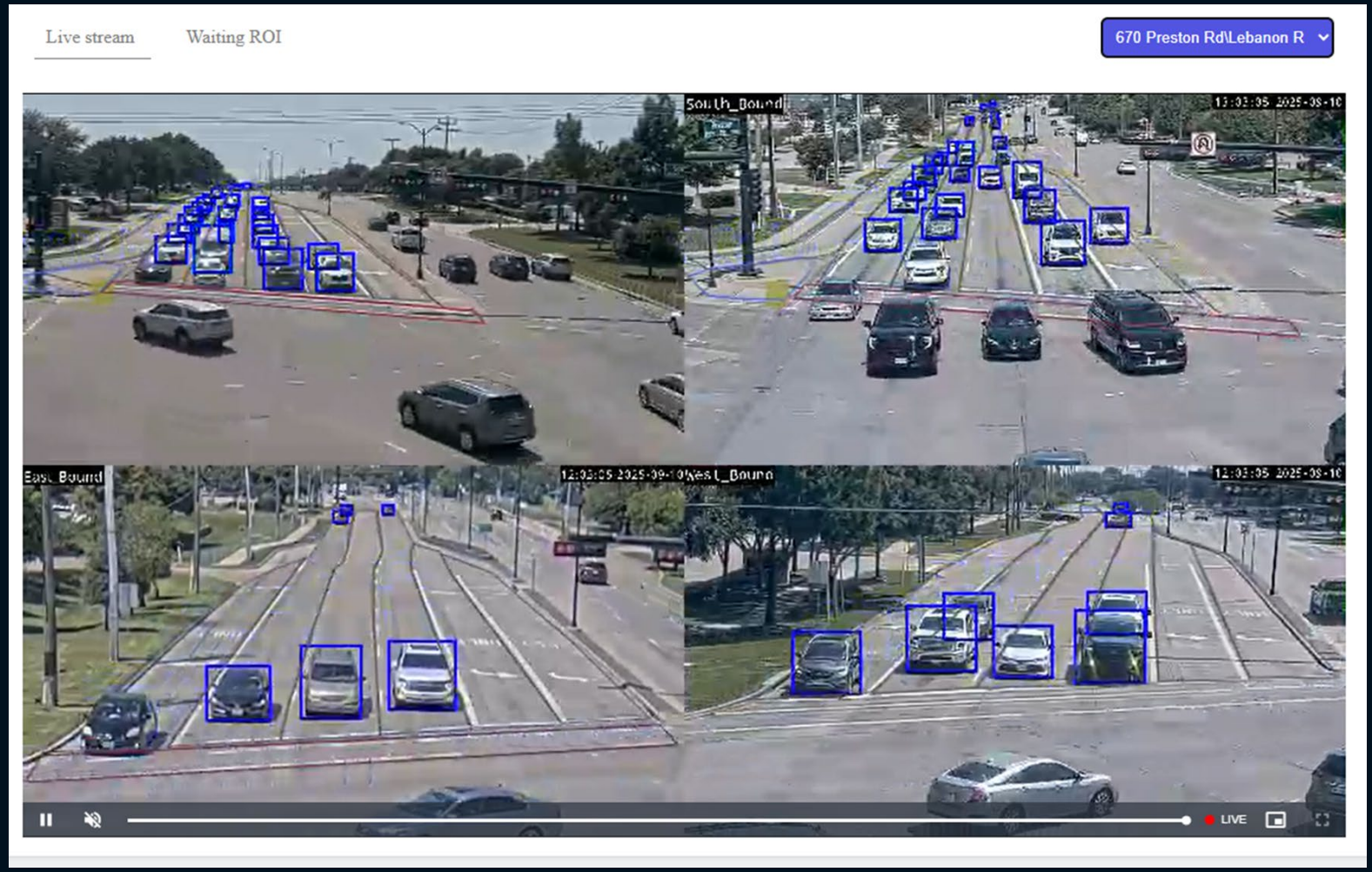
SynchroGreen

- Full adaptive
  - No setup needed
  - Existing operation
- Test splits only mode
  - Tricky to set up – would coord fail at plan changes and go back to backup timings. This took careful attention to “lag” settings
  - Determined this mode intended for isolated signals

Study Pre-stages

ITC City

- Video Algorithm looks at queues and a surrogate for split failure to tweak timings
- Creates digital twin based on months of data to generate suggested plans



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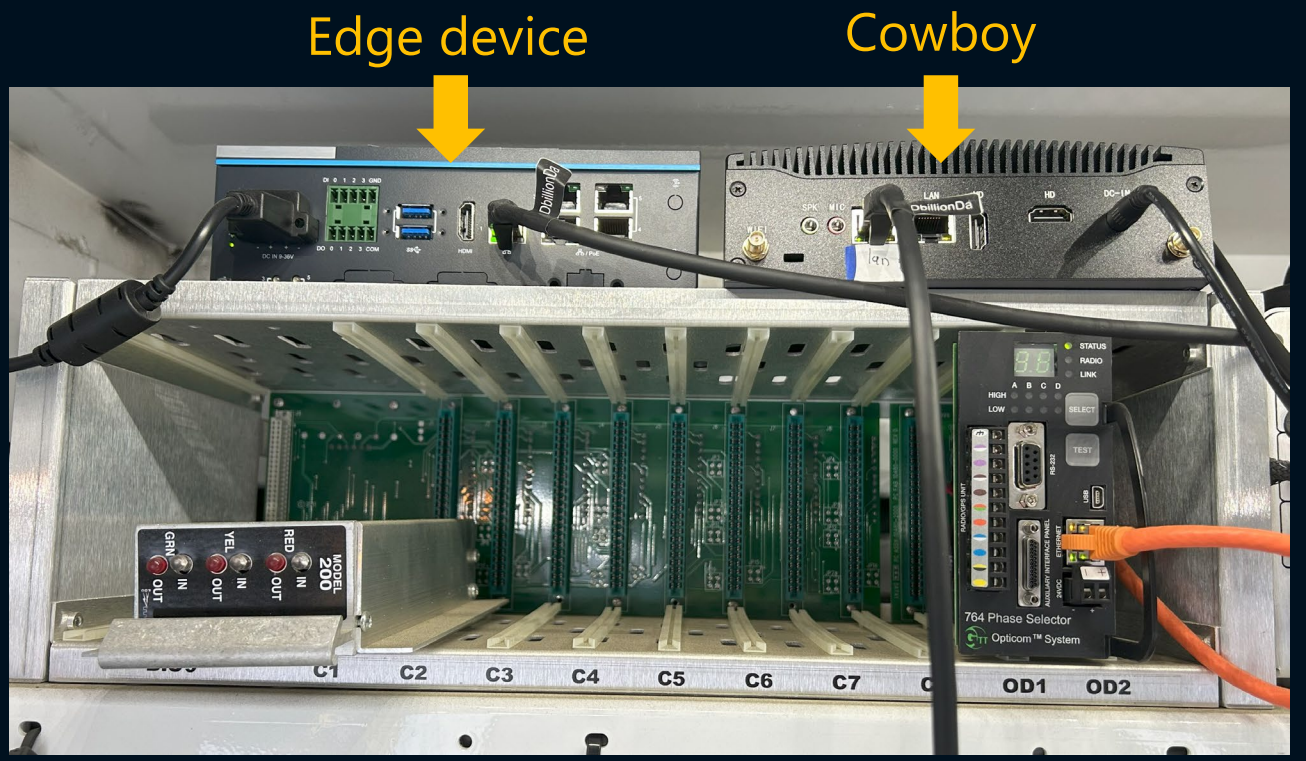
Study Pre-stages

ITC City

Equipment required:

- Uses existing Hi-rez cameras
- 1 edge device per cabinet
- 1 “Cowboy” control unit at one location



Study Pre-stages

ITC City

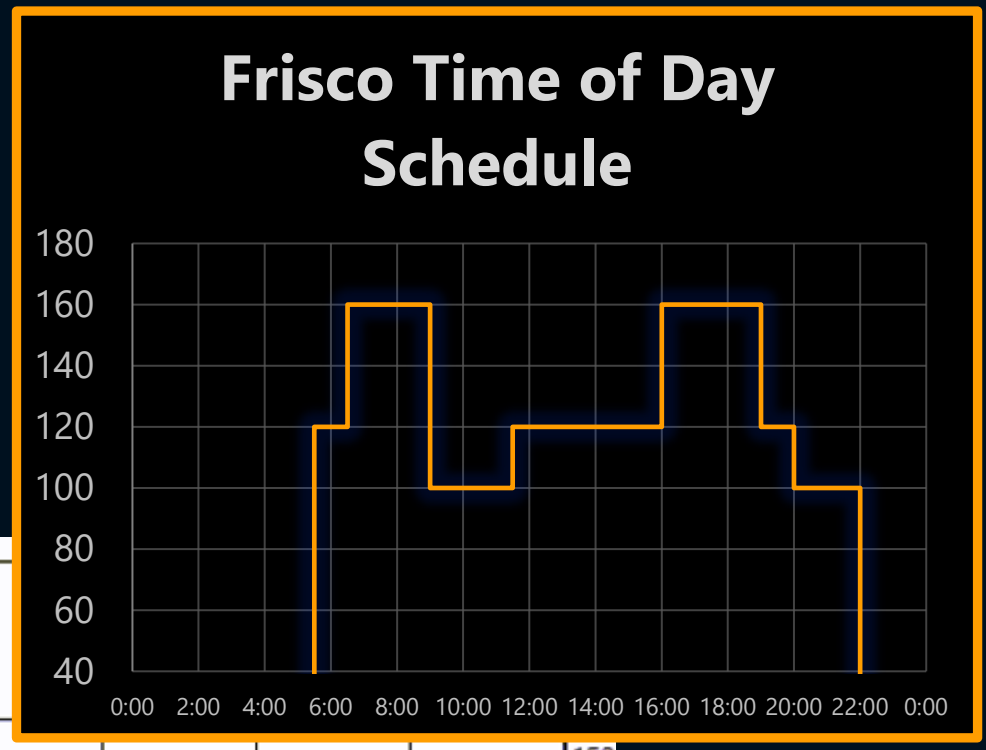
- Count verification
  - Compared reported volumes to manual counts
  - 15-min periods with various lighting conditions
  - >95% accuracy

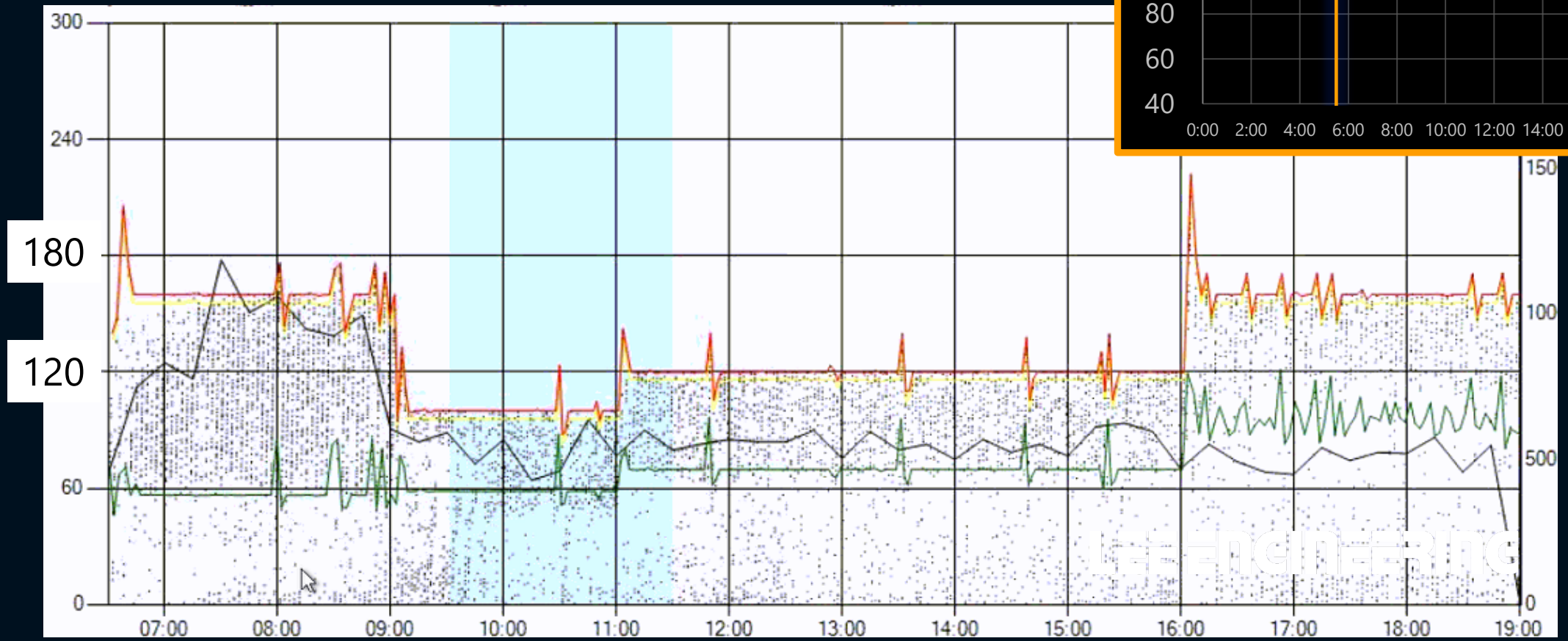
Study Schedule

- WEEK 1 – Neotraditional
- WEEK 2 – SynchroGreen full adaptive (current operation)
- WEEK 3 – SynchroGreen – splits only mode
- WEEK 4 – ITC City Pilot – suggested split changes

Neotraditional

- Time of Day coord plans (fine tuned)



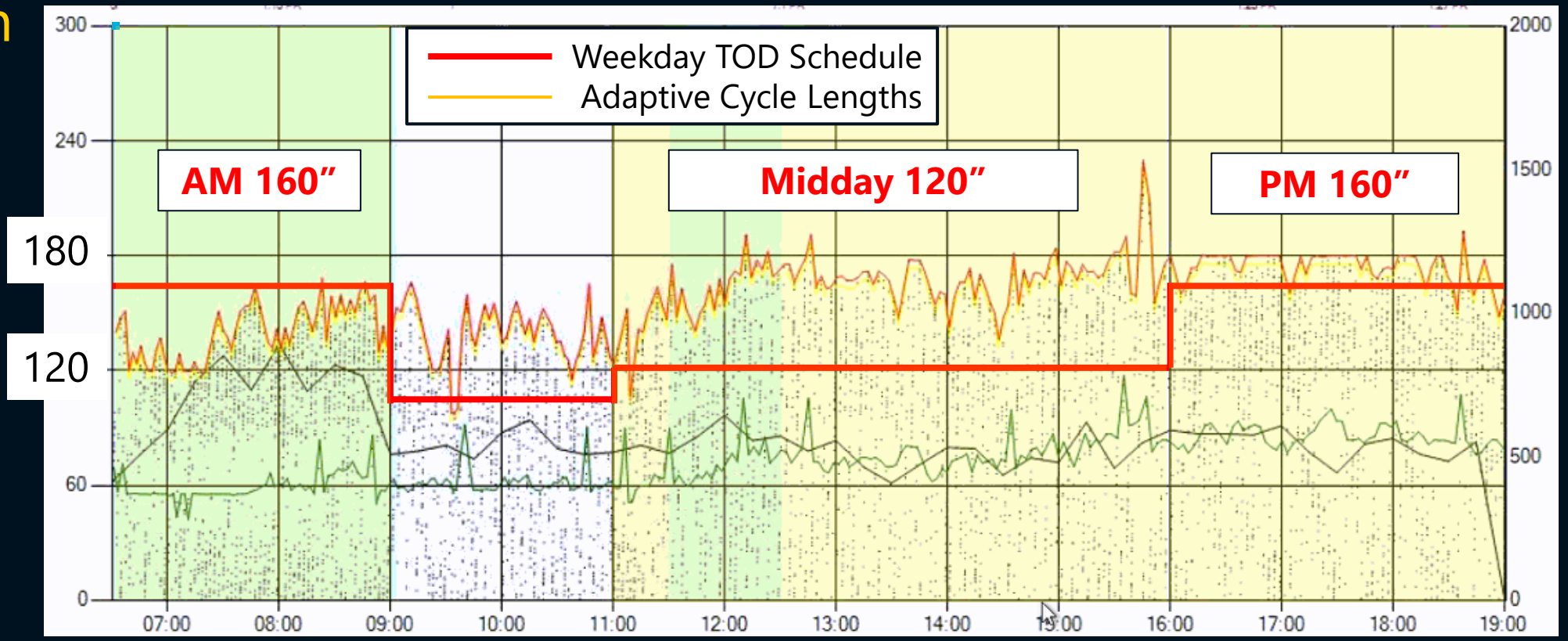


SynchroGreen Configuration

- Configured for Balanced Mode
- Runs 3 scenarios per day
  - AM – Favors southbound commute
  - Off Peak & Weekend – Dual Progression important
    - Minor movement splits allowed to be more generous
  - PM – Favors northbound commute

SynchroGreen Full Adaptive

- Cycle Length
- Offset
- Splits



SynchroGreen Full Adaptive

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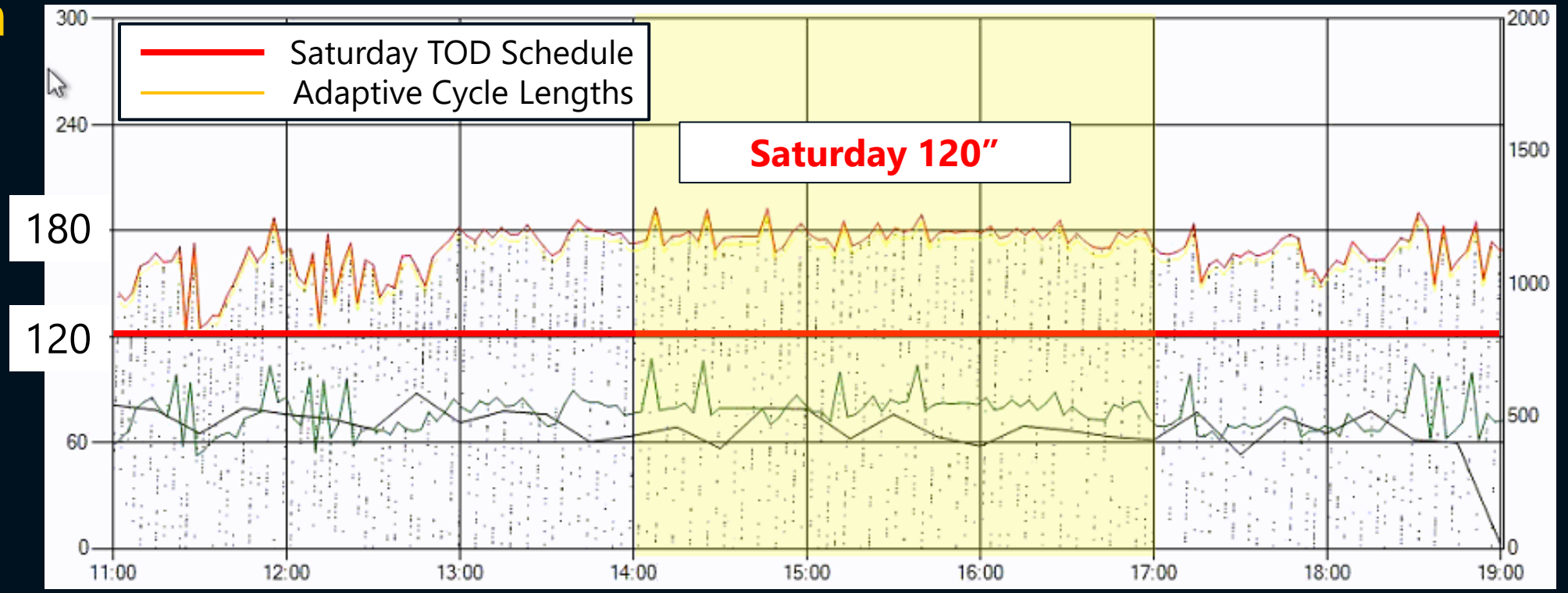

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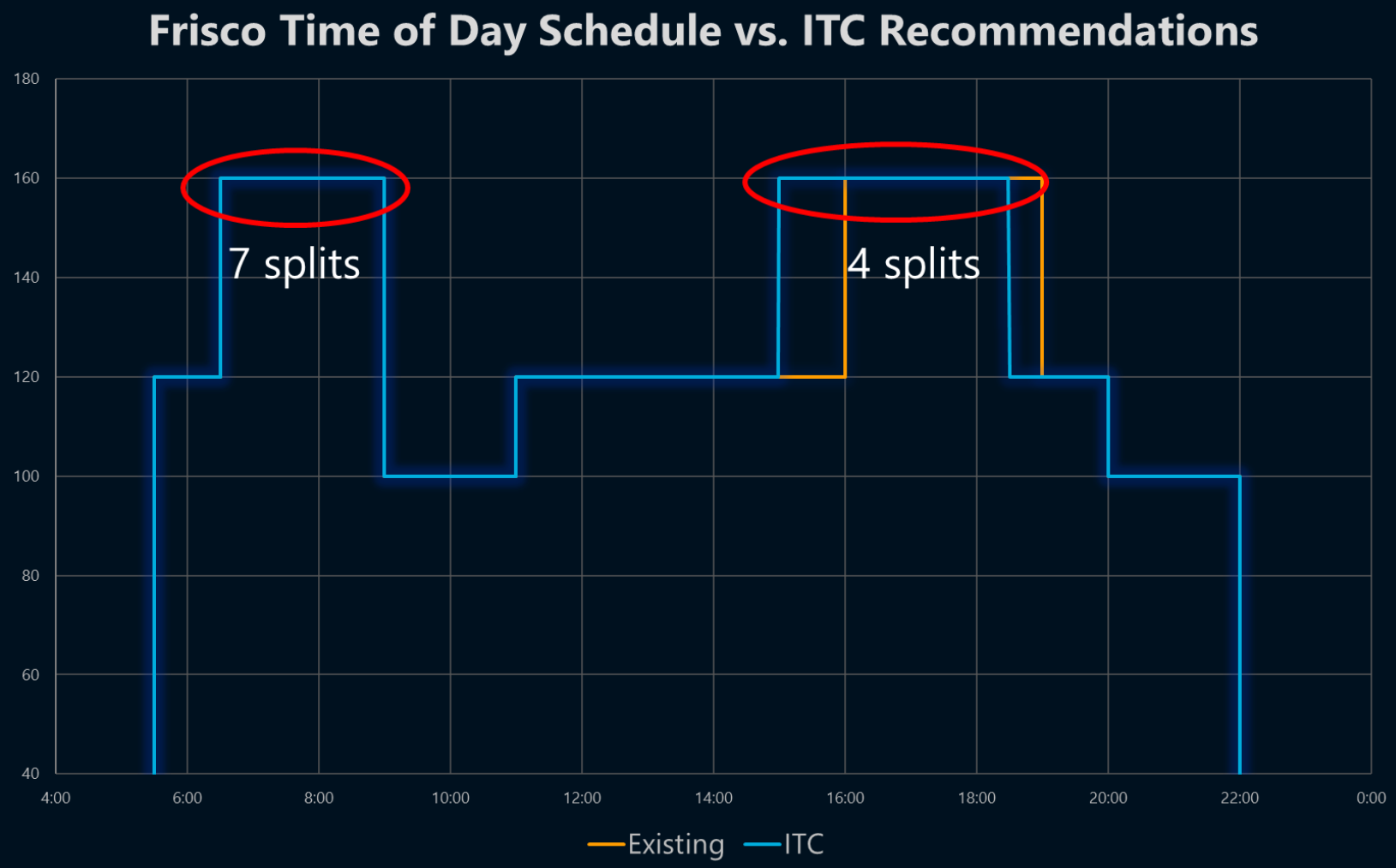
ITC City algorithm recommended timings

ITC City

- Original proposal was frequent split changes within peaks
- City requested single plan per peak for initial implementation



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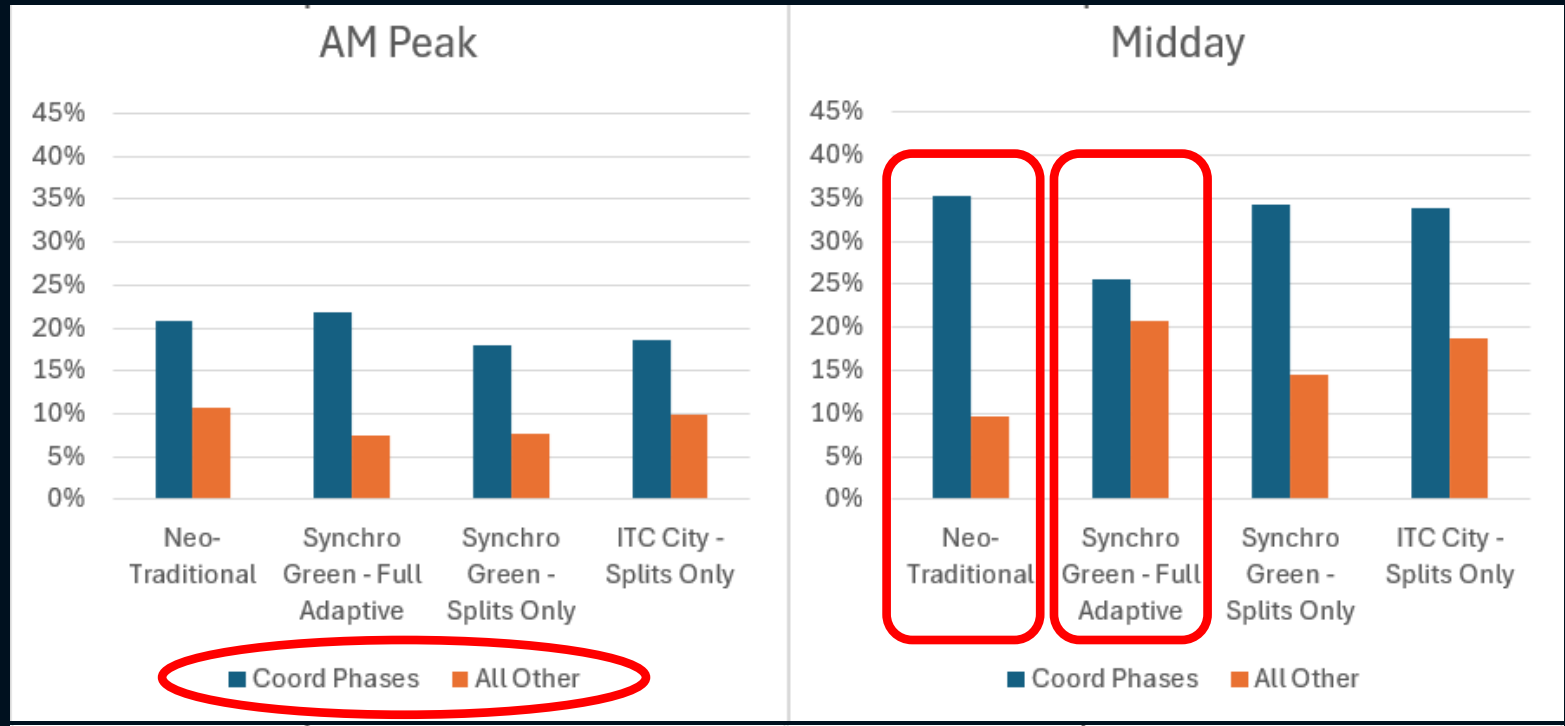
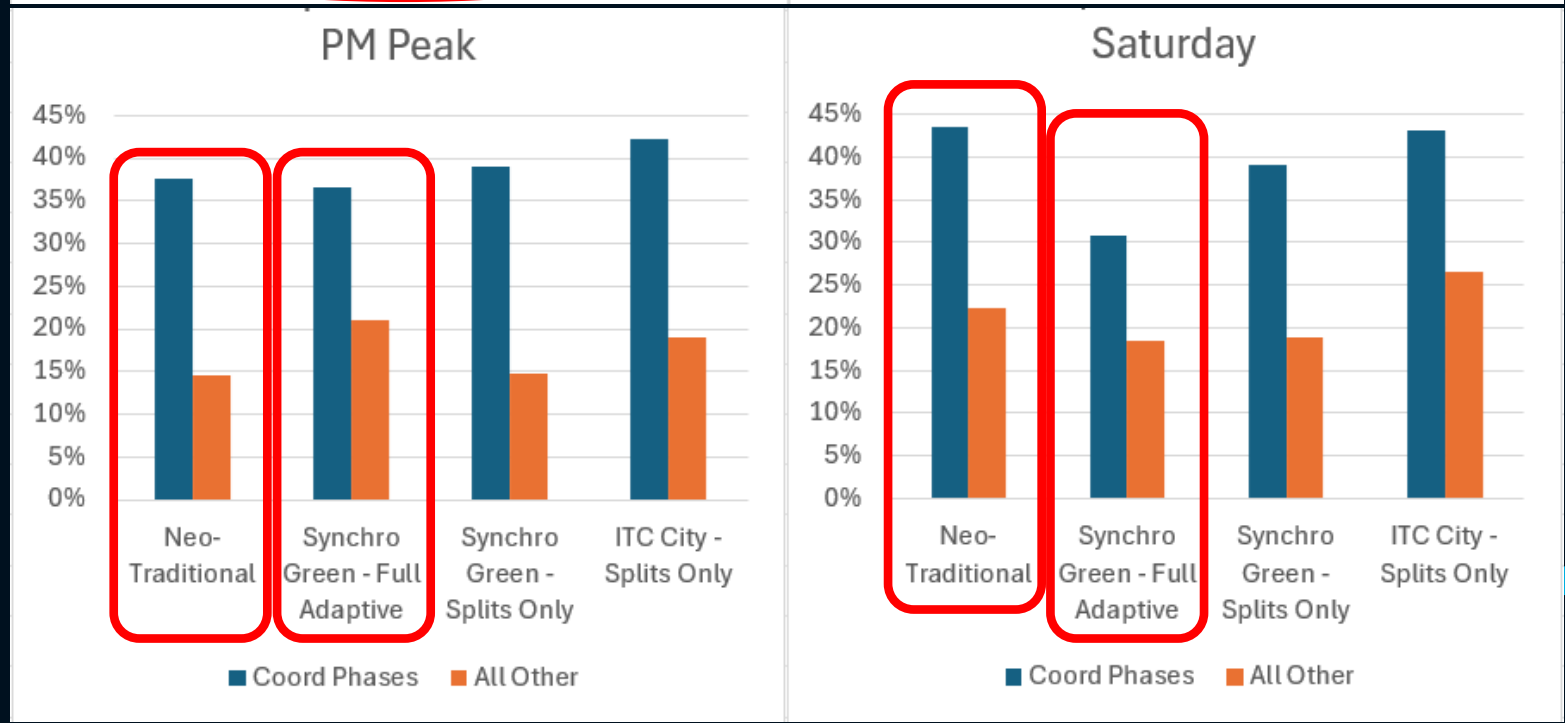
Study Results

Split Failures

ATSPM

- All algorithm-based strategies balance split failures
- Improves Coord Phases but at the expense of others



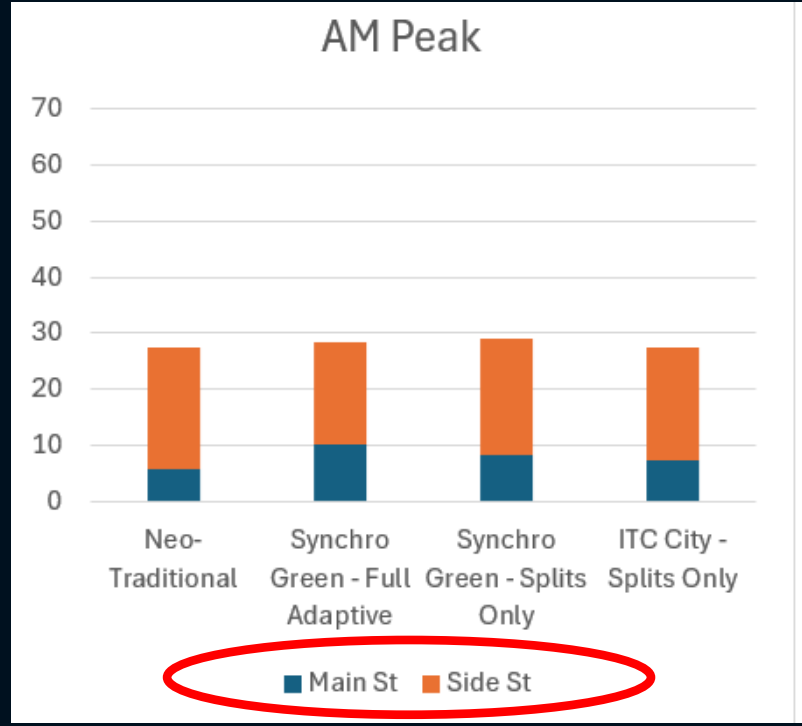


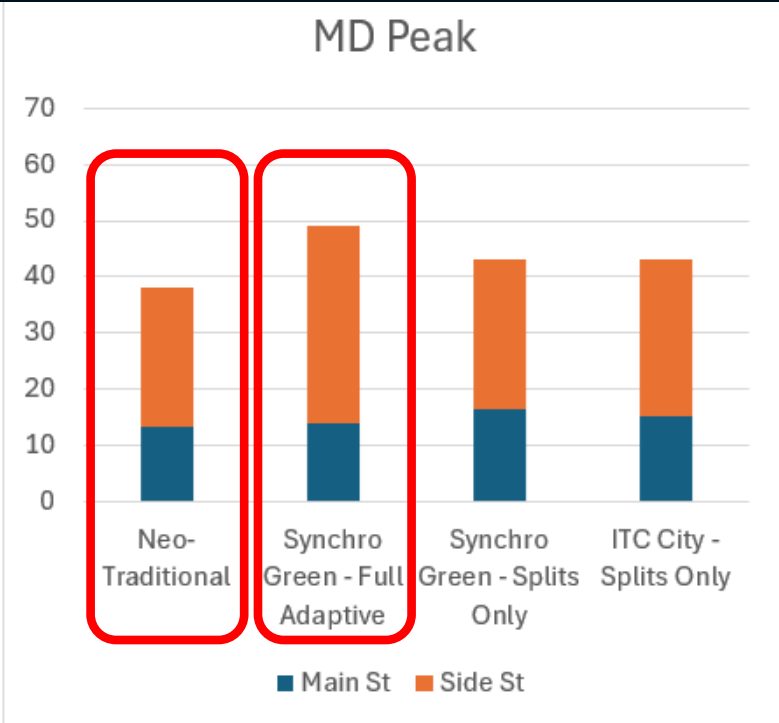
Study Results

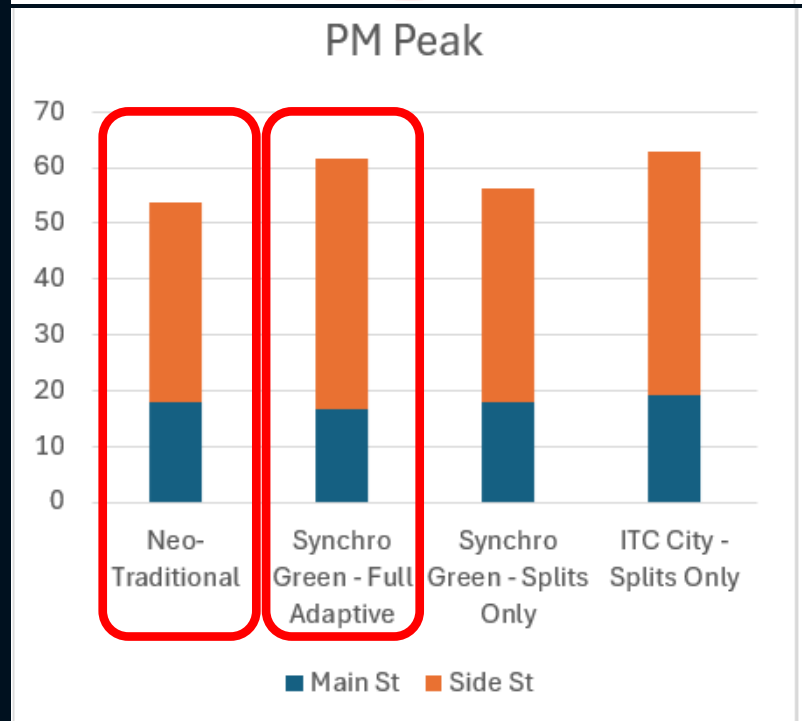
Network Delay

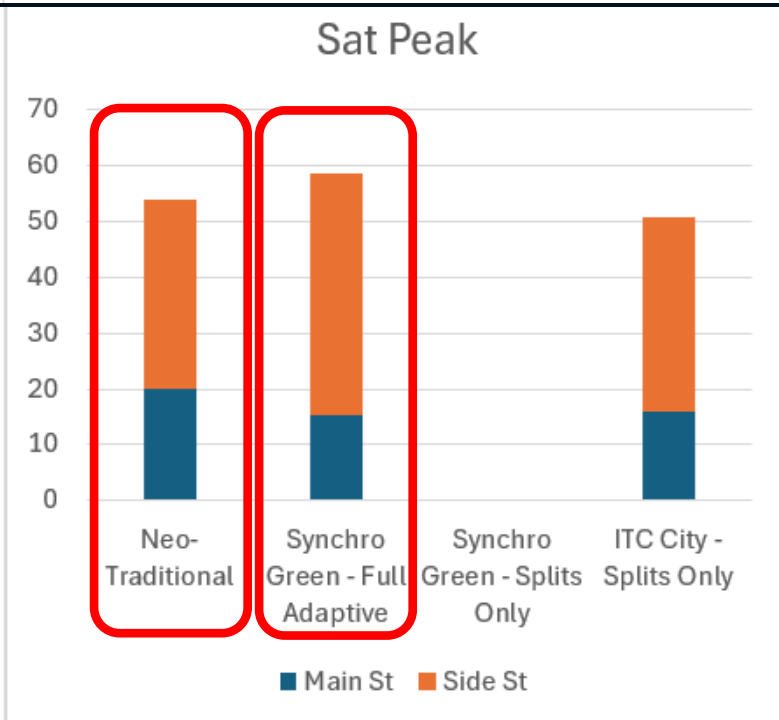
ATSPM

- Balancing split failures results in higher overall delay









Platoon Ratio

Platoon Ratio describes the quality of vehicle progression through an intersection. Higher ratios denote higher degrees of platooning.

$$R_p = \frac{P}{g/C} = \frac{P\ C}{g}$$

P = proportion of vehicles arriving on green, AoG%

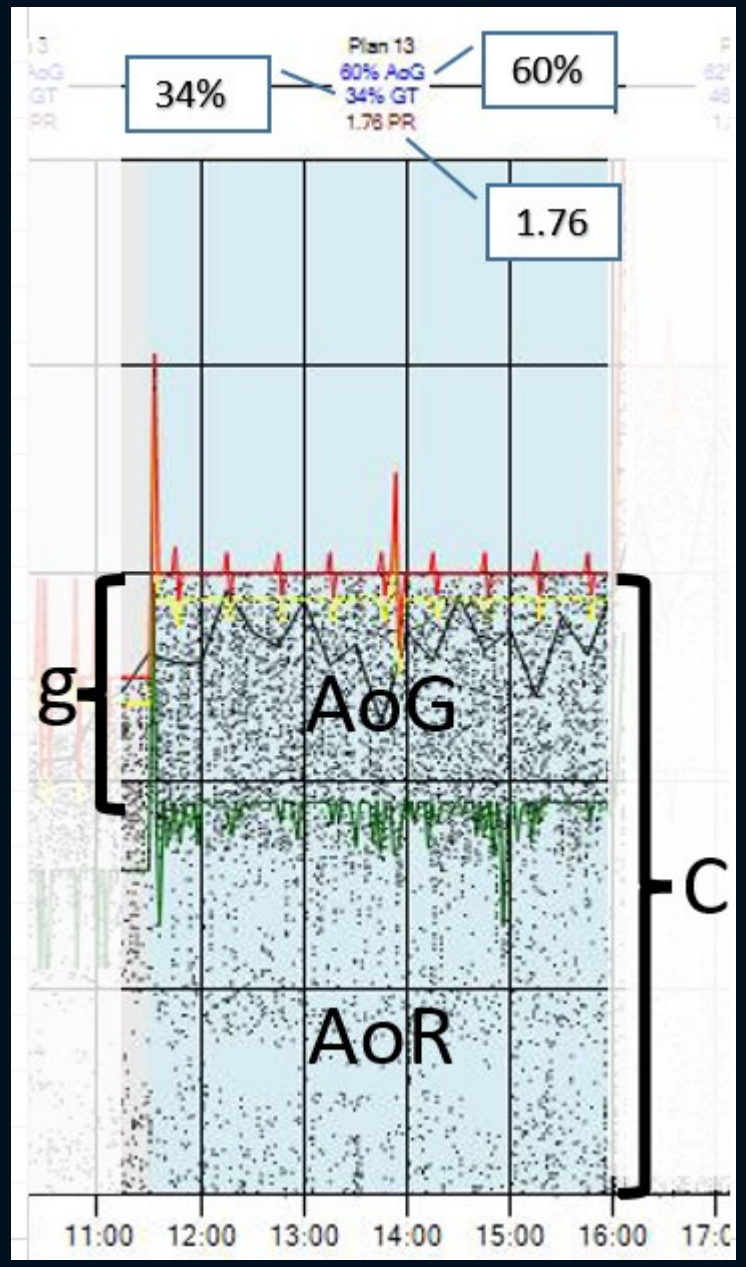
g = length of green in the cycle, s

C = overall cycle length, s

Platoon Ratio

$$R_p = \frac{P}{g/C} = \frac{P\ C}{g}$$

Purdue Coordination Diagram

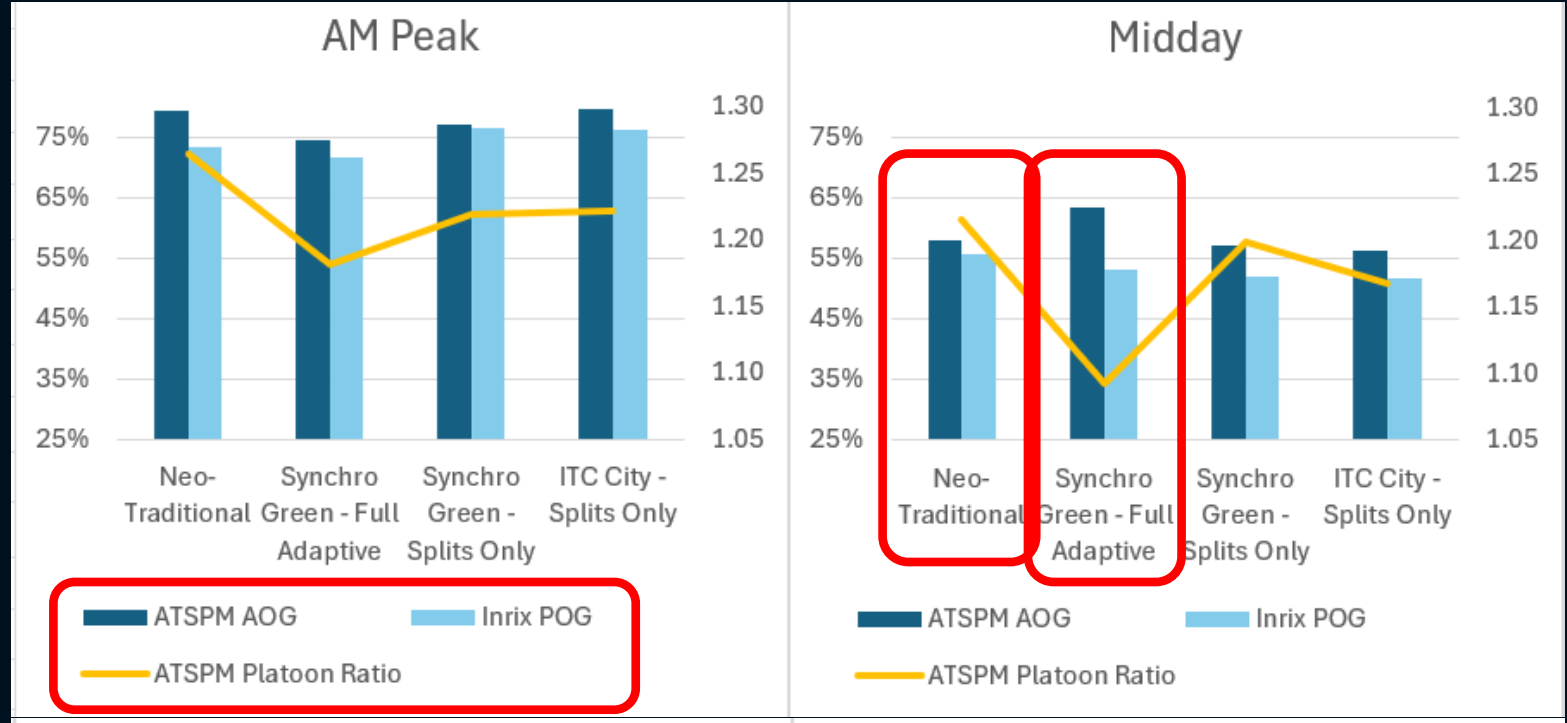


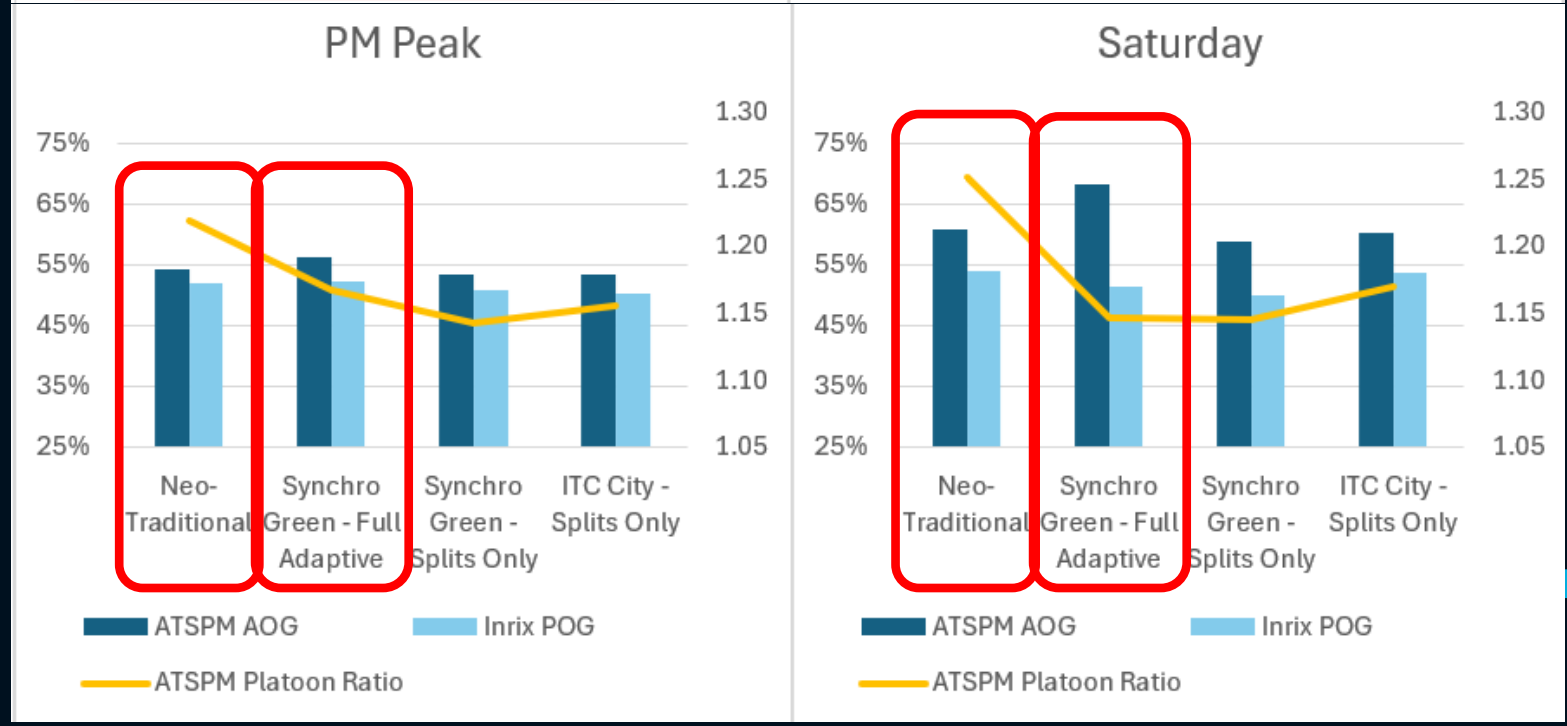
Study Results

Arrivals on Green

ATSPM & Inrix Signal Analytics

- Full adaptive had:
  - Improved Arrivals on Green
  - Lowest Platoon Ratio
- Any improvements to AOG% likely result of longer cycle lengths





Lessons Learned

- Already had good corridor timing plans – hard to beat
- Algorithm-based strategies got close
  - With locked-down parameters
  - Built enough trust to “loosen the chains” for next round

Next Steps

- Open up limits on SynchroGreen
  - cycle length upper limit
  - phase split min/max
- “Isolated” intersection SynchroGreen (3 locations)
  - Splits only mode at key intersection within a coordinated system
- ITC City full adaptive

Thank you!

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