ACS-Lite
FHWA adaptive control for closed-loop systems

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U.S. Department of Transportation
Federal Highway Administration

Outline

- Goals
- System architecture
- Adaptive approach
  - Cyclic performance measures
- Field trials

Adaptive in the U.S. (FHWA)

- 1970s-1980s: UTCS
  - Second by second central
- 1990s: Predictive control (ACS)
  - FHWA ACS: RHODES, OPAC
  - Second by second distributed
- 2002: Controller-based Adaptive
  - FHWA ACS "Lite": Siemens ITS
  - Leverage existing hardware
  - Update controller parameters every five minutes

FHWA Goals for ACS-Lite

- Low cost design
- Leverage existing infrastructure
  - Standard US-style actuated controllers (rings, phases, splits, barriers)
  - Standard fully-actuated detector layouts
  - Standard NTCIP Communications
- "Retro-fit" with major US signal system vendors

Project Team

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ECONOLITE CONTROL PRODUCTS, INC.

EAGLE Traffic Control Systems

SIEMENS

McCain

The University of Arizona. Tucson Arizona

PURDUE UNIVERSITY

PEEK

Sabra, Wang & Associates, Inc.
Engineers • Planners • Analysts

ITT Industries
Engineered for life

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System Architecture

9600bps, up to 12 controllers

ACS-Lite

Field Processor

Optional

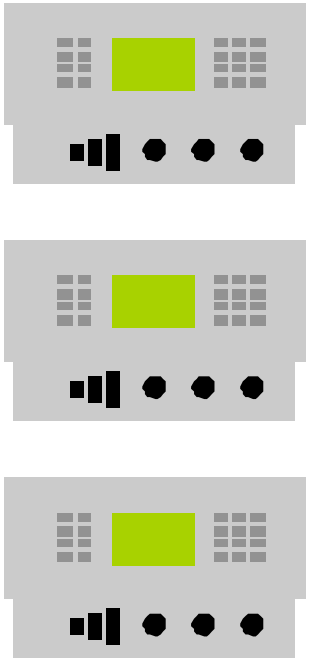
Protocol Translation

NTCIP

Vendor Specific or NTCIP

Vendor Field Master

Optional



NTCIP + ACS-Lite firmware upgrade

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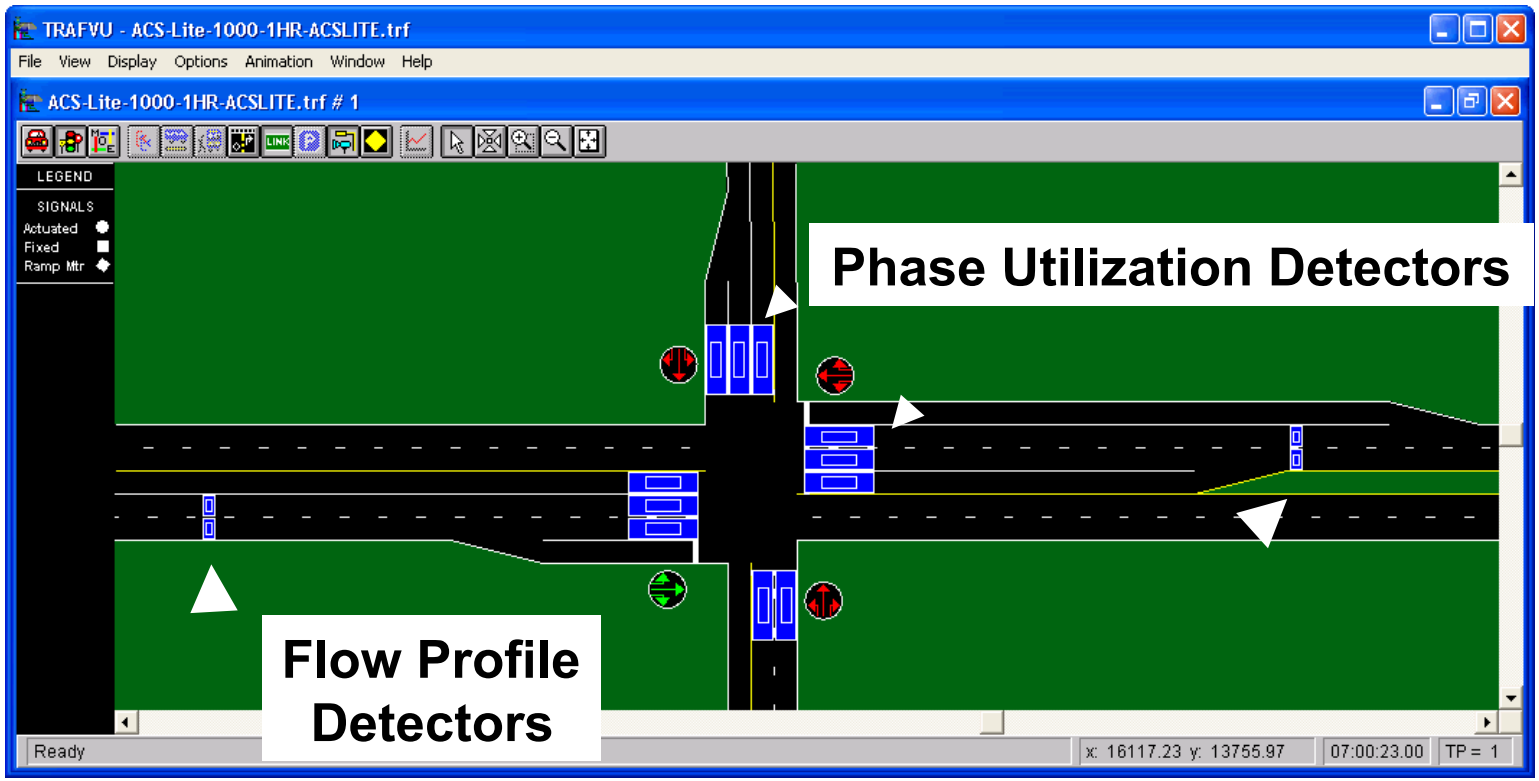
ACS-Lite Detection Layout

Need detectors at stop-bar of coordinated phases



ACS-Lite adaptive control philosophy

- Data-driven parameter tuning
- Limited/no traffic modeling
- Recent past predicts the near future

1
- Splits
  - **Phase Utilization**

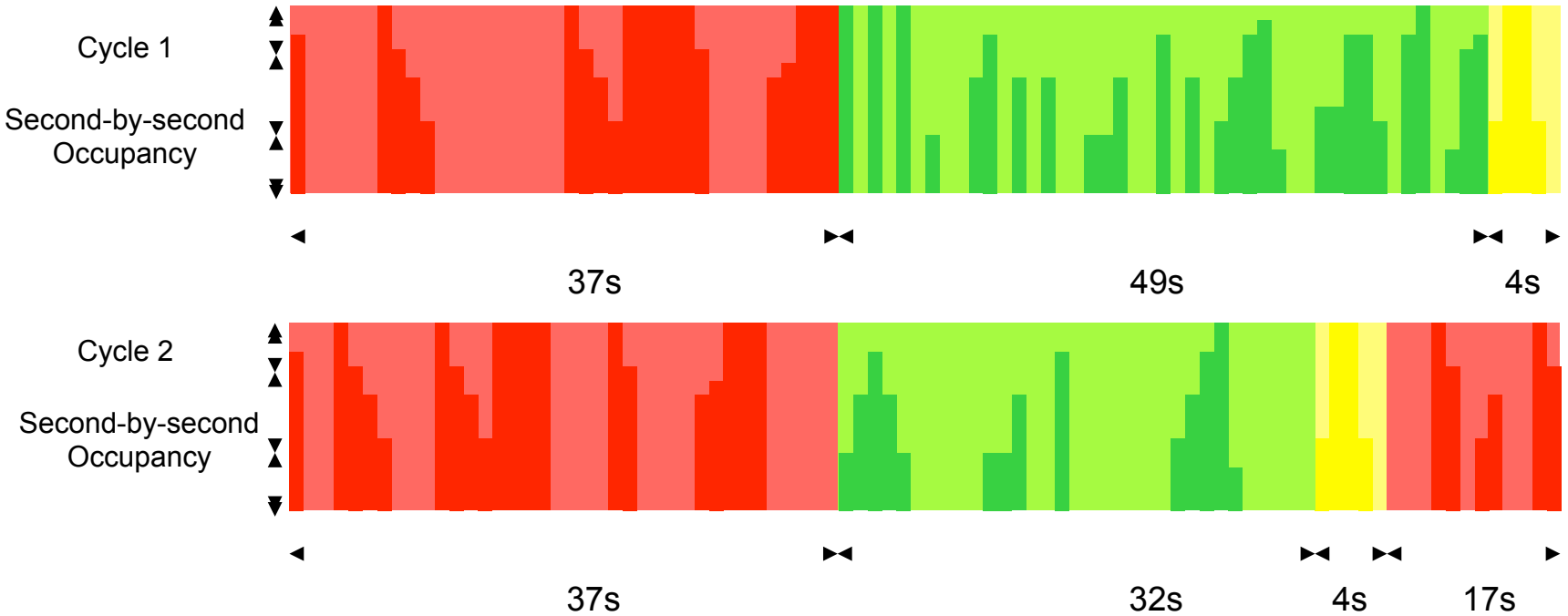
2
- Offsets
  - **Statistical Flow Profiles**

ACS-Lite NTCIP firmware upgrade

1. Phase Timing Status Object
2. Detector Status Object
3. Configuration Objects
- Polled once per minute
  - Second-by-second accuracy
  - Bandwidth efficient
- Minute-by-minute polls are “stitched” together for cycle-by-cycle performance assessment

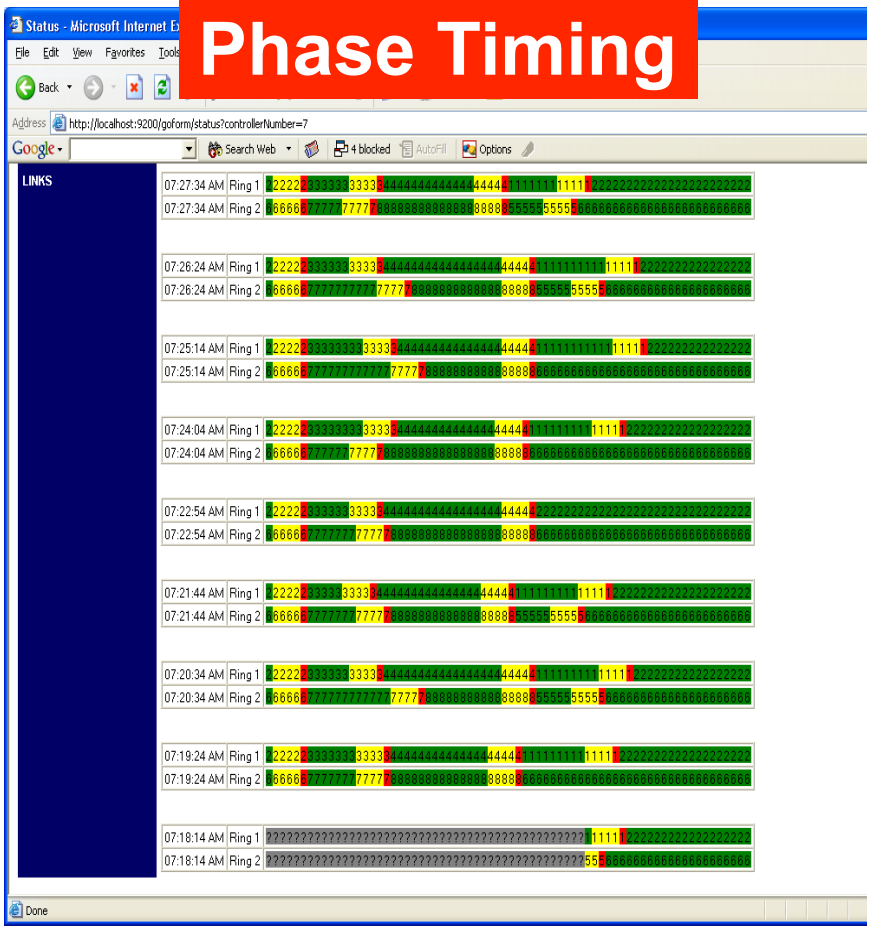
Occupancy per phase interval

- Occupancy values per second
- Correlated to Red/Green/Yellow

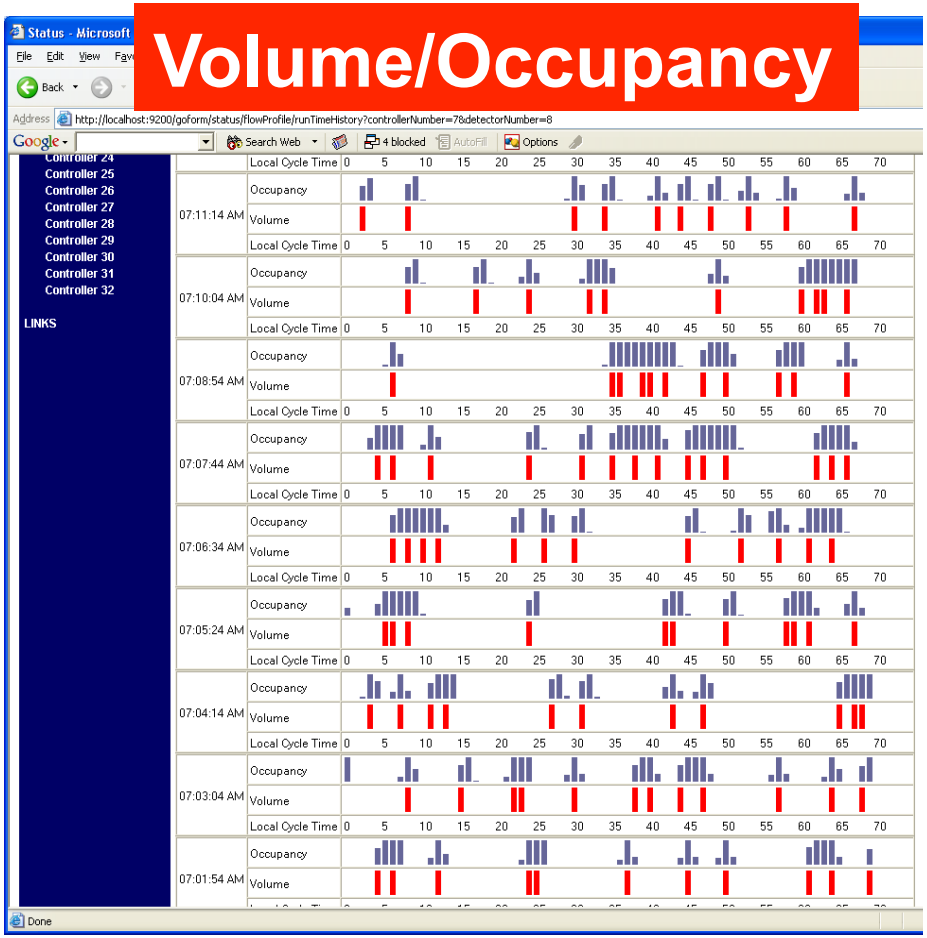


Cycle-by-cycle Data

Phase Timing



Volume/Occupancy



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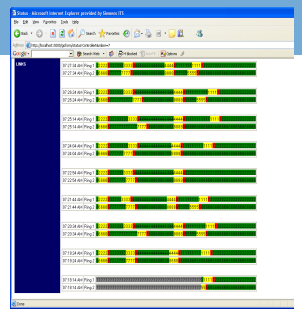
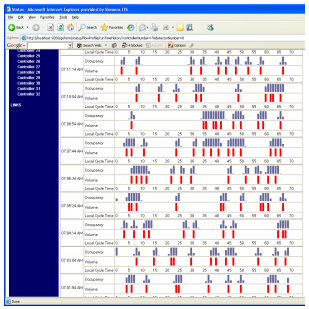
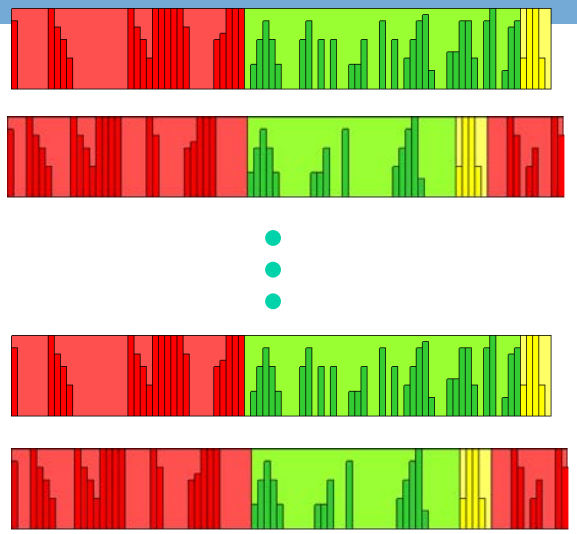
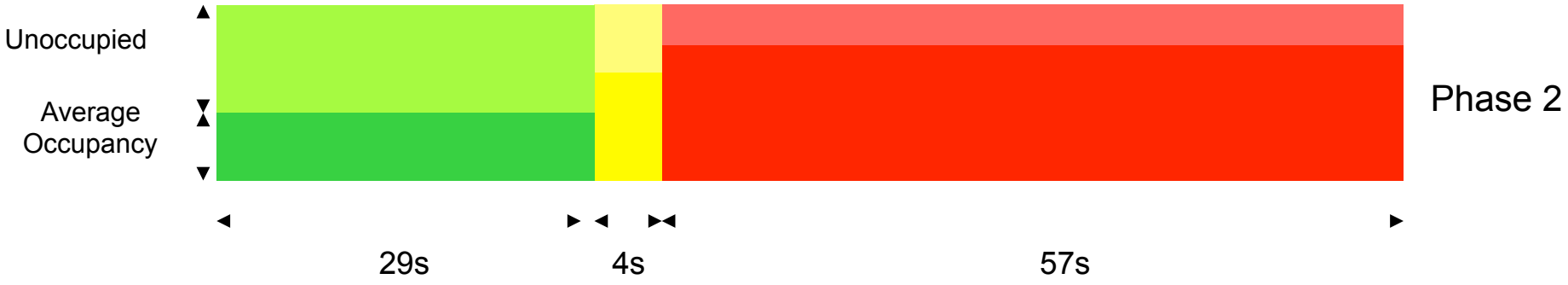
Occupancy per interval → split tuning



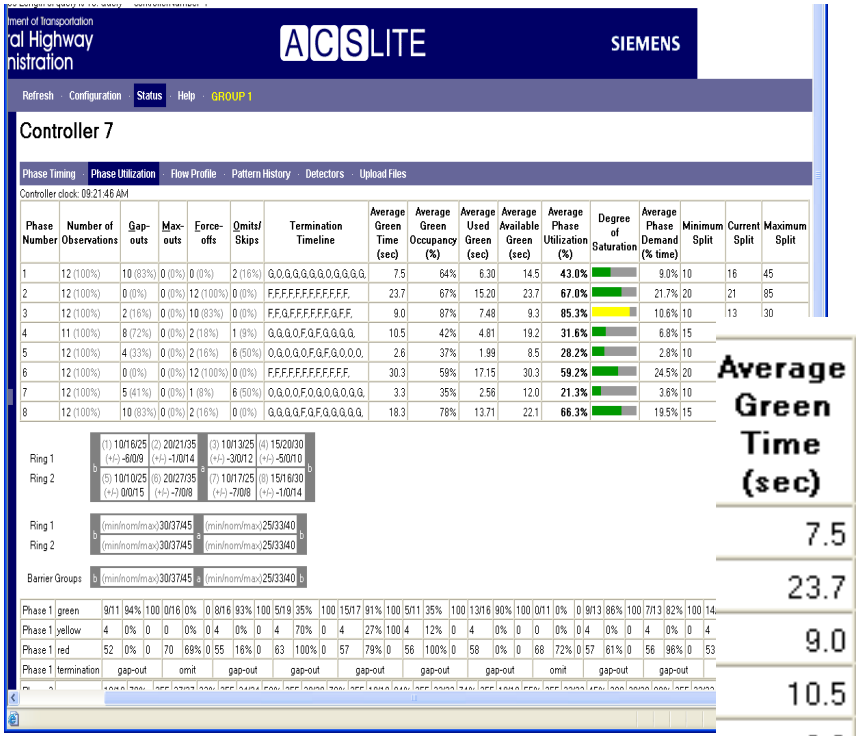




Averaging

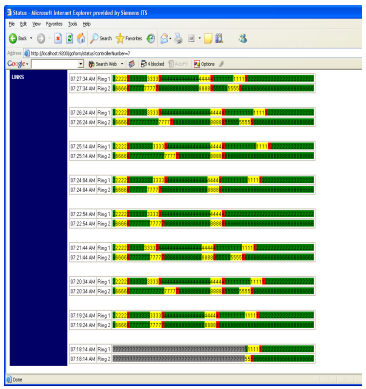


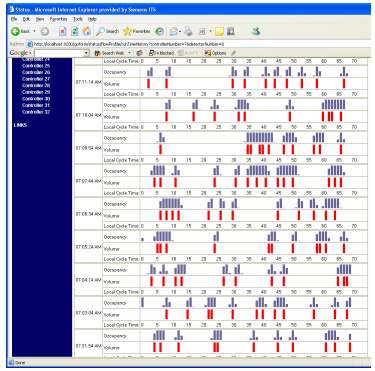
Green occupancy → Phase Utilization



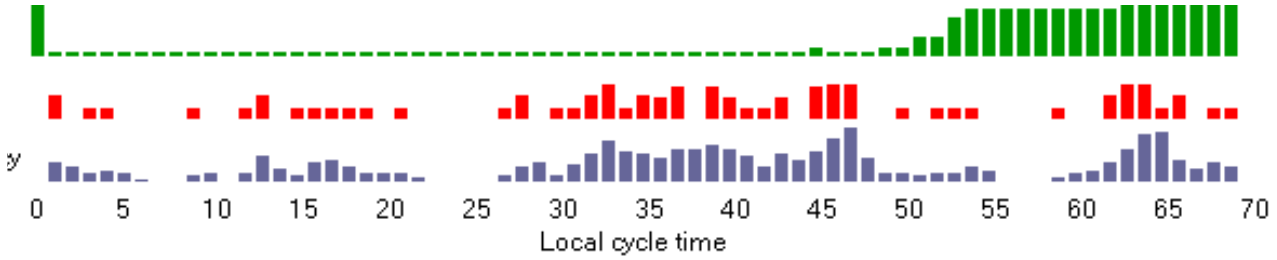
Average Green Time (sec)	Average Green Occupancy (%)	Average Used Green (sec)	Average Available Green (sec)	Average Phase Utilization (%)	Degree of Saturation	Average Phase Demand (% time)	M
7.5	64%	6.30	14.5	**43.0%**		9.0%	10
23.7	67%	15.20	23.7	**67.0%**		21.7%	20
9.0	87%	7.48	9.3	**85.3%**		10.6%	10
10.5	42%	4.81	19.2	**31.6%**		6.8%	15
2.6	37%	1.99	8.5	**28.2%**		2.8%	10
30.3	59%	17.15	30.3	**59.2%**		24.5%	20
3.3	35%	2.56	12.0	**21.3%**		3.6%	10
18.3	78%	13.71	22.1	**66.3%**		19.5%	15

Cyclic occupancy profiles → Statistical profile





Example shows need to move offset so green corresponds with traffic earlier in cycle



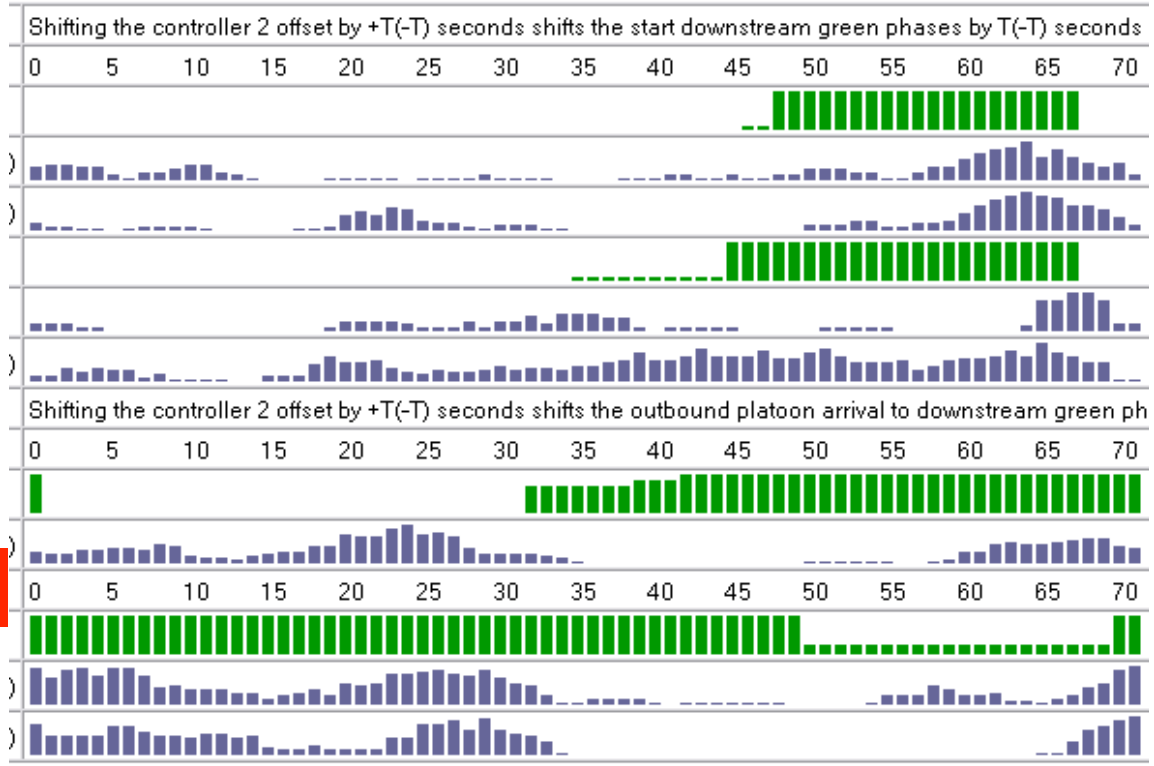
“statistical” flow profile

Progression Performance → Offset tuning

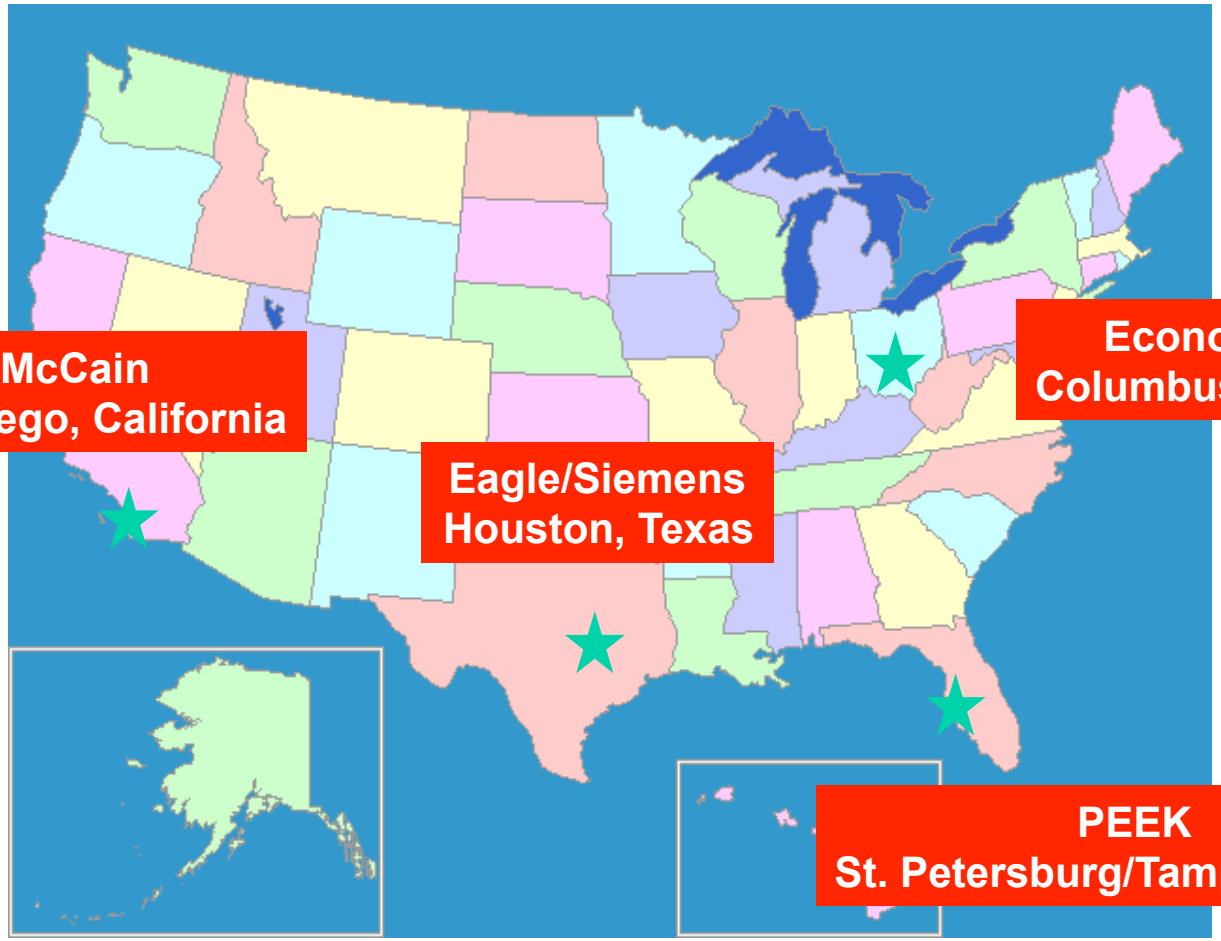
- Performance measure for offsets → "capture efficiency"
- Shift offsets small amount
- Constrain changes within user-configurable bounds

Inbound

Outbound



Field trials



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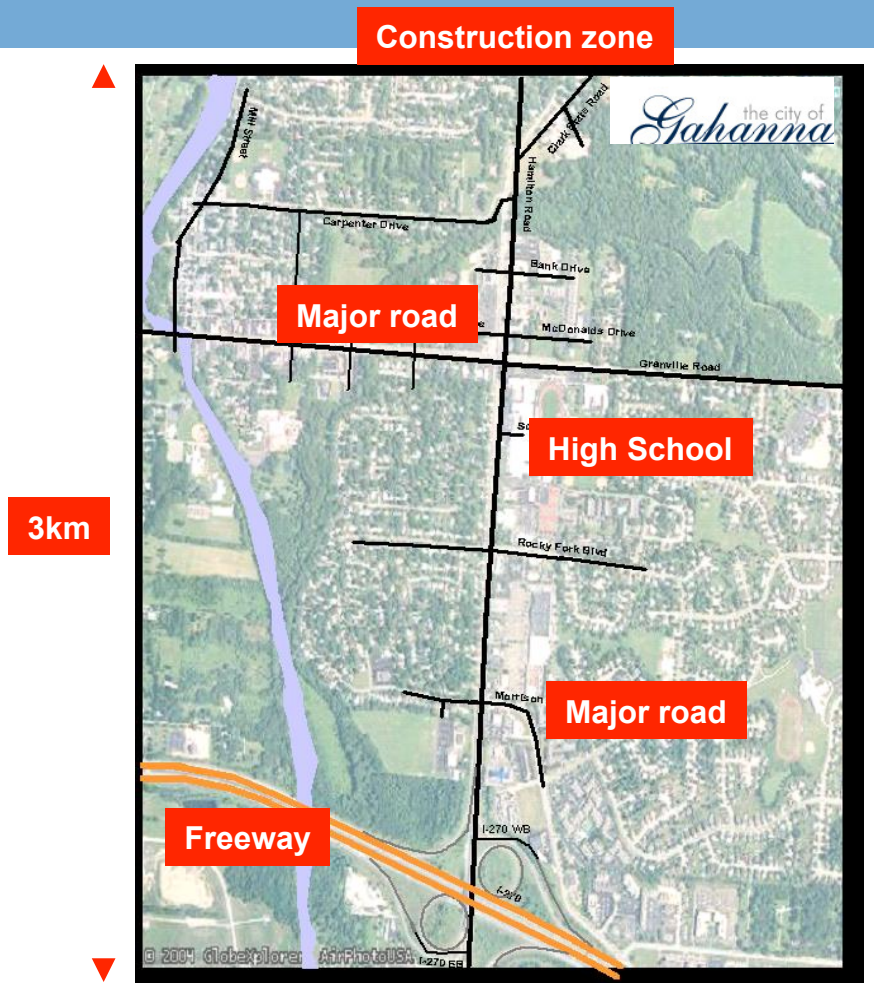
Field trial – Columbus, Ohio

- Early “lessons learned”
  - Communications integrity
  - Detector configuration
    - Separate channels per lane
  - Remote configuration capability
  - Details, details



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Future

- Field studies “before and after” results (TRB 2006)
  - Analysis/comparison of ACS-Lite performance data with traditionally collected data
- Algorithms enhancements (2006-2008):
  - Long-term parameter adjustment
    - Seasonal baseline parameters
    - TOD schedule switch points
  - Cycle time tuning
  - Selection of transition method
  - Weather-responsive