ACS-Lite
FHWA adaptive control for closed-loop systems

Raj S. Ghaman, PE

2nd Baltimore Regional Traffic Signal Form

December 14, 2005

Maryland, USA

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

U.S. Department of Transportation
Federal Highway Administration

ECONOLITE CONTROL PRODUCTS, INC.

PURDUE UNIVERSITY

EAGLE Traffic Control Systems

SIEMENS

McCain

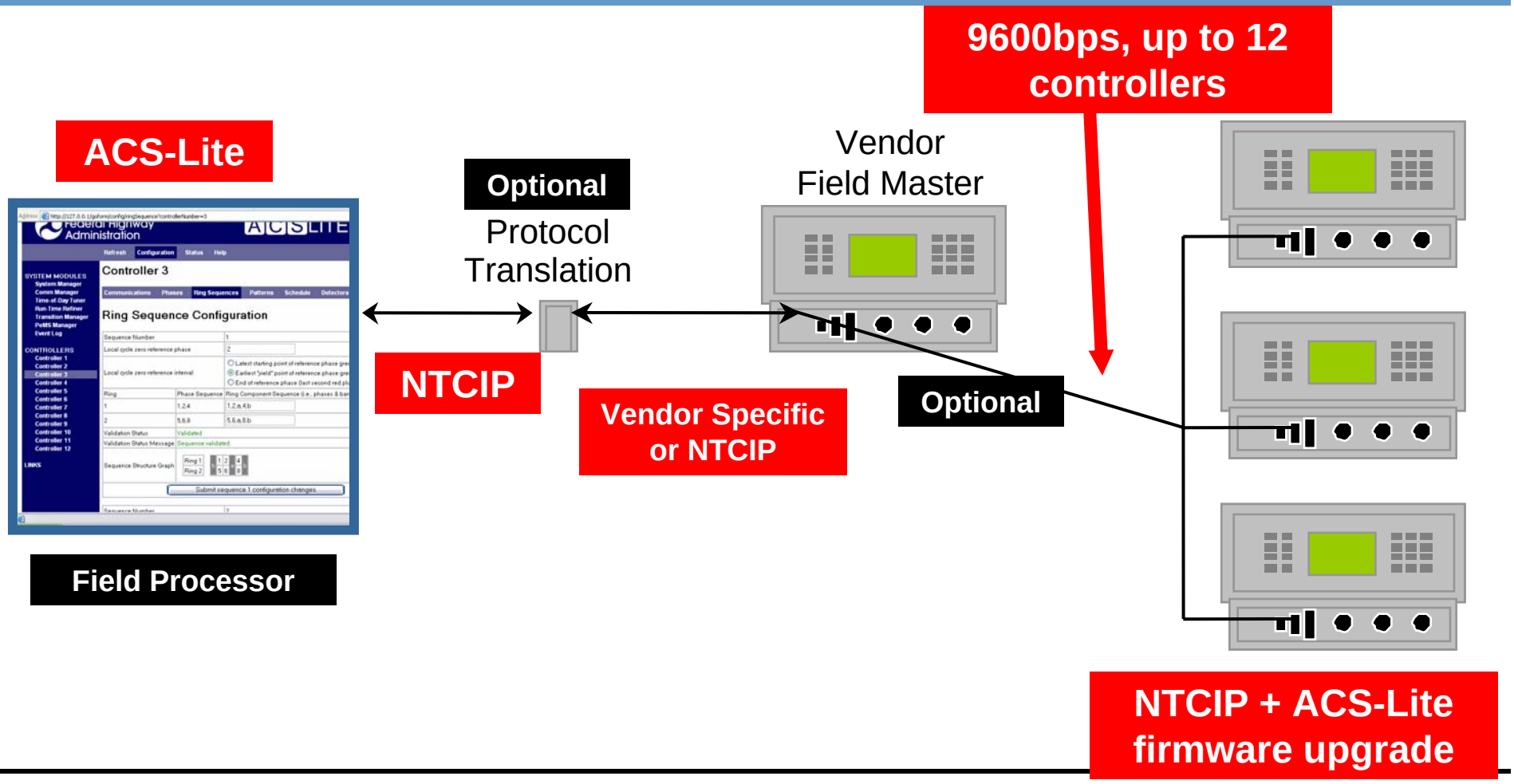
THE UNIVERSITY OF ARIZONA
TUCSON ARIZONA

PEEK

Sabra, Wang & Associates, Inc.

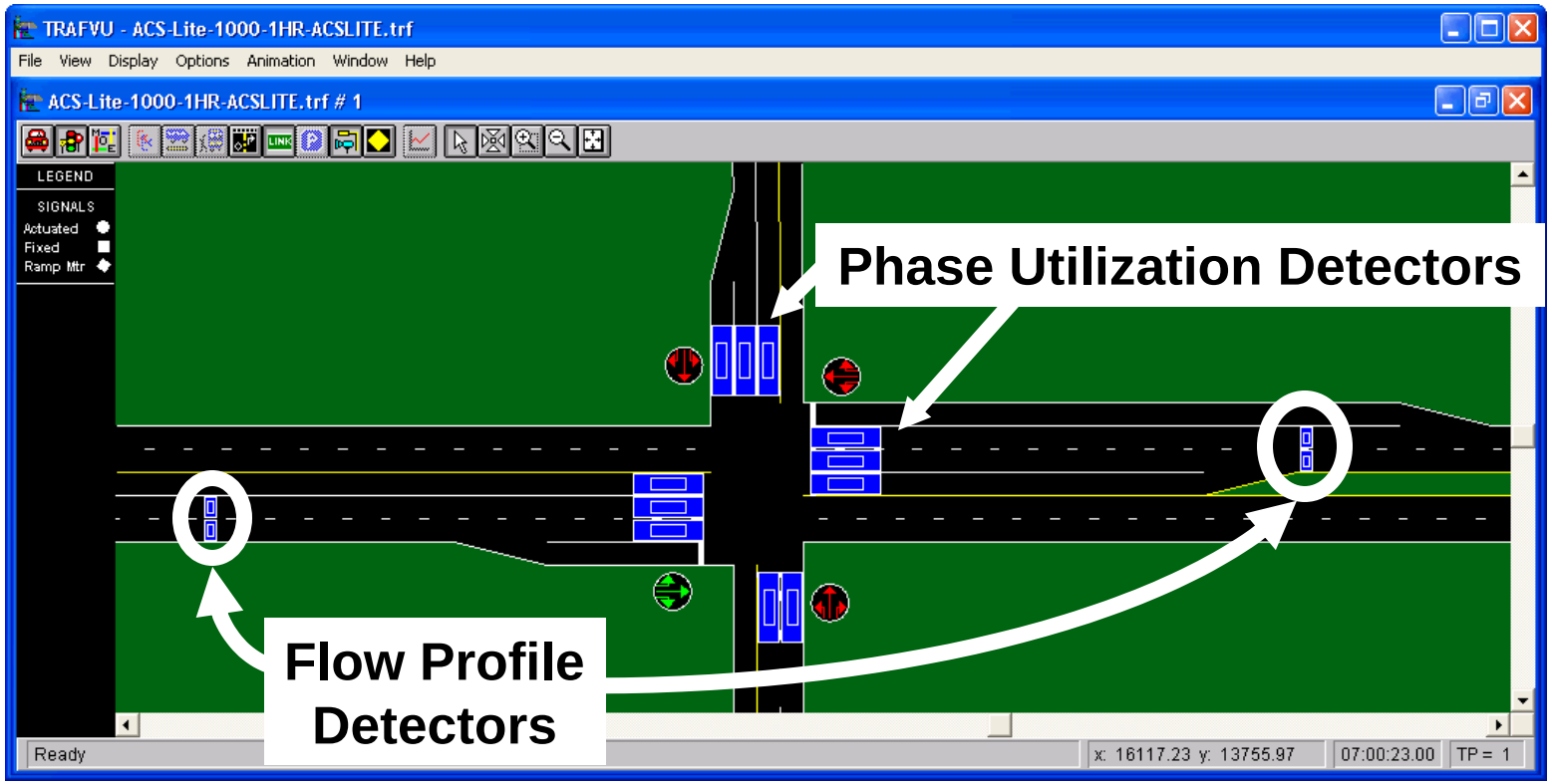
ITT Industries
Engineered for life

System Architecture



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**

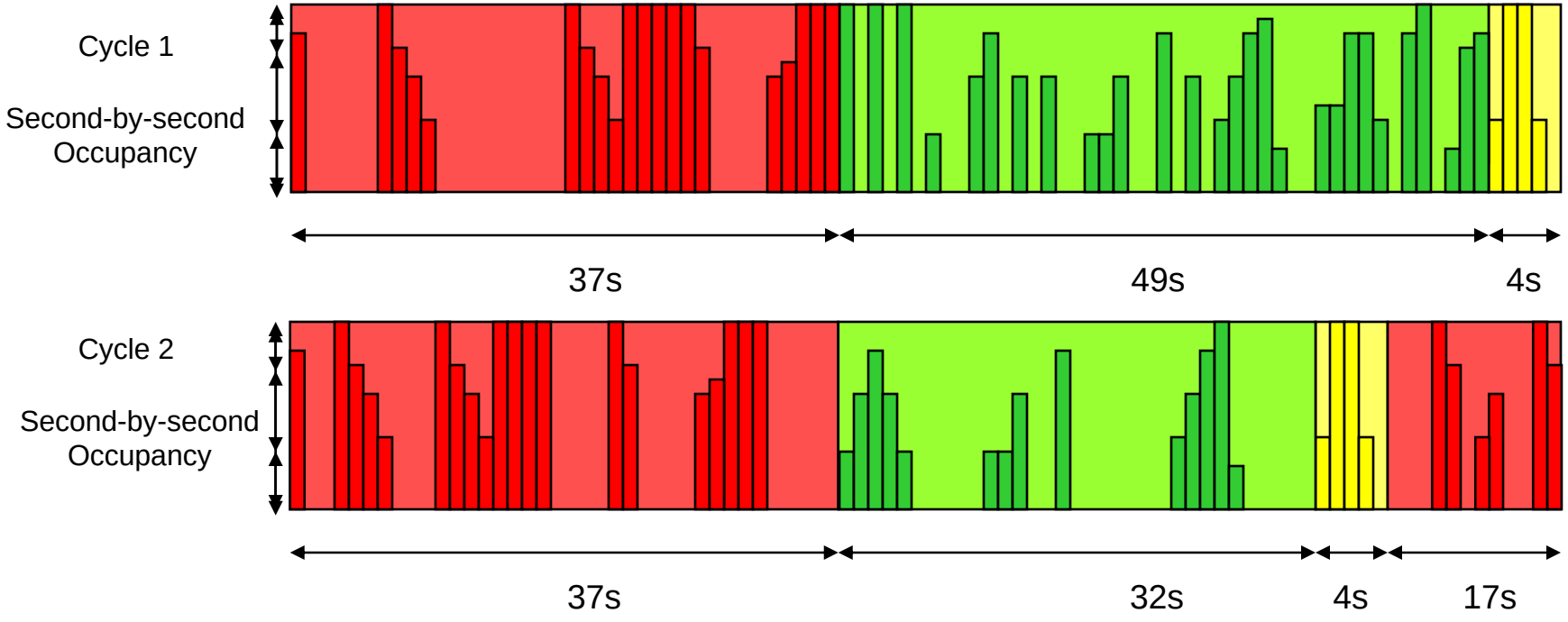
2
- Offsets
  - **Statistical Flow Profiles**

ACS-Lite NTCIP firmware upgrade

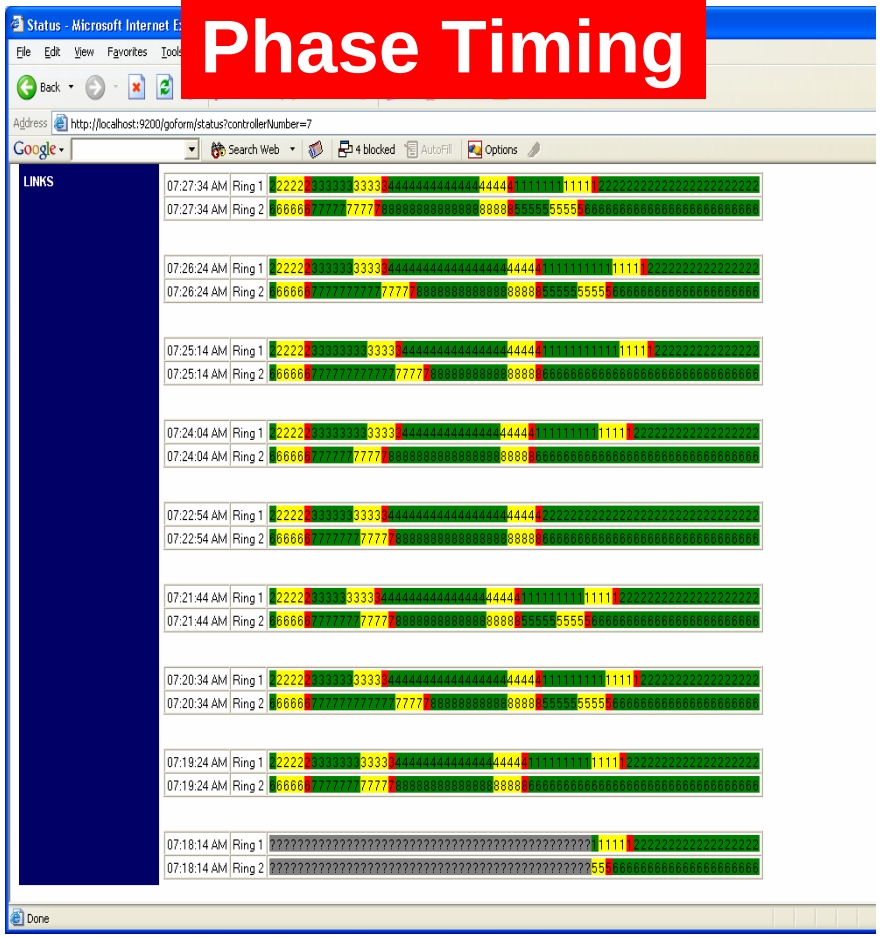
1. Phase Timing Status Object
2. Detector Status Object
3. Configuration Objects
- Polled once per minute
  - Second-by-second accuracy
  - Bandwidth efficient
- Minute-by-minute polls are “stitched” together for cycle-by-cycle performance assessment

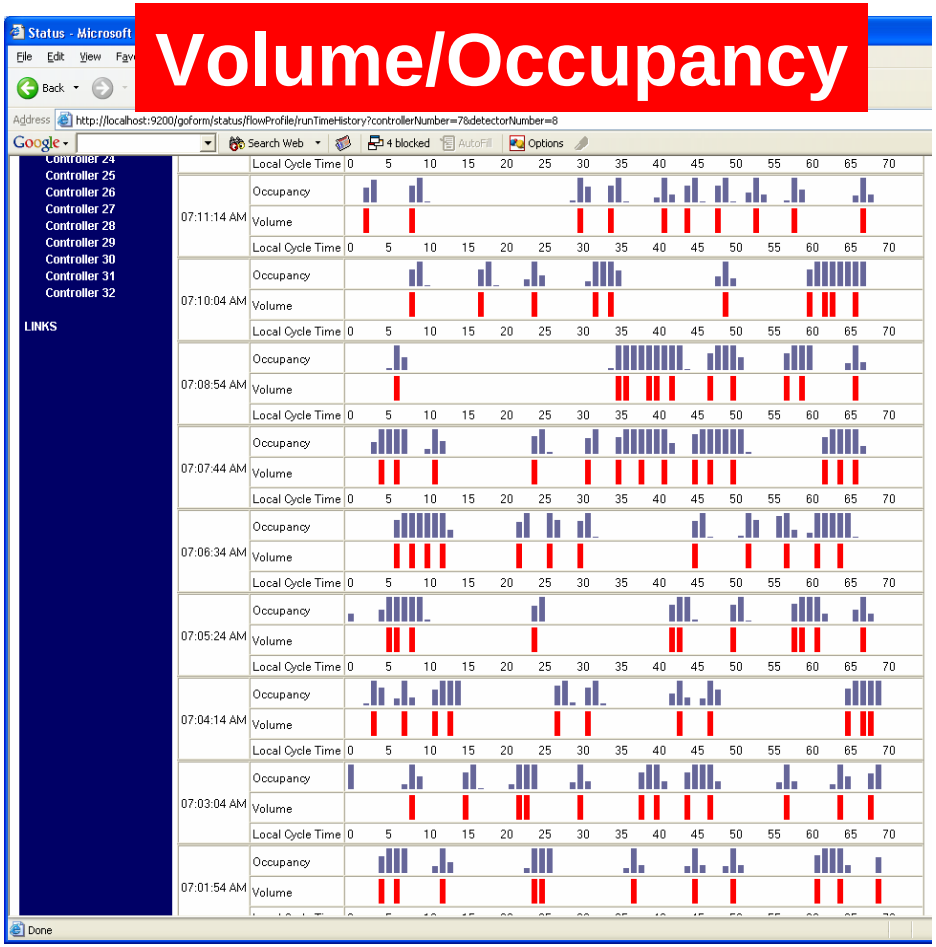
Occupancy per phase interval

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

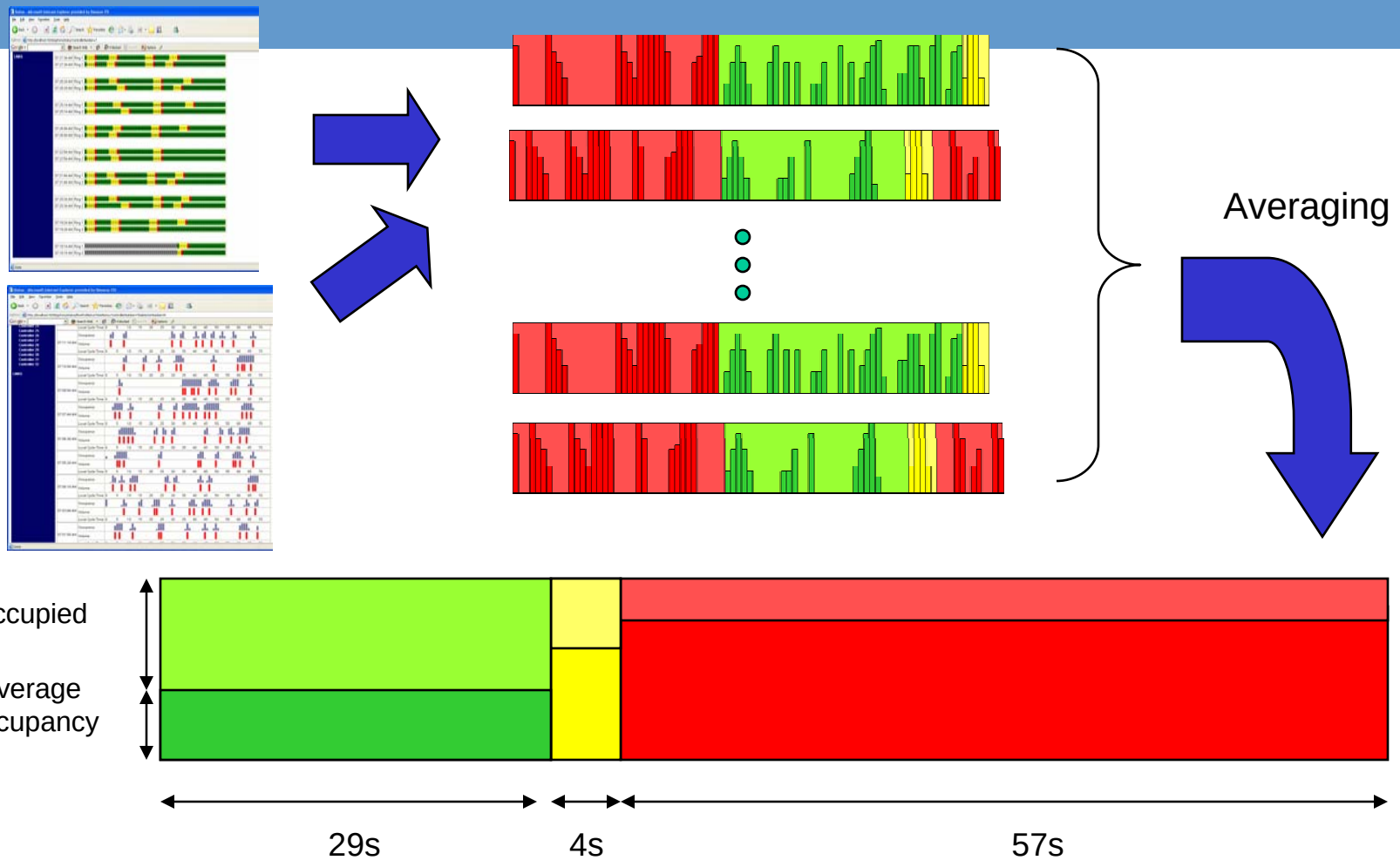


Cycle-by-cycle Data

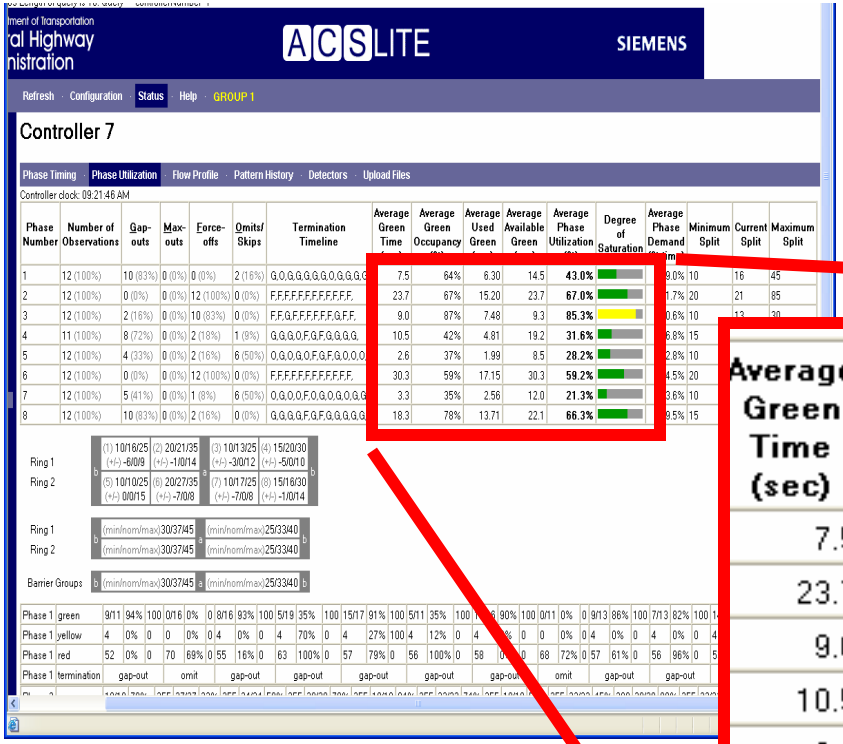




Occupancy per interval → split tuning

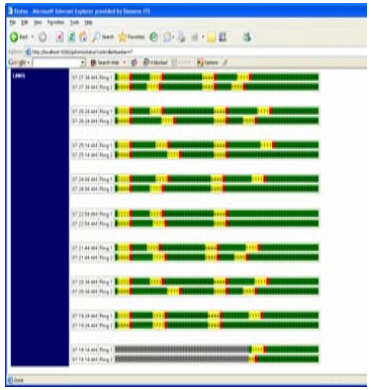


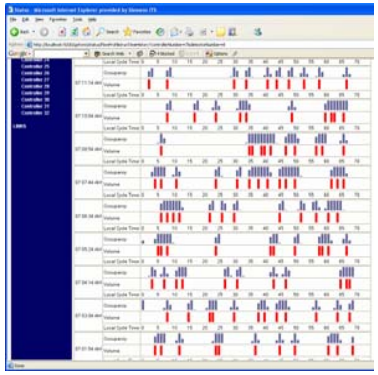
Green occupancy → Phase Utilization



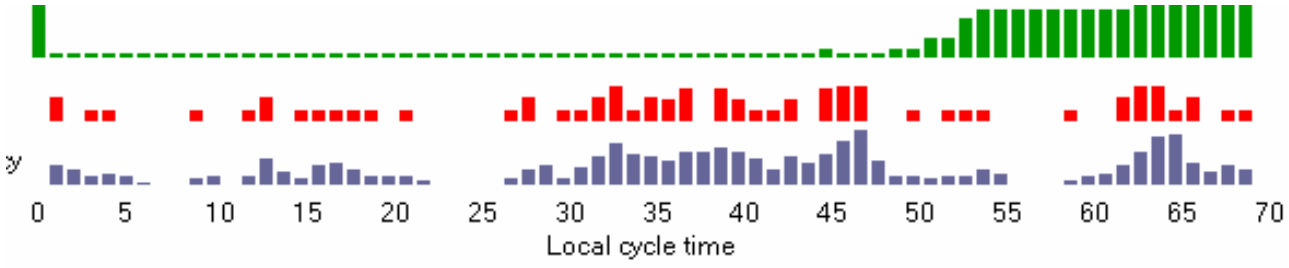
Average Green Time (sec)	Average Green Occupancy (%)	Average Used Green (sec)	Average Available Green (sec)	Average Phase Utilization (%)	Degree of Saturation	Average Phase Demand (% time)	M
7.5	64%	6.30	14.5	**43.0%**		9.0%	1
23.7	67%	15.20	23.7	**67.0%**		21.7%	2
9.0	87%	7.48	9.3	**85.3%**		10.6%	1
10.5	42%	4.81	19.2	**31.6%**		6.8%	1
2.6	37%	1.99	8.5	**28.2%**		2.8%	1
30.3	59%	17.15	30.3	**59.2%**		24.5%	2
3.3	35%	2.56	12.0	**21.3%**		3.6%	1
18.3	78%	13.71	22.1	**66.3%**		19.5%	1

Cyclic occupancy profiles → Statistical profile





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



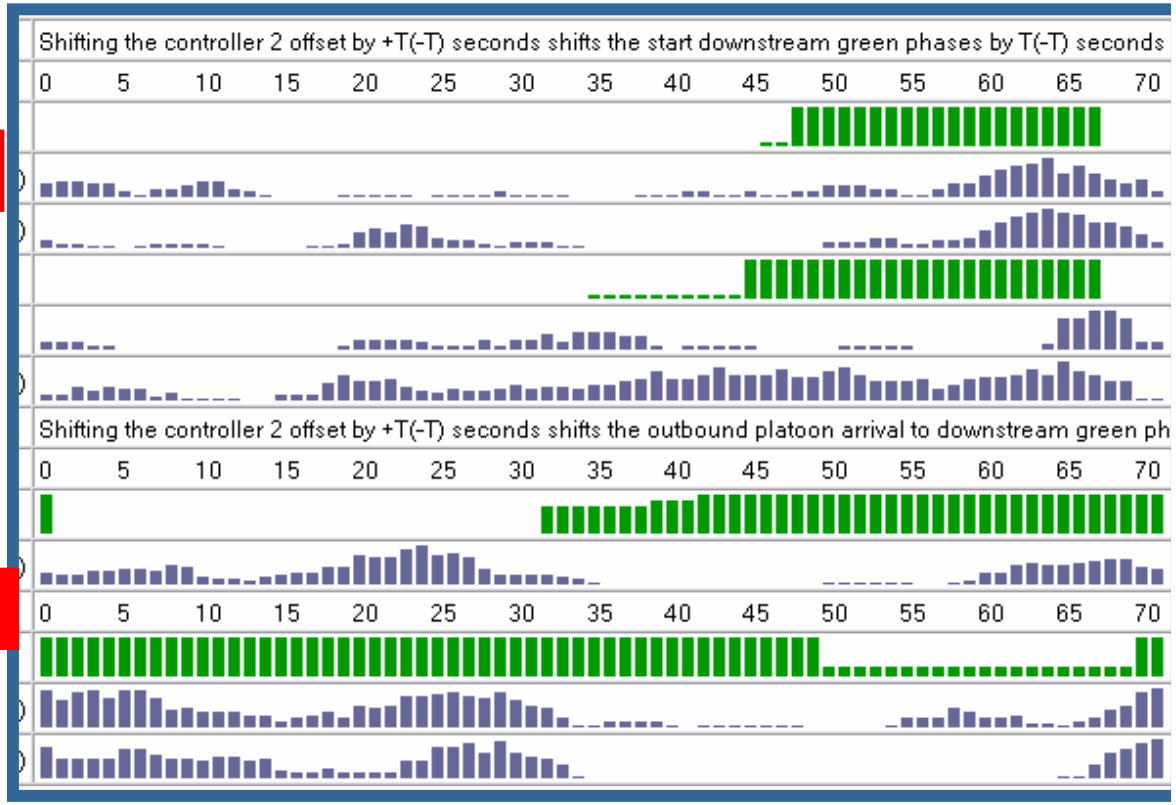
“statistical” flow profile

Progression Performance → Offset tuning

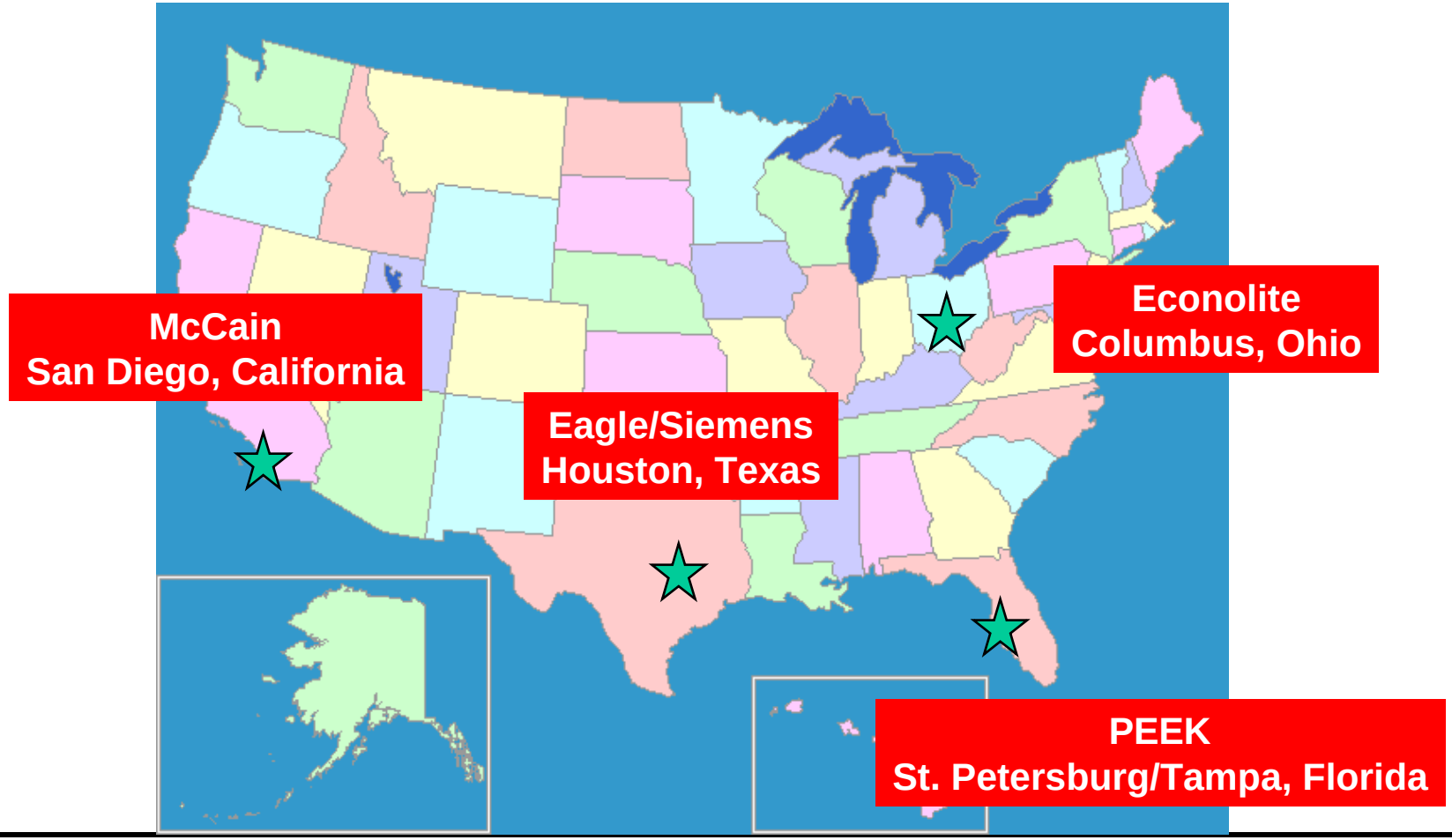
- Performance measure for offsets → "capture efficiency"
- Shift offsets small amount
- Constrain changes within user-configurable bounds

Inbound

Outbound

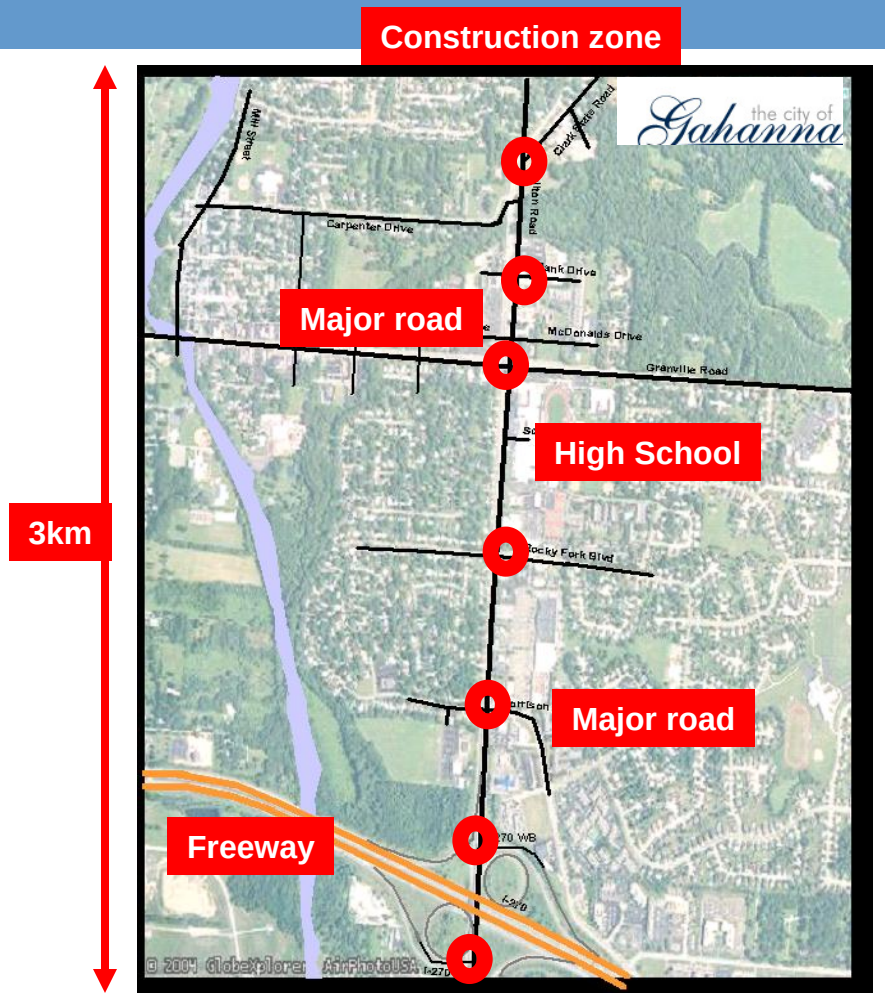


Field trials



Field trial – Columbus, Ohio

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



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