Adaptive Signal Control

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Federal Highway Administration

Outline

- Goals
- System architecture
- Adaptive approach
- 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.

EAGLE Traffic Control Systems

SIEMENS

McCain

The University of Arizona
Tucson Arizona

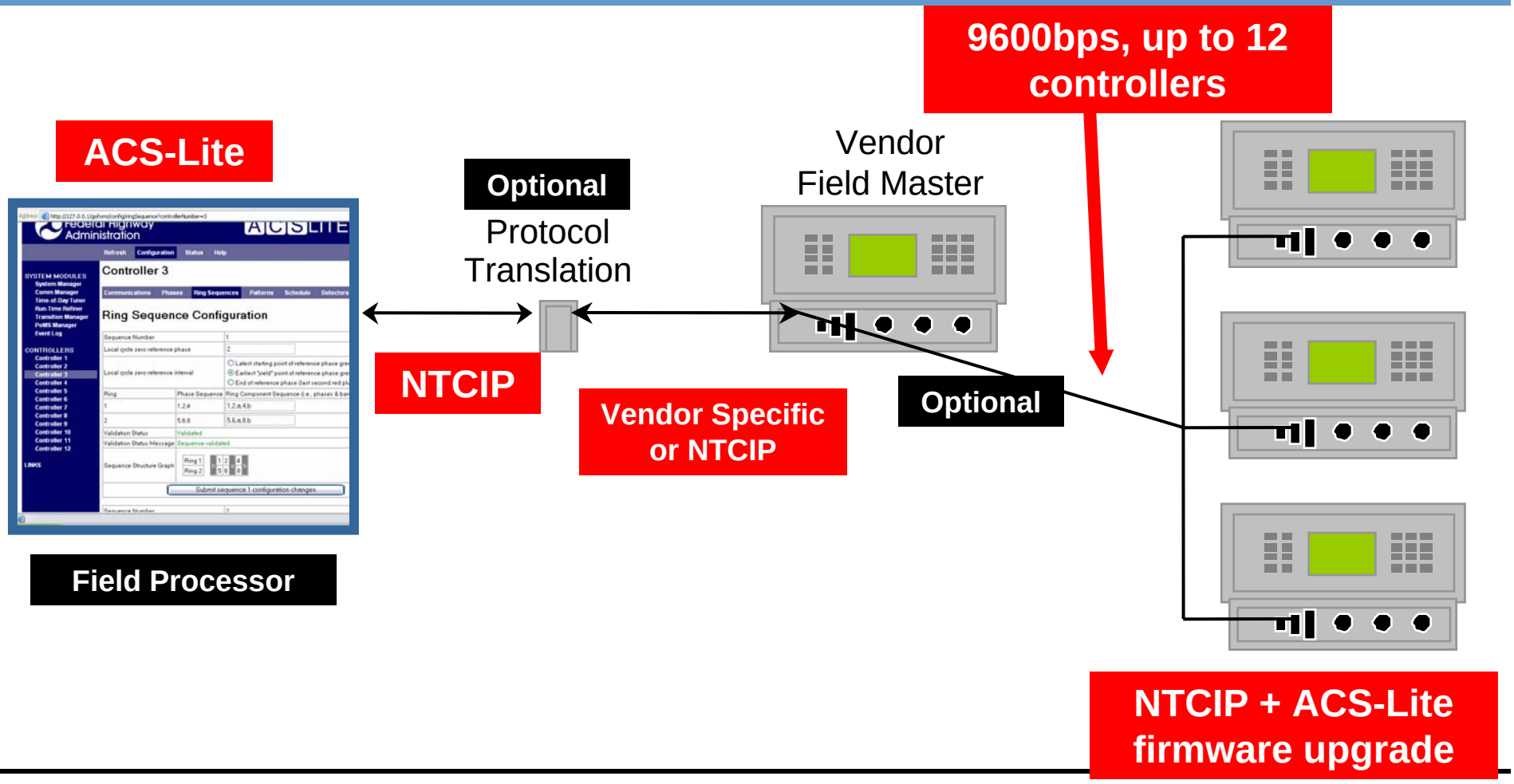
PURDUE UNIVERSITY

PEEK

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

ITT Industries
Engineered for life

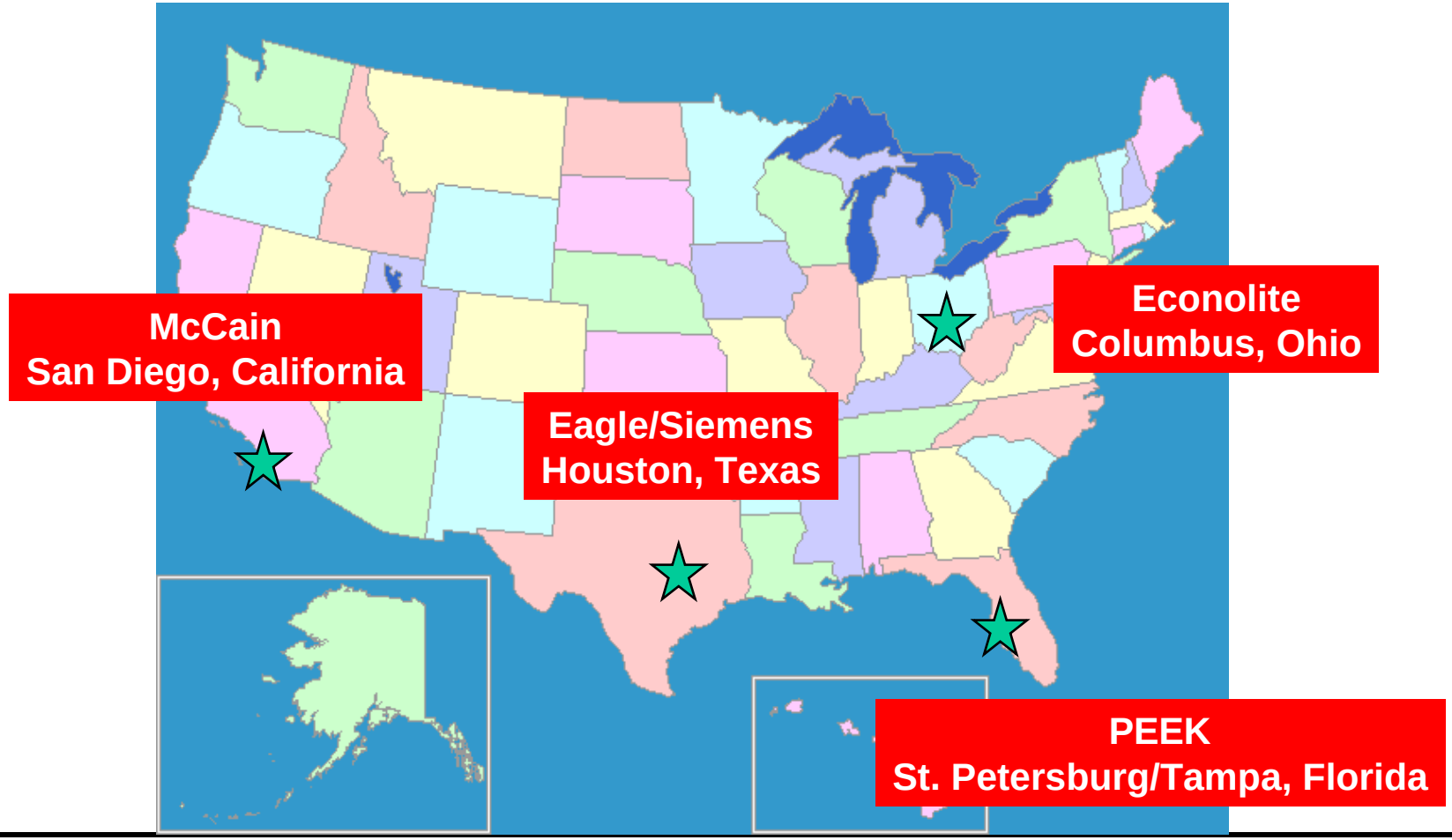
System Architecture



ACS-Lite NTCIP firmware upgrade

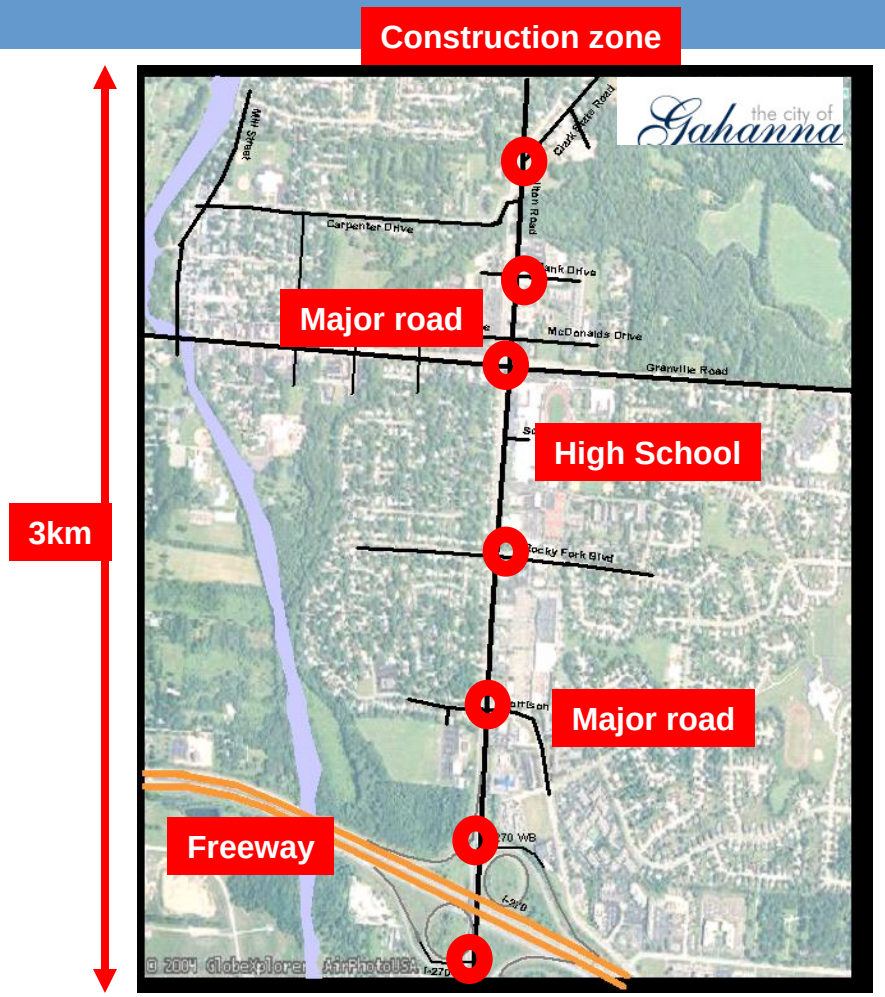
1. Phase Timing Status Object
2. Detector Status Object
3. Configuration Objects
- Polled once per minute
  - Second-by-second accuracy
  - Bandwidth efficient
- Minute-by-minute polls are “stitched” together for cycle-by-cycle performance assessment

Field trials

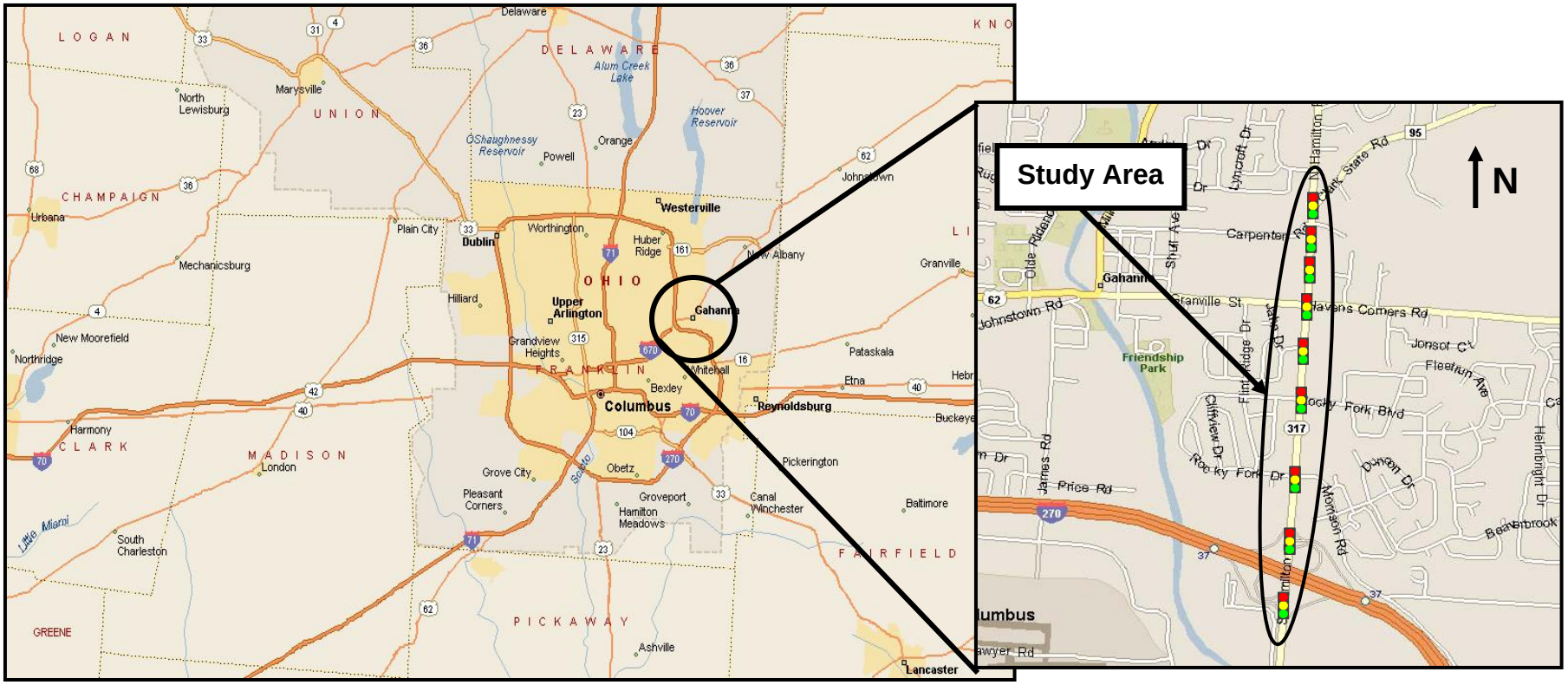


Field trial – Columbus, Ohio

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



Columbus, Ohio - Hamilton Road



Columbus, Ohio – Hamilton Road

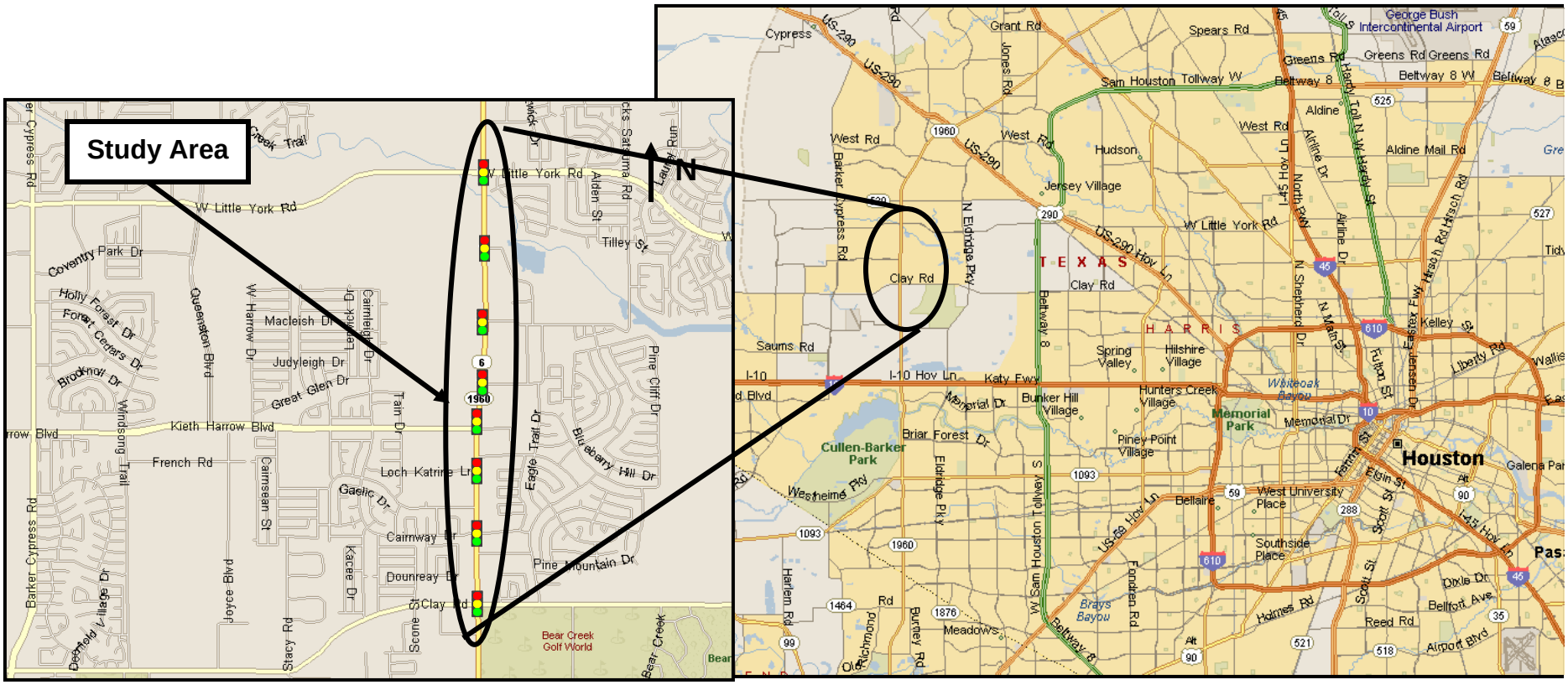
Hamilton Road Travel time results – before (after)

Measure of Effectiveness	NB AM	NB PM	SB AM	SB PM
Number of Runs	35 (30)	29 (31)	36 (29)	29 (31)
Travel Time (seconds)	290.4 (309.5)	265.1 (242.5)	264.8 (284.7)	265.6 (234.6)
Number of Stops	3.7 (3.7)	3.6 (1.8)	3.3 (3.0)	3.5 (2.7)
Stopped Delay (seconds)	88.0 (110.1)	65.9 (68.4)	72.2 (92.5)	78.2 (71.7)
Travel Time Delay (seconds)	153.8 (177.3)	129.0 (108.2)	134.0 (148.1)	125.6 (99.8)
Average Speeds (mph)	19.1 (17.3)	20.9 (22.4)	20.5 (19.3)	22.5 (23.0)

Hamilton Road Summary of ACS Lite Technology benefits analysis

	Before (per veh)	After (per veh)	Savings (per veh)	Peak Hours (all vehs)	Peak Hours Savings
Total Delay (hour)	0.03761	0.03758	0.00003	0.15588	$1.89
Total Stops	3.5	2.9	0.6	3117.6	$43.65
Fuel (Liters)	0.390	0.373	0.017	89.287	$53.08
Peak Hours Benefit					**$98.61**
Daily Benefit					**$340.03**
Annual Benefit					**$88,408.69**

Houston, Texas – State Route 6



Houston, Texas – State Route 6

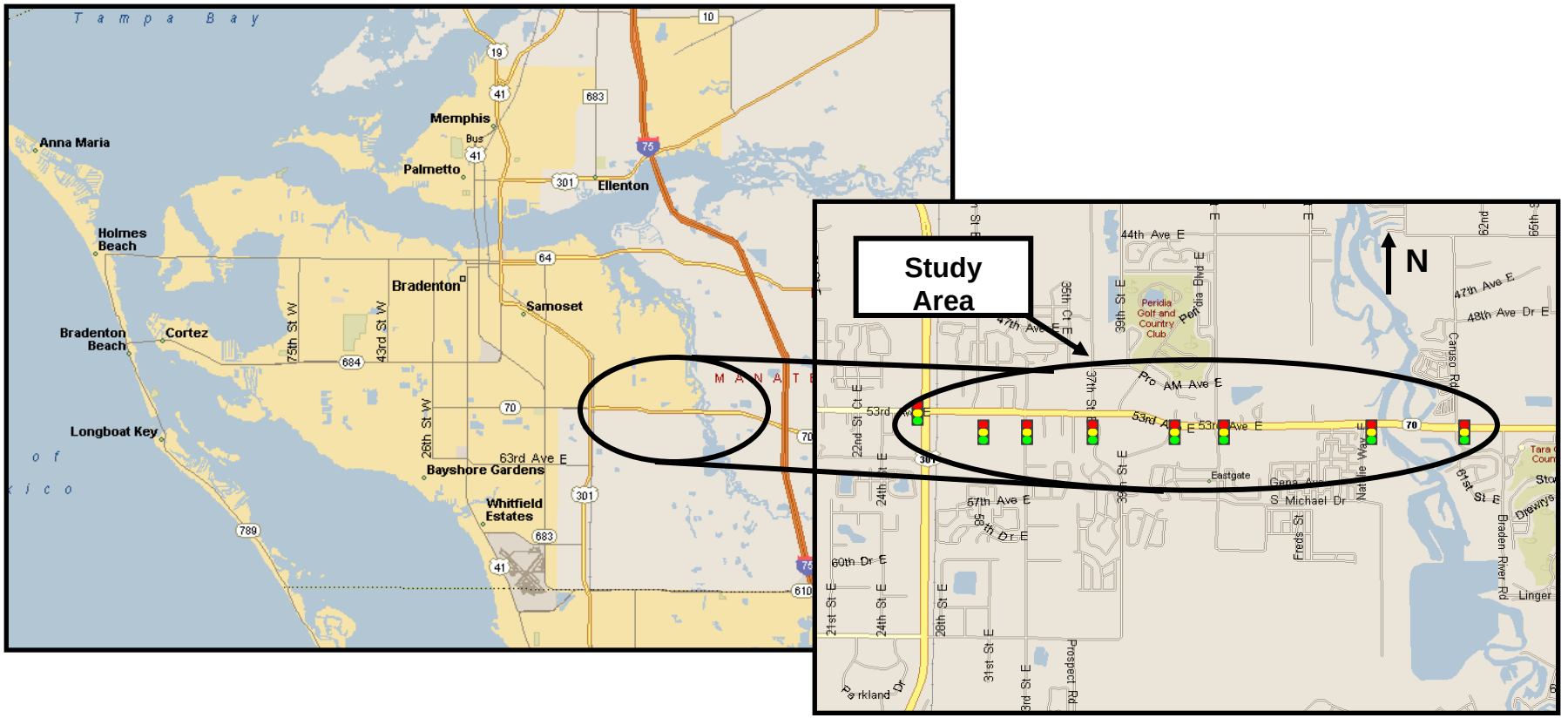
State Route 6 Travel time results – before (after)

Measure of Effectiveness	NB AM	NB PM	SB AM	SB PM
Number of Runs	35 (40)	32 (35)	35 (41)	32 (37)
Travel Time (seconds)	252.7 (197.9)	310.8 (256.5)	225.8 (208.8)	221.2 (211.3)
Number of Stops	2.2 (1.0)	3.0 (2.2)	1.4 (1.1)	0.8 (0.7)
Stopped Delay (seconds)	44.1 (19.2)	69.2 (39.5)	29.6 (25.2)	24.3 (18.9)
Travel Time Delay (seconds)	75.9 (32.8)	128.1 (83.0)	51.6 (41.8)	43.9 (38.9)
Average Speed (mph)	32.3 (39.8)	26.3 (30.7)	36.1 (37.4)	36.8 (37.7)

State Route 6 Summary of ACS Lite Technology benefits analysis

	Before (per veh)	After (per veh)	Savings (per veh)	Peak Hours (all vehs)	Peak Hours Savings
Total Delay (hour)	0.01856	0.01214	0.00642	39.16252	$474
Total Stops	1.7	1.2	0.5	3051.6	$43
Fuel (Liters)	0.490	0.455	0.035	214.837	$128
Peak Hours Benefit					**$644**
Daily Benefit					**$2,222**
Annual Benefit					**$577,648**

Tampa, Florida – State Route 70



Tampa, Florida – State Route 70

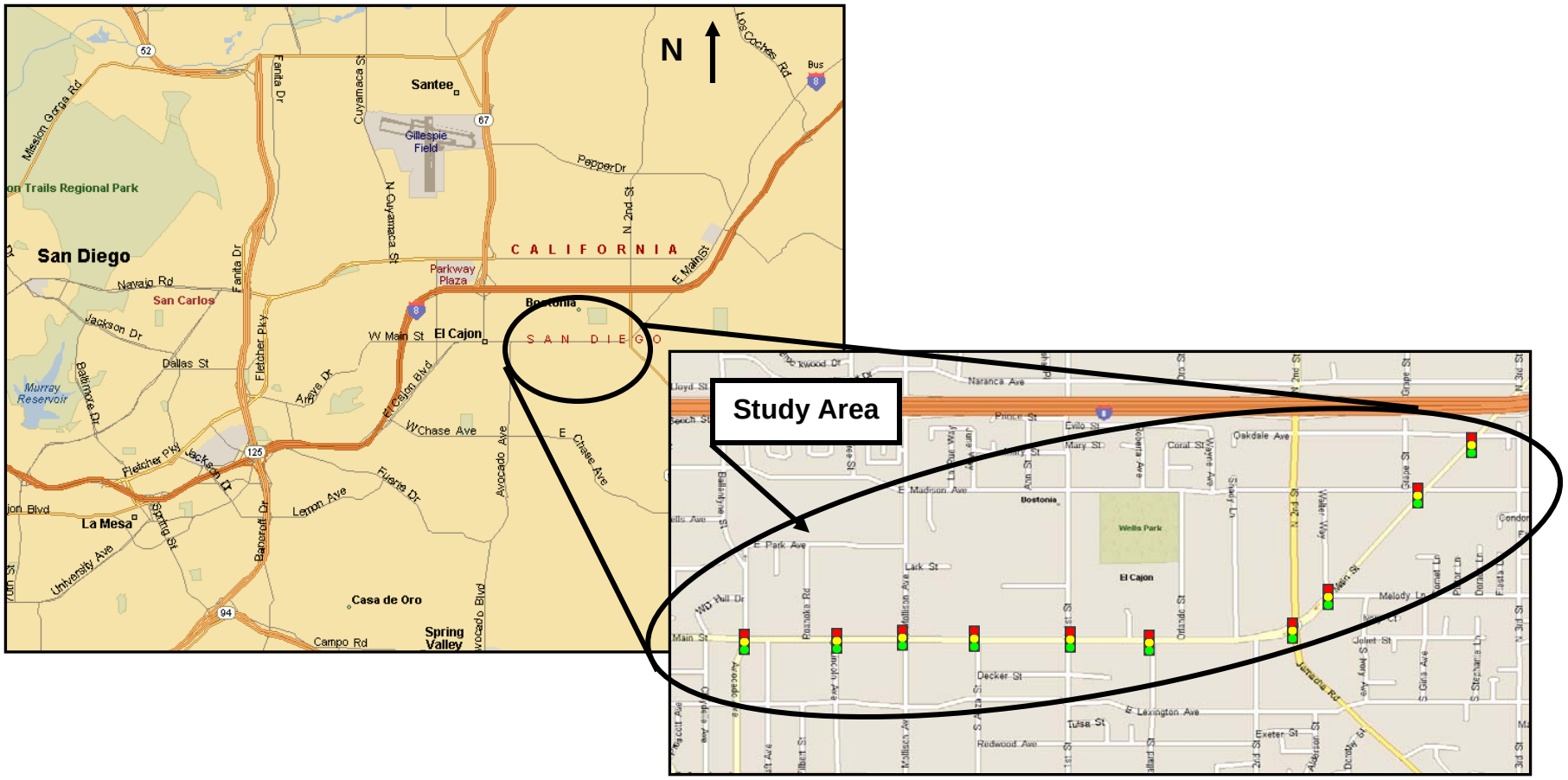
State Route 70 Travel time results – before (after)

Measure of Effectiveness	EB AM	EB PM	WB AM	WB PM
Number of Runs	34 (33)	28 (39)	36 (27)	31 (39)
Travel Time (seconds)	322 (309.1)	386.7 (336.7)	397.4 (331.1)	349.2 (310.5)
Number of Stops	2.1 (2.2)	4.3 (2.4)	4.1 (2.7)	2.9 (1.9)
Stopped Delay (seconds)	52.2 (49.5)	77.0 (66.2)	98.0 (65.7)	71.6 (60.1)
Travel Time Delay (seconds)	91.6 (80.2)	152.6 (104.9)	167.9 (104.6)	119.3 (87.1)
Average Speed (mph)	34.4 (35.8)	28.6 (32.8)	27.7 (33.3)	31.5 (35.5)

State Route 70 - Summary of ACS Lite Technology benefits analysis

	Before (per veh)	After (per veh)	Savings (per veh)	Peak Hours (all vehs)	Peak Hours Savings
Total Delay (hour)	0.0367	0.0264	0.010	54.529	**$659.80**
Total Stops	3.2	2.3	0.90	4762.125	**$66.67**
Fuel (Liters)	0.7199	0.6919	0.0280	148.203	**$117.47**
Peak Hours Benefit					**$843.94**
Daily Benefit					**$2,910.14**
Annual Benefit					**$757,000**

San Diego, California – Main Street



San Diego, California – Main Street

Main Street Travel time results – before (after)

Measure of Effectiveness	EB AM	EB PM	WB AM	WB PM
Number of Runs	36 (41)	34 (39)	29 (34)	34 (40)
Travel Time (seconds)	324 (312)	31 0 (377)	360 (350)	428 (394)
Number of Stops	3.4 (3.0)	2.9 (4.0)	4.4 (4.4)	5.2 (4.5)
Stopped Delay (seconds)	83.9 (84.0)	55.0 (114.7)	110.0 (106.4)	149.6 (130.6)
Travel Time Delay (seconds)	131.1 (117.3)	113.8 (182.7)	167.4 (158.1)	233.4 (199.6)
Average Speed (mph)	21.1 (22.3)	22.3 (18.4)	18.9 (19.6)	15.9 (17.3)

Main Street - Summary of ACS Lite Technology benefits analysis

	Before (per veh)	After (per veh)	Savings (per veh)	Peak Hours[1] (all vehs)	Peak Hours Savings
Total Delay (hour)	0.0794	0.0650	0.014	30.73	**$371.84**
Total Stops	4.0	4.0	0.0	0	**$0.0**
Fuel (Gallons)	0.123	0.124	-0.001	-2.13	**-$6.38**
Peak Hours Benefit					**$365.46**
Daily Benefit					**$1,260.20**
Annual Benefit					**$327.651**

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