



G R E S H A M
S M I T H A N D
P A R T N E R S

ADAPTIVE SIGNAL CONTROL, IS IT RIGHT FOR MY AGENCY?



Presented by: Adam Moser, P.E.

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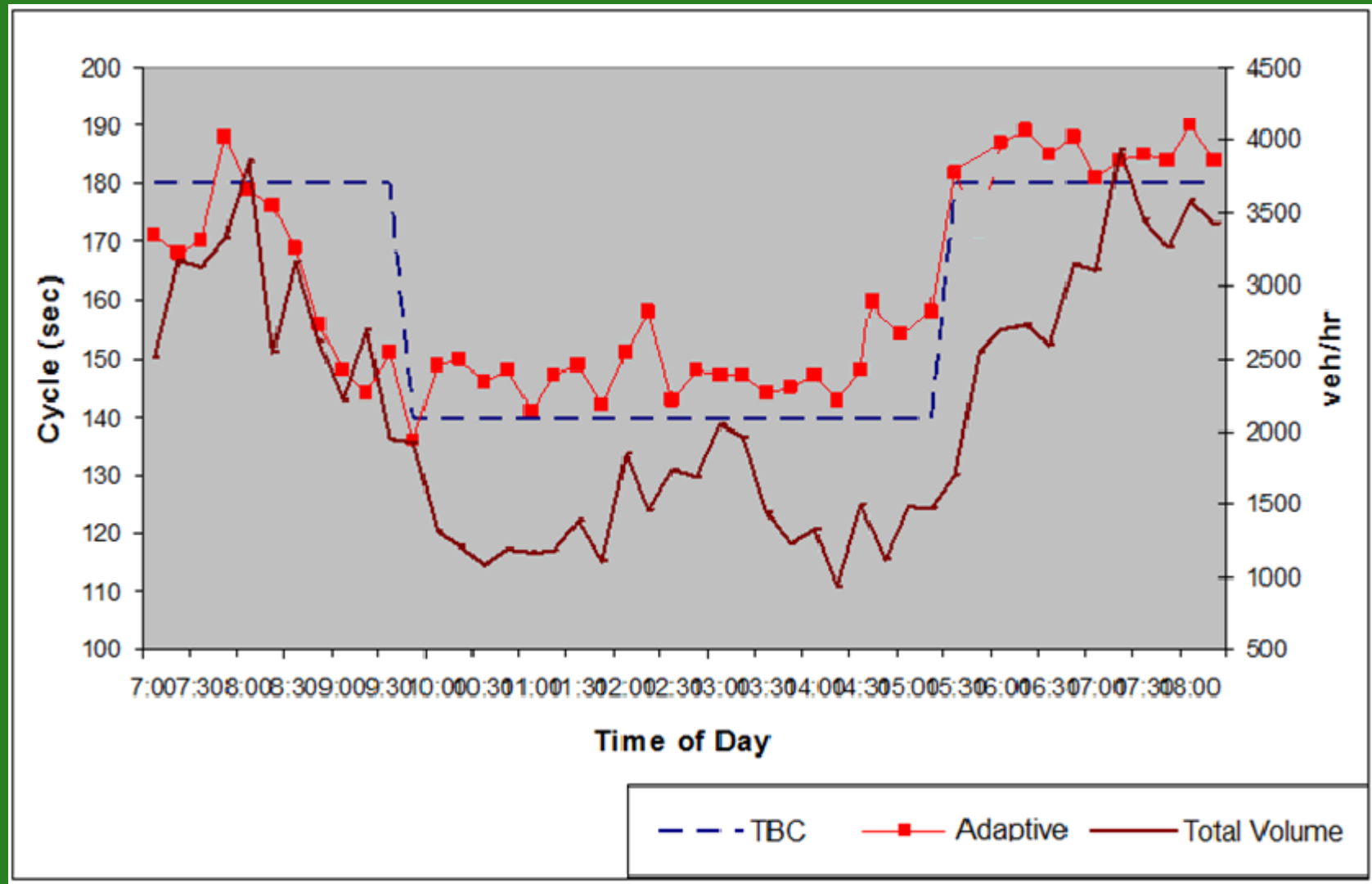
WHAT 'EXACTLY' IS ADAPTIVE SIGNAL CONTROL?



- It's a Good Question
 - FHWA Every Day Counts Initiative States: *"Outdated signal timing contributes to traffic congestion; this doesn't need to be commonplace. Adaptive signal control technologies can use real-time traffic information to reduce congestion by determining which lights should be red and which should be green."**
 - The answer will vary by who you ask
- What requirements can be agreed on?
 - It should adapt to unexpected changes in real-time traffic conditions
 - It should continuously distribute green time and phasing as necessary for all traffic movements
 - It should improve travel time reliability by keeping progression at all times of the day
 - It should reduce congestion, delay and accidents by creating smoother flow between signalized intersections
 - It should prolong the effectiveness of traffic signal timing and reduce complaints

* www.fhwa.dot.gov/everydaycounts/technology/adsc/

WHAT 'EXACTLY' IS ADAPTIVE SIGNAL CONTROL?



ADAPTIVE SIGNAL CONTROL OPERATIONS



- Adaptive Operation (and arguments) varies by software manufacturer/vendor:
 - Should it have a 'fixed' cycle time it must adhere to or be dynamic? How fast should the cycle adapt (I.E. transition effects)?
 - Should it be a peer to peer only system (no cycle length)?
 - Should it be open architecture/algorithms, or continue proprietary?
 - Should it reside locally in the cabinet, or controlled by central?
 - What should the degree of complexity be? Should it be easily adjusted by System Operators, by Signal Engineers, or ONLY by Software Developers (remotely)?



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PROACTIVE?



OR REACTIVE!!

ADAPTIVE SOFTWARE – “OLDER” DEPLOYED SYSTEMS

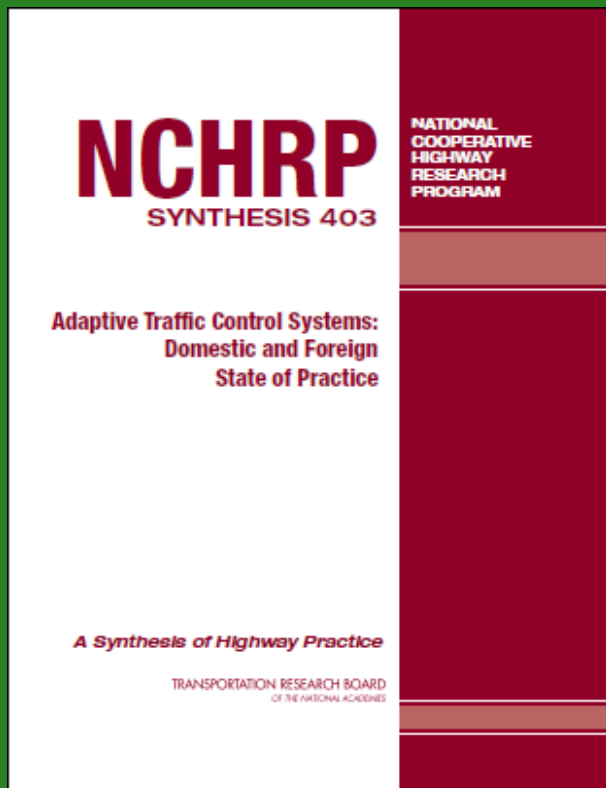


- **ACS Lite** – Siemens, Econolite, PEEK, McCain
- **InSync** – Rhythm Engineering
- **SCATS** - Roads and Traffic Authority (RTA) of New South Wales, Australia... TransCore is a distributor for North America
- **SCOOT** – UK developer... Siemens is a distributor for North America
- **RHODES** – University of Arizona & Gardner Systems (bought by Siemens), Arizona State University now holds rights
- **OPAC** – Telvent (Farradyne) & UMASS, now Schneider Electric/Telvent

ADAPTIVE SOFTWARE – “NEWER” SYSTEMS



- Other Systems that are in various stages of development and use in the US:



- **QuicTrac** (McCain)
- **Synchro Green** (Trafficware/Naztec)
- **Centracs Adaptive (Econolite)** – Builds off their version of ACS Lite
- **Adaptive Decision Support System (ACDSS)** – KLD developed for NYCDOT
- **LA ATCS** - McTrans holds rights - developed for Los Angeles, looks to sell to other states
- **NWS VOYAGE** – Northwest Signal
- **PTV BALANCE** - VISSIM and modeling adaptive software, used in Europe - trying to test in US
- **SPOT/UTOPIA** - Italy, 1985, Scandinavian countries use it too – trying to test in US
- Many others trying modules and algorithms out in their regular controller firmware releases

SOME APPROXIMATE INITIAL COSTS FOR ADAPTIVE



Adaptive System	Detection Cost	Additional hardware cost	Average software developer cost	Average Total per Intersection Cost(1)	Notes
ACS Lite	\$21,000	\$0	\$4,500	\$25,500	Per intersection cost of development is relatively unknown due to FHWA funding and the lack of new deployments
SCATS	\$12,000	\$0	\$14,000	\$26,000	Developer cost varies from \$13k - \$21k per intersection, depending on project size and/or adding to existing system
InSync	Included	Included	\$25,000*	\$30,000	Includes pedestrian optimization module, but not module to use existing detection with the manufacturer's detection (+\$5k)
RHODES	\$38,000	\$1,500	\$3,000	\$42,500	If run centrally, then additional hardware cost can be subtracted, cost is for adding to existing system
OPAC	\$38,000	\$1,500	\$3,500	\$43,000	"central only" solution currently available. Need field processor. Cost is for adding to existing system
SCOOT	\$38,000	\$0	\$10,000	\$48,000	Developer cost varies from \$10k - \$18k per intersection, depending on size and/or adding to existing

(1) NOTE: Does not include cost for comm network, central system hardware, or specific signal controller/cabinet requirements

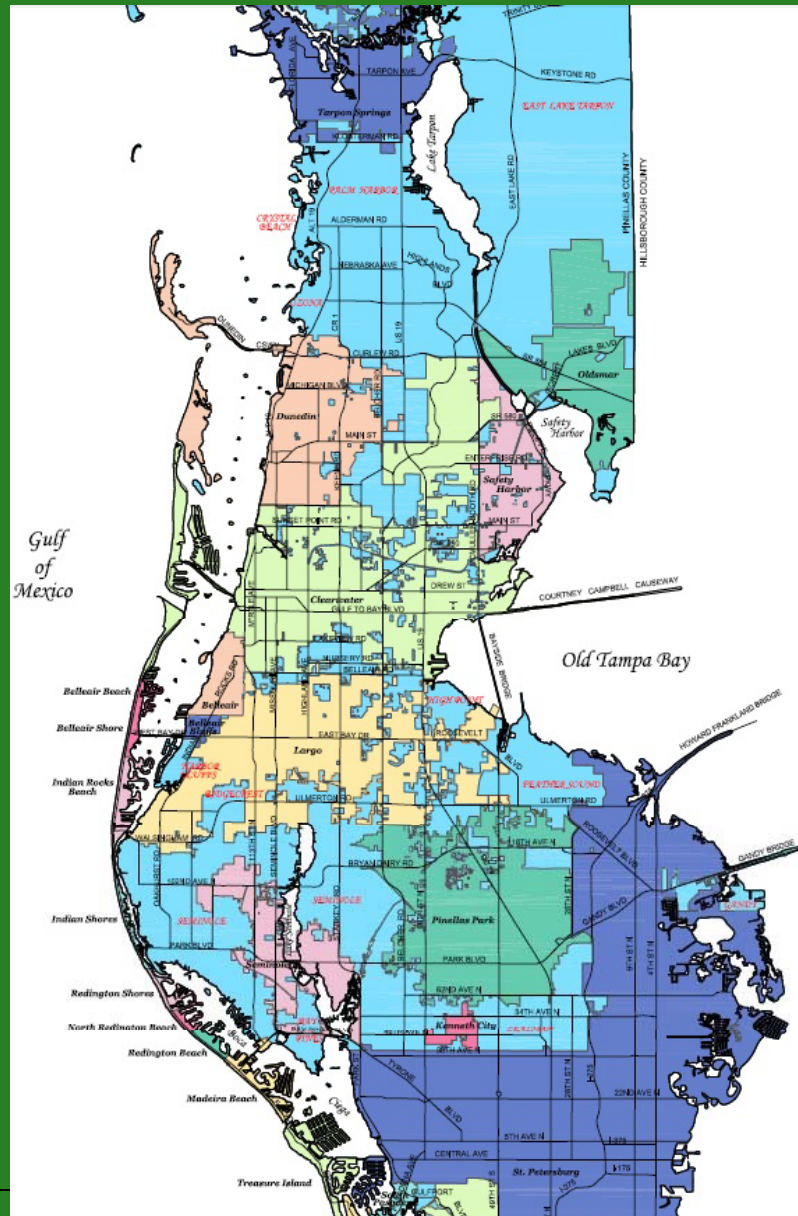
* Includes InSync Video Detection Solution – not separated out

ADAPTIVE DEPLOYMENTS NATIONWIDE



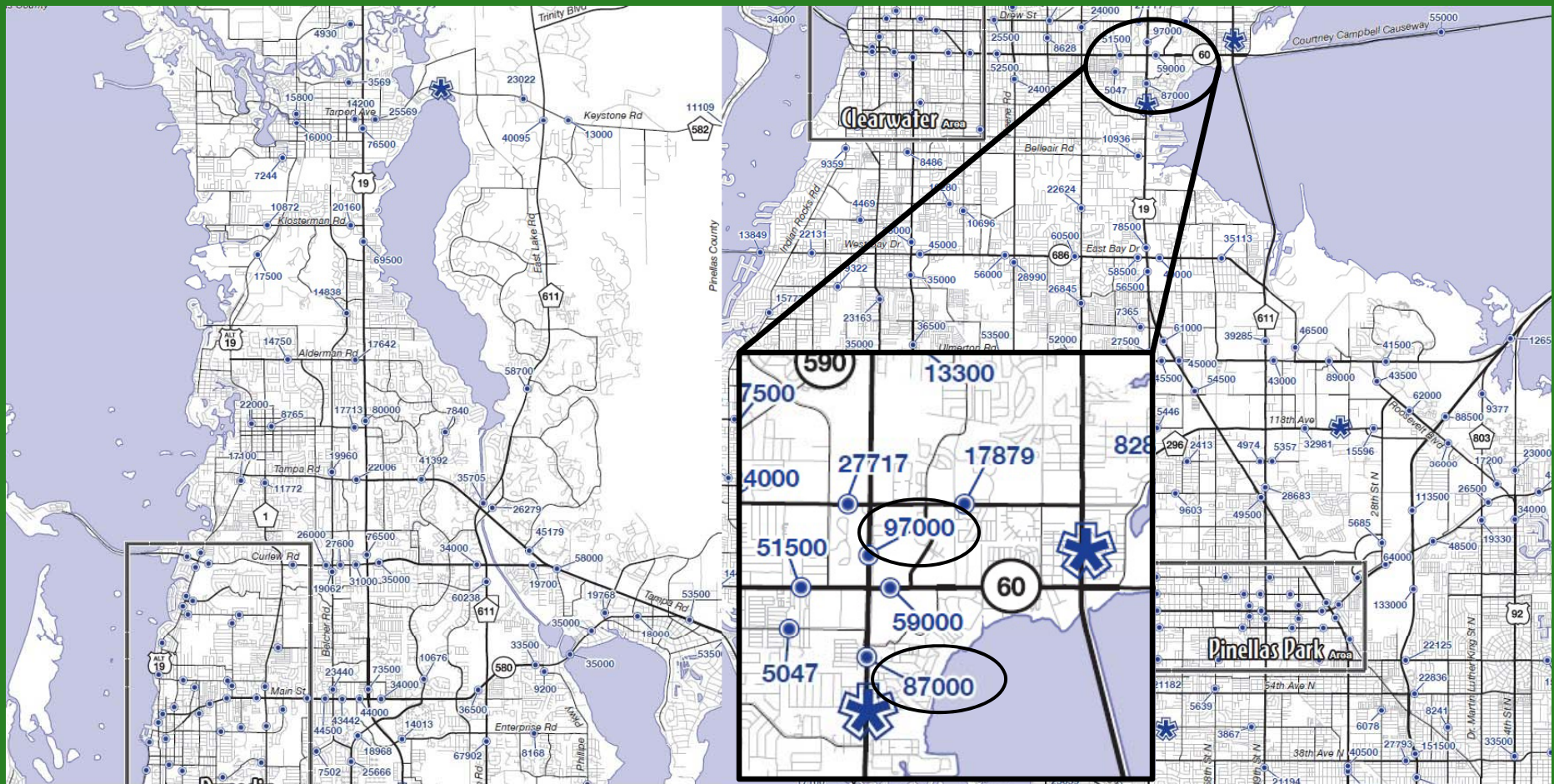
Source: Aleksandar Stevanovic, Assistant Professor, Florida Atlantic University

ADAPTIVE EXPERIENCE IN PINELLAS COUNTY, FL



- Peninsula County - west of the City of Tampa. Size approx 280 sq mi
- Home of Clearwater and St Pete Beaches
- Just under 1 million residents
- 24 incorporated municipalities
- Large retirement community
 - 43 Golf Courses
 - 1059 Tennis Courts
 - 2865 Shuffle Board Courts
- MLB: Tampa Bay Rays – St Pete
- Spring Training/Minor League:
 - Phillies (Clearwater)
 - Blue Jays (Dunedin)
- Most densely populated county in FL
 - Only 4% undeveloped
 - Only 17 miles of Interstate

WHAT'S THE TRAFFIC LIKE?



Pinellas County Major Arterials AADT = 25,000 – 97,000

ADAPTIVE DECISION (PRE-ADAPTIVE SYS. ENG.)



- Local ITS Steering Committee formed
 - Committee made up of State and Local government officials, members of the general public, and transportation professionals
 - Visited and gathered information on existing and emerging systems throughout the U.S.
 - Weighed pro's and con's of central software and adaptive signal systems
 - Roughly estimated needs for Operations and Maintenance
- In early 2000's, committee reviewed 4 adaptive systems in detail:
 - OPAC (FHWA RT-TRACS software)
 - RHODES (FHWA RT-TRACS software)
 - SCATS (Australia)
 - SCOOT (UK)

ADAPTIVE SYSTEMS DEPLOYED 2004 - 2012



- Sydney Coordinated Adaptive Traffic System (SCATS) - 04/05
 - 13 intersections in existing NEMA TS1 cabinets with 2070LN controllers
 - Pasco County, FL – Stand Alone System
- Optimized Policies for Adaptive Control (OPAC) - 05/06
 - 53 intersections in both 170/332 cabinets and NEMA TS2 cabinets, full 2070 (now can run on 2070L controllers)
 - Pinellas County, FL, Integrated with MIST
- Realtime Hierarchical Optimized Distributed Effective System (RHODES) – 05/06
 - 22 intersections in both 170/332 cabinets and NEMA TS2 cabinets, full 2070 (now can run on 2070L controllers)
 - Pinellas County, FL, Originally Integrated with Siemens' I2TMS, now with MIST
- InSync (Chosen in 2011 for Florida Test Bed) – Jan 2012
 - 9 intersections in NEMA TS2 cabinets with 2070L controllers running Econolite ASC3 Firmware
 - Pinellas County, FL, CentralSync Client software from Vendor, Controller still reports status to MIST (NTCIP)

ADAPTIVE SIGNALS DEPLOYED 2004 - 2012



- Why Try Four Different Systems In One Area?

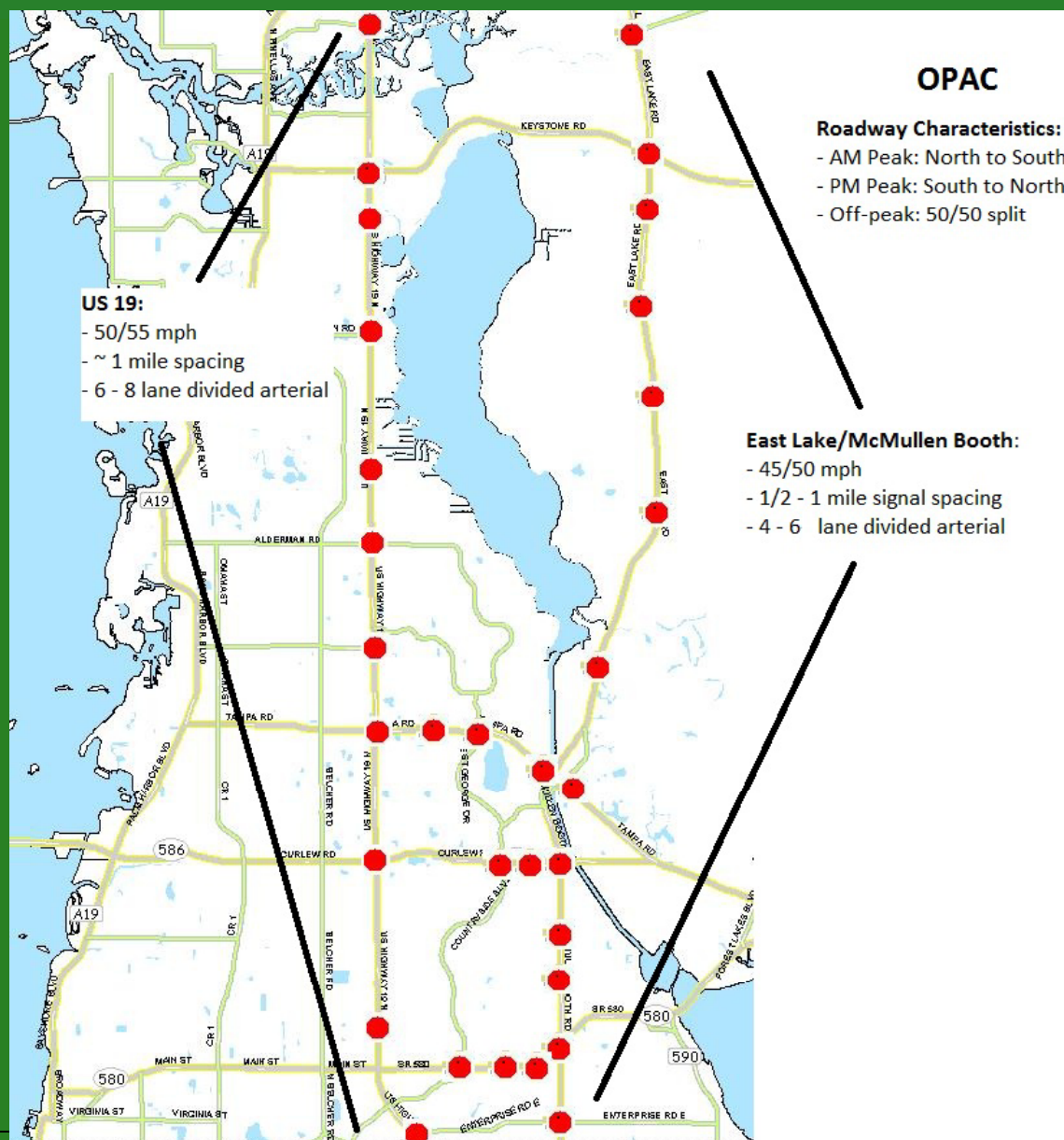
Feds (RITA personnel) believed that Adaptive Signal Control is not 'One Size Fits All', and Pinellas County ITS Steering Committee agreed. This idea was based on:

- Saturated - Highly Variable Volumes
- Medium Congestion (certain times of the day)
- Low Congestion with spurts in unpredictable volume

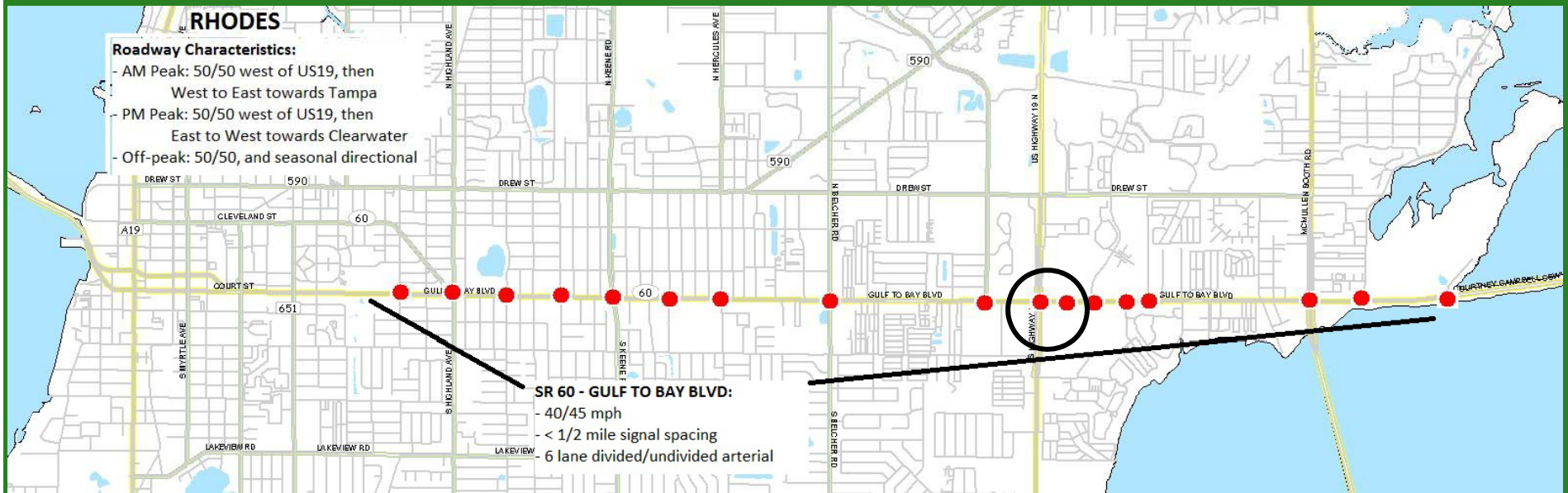
Other Factors Considered:

- Directional Peaks (more predictable) vs 50/50 Split
- Major/Minor Arterial Network vs Grid Networks
- High vs. Lower Capital Cost
- Ease of Operation and Maintenance
- Central vs Local operation
- Outside influences (Peds, Preempt, etc)

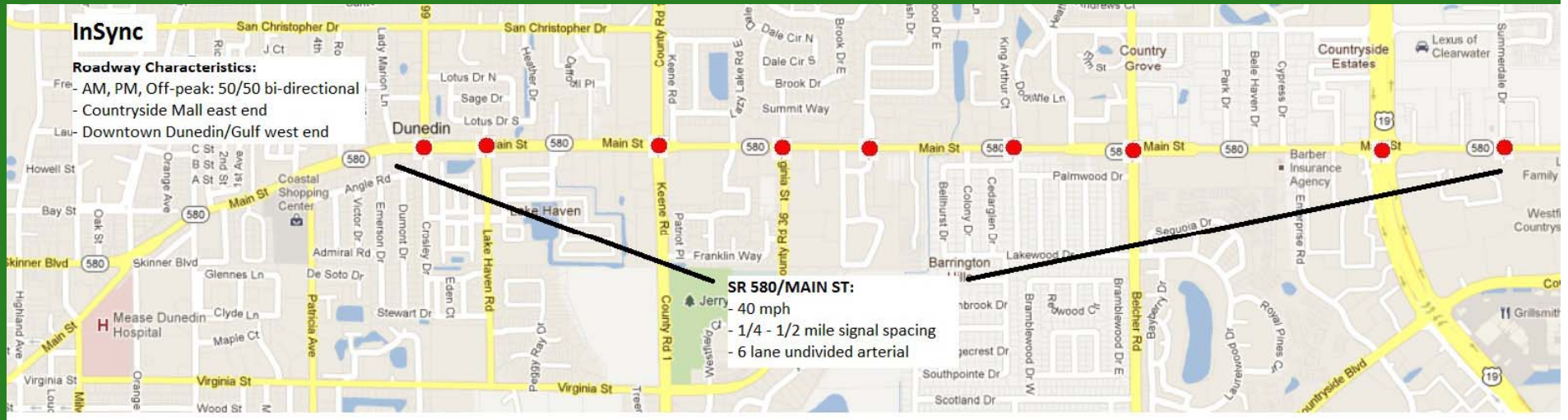
Areas of Deployment - OPAC



Areas of Deployment - RHODES



Areas of Deployment - InSync



MILLION DOLLAR QUESTION



WHAT KIND OF RESULTS CAN I EXPECT FROM ADAPTIVE SYSTEMS???

- Before and After Reports and Claims Vary... Reasons:
 - Depends on 'Before' operational scenario and timing
 - Type of corridor/saturation (over-capacity)
 - Independent Study** or Provided by Software Vendor
 - Time of Day, Days of Week – Measure Weekends!
 - Generally aim toward a 10 – 15% improvement in travel time, all things considered
 - Remember to incorporate other Performance Measures other than travel time, such as:
 - Safety (reduction in accidents – approx \$28,000 cost per accident)
 - Environmental (reduction in carbon footprint – carbon credits can be sold!)

PINELLAS COUNTY BEFORE/AFTER STUDIES



- Independent before/after study to determine the RT-TRACS software operation versus traditional time-of-day signal plans – Measured both end to end travel time and major intersection delay
- Study determined that OPAC US19 travel times were reduced by an average of 7.5%, with peak travel times dropping by as much as 25%
- Study determined that RHODES SR60 travel times were reduced by an average of 8% consistent in most all time periods
- Intersection Delay was slightly higher for side street and left turns, but volume of vehicles on all approaches showed overall improvement
- The results show an average of \$1.3 million in annual fuel savings alone (both corridors – 42 intersections) vs. TOD plans
- Benefit to Cost ratio is currently calculated at 7:1

PERFORMANCE MEASURES – TRAVEL TIME

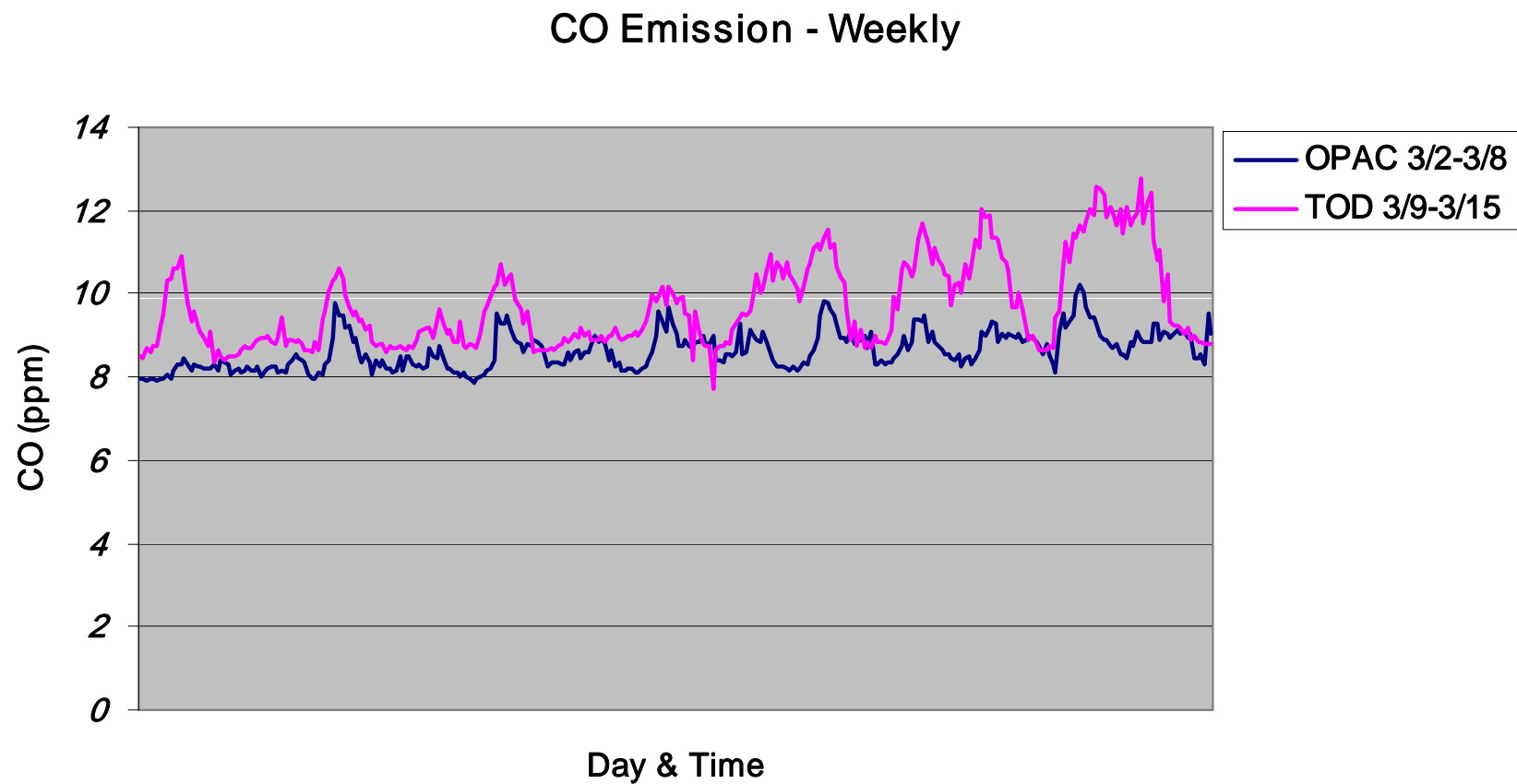


Gulf-to-Bay Before/After Travel Time Studies

Westbound						
	TBC 2006	Adaptive 2006	TBC vs Adapt 06	Adaptive 2008	TBC vs Adapt 08	Adapt 06 vs Adapt 08
	Before	After	% Improvement		% Improvement	% Improvement
AMP	11:02	10:11	7.70%	9:36	12.99%	5.73%
AMO	10:52	10:03	7.52%	10:01	7.82%	0.33%
PMO	12:04	10:38	11.88%	9:47	18.92%	7.99%
PMP	13:13	12:19	6.81%	10:01	24.21%	18.67%
Eastbound						
AMP	12:06	10:23	14.19%	9:42	19.83%	6.58%
AMO	10:32	10:03	4.59%	9:58	5.38%	0.83%
PMO	11:07	10:28	5.85%	9:54	10.94%	5.41%
PMP	11:45	11:42	0.43%	10:24	11.49%	11.11%

- Typically travel time improvements range from 7% - 20%
- Travel time improvement is at the expense of shorter left turn and side street green times (added delay on side streets and left turns)

PERFORMANCE MEASURES – ENVIRONMENTAL/EMISSIONS



- Environmental Sensor Data Measuring CO and Particulate Matter

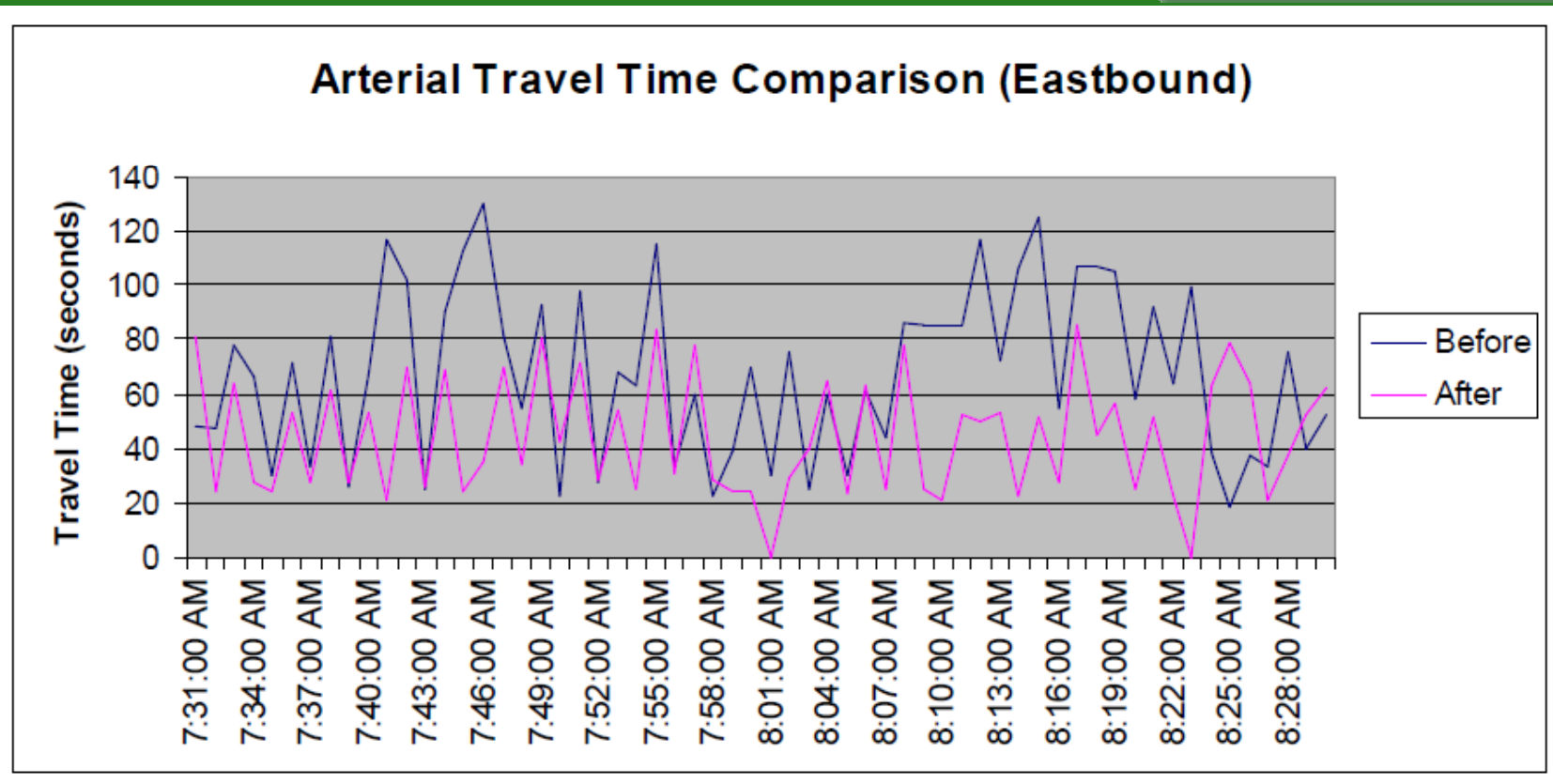
PERFORMANCE MEASURES - SAFETY



REAR END ACCIDENTS BEFORE / AFTER ANALYSIS

	SR 60				US 19			
DATES	TOTAL REAR ENDS	TOTAL # OF INJURY ACCIDENTS	INJURIES	FATALITIES	TOTAL REAR ENDS	TOTAL # OF INJURY ACCIDENTS	INJURIES	FATALITIES
BEFORE 10/1/2004 - 9/30/2006	261	135	172	0	1531	604	995	3
AFTER 10/1/2006 - 9/30/2008	248	87	114	0	1344	505	879	0
Total Reductions	13	48	58	0	187	99	116	3
Percent Reduction	5.0%	35.6%	33.7%	0.0%	12.2%	16.4%	11.7%	100.0%

OTHER ADAPTIVE RESULTS (ACS Lite)



- Most corridor travel time before/after studies range from 5 – 20% reduction for ACS Lite

OTHER ADAPTIVE RESULTS (InSync)



STATE HIGHWAY 26 Before After Comparison

Peak Period	Direction	Average Travel Time (Seconds)			Average Number of Stops			Average Speed (MPH)		
		Before	After	Change	Before	After	Change	Before	After	Change
Weekday AM	EB	320.4	298.4	-6.9%	3.6	1.4	-61.1%	25.9	27.9	7.7%
	WB	296.0	237.4	-19.8%	2.6	1.0	-61.5%	28.0	34.9	24.6%
	Average	308.2	267.9	-13.1%	3.1	1.2	-61.3%	27.0	31.4	16.5%
Weekday AM Off Peak	EB	274.0	209.4	-23.6%	2.8	0.4	-85.7%	30.2	40.1	32.8%
	WB	224.6	210.4	-6.3%	0.6	0.4	-33.3%	36.9	39.5	7.0%
	Average	249.3	209.9	-15.8%	1.7	0.4	-76.5%	33.6	39.8	18.6%
Weekday Midday	EB	237.4	241.0	1.5%	1.2	0.6	-50.0%	34.9	34.6	-0.9%
	WB	264.6	196.8	-25.6%	1.4	0.2	-85.7%	31.3	42.2	34.9%
	Average	251.0	218.9	-12.8%	1.3	0.4	-69.2%	33.1	38.4	16.0%
Weekday Midday Off Peak	EB	284.4	226.4	-20.4%	3.4	0.4	-88.2%	29.3	36.7	25.3%
	WB	272.2	190.4	-30.1%	2.2	0.2	-90.9%	30.5	43.6	43.0%
	Average	278.3	208.4	-25.1%	2.8	0.3	-89.3%	29.9	40.2	34.3%
Weekday PM	EB	271.6	237.0	-12.7%	1.8	0.8	-55.6%	30.7	35.1	14.3%
	WB	304.8	325.2	6.7%	3.0	3.4	13.3%	27.2	25.6	-5.9%
	Average	288.2	281.1	-2.5%	2.4	2.1	-12.5%	29.0	30.4	4.8%
Weekday PM Off Peak	EB	249.6	216.6	-13.2%	1.6	0.2	-87.5%	33.3	38.3	15.0%
	WB	273.2	196.8	-28.0%	2.4	0.0	-100.0%	30.5	42.3	38.7%
	Average	261.4	206.7	-20.9%	2.0	0.1	-95.0%	31.9	40.3	26.3%

- Decrease in operations
- Less than 10 % increase in operations
- Greater than 10% increase in operations

- Most corridor travel time before/after studies range from 10 – 20% reduction, sometimes higher depending on 'before' condition (i.e. signals ran free before, or very outdated timing plan)

PUBLIC COMPLAINTS FOR MOST ADAPTIVE SYSTEMS



- **SHORT CYCLE (CYCLE FAILURE)**
 - Some side street & left turn phases tend to only serve min. green due to high demand on main phases (reducing overall delay by counts)
 - Phase skipping (could be a problem for adaptive software that runs phase pairs not in sequence)
- **UNPREDICTABLE**
 - Many citizens have complained that they don't know when the light will turn green and can't 'plan' accordingly (they get used to pre-timed plans and route selection)
 - Thinks it may have 'skipped' them – Dynamic Phase Sequence algorithms
- **DON'T THINK IT WORKS**
 - Expectations are too high
 - Think they should be getting all green lights wherever they go

KEY QUESTIONS TO ANSWER BEFORE MAKING THE STEP!



- Start Gathering Data With Some Simple Questions:
 - Have I exhausted all other 'TIMING' avenues?
 - Who Are My Stakeholders?
 - Do I Have (Can I Get) Funding (see above)?
 - Is My Existing Hardware Compatible?
 - Detection Compatibility
 - Controller Compatibility
 - Communications Network Requirements
 - Do I Need a Central Software System to Manage It?
 - Does It Play Nicely With My Existing Central Software System?
 - What's My Operations and Maintenance Commitment?
 - Gather Annual Cost Analysis:
 - Operations - Personnel Requirements, Computer/Server life/cycle costs, Database Requirements
 - Maintenance – Added Detection, IT/Network, Training
 - Software – Does it require any annual contracts?



QUESTIONS (CON'T)

- Start Gathering Data With Some Simple Questions (con't):
 - Type of Roadway
 - Is the roadway already over capacity?
 - Issue to Solve - Mostly Directional, Bi-directional, or both
 - Variable or Constant Speed on Corridor
 - Intersection spacing – ¼ mile or less, 1 mile/high speed, isolated, etc.
 - Grid Network or Primary/Secondary Arterial Network
 - Pedestrians – Ped Signals/Crosswalks
 - Preemption – # of Activations (i.e. by an active fire station)
 - Light Rail/Transit Signal Priority
 - How Can I Specify A System That Works With All The Above Without Naming It?
 - Each System Has Proprietary protocols/Algorithms
 - Specific parameters for configuration & tweaking
 - Detection Requirements Vary
 - ASK THE RIGHT QUESTIONS OF THE POTENTIAL VENDOR!!
 - Can Use RFP/RFQ process instead of low bid...

SYSTEMS ENGINEERING PROCESS FOR ADAPTIVE



U.S. Department of Transportation
Federal Highway Administration

Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems

Draft Guidance Document

August 2011

FHWA-HOP-11-027

1. Identify portions of the regional ITS architecture being implemented
2. Identification of participating agencies roles and responsibilities
3. Requirements definitions
4. Analysis of technology options to meet requirements
5. Procurement options
6. Identification of applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system

QUESTIONS



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Have Answers, Will Travel

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