Agenda

- National issues in traffic signal control
- Every Day Counts and Adaptive Signal Control Technologies
- Existing Algorithms
- ASCT Implementation in Puerto Rico
- Corridor Optimization with ACS-Lite
2007 National Traffic Signal Report Card

- Improper traffic signal timing accounts for 5-10% of all traffic delay on major roadways
- Incorrectly functioning traffic sensors do not serve all vehicles and pedestrians equitably.
- Drivers must wait through more than one green signal at an intersection, causing long queues and clogged intersections.

### Report Card Findings

<table>
<thead>
<tr>
<th>Topic Area</th>
<th>Existing conditions / problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>• Philosophy for signal operation not documented or shared&lt;br&gt;• Annual reviews of major roadways are rarely conducted&lt;br&gt;• No established business plan for transportation operations with clearly defined performance measures and goals</td>
</tr>
<tr>
<td><strong>Score: D</strong></td>
<td></td>
</tr>
<tr>
<td>Signal Operation in Coordinated Systems</td>
<td>• Traffic signal timing is rarely reviewed&lt;br&gt;• Signal technicians are not current on the use of modern software&lt;br&gt;• Timing plans are not in place for emergencies and special events</td>
</tr>
<tr>
<td><strong>Score: D</strong></td>
<td></td>
</tr>
<tr>
<td>Signal Timing Practices</td>
<td>• Intersection operations are infrequently checked in the field to accommodate changing traffic conditions.</td>
</tr>
<tr>
<td><strong>Score: C</strong></td>
<td></td>
</tr>
<tr>
<td>Traffic Monitoring &amp; Data Collection</td>
<td>• Real-time traffic data are seldom available to the traveling public for information and route planning&lt;br&gt;• Few, if any, quality checks for traffic monitoring and collection systems</td>
</tr>
<tr>
<td><strong>Score: F</strong></td>
<td></td>
</tr>
</tbody>
</table>
Opportunities to Improve Traditional Traffic Signal Timing

- Traditional signal timing process emerged between 1940’s & 1960’s
- Limited signal timing plans
- Variable & unpredictable traffic conditions

Every Day Counts

“Every Day Counts is designed to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of roadways, and protecting the environment”

Víctor Méndez, FHWA Administrator
**Adaptive Signal Control Technology**

What is ASCT?

- **Sensors** monitor traffic
- Software evaluates performance
- Timing updated if necessary
- Process repeats

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What is ASCT?

- **Sensors** monitor traffic
- Software compares to baseline timing plan
- Timing change if necessary
- Process repeats

**Sensors**
- Type
- Placement
- Effective
- Well-maintained
What is ASCT?

Sensors monitor traffic

Software compares to baseline timing plan

Timing change if necessary

Process repeats

Evaluate Performance

• Data
• Timing Parameters
• Algorithms & Models
• Frequency of Analysis

Update Timing

• Uncongested
• Splits
• Offset
• Cycle
What is ASCT?

Sensors monitor traffic

Software compares to baseline timing plan

Timing change if necessary

Process repeats

Continuous Monitoring

• 24/7
• Weekdays, Weekends
• Holidays
• Special Events
• Incidents

Implementation Goals for Adaptive Signal Control Technologies

Goal 1

- By December 2011, ASCT will be comprehensively evaluated and demonstrated to underscore its opportunities and benefits

Goal 2

- By December 2012, ASCT / EDC tools will be used by 40 agencies
EXISTING ALGORITHMS

Existing Algorithms

- ACS Lite
- SCATS
- SCOOT
- RHODES
- OPAC
- InSync
### System Requirements

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Controller type</th>
<th>Detection Required</th>
<th>Field / Central Based Algorithm</th>
<th>Field Processor Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Lite</td>
<td>Various legacy controllers/cabients</td>
<td>Existing stop bar detection by phase. Prefer one or more advance detectors per coordinated phase</td>
<td>Field or central</td>
<td>Yes</td>
</tr>
<tr>
<td>SCATS</td>
<td>SCATS firmware on EPAC M50 and 2070</td>
<td>Stop bar only by lane</td>
<td>Central</td>
<td>No</td>
</tr>
<tr>
<td>SCOOT</td>
<td>SEPAC firmware on EPAC M50 and 2070</td>
<td>stop bar and upstream detection</td>
<td>Central</td>
<td>No</td>
</tr>
<tr>
<td>RHODES</td>
<td>Siemens NextPhase 1.7.6c-2070</td>
<td>stop bar and upstream detection</td>
<td>Field</td>
<td>Yes</td>
</tr>
<tr>
<td>OPAC</td>
<td>Econolite ASC2, ASC3; Other NTCIP controllers on way</td>
<td>stop bar and upstream detection</td>
<td>Field or central</td>
<td>Yes</td>
</tr>
<tr>
<td>InSync</td>
<td>Various - can work with most controller firmware</td>
<td>Video stop bar only</td>
<td>Field</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Cost Comparison

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Detection cost</th>
<th>Additional hardware cost</th>
<th>Average software developer cost</th>
<th>Average total cost per intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Lite</td>
<td>$35,000</td>
<td>$0</td>
<td>$4,500</td>
<td>$39,500</td>
</tr>
<tr>
<td>SCATS</td>
<td>$20,000</td>
<td>$0</td>
<td>$17,000</td>
<td>$37,000</td>
</tr>
<tr>
<td>SCOOT</td>
<td>$50,000</td>
<td>$0</td>
<td>$20,000</td>
<td>$70,000</td>
</tr>
<tr>
<td>RHODES</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>OPAC</td>
<td>$50,000</td>
<td>$1,200</td>
<td>$3,000</td>
<td>$54,200</td>
</tr>
<tr>
<td>InSync</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>$78,000</td>
</tr>
</tbody>
</table>
Traffic Signal Modernization Project and Adaptive Signal Control in Puerto Rico

- Update traffic signal equipment with Econolite ASC/3 NEMA TS2/NTCIP Actuated Controllers
- Replacement of wire detection loops with Autoscope Rack Vision Terra video detection system
- Installation of radar sensors for traffic data collection (volume, vehicle classification, speeds) in segments
- Installation of video cameras for traffic and incident monitoring
- Installation of wireless communication infrastructure in PR-2 corridor
- Establish a local Traffic Management Center at Mayaguez HTA Regional Office
Econolite Signal Control Equipment

Autoscope Rack Vision Terra Video Detection System
Traffic Monitoring, Data Collection and Communication Equipment

MMA TMC and Centracs Signal Management System

**CENTRACS FEATURES**

- Provides a platform for monitoring and control of all signals in the corridor.
- ASCT can be incorporated to optimize signal cycles and offsets.
- Provides reports of flow by lane in different periods of time, vehicle type, lane utilization and space-time diagrams.
Typical ACS Lite System

CORRIDOR OPTIMIZATION WITH ACS-LITE

1. Split tuning algorithm
2. Offset tuning algorithm
1. SPLIT TUNING ALGORITHM

Collect Data

Occupancy Data is collected from stop bar detectors

Correlate data to signal phasing
Perform Analysis

- Ø3 Cycle 1
- Ø3 Cycle 2
- Ø3 Cycle n-1
- Ø3 Cycle n

Averaging

we calculate the degree of saturation

Implement phase split adjustments
2. OFFSET TUNING ALGORITHM

Collect data from advance detectors on coordinated approaches

Volume and occupancy data is collected by the advanced detectors usually 250 feet or more upstream of the stop bar.

Develop a Statistical Flow Profile correlated to the phase state

Statistical flow profile using the volume and occupancy data.
Perform analysis to capture the most arriving flow during the green interval

Red Arrow points out vehicles arriving before the start of green. Shifting the offset to the left will match the green interval to a greater percentage of arrivals.

Implement offset adjustment
ACS-Lite Idaho Case Study

- US-95 section in Coeur d’Alene, Idaho with four signalized intersections
- Evaluation conducted using PM peak traffic conditions
- Traffic volumes, turning movements and network geometry information were taken from an existing Synchro model
- Signal timing plans were extracted from field controllers

Corridor Travel Time Comparison

<table>
<thead>
<tr>
<th>Scenario 1: Existing Signal Timings</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 95 Without</td>
<td>18%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
<tr>
<td>Entire Network Without</td>
<td>7%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 2: Poor Splits</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 95 Without</td>
<td>24%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
<tr>
<td>Entire Network Without</td>
<td>-4%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 3: Poor Offsets</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 95 Without</td>
<td>-17%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
<tr>
<td>Entire Network Without</td>
<td>9%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 4: Volume Changes</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 95 Without</td>
<td>-14%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
<tr>
<td>Entire Network Without</td>
<td>12%</td>
</tr>
<tr>
<td>With</td>
<td></td>
</tr>
</tbody>
</table>
ACS-Lite Fulton Co. Case Study

- Cascade Road section in Atlanta, GA with 5 signalized intersections
- Deployment of ACS-Lite included:
  - Upgrade controller firmware
  - Convert controller database
  - Set up detectors
  - System Integration

Side Street Queue Length Comparison

![Graph showing queue length comparison](image-url)
ACS-Lite Morgantown, VA Case Study

- Highway corridor with 19 signalized intersections
- Vehicle counts were obtained from 14 hour field observations
- Three TOD timing plans were developed in Synchro

Average Delay Comparison
Corridor Travel Times

Arrivals on Green w/o ACS-Lite
Conclusions

- Opportunities for improvements in traffic signal operations with ACST are
  - Non-saturated corridors
  - Irregular traffic patterns / diverge from simulated conditions
- Improvements in travel time and arrivals on green, individual intersection delay might increase
- Corridor selection guidelines for ASCT implementation are not developed
- Issues with high left-turn movements and pedestrian flows & preemption operation
References

- FHWA. 2010. Every Day Counts Summit Presentations. Atlanta, GA.