ACHIEVE YOUR AGENCY’S OBJECTIVES USING AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – APRIL 9, 2014
ITE Webinar Series on Automatic Traffic Signal Performance Measures (SPMs)

- Achieve Your Agency’s Objectives Using SPMs
  April 9, 2014 12:00 pm to 1:30 pm.

- SPMs Case Studies
  May 7, 2014 12:00 pm to 1:30 pm.

- Critical Infrastructure Elements for SPMs
  June 11, 2014 12:00 pm to 1:30 pm.
Automated Traffic Signal Performance Measures

Technology Implementation Group: 2013 Focus Technology

http://tig.transportation.org/

Mission: Investing time and money to accelerate its adoption by agencies nationwide
Your Speakers Today

Darcy Bullock

Jim Sturdevant

Rob Clayton

Rick Denney
ACHIEVE YOUR AGENCY’S OBJECTIVES USING AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – APRIL 9, 2014
PRESENTED BY DARCY BULLOCK, PURDUE UNIVERSITY, APRIL 9 2013
ACHIEVE YOUR AGENCY’S OBJECTIVES USING AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – APRIL 9, 2014
PRESENTED BY JIM STURDEVANT, INDOT, APRIL, 9 2013
How did we get here—Indiana Perspective

INDIANA HISTORY AND PATH TO SPM

- Purdue / INDOT Partnership
- Shared Vision
- Industry Collaboration
Emerging Shared Vision

1. Develop infrastructure and procedures to systematically prioritize investing engineering resources
2. Assess that impact
Dual Cabinets at Purdue
1998-2000

Photo: Indiana Joint Transportation Research Program
Signal Cabinet (INDOT)
Instrumentation Cabinet (Purdue)

- Fiber Connection
- Video Modems
- IP Based I/O Monitoring
Purdue Indoor Facility
Indoor End of Equipment
Indoor Interface: Signal Status & Cabinet
Pre-2004 Text Overlay - Phase calls and status

- Phase Indication
- ILD Status
- VID1 Status
- VID2 Status
Early 2000’s collaboration and problem solving

- Fall 2001 Purdue Completed study of video detection
  - Report identified some issues
  - INDOT verified issues in field
2002-2003 Indiana Detection Performance Concerns

- Summer 2002
  - Vendors proposed new design procedures for poles/arms/camera placement. *Will it work?*
  - INDOT drafts design and performance specifications *Will sensors meet it?*
  - INDOT plans for a test site with optimal camera placement *With capabilities to measure performance!*

- Fall 2003
  - INDOT Constructs test facility in Noblesville to evaluate design and performance specifications
  - Laid the ground work for further research.
High resolution intersection data
“Instrumented Intersections” Built

- Noblesville, IN
  - Suburban, High speed
  - Completed summer 2003.

- West Lafayette, IN
  - Urban, Pedestrians
  - Completed summer 2004
Lots of sensors!

Photo: Indiana Joint Transportation Research Program
Lots of Conduit!

Photos: Indiana Joint Transportation Research Program
Data collection - Switchboard

Patch Panel Switchboard

Homebrewed design/build
Dual Cabinets

Front view (INDOT, Purdue)  Rear view (Purdue, INDOT)
October 2006 State of the practice
Displays: 2000 Vs 2004
2003-2005 Intersection Subsystem Metrics

- Stopbar Detection
- Advance Detection
- Non-loop technologies
- Lane by Lane opportunities
- Controller features/ and functions
2004-2006 Dual Cabinet Data Collecting Procedure

- **8 inputs**
  - LT green
  - Th green

- 6 auxiliary for detector monitoring

- 24V signal or load switch

- Loop detector rack outputs

- 6 pair cable from camera

Overlay

Data file
Needed a scalable solution for all signal performance metrics
2008 Team Discussion of High Resolution Data Logging

Purdue
City Rep
INDOT
Siemens
Econolite
 Peek
Accepted Traffic Engineering Methods
- Applied to Traffic Controllers
- Picture book methods
- Surrogate for a trip to the field
2006-2008 Intersection Metrics

- Volume to Capacity
- Intersection Saturation
- Lane by Lane detection
- Actuated Coordination
- Counting detectors
- Advance detectors
15-Minute Counts (Phase “n”)

Counts per 15 minutes

Time of Day
Cycle-By-Cycle Counts (Phase “n”)
24 Hour Counts by phase

Vehicle Detections per Cycle

Time of Day
V/C Ratios by Phase, 24 Hours

Time of Day

Volume-to-Capacity Ratio

P1

P2

P3

P4

P6

P5

P7

P8
3/13/2008- Systemwide Metrics begin
Early PCD and POG - Created 4/30/08
Before
After
2014: Enumeration Support by 5 vendors

- Econolite
- Peek
- Eagle
- Intelight
- Naztec (Beta)

http://dx.doi.org/10.5703/1288284315018
2014: Monograph documenting

- Volumes
- v/c ratios
- Pedestrian Service
- Preempt Operation
- PCD
- Link Pivot Optimization
- Split Failures (GOR/ROR)
- Probe Data Assessment Techniques
- Detector Mapping

http://dx.doi.org/10.5703/1288284315333
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INSTITUTE OF TRANSPORTATION ENGINEERS WEBINAR PART 1 – APRIL 9, 2014
PRESENTED BY ROB CLAYTON, UDOT
Population 2,800,000 (34th largest state)
- 80% live along the Wasatch Front
Land Area: 84,900 sq. mi (13th largest state)
1900 Traffic Signals in the State of Utah
- 1150 owned and operated by UDOT
- 750 owned and operated by cities /counties
All partners share same ITS communications
- 83% of UDOT signals connected
- 71% of non-UDOT signals connected
John Njord, former UDOT Director & former AASHTO President:

“What would it take for UDOT’s Traffic Signal Operations to be World Class?”

What Defines World-Class Signals?

Signal Equipment Fully Functional

Signal Timing Optimal

Active Monitoring (SPMs)

Photos courtesy of the Utah Department of Transportation
<table>
<thead>
<tr>
<th>World Class Best Practice</th>
<th>UDOT Practice</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIGNAL OPERATIONS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of traffic signal control software to manage signal operations</td>
<td>UDOT uses Siemens i2 software, as do all of our partner agencies.</td>
<td>Green</td>
</tr>
<tr>
<td>Re-time signals every 30 to 36 months</td>
<td>Not possible with current resources. Efforts focus on obvious problems.</td>
<td>Yellow</td>
</tr>
<tr>
<td>Automated, real-time monitoring of signal system health and performance</td>
<td>None</td>
<td>Red</td>
</tr>
<tr>
<td>Performance measurement of signal operations</td>
<td>None</td>
<td>Red</td>
</tr>
<tr>
<td>Quality signal timing during construction</td>
<td>Not required or common. Large projects sometimes hire timing consultants.</td>
<td>Yellow</td>
</tr>
<tr>
<td>Quality signal timing during incidents, civic events, and weather events</td>
<td>Limited. There are no stated goals, or resources identified to support those goals.</td>
<td>Yellow</td>
</tr>
<tr>
<td>Implementation of adaptive signal operations</td>
<td>2 demonstration projects: SCATS in Park City; ACS Lite in Heber</td>
<td>Green</td>
</tr>
</tbody>
</table>
“Transition from reactive to proactive signal maintenance by increasing signal maintenance funding.”

“Require that communications and signal detection be maintained during construction projects, and require signals to be fully functional before turning them on.”

“Implement real-time monitoring of system health and quality of operations.”
Hats off!
Purdue University & Indiana DOT
Paving the Way since 2005

Automated Traffic Signal Performance Metrics

Darcy Bullock

Jim Sturdevant

Photos courtesy of Darcy Bullock and Jim Sturdevant
Performance Metrics Goals

- Transparency and Unrestricted Access
  - No Special Software – No Passwords – No Firewalls

- Access for Everyone
  - Intra Agency
  - Consultants
  - Academia
  - MPO’s
  - Local & Federal Governments
  - Executive Leaders
  - Public
Automated Signal Performance Metrics
(How does it work?)

1. Traffic signal controllers – 1/10th s. data logger time-stamps (Event Code, Parameter, Time Stamp)
   -- Econolite (ASC3; Cobalt) -- Intelight ATC -- Naztec (Beta)
   -- PEEK ATC -- Siemens Linux / ATC
2. Communications or storage memory on controllers needed
3. Server to store hi-def Indiana enumerations
4. FTP connections made every 10 minutes to signals on system
5. Enumerations analyzed and graphed

CENTRAL SIGNAL SYSTEM NOT USED OR NEEDED
(The signal metrics are independent of any central signal system)
<table>
<thead>
<tr>
<th>SPM Metric</th>
<th>Detection Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purdue Phase Termination</td>
<td>No detection needed or used</td>
</tr>
<tr>
<td>Split Monitor</td>
<td>No detection needed or used</td>
</tr>
<tr>
<td>Purdue Coordination Diagram</td>
<td>Setback count (350 ft – 400 ft)</td>
</tr>
<tr>
<td>Approach Volume</td>
<td>Setback count (350 ft – 400 ft)</td>
</tr>
<tr>
<td>Approach Delay</td>
<td>Setback count (350 ft – 400 ft)</td>
</tr>
<tr>
<td>Arrivals on Red</td>
<td>Setback count (350 ft – 400 ft)</td>
</tr>
<tr>
<td>Executive Reports</td>
<td>Setback count (350 ft – 400 ft)</td>
</tr>
<tr>
<td>Approach Speed</td>
<td>Setback count w/ speed (350 ft – 400 ft)</td>
</tr>
<tr>
<td>Turning Movement Counts</td>
<td>Stop bar (lane-by-lane) count</td>
</tr>
<tr>
<td>Purdue Travel Time Diagram</td>
<td>Probe travel time data (GPS)</td>
</tr>
</tbody>
</table>
Phases 4 & 7 Maxing Out Only at Night

Before Condition: Riverdale Road & 700 West, Ogden, UT – Sunday, March 24, 2013

Video Detection not working well at night

Minor street through & left turn max out at night only

Metric: Purdue Phase Termination
Phases 4 & 7 Maxing Out at Night - Fixed

**After Condition:** Riverdale Road & 700 West, Ogden, UT – Sunday, March 31, 2013

Video Detection replaced with a different detector technology

- **Gapout**
- **Max out**
- **Force off**
- **Pedestrian activation** (shown above phase line)
- **Skip**

**Metric:** Purdue Phase Termination
Quality of Progression

NB Bangerter Hwy: New Off-Peak Coordination Plan (38) installed on March 7, 2013

Bangerter & 5400 S Intersection

Metric: Purdue Coordination Diagram
Setting Yellow and All-Red using 85th percentile Speeds

Yellow Changed from 4.0 to 4.5 seconds

Location: NB Bluff St & 100 South, St George, UT – Sunday, May 5, 2013

Metric: Approach Speeds

Use 85th percentile to set yellow & red clearance intervals
**Lane-by-Lane Volume Counts**

Use for models, adjust splits, coordination balance, traffic studies

**Location:** US-89 & Main St, American Fork, UT – Tuesday, October 22, 2013

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**Westbound Thru**

TV: 7566 PH; 6:15 PM - 6:15 PM PHV: 721 VPH  
PHF: 0.9  
T/L: 0.96

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**Eastbound Thru**

TV: 8076 PH; 6:00 PM - 6:00 PM PHV: 757 VPH  
PHF: 0.95  
T/L: 0.74

---

**Metric: Turning Movement Counts**
Before and After Coordination

Corridor: Bangerter Hwy, SLC
To/From: SR-201 - 6200 South
Date: March 2013
Time Period: PM Peak

Results:
- 19% Increase Arrival on Green
- NB TT Savings: 0.3 Minutes
- NB Reliability: 55% Increase
- SB TT Savings: 1.1 Minute
- SB Reliability: 52% Increase
Executive Reports
Are things getting better, getting worse or staying the same?

Signal Performance Metrics
Intersection Adjustments using SPMs
January 1, 2013 to December 31, 2013

- Adjustments made at 325+ intersections
  - 185 work orders for detector problems
  - 40 offset adjustments
  - 5 time-of-day corrections
  - Several other changes

Metric: Usage Reports
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PRESENTED BY RICK DENNEY, FHWA, APRIL, 9 2013
FHWA Perspective

- Traffic Signal Report Card
- Traffic Signal Management (Good Basic Service)
- Asset Management
- Capability Maturity
- Planning for Operations and Systems Engineering
- Performance Management, Importance and Principles
Traffic Signal Management

- Good Basic Service
  - Objectives-Driven
  - Outcome-Oriented
  - Focused on what is important
    - What achieves agency vision and goals
    - What achieves motorist expectations
Good Basic Service

- Demands understanding of performance
  - For demonstration that program supports agencies vision and goals
  - For guidance to staff for day-to-day actions
  - For managing expectations
  - For achieving all that can be achieved
Signal timing database *is an asset*

- It costs money and resources to develop
- It costs money and resources to maintain
- **Frequency** and **type** of maintenance are key issues...
  
  ...that cannot be determined without understanding performance
The **best agencies** depend on brilliant staff (Level 1), but are vulnerable to staff loss

Mitigate that risk by developing brilliant processes (Level 2), but then vulnerable to becoming slaves to process

Mitigate that risk by *measuring process effectiveness* (Level 3), and

Optimizing processes against measurement (Level 4)
Planning for Operations and Systems Engineering

- Planning for Operations
  - Objectives-Driven
  - Performance measured against objectives

- Systems Engineering (23CFR940.11)
  - Needs and Requirements-Driven
  - Projects verified and validated against requirements and needs
  - Include performance measurement as use case
Planning For Operations Process

1. Regional Goals and Motivation
2. Operations Objectives
3. Systematic Process to Develop and Select M&O Strategies to Meet Objectives
4. M&O Strategies
   - Metropolitan or Statewide Transportation Plan
   - Metropolitan or Statewide Transportation Improvement Program or Other Funding Programs
5. Implementation/System Operations

Monitoring and Evaluation:
- Define Performance Measures
- Determine Operations Needs
- Identify M&O Strategies
- Evaluate M&O Strategies
- Select M&O Strategies for the Plan
Systems Engineering Process

- Systems Engineering Guidebook
Systems Engineering Process

- Systems Engineering Guidebook
Planning For Operations Process

- Regional Goals and Motivation
- Operations Objectives
- Systematic Process to Develop and Select M&O Strategies to Meet Objectives
- M&O Strategies
  - Define Performance Measures
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  - Evaluate M&O Strategies
  - Select M&O Strategies for the Plan
- Metropolitan or Statewide Transportation Plan
- Metropolitan or Statewide Transportation Improvement Program or Other Funding Programs
- Implementation/System Operations
Planning For Operations Process

- Regional Goals
- Objectives
- M&O Processes
- Metro/State Plan
- Metro/State TIP
- Implement/Operate

Monitoring/Evaluation

- Performance
- Needs
- Identify M&O
- Evaluate M&O
- Select M&O
SE and P4O Relationship
Importance

- When resources are constrained:
  - Data is everything
  - Demonstrating effectiveness key to program sustainability and funding
  - Increasing use of performance basis for funding decisions
- Resources are always constrained
Effective Performance Measurement

- Is sensitive to agency goals
  - But that’s not enough by itself
- Demonstrates achievement of objectives
  - Both funding objectives and engineering objectives
- Guides day-to-day operational decisions
  - Provide *actionable* operational assessment
- Guides decisions on *frequency* and *type* of operational resource expenditure
Thank you.

QUESTIONS & ANSWERS FOR OUR PRESENTER'S?

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