UDOT’s Experience

Automated Traffic Signal Performance Measures

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Brief Utah Update

- 2004 Traffic Signals in the State of Utah
  - 1189 owned and operated by UDOT (60%)
  - 815 owned and operated by cities/counties (40%)

- All cities share same ITS communications
  - 94% of UDOT signals connected
  - 78% of non-UDOT signals connected

- All cities in Utah & UDOT share same ATMS
Challenge from UDOT Executive Leaders (2011)

“What would it take for UDOT’s traffic signals to be world class?”

“What’s the trend – are signal operations improving, staying the same or getting worse?”

“What are our areas of most need?”

Quality Improvement Team
QIT Recommendations (July 2011)

- Communications and detection maintained during projects
- Proactive signal maintenance
- Real-time monitoring of system health and quality of operations
PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach

Signal Performance Measure Workshop
January 26 – 27, 2016

169 Representatives from 85 Different Organizations
PRESENTATIONS FROM JANUARY 26–27, 2016

2016

Tuesday, January 26th

Traffic Signal Performance Measures Workshop
Darcy Bullock, Purdue University

TSMQ in Florida
Raj Ponnaluri, Florida Department of Transportation

Automated Traffic Signal Performance Measures, AASHTO Innovation Initiative 2013 Focus Technology
Rob Clayton, Utah Department of Transportation

Lessons Learned from ASCT and Systems Engineering
Eddie Curtin, Federal Highway Administration

Transportation Pooled Fund Program Recap
Jim Stardevant, Indiana Department of Transportation
Richard Dominy, Federal Highway Administration

Public/Private Partnerships: Expanding the Reach of Traffic Signals
Lynne Yocom, Utah Department of Transportation

http://docs.lib.purdue.edu/atspmw
ATSPM Basic Concept

Hi Def Data Logger included in controller firmware

Hi Def logs retrieved every 10-60 minutes from controller to server

Website to display SPM's

(Or...Retrieve data logs from controller manually using Raspberry Pi)

A Central Signal System is NOT used or Needed!

Why Model what you can Measure?
System Requirements

High-resolution Controller with built in data logger using Indiana Enumerations

- Econolite Cobalt: Any Version
- Econolite ASC3 NEMA: V. 2.50+
- Econolite 2070 with 1C CPU Module: V. 32.50+
- Intelight Maxtime: V. 1.7.0+
- Peek ATC Greenwave 03.05.0528+
- Trafficware 980ATC V. 76.10+
- McCain ATC eX NEMA: V. ?
- Siemens M50 Linux & M60 ATC
  - ECOM V. 3.52+
  - NTCIP V. 4.53+

Data Logger records to the 1/10 second resolution

2070’s don’t work without 1C CPU
Objective: Vendor Neutrality
http://udottraffic.utah.gov/signalperformancemetrics

1694 traffic signals
http://challenger.nvfast.org/spm

Signal Performance Metrics

Charts
- Signal
- Time Space Diagram
- Enter Chart Comments

Reports

Links

FAQ

Selected Signal
No Signal Selected

Signals
Region
All
Metric Type
All
Filter
Signal Id

Signal List

Map

Metric Settings

Metric Type
- Approach Delay
- Approach Volume
- Arrivals On Red
- Purdue Coordination Diagram
- Purdue Phase Termination
- Speed
- Split Monitor
- Turning Movement Counts
- Ped Button Push Diagram

Time Y Axis Maximum
150
Volume Y Axis Maximum
2000
Volume Bin Size
15
Dot Size
Small

Export Data

Dates
Start Date: 8/11/2016 12:00 AM
End Date: 8/11/2016 11:59 PM
Reset Date: 8/11/2016

286 traffic signals
http://spm.seminolecountyfl.gov/signalperformancemetrics

Signal Performance Metrics

Selected Signal: No Signal Selected

Signals
Region: All
Metric Type: All
Filter: Signal Id

Data
- Metric Settings
  - Metric Type:
    - Approach Delay
    - Approach Volume
    - Arrivals On Red
    - Purdue Phase Termination
    - Speed
    - Split Monitor
    - Purdue Coordination Diagram
    - Turning Movement Counts

- Time Y Axis Maximum: 150
- Volume Y Axis Maximum: 2000
- Volume Bin Size: 15
- Dot Size: Small

- Dates
  - Start Date: 8/11/2016
  - End Date: 8/11/2016

- Reset Date
  - August 2016
  - Sun Mon Tue Wed Thu Fri Sat

316 traffic signals
45 traffic signals

http://signalmetrics.ua.edu

Signal Performance Metrics

Metric Settings:
- Time Y Axis Maximum: 150
- Volume Y Axis Maximum: 2000
- Volume Bin Size: 15
- Dot Size: Small
- Show Plan Statistics
- Show Volumes
- Export Data
- Upload Current Data

Dates:
- Start Date: 8/11/2016, 12:00 AM
- End Date: 8/11/2016, 11:50 PM

Reset Date:
- August 2016
- Sun Mon Tue Wed Thu Fri Sat
  1  2  3  4  5  6
  7  8  9  10  11  12
  13  14  15  16  17  18
  19  20  21  22  23  24
  25  26  27  28  29  30
  31

Create Metrics
Agencies using SPMs – Separate systems deployed (16 and growing)
<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Purdue Phase Termination</td>
</tr>
<tr>
<td></td>
<td>Split Monitor</td>
</tr>
<tr>
<td></td>
<td>Preemption Details</td>
</tr>
<tr>
<td></td>
<td>Pedestrian Delay</td>
</tr>
<tr>
<td>Advanced Count</td>
<td>Purdue Coordination Diagram</td>
</tr>
<tr>
<td></td>
<td>Approach Volume</td>
</tr>
<tr>
<td></td>
<td>Approach Speed (requires detection with</td>
</tr>
<tr>
<td></td>
<td>speed service)</td>
</tr>
<tr>
<td>Lane-by-lane Presence</td>
<td>Purdue Split Failure (Darcy will talk</td>
</tr>
<tr>
<td>Lane Group Presence</td>
<td>more about this)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane-by-lane Stopbar Count</td>
<td>Turning Movement Counts</td>
</tr>
</tbody>
</table>
Detection

Available Metrics

- Purdue Phase Termination
- Split Monitor
- Pedestrian Delay
- Preemption Details

1694 traffic signals
Metric: Purdue Phase Termination

- **Phase Number**
- **Time of Day**
- **Free Coordination**
- **Coordinated phases**
- **Gap out**
- **Max out**
- **Force off**
- **Pedestrian activation** (shown above phase line)
- **Skip**
Nighttime detection problem

BEFORE: Video detection not working at night

Minor street through & left turn max out at night only
Nighttime detection problem – Fixed!

- AFTER: New detection technology installed

Phases are rarely used at night

- Gap out
- Pedestrian activation (shown above phase line)
- Max out
- Skip
- Force off
Metric: Split Monitor

Phase 6

US-89 2700 North SIG#5372 Phase 6
Wednesday, March 09, 2016 12:00 AM - Thursday, March 10, 2016 12:00 AM

<table>
<thead>
<tr>
<th>Metric</th>
<th>Plan 1</th>
<th>Plan 7</th>
<th>Plan 13</th>
<th>Plan 7</th>
<th>Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
<td>Free</td>
</tr>
<tr>
<td>47.4 - 85 Percentile Split</td>
<td>34.8 - 85 Percentile Split</td>
<td>38.0 - 85 Percentile Split</td>
<td>33.9 - 85 Percentile Split</td>
<td>34.3 - 85 Percentile Split</td>
<td>29.3 - 85 Percentile Split</td>
</tr>
<tr>
<td>4.1% MaxOuts</td>
<td>41.4% ForceOffs</td>
<td>32.5% ForceOffs</td>
<td>73.4% ForceOffs</td>
<td>5.7% ForceOffs</td>
<td>1.5% MaxOuts</td>
</tr>
<tr>
<td>94.2% GapOuts</td>
<td>52.6% GapOuts</td>
<td>67.5% GapOuts</td>
<td>26.6% GapOuts</td>
<td>90.6% GapOuts</td>
<td>95.6% GapOuts</td>
</tr>
<tr>
<td>1.2% Skips</td>
<td>1.7% Skips</td>
<td>0.0% Skips</td>
<td>0.0% Skips</td>
<td>3.8% Skips</td>
<td>3.0% Skips</td>
</tr>
</tbody>
</table>

Phase Duration vs. Time of Day
Freeway Closure Example using SPMs - Nevada

Heavy rain rips apart I-15 in Nevada, forces freeway closure

By Ken Ritter, Michelle Rindels, Associated Press | Posted Sep 9th, 2014 @ 7:44pm
Closure: September 9-12, 2014

I-15 Closed Southbound in Nevada

- 4 day closure
- Detour thru Cedar City to get to Las Vegas.

Left Turn Needs More Green for Detour Traffic
Phase 4 Split Monitor - (Thru & Left Turn for SB off-ramp)
Freeway off-ramp - One week of data

Normal Traffic on Sunday and Monday

Increased traffic beginning Tuesday morning on SB due to freeway washouts in Nevada as shown by more frequent gap-out and higher split being used.

Implemented special timing plan to provide extra split.

SB freeway reopened on Friday afternoon as shown by more frequent gap-out and lower split being used.

- Gap out
- Pedestrian activation
- Max out
- Force off
Pedestrian Delay
(Time from pedestrian call received to start of the walk indication)

Phase 4 – Side Street – Friday September 16th 2016

89 Ped Actuations
48 s = Average Delay
Detection
Setback Count Zones

Available Metrics
- Purdue Coordination Diagram
- Approach Volume
- Arrivals on Red
- Approach Delay

665 traffic signals
Purdue Coordination Diagram

Bangerter Hwy (SR-154) 5400 South (SR-173) Signal 7063 Overlap: 10 Northbound
Thursday, March 07, 2013 12:00 AM - Thursday, March 07, 2013 11:59 PM

66% AoG

Plan... | Plan 16 | Plan 19 | Plan 34 | Plan 38 | Plan 41 | P... | Plan 13 | P...
89% AoG | 90% AoG | 75% AoG | 63% AoG | 56% AoG | 71% AoG | 79% AoG | 9%
1.3... | 1.25 PR  | 1.23 PR  | 1.21 PR  | 1.27 PR  | 1.45 PR  | 1.61 PR  | 1.2...

Cycle Time [Seconds]

Time (Hour of Day)

Volume Per Hour
Purdue Coordination Diagram

Left turns from upstream signal
Metric: Approach Volume

![Graph showing volume (vph) over time of day with directional split. The graph includes lines for Northbound, Southbound, Northbound D-Factor, and Southbound D-Factor.]
Detection

Setback Count Zones with speed

Available Metrics

Approach Speed

660 traffic signals
Metric: Approach Speed

The graph shows the speed (in MPH) over time of day, categorized by different plans. There is a notable drop in speed starting at around 15:00, labeled as "Snow storm starts."
Detection

Lane-by-lane Presence

Lane Group Presence

Available Metrics

Purdue Split Failure

253 traffic signals
Detection
Lane-by-lane Count

Available Metrics
Turning Movement Counts

343 traffic signals
Metric: Turning Movement Counts

US-89 Main Street (American Fork) SIG#6023
Tuesday, October 22, 2013 12:00 AM - Tuesday, October 22, 2013 11:59 PM

Eastbound Thru

TV: 8076 PH: 5:00 PM - 6:00 PM PHV: 757 VPH
PHF: 0.95  fLU: 0.74

Time of Day
System Health

SPM Alerts for 5/22/2016

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The following signals had too few records in the database:
4671 - 13400 South & 4600 West - Phase: 0 (Missing Records)
5761 - 500 South & 400 East (Bluff) - Phase: 6 (Missing Records)

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The following signals had too many force off occurrences:
1124 - North Temple & Main Street - Phase: 3 (Force Offs 97.6%)
7252 - 500 South & Main Street - Phase: 2 (Force Offs 100%)
2752 - 500 South & Main Street - Phase: 6 (Force Offs 100%)

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The following signals had too many max out occurrences:
1124 - Sunnyside (860 S) & Gaurdman Way - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Gaurdman Way - Phase: 6 (Max Outs 100%)
4024 - 4900 South (Fort Union) & 1300 East - Phase: 7 (Max Outs 92.6%)
4025 - 4700 South & 700 East - Phase: 1 (Max Outs 100%)
4103 - 4680 South (Murray-Holladay) & 2320 East (Holladay) - Phase: 5 (Max Outs 100%)
4118 - 6200 South & 3655 West (Dixie) - Phase: 2 (Max Outs 100%)
4511 - 4100 South & 3200 West - Phase: 4 (Max Outs 100%)
4820 - 4335 South & 2700 West - Phase: 2 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 4 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 6 (Max Outs 100%)
5170 - 200 N (Kaysville) & Main St. - Phase: 4 (Max Outs 100%)
5305 - Main St. & 200 North (Logan) - Phase: 7 (Max Outs 96.2%)
5500 - 900 W. (Kays Dr.) & 200 North, (Kaysville) - Phase: 4 (Max Outs 90.4%)
6035 - Pioneer Crossing & Millpond Drive - Phase: 8 (Max Outs 91.9%)
6608 - 100 West & 100 North - Phase: 8 (Max Outs 98.5%)
7107 - Redwood Road & 4700 South - Phase: 5 (Max Outs 93.2%)

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The following signals had unusually low detector hits:
5134 - SR-193 (700 S) & I-15 NB (Clearfield) - Phase: 2 (Has Unusually Low Counts.)
7061 - Bangertor Hvy (SR-154) & 4100 South - Phase: 1 (Has Unusually Low Counts.)
7061 - Bangertor Hvy (SR-154) & 4100 South - Phase: 7 (Has Unusually Low Counts.)
7361 - Bangertor Hvy (SR-154) & 13400 South - Phase: 1 (Has Unusually Low Counts.)

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The following signals have stuck ped detectors:
1023 - South Temple & 200 West - Phase: 2 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 4 (Stuck Ped)
123 - South Temple & 200 West - Phase: 6 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 8 (Stuck Ped)
4511 - 4100 South & 3200 West - Phase: 4 (Stuck Ped)
6009 - Main (Lehi) & I-15 SPUI - Phase: 6 (Stuck Ped)
7826 - 9900 S (Little Cottonwood Rd) & Wasatch Blvd (3500 E) - Phase: 4 (Stuck Ped)

1694 traffic signals
Metric: Purdue Phase Termination Detection Requirements: None

Phase 4 starts constant call

4/8/2014

SPMs evaluated for % max outs

4/9/2014

Alert email sent

Too many max outs

Gap out  Max out  Pedestrian activation

0%  100%  100%

3%  100%  100%

5%  100%

Metric: Purdue Phase Termination Detection Requirements: None
Monitoring Trends
(Riverdale Rd – 11 intersections)

Percent of Vehicles Arriving on Green - Riverdale Rd
10:00 AM to 2:00 PM Monday through Friday

Retiming Project
UDOT Signal Timing Focus Group (July 2014)

• How do you feel about UDOT?

• How do traffic signals make you feel?
Focus Group Key Findings (July 2014)

UDOT is perceived **positively**, with **innovation** as the primary driver of positive impressions.

Drivers believe traffic **signal synchronization** is **improving**.

Drivers feel UDOT should be **open** about its **accomplishments** in a way that protects its credibility.
60 S Commercial –
Love green lights? So do UDOT traffic engineers

http://udot.utah.gov/greenlights
Metric: Purdue Split Failure
Case Study: Moab, Utah

- The Adventure Capital of the U.S.A.
- Two National Parks within 20 miles
Purdue Split Failure – Center St & Main St – Moab, Utah
Memorial Day Weekend – Saturday

NORTHBOUND

2015

2016
Moab – Split Failure Results

Northbound

- Before (5/23/2015):
  - Main @ 100 North: 700
  - Main @ Center St: 500
  - Main @ 100 South: 400
  - Main @ 300 South: 300
  - Main @ Kane Creek: 200

- After (5/28/2016):
  - Main @ 100 North: 100
  - Main @ Center St: 100
  - Main @ 100 South: 100
  - Main @ 300 South: 100
  - Main @ Kane Creek: 100

86% decrease

Southbound

- Before (5/23/2015):
  - Main @ 100 North: 700
  - Main @ Center St: 500
  - Main @ 100 South: 400
  - Main @ 300 South: 300
  - Main @ Kane Creek: 200

- After (5/28/2016):
  - Main @ 100 North: 100
  - Main @ Center St: 100
  - Main @ 100 South: 100
  - Main @ 300 South: 100
  - Main @ Kane Creek: 100

85% decrease
Moab – Split Failure Results

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Main @ 100 North</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Main @ Center St</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Main @ 100 South</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Main @ 300 South</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Main @ Kane Creek</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Eastbound: 7% increase

Westbound: 26% decrease