UDOT AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

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“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 construction
- Proactive signal maintenance
- Real-time monitoring of system health and quality of operations

PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach


http://docs.lib.purdue.edu/jtrpaffdocs/3/
Automated Traffic Signal Performance Measures (ATSPM) Basic Concept

Automated Data Collection
- Signal controller
- Probe source

Useful Information about Performance
- Signal
- Corridor
- System

Why Model what you can Measure?
Standard Controller Enumerations

http://docs.lib.purdue.edu/jtrpdata/3/

Purdue University
Purdue e-Pubs

JTRP Data Papers

11-2012

Indiana Traffic Signal Hi Resolution Data Logger Enumerations

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INDOT

Eric Raamot
Econolite Group Inc.

Ray Deer
Peek Traffic Corporation

Dave Miller
Siemens Industry, Inc.

See next page for additional authors
### Active Phase Events:

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Phase On</td>
</tr>
<tr>
<td>1</td>
<td>Phase Begin Green</td>
</tr>
<tr>
<td>2</td>
<td>Phase Check</td>
</tr>
<tr>
<td>3</td>
<td>Phase Min Complete</td>
</tr>
<tr>
<td>4</td>
<td>Phase Gap Out</td>
</tr>
<tr>
<td>5</td>
<td>Phase Max Out</td>
</tr>
<tr>
<td>6</td>
<td>Phase Force Off</td>
</tr>
<tr>
<td>7</td>
<td>Phase Green Termination</td>
</tr>
<tr>
<td>8</td>
<td>Phase Begin Yellow Clearance</td>
</tr>
<tr>
<td>9</td>
<td>Phase End Yellow Clearance</td>
</tr>
<tr>
<td>10</td>
<td>Phase Begin Red Clearance</td>
</tr>
<tr>
<td>11</td>
<td>Phase End Red Clearance</td>
</tr>
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</table>

### Detector Events:

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>Detector Off</td>
</tr>
<tr>
<td>82</td>
<td>Detector On</td>
</tr>
<tr>
<td>83</td>
<td>Detector Restored</td>
</tr>
<tr>
<td>84</td>
<td>Detector Fault- Other</td>
</tr>
<tr>
<td>85</td>
<td>Detector Fault- Watchdog Fault</td>
</tr>
<tr>
<td>86</td>
<td>Detector Fault- Open Loop Fault</td>
</tr>
</tbody>
</table>

### Preemption Events:

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>Preempt Advance Warning Input</td>
</tr>
<tr>
<td>102</td>
<td>Preempt (Call) Input On</td>
</tr>
<tr>
<td>103</td>
<td>Preempt Gate Down Input Received</td>
</tr>
<tr>
<td>104</td>
<td>Preempt (Call) Input Off</td>
</tr>
<tr>
<td>105</td>
<td>Preempt Entry Started</td>
</tr>
</tbody>
</table>
## High-resolution Data Example

Detector 5 OFF

### Phase 8 GREEN

Detector 5 ON

### Phase 8 YELLOW

**0.1-second resolution**

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>Event Code</th>
<th>Event Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/27/2013 1:29:51.1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>6/27/2013 1:29:51.1</td>
<td>82</td>
<td>5</td>
</tr>
<tr>
<td>6/27/2013 1:29:52.2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6/27/2013 1:29:52.2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>6/27/2013 1:29:52.3</td>
<td>82</td>
<td>2</td>
</tr>
<tr>
<td>6/27/2013 1:29:52.8</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>6/27/2013 1:29:52.9</td>
<td>81</td>
<td>4</td>
</tr>
<tr>
<td>6/27/2013 1:29:54.5</td>
<td>81</td>
<td>2</td>
</tr>
<tr>
<td>6/27/2013 1:30:02.2</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>6/27/2013 1:30:02.2</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>6/27/2013 1:30:06.1</td>
<td>10</td>
<td>2</td>
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<tr>
<td>6/27/2013 1:30:06.1</td>
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<td>6/27/2013 1:30:08.1</td>
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<td>8</td>
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<td>6/27/2013 1:30:15.8</td>
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<td>5</td>
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<td>6/27/2013 1:30:18.5</td>
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<td>6</td>
</tr>
<tr>
<td>6/27/2013 1:30:27.5</td>
<td>81</td>
<td>6</td>
</tr>
<tr>
<td>6/27/2013 1:30:30.4</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>
Why is High-resolution Data Important?

Advanced Detector Count Comparison

- **High-definition Data**
  - (1/10-sec resolution)
  - Capture rate: 20%

- **Central System**
  - (1/3-sec resolution)
ATSPM System Architecture

High-res data

Image courtesy of Wavetronix
System Requirements

High-resolution Controller
(or stand-alone data aggregator)

Communications

Server

Software

Detection
(optional)
System Requirements

Does NOT require Central Traffic Management Software!

1) Get .dat Files
2) Translate Files
   .dat  →  .csv
3) Store in Database

Server

Software

Detection (optional)
Vendor Neutrality
Traffic Signals in Utah

UDOT Signals: 1237
90% connected

Partner Signals: 887
73% connected
Signals without Communication

Raspberry Pi
- Stores controller logs
- Updates controller clock

Controller with High-res Data Logger

GPS Antenna

$100
UDOT’s ATSPM Website

http://udottraffic.utah.gov/ATSPM
UDOT’s ATSPM Website

http://udottraffic.utah.gov/ATSPM

1. Select signal from map OR enter 4 digit signal number

Filter map by available metrics
Select metric from list
(Note: not all metrics are available at all signals)
UDOT’s ATSPM Website

http://udottraffic.utah.gov/ATSPM

3. Select time and date range

4. Click “Create Chart”
https://www.itsforge.net
## UDOT ATSPM Implementation Cost

<table>
<thead>
<tr>
<th></th>
<th>Small System (~50 signals)</th>
<th>Large System (~1000 signals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controllers w/ High-definition Loggers</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Communication or In-cabinet Data Storage</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>UDOT ATSPM Software</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Server</td>
<td>$3,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>SQL Database License</td>
<td>$7,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>IT Consultant</td>
<td>$5,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Engineering Consultant (detector configuration)</td>
<td>$5,000</td>
<td>$100,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$20,000</strong></td>
<td><strong>$230,000</strong></td>
</tr>
<tr>
<td><strong>Cost per signal</strong></td>
<td>$400</td>
<td><strong>$230</strong></td>
</tr>
</tbody>
</table>
DETECTION

UDOT Automated Traffic Signal Performance Measures
UDOT Full Detection Setup

- **65’ or 50’ Presence zone, used for Split Failure**
- **15’ Presence zone w/ 3-sec delay in controller, not used for ATSPMs**
- Small zone, used for **Turning Movement Counts**
- Small zone with 15 mph min speed filter, used for **Yellow & Red Actuations** (Note: Place immediately in front of stop bar and do not use in lanes that permit turns on red)
- Count zone located 350 to 600 ft behind the stop bar, used for **Purdue Coordination Diagram**
Turning Movement Counts Detection

Wavetronix SmartSensor Matrix

Wavetronix Cabinet Interface Device Click 650
Wavetronix Matrix – Standard Detection Layout w/ Click 650

Queue zone for P&P left turns

Presence zones can be combined within lane groups

No presence or YRA in right-turn lane

Detection Channel Order
1. Presence zones, inside to outside. If P&P zones, the queue zone is first.
2. Count channels, inside to outside
3. YRA zones, inside to outside
4. Count zones in exit lanes, inside to outside (often skipped)

Protected-only left-turn lanes

Presence zones can be combined within lane groups

No YRA in shared through/right lane

Matrix Sensor Order
1. Phase 2
2. Phase 6
3. Phase 4
4. Phase 8

65’ or 50’ Presence zone, used for Split Failure

15’ Presence zone w/ 3-sec delay in controller, not used for ATSPMs

Small zone, used for Turning Movement Counts

Small zone with 15 mph min speed filter, used for Yellow & Red Actuations (Note: Place immediately in front of stop bar and do not use in lanes that permit turns on red)
Wavetronix Matrix – Configuration for Turning Movement Counts

Min Speed = 15 or 20 mph for Yellow & Red Actuations (YRA)

Channel Configuration
- Make small zone

Zone Configuration
- Min Speed = None
- Max Speed = None
Approach Volume Detection

Wavetronix
SmartSensor
Advance

Image courtesy of Wavetronix
Wavetronix Advance Count Setup

Channel 1 – Dilemma Zone and Queue Clearance
Channel 2 – Counting

Monitor trackers and place count zone at distance with good detection. Preference is 400-500 ft from stop bar.
METRICS

UDOT Automated Traffic Signal Performance Measures
<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
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<tbody>
<tr>
<td>None</td>
<td>Phase Termination Chart</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>Lane-by-lane or</td>
<td>Purdue Split Failure</td>
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<tr>
<td>Lane Group Presence</td>
<td></td>
</tr>
<tr>
<td>Lane-by-lane</td>
<td>Turning Movement Counts</td>
</tr>
<tr>
<td>Stop Bar Count</td>
<td></td>
</tr>
<tr>
<td>Advanced Count</td>
<td>Purdue Coordination Diagram</td>
</tr>
<tr>
<td></td>
<td>Purdue Link Pivot Offset Optimization</td>
</tr>
<tr>
<td></td>
<td>Approach Volume</td>
</tr>
<tr>
<td></td>
<td>Approach Speed</td>
</tr>
<tr>
<td></td>
<td>(requires detection with speed service)</td>
</tr>
</tbody>
</table>
Detection

None

Available Metrics

- Phase Termination Chart
- Split Monitor
- Pedestrian Delay
- Preemption Details
Metric: Phase Termination Chart

![Phase Termination Chart]

- **Free Coordination**: Phases 1-2.
- **Coordination Phases**: Phases 3-6.
- **Free**: Phases 7-12.

- **Phase Number**
- **Time of Day**

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

**Legend**:
- Green circle: Gap out
- Yellow circle: Pedestrian activation
- Red circle: Max out
- Blue circle: Force off
- Circle: Skip
Complaint: Long main street red at 2 a.m.

Before

Video detection not working at night

Minor street through & left turn max out at night only
Complaint: Long main street red at 2 a.m.

After

New detection technology installed

Phases are rarely used at night

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

Foothill Drive @ 1300 South - SIG#7220
Wednesday, June 14, 2017 12:00 AM - Wednesday, June 14, 2017 11:59 PM

Phase Duration

Time of Day
Complaint: Long queue, short green, PM peak

Split Monitor shows mostly gap outs in PM peak

Correct passage time results in force offs
Example: I-15 Freeway Closure, September 9-12, 2014

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

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

Source: KSL
Example: I-15 Freeway Closure, September 9-12, 2014

Southbound I-15 Closed in Nevada

- 4-day closure
- Detour to Las Vegas: Exit I-15 in Cedar City
Split Monitor for Incident Management

Split Monitor

200 N. (Cedar City) @ 1400 W/I-15 SB - SIG#8223
Tuesday, September 09, 2014 12:00 AM - Tuesday, September 09, 2014 11:59 PM

Phase 4

Free
98.1% Gap Outs
Pl

Implement Timing Plans

Revise Timing Plan for better % gap outs

Detour starts
Split Monitor for Incident Management

Implemented timing plans

Full freeway closure
Metric: Preemption Details

Preempt Service Request
State Street @ Center Street - SIG#6311
Wednesday, April 05, 2017 6:00 AM - Wednesday, April 05, 2017 6:00 PM

Preempt Service
State Street @ Center Street - SIG#6311
Wednesday, April 05, 2017 6:00 AM - Wednesday, April 05, 2017 6:00 PM
Metric: Preemption Details

Emergency Vehicle

Preemption Details
State Street @ Center Street - SIG#6311
Wednesday, April 05, 2017 12:00 AM - Wednesday, April 05, 2017 11:59 PM
Preempt Number: 4

Railroad

Preemption Details
Geneva Rd. @ 200 S (Lindon) - SIG#6057
Thursday, May 18, 2017 12:00 AM - Thursday, May 18, 2017 11:59 PM
Preempt Number: 1
Case Study: Preemption
Case Study: Preemption

**Preempt Service Chart**
SIG#6057 Geneva Rd & 200 S (Lindon)
Wednesday, May 25, 2016, 9:00 AM to 4:00 PM

- **56** Preempt Requests & Services in **70** minutes
- Gate down **35%** of the time
Case Study: Preemption

Preempt Service Chart
SIG#6057 Geneva Rd & 200 S (Lindon)
Wednesday, May 25, 2016, 9:00 AM to 4:00 PM

Preempt Service Chart
SIG#6057 Geneva Rd & 200 S (Lindon)
Wednesday, June 22, 2016, 9:00 AM to 4:00 PM

Fixed!
Metric: Pedestrian Delay

Phase 2
Coordinated phase

Phase 4
Side street
Active Transportation
Detection

Lane-by-lane Presence

Lane Group Presence

Available Metrics

Purdue Split Failure
Metric: Purdue Split Failure

Green Occupancy Ratio (GOR) =
% of time stop bar detector is ON during GREEN

Red Occupancy Ratio (ROR5) =
% of time stop bar detector is ON during FIRST 5s of RED

Split Fail = GOR & ROR5 ≥ 80%
Future Metric: Purdue Split Fail Ticker

Figure 9. Aggregated split-failures over 24 hours on US-31 Greenwood for all Saturdays from January 1 to June 30, 2015.

Source: Scaling detailed high-resolution data split performance measures to statewide system level management (Paper No. 16-4149).
Detection

Lane-by-lane Count

Available Metrics

Turning Movement Counts
Metric: Turning Movement Counts

Turning Movement Counts
Foothill Drive @ Wakara Way (660 S.) - SIG#7218
Wednesday, April 12, 2017 12:00 AM - Wednesday, April 12, 2017 11:59 PM

Northbound Thru Vehicle Lanes
Total Volume = 18734; Peak Hour = 7:30 AM - 8:30 AM; Peak Hour Volume = 2151 VPH; PHF = 0.94; fLU = 0.67

Volume (VPH)
Time of Day

- Free
- PI
- Plan 1
- Plan 7
- Plan 13
- Plan 7
- Free
## TMC Data Table

<table>
<thead>
<tr>
<th>Time</th>
<th>Vehicle</th>
<th>Eastbound</th>
<th>Westbound</th>
<th>Northbound</th>
<th>Southbound</th>
<th>Vehicle Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>R</td>
<td>Total</td>
<td>L</td>
<td>R</td>
</tr>
<tr>
<td>4:00 PM</td>
<td></td>
<td>18</td>
<td>29</td>
<td>47</td>
<td>202</td>
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<tr>
<td>4:15 PM</td>
<td></td>
<td>7</td>
<td>35</td>
<td>42</td>
<td>188</td>
<td>186</td>
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<tr>
<td>4:30 PM</td>
<td></td>
<td>13</td>
<td>37</td>
<td>50</td>
<td>206</td>
<td>165</td>
</tr>
<tr>
<td>4:45 PM</td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>202</td>
<td>188</td>
</tr>
<tr>
<td>5:00 PM</td>
<td></td>
<td>7</td>
<td>17</td>
<td>24</td>
<td>214</td>
<td>192</td>
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<tr>
<td>5:15 PM</td>
<td></td>
<td>5</td>
<td>19</td>
<td>24</td>
<td>187</td>
<td>163</td>
</tr>
<tr>
<td>5:30 PM</td>
<td></td>
<td>7</td>
<td>21</td>
<td>28</td>
<td>163</td>
<td>149</td>
</tr>
<tr>
<td>5:45 PM</td>
<td></td>
<td>9</td>
<td>11</td>
<td>20</td>
<td>122</td>
<td>124</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td>76</td>
<td>189</td>
<td>265</td>
<td>1484</td>
<td>1348</td>
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</tbody>
</table>

### Peak Hour (PHF = 0.98)

<table>
<thead>
<tr>
<th>Time</th>
<th>Vehicle</th>
<th>Eastbound</th>
<th>Westbound</th>
<th>Northbound</th>
<th>Southbound</th>
<th>Vehicle Total</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>R</td>
<td>Total</td>
<td>L</td>
<td>R</td>
</tr>
<tr>
<td>4:30 PM - 5:30 PM</td>
<td></td>
<td>35</td>
<td>93</td>
<td>128</td>
<td>809</td>
<td>708</td>
</tr>
</tbody>
</table>
Detection

Setback Count Zones

Available Metrics

- Purdue Coordination Diagram
- Approach Volume
- Arrivals on Red
- Approach Delay
Metric: Purdue Coordination Diagram

Bangerter Hwy (SR-154) @ 9000 South - SIG#7067
Tuesday, January 17, 2017 12:00 AM - Tuesday, January 17, 2017 11:59 PM
Advanced detector located 377 ft. upstream of stop bar

Phase 6: Southbound

Queuing past sensor

Time in Cycle (s)

Vehicle arrivals

Time of Day
Purdue Coordination Diagram: Progression Quality

Bangerter Hwy (SR-154) @ 5400 South (SR-173) - SIG#7063
Thursday, March 07, 2013 5:00 AM - Thursday, March 07, 2013 8:00 PM
Advanced detector located 350 ft. upstream of stop bar

Phase 10: Northbound
AoG = 63%

Plan 19 P
74% AoG
1.32 PR

Plan 34
64% AoG
1.23 PR

Plan 38
55% AoG
1.25 PR

Plan 41
71% AoG
1.45 PR

PIP Plan 13
6.976% AoG
1.11.65 PR

Time in Cycle (s)

Time of Day
Metric: Approach Volume

Approach Volume
University Avenue @ East Bay Boulevard - SIG#6402
Wednesday, May 17, 2017 12:00 AM - Wednesday, May 17, 2017 11:59 PM

Northbound and Southbound Approaches
WaveTronic® Matrix at stop bar

Approach Volume
University Avenue @ East Bay Boulevard - SIG#6402
Wednesday, May 17, 2017 12:00 AM - Wednesday, May 17, 2017 11:59 PM

Northbound and Southbound Approaches
WaveTronic® Advance located 400ft. upstream of the stop bar
## Metric: Approach Volume

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Peak Hour</td>
<td>5/17/2017 5:15:00 PM</td>
</tr>
<tr>
<td>Peak Hour Factor</td>
<td>0.364</td>
</tr>
<tr>
<td>Peak Hour Volume</td>
<td>9028</td>
</tr>
<tr>
<td>Peak Hour Factor</td>
<td>0.927</td>
</tr>
<tr>
<td>Total Volume</td>
<td>24827</td>
</tr>
<tr>
<td>Northbound Peak Hour</td>
<td>8:00 AM - 9:00 AM</td>
</tr>
<tr>
<td>Northbound Peak Hour D Value</td>
<td>0.424</td>
</tr>
<tr>
<td>Northbound Peak Hour K Value</td>
<td>0.394</td>
</tr>
<tr>
<td>Northbound Peak Hour Volume</td>
<td>5196</td>
</tr>
<tr>
<td>Northbound Peak Hour Factor</td>
<td>0.664</td>
</tr>
<tr>
<td>Northbound Total Volume</td>
<td>13204</td>
</tr>
<tr>
<td>Southbound Peak Hour</td>
<td>5:15 PM - 6:15 PM</td>
</tr>
<tr>
<td>Southbound Peak Hour D Value</td>
<td>0.632</td>
</tr>
<tr>
<td>Southbound Peak Hour K Value</td>
<td>0.476</td>
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<tr>
<td>Southbound Peak Hour Volume</td>
<td>5532</td>
</tr>
<tr>
<td>Southbound Peak Hour Factor</td>
<td>0.896</td>
</tr>
<tr>
<td>Southbound Total Volume</td>
<td>11623</td>
</tr>
</tbody>
</table>
Allow Lane Closures
Detection

Setback Count Zones with speed

Available Metrics

Approach Speed

~400ft
Metric: Approach Speed

Approach Speed
SR-126 (1900 W) @ 5700 South (Roy) - SIG#5088
Wednesday, September 30, 2015 12:00 AM - Wednesday, September 30, 2015 11:59

Phase 6: Southbound
Detection Type: Unknown; Speed Accuracy +/- 2 mph
Detector Distance from Stop Bar: 350 feet
Includes records over 5mph that occur between 15s after start of green to start of yellow.
Metric: Approach Speed

Approach Speed
Riverdale Rd @ Shopko - SIG#5008
Thursday, January 10, 2013 12:00 AM - Thursday, January 10, 2013 11:59 PM

Phase 2: Northbound
Detection Type: Wavetronix Advance; Speed Accuracy +/- 2 mph
Detector Distance from Stop Bar: 285 feet;
Includes records over 5mph that occur between 15s after start of green to start of yellow.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>6-7</th>
<th>8-9</th>
<th>10-11</th>
<th>12-13</th>
<th>14-15</th>
<th>16-17</th>
<th>18-19</th>
<th>20-21</th>
<th>22-23</th>
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<tbody>
<tr>
<td>85% Sp 43</td>
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<td>85% Sp 42</td>
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</tbody>
</table>

Snow storm starts
Metric Usage

Metrics Run
1/1/2017 – 5/21/2017

Collected by automatic logger
UDOT ATSPM Configuration Records

Detector Count by Metric

<table>
<thead>
<tr>
<th>Metric</th>
<th>Number of Detectors Configured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Metrics Only (No Detectors Configured)</td>
<td>1000</td>
</tr>
<tr>
<td>Lane-by-lane Presence (Avg./Signal: 8.4)</td>
<td>3000</td>
</tr>
<tr>
<td>Stop Bar Count (Avg./Signal: 11.4)</td>
<td>5000</td>
</tr>
<tr>
<td>Advanced Count (Avg./Signal: 2.1)</td>
<td>1000</td>
</tr>
</tbody>
</table>

Total: 10,700 detectors + 1785 signals
SIGNAL OPTIMIZATION

UDOT Automated Traffic Signal Performance Measures
Optimization with ATSPMs

**Traditional Process**

1. Collect Data
2. Model
3. Optimize
4. Implement & Fine-tune

**Modified Process with SPMs**

1. Review ATSPMs & Field Observation
2. Model
3. Optimize
4. Implement & Fine-tune

- Time-of-day
- Cycle Length
- Splits
- Offsets

- Time-of-day
- Cycle Length
- Splits
- Offsets
Evaluate Impact of Timing Change

- Before:
  1 2 | 3 4
  5 6 | 7 8

- After:
  1 2 | 4 3
  5 6 | 7 8
“Can we oversize the peds?”

Peds for Phases 4 & 8 are called **frequently**
Recommendation: Do not oversize peds

Peds for Phases 4 & 8 are **rarely** called
Recommendation: Oversize peds, if needed

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

~20 peds/hour

~20 peds/hour

0 peds

~1 ped/hour
SYSTEM HEALTH ALERTS

UDOT Automated Traffic Signal Performance Measures
System Health Alerts

1. **No SPM data**: identifies signals with less than 500 records in the database between midnight and midnight the previous day.

2. **Too many max outs**: identifies phases with more than 90% max outs in at least 50 activations between 1 a.m. and 5 a.m.

3. **Too many force offs**: identifies phases with more than 90% force offs in at least 50 activations between 1 a.m. and 5 a.m.

4. **Too many ped calls**: identifies phases with more than 200 pedestrian activations between 1 a.m. and 5 a.m.

5. **Low PCD detector count**: identifies phases with PCD detectors that have less than 100 vehicles counted between 5 p.m. and 6 p.m. the previous day.
Alert Evaluation

1. No ATSPM data
   - Check communication to signal
   - Check controller clock
   - Check IP address in SPM configuration
   - Check VIOT = NO & DB State = All Saved (Econolite MM 9-3-1 SpFn*3)
   - Try enabling Upload Current
   - Create a WO to cold start the controller

2. Too many max outs
   - Check for recalls
   - Check for constant call on a detector channel
   - Consider whether a bandaid is necessary

3. Too many force offs
   - Should the signal be in coordination?
   - Is a non-coordinated phase maxing out?
   - Skip only 2-6 pairs and dummy phases

4. Too many ped calls
   - Check for recalls
   - Check for constant call on a detector channel

5. Low PCD detector count
   - Note: Evaluate the VOLUME on the PCD charts, not the phase data
   - Is count channel configured correctly in SPM Config Tool?
   - Is ECPI Log enabled for count channel?
   - Is the detector working?
   - Is the detector communicating to the controller?
   - Try resetting the sensor and VERIFY with Upload Current
No ATSPM Data

Data Lost

ATSPMs evaluated for Data

Alert email sent

Clock Reset

6/13/2016

6/14/2016

6/15/2016
2 Too many max outs

Phase 4 starts constant call

4/8/2014

4/9/2014

Alert email sent

ATSPMs evaluated for % max outs

0%
3%
100%
5%
100%

Gap out
Max out
Force off
Pedestrian activation (shown above phase line)

Skip
4. Too many ped calls

Ph6 Ped Constant Call

Alert email sent

ATSPMs evaluated for Ped Activations

5/21/2016

5/22/2016
Low PCD detector count

ATSPMs evaluated for PCD
Detector Volume

Sensor quits working
Alert email sent
Sensor Reset

12/10/2016
12/11/2016
12/12/2016
# Work Orders for ATMS Equipment
July 2015 to July 2016

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Traffic Signals</th>
<th>VMS, TMS, &amp; VSL</th>
<th>RWIS</th>
<th>Cabinet</th>
<th>Ramp Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection Problem</td>
<td>1200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Flash</td>
<td>400</td>
<td>0</td>
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<td>0</td>
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<td>Operations</td>
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<td>Damaged/Broken Equipment</td>
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<td>0</td>
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<tr>
<td>No power or comm</td>
<td>80</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>Bad Image</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>No power or comm</td>
<td>20</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Damaged/Broken Equipment</td>
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<td>Sensor Problem</td>
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</tr>
</tbody>
</table>

Note: The chart shows the number of work orders for different equipment types and issues from July 2015 to July 2016.
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.
60s Commercial – Green Lights

http://udot.utah.gov/greenlights
https://www.itsforge.net
21 Installations of UDOT ATSPMs

- MnDOT
- Overland Park, KS
- Utah
- INDOT
- FDOT
- Seminole County, FL
- WISDOT
- VDOT
- GDOT
- College Station, TX
- Tuscaloosa, AL
- PennDOT
- Pocatello, ID
- Las Vegas (FAST)
- Phoenix, AZ
- Albuquerque, NM
- Tucson, AZ
- Lakewood, CO
- Richardson, TX
- ODOT
- Portland
- CDOT
Community Forums

National Operations Center of Excellence (NOCoeE)
http://forum.transportationops.org/forum/5-traffic-signals/
➢ General ATSPM topics (e.g. how to use metrics, detection setup, lessons learned, upcoming workshops & seminars, etc.)

FHWA's Open Source Application Development Portal
https://www.itsforge.net/forum/ATSPM
➢ Questions regarding UDOT's ATSPM source code (e.g. problems with installations, bugs, plans for future development, etc.)
What’s Next

• New Metrics
  • Transition
  • Transit Signal Priority
• Watchdog analytics (GDOT)

• 15-minute data aggregation
• High-level reporting and alerts
What’s Next

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Count of Daily Failures by # of Consecutive Occurrences

- < 1 week
- 2 weeks
- 3 weeks
- 4+ weeks
What’s Next

- New Metrics
  - Transition
  - Transit Signal Priority
- Watchdog analytics (GDOT)

- 15-minute data aggregation
- High-level reporting and alerts

![Retiming Project Chart](chart.png)

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

UDOT ATSPMs

**ATSPM Website**
http://udottraffic.utah.gov/ATSPM

**Green Lights Commercial**
http://udot.utah.gov/greenlights

**FHWA's Open Source Application Development Portal (OSADP)**
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- Questions regarding UDOT's ATSPM source code

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Jamie Mackey
UDOT Statewide Signal Engineer
jamiemackey@utah.gov
Crossing Guard Key Switch to Extend Walk Time

$40
Emergency Response Plan – Additional support from non-technical personnel

2-3 per maintenance shed