UTAH’S EXPERIENCE WITH AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

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Traffic Signal Operations Engineer
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Objectives

• UDOT Update & History with ATSPMs
• How ATSPMs Work
• ATSPMs & How UDOT has used them
• Options for Louisiana to obtain ATSPMs
• Some UDOT Results using ATSPMs
2075 Traffic Signals in the State of Utah
- 1223 owned and operated by UDOT (59%)
- 852 owned and operated by cities/counties (41%)

All cities share same ITS communications
- 96% of UDOT signals connected
- 79% of partner agency signals connected

All cities in Utah & UDOT share same ATMS
Opportunity 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 construction
• Proactive signal maintenance
• Real-time monitoring of system health and quality of operations

Started Development November 2012.

- State of Utah Department of Technology Services

Estimate 8,000 hours of UDOT development
(November 2012 to February 2018)
History of ATSPMs

- 2005: Purdue & InDOT initiated research to develop new performance measures.
- 2012: Purdue publishes “Indiana Traffic Signal Hi Resolution Data Logger Enumerations”.
- 2012: UDOT (with Purdue & InDOT assistance) started development on ATSPMs.
- 2014: AASHTO Innovation Initiative (AASHTO Aii) accelerated ATSPMs.
- 2016: UDOT released UDOT ATSPMs as open source and free to everyone (public & private).
- 2017: FHWA EDC-4 accelerated ATSPMs.
- April/May 2018: ATSPM Version 4.2.0 will be available.
22+ Installations of ATSPMs
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/
# Standard Controller Enumerations

<table>
<thead>
<tr>
<th>Active Phase Events:</th>
<th>Detector Events:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0  Phase On</td>
<td>81  Detector Off</td>
</tr>
<tr>
<td>1  Phase Begin Green</td>
<td>82  Detector On</td>
</tr>
<tr>
<td>2  Phase Check</td>
<td>83  Detector Restored</td>
</tr>
<tr>
<td>3  Phase Min Complete</td>
<td>84  Detector Fault- Other</td>
</tr>
<tr>
<td>4  Phase Gap Out</td>
<td>85  Detector Fault- Watchdog Fault</td>
</tr>
<tr>
<td>5  Phase Max Out</td>
<td>86  Detector Fault- Open Loop Fault</td>
</tr>
<tr>
<td>6  Phase Force Off</td>
<td>88  Detector Fault- Unknown</td>
</tr>
<tr>
<td>7  Phase Green Termination</td>
<td>89  Detector Fault- Internal</td>
</tr>
<tr>
<td>8  Phase Begin Yellow Clearance</td>
<td>Detector Fault- I/O Failure</td>
</tr>
<tr>
<td>9  Phase End Yellow Clearance</td>
<td>Detector Fault- Power Supply</td>
</tr>
<tr>
<td>10 Phase Begin Red Clearance</td>
<td>Detector Fault- Sensor Fault</td>
</tr>
<tr>
<td>11 Phase End Red Clearance</td>
<td>Detector Fault- Communication</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preemption Events:</th>
</tr>
</thead>
<tbody>
<tr>
<td>101 Preempt Advance Warning Input</td>
</tr>
<tr>
<td>102 Preempt (Call) Input On</td>
</tr>
<tr>
<td>103 Preempt Gate Down Input Received</td>
</tr>
<tr>
<td>104 Preempt (Call) Input Off</td>
</tr>
<tr>
<td>105 Preempt Entry Started</td>
</tr>
</tbody>
</table>

>100 different enumerations
### High-resolution Data Example

#### 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>82</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>
</tr>
<tr>
<td>6/27/2013 1:30:06.1</td>
<td>10</td>
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</tr>
<tr>
<td>6/27/2013 1:30:08.1</td>
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</tr>
<tr>
<td>6/27/2013 1:30:15.8</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>6/27/2013 1:30:18.5</td>
<td>82</td>
<td>6</td>
</tr>
<tr>
<td>6/27/2013 1:30:27.5</td>
<td>81</td>
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</tr>
<tr>
<td>6/27/2013 1:30:30.4</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

**Detector 5 ON**

**Phase 8 GREEN**

**Detector 5 OFF**

**Phase 8 YELLOW**
Why is High-resolution Data Important?

Advanced Detector Count Comparison

High-definition Data (1/10-sec resolution)

Central System (1/3-sec resolution)

20% capture rate
ATSPM System Architecture

High-res data
System Requirements

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

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

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)
Your Trafficware 980 ATC controllers will work!

- FDOT & Seminole County ATSPMs ([https://atspm.cflsmartroads.com/ATSPM](https://atspm.cflsmartroads.com/ATSPM))
- Las Vegas/FAST ATSPMs ([http://challenger.nvfast.org/spm/](http://challenger.nvfast.org/spm/))

Best point of contact at Trafficware:
Marshall Cheek – 281-240-7233 x415
Vendor Neutrality
Signals without Communication

- **Raspberry Pi**
  - Stores controller logs
  - Updates controller clock

- **GPS Antenna**

- **Controller with High-res Data Logger**

$100
UDOT’s ATSPM Website

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

https://udottraffic.utah.gov/ATSPM

Select signal from map OR enter 4 digit signal number

Filter map by available metrics
UDOT’s ATSPM Website

https://udottraffic.utah.gov/ATSPM

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

https://udottraffic.utah.gov/ATSPM

3. Select time and date range

4. Click “Create Chart”
<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
</tr>
</thead>
<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 Lane Group Presence</td>
<td>Purdue Split Failure</td>
</tr>
<tr>
<td>Lane-by-lane Stop Bar Count</td>
<td>Turning Movement Counts</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 <em>(requires detection with speed service)</em></td>
</tr>
</tbody>
</table>
Metric Usage

Metrics Run
1/1/2017 – 5/21/2017

Collected by automatic logger
Metric: Phase Termination Chart

- Free Coordination
- Coordinated Phases
  - Phase Number
    - WBT
    - EBL
    - SBT
    - NBL
    - EBT
    - WBL
    - NBT
    - SBL
  - Time of Day

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

Phase Number

Time of Day

Gap out
Skip
Max out
Pedestrian activation (shown above phase line)
Force off
Complaint: Long main street red at 2 a.m.

After

New detection technology installed

Phases are rarely used at night
Complaint: Long queue, short green, PM peak

<table>
<thead>
<tr>
<th>Time (Hour of Day)</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
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<td>01</td>
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<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Before

- Split Monitor shows mostly gap outs in PM peak

After

- Correct passage time results in force offs
Complaint: Green too short in the morning

Before

Split Monitor

Purdue Split Failure
Complaint: Green too short in the morning

After

Split Monitor

Purdue Split Failure
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

Revise Timing Plan for better % gap outs

Detour starts
Implement Timing Plans
Split Monitor for Incident Management

Implemented timing plans

Full freeway closure
Purdue Coordination Diagram

Vehicles arriving on green

Vehicles arriving on yellow

Vehicles arriving on red
Complaint: Too many vehicles arriving during red (starting at 9:00 AM)
Metric: Approach Volume

![Graph showing Approach Volume over Time of Day]

- **Northbound**
- **Southbound**
- **Northbound D-Factor**

**Y-axis:** Volume (vph)

**X-axis:** Time of Day
Allow Lane Closures?

Volume report for University Avenue East Bay Boulevard on the Northbound and Southbound approaches.
7/7/2016 12:00:00 AM - 7/7/2016 11:59:00 PM - Using Advanced Detection
Metric: Turning Movement Counts

Volume (VPH)

Time of Day

Eastbound Thru

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

Free Plan 1 Plan 7 Plan 13 Plan 7 Free

00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00

800 700 600 500 400 300 200 100 0

Total Volume Lane 1 Lane 2 Thru Right
Yellow & Red Actuations (Southbound Through)

5600 West & 2700 South – October 17, 2017
Railroad Preemption Example – Lindon Utah
Preemption Calls

Wednesday May 25, 2016 between 9:00 AM and 4:00 PM

56 Preempt Requests & Services in 70 minutes

Gate down 35% of the time

• Train passes through 2x a day Monday, Wednesday, Friday
• Complaints received monthly for a long time. Techs frustrated at this signal.
• Previously, there was no data to provide Union Pacific.
Union Pacific installed some isolation on the spur line where the track switched so the circuit wasn't being falsely triggered.

Wednesday, May 25, 2016: 9:00 AM to 4:00 PM

Wednesday, June 22, 2016: 9:00 AM to 4:00 PM

Fixed!
Pedestrians: Delay & Actuations

North Leg of Intersection: 8890 South (Newcastle) & Highland– Monday Feb 12, 2018

Ped Actuations (PA) = 24; Min Delay = 00:01; Max Delay = 01:54; Average Delay (AD) = 00:48
Pedestrian Actuations

Average Daily Pedestrian Actuations
- <50
- 50 - 99
- 100 - 199
- 200 - 299
- 300 - 399
- 400 - 499
- 500+
- Unknown

SR-173
W 1300 S
Corridor Metrics: Purdue Split Fail
SIGNAL OPTIMIZATION

UDOT Automated Traffic Signal Performance Measures
Optimization with ATSPMs

**Traditional Process**
- Collect Data
- Model
- Optimize
- Implement & Fine-tune

**Modified Process with SPMs**
- Review ATSPMs & Field Observation
- Model
- Optimize
- Implement & Fine-tune

- Time-of-day
- Cycle Length Splits Offsets
- Time-of-day Cycle Length Splits
- Offsets
SYSTEM HEALTH ALERTS
FOR PROACTIVE MAINTENANCE

UDOT Automated Traffic Signal Performance Measures
System Health Alerts

1. **No ATSPM 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.
Phase 4 starts constant call

4/8/2014

Too many max outs

ATSPMs evaluated for % max outs

0%
3%
100%
5%
0%

4/9/2014

Alert email sent

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

538 ped activations
https://www.itsforge.net
## Open Source ATSPM Implementation Cost Estimate

<table>
<thead>
<tr>
<th>Item</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>ATSPM Open Source 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 (software installation)</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>
</tbody>
</table>

*Cost per signal*  
- Small System: $400  
- Large System: $230
# More Information

## UDOT ATSPMs

- **ATSPM Website**
  - [https://udottraffic.utah.gov/ATSPM](https://udottraffic.utah.gov/ATSPM)

- **ATSPM Forums**

  - **National Operations Center of Excellence (NOCoE)**
    - [http://forum.transportationops.org/forum/5-traffic-signals/](http://forum.transportationops.org/forum/5-traffic-signals/)
    - General ATSPM topics

  - **FHWA's Open Source Application Development Portal (OSADP)**
    - [https://www.itsforge.net/forum/ATSPM](https://www.itsforge.net/forum/ATSPM)
    - Questions regarding UDOT's ATSPM source code

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## Mark Taylor
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## Green Lights Commercial
- [http://udot.utah.gov/greenlights](http://udot.utah.gov/greenlights)
Some Options for Louisiana

TrafficWare Cloud Based or other ATSPM systems

ATSPM Open Source
If desired to obtain open source ATSPMs

• Install ATSPM source code from OSADP (https://www.itsforge.net/)
  • In-house I.T. or qualified consultants (Kittleson, Stantec, Pinetop, etc.)
• Decide if website will be open to all or private behind a firewall
If desired to obtain open source ATSPMs

• Obtain from Trafficware the proprietary data log code translator
  • Need to translate records from binary to csv
  • FDOT, Seminole County, Las Vegas use Trafficware controllers
    (https://atspm.cflsmartroads.com/ATSPM)

• Update firmware on 980 ATC controllers (76.10+)

• Decide on the measures desired, and upgrade detection accordingly

• Consider Raspberry Pi boxes for non-communication signals (only 10% of 2800 signals online).
### UDOT Asset Management Tiers (2015 & Prior)

**Asset Management Tiers range from 1 to 3, Tier 1:**
- Highest value combined with highest risk of negative financial impact for poor management.
- Very important to UDOT.
- Receive separate funding source.
- Targets and measures are set and tracked.

<table>
<thead>
<tr>
<th>Tier 1 Assets</th>
<th>Tier 2 Assets</th>
<th>Tier 3 Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement</td>
<td>ATMS / Signal Devices</td>
<td>Cattle Guards</td>
</tr>
<tr>
<td>Bridges</td>
<td>Pipe Culverts</td>
<td>Interstate Lighting</td>
</tr>
<tr>
<td></td>
<td>Signs</td>
<td>Fences</td>
</tr>
<tr>
<td></td>
<td>Barriers &amp; Walls</td>
<td>Curb &amp; Gutter</td>
</tr>
<tr>
<td></td>
<td>Rumble Strips</td>
<td>Rest Areas</td>
</tr>
<tr>
<td></td>
<td>Pavement Markings</td>
<td></td>
</tr>
</tbody>
</table>
UDOT Asset Management Tiers (2016 & Future)

• Asset Management Tiers range from 1 to 3: Tier 1:
  • Highest value combined with highest risk of negative financial impact for poor management.
  • Very important to UDOT.
  • Receive separate funding source.
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Source: https://www.udot.utah.gov/main/uconowner.gf?n=15663419239657232
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.
60s Commercial – Green Lights
http://udot.utah.gov/greenlights
udottraffic.utah.gov/ATSPM

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