Automated Traffic Signal Performance Measures: UDOT’s Experience

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Utah Department of Transportation
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Brief Utah Update

- 2012 Traffic Signals in the State of Utah
  - 1192 owned and operated by UDOT (59%)
  - 820 owned and operated by cities /counties (41%)

- All cities share same ITS communications
  - 93% of UDOT signals connected
  - 79% of non-UDOT signals connected

- All cities in Utah & UDOT share same ATMS
Utah
Green = UDOT Comm.
Blue = City Comm.
Red = No Comm.

Wasatch Front
UDOT’s Road Map

Vision: Keeping Utah Moving

Mission: **Innovating** transportation solutions that **strengthen** Utah’s economy and **enhance** quality of life.

Strategic Goals:
1. **Zero Crashes, Injuries and Fatalities**
   - Yellow & Red Actuations, Speed, Preemption Details
2. **Optimize Mobility**
   - PCD, Split Monitor, Volumes, Purdue Link Pivot, Purdue Split Failure
3. **Preserve Infrastructure**
   - Purdue Phase Termination, Daily Detector Problem Email
## Objective

<table>
<thead>
<tr>
<th>Objective</th>
<th>Approach Volumes</th>
<th>Turning Movement Counts</th>
<th>Split Monitor</th>
<th>Purdue Phase Termination</th>
<th>Purdue Coordination Diagram</th>
<th>Purdue Travel Time Diagram</th>
<th>Purdue Link Pivot</th>
<th>Purdue Split Failure</th>
<th>Percent Arrivals on Green</th>
<th>Detector Error Alarms</th>
<th>Executive Reports</th>
<th>Yellow &amp; Red Actuations</th>
<th>Approach Delay</th>
<th>Arrivals on Red</th>
<th>Speed</th>
<th>Pedestrian Delay</th>
<th>Preemption Details</th>
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UDOT Asset Management Tiers (2015 & Prior)

- Asset Management Tiers range from 1 to 3
- Tier 1 assets:
  - 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>
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<tbody>
<tr>
<td>Pavement</td>
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<tr>
<td>Bridges</td>
<td>Pipe Culverts</td>
<td>Interstate Lighting</td>
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<td>Signs</td>
<td>Fences</td>
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<td>Barriers &amp; Walls</td>
<td>Curb &amp; Gutter</td>
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<td>Rumble Strips</td>
<td>Rest Areas</td>
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<td></td>
<td>Pavement Markings</td>
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Source: https://www.udot.utah.gov/main/uconowner.gf?n=15663419239657232
UDOT Asset Management Tiers (2016 & Future)

- Asset Management Tiers range from 1 to 3
- **Tier 1 assets:**
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ATSPM Basic Concept

Automated Data Collection
- Signal controller
- Probe source

Useful Information about Performance
- Signal
- Corridor
- System

Why Model what you can Measure?

Does NOT require Central Traffic Signal Management Software!
### Standard Controller Enumerations

**Active Phase Events:**
- 0  Phase On
- 1  Phase Begin Green
- 2  Phase Check
- 3  Phase Min Complete
- 4  Phase Gap Out
- 5  Phase Max Out
- 6  Phase Force Off
- 7  Phase Green Termination
- 8  Phase Begin Yellow Clearance
- 9  Phase End Yellow Clearance
- 10 Phase Begin Red Clearance
- 11 Phase End Red Clearance

**Detector Events:**
- 81  Detector Off
- 82  Detector On
- 83  Detector Restored
- 84  Detector Fault - Other
- 85  Detector Fault - Watchdog Fault
- 86  Detector Fault - Open Loop Fault

**Preemption Events:**
- 101 Preempt Advance Warning Input
- 102 Preempt (Call) Input On
- 103 Preempt Gate Down Input Received
- 104 Preempt (Call) Input Off
- 105 Preempt Entry Started

[http://docs.lib.purdue.edu/jtrpdata/3/](http://docs.lib.purdue.edu/jtrpdata/3/)
Active Phase Events:
0  Phase On
1  Phase Begin Green
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101 Preempt Advance Warning I
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103 Preempt Gate Down Input R
104 Preempt (Call) Input Off
105 Preempt Entry Started

http://docs.lib.purdue.edu/jtrpdata/3/
### High-resolution Data

**0.1-second resolution**

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<th>Event Code</th>
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<td>6/27/2013 1:30:30.4</td>
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- **Detector 5 ON**
- **Phase 8 GREEN**
- **Detector 5 OFF**
System Requirements

High-resolution Controller

Communications

Server

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

Software

Detection (optional)

Photo courtesy of the Indiana Department of Transportation
System Requirements

Does NOT require Central Traffic Signal Management Software!

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

Server

Software

Detection (optional)

Photo courtesy of the Indiana Department of Transportation
PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach

1710 (85%) Utah’s traffic signals
Signal Performance Metrics

286 traffic signals
316 traffic signals
Signal Performance Metrics

http://signalmetrics.ua.edu

45 traffic signals
Agencies using SPMs – Separate systems deployed (16 and growing)
Metric: Purdue Coordination Diagram
Metric: Approach Volume
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

Volume (VPH)

Time of Day

Total Volume  Lane 1  Lane 2  Thru Right
Metric: Approach Speed

Snow storm starts
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 due to freeway washouts in Nevada as shown by more frequent force-off and higher split being used

Gap out  Pedestrian activation
Max out
Force off
Railroad Preemption Example – Lindon Utah
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

- 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.
SPMs also provide information on how long the gate is down. On September 7th, it ranged from 18 seconds to 57 seconds.
Outcome Assessment of Peer-to-Peer Adaptive Control Adjacent to a National Park

Lucy Richardson
Christopher Day
Darcy Bullock
Matthew Luker
Mark Taylor
A view of the Arches entrance line. Cars are lined up onto US 191. (cw) #archesnps #archesnationalpark
Case Study: Moab, Utah

- The Adventure Capital of the U.S.A.
- Two National Parks within 20 miles
Corona Arch & Balanced Rock - Moab
Unpredictable Traffic – Very Seasonal
Memorial Day 2015 vs. 2016

Northbound

Southbound

Before (5/23/2015)  
After (5/28/2016)
Allocation of Green Time

Northbound

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<tr>
<th>Intersection #</th>
<th>Total Green Time (sec)</th>
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Southbound

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Eastbound

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Legend:
- Before (5/23/2015)
- After (5/28/2016)
Corridor Progression: PCDs

Memorial Day

Northbound

Before 2015

After 2016

Southbound

Time In Cycle (s)

Beginning of Green  End of Green  Green Interval  Vehicle Arrival

LTDOT

Keeping Utah Moving

PURDUE
UNIVERSITY
Moab – Split Failure Results

- **Northbound**: 86% decrease
- **Southbound**: 85% decrease
- **Eastbound**: 7% increase
- **Westbound**: 26% decrease

Intersection #
- Main 1
- Main 2
- Main 3
- Main 4
- Main 5

[Images of bar charts showing before and after failure occurrences for each direction.]
System Health

SPM Alerts for 5/22/2016

1. No SPM Data
2. Too many max outs
3. Too many force offs
4. Too many ped calls
5. Low PCD detector count
6. High PCD detector count

1710 traffic signals
Metric: Purdue Phase Termination Detection Requirements: None

Phase 4 starts constant call

SPMs evaluated for % max outs

Alert email sent

4/8/2014

4/9/2014

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

2 Too many max outs

Too many max outs

0%
3%
100%
5%
100%
Purdue Split Failure – Center St & Main St – Moab, Utah
Memorial Day Weekend – Saturday

2015

2016

PURDUE UNIVERSITY

LTDOT
Keeping Utah Moving
Monitor Trends

Percent of Vehicles Arriving on Green - Riverdale Rd

10:00 AM to 2:00 PM Monday through Friday

Retiming Project
SPM Source Code -> Open Source
Mid Nov. 2016
Salt Lake SPM Workshop Participants – Jan 2016

20 State & Federal Agencies
25 Public Agencies
5 Universities
35 Private Sector Locations

170 Representatives from 85 Different Organizations, 28 States, DC, & Canada
Train the Trainer Workshop

When: Salt Lake City: January 18 & 19, 2017

For Whom: Consultants, Vendors, IT Personnel

Learning Objectives: Installing UDOT ATSPM Source Code, Server/Network Requirements, Configuration, Q&A.

Register: https://www.eventbrite.com/e/udot-train-the-trainer-workshop-for-atspm-tickets-28563394883?aff=es2

Attendance is free.
Implementation of Automated Traffic Signal Performance Measures

What does it take to get ATSPM’s?

• Controller with Purdue hi-res data
• Comm to intersection or external memory (Raspberry Pi)
• Server
  – Price ranges from $3K to $20K (UDOT: $15K on a 20 TB server)
• SQL Database License: Free (Express) to $100K (Enterprise)
• ATSPM Software: Free: (http://www.itsforge.net/)
• Consultant to do installation: $5K to $10K

Total Price for ATSPM’s: $3K to $130K+
Optimization with SPMs

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

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

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