Automated Traffic Signal Performance Measures

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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.
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

Salt Lake ATSPM Workshop Participants – Jan 2016

170 Representatives from 85 Different Organizations, 28 States, DC, & Canada
PRESENTATIONS FROM JANUARY 26–27, 2016

2016

Tuesday, January 26th

Traffic Signal Performance Measures Workshop
Darcy Bullock, Purdue University

TSM&O 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 Curtis, Federal Highway Administration

Transportation Pooled Fund Program Recap
Jim Sturdevant, Indiana Department of Transportation
Richard Denney, Federal Highway Administration

Public/Private Partnerships: Expanding the Reach of Traffic Signals
Lynne Yocom, Utah Department of Transportation
Implementation of Automated Traffic Signal Performance Measures

SPM Source Code –> Open Source

Mid Nov. 2016
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.


Attendance is free.
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
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>
<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>

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:
  - 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.

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<td>Rumble Strips</td>
<td>Curb &amp; Gutter</td>
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<td>Rest Areas</td>
</tr>
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</table>

Source:  https://www.udot.utah.gov/main/uconowner.gf?n=15663419239657232
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

A Central Signal System is NOT used or Needed!
Why Model what you can Measure?
1710 (85%) Utah’s traffic signals
SILOS of Traffic Data
Full Transparency & Data for Everyone
http://challenger.nvfast.org/spm

Signal Performance Metrics

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

Signal Performance Metrics

316 traffic signals
http://signalmetrics.ua.edu

Signal Performance Metrics

45 traffic signals
Agencies using ATSPMs – Separate systems deployed
(16 and growing)
Old Website

Signal Performance Metrics

Selected Signal: No Signal Selected

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

Signal List

Map

Metric Settings
- Metric Type:
  - Purdue Phase Termination
  - Approach Volume
  - Approach Delay
  - Arrivals On Red
  - Approach Speed
  - Yellow and Red Actuations
  - Purdue Coordination Diagram
  - Purdue Split Failure

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

Report Data
- Show Plan Statistics
- Show Volumes

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

Create Metrics

Version 3.1.5. Release Date: May 2016
New Website – November 15th
http://udottraffic.utah.gov/SPM
How to use ATSPM Website

1. Pick a signal from the map OR enter 4 digit signal number (if known).
How to use ATSPM Website

2 Select an available Metric from the list.

Note: Not all signals have all metrics.
How to use ATSPM Website

3. Select a date and time range

4. Click “Create Metric”, wait a few seconds and scroll down to see data.
How to use ATSPM Website
(Filter Map by Metric Type)

A. Select a Metric from the dropdown list.

The map will filter all available signals with that metric.

B. Zoom in on map and select your desired signal.

C. Follow steps 3&4 shown previously (e.g. select date & click “create metrics”)
METRICS & DETECTION REQUIREMENTS
<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 Presence</td>
<td>Purdue Split Failure</td>
</tr>
<tr>
<td>Lane Group Presence</td>
<td></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>Approach Volume</td>
</tr>
<tr>
<td></td>
<td>Approach Speed (requires detection</td>
</tr>
<tr>
<td></td>
<td>with speed service)</td>
</tr>
</tbody>
</table>
Detection

None

Available Metrics

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

Free
Coordination
Free

Coordinated phases

Gap out
Max out
Force off
Skip
Pedestrian activation (shown above phase line)
Complaint: Long red at 2 a.m., no other traffic

Before

Video detection not working at night

Minor street through & left turn max out at night only

Metric: Purdue Phase Termination Detection Requirements: None
Complaint: Long red at 2 a.m., no other traffic

After

New detection technology installed

Phases are rarely used at night

Metric: Purdue Phase Termination
Detection Requirements: None

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>Phase 6</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>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% ForceOns</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

Time of Day
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
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

Detour

Cedar City
Split Monitor for Northbound (Phase 4) at I-15 and 200 N, Cedar City

- Gap out
- Max out
- Force off

Implemented timing plans

Full freeway closure
System Health Alerts

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

SPM Alerts for 5/22/2016

---The following signals had too few records in the database:
4671 - 13400 South & 4500 West - Phase: 0 (Missing Records)
5701 - 500 South & 400 East (Bffl) - Phase: 0 (Missing Records)

---The following signals had too many force off occurrences:
1224 - North Temple & Main Street - Phase: 3 (Force Offs 97.6%)
7252 - 500 South & Main Street - Phase: 2 (Force Offs 100%)
7252 - 500 South & Main Street - Phase: 6 (Force Offs 100%)

---The following signals had too many max out occurrences:
1123 - Wolcott St & 100 South - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Gardsman Way - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Gardsman Way - Phase: 6 (Max Outs 100%)
4024 - 7000 South (Fort Union) & 1300 East - Phase: 7 (Max Outs 92.6%)
4029 - 7200 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 - 4835 South & 2700 West - Phase: 2 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 4 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 8 (Max Outs 100%)
5080 - Washington & Adams - Phase: 5 (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%)
5900 - 900 W. (Kays Dr.) & 200 North, (Kaysville) - Phase: 4 (Max Outs 90.4%)
6035 - Pioneer Crossing & Millpond Drive - Phase: 8 (Max Outs 91.5%)
6608 - 100 West & 100 North - Phase: 8 (Max Outs 98.5%)
7107 - Redwood Road & 4700 South - Phase: 5 (Max Outs 93.2%)

---The following signals had unusually low detector hits:
5134 - SR-193 (700 S) & I-15 NB (Clearfield) - Phase: 2 (Has Unusually Low Counts.)
7051 - Bangerter Hwy (SR-154) & 4100 South - Phase: 1 (Has Unusually Low Counts.)
7051 - Bangerter Hwy (SR-154) & 4100 South - Phase: 7 (Has Unusually Low Counts.)
7351 - Bangerter Hwy (SR-154) & 13400 South - Phase: 1 (Has Unusually Low Counts.)

---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)
1023 - 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 - 9800 S (Little Cottonwood Rd) & Wasatch Blvd (3500 E) - Phase: 4 (Stuck Ped)
Too many max outs

Phase 4 starts constant call

SPMs evaluated for % max outs

Alert email sent

Metric: Purdue Phase Termination Detection Requirements: None
4 Too many ped calls

Ph6 Ped Constant Call

SPMs evaluated for Ped Activations

Alert email sent

5/21/2016

5/22/2016
Work Orders for UDOT ATMS

# Work Orders for ATMS Equipment
July 2015 to July 2016

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Traffic Signals</th>
<th>CCTV</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></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td>400</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damaged/Broken Equipment</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No power or comm</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bad Image</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No control</td>
<td>100</td>
<td></td>
<td></td>
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<tr>
<td>Damaged/Broken Equipment</td>
<td>50</td>
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<tr>
<td>Detection Problem</td>
<td>40</td>
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<tr>
<td>Sensor Problem</td>
<td>20</td>
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<td></td>
<td></td>
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<tr>
<td>No power or comm</td>
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<tr>
<td>Damaged/Broken Equipment</td>
<td>5</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection Problem</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No power or comm</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damaged/Broken Equipment</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection Problem</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No power or comm</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Metric: Pedestrian Delay

Event Codes
45 – Ped Call on
21 – Ped Walk on

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

700 East 900 South Signal 7184 Phase: 6 Southbound
Wednesday, April 27, 2016 12:00 AM - Wednesday, April 27, 2016 11:59 PM
Total split fails for the selected period = 93

<table>
<thead>
<tr>
<th>Plan 1</th>
<th>Plan 10</th>
<th>Plan 13</th>
<th>Plan 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 SF</td>
<td>9 SF</td>
<td>58 SF</td>
<td>5 SF</td>
</tr>
<tr>
<td>0% SF</td>
<td>9% SF</td>
<td>64% SF</td>
<td>5% SF</td>
</tr>
</tbody>
</table>

Occupancy (%) vs. Time of Day
### Detection

Lane-by-lane Count

### Available Metrics

- Turning Movement Counts
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

Detection Requirements: Stop Bar Counters
Turning Movement Counts Detection

Wavetronix SmartSensor Matrix

Wavetronix Cabinet Interface Device Click 650
Turning Movement Counts Detection
Lane Counts Availability

380 signals statewide
UDOT signals 32%
CALIBRATION OF AUTOMATIC PERFORMANCE MEASURES – SPEED AND VOLUME DATA: VOLUME 1, EVALUATION OF THE ACCURACY OF TRAFFIC VOLUME COUNTS COLLECTED BY MICROWAVE SENSORS

Prepared For:
Utah Department of Transportation
Research Division

Submitted By:
Brigham Young University
Department of Civil and Environmental Engineering

Authored By:
Mitsuru Saito, Ph.D., P.E.
David Keali'i Chang, EIT
Grant G. Schultz, Ph.D., P.E., PTOE

Final Report
September 2015

TMC Volume Accuracy

2-lane Approach

3-lane Approach

4-lane Approach

5-lane Approach

6-lane Approach

<table>
<thead>
<tr>
<th></th>
<th>≤100 v/h/ln</th>
<th>101-250 v/h/ln</th>
<th>&gt;250 v/h/ln</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Lanes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

95% Confidence Interval Percentages
**TMC Volume Accuracy - Example**

*9000 S & Monroe WB Thru Lanes (4 lanes)*

Correction Range: 25 to 180 vehicles (1.4% to 10.1%)
TMC Data Smell Test

Incorrect detectors configured

State St & 3300 S SB Thru Lanes
TMC Uses

- Traffic Studies
  - Counts
  - Signal Warrants
  - Growth
- Performance evaluation
  - Capacity analysis
  - Lane utilization
- Planning models
- Traffic patterns and impacts
  - Weather
  - Events, School, Holiday
  - Construction, Maintenance

- Construction & Maintenance
  - Lane closures
  - Performance targets
- Signal Timing Optimization
  - Split allocation
  - TOD schedule
Determine Approach Capacity

Northbound Thru

TV: 16693 PH: 4:45 PM - 5:45 PM PHV: 2505 VPH
PHF: 0.97    fLU: 0.95

Time (Hour of Day)

| 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 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Free | Plan 1 | Plan 7 | Plan 13 | Plan 7 | Free |

Volume (VPH)

- Total Volume
- Lane 1
- Lane 2
Quantify Lane Utilization

9000 South Monroe SIG#7621
Wednesday, October 26, 2016 12:00 AM - Wednesday, October 26, 2016 11:59 PM

Westbound Thru

TV: 19850 PH: 7:30 AM - 8:30 AM PHV: 1575 VPH
PHF: 0.88  fLU: 0.86

Volume [VPH]

Time (Hour of Day)

Lane 1  Lane 2  Thru Right

TR1
T2
T1
L1
Detection

Setback Count Zones

Available Metrics

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

- Vehicles arriving on green
- Vehicles arriving on red

Time of Day

Time in Cycle (s)
Metric: Approach Volume

![Graph showing daily volume of northbound and southbound traffic. The graph plots volume (vph) against time of day.]
### Metric: Approach Volume

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume</td>
<td>26,065</td>
</tr>
<tr>
<td>Peak Hour</td>
<td>5:00 PM - 6:00 PM</td>
</tr>
<tr>
<td>Peak Hour Volume</td>
<td>2,097</td>
</tr>
<tr>
<td>PHF</td>
<td>0.96</td>
</tr>
<tr>
<td>Peak-Hour K-factor</td>
<td>0.0805</td>
</tr>
<tr>
<td>Northbound Total Volume</td>
<td>12,330</td>
</tr>
<tr>
<td>Northbound Peak Hour</td>
<td>7:45 AM - 8:45 AM</td>
</tr>
<tr>
<td>Northbound Peak Hour Volume</td>
<td>1,044</td>
</tr>
<tr>
<td>Northbound PHF</td>
<td>0.906</td>
</tr>
<tr>
<td>Northbound Peak-Hour K-factor</td>
<td>0.0847</td>
</tr>
<tr>
<td>Northbound Peak-Hour D-factor</td>
<td>0.586</td>
</tr>
<tr>
<td>Southbound Total Volume</td>
<td>13,735</td>
</tr>
<tr>
<td>Southbound Peak Hour</td>
<td>5:00 PM - 6:00 PM</td>
</tr>
<tr>
<td>Southbound Peak Hour Volume</td>
<td>1,248</td>
</tr>
<tr>
<td>Southbound PHF</td>
<td>1</td>
</tr>
<tr>
<td>Southbound Peak-Hour K-factor</td>
<td>0.0909</td>
</tr>
<tr>
<td>Southbound Peak-Hour D-factor</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Approach Volume Detection

Wavetronix SmartSensor Advance
**Approach Volume Detection**

### Setup Channels-Alerts-Zones

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>EB Count</td>
</tr>
<tr>
<td>Type</td>
<td>Pulse</td>
</tr>
<tr>
<td>Enabled</td>
<td>Yes</td>
</tr>
<tr>
<td>Range (feet):</td>
<td>390 to 400</td>
</tr>
<tr>
<td>Speed (mph):</td>
<td>035 - 100</td>
</tr>
</tbody>
</table>

![Image of an aerial view of a road intersection with vehicles and a device indicating traffic volume and speed.]
Approach Volume Availability

679 signals statewide

UDOT signals 57%
Approach Volume Accuracy

CALIBRATION OF AUTOMATIC PERFORMANCE MEASURES – SPEED AND VOLUME DATA: VOLUME 2, EVALUATION OF THE ACCURACY OF APPROACH VOLUME COUNTS AND SPEEDS COLLECTED BY MICROWAVE SENSORS

Prepared For:
Utah Department of Transportation
Research Division

Submitted By:
Brigham Young University
Department of Civil and Environmental Engineering

Authored By:
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Gregory H. Sanchez, EIT
Grant G. Schultz, Ph.D., P.E., PTOE

Final Report
May 2016

Approach Volume Accuracy

<table>
<thead>
<tr>
<th>1-lane Approach</th>
<th>2-lane Approach</th>
<th>3-lane Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤100 v/h/ln</td>
<td>≤100 v/h/ln</td>
<td>≤100 v/h/ln</td>
</tr>
<tr>
<td>101-250 v/h/ln</td>
<td>101-250 v/h/ln</td>
<td>101-250 v/h/ln</td>
</tr>
<tr>
<td>&gt;250 v/h/ln</td>
<td>&gt;250 v/h/ln</td>
<td>&gt;250 v/h/ln</td>
</tr>
<tr>
<td>1 Lane</td>
<td>2 Lanes</td>
<td>3 Lanes</td>
</tr>
</tbody>
</table>

95% Confidence Interval Percentages
Approach Volume Accuracy - Example

University Avenue & 3300 N NB Lanes (2 lanes)

Correction Range: 129 to 301 vehicles (8.5% to 20%)
Approach Volume Smell Test - Undercounting

PCD is very sparse. Low volume without peaks.
Approach Volume Smell Test - Overcounting

Volume report for Washington 12th on the Northbound and Southbound approaches.
8/4/2016 12:00:00 AM - 8/4/2016 11:59:00 PM - Using Advanced Detection

Too high

Normal
Approach Volume Smell Test - Overcounting

Volume report for Washington 12th on the Northbound and Southbound approaches.
8/4/2016 12:00:00 AM - 8/4/2016 11:59:00 PM - Using Advanced Detection

Time of Day
Time in Cycle (s)
Volume (VPH)

PCD is uniformly dense – Sensor needs calibration

Normal
Approach Volume Uses

- **Traffic Studies**
  - TOD distribution
  - AADT
  - Growth
- **Performance evaluation**
  - Overcapacity periods
- **Planning models**
- **Traffic Impacts**
  - Weather
  - Events, School, Holiday
  - Construction, Maintenance

- **Construction & Maintenance**
  - Lane closures
  - Performance targets
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

Volume (Vehicles Per Hour) vs Time (Hour of Day)
Detection

Setback Count Zones with speed

Available Metrics

Approach Speed

~400ft
Metric: Approach Speed

SR-126 (1900 W) 5700 South (Roy) Signal 5088 Phase 6 Southbound
Wednesday, September 30, 2015 12:00 AM - Wednesday, September 30, 2015 11:59 PM
Detector Distance from Stop Bar: 350 feet; Min Speed Filter: 5 MPH;
Time Filter: 15s after start of green to start of yellow
Speed Accuracy: + - 5 MPH

Free
85% Sp 38
Ave Sp 32
Std Dev 8

Plan 1
85% Sp 39
Ave Sp 31
Std Dev 10

Plan 7
85% Sp 40
Ave Sp 32
Std Dev 8

Plan 13
85% Sp 38
Ave Sp 31
Std Dev 9

Plan 7
85% Sp 40
Ave Sp 33
Std Dev 8

Free
85% Sp 38
Ave Sp 33
Std Dev 7

Speed (MPH)

0 5 10 15 20 25 30 35 40 45 50 55 60
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

Time of Day

Posted Speed
85th Percentile Speed
Average MPH
Approach Speed Detection

Setup Channels-Alerts-Zones

1 2-EB Count

Name: EB Count
Type: Pulse

Enabled

Zone Settings

Range (feet):
390 to 400

Speed (mph):
035 - 100

OK  Undo  Cancel
Approach Speed Data Accuracy

LiDAR

Advance sensor

“Good enough for practical engineering applications”

+/- 2 mph
Approach Speed Uses

- Traffic studies
  - Speed Limits
- Performance evaluation
  - Overcapacity periods
  - Corridor evaluation and comparison
  - Purdue Traffic Ticker
- Planning models
- Traffic Impacts
  - Weather
  - Events, School, Holiday
  - Construction, Maintenance

- Signal Timing Optimization
  - Yellow/Red calculations
  - Link travel times
Metric: Approach Speed

Riverdale Rd Shopko Signal 5008 Phase 2 Northbound
Thursday, January 10, 2013 6:00 AM - Thursday, January 10, 2013 11:00 PM
Detector Distance from Stop Bar: 350 feet; Min Speed Filter: 5 MPH;
Time Filter: 15s after start of green to start of yellow
Speed Accuracy: + - 5 MPH

Snow storm starts
Optimization with ATSPMs

**Traditional Process**
- Collect Data
- Model
- Optimize
- Implement & Fine-tune
- Time-of-day
- Cycle Length Splits Offsets
- Review SPMs & Field Observation
- Model
- Optimize
- Implement & Fine-tune
- Time-of-day Cycle Length Splits
- Offsets

**Modified Process with SPMs**
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
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