AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

TEXITE SPRING MEETING – MAY 30, 2014

Jamie Mackey, Utah DOT
ITE 3-part Webinar
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Automated Traffic Signal Performance Measures

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Improved signal operations with smooth and equitable traffic flow are goals for most
traffic engineers; however the limited snapshot-view retiming methods that involve
manual data collection, traffic signal modeling, and field fine-tuning are resource
intensive and unresponsive to changes in traffic patterns. The National Transportation
Operations Coalition’s 2012 National Traffic Signal Report Card has led agencies to focus
resources on these activities and develop methodologies to examine all the components of traffic
signal operations. These data-driven program management plans provide objective methods
for identifying shortcomings and encourages coordination with neighboring jurisdictions. In
addition, agencies need tools to prioritize activities when resources are constrained.
PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach

SPM Basic Concept

Automated Data Collection
- Signal controller
- Probe source

Useful Information about Performance
- Signal
- Corridor
- System
Agencies using UDOT software for SPMs

http://udottraffic.utah.gov/signalperformancemetrics
Salt Lake Valley
System Requirements

Can be done independent of a Central System!

- High-resolution Controller
- Communications
- Website
- Detection (optional)

3) Store in Database

Server

Photo courtesy of the Indiana Department of Transportation
# 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/)
### High-resolution Data

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Performance Metrics Uses

- **Daily Operations**
  - Basic parameters
  - Detection problems
  - Complaint response/troubleshooting
  - Coordination
  - Events, Incidents, Weather, & Construction
  - Alerts

- **Reporting**
  - Prioritize signal needs
  - Communicate system status to region/senior leaders and public

- **Modeling/planning**
  - Approach Volumes
  - Turning Movement Counts
  - Speed
Optimization with SPMs

**Traditional Process**

- Collect Data
  - Model: Cycle length, splits, offsets
  - Optimize
  - Implement & Fine-tune

**Modified Process with SPMs**

- Review SPMs & Field Observation
  - Model: Offsets
  - Optimize
  - Review SPMs
  - Implement & Fine-tune
Normal Intersection Example: Phase Termination Chart

- 8-phase signal with working detection

Free | Coordination | Free

Metric: Phase Termination Chart
Detection Requirements: None
Maintenance Example: Nighttime detection problem

BEFORE: Video detection not working at night

- Minor street through & left turn max out at night only

Detection Requirements: None

**Metric:** Purdue Phase Termination

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

**Detection Requirements:** None
Maintenance Example: Nighttime detection problem

BEFORE: Video detection not working at night

Major Street (Ø2) and Minor Street (Ø4)

Major Street sees 20s of green and 30s of red.

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

Metric: Split Monitor
Detection Requirements: None
Maintenance Example: Nighttime detection problem

AFTER: New detection technology installed

Phases are rarely used at night

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

Metric: Purdue Phase Termination Detection Requirements: None
Alert Example:
100% Max Out

- Daily email at 7 a.m.
- Uses Purdue Phase Termination chart data
- Flags phases with >90% max-outs on each phase between 1 a.m. and 5 a.m.
- Compare to previous day’s list. Only phases with new flags are sent in the email.

Example:

```
SPM Alerts for 4/9/2014

SPMWatchDog@utah.gov
5092 - SR-126 (1900 W) & Riverdale (5300 S) (Roy) - Phase: 1
5105 - Antelope (SR-108/2000 N) & I-15 NB (Layton) - Phase: 4
6022 - US-89 & Pacific Dr (American Fork) - Phase: 3
6305 - 400 East & 800 North - Phase: 4
6310 - Center Street (Orem) & I-15 SPUI - Phase: 8
7055 - Bangerter Hwy (SR-154) & SR-201 DDI - Phase: 5
7062 - Bangerter Hwy (SR-154) & 4700 South - Phase: 11
7613 - 10600 South & 700 West - Phase: 8
8114 - Bluff Street & I-15 NB Ramps - Phase: 4
```

Metric: Purdue Phase Termination
Detection Requirements: None
Alert Example: 100% Max Out

- Phase 4 at 400 E & 800 N, 4/9/2014

Phase 4 starts constant call
SPMs evaluated for % max outs
Alert email sent

4/8/2014
4/9/2014

Metric: Purdue Phase Termination Detection Requirements: None
Optimization Example: Progression Quality

- Fine-tuning new coordination plans

**Metric:** Purdue Coordination Diagram

Detection Requirements: Advance

- **Vehicle arrivals**
- **Phase Green**
- **Phase Red**

- **Bad offset**
- **Good offset**

**Cycle Time (Seconds)**

**Time (Hour of Day)**
Offset Optimization Case Study

System 1
2.4 mi (3.8 km)

System 2
2.8 mi (4.5 km)

Int. 1 (SR 32)
Int. 2 (Pleasant St.)
Int. 3 (Town and Country Blvd.)
Int. 4 (Greenfield Ave.)
Int. 5 (146th St.)
Int. 6 (141st St.)
Int. 7 (131st St.)
Int. 8 (126th St.)

BT Case A
BT Case B
BT Case C

8350 ft (2530 m)
5320 ft (1610 m)
2650 ft (800 m)
2650 ft (800 m)
Offset Optimization - BEFORE

Int. 1 (SR 32)
Int. 2 (Pleasant St.)
Int. 3 (Town and Country Blvd.)
Int. 4 (Greenfield Ave.)
Int. 5 (146th St.)
Int. 6 (141st St.)
Int. 7 (131st St.)
Int. 8 (126th St.)

SB
NB

Bad

BT Case A
BT Case B
BT Case C
System 1
2.4 mi (3.8 km)
System 2
2.8 mi (4.5 km)
Offset Optimization – AFTER

Int. 5 (146th St.)
Int. 6 (141st St.)
Int. 7 (131st St.)
Int. 8 (126th St.)

SB

NB

Better

Good

BT Case A
BT Case B
BT Case C
System 1
2.4 mi
(3.8 km)
System 2
2.8 mi
(4.5 km)

8350 ft
(2530 m)
5320 ft
(1610 m)
2650 ft
(800 m)
2500 ft
(760 m)
3660 ft
(1110 m)
2300 ft
(700 m)

Advance loop
detector locations
Bluetooth MAC sensors
I-69
SR 37
2300 ft
(700 m)
2500 ft
(760 m)
3660 ft
(1110 m)
8350 ft
(2530 m)
2650 ft
(800 m)
2650 ft
(800 m)
5320 ft
(1610 m)
Metric 1: Purdue Coordination Diagram
Detection Requirements: Advance
Metric 2: Purdue Travel Time Diagram
Requirements: Probe data set

Corridor PM Peak Arrival on Green
- 23% Green
- 19% Yellow
- 57% Red

Initial Percent Arrival on Green
Increase in Percent Arrival on Green
Decrease in Percent Arrival on Green
## Metrics & Detection Requirements

**Controller high-resolution data only**
- Purdue Phase Termination
- Split Monitor

**Advanced Count Detection (~400 ft behind stop bar)**
- Purdue Coordination Diagram
- Approach Volume
- Platoon Ratio

**Advanced Detection with Speed**
- Approach Speed

**Lane-by-lane Count Detection**
- Turning Movement Counts

**Lane-by-lane Presence Detection**
- Arrivals on Red
- Approach Delay
- Executive Summary Reports

**Probe Travel Time Data (GPS or Bluetooth)**
- Purdue Travel Time Diagram

**Split Failure (future)**
Setback Count Detectors

Wavetronix Advance

- Used to timestamp vehicle arrivals
- 10’ count zone placed ~350’ behind stop bar
- No additional expense if already in place for dilemma zones
- May undercount dense traffic
Stop Bar Count Detectors

Wavetronix Matrix

- Used for turning movement counts
- Lane-by-lane detection zones in front of stop bar
- Requires detection rack card for every two zones ($$$$$$$) or Click 650 Detector BIU
Mission: Investing time and money to accelerate technology adoption by agencies nationwide

Automated Traffic Signal Performance Measures

Technology Implementation Group: 2013 Focus Technology

http://tig.transportation.org

Mission: Investing time and money to accelerate technology adoption by agencies nationwide
Find out more: http://tig.transportation.org

AASHTO's Technology Implementation Group — or TIG — scans the horizon for outstanding advanced technology and invests time and money to accelerate their adoption by agencies nationwide.

Each year, TIG selects a highly valuable, but largely unrecognized procedure, process, software, or technology that has been adopted by at least one agency, is market ready and is available for use by other agencies.

Guided by the vision of "a culture where rapid advancement and implementation of high payoff, high expectation of the transportation community," TIG's objective is to share information with AASHTO agencies, and their industry partners to improve the Nation's transportation system.

Recently selected technologies with links to additional information are listed below. Also, you may view the Lead States Team Focus Technologies and Additionally Selected Technologies categorized by AASHTO subcommittee interest area.

### Lead States Team Focus Technologies

**2013 Focus Technologies**

- Automated Traffic Signal Performance Measures
- UPlan Phase II

**Prior Four Years Focus Technologies**

- Embedded Data Collector
- Environmental Planning GIS Tools

### Additionally Selected Technologies

**2013 ASTs**

- Double Crossover Diagram

**Prior Four Years ASTs**

- Anonymous Wireless Area Time Data Collection
- Curvature Extension for...
Additional Information

UDOT Signal Performance Metrics
http://udottraffic.utah.gov/signalperformance

Purdue/INDOT JTRP Report →
http://tinyurl.com/signalmoe

AASHTO TIG
http://tig.transportation.org