PERFORMANCE MEASURES FOR
TRAFFIC SIGNAL MAINTENANCE

Jay Grossman, Elkhart County Highway Department
Outline:

- **Background and Motivation**
- **Pedestrian Calls**
  - Operational Verification
  - Methodology
  - Call Button Error Detection
- **Vehicle Detector Analysis**
  - Methodology
  - Case Studies
  - Conclusions
Maintenance Performance Measures
Developed on two local agency systems in Indiana

Mishawaka
- 64 signals
- 37 reporting
- 22 with peds
- 1181 detection channels
- 6.6 M records per day

Elkhart County
- 29 signals
- 21 reporting
- 3 with peds
- 671 detection channels
- 2.7 M records per day
Original Performance Measure Evolution

- Time of Day
  - 0:00:00
  - 4:00:00
  - 8:00:00
  - 12:00:00
  - 16:00:00
  - 20:00:00

- Exceptional (6)
- Highly Favorable
- Favorable (4)
- Random (3)
- Unfavorable (2)
- Poor (1)

Central System

Procurement Specification

- 2003
- 2006
- 2008
- 2010
- 2011
Performance Measures Converted to Specifications
Reports generated within central system

First used within central system in 2011
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  • Conclusions
Pedestrian Calls
Operational Verification

Some phases are rarely activated. Still working?

Staff activated each call button, logs used for operational verification.
Methodology:

- Use Historic Data for a sensor channel to develop base lines of ‘normal’ behavior
- Plot current period activity
- Identify potential errors
Methodology:

- Use Historic Data for a sensor channel to develop base lines of ‘normal’ behavior
- **Plot current period activity**
- Identify potential errors
Methodology:

- Use Historic Data for a sensor channel to develop base lines of ‘normal’ behavior
- Plot current period activity
- Identify potential errors
Mishawaka: pedestrian call analysis
Mishawaka: pedestrian call analysis
Mishawaka: pedestrian call analysis

Main and Mishawaka Ped Calls, Week 3

June-14

<table>
<thead>
<tr>
<th>Date</th>
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- **Calls**: Graph showing the number of calls on different dates.
- **Average**:
- **>stDev**: Red circles indicating days with more than average calls.

Map showing pedestrian call analysis.
Mishawaka: pedestrian call analysis

Main and Mishawaka Ped Calls, Week 4
Mishawaka: pedestrian call analysis

Main and Mishawaka Ped Calls, Week 3

Calls

Date

June-14

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Calls
Average
>stDev
Mishawaka: pedestrian call analysis
Mishawaka: pedestrian call analysis

4th of July, adjacent to a park on riverfront, not an error
Outline:

• Background and Motivation

• Pedestrian Calls
  • Operational Verification
  • Methodology
  • Call Button Error Detection

• Vehicle Detector Analysis
  • Methodology
  • Case Studies
  • Conclusions
Vehicle Detector Analysis
Methodology: Base Line

1 Week of Data
Vehicle Detector Analysis
Methodology: Base Line

2 Weeks of Data
Vehicle Detector Analysis
Methodology: Base Line

3 Weeks of Data
Vehicle Detector Analysis
Methodology: Base Line

4 Weeks of Data
Vehicle Detector Analysis
Methodology: Base Line

Three weeks of data for base line creation has worked best in our analysis. Four weeks adds little extra detail for error identification.

Computationally, entire system of more than 1100 detection channels can be analyzed in less than 5 minutes.
Vehicle Detector Analysis
Methodology: Error Threshold

Minimize false error alerts

Standard Deviation $\geq 1.5$

Standard deviation threshold better as a user definable value due to range of normal calls for various detectors within system. 1.5—2.0 is generally a good range.
Case Study: CR 14 January error event
Case Study: CR 14 January error event

CR14 Detector 12

Calls vs. Date

January 2014

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<th>Date</th>
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Legend:
- Calls
- Average
Case Study: CR 14 January error event
Case Study: CR 14 January error event
Case Study: CR 14 January error event

Look at week of 1/19 with error analysis

Unusual pattern of intermittent errors, generally early morning
Case Study: CR 14 January error event

CR14 Detector 12

Found bad cable, intermittently failing—apparently temperature related. Fixed at this time

January 2014

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Date
Case Study: CR 14 January error event
Case Study: March 12, 2014 Snow Event

Heavy, wet snow blowing from the North, covering lenses and signal indications

<table>
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<tr>
<th>Time (EDT)</th>
<th>Temp.</th>
<th>Dew Point</th>
<th>Visibility</th>
<th>Wind Dir</th>
<th>Wind Speed</th>
<th>Precip</th>
<th>Events</th>
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<td>37.9°F</td>
<td>35.1°F</td>
<td>8.0 mi</td>
<td>NNE</td>
<td>10.4 mph</td>
<td>0.00 in</td>
<td>Rain</td>
<td>Light Rain</td>
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<td>1:53 AM</td>
<td>37.9°F</td>
<td>35.1°F</td>
<td>10.0 mi</td>
<td>NNE</td>
<td>10.4 mph</td>
<td>0.01 in</td>
<td>Rain</td>
<td>Light Rain</td>
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<td>2:53 AM</td>
<td>37.9°F</td>
<td>35.1°F</td>
<td>10.0 mi</td>
<td>NE</td>
<td>13.8 mph</td>
<td>0.00 in</td>
<td>Overcast</td>
<td>Snow</td>
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<tr>
<td>3:53 AM</td>
<td>36.0°F</td>
<td>33.1°F</td>
<td>10.0 mi</td>
<td>NE</td>
<td>20.7 mph</td>
<td>N/A</td>
<td>Overcast</td>
<td>Snow</td>
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<tr>
<td>4:53 AM</td>
<td>34.0°F</td>
<td>32.0°F</td>
<td>0.8 mi</td>
<td>North</td>
<td>-</td>
<td>0.06 in</td>
<td>Snow</td>
<td>Light Snow</td>
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<tr>
<td>5:53 AM</td>
<td>33.1°F</td>
<td>32.0°F</td>
<td>0.2 mi</td>
<td>North</td>
<td>-</td>
<td>0.08 in</td>
<td>Fog,</td>
<td>Snow</td>
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<td>6:53 AM</td>
<td>32.0°F</td>
<td>28.9°F</td>
<td>0.5 mi</td>
<td>North</td>
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<td>0.03 in</td>
<td>Fog</td>
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<td>7:53 AM</td>
<td>30.9°F</td>
<td>28.0°F</td>
<td>0.5 mi</td>
<td>North</td>
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<td>0.02 in</td>
<td>Fog,</td>
<td>Snow</td>
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<td>8:53 AM</td>
<td>28.9°F</td>
<td>27.0°F</td>
<td>0.5 mi</td>
<td>North</td>
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<td>0.01 in</td>
<td>Fog,</td>
<td>Snow</td>
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<td>9:53 AM</td>
<td>28.9°F</td>
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<td>0.8 mi</td>
<td>North</td>
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<td>0.00 in</td>
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<td>10:53 AM</td>
<td>28.9°F</td>
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<td>0.8 mi</td>
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<td>0.00 in</td>
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*F 1.2 mi North - N/A Overcast
*F 4.0 mi North - N/A Haze
*F 10.0 mi North - 0.00 in Snow Light Snow
*F 10.0 mi North - 0.00 in Clear
*F 10.0 mi North - N/A Mostly Cloudy
*F 9.0 mi North - N/A Overcast
*F 10.0 mi North - N/A Overcast
*F 10.0 mi North - N/A Partly Cloudy
*F 10.0 mi North - N/A Clear
*F 10.0 mi North - N/A Clear
*F 10.0 mi North - N/A Clear
*F 10.0 mi North - N/A Clear

Photo: Elkhart Truth
Case Study: March 12, 2014 Snow Event
Beck Intersection Video Detection

SB Detector 18

NB Detector 22
Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection

Beck Detector 22

Detector Calls

Facing South

NB Detector 22
Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection

Beck Detector 18

Facing North

SB Detector 18
Case Study: March 12, 2014 Snow Event

Beck Intersection Video Detection

Beck Detector 18

Detector Calls vs. Hour

Compare with historic ‘Normal’ values to trigger system alerts

Facing North

SB Detector 18
System Didn’t Report Any Detection Errors
Case Study: CR 4 Loop failure
Case Study: CR 4 Loop failure
Case Study: CR 4 Loop failure
Case Study: CR 4 Loop failure
Case Study: CR 4 Loop failure

- Pothole, lead-in exposed
- Loop removed from series
- Labelled for repair

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September-14

- Pothole, lead-in exposed
- Loop removed from series
- Labelled for repair
Case Study: CR 4 Loop failure

Post-repair counts flagged because while out of service, the average was degraded. A ‘false positive’ situation
Conclusions

Maintenance performance measures
can be used to verify operation of call buttons
can be used to identify potential call button errors
Conclusions

Maintenance performance measures can be used to identify intermittent errors that equipment failure reports may not.

can be used to identify traditional failures.

Three weeks of data for base line creation and a standard deviation of 1.5—2.0 worked well in study for error determination.
Conclusions

Performance measures allow local agencies to more effectively manage signal systems with limited staffing.

Find errors before this:
This work was sponsored by:

Indiana LTAP

and the

Joint Transportation Research Program at Purdue University