Maintenance Focused ATSPM

Case study of implementation

Charlie McKenzie, Elkhart County Highway
Jay Grossman, Valparaiso University
Maintenance Focused ATSPM

Outline:

• Background Research
• Contract Process
• Implementation
Traffic Signal Performance Measures recognized by FHWA and incorporated into Everyday Counts 4
Background
Traffic Signal Performance Measures recognized by FHWA and incorporated into Everyday Counts 4

Automated Traffic Signal Performance Measures (ATSPMs)

**Benefits**

- **Targeted Maintenance.** ATSPMs provide the actionable information needed to deliver high-quality service to customers, with significant cost savings to agencies.

- **Improved Operations.** Active monitoring of signalized intersection performance lets agencies address problems before they become complaints.

- **Increased Safety.** A shift to proactive operations and maintenance practices can improve safety by reducing the traffic congestion that results from poor and outdated signal timing.

**State of the Practice**
This technology is the outcome of a collaboration.

Source: FHWA
Relevance?

~2000 Detectors
Reductions in user daily costs if maintenance issues found quickly

*US24 at Liberty Mills Example Loop Failure (single detector failure on a single phase)*

Phase 7 faulted (Max = 30 sec)
- 12.5 veh-h of delay increase per day
- 4560 veh-h of delay increase per year
- Using a $17 per hour value of travel time, this amounts to $78,000 per year in increased user cost

Phase 8 Faulted (Max = 40 sec)
- 55 veh-h of delay increase per day
- Approx. 20000 veh-h of delay increase per year
- $340,000 per year in increased user cost
Developed and tested on local agency system

Signal System
Elkhart County, IN

- 15 miles of fiber optic along CR17
- 14 county signals on fiber network
- 4 INDOT signals on fiber network
- 1 microwave link
- 4 signals on broadband radio
- 7 signals with no data connection
- 1 Centracs system
- 10 FLIR thermal sensors
- 5 PTZ cameras
Detection Anomalies:

- Patterns of vehicle arrivals at intersections are cyclical, repetitive and statistically similar.
- High-resolution data files are easy to acquire and allow isolation of distinct detector channels.
- Historic detector patterns can be used to inform an ‘expected’ pattern for any period for that detector.
- Detector patterns can be treated similarly to communications signals, using same tools to identify statistically significant deviations.
Kolmogorov-Smirnov Test:

Comparison of analysis week to average of previous weeks data, showing similarity of detection patterns.

Comparison of the cumulative probability distributions of two sets of data using the two sample KS test.
Kolmogorov-Smirnov Test:

Detection rate of anomalies in detector data by duration and magnitude using the K-S test.
Kolmogorov-Smirnov Test:

Benefits of a statistical based detection error test:
• Works for intermittent errors
Kolmogorov-Smirnov Test:

Benefits of a statistical based detection error test:

- Works for intermittent errors
- Misalignment/obscurance errors
Split Failures: Grape/Univ

Split Failures, 12/12/2015 and 12/19/2015
University/Grape by lane, by 15 min, Saturdays

Except for EB Thru, all other Thru lanes have few split failures. Reassign time to turn lanes?
Red Light Running

Developed by Lavrenz et. al.
Published in TRR
Goal is to make this tool accessible to agencies by including in specs for performance measures.

(Side note: Elkhart County was one site used for validation)
Red Light Running

- End of Green Interval
- Yellow Interval
- Start of Red Interval

Det On

Det Off

Vehicle Arrival

Vehicle Departure

$t_{arr}$ $t_{on}$

Det On

Det Off

No
Red Light Running SR 120 at CR 17 Intersection in Elkhart County

ECH Data Center

ECH fiber connection to cabinet
NB Stop Bar Detector
NB Stop Bar Detector
NB Stop Bar Detector
NB Stop Bar Detector
NB Stop Bar Detector
For ATSPM inclusion, Create Specifications

Turn previous series into a graph showing potential RLR occurrences by phase and time of day

Intersection Red Light Running Indicator

The system shall produce a report identifying the number of potential red light running instances on each approach lane of an intersection with detection capable of such identification.

The data for analysis shall be user definable.

The intersection included in the analysis and plot shall be user selectable, chosen from all intersections on the system.

Potential Red Light Running instances shall be summed by approach phase and by one hour interval of the selected day.

A Red Light Running instance shall be defined as any stop bar detector/detector zone activation for a single lane that occurs within the first five seconds of the associated approach phase start of red, and is active for 0.2 to 2.0 seconds.

The plot shall be displayed as follows:

X axis showing the time (in hours) of the analysis day. The X axis shall be labelled "Hour."

Y axis showing the sum of indicated Red Light Running instances for each hour of the selected day. The Y axis shall be labelled "Red Light Running Instances."

Each intersection chosen for analysis will have the Red Light Running instances for each
Contract Process for Implementation

Identify Funding
Local vs Federal-Aid
Federal-Aid
• STP
• HSIP
• CMAQ
• Eligibility Review First
• Every Day Counts Initiative

Procurement vs Professional Services

Contract Specifications

<table>
<thead>
<tr>
<th>CMAQ REQUEST FORM (rev 3/2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission Date:</td>
</tr>
<tr>
<td>1. Project Title:</td>
</tr>
<tr>
<td>2. Sponsoring Agency:</td>
</tr>
<tr>
<td>3. STP, HSIP, CMAQ (Federal Aid)</td>
</tr>
<tr>
<td>4. HSIP (Eligibility Review First)</td>
</tr>
<tr>
<td>5. Every Day Counts Initiative</td>
</tr>
<tr>
<td>6. Project Category:</td>
</tr>
<tr>
<td>7. Project Description:</td>
</tr>
<tr>
<td>8. Estimated Total Funds Needed:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>CMAQ $</th>
<th>Local Match $</th>
<th>State $</th>
</tr>
</thead>
<tbody>
<tr>
<td>201</td>
<td>80,000</td>
<td>20,000</td>
<td>0</td>
</tr>
<tr>
<td>201</td>
<td>80,000</td>
<td>20,000</td>
<td>0</td>
</tr>
<tr>
<td>201</td>
<td>80,000</td>
<td>20,000</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air Quality Analysis (check appropriate box)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative: Yes</td>
</tr>
<tr>
<td>Qualitative: Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction in Ozone Precursors:</th>
<th>NOX</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Year</td>
<td>0.012</td>
<td>0.005</td>
</tr>
<tr>
<td>Change/Year</td>
<td>360</td>
<td>360</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction in PM$_2.5$ Precursors:</th>
<th>PM$_2.5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Year</td>
<td>0.012</td>
</tr>
<tr>
<td>Change/Year</td>
<td>360</td>
</tr>
</tbody>
</table>

A complete description of the involvement/participation in the development of the project must accompany the completed CMAQ Request Form.
Contract Process for Implementation

Identify Funding
Local vs Federal-Aid
Federal-Aid
• STP
• HSIP
• CMAQ
• Eligibility Review First
• Every Day Counts Initiative

Procurement vs Professional Services

Contract Specifications
Contract Process for Implementation

TRAFFIC SIGNAL MAINTENANCE PERFORMANCE MEASURES

DESCRIPTION. This work shall consist of providing software tools within the Traffic Management Center (TMC) Management System Software to analyze performance measures from data recorded by the traffic signal controllers, and provide graphical representations of these measures.

1. General
   a. The required performance measures shall be available, user selectable, for any intersection within the control system.
   b. The data of the performance measure plot shall be used selectable from all available dates in the data set.
   c. In performance measures where only one phase of an intersection is plotted, the phase plotted shall be selectable from all available.
   d. In performance measures where only one detection channel an intersection is plotted, the channel plotted shall be selectable.
Contract Process for Implementation

Procurement vs Engineering Services

Engineering Services:
• Performance Based Selection
• Management of sub-consultant writing code
• Validation and testing when complete
• Handle the DOT paperwork required

Minimize County time requirement – Staff already stretched thin...which is why this was needed.
Project Timeline

- CMAQ Funding Request
- DOT/LPA Contract
- Consultant NTP
- Functional Acceptance
- Field Verification Passed

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2018</td>
</tr>
</tbody>
</table>
Testing

Functional Acceptance

• Verify that each performance measure tool was present and met the specifications
• Requirement (per specifications), test, expected result, and pass/fail

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Test</th>
<th>Expected Result</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>The system shall produce a stacked bar chart plot by showing the total number of split failures on the system.</td>
<td>Click on &quot;Metrics&quot; and select &quot;Longitudinal Split Failure&quot; from the chart dropdown list. Select the signal and the start/end dates and click &quot;Apply&quot;</td>
<td>A graphical display will open with a stacked bar chart plot that shows the total number of Split Failure occurrences per day</td>
<td>Pass</td>
</tr>
</tbody>
</table>
Testing

Field Verification

• Verification process developed by consultant
• Required access to raw data and video archives from Elkhart County
• Chose 3 intersections with high traffic volume
<table>
<thead>
<tr>
<th>Date</th>
<th>Detector</th>
<th>Name</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/10/2018 10:00:00 AM</td>
<td>4</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>7/10/2018 2:00:00 PM</td>
<td>4</td>
<td></td>
<td>0.01</td>
</tr>
</tbody>
</table>

Signal: CR14 @ CR17 Detector: 4
Tuesday, July 10, 2018
Kolmogorov Smirnov

Chart showing detector volume over time with annotations for concerns and historical volume.
CR 17 and SR 120
Lane restriction due to construction
Mowing crew hit service
Implemented new timing plans during Holiday period
Maintenance Focused ATSPM
Case study of implementation

Charlie McKenzie, Elkhart County Highway
Jay Grossman, Valparaiso University