• Overview of Data Source
• Signal Performance Measures
• Infrastructure Requirements
• Lessons Learned
Traffic Signal Performance Measures: a new tool for traffic signal operations
Performance Metrics:
Delay, stops, fuel

Floating Car Runs

Modeling Software

Measure?
SPMs:
- Arrivals on Green
- V/C
- Phase Utilization
- Estimated Delay

Preliminary Splits, Offsets, V/C

Field Implementation

Fine-Tuning

As-built
High-Resolution Data

Traffic Signals → Log Files → Database → Performance Measure Graphs

Performance Measures

- 18,468 steps
- 8.3 miles
- 2,889 cals
- 126 minutes

Field

Traffic Management Center
National Practice

- Purdue, INDOT, controller vendors
- UDOT, vendor implementation
- FHWA Every Day Counts
  - Performance-based management
- ATSPM – Automated Traffic Signal Performance Measures
High-Resolution Data

• Native logging capability in compatible controllers

• For each data point:
  • Event Timestamp
  • Event Code
  • Event Parameter
Controller Events Logged

- Phase (Vehicular, Pedestrian)
- Overlap
- Phase Control
- Detector
- Preemption
- Coordination
- Cabinet/System
# Sample Hi-Res Data

<table>
<thead>
<tr>
<th>Event Timestamp</th>
<th>Event Code</th>
<th>Event Parameter</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:57:27.5</td>
<td>1</td>
<td>6</td>
<td>Begin Green – Phase 6</td>
</tr>
<tr>
<td>09:57:36.0</td>
<td>82</td>
<td>9</td>
<td>Detector On – Channel 9</td>
</tr>
<tr>
<td>09:57:50.1</td>
<td>82</td>
<td>10</td>
<td>Detector On – Channel 10</td>
</tr>
<tr>
<td>09:57:56.3</td>
<td>81</td>
<td>10</td>
<td>Detector Off – Channel 10</td>
</tr>
<tr>
<td>09:58:19.8</td>
<td>7</td>
<td>6</td>
<td>Green Termination – Phase 6</td>
</tr>
<tr>
<td>09:58:19.8</td>
<td>8</td>
<td>6</td>
<td>Begin Yellow Clearance – Phase 6</td>
</tr>
<tr>
<td>09:58:22.8</td>
<td>10</td>
<td>6</td>
<td>Begin Red Clearance – Phase 6</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>
Benefits of Hi-Res Data

• 24/7 data collection not limited by business hours
• Detailed analysis, or aggregated trends
• Larger sample size
Signal Performance Measures
Example Uses

• Flagging detector maintenance needs
• Investigating citizen service requests
• Fine-tuning splits & offsets
• Timing plan maintenance
• Measuring performance before and after retiming
# Sample Performance Measures

<table>
<thead>
<tr>
<th>Objective</th>
<th>Signal System Components</th>
<th>Example Performance Measures &amp; Visualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Infrastructure</td>
<td>Comm, Detection</td>
<td>Intersections Online</td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td>Detector Health</td>
</tr>
</tbody>
</table>

Source: Purdue
Sample Performance Measures

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<thead>
<tr>
<th>Objective</th>
<th>Signal System Components</th>
<th>Example Performance Measures &amp; Visualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimizing &amp; Balancing Congestion</td>
<td>Local Control</td>
<td>Pedestrian Utilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vehicle Flow Rates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume-to-Capacity Ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phase Termination Type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red/Green Occupancy Ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Split Failures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Estimated Delay</td>
</tr>
</tbody>
</table>

Source: Purdue
Sample Performance Measures

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Intersection Safety</td>
<td>Local Control</td>
<td>Red Light Running</td>
</tr>
</tbody>
</table>

Source: Purdue
## Sample Performance Measures

<table>
<thead>
<tr>
<th>Objective</th>
<th>Signal System Components</th>
<th>Example Performance Measures &amp; Visualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth Traffic Flow</td>
<td>System Control</td>
<td>Arrivals on Green Platoon Ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Purdue Coordination Diagram</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclic Flow Profile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measured Travel Time</td>
</tr>
</tbody>
</table>

Source: Purdue
Purdue Coordination Diagram

Sample Intersection
Westbound Approach

Time in Cycle (s)

Start of Green
End of Green
Green Window
Vehicle Arrival
Purdue Coordination Diagram

- Overnight Period (Free Operation)
- Coordinated Platoon
- Varying Cycle Lengths
- Phase Actuation
- 24 Hours

- Time in Cycle (s)
- Start of Green
- End of Green
- Green Window
- Vehicle Arrival

- Time
Sample PCD

Preston & Main (Northbound Approach)
Frisco, TX

- Cycle Time (Seconds)
- Volume per Hour
- Detectors Activated
- Volume per Hour
Corridor Visualization

Source: INDOT
Split Failures

Beginning of green
Split Failures

Beginning of yellow
Split Failures

GOR $\geq 80\%$ & $ROR_5 \geq 80\% \rightarrow$ split failure
Split Failures

Preston & Main (Westbound Approach)
Frisco, TX

Time (Hour of Day)

Occupancy Ratio

80% threshold

Residual queue
Red Light Running

False calls from cross-traffic
Infrastructure Requirements
Overview

• Compatible controllers
• Detection for the desired performance measures
• Reliable communication
• Data processing & storage
## Controllers

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Model</th>
<th>Firmware Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Econolite</td>
<td>ASC/3</td>
<td>OS version 01.14.03 or higher Application version 12.50 or higher</td>
</tr>
<tr>
<td></td>
<td>Cobalt</td>
<td>Any version</td>
</tr>
<tr>
<td>Intelight</td>
<td>All</td>
<td>1.7.0 or higher</td>
</tr>
<tr>
<td>Peek</td>
<td>ATC-1000</td>
<td>03.05.0528 or higher</td>
</tr>
<tr>
<td>Siemens</td>
<td>M52</td>
<td>3.52 or higher</td>
</tr>
<tr>
<td></td>
<td>M60 ATC</td>
<td>4.52 or higher</td>
</tr>
<tr>
<td>Trafficware</td>
<td>970 ATC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>980 ATC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATC</td>
<td>76.10 or higher</td>
</tr>
<tr>
<td></td>
<td>2070 L, LN, E, EN, ATC</td>
<td></td>
</tr>
<tr>
<td>McCain</td>
<td>ATC eX</td>
<td>1.7.0.5484 or higher</td>
</tr>
<tr>
<td>D4</td>
<td>n/a</td>
<td>1.5L-20 or higher</td>
</tr>
</tbody>
</table>

Source: Purdue
## Detection

<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>
</tbody>
</table>
# Detection

<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane-by-lane or Lane Group Presence</td>
<td>Purdue Split Failure</td>
</tr>
</tbody>
</table>

- Lane-by-lane is ideal
Detection

<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane-by-lane Stop Bar Count</td>
<td>Turning Movement Counts</td>
</tr>
<tr>
<td></td>
<td>Red Light Running</td>
</tr>
</tbody>
</table>
Detection

<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Count</td>
<td>Purdue Coordination Diagram</td>
</tr>
<tr>
<td></td>
<td>Purdue Link Pivot Offset Optimization</td>
</tr>
<tr>
<td></td>
<td>Approach Volume</td>
</tr>
<tr>
<td></td>
<td>Approach Speed (requires detection with speed service)</td>
</tr>
</tbody>
</table>
Communication

- Remote retrieval of data and performance measures
- Options for local storage of data
Software

• UDOT software
  • Free download of software
  • Agency must install software
  • Agency must store data on-site
UDOT Software
Software

• Vendor solution
  • Cost for software
  • Limited technical configuration needed
  • Cloud storage of data
Vendor Solution
GDOT Interface

- Arterial performance measures:
  - Throughput (vph): 2,468 (-1.3%)
  - Arrivals on Green: 73.8% (+0.7%)
  - Split Back Rate: 11.1% (-4.5%)
  - Split Failures: 2.9% (+5.4%)
  - Travel Time Index: 1.33 (+0.7%)
  - Planning Time Index: 1.44 (+3.1%)

- Volume-Based Measures:
  - Corridor volumes:
    - Traffic Volume (veh/day): 35,364 (+22.7%)
    - AM Peak Volume (veh/hr): 1,730 (+28.3%)
    - PM Peak Volume (veh/hr): 2,090 (+28.7%)

- Equipment Measures:
  - Vehicle Detector Availability (manually collected): 95.3% (+1.5%)
  - Pedestrian Detector Availability (manually collected): 98.8% (-0.9%)
  - CCTV Availability: 62.0% (-8.6%)
  - Communications Uptime: 97.0% (+6.2%)

- Activity Measures:
  - TEAMS Tasks Reported This Month: 465 (+24.3%)
  - TEAMS Tasks Resolved This Month: 363 (+0.6%)
  - TEAMS Tasks Outstanding (Unresolved): 317 (+47.4%)
Software Configuration

• Mapping each detector & phase for translation of raw data

<table>
<thead>
<tr>
<th>Channel 1</th>
<th>prot 1, perm 2, OL 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northbound Left Lane 1</td>
<td>Split Fail</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel 2</th>
<th>prot 2, perm 0, OL 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbound Thru Lane 1</td>
<td>Split Fail</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel 3</th>
<th>prot 3, perm 4, OL 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastbound Left Lane 1</td>
<td>Split Fail</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel 4</th>
<th>prot 4, perm 0, OL 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westbound Thru Lane 1</td>
<td>Split Fail</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel 5</th>
<th>prot 5, perm 6, OL 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbound Left Lane 1</td>
<td>Split Fail</td>
</tr>
</tbody>
</table>
Data Storage

• Raw data & aggregated metrics
• Up to 20 MB/intersection/day
  • Depending on number of detectors & actuations
• Agency policy for data archival
Lessons Learned
Relationship with IT Department

• Important to work together
• Firewalls
• Servers for data processing and storage
Detection Upgrades

• Prioritize detection upgrades based on desired SPMs & critical intersections
  • Piecemeal upgrades can work

• Consider different types of non-intrusive detection
  • Understand limitations of each
Detection Numbering

• Standardization will make software configuration much easier
• Use available inputs wisely
Leverage Funding Sources

• For controller, communication, detection upgrades
Get Creative

• New metrics and ways to analyze data
• Excel can be used for small analyses of raw data
Austin Example
PLAN your objectives and target performance measures

PROCURE necessary hardware (servers, detection devices, etc.)

INSTALL the UDOT software

CONFIGURE your signals and detection devices in the system

INTEGRATE the data into daily operations

ANALYZE the data to drive decisions and future initiatives
Questions?

Lucy Richardson

Lucy.Richardson@kimley-horn.com