Automated Traffic Signal Performance Measures

NJ State Transportation Innovation Council
May 7th, 2019

Kelly McVeigh, Principal Traffic Engineer
NJDOT – Transportation Mobility
• Introduction to Automated Traffic Signal Performance Measures (ATSPMs)
• NJDOT Research Project
• Future work involving ATSPMs
• Questions
Introduction to ATSPMs

- What is the NEED?
Introduction to ATSPMs

- Traffic Engineers **NEED** to know how signal timings perform.
- Traditional process of knowing is a lengthy one.

Choose corridor based on congestion, complaints, crashes, etc. → Data Collection (turning movement counts, queue estimates, etc.) → Develop Synchro or HCM models → Transcribe model timings to Timing Directive → Program traffic signal controller timing parameters → Compare before and after performance (travel times, number of stops, queues, etc.)

ATSPMs

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Introduction to ATSPMs

• Most practitioners would agree.
Introduction to ATSPMs

• HOW do you generate ATSPMs?

Indiana Traffic Signal Hi Resolution Data Logger Enumerations

6 Events occur at the signal head:
1. Begin of Green
2. End of Green
3. Begin of Yellow
4. End of Yellow
5. Begin of Red
6. End of Red

When a controller timestamps those events, they become Hi-resolution Data

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Introduction to ATSPMs

• **WHY** would you generate ATSPMs?

• **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operations and maintenance practices can improve safety by reducing the traffic congestion that results from poor and outdated signal timing.

• **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.

• **Improved Traffic Signal Timing and Optimization Policies.** Agencies are able to adjust traffic signal timing parameters based on quantitative data without requiring a robust data collection and modeling process.
NJDOT Research Project

NJDOT Project 2016-14
Real-Time Traffic Signal Performance Measurement

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Project Team

NJDOT Research
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NJDOT Transportation Mobility
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Rowan University
   Mohammad Jalayer, Ph.D., Assistant Professor

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Objectives:
- Based on the existing infrastructure operated and maintained by NJDOT.
- Develop a prototype ATSPM system.

NJDOT Infrastructure:
- Centralized control (servers)
- Fiber-optic communication
- Adaptive Signal Control Technology (ASCT)
NJ DOT Research Project

• NJDOT is actively deploying ASCT.

Full Operation:
NJ-18 (SCATS) = 13 Signals
US-1 (InSync) = 22 Signals
US-130 (SCATS) = 18 Signals
US-130 (InSync) = 12 Signals
NJ-168 (InSync) = 11 Signals
MASSTR (SCATS) = 123 Signals

Under Construction/Final Design:
US-1 = 12 Signals
NJ-73 = 29 Signals

Concept Development:
11 Corridors = 122 Signals

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### NJ DOT Research Project

- What do Adaptive Systems have to offer?

<table>
<thead>
<tr>
<th>Time</th>
<th>Duration</th>
<th>Movement</th>
<th>Phase 2 (NT)</th>
<th>Phase 3 (WL)</th>
<th>Phase 4 (ET)</th>
<th>Phase 6 (ST)</th>
<th>Period</th>
</tr>
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<tbody>
<tr>
<td>06:03:32 AM</td>
<td>148</td>
<td></td>
<td>13</td>
<td>47</td>
<td>0</td>
<td>6</td>
<td>31</td>
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<tr>
<td>06:05:09 AM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06:06:09 AM</td>
<td></td>
<td>Ped Called</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06:06:24 AM</td>
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<td></td>
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<td>06:06:33 AM</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>06:09:04 AM</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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What do Adaptive Systems have to offer?
NJ DOT Research Project

- Project Team Challenge:
- Translate Adaptive Signal Data to ATSPM Source Code Data

Indiana Traffic Signal Hi Resolution Data Logger Enumerations

<table>
<thead>
<tr>
<th>Event Code</th>
<th>Event Descriptor</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Phase On</td>
<td>Phase # (1-16)</td>
<td>Set when NEMA Phase On becomes active, either upon start of green or walk interval, whichever occurs first.</td>
</tr>
<tr>
<td>1</td>
<td>Phase Begin Green</td>
<td>Phase # (1-16)</td>
<td>Set when either solid or flashing green indication has begun. Do not set repeatedly during flashing operation.</td>
</tr>
<tr>
<td>2</td>
<td>Phase Check</td>
<td>Phase # (1-16)</td>
<td>Set when a conflicting call is registered against the active phase. (Marks beginning of MAX timing)</td>
</tr>
<tr>
<td>3</td>
<td>Phase Min Complete</td>
<td>Phase # (1-16)</td>
<td>Set when phase min timer expires.</td>
</tr>
<tr>
<td>4</td>
<td>Phase Gap Out</td>
<td>Phase # (1-16)</td>
<td>Set when phase gaps out, but may not necessarily occur upon phase termination. Event may be set multiple times within a single green under simultaneous gap out.</td>
</tr>
<tr>
<td>5</td>
<td>Phase Max Out</td>
<td>Phase # (1-16)</td>
<td>Set when phase MAX timer expires, but may not necessarily occur upon phase termination due to last car passage or other features.</td>
</tr>
<tr>
<td>6</td>
<td>Phase Force Off</td>
<td>Phase # (1-16)</td>
<td>Set when phase force off is applied to the active green phase.</td>
</tr>
</tbody>
</table>

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NJ DOT Research Project

- Project Test Intersections
- US-1 at Harrison (InSync)
- US-1 at Henderson (InSync)
- NJ-18 at Hillsdale (SCATS)
### Insync Signal Event Conversion

**Convertible Signal Event**

<table>
<thead>
<tr>
<th>Code</th>
<th>Event</th>
<th>Insync Translator Logic</th>
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<tbody>
<tr>
<td>0</td>
<td>PhaseOn</td>
<td>Get from movement start time</td>
</tr>
<tr>
<td>1</td>
<td>PhaseBeginGreen</td>
<td>&quot;Current Running&quot; in SCATS message</td>
</tr>
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<td>&quot;Phase demand&quot; in SCATS message</td>
</tr>
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<td>PhaseMinComplete</td>
<td>&quot;signal Group: SG6-off&quot; in SCATS message</td>
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<td>4</td>
<td>PhaseGapOut</td>
<td>Green Duration &lt; Maximum Green</td>
</tr>
<tr>
<td>5</td>
<td>PhaseMaxOut</td>
<td>Green Duration &gt; Maximum Green</td>
</tr>
<tr>
<td>6</td>
<td>PhaseGreenTermination</td>
<td>Movement End Time</td>
</tr>
<tr>
<td>7</td>
<td>PhaseBeginYellowClr</td>
<td>Phase interval: Yellow in SCATS message</td>
</tr>
<tr>
<td>8</td>
<td>PhaseEndYellowClr</td>
<td>Phase interval: Yellow in SCATS message</td>
</tr>
<tr>
<td>9</td>
<td>PhaseBeginRedClr</td>
<td>&quot;Phase interval: All Red&quot; in SCATS message</td>
</tr>
<tr>
<td>10</td>
<td>PhaseEndRedClr</td>
<td>&quot;Phase interval: All Red&quot; in SCATS message</td>
</tr>
<tr>
<td>11</td>
<td>PhaseInactive</td>
<td>keyword: &quot;Phase termination&quot;</td>
</tr>
<tr>
<td>12</td>
<td>PedBeginWalk</td>
<td>&quot;Pedestrian Sent&quot; is in Insync log</td>
</tr>
<tr>
<td>13</td>
<td>PhaseCallRegistered</td>
<td>conflicting movements have waiting time</td>
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**SCATS Signal Event Conversion**

**Convertible Signal Event**

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<td>Phase interval: Yellow in SCATS message</td>
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**NJDOT – Transportation Mobility**

“Improving Lives by Improving Mobility”
<table>
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<tr>
<th>Key ATSPM Performance Metrics translated from Adaptive Systems</th>
<th>ATSPM Event Code Used</th>
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<tr>
<td>Purdue Coordinate Diagram (PCD)</td>
<td>Controller timing of red, yellow, and green intervals (event 1, event 7, event 8, event 9, event 10, event 11)</td>
</tr>
<tr>
<td>Purdue Phase Termination Charts</td>
<td>Termination reasons (event 4, event 5)</td>
</tr>
<tr>
<td>Split Monitor</td>
<td>Phase Termination Events (event 0, event 7, event 8, event 9, event 11)</td>
</tr>
<tr>
<td>Pedestrian Delay</td>
<td>Pedestrian Actuation (event 21, event 43, event 45)</td>
</tr>
</tbody>
</table>

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- Translator:

```
def NEMAphaseNumber():
    # get NEMA Phase and Number hashtable from metadata
    global InsyncMetaData
    nemaPhase2Number = {}
    nemaNumber2Phase = {}
    phaseFieldNum = []

    movesAndNums = set(zip(InsyncMetaData["phaseMove"], InsyncMetaData["phaseNum"]))
    for item in movesAndNums:
        moves, nemaNumbers = item
        for item in zip(moves.split("/"), nemaNumbers.split("/")):
            nemaPhase2Number[item[0]] = int(item[1])
            nemaNumber2Phase[item[1]] = int(item[0])
            phaseFieldNum.append(int(item[1]))
    phaseFieldNum = list(set(phaseFieldNum))
    phaseFieldNum.sort()
    return nemaPhase2Number, nemaNumber2Phase, phaseFieldNum
```

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• Example Event Translation: Pedestrian Delay (SCATS to ATSPM)

This SCATS logged event indicates that the Phase 8 pedestrian push button was triggered. This translates to ATSPM Event Code 45: “Pedestrian Call Registered”.

This SCATS logged event indicates that the Phase 8 pedestrian walk signal is on. This translates to ATSPM Event Code 21: “Pedestrian Begin Walk”.

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- Example Event Translation: Pedestrian Delay (SCATS to ATSPM)

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- Overall Process:

   SCATS (Central)

   InSync (De-centralized)

   NJDOT Folder

   ATSPM

   Database

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- **Challenges:**
  - Python Code sits outside of ATSPM software. This process is mostly independent of the ATSPM software.
  - Estimating maximum green time for individual phases (Adaptive). Issue for Phase Termination.
  - Obtaining the hi-resolution detector inputs is not currently possible. Limits available measures.

- **Successes:**
  - Able to provide Purdue Phase Termination graph, Pedestrian Delay, Split Monitor, Purdue Coordination Diagram (without detector actuations).
  - Able to automatically generate an ATSPM file that can be read by the FHWA ATSPM source code.
Future ATSPM Work

• Develop NJDOT ATSPM architecture.
  • Work with OIT to assign server for ATSPM suite of applications (includes Web Server) and SQL DB.
  • Map ATSPM server to InSync and SCATS Data Folders.
  • Download Python Software Package and web-scraper tool.
  • Update field hardware (TS Controllers) for traditional ATSPM deployment.

• ATSPM source code edits.
  • 3rd party software developer proficient in C# and Adaptive Vendors.
  • SCATS Degree of Saturation, Original Volume, and Corrected Volume.
  • InSync Queue and Wait Times.

• Determine how to best utilize ATSPM outputs.
  • Develop policy for changing signal timings (e.g. using Link Pivot algorithm).
  • Potential for utilizing specific ATSPMs in an Adaptive or Responsive mode of operation.

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