Signal Operators Experience
Signal Timing Assessment
Methodologies
Outline for Presentation

- Objectives
- Measures of Effectiveness
- Signal Timing Assessment Methods
  - Intersection Delay Surveys
  - Floating Car
  - Bus Probes
- Challenges
Insightful Commentary from Todd Litman, VTPI taken from the ITE Journal, Oct 2003

- “Management experts often say that you cannot manage what you cannot measure. However, what is measured, how it is measured and how data are presented can affect how problems are evaluated and solutions are selected.

- For example, a baseball player's performance can be evaluated based on batting averages, base hits, runs batted in and the ratio of wins to losses, plus various defense statistics that depend on the player's position. Performance statistics can be calculated per at-bat, per inning, per game, per season, or for a career. A player can be considered outstanding according to one set of statistics but inferior according to another.”
Categories of Performance Measures from Todd Litman

- Traffic
- Mobility (persons or freight)
- Accessibility

Food for thought: What’s better?

- 10 1-mile trips, or 1 10-mile trips
- 10 people driving 35 mph, or 35 people driving 10 mph
Establish Objectives

- Objectives need to consider policies and local interests
  - Downtown merchants may favor pedestrian traffic over vehicular traffic
  - Speed control may be an objective for a neighborhood
  - Traffic volume throughput may be the state highway’s interest
  - Signal delay may be a transit agency’s concern
Measures of Effectiveness (MOEs)

- Measures of Effectiveness fall into two categories as shown in the table below.

<table>
<thead>
<tr>
<th>Measurable</th>
<th>Calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Delay</td>
<td>Fuel Consumption</td>
</tr>
<tr>
<td>★★ Stops</td>
<td>Emissions</td>
</tr>
<tr>
<td>★★★ Arterial Travel Time</td>
<td>Performance Index</td>
</tr>
<tr>
<td>★★★★★ Bandwidth</td>
<td></td>
</tr>
<tr>
<td>★★★★★★ Travel Speed</td>
<td></td>
</tr>
</tbody>
</table>

- Bandwidth, vehicle travel time, and delay are the most commonly used MOEs in signal systems.
  - MOEs that can be measured and field verified allow calibration of the model. Vehicle travel time is a commonly used measure.
How MOEs Affect the Signal Timing Plan

- **Bandwidth**
  - Selection of bandwidth as a key MOE may lead to longer cycle lengths, depending on the length of the arterial
  - Smoothness of flow?

- **Stops**
  - Using stops may lead to a similar timing plan (as in Bandwidth) with long delays on the side streets.
  - These solutions may lead to high variability in speeds depending on the cycle length

- **Delay**
  - May not meet expectations of the reviewing agency
MOEs and Project Development

- It is important to clarify MOEs as a part of the scope development.
  - Assist with determining the types of data that must be collected
  - Selection of the model to be used
  - Development of the model

- Even the HCM can’t decide upon a single MOE
  - Signalized Intersections: Control delay for an intersection
  - Urban Streets: Through movement travel speed
  - Interchanges (proposed): Control delay and queue length

- Finally, there are other MOEs that may complicate implementation, specifically the number of complaints that the traffic engineer receives
Industry Standard for Urban Street MOEs
Urban Streets Analysis- Define Segments

EXHIBIT 15-13. TYPES OF URBAN STREET SEGMENTS

(a) Segment on a One-Way Street

(b) Segment on a Two-Way Street
Urban Streets Analysis - Methodology, continued

- **Computation**
  - Compute running time and intersection control delays

- **Field Measurement**
  - Travel time between signals and delay at intersections
Urban Streets Analysis—Bias of the Procedure

- Lower running speeds are assigned to the facility as segment length is reduced
  - Insensitive to green/cycle ratio or side street friction
  - Limited recognition of important factors that affect operations

- Longer segments yield increased speeds

- No consideration of person delay (peds, transit, etc)

- No consideration of freight
Travel Time and Delay Study

- The purpose is to evaluate the quality of traffic movement along a route and determine the locations, types, and extent of traffic delays by using a moving test vehicle. (*FDOT Manual on Uniform Traffic Studies*)

- Used in “Before and After Studies” for signal retiming projects

- Provides an assessment of the following:
  - Travel Time
  - Delay
  - Stops
  - Arterial Speed
Travel Time and Delay Study – Methodology and Results

- Perform between five and ten floating car travel runs in each direction

- Data can be field recorded or by automated use
  - Data Sheets
  - Moving Vehicle Run Analysis Package (MVRAP)
  - GPS Data Collection

- Data summarized in tables and illustrated graphically

Is this statistically significant?
Any link to the signal system performance?
Traditional Travel Time and Delay Study

- Does not address side street delay
- May encourage increases to cycle length or speed limit
- Insensitive of policies beyond traditional transportation
Travel Time and Delay Study – Before and After Study

- Are the results reasonable?
  - In PM, Westbound “After” operated poor; Why?

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Direction</th>
<th># of Runs</th>
<th>Average Travel Time (sec)</th>
<th>Std. Dev. Travel Time (sec)</th>
<th>Average Delay (sec)</th>
<th>Average Stops</th>
<th>Average Speed (mph)</th>
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</thead>
<tbody>
<tr>
<td>AM</td>
<td>EB Before¹</td>
<td>10</td>
<td>241</td>
<td>25</td>
<td>16</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EB After</td>
<td>8</td>
<td>227</td>
<td>32</td>
<td>11</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WB Before¹</td>
<td>9</td>
<td>252</td>
<td>22</td>
<td>24</td>
<td>1.0</td>
<td>38.8</td>
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<tr>
<td></td>
<td>WB After</td>
<td>8</td>
<td>237</td>
<td>21</td>
<td>25</td>
<td>0.9</td>
<td>41.1</td>
</tr>
<tr>
<td>MIDDAY</td>
<td>EB Before¹</td>
<td>8</td>
<td>243</td>
<td>27</td>
<td>20</td>
<td>0.6</td>
<td>40.1</td>
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<td></td>
<td>EB After</td>
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<td>222</td>
<td>14</td>
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<td>WB Before¹</td>
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<td>242</td>
<td>21</td>
<td>16</td>
<td>0.6</td>
<td>40.2</td>
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<tr>
<td></td>
<td>WB After</td>
<td>8</td>
<td>228</td>
<td>24</td>
<td>17</td>
<td>0.9</td>
<td>42.9</td>
</tr>
<tr>
<td></td>
<td>EB Before¹</td>
<td>7</td>
<td>246</td>
<td>28</td>
<td>17</td>
<td>0.9</td>
<td>39.7</td>
</tr>
</tbody>
</table>

Were volume levels same as data collection effort?

EB Speed Comparison

Westbound Results?
Travel Time and Delay Study – Before and After Study

- What are the annual savings?
  - Would anyone pay me for this?
- Why report this information?
- Is it a measure of success?

<table>
<thead>
<tr>
<th>Measures of Effectiveness (MOE)</th>
<th>Estimated Daily Savings</th>
<th>Estimated Adjusted Annual Savings</th>
<th>Estimated Adjusted Annual Cost Savings to Motorists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Travel Time</td>
<td>60 vehicle hours</td>
<td>18,000 vehicle hours</td>
<td>$185,000</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>30 gallons</td>
<td>9,000 gallons</td>
<td>$14,400</td>
</tr>
<tr>
<td>Vehicle Stops</td>
<td>(3,800 stops)</td>
<td>(1,150,000 stops)</td>
<td>($16,000)</td>
</tr>
<tr>
<td><strong>Total Estimated Adjusted Annual Cost Savings</strong></td>
<td></td>
<td></td>
<td><strong>$184,000</strong></td>
</tr>
<tr>
<td><strong>Total Cost Per Intersection</strong></td>
<td></td>
<td></td>
<td><strong>$30,500</strong></td>
</tr>
</tbody>
</table>
Travel Time and Delay Study
Floating Car Data
Future Research

- NCHRP 3-79 is exploring link to signal system technology while considering update to HCM Methodologies
- Other research has considered other users and system issues
- FHWA continues to refine use of simulation
Transit Issues

- Automatic Vehicle Location systems provide yet another source of data
Pedestrian Issues

- Pedestrian Movements
  - No consistent practice for accommodating pedestrian arrivals within signal timing strategies
    - Timing for pedestrians may lead to long cycle lengths, or
    - Pedestrian actuation may cause the controller to lose coordination
  - **Outcome:** a pedestrian actuation may result in significantly different results on a cycle by cycle basis

- Pedestrian MOEs
  - No deterministic model incorporates pedestrian delay in procedure
  - **Outcome:** a lack of focus on an important user