Work Zone Performance Measurement - Mobility

Work Zone Performance Management Peer Exchange Workshop
May 8, 2013  •  Atlanta, Georgia
Mobility-Related Performance Measures

Mobility impacts commonly measured as

- Throughput
- Delays
- Travel times
- Travel time reliability
- Vehicle queues
Throughput Performance Measures

1. Reduction in maximum vehicle throughput flow rate
   - Overall
   - During certain work tasks
   - When work zone inactive

2. Maximum person throughput flow rate
Throughput

Existing Agency Data Sources

- TOC or traffic signal system vehicle count data
- Toll facility usage data
- Automatic traffic recording (ATR) station data
- Planning and programming AADT estimates

Work Zone Specific Throughput Data

- Data from work zone ITS deployment
- Temporary mechanical data collection device
- Manual vehicle count at key times & locations

Person Throughput Data

- Manual sampling of per-vehicle occupancy levels
- Manual sampling or video detection of pedestrian throughput

Source: TTI
Throughput

Potential Future Data Source

- Connected vehicle technology (sufficient market penetration of V2V and V2I technology will be needed).

Source: TTI
Throughput

Non-congested

Demand < Capacity

Demand

Throughput = Demand

Congested

Demand ≥ Capacity

Demand

Throughput = Capacity

Source: TTI
<table>
<thead>
<tr>
<th>Data Source</th>
<th>Key Considerations and Trade-offs</th>
</tr>
</thead>
<tbody>
<tr>
<td>All data types</td>
<td>• Is it a demand or throughput measurement?</td>
</tr>
<tr>
<td></td>
<td>• Multiple days of data is needed to reduce day-to-day variations</td>
</tr>
<tr>
<td>TOC sensor data and toll facility usage data</td>
<td>• Important to verify data will be available once work has started</td>
</tr>
<tr>
<td>ATR station data</td>
<td>• Important to verify that counts are “true” values (not adjusted)</td>
</tr>
<tr>
<td>Agency AADT estimates</td>
<td>• Overestimates throughput and exposure if diversion occurs</td>
</tr>
<tr>
<td>Work Zone ITS data</td>
<td>• Important to verify that data will be archived</td>
</tr>
<tr>
<td>Mechanical counters or manual counts</td>
<td>• Not practical for high-volume, high-speed roadways</td>
</tr>
<tr>
<td></td>
<td>• Labor intensive</td>
</tr>
<tr>
<td>Manual collection of person/vehicle occupancy</td>
<td>• Useful for evaluating non-vehicular travel mitigation strategies</td>
</tr>
<tr>
<td>levels</td>
<td></td>
</tr>
<tr>
<td>Manual or electronic collection of pedestrian</td>
<td>• Useful if non-vehicular travel mitigation strategies</td>
</tr>
<tr>
<td>throughput</td>
<td>• Pedestrian and vehicle peak hours may not coincide</td>
</tr>
<tr>
<td>Connected vehicle data</td>
<td>• Date of availability still uncertain</td>
</tr>
</tbody>
</table>
Travel Time and Delay Performance Measures

• Average unit travel times (or changes in unit travel times)
  – Corridor-based (when multiple work zones)
  – During specific periods or work tasks
• Average delays per vehicle
• Percent of time when delays exceed threshold
• Total delay (veh-hrs)
Travel Time and Delay Measures (cont’d)

• Time required to convey delay information to travelers

• % of projects exceeding delay thresholds
  – Maximum value
  – Allowable duration

• % of travelers experiencing delays
  – Corridor or region-wide
  – In a specific project
Travel Time Reliability Performance Measures

• Change in “xx”-percentile travel times
  – Project
  – Corridor or route

• Change in planning time index
  \[\text{planning index} = \frac{\text{average travel time}}{\text{freeflow travel time}}\]

• Change in buffer index
  \[\text{buffer index} = \frac{xx - \text{percentile travel time}}{\text{average travel time}}\]
Delay, Travel Time, Travel Time Reliability

Existing Agency Data Sources

- TOC spot speed sensor data
- TOC tracking of vehicles through use of cameras
- TOC point-to-point travel time data using AVI, AVL, or license-plate recognition technology

Work Zone Specific Travel Time and Delay Data

- Data extracted from a work zone ITS deployment
- Portable point-to-point travel time data collection devices
- Manual spot speed sampling using radar or lidar devices
- Travel time runs through the work zone
- Estimation of travel time delays from observed queue length data

Source: TTI
Delay Estimation from Observed Queue

\[
\frac{\text{Delay}}{\text{Vehicle}} = L_q \left( \frac{1}{u_q} - \frac{1}{U_{WZSL}} \right) + L_{WZ} \left( \frac{1}{u_f} - \frac{1}{U_{WZSL}} \right)
\]

- Delay in Queue
- Delay in WZ

- \(L_q\)
- \(L_{WZ}\)

- Average Speed in Queue \((U_q)\):
  \[
  \left( \frac{U_f}{2} \right) \left( 1 - \left( \frac{WZ \text{ Capacity}}{\text{Normal Capacity}} \right)^{\frac{1}{2}} \right)
  \]

- Speed at Capacity Flow:
  \[
  \left( \frac{U_f}{2} \right)
  \]

Assuming Linear Speed-Density Relationship
Delay, Travel Time, Travel Time Reliability

Potential Future Data Source

• Travel Times from Bluetooth Address Matching

• Private (3rd Party) Sources of Travel Time and Speed Data

• Connected vehicle technology

Source: TTI

Source: Google traffic map captured with the Snagit
<table>
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</table>
| TOC spot speed data               | • Less accurate when congestion is present  
• Important to verify data availability once work has started |
| TOC point-to-point travel time data | • Important to verify data availability once work has started                                   |
| Work zone ITS data                | • Data must be archived and available for PM computations                                          |
| Portable point-to-point travel time data collection | • Accuracy depends on market penetration of technology  
• Time lags exist during congestion. |
| Manual spot-speed data            | • Labor intensive  
• Most useful if the impacts occur in a fairly small section  
• Most useful for assessing short time periods                                                   |
| Manual travel time data collection | • Labor intensive  
• Most useful for assessing short time periods  
• Multiple runs increase accuracy and precision                                                      |
| 3rd party travel time and speed data | • Level of detail available may vary by vendor  
• Translation to agencies’ data mapping protocol is needed                                             |
| Bluetooth data                    | • Accuracy depends on market penetration  
• Time lags exist during congestion.                                                               |
| Connected vehicle data            | • Date of availability still uncertain                                                             |
Traffic Queue Performance Measures

- Average queue duration
  - Overall
  - During certain times or tasks
- % of time when queues occur
  - Overall
  - Those exceeding a threshold level
- Maximum queue length
  - Project
  - Combined along route or corridor
Traffic Queue Measures (cont’d)

• Average queue length
  – Overall
  – During certain phases or work tasks

• % of projects with queues exceeding thresholds
  – Maximum length
  – Maximum duration

• % of travelers experiencing a queue
Traffic Queue Data Sources

Existing Data Sources

- Speed data extracted from a work zone ITS deployment
- Observation of queues from a permanent or work zone TOC
- Observation of queues by field personnel at the work zone

Queue Length Estimation from Spot-Speed Sensors

Step 1: Divide the Roadway into Regions of Assumed Uniform Speed

Step 2: Examine Speeds and Volumes Hour-by-Hour at each Sensor Location

Step 3: Compare Hourly Speed/Volume Profiles across Sensors to Identify Length of Queue

Step 4: Sum Region Lengths where Speeds are below Thresholds
Example:

- Spot traffic sensors are located 0.2 mile, 0.8 mile, and 1.3 miles upstream.
- Project diary information indicates that a lane closure began at 9:00 AM and ended at 3:30 PM.

<table>
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<tr>
<th>Time</th>
<th>Estimated Location of Upstream End of Queue</th>
<th>Estimated Queue Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00 am</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>Between Sensors 1 &amp; 2</td>
<td>0.2 + (0.6/2) = 0.5 mile</td>
</tr>
<tr>
<td>1:00 pm</td>
<td>Between Sensors 2 &amp; 3</td>
<td>0.2 + 0.6 + (0.5/2) = 1.05 mile</td>
</tr>
<tr>
<td>2:00 pm</td>
<td>Between Sensors 2 &amp; 3</td>
<td>1.05 mile</td>
</tr>
<tr>
<td>3:00 pm</td>
<td>Between Sensors 2 &amp; 3</td>
<td>1.05 mile</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>None</td>
<td>0</td>
</tr>
</tbody>
</table>
Traffic Queue Data Sources

Potential Future Data Sources

• Screenshot Captures from 3rd Party Traveler Information Providers

• Private (3rd Party) Sources of Travel Time and Speed Data

• Connected vehicle technology

Source: TTI

Source: Google traffic map captured with the Snagit
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| All data types                                                             | • Definition of queues (e.g., min speed threshold) is critical  
• Both queue duration and queue length are important                                |
| TOC or work zone ITS data using spot speed sensors                        | • Requires speed analysis on sensor by sensor basis  
• Important to verify data availability once work has started                                    |
| Visual queue identification by TOC operators                               | • Requires good camera coverage upstream of work zone                                                                                                          |
| Collection of queue data by field personnel                               | • Data collection protocol training is needed  
• May be difficult to accurately monitor the end of queue                                                                                                     |
| Screenshot of real-time traffic condition maps                            | • Required screen resolution depends on expected queue length  
• Time-lapse capabilities do not exist in most screen capture software                                                                                      |
| 3rd party traveler information data                                       | • Level of detail available may vary by vendor  
• Translation to agencies’ data mapping protocol is needed                                                                                                   |
| Connected vehicle data                                                    | • Date of availability still uncertain                                                                                                                         |
Discussion

• Are there other mobility-related measures you have thought about using in your agency? Why are you considering those?

• How would you use these or other mobility measures to decide how to modify your agency’s current policies or practices?