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
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

Throughput = Demand

**Congested**

Demand \(\geq\) Capacity

Throughput = Capacity

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

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

- Delay in Queue
- Delay in WZ

\[ L_q \]
\[ L_{WZ} \]

Average Speed in Queue: \( u_q \)

\[ \left( \frac{u_f}{2} \right) \left( 1 - \left( 1 - \frac{WZ \text{ Capacity}}{\text{Normal Capacity}} \right)^{\frac{1}{2}} \right) \]

Speed at Capacity Flow: \( u_f \)

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
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| 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       | • 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>
<thead>
<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 Snagit
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<td>• Definition of queues (e.g., min speed threshold) is critical</td>
</tr>
<tr>
<td></td>
<td>• Both queue duration and queue length are important</td>
</tr>
<tr>
<td>TOC or work zone ITS data using spot</td>
<td>• Requires speed analysis on sensor by sensor basis</td>
</tr>
<tr>
<td>speed sensors</td>
<td>• Important to verify data availability once work has started</td>
</tr>
<tr>
<td>Visual queue identification by TOC</td>
<td>• Requires good camera coverage upstream of work zone</td>
</tr>
<tr>
<td>operators</td>
<td></td>
</tr>
<tr>
<td>Collection of queue data by field</td>
<td>• Data collection protocol training is needed</td>
</tr>
<tr>
<td>personnel</td>
<td>• May be difficult to accurately monitor the end of queue</td>
</tr>
<tr>
<td>Screenshot of real-time traffic</td>
<td>• Required screen resolution depends on expected queue length</td>
</tr>
<tr>
<td>condition maps</td>
<td>• Time-lapse capabilities do not exist in most screen capture software</td>
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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?