Work Zone Performance Measurement - Mobility

Work Zone Performance Management Peer Exchange Workshop

May 8, 2013 ◆ Atlanta, Georgia

Texas A&M Transportation Institute

Mobility-Related Performance Measures

Mobility impacts commonly measured as

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

Throughput Performance Measures

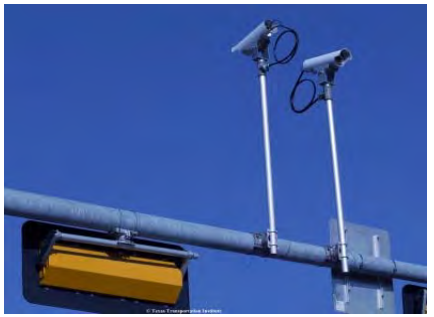
1. Reduction in maximum vehicle throughput flow rate
   - Overall
   - During certain work tasks
   - When work zone inactive

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



Source: TTI

Source: TTI

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).

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Source: TTI

Throughput

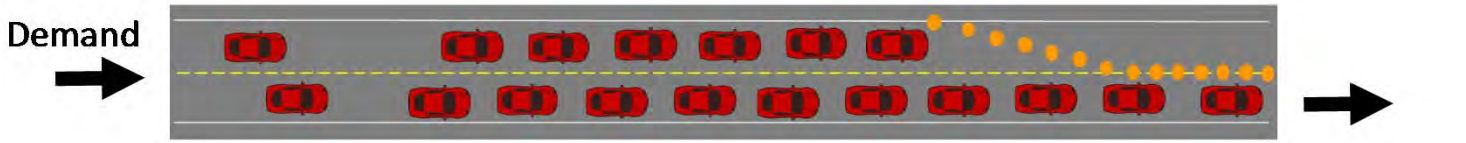
Non-congested

Demand < Capacity

Throughput = Demand

Congested

Demand ≥ Capacity



Throughput = Capacity

Source: TTI

Data Source	Key Considerations and Trade-offs
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

$$planning\ index = \frac{average\ travel\ time}{freeflow\ travel\ time}$$

- Change in buffer index

$$buffer\ index = \frac{xx - percentile\ travel\ time}{average\ travel\ time}$$

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

Source: TTI

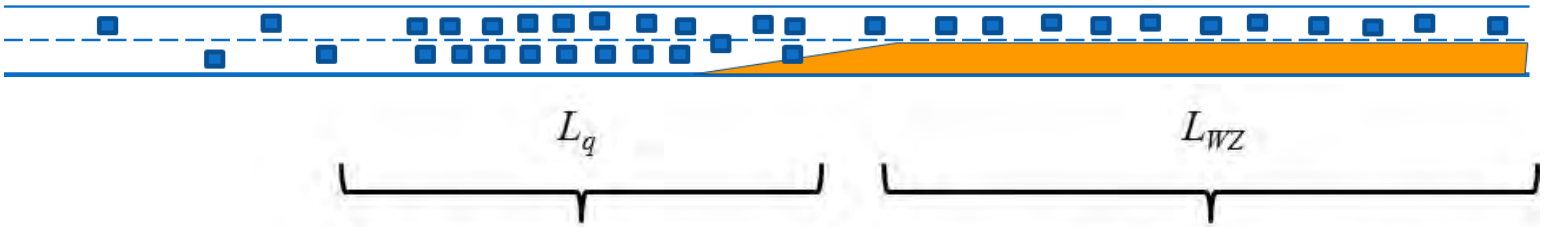
Work Zone Specific Travel Time and Delay Data

- 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

$$\frac{Delay}{Vehicle} = L_q\left(\frac{1}{u_q} - \frac{1}{U_{WZSL}}\right) + L_{wz}\left(\frac{1}{\frac{u_f}{2}} - \frac{1}{U_{WZSL}}\right)$$

Delay in Queue + Delay in WZ



L_q L_{WZ}

Average Speed in Queue (U_q)

$$\left(\frac{U_f}{2}\right)\left(1 - \left(1 - \frac{WZ\ Capacity}{Normal\ Capacity}\right)^{\frac{1}{2}}\right)$$

Speed at Capacity Flow

$$\left(\frac{U_f}{2}\right)$$

Assuming Linear Speed-Density Relationship

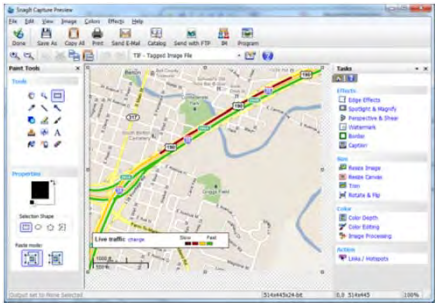
Delay, Travel Time, Travel Time Reliability

Potential Future Data Source

- Travel Times from Bluetooth Address Matching

Source: TTI

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



Source: Google traffic map captured with the Snagit

- Connected vehicle technology

Data Source	Key Considerations and Trade-offs
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)

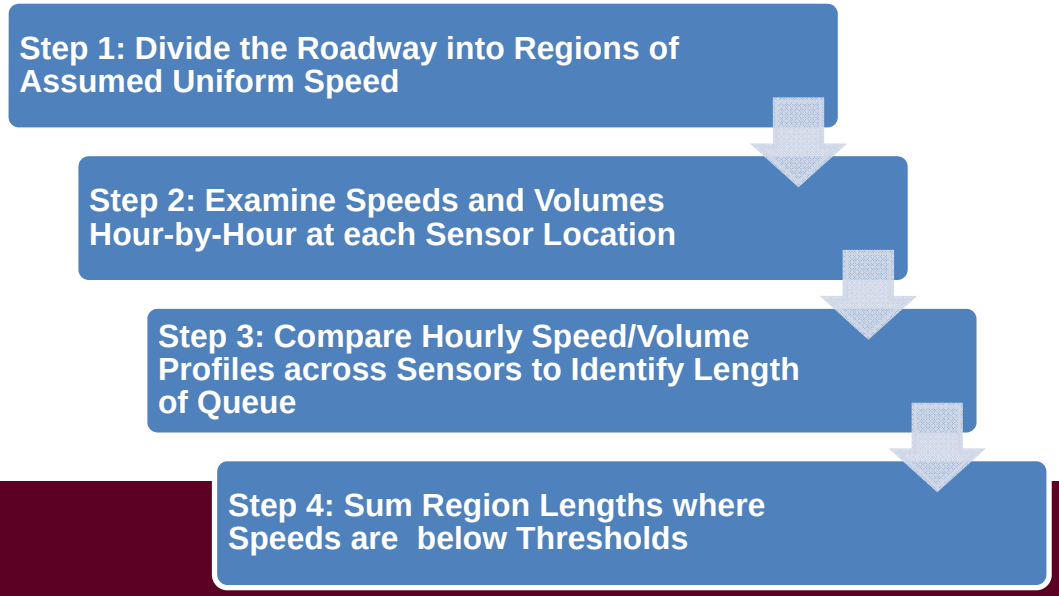
- Average queue length
  - Overall
  - During certain phases or work tasks
- % of projects with queues exceeding thresholds
  - Maximum length
  - Maximum duration
- % of travelers experiencing a queue

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

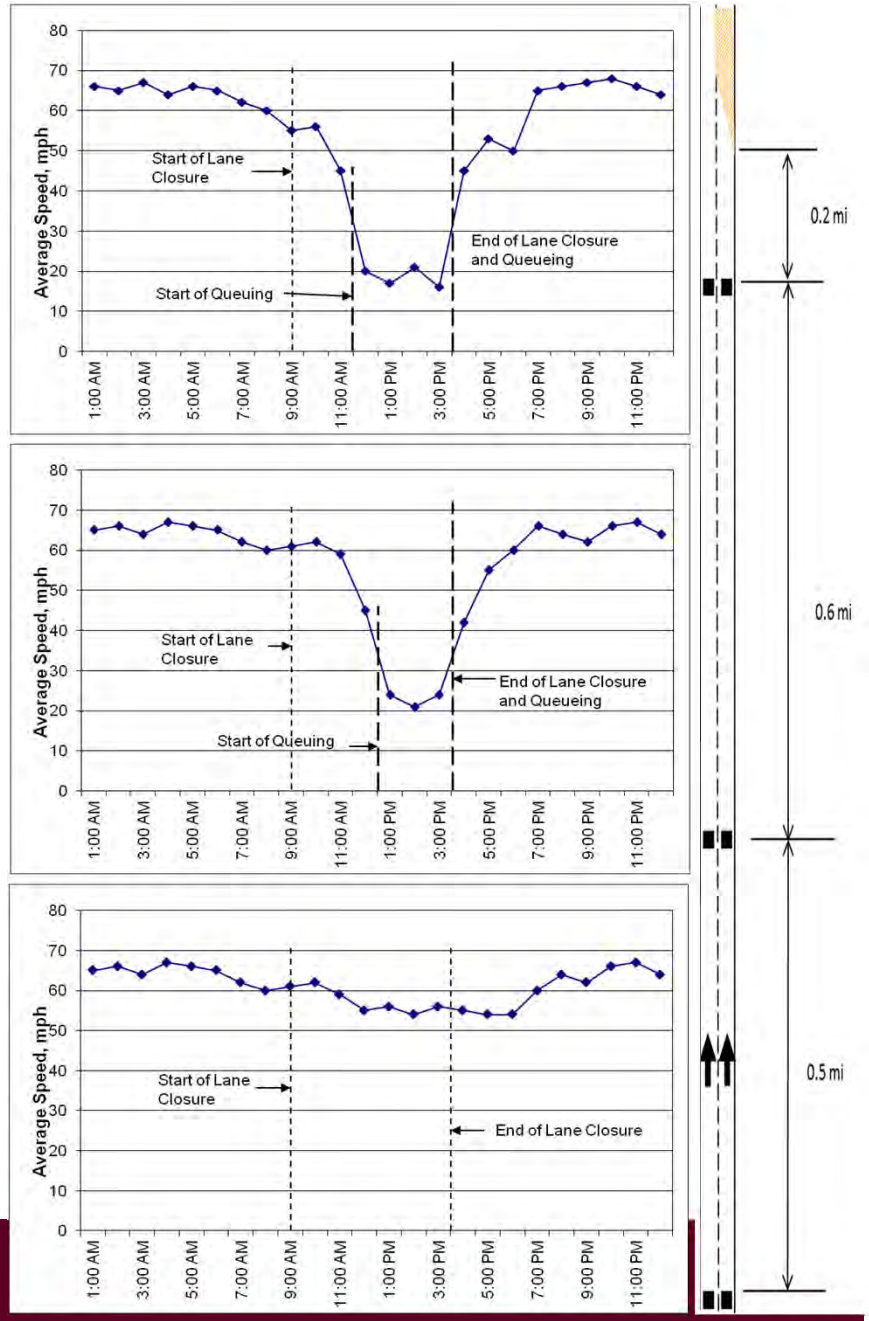
Queue Length Estimation from Spot-Speed Sensors



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.

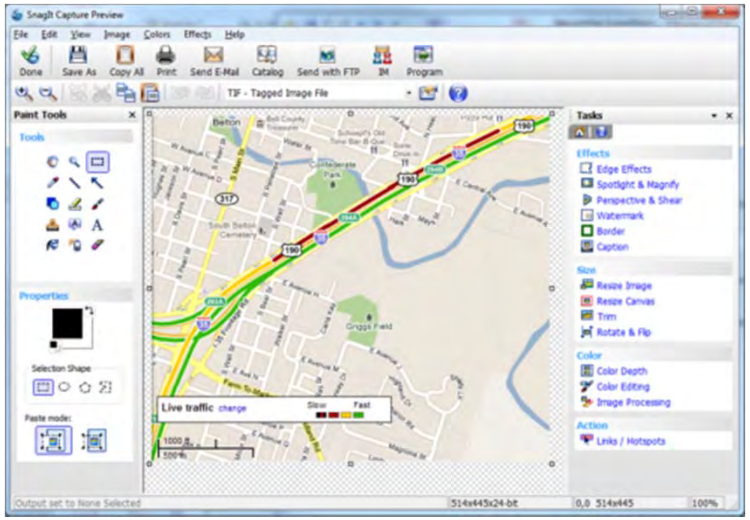
Time	Estimated Location of Upstream End of Queue	Estimated Queue Length
11:00 am	None	0
12:00 pm	Between Sensors 1 & 2	0.2+(0.6/2)=0.5 mile
1:00 pm	Between Sensors 2 & 3	0.2+0.6+(0.5/2)= 1.05 mile
2:00 pm	Between Sensors 2 & 3	1.05 mile
3:00 pm	Between Sensors 2 & 3	1.05 mile
4:00 pm	None	0



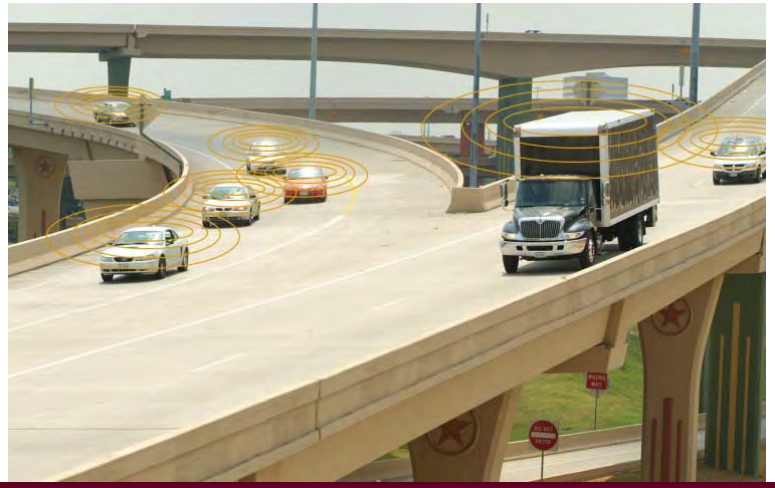
Traffic Queue Data Sources

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: Google traffic map captured with the Snagit



Source: TTI

Data Source	Key Considerations and Trade-offs
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?