Performance Measures for Urban Street Applications

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Outline for Presentation

- Background
  - Performance Measures
  - Downtown Baltimore: A Case Study
  - Objectives for Signal Timing

- NCHRP 3-79: Measuring and Predicting Arterial Travel Time
  - Task B – Signal System *Measurements*
  - Task A – HCM *Prediction*

- Parting Comments
### NCHRP 3-79 Literature Review
### Traditional Arterial Performance Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Agency</th>
<th>Traveler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Travel speed</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Stop rate</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Volume-to-capacity ratio</td>
<td>X</td>
<td></td>
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<tr>
<td>Bandwidth efficiency</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cycle failure rate</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Queue length</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Travel time reliability</td>
<td></td>
<td>X</td>
</tr>
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Why do we care about MOEs?

- In collecting them, we might make better decisions about the transportation system
- If we collect them, we may respond more efficiently to decision makers which may lead to more funding
“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, etc...

...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 one-mile trips, or one 10-mile trip
- 10 people driving 35 mph, or 35 people driving 10 mph
Specific Performance Measures

- Traffic
  - Variability and Reliability of Travel Time
  - Delay
  - Stops

- Mobility
  - Capacity and Throughput
  - Person Delay (transit corridor effects)
  - Travel Time Runs (on a corridor)

- Accessibility
  - Pedestrian Delay
  - Travel Time Runs (on a route)
Warning: Practical Application Ahead
Case Study: Downtown Baltimore

- Downtown Ring Road serves vehicles
- Mostly one way street system over the grid (inside ring)
- Our project is to retime the network
- What should our MOEs be?
Case Study: Downtown Baltimore

- Traditional travel time surveys through the City?
  - Increase Speeds?
  - Reduce Delay?

- What’s the Mayor going to say?
  - Previous request for reducing the cycle length in downtown
Case Study: Downtown Baltimore

- Traditional travel time surveys through the City
  - Does not recognize multimodal needs
  - Local issues with property owners
  - May bias retiming to increase speeds
Case Study: Downtown Baltimore

- LRT Corridor
  - LRT delay survey
- Center of the City
  - Speed management
- Vehicular Travel speed
  - Bandwidth
- Bus Corridor
  - Bus signal delay
- Community Planning
  - Neighborhood wants reduced through traffic
Case Study: Downtown Baltimore

- Speed Management in Center City
  - Stops and Delay
  - Pedestrian Delay
  - Min, Max, Average Speed

- LRT Corridor
  - Let transit conduct a delay survey

- Vehicular Travel Speed
  - Bandwidth
  - Stops and Delay
Establish Objectives for Signal Timing

- Objectives need to consider policies and local interests
  - Downtown merchants may favor pedestrian traffic over vehicular traffic; reduced speeds
  - 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
Arterial Signal Timing
Measures of Effectiveness (MOEs)

- Measures of Effectiveness fall into Measurable and Calculated

<table>
<thead>
<tr>
<th>Measurable</th>
<th>Calculated</th>
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<tbody>
<tr>
<td>★★ Delay</td>
<td>Fuel Consumption</td>
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<tr>
<td>★★ Stops</td>
<td>Emissions</td>
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<tr>
<td>★★★ Arterial Travel Time</td>
<td>Performance Index</td>
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<tr>
<td>★★★ Bandwidth</td>
<td></td>
</tr>
<tr>
<td>★★☆ Travel Speed</td>
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- 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, may not recover well from oversaturated conditions

- **Delay**
  - May not meet expectations of the reviewing agency, traveling public
MOEs and Timing Development

- It is important to clarify MOEs as a part of the timing development.
  - MOEs should assist us to determine the types of data that must be collected

- 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

- Choice of MOEs may complicate implementation
  - Number of complaints that the signal timing engineer receives
NCHRP 3-79 Research
Measuring and Predicting Arterial Performance

- Signal Systems and HCM Research Problem Statement resulted in two objectives:

A. Identify new ways to use traffic signal state and detector information to develop MOEs
B. Update the HCM with information relative to offset and other parameters
Task A: NCHRP 3-79 Measurement Techniques

- Delay & Queue Measurement
  - Input-output analysis
  - Bus probe
  - Queue discharge characteristics
  - Non-intrusive detection

- Running time
  - Platoon detection (matching)
  - Bus probe
  - Traffic flow characteristics (speed-volume)
  - Spot speed conversion
Task A: NCHRP 3-79 Measurement Techniques Traffic Signal Advancements

- ACS Lite like Measures
  - Information from detectors to identify vehicles coming in
  - Information from signal state to determine output
Video Detection – Noblesville, IN: Data Collection Cabinet

A – Remote Windows Computer for Data Collection
B – Video Multi-plexer
C – Camera Detector Cards
D – Loop Detector Cards
E – Patch Panel
Task A: NCHRP 3-79 Measurement Techniques
Traffic Signal Advancements

- Input-Output Analysis
  - +: measurement of arrival flow profile
  - -: accuracy dependent on sat. flow estimate

- Many intersections already have this hardware available – we just don’t collect it and use it to our advantage
NCHRP 3-79 Task A
Comparison of Status Quo vs. Research and NTOC Language

- Limited use of available data from the signal system
  - Loop detector counts
  - Phase status
  - *Bill Kloos’ note about using what we have to get MOEs*

- No transit, freight, or pedestrian considerations in the model
  - *More research necessary, talk to Alex Skabardonis*

- No reliability index in typical signal timing plans
  - Limited research available to practitioners in this area
NCHRP 3-79 Task B: Industry Standard for Urban Street MOEs
NCHRP 3-79 Task B: 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
NCHRP 3-79 Task B: Urban Streets Analysis—Methodology

- Field Measurement or Computation
  - Measure travel time between signals
  - Measure delay at intersections
    - Utilizes HCM Signalized Intersections Chapter

Measure this with available technology
Leaving Research Behind... back to the Real World
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

Potential link to the signal system
Travel Time and Delay Study – What we heard today

- **Traditional Practice:**
  - Perform between five and ten floating car travel runs in each direction

- **Mike Hunter’s point:**
  - What if drivers aren’t going all the way through

- **Bill Kloos’ perspective:**
  - Expensive to complete this type of study

- **Mark Hickman’s research:**
  - How would you link a view of one intersection to yield system data?

- **Action Item for Practitioners in the Audience**
  - *Talk to Darcy about how to build a super cabinet!*

Is this statistically significant? Does it address the right MOEs?
The Purdue Research Cabinet: Diagnostic Performance of Signals for Improved MOEs

- Measure the flow on each phase
- Evaluate the average phase length and return to main street
- Assess the effectiveness of time as it relates to other movements
- Define relationship between offset and arrival type
  - Bandwidth is reliant on variability of side street demand
  - Quality of Arrival type is based on existing queue
Arrival Type Considerations
Early Green Return may Increase Speed Variability

- Light side street demand results in early return to green
- Offset entered into the controller defines end of green (traditional coordination), but both start and end of green relationships are important for performance measures

Early return to Green results in simultaneous green – higher speeds, increased variability
Arrival Type Considerations
Measures of Effectiveness

No delay for through- through vehicle at second intersection

Vehicle trajectory shows speed consistent with timing assumption

Assumes no queue at downstream (second) intersection…

how often does this happen?
Arrival Type Considerations
MOE – negative delay? Or variability of speed

Does variability of speed effect the quality of the timing plan?

How do we measure delay with a vehicle arrival on green?

Is a faster vehicle negative delay?

Fixed Offset
End of Green
Arrival Type Considerations
Desirable Start of Green

- Desirable start of green depends on side street traffic and downstream conditions.
Arrival Type Considerations
Desirable Start of Green

- Determination of “good” Arrival Type or projection of delay based on timing is only as good as measurement of the existing queue
Summary

- Research is ongoing
- As an industry, we need to capture the available data
  - *We can’t figure out how to use it if we don’t have it available*
- Averages aren’t meaningless, but cycle by cycle sure would be nice
- We have a long way to go to consider all MOEs
  - Vehicular (intersection vs. system)
  - Pedestrians
  - Transit