SHRP 2 Local Methods for Modeling, Economic Evaluation, Justification and Use of the Value of Travel Time Reliability in Transportation Decision Making (L35)

SHRP 2 Tuesdays Webinar Series
September 9, 2014
Today’s Presentation

• Introduction
• SHRP 2 L35B Objectives & Research Approach
• Existing Congestion Relief Process
• Approaches to VTTR
• Travel Time Data Driven Methodology (TTDDM)
• TTDM Application Results & Implementation
• Caveats & Conclusions
L35B Project Objectives

• “Select and defend a value or range of values for travel time reliability for the Maryland State Highway Network”;
• “Use the VTTR in the Maryland SHA project development process to prioritize operational and capital improvements and determine if (and how) the ranking of projects changes due to the addition of VTTR”; and
• “Report for the benefit of others the step-by step process used to develop, justify, apply, and assess the use of VTTR in the Maryland SHA project evaluation and decision process.”
Research Approach

• Documented established processes
• Conducted detailed literature search
• Developed travel time data driven methodology
• Acquired data needed
• Applied TTDDM to multiple corridors to calculate RR/VOR
• Incorporated RR/VOR results in short term and long term project selection processes
Overview of Existing Process(es)

- State Report on Transportation
- MDOT Budget Allocation Process
- SHA Budget Allocation Process
Congestion Relief DM Process

**Step 1 – Diagnosis**
- Identify unreliable segments
- SHA uses PTI (95th % TT)

**Step 2 – Analysis**
- Identify project alternatives
- B/C prioritization
- SHA uses RR=0.75 for VTTR benefits

**Step 3 – Selection**
- Work with stakeholders to select projects & program for design/construction

**Step 4 – Assessment**
- Assess reliability improvement
- SHA uses PTI (95th % TT)
Value of Time (VOT)
- Passenger: U.S. Census Bureau data
- Cargo: TTI, and other studies

Value of Travel Time Reliability (VTTR)
- Reliability Ratio (RR=0.75)
- Based on literature review and current practice in other parts of the world

<table>
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<tr>
<th>Saving Type</th>
<th>Parameter</th>
<th>Unit</th>
<th>Categories</th>
<th>SHA Value*</th>
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<tr>
<td>Travel time</td>
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<td>$/hr</td>
<td>Passenger</td>
<td>29.82</td>
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<td></td>
<td>Truck driver</td>
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<tr>
<td></td>
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<td></td>
<td>Cargo</td>
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<tr>
<td>Travel time reliability</td>
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<td>Truck driver</td>
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<td></td>
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<td>Cargo</td>
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<td>Fuel cost</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Diesel</td>
<td>3.97</td>
</tr>
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</table>

*Parameters used by SHA in project benefit estimation (2012 values)
Previous Approaches to Estimate VTTR

- **Statistical methods (early studies)**
  - Directly estimate TT distribution and variations
    - Mean-variance
    - Scheduling delay
    - Combined mean-variance and scheduling delay

- **Survey-based methods (later)**
  - Discrete choice models
    - Disaggregate survey data, stated preferences (SP) or revealed preferences (RP) or combination

- **Options Theory (emerging)**
  - Unique approach based on statistical/financial concepts
  - Uses an analogy where premiums are set for an insurance policy that guards against being late
  - Data driven
    - uses historical travel time, speed and volume data as input readily available to most agencies
  - Easy to update, generalize and localize
Travel Time Data Driven Methodology

- Expected Travel Time
- Level of Travel Time Variations
- Tolerance Level for Travel Time Variations
- Impacts of longer/shorter Expected Travel Times

# Trips

Average Travel Time

30 min

Travel Time

VOR
Travel Time Data Driven Methodology

**Inputs**
- Mass quantities of historical travel time data (INRIX)
- Value of time

**Calculations**
- Travel time distribution
- Stochastic process
- Binomial tree
- Certainty-equivalent probabilities

**Outputs**
- Value of reliability
- Reliability ratio

\[
\begin{align*}
\text{Outputs:} & \quad \text{Value of reliability} \\
\text{Reliability ratio} & \quad \text{Reliability ratio}
\end{align*}
\]
### Steps Involved in the TTDDM

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1. How can <strong>travel time evolutions</strong> over time be modeled?</td>
<td>Travel time series can be characterized as <strong>Geometric Brownian Motion (GBM)</strong> with drift stochastic process; hence, given the process parameters, future travel time probability distributions can be specified.</td>
</tr>
<tr>
<td>2. How can a <strong>penalty/reward (payoff)</strong> of early/late arrivals at the destination be determined?</td>
<td>Penalty is simply defined as an <strong>asymmetric bilinear function</strong> of the amount of time by which the traveler is late or early at the destination.</td>
</tr>
<tr>
<td>3. What is the <strong>guaranteed level</strong> of travel time?</td>
<td><strong>Expected travel time</strong> is taken as the guaranteed travel time level.</td>
</tr>
<tr>
<td>4. What is the <strong>duration of time</strong> for which the travel time insurance policy is issued?</td>
<td>Travel time insurance policy is issued for the longest trip time possible under recurrent congestion scenarios (<strong>95th percentile travel time</strong> is used for this purpose).</td>
</tr>
<tr>
<td>5. How the <strong>future payoffs</strong> get valued at the <strong>outset of trip</strong>?</td>
<td>A <strong>certainty-equivalent payoff valuation</strong> strategy is adopted. This payoff valuation method takes advantage of the GBM assumption for the travel time process to greatly simplify the insurance valuation process.</td>
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Corridors Analyzed
TTDDM Application Results

- **Average Travel Time (Minute)**

- **Reliability Ratio - RR (Unitless)**

  - **Path Level / Across Days**
    - **AM Peak**
    - **PM Peak**

- **CENSUS BUREAU**
  - AVERAGE COMMUTE TRIPS (2006-2010)
  - 0.87

- **CURRENT AND VALIDATED**
  - (COMMUTE TRIPS DURING PEAK HOURS)
  - 0.75
  - 0.68
  - 0.52

- **MSTM**
  - AVERAGE COMMUTE TRIPS
  - 0.87

- **MSTM ALL TRIPS (NON URBAN/OFF PEAK)**
  - 0.68
  - 0.52
Incorporating Application Results (Short Term Projects)

• Improvement Projects Identified for I-695 Using Existing Process Selected as Case Study
• Total of 16 Projects Ranked Using Life Cycle BCA
• Improvements are Low Cost Congestion Relief Projects (e.g., addition of auxiliary lanes, extending acceleration lanes)
• VISSIM Used as Analysis Tool
• Performed Sensitivity Analysis on RR/VOR Impact on Project Selection

Step 1 – Diagnosis
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Step 3 – Selection
  • Work with Stakeholders to select projects & program for design/ construction

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Incorporating Application Results (Short Term Projects)
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• Benefits include cost savings related to: delay reduction, auto, freight, fuel as well as reliability (VOR=RR*VOT), and safety
• Costs include construction as well as O&M
• How do changes in the RR impact project B/C ranking?
Incorporating Application Results (Short Term Projects)

- Auxiliary Lane Extension on Outer Loop, TC = $5.5M
- Extension of auxiliary lanes, new retaining wall Outer Loop, TC = $10.9M
- Remove ramp on inner loop and install signal, TC = $2.6M
- Acceleration lane extension on inner loop, TC = $6.5M
- Additional through lane outer loop (JFX to Stevenson Rd), TC = $5.9M
Note: This was a “proof of concept” using the Maryland Statewide Transportation Model (MSTM)

However, proof of concept shows how a post-processing module can be used with any travel demand model to determine long term travel time reliability valuation
Incorporating Application Results
(Long Term Projects)

• RR vs average TT function used with MSTM to compute travel time & travel time reliability savings for:
  – Base year no build (pre-ICC)
  – Base year build (post – ICC)
  – Future year – no build
  – Future year build
County Level Findings

• Typical day, AM peak period, base year post-ICC vs. pre ICC
County Level Findings

- Typical day, AM peak period, future year build
TAZ Level Findings

• Travel time reliability savings $/trip post-ICC vs. pre-ICC
TAZ Level Findings

• Travel time reliability savings $/trip post- future year build vs. future year no build
Caveats & Conclusions

• SHA’s use of 0.75 RR appears reasonable based on TTDDM application
  – However, TTDDM Must be Validated

• Caution! Results for Short-term Improvement Projects are Based on Aggregate Travel Time Savings

• Travel Time Data Driven Methodology has Promise, but Additional Research is Needed

• Methodology is Transferable to other DOT’s as TT Data has Become More Readily Available

• SHA Plans to Build Upon Research Results