Incorporating Travel Time Reliability Into Planning Applications

presented to
Tennessee Model Users Group

presented by
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Definition of travel time reliability (TTR) and why it’s important

Measuring reliability: data and methods

Forecasting reliability
  » SHRP 2 products
  » Example applications: Tampa and Knoxville MPOs
A Model of Congestion and Its Sources

Physical Capacity \( \text{4} \) \( \ldots \) interacts with \( \text{Demand Volume} \)

Base Delay ("Recurring" or "Bottleneck")

n = Source of Congestion
A Model of Congestion and Its Sources

Daily/Seasonal Variation

Special Events

Planned

Emergencies

Physical Capacity

...interacts with...

Demand Volume

...determine...

Base Delay
(“Recurring” or “Bottleneck”)
A Model of Congestion and Its Sources

1. Traffic Control Devices
2. Daily/Seasonal Variation
3. Special Events
4. Physical Capacity
5. Demand Volume
6. Roadway Events
   - Weather
   - Incidents
   - Work Zones

- Base Delay (“Recurring” or “Bottleneck”)
- ...interacts with...
- ...determine...
- ...lowers capacity and changes demand...
- ...can cause...

= Source of Congestion
Travel Time Reliability

- Measured by how travel time of a trip varies over time (from day-to-day) for a specific time period (e.g., peak period)

- In other words, reliability is measured as the variability of travel times
  - “How long will my trip take today compared to the same trip at the same time on any average day?”
  - … this implies …
  - Travelers should have the ability to predict travel time for a trip and to arrive at destination within an “on-time window”
Why Is Reliability Important?

- Less tolerance for unexpected delay
- Planning for unreliable travel has costs for users
  - In the past we assumed only the average travel time for a trip was valued, …but..
  - Studies have shown that variability/unpredictability has cost too
    - VOR ~ 80% of VOT
- Can be treated cost-effectively by addressing roadway “events” through operations strategies
  - But any capacity increase or demand reduction will also improve reliability
An analysis segment.

Each cell is one analysis period of an analysis segment.
Effects of Incidents and Weather

Weekday Travel Times
5:00-6:00 P.M., on State Route 520 Eastbound, Seattle, WA

Travel Time (in Minutes)

- 2 Incidents with Rain
- 3 Incidents
- 1 Incident with Rain
- 4 Incidents
- Rain
- 1 Incident

Jan 3 | Feb 2 | Mar 4 | Apr 3

Martin Luther King Day | Presidents Day

Number of Incidents

CAMBRIDGE SYSTEMATICS
## Reliability Measures in the New HCM

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Core Measures</strong></td>
<td></td>
</tr>
<tr>
<td>Planning Time Index (PTI)</td>
<td>95th percentile Travel Time Index (TTI) (95th percentile travel time divided by the free flow travel time)</td>
</tr>
<tr>
<td>80th Percentile Travel Time Index</td>
<td>80th percentile Travel Time Index (80th percentile travel time divided by the free flow travel time)</td>
</tr>
<tr>
<td>Semi-Standard Deviation</td>
<td>The standard deviation of travel time pegged to free flow travel time rather than the mean travel time (variation is measured relative to free flow travel time)</td>
</tr>
<tr>
<td><strong>Failure/On-Time Measures</strong></td>
<td></td>
</tr>
<tr>
<td>Percent of trips with space mean speed less than 50 mph; 45 mph; and 30 mph</td>
<td>Reliability Rating: Percent of trips serviced at or below a threshold travel time index (1.33 for freeways, 2.50 for urban streets)</td>
</tr>
<tr>
<td><strong>Supplemental Measures</strong></td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>Usual statistical definition</td>
</tr>
<tr>
<td>Misery Index (Modified)</td>
<td>The average of the highest five percent of travel times divided by the free flow travel time</td>
</tr>
</tbody>
</table>
The Travel Time Distribution is the Key to Understanding Reliability

Travel time (minutes) vs. Number of trips

- Free-flow = 11.5 minutes
- Avg. = 15.9 minutes
- 95th percentile = 22.7 minutes
- Planning time index = \( \frac{22.7}{11.5} = 1.97 \)
- Buffer time = \( 22.7 - 15.9 = 6.8 \) min.
- Buffer time index = \( \frac{22.7 - 15.9}{15.9} = 43\% \)

SR 520 Eastbound Seattle, 4-7pm weekdays
Another Travel Time Distribution

Travel Time (in Minutes) vs. Number of Trips (in Thousands)

- Free Flow
- Mean
- 95th Percentile
- 99th Percentile
- Misery Time
- Buffer Time
- Planning Time
- Standard Deviation
- Failure Measure
## Reliability Prediction: SHRP 2 Tools

<table>
<thead>
<tr>
<th>SHRP 2 Project</th>
<th>Analysis Scale (in order of increasing complexity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C11</td>
<td>Sketch planning; system or project level</td>
</tr>
<tr>
<td>L07</td>
<td>Detailed sketch planning; mainly project level</td>
</tr>
<tr>
<td>L08</td>
<td>Facility analysis using HCM scale of analysis</td>
</tr>
<tr>
<td>C10</td>
<td>Regional planning using linked travel demand and mesoscopic simulation analysis</td>
</tr>
<tr>
<td>L04</td>
<td>Regional planning using linked travel demand and mesoscopic or microscopic simulation analysis</td>
</tr>
</tbody>
</table>
L02: Guidelines for creating Reliability Monitoring Programs

- Types of data needed
- Data collection and processing
- Graphics

L05: Incorporating Reliability into Planning and Programming

- Process oriented

Main goals:

- Reliability used as a performance measure in project evaluations, deficiency analysis
- Operations projects considered at all phases of project development
Reliability Prediction for Tampa LRTP
Update: SHRP 2 C11

- Part of a larger FDOT effort to get SHRP 2 analytic products into practice
  - Reliability as a performance measure in alternative evaluations
  - “Mainstream” consideration of operations projects
- Methodology doesn’t require much data: sketch planning level
  - AADT, capacity, incident characteristics
- Considers both recurring and incident delay
  - BPR variant for recurring; IDAS model for incident
- Predicts several reliability metrics
  - Planning Time Index used: 95th %ile TT/Ideal TT
Approach

- Adapt recently developed methodologies to work with the TBRPM
  - Create a Post-Processor for model output
    - SHRP 2 Project C11 for Reliability
    - *Highway Safety Manual for Safety*

- Develop investment scenarios for operations and safety projects
  - Including project costs

- Conduct trade-off analysis: cost vs. outcomes
Reliability Prediction in Tampa

Tampa Data, 2010-2012

95th %ile TTI vs. Mean TTI
Scenarios Studied

- Low: traffic responsive signal control only
- Medium: “Low” + intersection geometric improvements + freeway TIM
- High: “Medium” + freeway ATM (ramp metering, VSL, lane control)
## Operations Impacts

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Scenario</th>
<th>20-Year Cost</th>
<th>Impact Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations &amp; Congestion Management</td>
<td>Low</td>
<td>$295M</td>
<td>Arterial capacity: +7%</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>$806M</td>
<td>Arterial capacity: +17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Incident frequency: -5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Incident duration: -25%</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>$957M</td>
<td>Arterial capacity: +17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Incident frequency: -7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Incident duration: -25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Freeway capacity: +10%</td>
</tr>
</tbody>
</table>
## Tampa Reliability Results

<table>
<thead>
<tr>
<th>Highway Type</th>
<th>Mobility Measure</th>
<th>2040 Scenario</th>
<th>Investment Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeways</td>
<td>Average TTI</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Base</td>
<td></td>
<td>1.580</td>
</tr>
<tr>
<td></td>
<td>With Improvements</td>
<td></td>
<td>1.580</td>
</tr>
<tr>
<td></td>
<td>80th percentile TTI</td>
<td>Base</td>
<td>1.891</td>
</tr>
<tr>
<td></td>
<td>With Improvements</td>
<td></td>
<td>1.891</td>
</tr>
<tr>
<td></td>
<td>Planning Time Index</td>
<td>Base</td>
<td>2.206</td>
</tr>
<tr>
<td></td>
<td>With Improvements</td>
<td></td>
<td>2.206</td>
</tr>
<tr>
<td></td>
<td>Centerline Miles Improved</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Goal is to move products into practice

TDOT & Knoxville TPO have FHWA assistance funding

» Develop L02-style monitoring system
  • MPO and state levels

» L05: Incorporate reliability and operations into all planning documents and analyses

» C11: Reliability forecasting for the LRTP and other planning activities

» Replace “static” HCM analysis with L08 reliability method

» Target setting tool based on L07 prediction model
Create “user grade” post-processor
  » Make available for other TN MPOs

Include demand variability; maybe weather?

Replace BPR function for recurring with HCM methods

Custom reliability relationships using local vehicle probe data

Account for synergies between safety and capital expansion/operations projects

Consider all congestion relief projects simultaneously: operations, Capital expansion, demand management, transit

Can help with MAP-21 target setting
L08 Approach

1- Seed File Data
Facility description
Current HCM2010

2- Create Seed File

3a- Scenario Generator Data
Facility profiles
--demand
--incident
--weather

3b- Generate Scenarios
Generates:
--Probability
--demand adjust.
--cap. adjust.
--FFS adjust.
--lane adjust.

4- Execute Scenarios in FREEVAL-RL
Expanded, enhanced version of FREEVAL2010

5- Generate Output and Summary Report
Travel time index distribution, other statistics
At zero inclusion threshold, # of scenario runs → 1,928

At recommended threshold of 0.01% → 602 (about 90 min)

Mean facility travel speed between 4-7 pm on weekdays ~ 49.7 mph

Worse 5% of time facility operates at speed < 36 mph

Unacceptable operations (TTI > 1.33) --- affect about 15% of the VMT
LO2: Why do we need a Travel Time Reliability Monitoring System (TTRMS)?

- This is really just a system for measuring congestion/mobility
  - But we need to capture the “Seven Sources”

- Can have real-time applications
  - What is happening now vs. “typical” or “worst case”

- The value for planning is to support performance management
A TTRMS Supports the Performance Management Process

- Goals and Objectives
- Develop Performance Measures
- Establish Targets
- Develop Program and Strategy Types
- Monitor Conditions and Trends Empirically
- Identify Problems; Implement Projects and Policies
- Evaluate Actions
- Library of Benefits and Costs
- Refine Measures
- Adjust Targets
- Continuous Monitoring
- TTRMS

Success?

Y

Remediate Original Action

N

Assess Progress Toward Targets

Provide Data for Forecasting

Develop PM Reports, Dashboard, and MAP-21

Report Bottleneck ID and Corridor Performance

Provide Data for Evaluations

Annual Target Achievement Report
WHAT THEY TELL YOU

Level 1
- Travel conditions are unreliable (Variable over time)

Level 2
- What's causing unreliable travel (e.g., incidents, weather, work zones)

Level 3
- What aspects of operations, management, and construction need to be improved

MEASURES

Overall Reliability
- e.g., buffer index

Delay by Source
- e.g., vehicle-hours

USED BY

- Upper Management
- Public Relations
- Planners

- Mid-Management
- Operators
- Planners

Activities, Procedures, and Policies

INCIDENT TIMELINE

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident Occurs</td>
<td>6:35 A.M.</td>
</tr>
<tr>
<td>Incident Recorded into CAD (Detection)</td>
<td>6:42 A.M.</td>
</tr>
<tr>
<td>Incident Verified</td>
<td>6:47 A.M.</td>
</tr>
<tr>
<td>Personnel Dispatched and Actions Initiated</td>
<td>6:49 A.M.</td>
</tr>
<tr>
<td>Responders Arrive to Scene</td>
<td>6:50-7:00 A.M.</td>
</tr>
<tr>
<td>Incident Cleared and Actions Canceled</td>
<td>7:15 A.M.</td>
</tr>
<tr>
<td>Return to Normal Conditions</td>
<td>8:26 A.M.</td>
</tr>
</tbody>
</table>

Detection Time  
Verification Time 
Dispatch Time  
Response Time  
Clearance Time  
Time to Normal Conditions
Questions?

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