Estimating Freeway Route Travel Time Reliability from Data on Component Links and Associated Cost Implications

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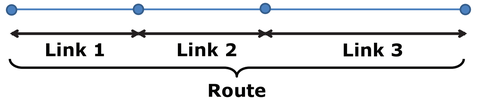
Motivation

- Data on travel time (speed) and traffic volume are collected for relatively short homogenous links of a roadway, but travelers need reliability information for entire routes they travel.
- There is a need to estimate reliability on an entire route from data collected at the link level.
- Reliability measures (Planning Time Index [PTI]) are more sensitive to skew and dispersion of travel time than mobility measures of average conditions (Travel Time Index [TTI]).
- Weighting link indices by vehicle miles traveled (VMT) to get the corresponding route index (see graphic below) does not work well for route PTI estimation. It gives unreasonably high route PTI values.



- There is a need to incorporate skew and dispersion properties of travel time to more realistically estimate route traveler experiences.
- More accurate index estimates provide better congestion cost and planning time cost estimates. Overestimated PTIs result in wasted planning time and associated costs for travelers.

Index Estimation Methods

Current Practices

1. VMT-weighting of link indices to get corresponding route index (TTI and PTI).
2. SHRP-2 L03 equation: $PTI_{95,trip} = X_1^{0.8014}$
   X_1= VMT-weighted average of PTIs of all links in the route
3. Modified SHRP-2 C11 equation: $PTI_{95,trip} = 1 + 3.67 * \ln(TTI)$
   where TTI = VMT-weighted average of link TTIs
   Note: Methods 2 and *3 use "data-poor" equations (developed with limited data).*
4. Trajectory method (tracing the vehicle in time and space through the entire route to estimate travel time and subsequent measures).

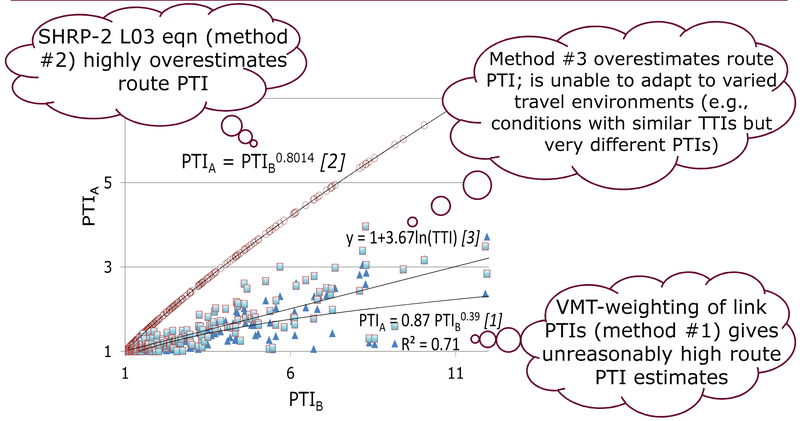
Alternate Method

5. Approximating dispersion measures (percentiles) from 15-minute annual average travel times from profiles provided by INRIX.

Procedure and Assumptions

- Simplified eqn behind current study: $A = \alpha * B^{\beta} + \varepsilon$ (Eqn 1)
  - A ⟶ "trajectory" method: Tracing the vehicle in time and space through the entire route.
  - B ⟶ VMT-weighting method: Weighting of link indices from respective route.
- Cost estimate: 70% of overestimated planning time wasted.

Results



subscripts A and B in the above graph from Eqn (1)

Conclusions

- Traffic conditions on constituent links are not independent of each other; route PTIs fluctuate significantly less than link PTIs.
- Simple VMT-weighting gives inflated results because travelers do not face the 5 percent worst times on all links of the trip.
- Alternate method #5 gives better estimates of PTI and cost.

Cost of Wasted (Planning) Time Using Different PTI Estimates	
PTI Estimation Method	Congestion Cost (billion $)
1 - very high overestimation	$ 17.96 B
2 - high overestimation	$ 11.93 B
3 - better than [2]; not as good for high PTIs	$ 3.57 B
4 - close to ground truth (trajectory method)	$ 3.74 B
5 - alternate method	$ 3.65 B