Calibrating Travel Demand Model Volume-Delay Functions Using Bottleneck and Queuing Analysis

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Overview

• Literature Review
• Motivation
• Approach
• Results
• Conclusions and Future Research
Literature Review

- BPR, Conical, HCM, Akcelik
- Adjustments made during highway assignment
- Some agencies use locally collected data, most rely on defaults
- Need for more research on methods for using locally collected data
Motivation

Challenge:
- Models heavily dependent on data
- Highway assignment relies primarily on traffic counts
- How to represent demand greater than capacity

Solution:
- Freeway detector data
- Bottleneck and Queue Analysis
- Approach for estimating demand beyond capacity
Processing: Density

\[ k = \left( \frac{52.8}{L_v + L_d} \right) \times \%OCC \]

K = density (pc/mile)

L_v = average vehicle length (feet)

L_d = detection zone length (feet)

\%OCC = percent occupancy
Processing: Reasonableness Checks
Identification of Bottleneck Approach
Spatial Extent of Queue

Queue Time-Space Domain

- Time of Day
- Downstream Distance from Location 1

Approach
Length of Queue

\[ A = \left(0.5d_{ud} \times L\right) + \left(0.5d_{dd} \times L\right) \]

A = area of influence
\(d_{ud}\) = distance to upstream detector (mi)
\(d_{dd}\) = distance to downstream detector (mi)
L = number of lanes
Queue per Time Interval

\[ Queue_T = \sum_{i=1}^{n} [(k_{Ti}) \times (A_i)] \]

T = time interval of interest (min)
i = detector
n = maximum number of detectors
\( k_{Ti} \) = density at time interval T for detector i (pc/mi)
\( A_i \) = number of lanes
Demand

\[ \text{Demand}_B = (\text{DemandAtCapacity}) + (\text{Queue}_T) \]

\( D_B \) = demand at the bottleneck

DemandAtCapacity = calculated as the average of the top 1% measured flow rate

Queue\(_T\) = queue per time interval

Finally:

\[ D / C = (\text{Demand}_B) / (\text{Capacity}) \]
Model Fitting

Results
## Model Fitting

<table>
<thead>
<tr>
<th>Function</th>
<th>$t_0$ (hrs)</th>
<th>FFS (mph)</th>
<th>Alpha</th>
<th>Beta</th>
<th>J</th>
<th>$R^2$</th>
<th>MSE (mph)$^2$</th>
<th>T-test</th>
<th>F-test</th>
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<tbody>
<tr>
<td>BPR</td>
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<td>63.4</td>
<td>0.17</td>
<td>4.50</td>
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<td>0.88</td>
<td>.06</td>
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<td>0.72</td>
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<td>0.10</td>
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<td>Exponential</td>
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<td></td>
<td>0.86</td>
<td>.07</td>
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<td>0.19</td>
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</tbody>
</table>
Findings

- Models perform well
- Parameters are within expected range
- Akcelik, BPR, and exponential acceptable models
- Bottleneck and queuing analysis effective approach
Conclusions / Future Research

Conclusions:
- Analysis tools needed
- Visualize demand > capacity
- Straightforward approach

Future Research:
- Transferability
  - Other freeways in Raleigh-Durham
  - Other freeways in other areas
  - Multi-lane highways
Thank You!