Intersection Delay Relationships in Travel Models – Minimum Recommendations and Deployment Challenges

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24 Year Saga

- 1991: “Delay/Volume Relations for Travel Forecasting Based upon the 1985 Highway Capacity Manual” for FHWA by me
- 2015: “Traffic Assignment and Feedback Research to Support Improved Travel Forecasting” for FTA by Caliper
Lesson from Caliper/FTA Report

○ Recap:
  ● 5 very large MPO models
  ● All models used VDFs, exclusively
  ● Comparison of forecasted speeds (travel times) with HERE travel times
  ● Speed estimates were not good.
  ● Caliper recommendation: Need better calibrations of VDFs

○ My recommendation: Ditch VDFs for node delays at urban intersections.
Correct Method Outlined in 1991 FHWA Report

- Delay at intersections should be calculated with operational analysis procedures in the HCM or similar.
- Must consider: turning, opposing and conflicting traffic.
- Restrictive conditions on VDFs required for Frank-Wolfe decomposition cannot be attained:
  - Non-monotonic
  - Non-continuous
  - Not closed form, cannot be integrated
Sample 1985 HCM Results

Figure C.8
Delay on All Approaches of a Signalized Intersection as a Function of Volume on a Single Approach (25% Right Turns, 25% Left Turns, 600 VPH at Opposing and Conflicting Approaches, Exclusive Right, 1800 VPH Ideal Saturation Flow Rate, 20 MPH Speed, Arrival Type = 3, 90 Second Cycle)
QRS II’s Signalized Implementation, 2010 HCM

- Two lane groups, L + TR.
- 4 phase plans, up to 2 phases per approach.
- $d_1$ and $d_2$ terms for delay ($d_3$ is unnecessary because of DTA queuing.)
- Three options for timing:
  - Adaptive (medium to long range)
  - Fixed (short range)
  - Actuated (short range)
Other Node Delay, Briefly

- Some-way stops
- All-way stops
  - M/G/1 queuing model
  - Predates HCM but results are very similar
- Roundabouts
  - Based on SIDRA gap acceptance theory
  - Predates HCM but results are likely better, given stronger theory for circulating traffic
- Ramp Meters
  - No conflicting or opposing traffic
Implications for Sensitivity

- Cedar Rapids Experiment (MS Thesis at UWM, Craig Holan)
  - Network originally developed with node delays, but a second network was calibrated with VDFs only.
  - Node delays v. VDF under growth scenarios
  - Compare emissions changes
- Changes with node delays were about **twice** those seen with VDFs.
The Inadvertant Parkersburg + Huntington Experiments

- Comparison of Two Models
  - Ohio DOT – QRS II with node delays, DTA
  - Consultant – TransCAD with VDFs
- WWW: Parkersburg
- KYOVA: Huntington
<table>
<thead>
<tr>
<th>Model Description</th>
<th>Volume RMS Error</th>
<th>Arterial Travel Time Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>QRSII-based (2005) model</td>
<td>29% (w/1,217 counts)</td>
<td>9.5%</td>
</tr>
<tr>
<td>TransCad-based (2010) model</td>
<td>35% (w/727 counts)</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>35% (w/1,426 counts)</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>42% (w/456 counts)</td>
<td>25%</td>
</tr>
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</table>
### Validation Accuracy

<table>
<thead>
<tr>
<th>Volume Range, ADT</th>
<th>Ohio Minimum Standard</th>
<th>Best Practical Experience</th>
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<tbody>
<tr>
<td>0-499</td>
<td>200%</td>
<td>166%</td>
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<tr>
<td>500-1499</td>
<td>100%</td>
<td>80%</td>
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<tr>
<td>1500-2499</td>
<td>62%</td>
<td>48%</td>
</tr>
<tr>
<td>2500-3499</td>
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<td>3500-4499</td>
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<td>32%</td>
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<td>4500-5499</td>
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<tr>
<td>5500-6999</td>
<td>42%</td>
<td>25%</td>
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<td>7000-8499</td>
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<td>10000-12499</td>
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<td>15000-17499</td>
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<tr>
<td>17500-19999</td>
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<td>11%</td>
</tr>
<tr>
<td>20000-24999</td>
<td>26%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Travel Time Comparisons, Milwaukee Mitchell Window
Forecast of Arterial Travel Times Following Closures

- Prior to Closure: Estimate OD table from traffic counts (static 1 hour); obtain NAVTEQ travel time data
- Apply closures to network; assign OD table; observe delays
- Perform floating car runs of most arterials (8 samples per trajectory)
- Compare sets of travel times
Floating Car Runs, Sample Results (Youngblom/Virk)

Average Travel Time (Min) per Mile

20th Street
- Navteq Patterns
- Navteq Analytics
- QRS II with Closure
- QRS II without Closure
- Floating Car w/o Stop Delay
- Floating Car

Layton Avenue
- Navteq Patterns
- Navteq Analytics
- QRS II with Closure
- QRS II without Closure
- Floating Car w/o Stop Delay
- Floating Car
RADIUS: Very General
Overview

- RADIUS 39 and RADIUS 94 are dynamic traffic assignments of traffic for short-term estimation of freeway work zone traffic volumes considering the possibility of diversion.
- Two large regions:
  - I-39 corridor from South Beloit to Madison
  - I-94 corridor from Northern IL to Madison
- Platform is Quick Response System II (QRS II) and General Network Editor
I-94 Whole Network
Models Differ by Time Period

- Four models for each area:
  - Weekday AM (6 am to 10 am)
  - Weekday PM (Mon-Thurs, 3 pm to 7 pm)
  - Friday PM (3 pm to 7 pm)
  - Sunday PM (3 pm to 7 pm)
Intersections Features

- Every Signal
  - Adaptive (adjusted for traffic flows as forecast, per HCM signal timing method using flow ratios, and then uses 2010 HCM fixed time procedures)
  - Actuated (uses the 2010 delay actuated procedures with local signal timing parameters)
  - Fixed-timed available, but not used so far

- Every Roundabout

- Many Stop Signs
  - HCM some-way or all-way procedures within 2 miles of a freeway

- Budget: ½ student-hour per intersection
Assignment Details

- **OD Table Creation**
  - NCHRP Report 365, Trip Generation, Trip Distribution and TOD (static)
  - Static refinement with 6500 counts.
  - Dynamic refinement with 6500 counts stations in 4 one-hour intervals.
  - 31,000,000 OD pairs statistically estimated for each time period.

- **Left Turn Penalties**

- **MSA**
Conclusion

- IMHO, ignoring node delays is no longer an option.