Day-to-day variability of signalized intersections performance and the importance for field evaluations

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Description of the Issue

Estimating signalized intersection performance: current practice
Peak hour traffic volumes are not constant from one day to the next.
Description of the Issue...
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Design Threshold

- **80% TIME < LOS D**
- **20% TIME < LOS C**
- **LOS C 20% of Time**
- **LOS D 60% of Time**
- **LOS E / F 20% of Time**

Average Intersection Delay (seconds)

(Computed using Peak Hour Volume from different weekdays)

ITS AGM 2007
Objectives of Research

Objectives:

- Determine the importance of day-to-day variability of intersection performance due to variability of peak hour traffic volumes
- Devise practical methods accounting for variability in decision making.
Research Methodology

1. Determine variability of peak hour traffic volumes using field data
2. Use Monte Carlo Simulation to find impact of variations in approach volumes on intersection delay
3. Apply statistical techniques to determine the number of peak-hour traffic counts required to make decisions with given level of confidence
Empirical Data set

Descriptive statistics for Peak Hour Volume (PHV)

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean</th>
<th>Std</th>
<th>COV</th>
<th>No of days</th>
</tr>
</thead>
<tbody>
<tr>
<td>62 (1-way)</td>
<td>1287</td>
<td>69.6</td>
<td>0.054</td>
<td>209</td>
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<tr>
<td>182-WB</td>
<td>1375</td>
<td>97.6</td>
<td>0.071</td>
<td>213</td>
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<tr>
<td>184-WB</td>
<td>658</td>
<td>61.5</td>
<td>0.094</td>
<td>213</td>
</tr>
<tr>
<td>184-EB</td>
<td>594</td>
<td>54.9</td>
<td>0.093</td>
<td>213</td>
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<tr>
<td>290-WB</td>
<td>1282</td>
<td>111.5</td>
<td>0.087</td>
<td>213</td>
</tr>
<tr>
<td>312-NB</td>
<td>971</td>
<td>62.6</td>
<td>0.065</td>
<td>214</td>
</tr>
<tr>
<td>313-NB</td>
<td>822</td>
<td>52.7</td>
<td>0.064</td>
<td>214</td>
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<tr>
<td>313-SB</td>
<td>855</td>
<td>112.3</td>
<td>0.131</td>
<td>214</td>
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<tr>
<td>484-NB</td>
<td>720</td>
<td>69.4</td>
<td>0.096</td>
<td>204</td>
</tr>
<tr>
<td>484-SB</td>
<td>961</td>
<td>106.6</td>
<td>0.111</td>
<td>171</td>
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<tr>
<td>Average</td>
<td>952</td>
<td>79.9</td>
<td>0.087</td>
<td>208</td>
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<tr>
<td>Maximum</td>
<td>1375</td>
<td>112.3</td>
<td>0.131</td>
<td>214</td>
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<tr>
<td>Minimum</td>
<td>594</td>
<td>52.7</td>
<td>0.054</td>
<td>171</td>
</tr>
</tbody>
</table>

Data from vehicle count stations (Kitchener Waterloo, 2005)
Empirical Data

- Average COV = Std/Mean = 0.087
- Follows a Normal Distribution

X-axis = peak hour volume; Y-axis = frequency
Monte Carlo Simulations

Simulate a hypothetical 4-leg intersection

- Turning movement proportions fixed
- Two-phase fixed time signal control
- 11 v/c ratios (11,000 trials)
- Approach volumes vary
  - Normal distribution; COV=0.087
Results: Variation in Delay

![Graph showing intersection average vehicle delay versus cumulative probability for different LOS levels and V/C ratios.](image)
Results:
Confidence limits of delay

<table>
<thead>
<tr>
<th>LOS</th>
<th>Lower 99% Confidence Limit</th>
<th>Lower 95% Confidence Limit</th>
<th>Mean</th>
<th>Upper 95% Confidence Limit</th>
<th>Upper 99% Confidence Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>B</td>
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<tr>
<td>E</td>
<td></td>
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<tr>
<td>F</td>
<td></td>
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</tbody>
</table>

Direction of travel:

- LOS = F
- LOS = E
- LOS = D
- LOS = C
- LOS = B
- LOS = A

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Results:
Number of Peak Hour Traffic Counts Required

- Estimation error = 10% of Mean
- 20%
- 30%
- 50%

Required Number of Observations

Degree of Saturation (v/c)

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Conclusions & Implications

- Variability of intersection peak hour delay can be quite large
- Variation increases as v/c increases
- It is generally NOT sufficient to estimate intersection performance on the basis of traffic counts from a single day.
  - This is particularly important for “before and after” studies of the effectiveness of ITS applied to signalized intersections.
On Going Work

- Impact of day to day variability on evaluation of Transit signal priority.
- Establish warrants for Transit Signal Priority implementation considering important sources of random variability
Outline

Description of the Issue
Objectives of Research
Analysis Approach
Results
Conclusions and Implications
On-Going Work
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- 20%
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- 50%