CITE 2007

IMPACT OF DAY TO DAY VARIABILITY OF PEAK HOUR VOLUMES ON SIGNALIZED INTERSECTION PERFORMANCE

ZEESHAN ABDY AND BRUCE HELLINGA
UNIVERSITY OF WATERLOO
Outline

Problem Description
Objectives of Research
Research Methodology
Results
Practical Implications
On-Going Work
Problem Description

Input Parameters
- Geometric
- Peak Hour Volume
- Signal
- Peak Hour Factor
- Saturation Flow rate
- Capacity
- v/c

Performance Measures
- Delay
- LOS
- Queue

CCG and HCM procedures
Peak hour traffic volumes vary from one day to next.
Problem Description ...
Problem Description ...

(Computed using Peak Hour Volume from different weekdays)
Objectives of Research

- Quantify the impact of peak hour traffic volume variability on intersection performance
  - i.e. Is the variation significant?
- Devise practical methods to account for variability in decision making
Research Methodology

1. Quantify variability of peak hour volume using empirical data.
2. Determine the impact of variations in approach volume on intersection delay using Monte Carlo Simulation (MCS).
3. Determine the number of peak-hour traffic counts required to make decision with given level of confidence.
Data from vehicle count stations (Kitchener - Waterloo, 2005)

<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>
</tr>
<tr>
<td>182-WB</td>
<td>1375</td>
<td>97.6</td>
<td>0.071</td>
<td>213</td>
</tr>
<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>
</tr>
<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>
</tr>
<tr>
<td>313-SB</td>
<td>855</td>
<td>112.3</td>
<td>0.131</td>
<td>214</td>
</tr>
<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>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>952</td>
<td>79.9</td>
<td>0.087</td>
<td>208</td>
</tr>
</tbody>
</table>
Empirical Data

Follows a Normal Distribution

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

- 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

HCM 2000

Intersection Delay
Results: Variation in Delay

Intersection Average Vehicle Delay (seconds)

Cumulative Probability

v/c = 0.6
v/c = 0.9

LOS A LOS B LOS C LOS D LOS E LOS F

v/c = 0.6
v/c = 0.9
As v/c increases, so does variability in intersection performance (COV)
Practical Implications (1)

• Question 1:
  – How accurate does the estimate of average intersection delay need to be?

• Answer:
  – Choice of engineer BUT higher accuracy = higher level of confidence
  – Likely want higher level of confidence to support more costly decisions
Question 2:
- For a given desired level of accuracy, how many days of volume counts are required?

Answer:
- Function of variability of intersection delay
  - This is a function of intersection v/c
Required Number of Peak Hour Traffic Counts

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

Degree of Saturation (v/c)

Required Number of Observations

- 0.5
- 0.6
- 0.7
- 0.8
- 0.9
- 1
- 1.1
Practical Implications (3)

Traffic Counts

Day 1 → HCM/CCG → Delay 1
Day 2 → HCM/CCG → Delay 2
Day 3 → HCM/CCG → Delay 3
...
Day N → HCM/CCG → Delay N

Average Delay

Average PHV → HCM/CCG → Average Delay
On Going Research

- Obtain additional field data from another location to confirm the findings of this study.
- Examine the impact of day-to-day variability of the PHF and turning movement proportions.
- Establish criteria to incorporate the day-to-day variability of these parameters within existing signalized intersection evaluation and analysis methodologies.
- Consider variability within warrant methods for traffic signals and transit signal priority.