INTERSECTION TRAFFIC CONTROL COMMITTEE

Meeting Minutes
November 4th, 2015

ATTENDEES

<table>
<thead>
<tr>
<th>Name</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean Chamberlain (Chair)</td>
<td>Toole Design Group</td>
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<tr>
<td>Mark Wagner (Co-Chair)</td>
<td>SEH</td>
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<tr>
<td>Jake Bongard</td>
<td>Bolton &amp; Menk</td>
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<tr>
<td>Ben Hao</td>
<td>AECOM</td>
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<tr>
<td>Molly Stewart</td>
<td>Bolton &amp; Menk</td>
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<tr>
<td>Allen Bradford</td>
<td>Scott County</td>
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<tr>
<td>Scott Poska</td>
<td>SRF</td>
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<td>Angie Christo</td>
<td>AECOM</td>
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<tr>
<td>Jacob Rojer</td>
<td>Westwood</td>
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<tr>
<td>Roger Plum</td>
<td>SEH</td>
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<tr>
<td>Ken Levin</td>
<td>Hennepin County</td>
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<tr>
<td>Jacqueline Nowak</td>
<td>U of M</td>
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<td>Jon Krieg</td>
<td>Hennepin County</td>
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<tr>
<td>Nicole Flint</td>
<td>MnDOT</td>
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<td>Kevin Schwartz</td>
<td>MnDOT</td>
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<td>Jerry Kotzenmacher</td>
<td>MnDOT</td>
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<tr>
<td>Joel Marcuson</td>
<td>Hennepin County Traffic</td>
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<tr>
<td>Max Moreland</td>
<td>TDI</td>
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<td>Mike Fairbanks</td>
<td>MnDOT</td>
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<tr>
<td>Mike Klobuchar</td>
<td>City of Saint Paul</td>
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<tr>
<td>Nick Ollrich</td>
<td>Metro Transit</td>
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<tr>
<td>Nik Costello</td>
<td>Washington County</td>
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<tr>
<td>Sean Jenkins</td>
<td>City of Bloomington</td>
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<td>Sonja Piper</td>
<td>Westwood</td>
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<td>Sudheer Dhulipala</td>
<td>WSB</td>
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<td>Sue Zarling</td>
<td>MnDOT</td>
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<tr>
<td>Suzanne Hanrahan</td>
<td>Dakota County</td>
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<td>Joel Hinnekamp</td>
<td>Kimley-Horn</td>
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<td>Brian Villa</td>
<td>Kimley-Horn</td>
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<td>Cindy Hazelton Dittberner</td>
<td>MnDOT</td>
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<tr>
<td>Jane Williams</td>
<td>City of Grand Forks</td>
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<tr>
<td>Vic Lund</td>
<td>St Louis County</td>
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<td>Yiluh Xu</td>
<td>U of M</td>
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MEETING LOCATION: SRF Consulting Group

I. Remaining meeting times/locations for 2015
   December 2, 2015 (8:00-10:00am): MnDOT Water’s Edge

II. Presentation – Flashing Yellow Arrows: LRRB Training: Tool for Time of Day Use – Vahid Moshtagh (SRF Consulting Group)
   The following is a summary of Vahid’s presentation. The full presentation is attached at the end of these minutes.

1. Introduction
2. Problem Statement
3. Methodology Overview
4. Data Collection
5. Geometric Characteristics
6. Sight Distance Issue
7. Crash Data
8. TOD Adjustment
9. Crash Prediction Models
10. Site Classification
11. Relative Risk Models & Diagram
12. Example Implementation
13. Estimating Hourly Volume
14. Base Condition
15. Spreadsheet Tool example
16. Spreadsheet Tool: SD sheet
17. Threshold Relative Risk
18. Next Steps
19. Questions
   a. Q – Are pedestrians confused by FYA and a WALK hand showing at the same time? A – Pedestrians are still adjusting. Risk analysis does not account for pedestrian risk.
   b. Q – Minimum amount of hourly data needed for spreadsheet to work? A – 8 is desired, but 6 will suffice.
   c. Q – Most studied intersections were outside Minneapolis/Saint Paul. What’s the applicability to compact city intersections? A – The research captured many types of intersections at different speeds, so the analysis tool should be applicable.
   e. Q – Could the base condition change over time? A – Yes, agencies could change their base conditions in the future.

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III. Round Robin
1. Ken Levin noted that time-of-day usage of FYA can affect driver expectations.
2. Bob Betts noted that with FYA, left-turn trap scenarios should be avoided. Also noted that the right-most lane should be used for the sight distance calculations related to dual-left scenarios.

NEXT MEETING:

Date: Wednesday, December 2nd, 2015 (8:00-10:00am)

Location: MnDOT Water’s Edge
1500 West County Road B2
Roseville, MN 55113

Topics: Crosswalk Treatments Tech Memo

Presenting: Melissa Barnes
Outline

- Research background
- Example implementation using the spreadsheet tool
- Considerations and limitations
- Potential improvements

Introduction

- Left-turn Control types
  - Protected-only
    - 3-section head
  - Permissive-only
    - 3-section head
  - Protected/Permissive (PPLT)
    - 5-section head
  - FWA
Introduction

- Protected LT phasing
  - Eliminate most LT crashes
  - Increases LT delay, especially during low demand
- Permitted LT phasing
  - Increases opportunity for LT crashes
  - Decrease LT delay during low demand
- Switch between protected and permitted
  - FYA
    - support time-of-day phasing changes

Problem Statement

- Two aspects of the decision regarding left-turn treatment:
  - Operational impacts: signal optimization or traffic simulation programs
  - Safety impacts: how risk of a left-turn crash varies as traffic conditions vary was still an open question
- Objectives
  - To develop statistical models which predict within-day variation of left-turn crash risk
  - To provide risk-related information to aid agencies in making decisions regarding time-of-day use of permitted left-turn phasing

Methodology overview

- Models (safety performance functions) do exist for predicting annual totals of left-turn crashes
- No one has attempted to model crash frequency per hour
- Size of database required for such analysis increases from thousands of rows to tens of millions of rows
- Developing safety performance functions for hourly crashes is not practical
Methodology overview

• Matched case-control design
  • Does not rely on the accuracy of crash inventory databases
  • Size of required database drops down to thousands of rows
  • Will not predict the expected frequency of LT crashes
  • It describes how the risk changes as dominating conditions change

Data Collection

1. Candidate intersection approaches
2. Approach characteristics
3. Crash data
4. Traffic volume data

Intersection location

328 intersections having 714 approaches
Geometric characteristics

- Left-turn offset
  - a) Negative offset
  - b) Zero offset
  - c) Positive offset
  - d) Not applicable: No opposing left-turn movement e.g. T-intersections, Diamond interchanges

Sight distance issue

- Different from the sight distance concept in AASHTO Green Book caused by fixed obstacles
- It assumes the opposing vehicle presence

Crash data

- 2007-2011
- HSIS: 575 LT crashes at 328 intersection
  - Accuracy issues
- MNCMAT: 222 new crashes
Available turning movement counts

Time-of-day adjustment
• Peak period counts can be adjusted to reflect off-peak traffic volumes if one knows how traffic volumes vary during the day
  • Turning movement counts from 6 intersections during one week
  • 70 sets of 24-hour turning movement patterns

Crash prediction models
• Highway Safety Manual: Safety Performance Functions (SPF)
  \[ E[Y_{it}] = \exp(\beta_0 + \beta_1 \ln(x_{1t}) + \beta_2 \ln(x_{2t})) \]
  • \(E[Y_{it}]\) = expected left-turn crash hour \(t\),
  • \(x_{1t}\) = left-turn volume hour \(t\),
  • \(x_{2t}\) = opposing through plus right-turn volume hour \(t\),

• Matched case-control design
  • \(\beta_1, \beta_0\) can be estimated
  • \(\beta_2\) cannot be estimated
  • Features that are constant to cases and controls, such as an intersection’s geometric features, cannot be estimated from matched case-control sampling
Site classification

- Classification of crash-occuring approaches

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Prot-Per</th>
<th>Opps</th>
<th>More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opposing SL &lt; 45 mph</td>
<td>50 pred.</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No pred.</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Opposing SL &gt; 60 mph</td>
<td>14 pred.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No pred.</td>
<td>3</td>
<td>1</td>
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- Only three categories had adequate number of crashes to fit reliable statistical models

Relative Risk (RR) models

- Risk for a left-turning crash during a target hour \( t \) to the risk during a reference condition

\[ RR = \frac{P(\text{crash}|x_{1,t},x_{2,t})}{P(\text{crash}|x_{1,0},x_{2,0})} = \exp\left(\beta_1 \ln\left(\frac{x_{1,t}}{x_{1,0}}\right) + \beta_2 \ln\left(\frac{x_{2,t}}{x_{2,0}}\right)\right) \]

- Analogy: Epidemiology studies

Relative Risk (RR) diagram

- Base condition: LT volume=50 vph, Opposing volume=200 vph
- Protected-permitted, opposing speed limit<45 mph, and no potential sight distance issue
Example implementation

- Northbound at Robert and Mendota
- Prot-perm, No SD problem, Opp SL=40 mph
  - Parameters: \( \beta_1=0.38, \beta_2=0.37 \)
- Base condition:
  - \( x_1,0=100 \) vph
  - \( x_2,0=500 \) vph

Estimating hourly volumes

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>8-9</th>
<th>9-10</th>
<th>10-11</th>
<th>11-12</th>
<th>12-13</th>
<th>13-14</th>
<th>14-15</th>
<th>15-16</th>
<th>16-17</th>
<th>17-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Turn (veh/hour)</td>
<td>61</td>
<td>68</td>
<td>125</td>
<td>96</td>
<td>131</td>
<td>67</td>
<td>36</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Turn (veh/hour)</td>
<td>316</td>
<td>304</td>
<td>372</td>
<td>365</td>
<td>327</td>
<td>276</td>
<td>262</td>
<td>304</td>
<td></td>
<td></td>
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Estimated turning movement volumes along with ±1 std. deviation

Relative Risk (RR) diagram
Base condition

• FHWA Signal Timing Manual

Base condition

• HCM 2000

<table>
<thead>
<tr>
<th>Number of Through Lanes</th>
<th>Min Cross Product</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>50,000</td>
</tr>
<tr>
<td>2</td>
<td>90,000</td>
</tr>
<tr>
<td>3</td>
<td>110,000</td>
</tr>
</tbody>
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Base condition

• MnDOT Traffic Signal Timing and Coordination Manual 2013

Question 6: Speed and Cross Product

- If the answer is Yes, Protected Operation is suggested for the TDO.
- If the answer is No, PIA may be possible during the time period.

Less conservative than the other references
Spreadsheet Tool: example

- McKnight Rd N & Burns Ave southbound direction
  - Sight Distance (SD) sheet
  - Recommended defaults:
    - OTLw = 12 feet
    - OLTLw = 12 feet
    - Y = 0 feet
    - Vi = 7 feet
    - Wi = 3.5 feet
    - Xi = 3.5 feet

Spreadsheet Tool: SD sheet

Spreadsheet Tool: RR diagrams
Spreadsheet Tool: more discussion

• Remove the off-peak counts and try again
• Differentiates LT=250 & Opp=400 from LT=400 & Opp=250
• Vertical or horizontal curve?
  • Use the tool to calculate the required sight distance.
  • Use Google Maps, Google Earth, site plan, etc. to approximate the available sight distance.
  • Compare these two to identify the SD situation.
  • Manipulate LT offset (X0) to make sure the SD sheet is identifying the same SD situation.

• Yi=0

• Do not insert any rows or columns

Threshold Relative Risk

<table>
<thead>
<tr>
<th>Base: LT=50, Opp=200</th>
<th>LT=100, Opp=500</th>
</tr>
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<tbody>
<tr>
<td>![Graph 1]</td>
<td>![Graph 2]</td>
</tr>
</tbody>
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What is the next step?

• Site classification
  • 3 criteria: 8 site categories
  • Models were developed for 3 categories
• Expand the sample size for other intersection approach types and re-estimate their beta coefficients
  • Speed limit ≥45 with no sight distance issue

• Suggestions and feedbacks
Access to the Tool

- The spreadsheet tool can be accessed on the LRRB or MnDOT research services websites
- LRRB.org Search: Flashing Yellow Arrow
- http://dotapp7.dot.state.mn.us/projectPages/pages/projectDetails.js?id=9151&type=CONTRACT

Questions

Vahid Moshtagh
vmoshtagh@srfconsulting.com
763-452-4778
**Spreadsheet Tool: SD sheet**

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td># opposing lanes</td>
<td>3</td>
</tr>
<tr>
<td>Opposing speed limit (mph)</td>
<td>40</td>
</tr>
<tr>
<td>LT offset (ft)</td>
<td>-6</td>
</tr>
<tr>
<td>Intersection Length, L (ft)</td>
<td>85</td>
</tr>
<tr>
<td>OTHLtw (ft)</td>
<td>12</td>
</tr>
<tr>
<td>OLTLtw (ft)</td>
<td>11</td>
</tr>
<tr>
<td>Yi (ft)</td>
<td>0</td>
</tr>
<tr>
<td>Yw (ft)</td>
<td>7</td>
</tr>
<tr>
<td>Lateral position of OLT vehicle Xi (ft)</td>
<td>1.5</td>
</tr>
<tr>
<td>Xi (ft)</td>
<td>3.5</td>
</tr>
<tr>
<td>Yp (ft)</td>
<td>77</td>
</tr>
<tr>
<td>x (ft)</td>
<td>2.5</td>
</tr>
<tr>
<td>Vehicle offset (ft)</td>
<td>7</td>
</tr>
</tbody>
</table>

**Required SD (ft):** 381

**Available SD (ft):** 171

* *Y* is negative in this figure because the driver’s eye is behind the end of the median at the time of making decision.*

**SD Problem**

1. the number of lanes that a left-turning vehicle has to cross to complete a left-turn maneuver, including the right-turn lane unless the right turn lane is channelized as a free right turn.

2. Yi is positive if the driver’s eye is beyond the tip of median or stop bar at the decision time. It is negative if the driver is behind the tip of median/stop bar.

3. This parameter can be between 0.5 to 2.5 feet depending on the OLTLw and opposing median condition. Keep it at 1.5 ft unless you have a good reason.

4. This parameter can be between 2.5 to 4.5 feet depending on the LTLw and median condition. Keep it at 3.5 ft unless you have a good reason.
Spreadsheet Tool: RR diagrams