INTERSECTION TRAFFIC CONTROL COMMITTEE

Meeting Minutes

November 4th, 2015

ATTENDEES

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

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.
    d. Q – How to select the Base Condition in the spreadsheet? A – Can be determined using MnDOT recommendations, HCM, FHWA Signal Timing Manual.
    e. Q – Could the base condition change over time? A – Yes, agencies could change their base conditions in the future.

f. Q – Is the model applicable to dual-lefts? A – Most likely. Hard to determine what lane to use for sight distance measurements.

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

Minutes Submitted By: Mark Wagner

Flashing Yellow Arrows

LRRB Training: Tool for Time-of-Day Use

Vahid Moshtagh
SRF Consulting Group, Inc.

November 4, 2015

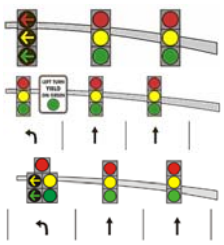
Outline

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

2

Introduction

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



Source: www.fhwa.dot.gov

3

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

Flashing yellow arrow: Drivers are allowed to turn left after yielding to all oncoming traffic and to any pedestrians in the crosswalk. Oncoming traffic has a green light. Drivers must wait for a safe gap in oncoming traffic before turning.

Solid green arrow: Left turns have the right of way. Oncoming traffic has a red light.

4

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

5

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

6

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

7

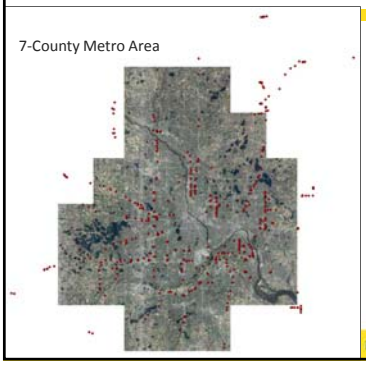
Data Collection

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

8

Intersection location

7-County Metro Area



328 intersections having 714 approaches

Geometric characteristics

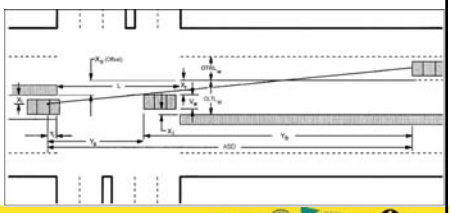
- Left-turn offset
  a) Negative offset
  b) Zero offset
  c) Positive offset
  d) Not applicable: No opposing left-turn movement e.g. T-intersections, Diamond interchanges

(d)

10

Sight distance issue

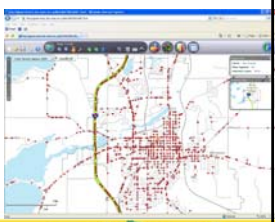
- Different from the sight distance concept in AASHTO Green Book caused by fixed obstacles
- It assumes the opposing vehicle presence



11

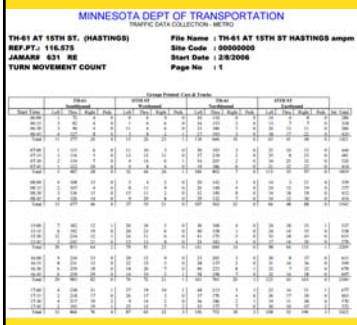
Crash data

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



12

Available turning movement counts


MINNESOTA DEPT OF TRANSPORTATION

TRAFFIC DATA COLLECTION - METRO

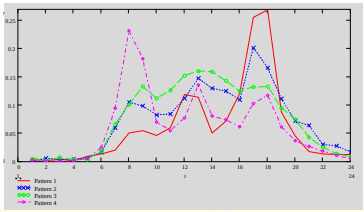
TH-61 AT 15TH ST. (HASTINGS)
REF.PT.: 116.575
JAMAR# 631 RE
TURN MOVEMENT COUNT

File Name : TH-61 AT 15TH ST HASTINGS amptm
Site Code : 00000000
Start Date : 2/9/2006
Page No : 1

13

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



14

Crash prediction models

- Highway Safety Manual: Safety Performance Functions (SPF)

$$E[Y_t] = \exp(\beta_0 + \beta_1 \ln(x_{1,t}) + \beta_2 \ln(x_{2,t}))$$

  - E[Yt] = expected left-turn crash hour t,
  - x1,t = left-turn volume hour t,
  - x2,t = opposing through plus right-turn volume hour t,

- Matched case-control design
  - β_1, β_2 can be estimated
  - β_0 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

15

Site classification

- Classification of crash-occurring approaches

criteria		Prot-Perm	Perm
Opposing SL <45 mph	SD prob.	109	27
	No SD prob.	185	20
Opposing SL >=45 mph	SD prob.	54	1
	No SD prob.	35	5

- Only three categories had adequate number of crashes to fit reliable statistical models

16

Relative Risk (RR) models

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

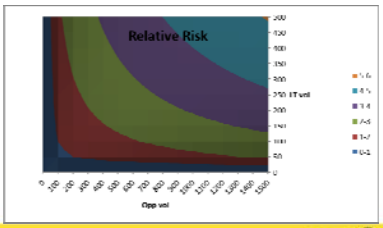
$$RR = \frac{P(crash|x_{1,t}, x_{2,t})}{P(crash|x_{1,0}, x_{2,0})} \approx exp\left(\beta_1 ln\left(\frac{x_{1,t}}{x_{1,0}}\right) + \beta_2 ln\left(\frac{x_{2,t}}{x_{2,0}}\right)\right)$$

- Analogy: Epidemiology studies

17

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



18

Example implementation

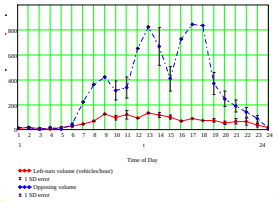
- Northbound at Robert and Mendota
- Prot-perm, No SD problem, Opp SL=40 mph
  - Parameters: $\widehat{\beta_1}$=0.38, $\widehat{\beta_2}$=0.37
- Base condition:
  - x1,0 (left-turn) = 100 vph
  - x2,0 (opposing)= 500 vph

19

Estimating hourly volumes

Available turning movement counts

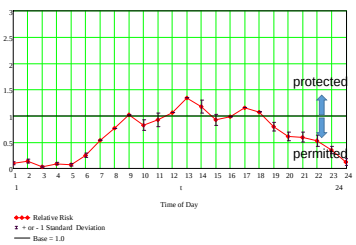
	Hour of Count							
	6-7	7-8	8-9	11-12	12-13	15-16	16-17	17-18
Left Turn (veh/hour)	43	68	125	91	134	67	88	73
Opposing (veh/hour)	219	363	421	649	822	726	842	836



Estimated turning movement volumes along with ±1 std. deviation

20

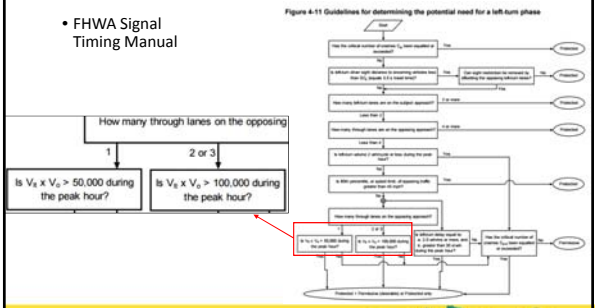
Relative Risk (RR) diagram



21

Base condition

- FHWA Signal Timing Manual

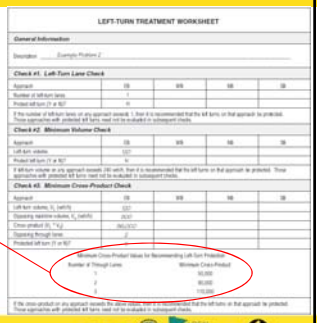


22

Base condition

- HCM 2000

Number of Through lanes	Min Cross-Product
1	50,000
2	90,000
3	110,000



23

Base condition

- MnDOT Traffic Signal Timing and Coordination Manual 2013

Question 6: Speed and Cross Product

○ Yes ○ No	Is the Speed 45 MPH or greater and the Peak Hour left turn volume greater than 240 vph or is the peak hour cross product greater than 80,000 (100,000 if 2 opposing lanes)?	> If the answer is **Yes**, Protected Operation is **suggested** for this TOD. > If the answer is **No**, FYA may be possible during this time period.

> If the answer is **Yes** to any Question, Protected Only Operation is **Suggested** during this TOD (use Engineering Judgment if Decision to run FYA by TOD).
> If the answer is **No** to all Questions, FYA (permitted mode) may be used during this TOD.

- Less conservative than the other references

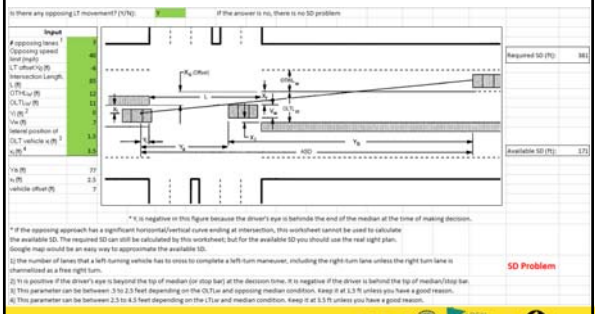
24

Spreadsheet Tool: example

- McKnight Rd N & Burns Ave southbound direction
  - Sight Distance (SD) sheet
  - Recommended defaults:
    - OTHLw = 12 feet
    - OLTLw = 12 feet
    - Yi = 0 feet
    - Vw = 7 feet
    - Xl = 1.5 feet
    - Xi = 3.5 feet

25

Spreadsheet Tool: SD sheet



26

Spreadsheet Tool: RR diagrams

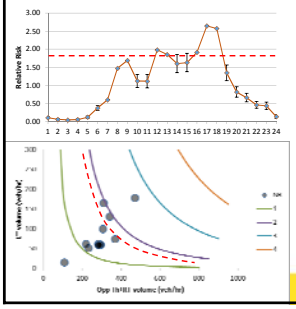
27

Spreadsheet Tool: more discussion

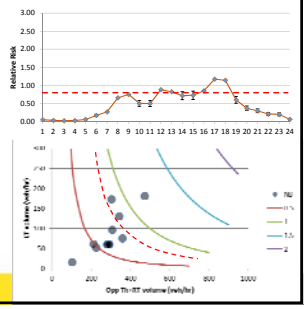
- Remove the off-peak counts and try again
- Differentiates LT=250 & Opp=400 from LT=400 & Opp=250
- Vertical or horizontal curve?
  - Use the tool to calculate the required sight distance.
  - Use Google Map, Google Earth, site plan, etc. to approximate the available sight distance
  - Compare these 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

Base: LT=50, Opp=200



LT=100, Opp=500



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.jsf?id=9151&type=CONTRACT

31

Questions

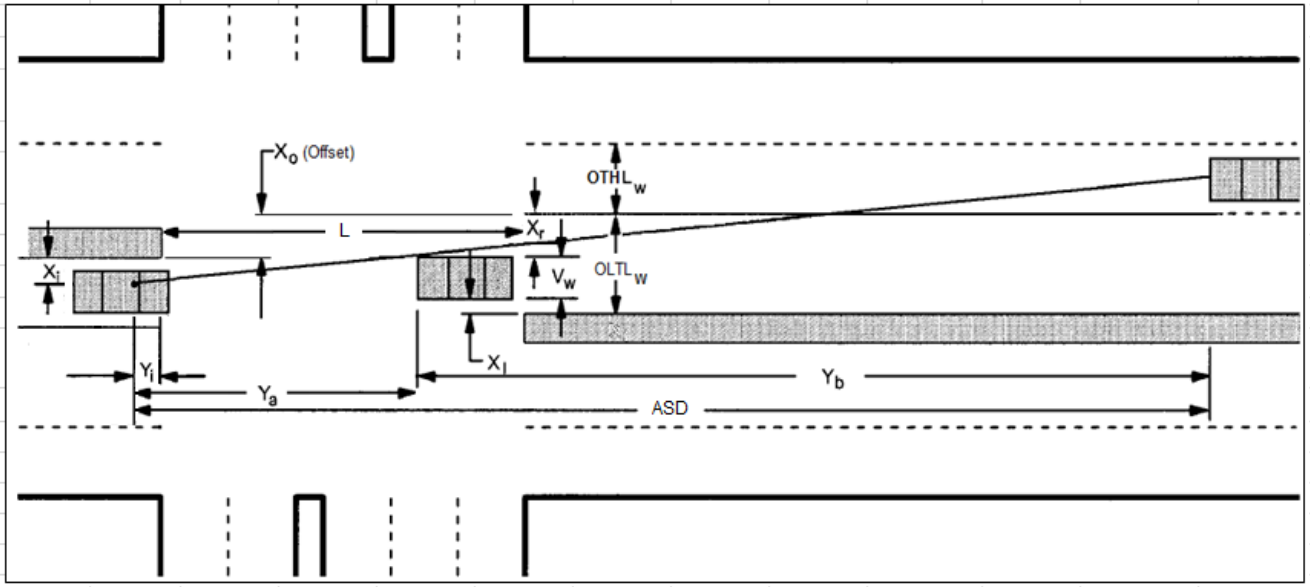
Vahid Moshtagh
vmoshtagh@srfconsulting.com
763-452-4778

32

Spreadsheet Tool: SD sheet

Is there any opposing LT movement? (Y/N):	Y	If the answer is no, there is no SD problem

Input	
# opposing lanes [1]	3
Opposing speed limit (mph)	40
LT offset X_0 (ft)	-6
Intersection Length, L (ft)	85
$OTHL_W$ (ft)	12
$OLTL_W$ (ft)	11
Y_i (ft) [2]	0
V_W (ft)	7
lateral position of OLT vehicle x_l (ft) [3]	1.5
x_i (ft) [4]	3.5
Y_a (ft)	77
x_r (ft)	2.5
vehicle offset (ft)	7



Required SD (ft):	381
Available SD (ft):	171

SD Problem

* Y_i is negative in this figure because the driver's eye is behinde the end of the median at the time of making decision.

* If the opposing approach has a significant horizontal/vertical curve ending at intersection, this worksheet cannot be used to calculate the available SD. The required SD can still be calculated by this worksheet; but for the available SD you should use the real sight plan. Google map would be an easy way to approximate the available SD.

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 .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

Protected/Permited left turn phasing, Speed limit <45 mph, Sight Distance Problem

Model Parameters			Base Condition	
beta 1:	0.33		LT vol	250
beta 2:	0.64		Opp vol	400

Run

Sampled hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
LT vol							64	438	146	115	158	217	205	201	213	336	527	464	276					
Opp vol							359	595	525	314	273	265	351	299	330	349	423	405	326					

Estimated 24-hour turning movement volumes

LT vol	22	0	0	11	22	33	64	438	146	115	158	217	205	201	213	336	527	464	276	261	98	87	76	11
LT st. deviation	5.2	0.6	0.6	3.5	5.2	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	14.0	12.8	11.7	3.5
Opp vol	9	12	6	9	5	89	359	595	525	314	273	265	351	299	330	349	423	405	326	178	142	117	82	13
Opp st. deviation	4.8	5.3	2.8	3.9	8.1	22.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.2	34.0	29.1	23.6	8.8
Relative Risk	0.04	0.01	0.01	0.03	0.03	0.19	0.60	1.55	1.00	0.66	0.67	0.73	0.86	0.77	0.84	1.01	1.33	1.24	0.91	0.60	0.38	0.32	0.25	0.04
RR sd	0.01	0.01	0.00	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.06	0.05	0.05	0.02