PREDICTED EFFECTIVENESS COUNTERMEASURE USING TRAFFIC CONFLICT TECHNIQUES TO IMPROVE TRAFFIC SAFETY AT 4 - LEGS SIGNALIZED INTERSECTIONS

Sahar S. Naham [1]

ABSTRACT:

Improving road traffic safety has high effect to reduce the cost of traffic accident and save the user of highway. Since 1985 the average stopped delay has been used as the measure of service in signalized intersections analyses , on the other hand it is difficult to evaluate the traffic safety in terms of change in number of traffic accident, because the traffic accidents accord has no reliable accident recorded ,while it not only reflect the number of accidents well, but also their nature ; traffic conflict technique is an efficient tool for analyses traffic safety.

This study is aimed to developed traffic safety at 4 four- leg signalized intersections in Baghdad City. Regression analyses is performed to relate hourly traffic conflict and average stopped delay .Specific categories of countermeasures such as signalization and geometric countermeasures are adopted. HCS 2000 software are adopt to determine the average stopped delay before and after countermeasure implemented.

The results show that the negative exponential model related hourly traffic conflict to average stopped delay and show a better explanation rather than linear model ,as well as it is found that exponential model explains increasing variation (81.6) of total hourly traffic conflict in relation with average stopped delay . The highest reduction in number of traffic conflict after signalization countermeasures is 74.63% more than the highest reduction after geometric countermeasures when it reduce by 58.07% . This study recommends to use traffic conflict technique as a tool to improve traffic safety by any proposed countermeasures.

Key wards: Safety, Traffic, Conflict, Delay, Countermeasure

التنبؤ بكفاءة المعالجات بأستخدام تقنية التعارضات المرورية لتحسين السلامة المرورية في التقاطعات الرباعية المسيطر عليها بإشارات ضوئية

تحسين السلامة المرورية في الطرق لها تأثير عالي في تقليل كلفة الحوادث المرورية والحفاظ علـى سـلامة مستخدمي الطريق . منذ ١٩٨٥ معدل زمن التوقفات كان يستخدم كمقياس لتحليل مستوى الخدمة في التقاطعات المسيطر عليها بإشارات ضوئية ،من جانب أخر صعوبة تقييم السلامة المرورية من خلال تغير عدد الحـوادث المرورية وذلك لعدم تدوين عدد تلك الحوادث بمصداقية ، وبما أنه تقنية التعارضات المرورية لا تعكس فقـط عدد الحوادث المرورية بل حتى طبيعة تلك الحوادث: تقنية التعارضات المرورية ممكن أستخدمها كأداة فعالـة لتحليل السلامة المرورية.

[1] Assist. Lect M.SC. Road & Airport Engineering,. Institute of Karbalaa, naham_1969@ yahoo.com

هذه الدراسة تهدف إلى تطوير السلامة المرورية في أربع تقاطعات رباعية مسيطر عليها بإشارات ضوئية في مدينة بغداد. اجري تحليل الانحدار لارتباط التعارضات المرورية الساعية مع معدل زمن التأخر. تم اتخاذ فئة من المعالجات للسيطرة المرورية والتصميم الهندسي. دليل السعة المرورية لعام ٢٠٠٠ اتخذ للحصول على معدل زمن التأخير قبل وبعد إتمام المعالجات. أوضحت النتائج انه يمكن ربط التعارضات المرورية الساعية مع معدل زمن التوقفات بعلاقة آسية سالبة أفضل مما يمكن ربطها بعلاقة خطية ، بالإضافة إلى ذلك وجد إن الموديل الآسي يمثل ٨١,٦ من التغير في التعارضات المرورية الساعية بدلالة معدل زمن التوقفات . أعلى تقليل في عدد التعارضات المرورية كان بعد إجراء معالجات السيطرة المرورية بمقدار ٧٤,٦٣% مما كان عليه بعد إجراء معالجات التصميم الهندسي بمقدار ٥٨,٠٧% . توصي هذه الدراسة باستخدام تقنية التعارضات المرورية لتحسين السلامة المرورية بواسطة المعالجات المقترحة.

1.INTRODUCTION

According to 2002 data complied by the National Highway Traffic Safety Administration, 21 percent of crashes and 24 percent of all fatalities and injuries occurred at signalized intersections [1].

This paper aims at improving traffic safety at signalized intersections using traffic conflict technique depend on criteria of average stopped delay . However, attempts to estimate the relative safety of a highway facility are usually hindered by the un reliability of accident records as well as the long period to achieve adequate sample size ; traffic conflict technique is a concept as a surrogate measure for predicting accident occur are used to overcome these problem . Manual countermeasures are entities to expected if a specified conflict reductions are implemented.

2. HISTORICAL OF USING TRAFFIC CONFLICT TECHNIQUE

The traffic conflict technique (T.C.T) is perhaps the most developed indirect measure of traffic safety. The technique itself is grounded in the ability to register the occurrence of near – accidents directly in real time [2]. FHWA [3] define traffic conflict technique as" an event involving two or more road user which the action of one user causes the other user to make an evasive maneuver to avoid collision" .There are many Author delis with this techniques such as:

Spicer 1973 [4] : recognized the need to add a subjective scale for observed conflicts as a measure of severity .
Hyden 1987 [5] : describe the point at which the aversive action is taken is recorded through observation as the Time – to – Accident (TA) . The TA value and conflicting speed are used to determine the seriously of conflict.
Svensson 1992 [6] : serious conflict provide a better estimate of the number of expected accidents involving personal injury.

3. ACCIDENT INVESTIGATION

Accident investigation is a device for preventing future accidents . A good accident investigation program is designed to discover the basic causes of accident incident [7].

In the past , the development of accident prediction models has relied on an assessment of before – and after accident experience to generate linear regression models that are used predict future accident neglable the expected change in traffic road environment this may lead to poor correlation to historical report accident occur according to this numerous studies have reported on the correlation of traffic conflict to annual traffic accidents such as :

Mladen Gledec 1996 [8] : This study recommend to applying the traffic conflict technique because it has a good correlation with the accidents and that these techniques are (mainly) evaluated in a satisfying way as a procedure used for establishing the risk in road traffic .

Dominique Lord [9]: Studied two type of signalized intersections ;T–intersections and X – intersections to study the interaction between pedestrian and left – turning vehicles , these tests indicate that appositive correlation between traffic conflict and expected number of accidents exists.

Douglas R. & Kristin M. 2005 [10]: Estimating roundabout safety performance in comparison to signalized and unsignalized intersections using conflict opportunity technology rather than regression – based accident estimates.

4. DATA COLLECTION

According to the definition of FHWA the data are collect by using a Sony video digital , 700x/ zoom , high quality USB streaming . A four weekday (4 hour minimum at each day), traffic conflict study was conducted at each of the intersections selected . Data was collected between the hours of 7:00 A.M. and 6:00 P.M. The data collection procedure included a 10 minute set – up period before the start of the conflict study followed by data collection for 20 minutes , then changes the place of set – up the video camera . This recommendation was followed ,as well as these data include peak hour volume , geometric design and cycle timing.

5. CONFLICT TYPE

Traffic conflicts are generally categorized by type of maneuver [11].Five type of conflict are observed at four – leg signalized intersections these are [3]:

- Slow vehicle : A slow vehicle conflict occurs when the first vehicle slows while approaching or passing through the intersection , placing a second , following vehicle in danger of a rear – end collision.
- Lane change : Lane change conflict occurs when the first vehicle change from one lane to another , thus placing a second , following vehicle in the new lane in danger of a rear – end or sideswipe collision .
- Right turn same direction : A right turn same direction conflict occurs when the fist vehicle slows to make a right turn , thus placing a second , following vehicle in danger of a rear – end collision.
- Left turn same direction : A left turn same direction conflict occurs when the fist vehicle slows to make a left turn , thus placing a second , following vehicle in danger of a rear – end collision.
- Right turn cross traffic from left : A right turn cross traffic from left conflict occur when vehicle on the right hand cross street make a right turn , thus placing a second vehicle on the main street in jeopardy of a boards or rear – end collision .

6. SITE SELECTION

Four – leg signalized intersections in Baghdad city in 2003 are selected according to the guidelines recommended by FHWA [3], where the specific intersections has no pedestrian facilities, no appreciable grades and had entering traffic volume more than 1000 vehicle per day.

7. TRAFFIC AND CONFLICT ANALYSES

Traffic conflicts at each approach are obtained due to different type of conflict. A software of HCS 2000 is used to determine the average stopped delay for all approaches in the studies intersections to estimate the traffic safety by developing model correlates hourly traffic conflict to average stopped delay , Table (1) summarized the result as well as Figure (1) shows the exponential relation explains increasing variation (81.6) of hourly traffic conflict in relation with average stopped delay , on the other hand Table (2) show the parameters of the statistical model in two cases linear and exponential model .

Table (1) Summary of collected hourly traffic conflict & analyses average stopped delay (sec/ veh)

App.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Hourly total traffic conflict	53	45	50	62	171	53	159	52	112	82	51	70	47	80	49	78
Average stopped delay	78	71	74	80	129	70	124	62	123	114	75	73	42	109	70	104

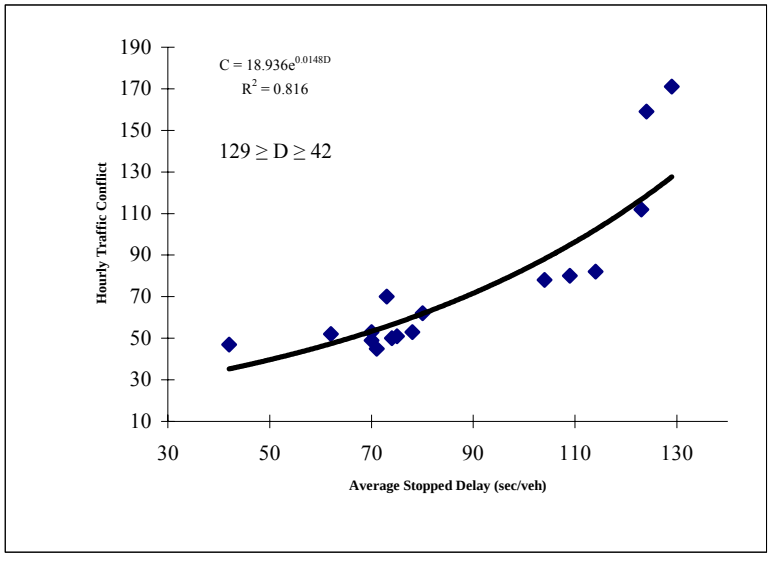


Fig. (1) Exponential relationship between hourly traffic conflict & average stopped delay

Table (2) Developed models relate hourly traffic conflict to average stopped delay (sec/ veh)

Developed Model	R	R^2	Standard Error	P-value (Intercept)	P-value (Delay)
Linear Model C = 1.2853*D - 36.43	0.850	0.723	21.310	0.080	3.002E-05
Exponential Model C = 18.936e0.0148*D	0.934	0.816	13.237	0.046	2.578E-06

C :- Hourly traffic conflict.
D :- Average stopped delay.

8. TRAFFIC SAFETY IMPROVEMENT

Signalization and efficient geometric design not only improve the performance of signalized intersection but it also reducing the traffic delay also it has appreciable effect in traffic conflict and this is a good for road traffic safety .

There are 11 variables significantly affected the safety at intersections , the total approach volume , the number of phases per cycle , the uncontrolled left – turn lane are among the variables that are the highly significant [12] . Many researchers adopt that the average stopped delay as the measure of traffic safety at signalized intersections such as:

- **Lin Zhang & Panos D. 2002 [13] :** Used methodology based on and designed to be compatible with HCM 2000 , and developed model to combine delay and safety index (DS).
- **Jian Johnlu & Zhenyu Wang 2005 [14] :** This study developed a new procedure considering both safety and operational factors , criteria of performance are delay reduction due to improvements and existing delay . These two criteria are estimated based on algorithms in HCM 2000.

9. COUNTERMEASURES EFFECTIVENESS TO MAKE INTERSECTIONS SAFER

Safety is a prime consideration for traffic planners when designing. A safe road is one which recognizes the realities and limitations of human decision making. The process of countermeasure development should aim to [15]:

- Select countermeasures which, on the basis of professional judgment and experience, can be expected to reduce the number or severity of accidents of the type dominant at the location.
- Check that adopted countermeasures do not have undesirable consequences, either in safety terms or in traffic environmental terms.

According to above guides two type of countermeasure are tested these are:

1. Signalization countermeasures :-
   - Use of permitted left turn treatment.
   - Use of protected left turn treatment.
2. Geometric Countermeasures.
   - Use of adequate auxiliary left turn lane treatment.
   - Increase lane width (existing lane width is ranged between 2.5m to 3.5m and increased to 3.65m according to AASHTO 1994 [16] recommendations.

- Increase number of lane (existing number of lane is three and proposed increase to four).

Table (3) Shows a review summary of authors adopt countermeasures to reduce percent of traffic accident to improve traffic safety.

Table (3) Review summary of reduction in traffic accident after adopt countermeasures

Reduction in Traffic Accident %	Type of countermeasures	Author
3.5	Increase lane width by 1 ft	Dart,K.O.& Mann,L,jr 1970 [17]
14	Increase lane width by 1 ft	Miaou 1996 [18]
42 25-36	Provide separated left turn lane Provide left turn lane	Institute of transportation Engineers 1999 [19]
75	Increase lane width	Hauer, E. 2000 [20]
46-69	Add left turn phasing	Thomas ,Gary B. & Daniel J.2001 [21]
25-41 4-10	Add left turn phasing Add protected / permitted LT phase	Polanis , Stanley F. 2003 [22]
15-30 23-48	Provide adequate length turn lane Add left turn phasing	NCHRP 2003 [23]
48-85	Displaced left turn lane	Joe G. Bared 2005 [1]
5-56	Additional lane	Agent , Kenneth 1996 [24]
18-24	Installation of left-turn lane	Harwood et al. 2005 [25]
54	Installation of left-turn lane	Gluck et al. 1999 [26]
5.5 35	Add permitted left-turn phase Add protected / permitted LT phase	Maze et al. 1994 [27]
7 10	Installation of left-turn lane Installation of left-turn lane	FHWA 2002 [28]

Hourly traffic conflict are determined from the developed model shown in figure (1) after estimated average stopped delay manually when the expected countermeasure are implemented, the final results are summarized in table (4) as well as table (5) summarized the percent of reduction in hourly traffic conflict and average delay traffic after the development of countermeasure accord at the sit selections on the other hand figure (2) shows the range of the percent of reduction .

Table (4) Summary of average stopped delay & hourly traffic conflict after applied the manually estimated countermeasure

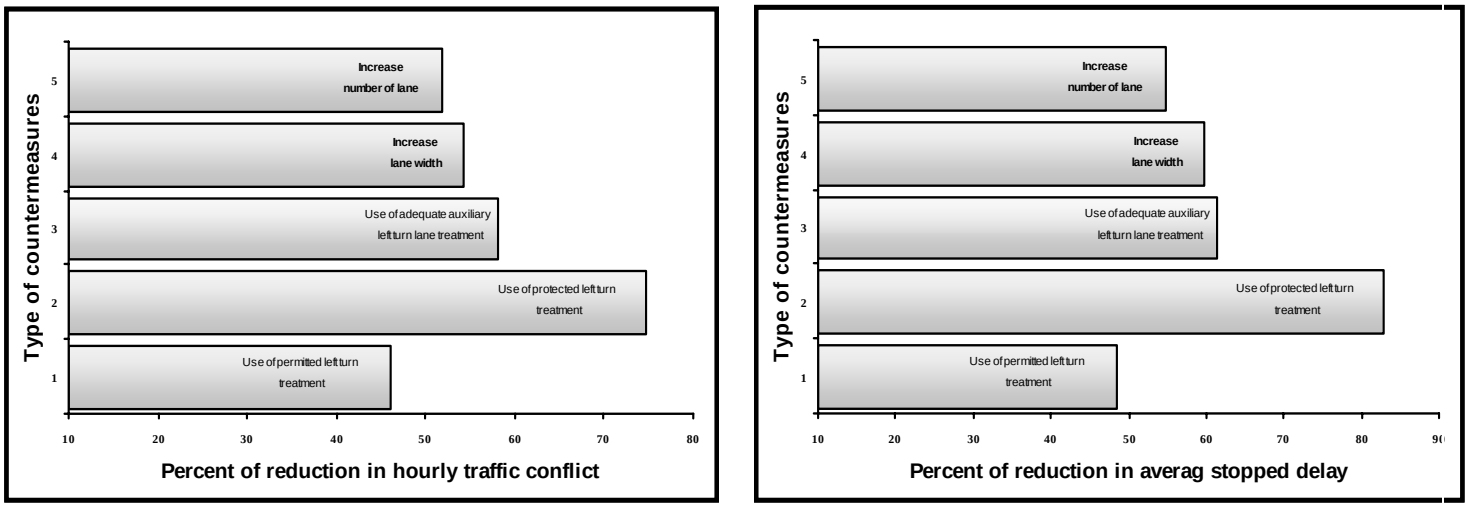
App. No.	Type of Countermeasures									
	Signalization countermeasures				Geometric Countermeasures					
	Countermeasure (1)		Countermeasure (2)		Countermeasure (3)		Countermeasure (4)		Countermeasure (5)	
	Delay	Conflict	Delay	Conflict	Delay	Conflict	Delay	Conflict	Delay	Conflict
1	35	31	62	46	46	44	43	32	43	33
2	33	30	55	42	40	34	39	33	39	36
3	60	45	56	43	72	54	70	58	70	51
4	36	31	65	49	55	42	53	40	53	46

5	39	33	100	78	54	41	53	40	53	38
6	42	36	65	49	63	48	61	44	61	41
7	36	31	98	76	51	40	50	38	50	31
8	31	28	49	40	39	33	37	32	37	30
9	56	42	112	98	72	73	70	58	70	50
10	53	40	94	74	69	54	67	51	67	48
11	38	33	61	47	42	36	40	34	40	32
12	31	28	63	48	37	32	35	31	35	33
13	33	30	35	31	35	31	34	31	34	33
14	61	47	102	80	81	61	78	59	78	51
15	39	33	55	42	42	36	41	35	41	34
16	54	41	85	63	62	46	61	44	61	42
Average	42.32	34.94	72.35	56.63	53.60	44.06	52.13	41.25	52.13	39.31

Countermeasure (1): Use of permitted left turn treatment.
Countermeasure (2): Use of protected left turn treatment.
Countermeasure (3): Use of adequate auxiliary left turn lane treatment.
Countermeasure (4): Increase lane width.
Countermeasure (5): Increase number of lane.

Table (5) Summary of percentage of reduction in average stopped delay & hourly traffic conflict after applied the estimated countermeasure

Type of countermeasures	Percentage of reduction	
	Average stopped delay	Hourly traffic conflict
Use of permitted left turn treatment	48.43	46.05
Use of protected left turn treatment	82.81	74.63
Use of adequate auxiliary left turn lane treatment	61.35	58.07
Increase lane width	59.66	54.37
Increase number of lane	54.80	51.81



a- Percent of reduction in hourly traffic conflict **b- Percent of Reduction in Average stopped delay**

Fig. (2) Percent of reduction in hourly traffic conflict conflict & average stopped delay after adopted the estimated countermeasure

10. CONCLUSIONS

- The results show that the negative exponential model related hourly traffic conflict to average stopped delay and show a better explanation rather than linear model as well as it is found that exponential model explains increasing variation (81.6%) of total hourly traffic conflict in relation with average stopped delay.
- Implementation countermeasure can be used to determine average stopped delay based on HCS output to improve traffic safety using traffic conflict technique.
- The estimated countermeasures strategies show that : -
  - -Provided permitted left turn treatment reduce average stopped delay 48.43% while it reduce hourly traffic conflict 46.05% .
  - -Provided Protected left turn phase treatment reduce average stopped delay 82.81 % while it reduce hourly traffic conflict 74.63%.
  - -Provided adequate auxiliary left turn lane treatment reduce average stopped delay 61.35% while it reduce hourly traffic conflict 58.07%.
  - -Increase lane width treatment reduce average stopped delay 59.66% while it reduce hourly traffic conflict 54.37%.
  - -Increase number of lane treatment reduce average stopped delay 54.80% while it reduce hourly traffic conflict 51.81%.

- The final result show the hourly traffic conflict reduce after geometric countermeasures treatment about 58.07% while it reduce about 74.63% after signalization countermeasures treatment .
- Traffic conflict technique is a good tool to evaluate traffic safety after any proposed countermeasure before it adopted.

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