Traffic Conflict Values for Three-Leg, Unsignalized Intersections

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Traffic conflicts are good surrogates for accidents when sufficient accident data are not available but the conflict technique can be used to identify safety problems. Extensive research has previously been performed on four-leg intersections, and average and abnormally high values for traffic conflicts have been identified for them. Such information for three-leg, unsignalized intersections is not currently available. The method detailed in *Traffic Conflict Techniques for Safety and Operations* published by the U.S. Department of Transportation, FHWA, was used to identify average and abnormally high values for traffic conflicts at three-leg, unsignalized intersections. The data on which the conclusions were based were collected during the summer of 1989 in the Houston, Texas, area with most intersections located on two-lane, undivided roadways. The conclusions were limited to daytime (7:00 a.m. to 6:00 p.m.) and weekday (Monday through Friday) traffic, and to dry-pavement conditions. The results can be used to evaluate comparable three-leg, unsignalized intersections by the traffic conflict technique.

A traffic conflict is a potential accident situation. It involves two or more road users where one or both drivers put on their brakes or swerve in order to avoid a collision. The traffic conflict technique was initially developed in 1967 to set up a formal set of definitions and procedures for observing traffic conflicts at intersections (*1*). Perkins (*1*) identified conflict patterns related to accident types. Additional research in 1979 through 1985 provided standard definitions and refined data collection procedures as well as applying this technique to estimate the number of predicted accidents at an intersection (*2*). The technique can now be used as a substitute for accident data.

Parker and Zegeer (*3*) published mean, variance, and abnormally high (90th- and 95th-percentile) conflict counts for four-leg intersections, both unsignalized and signalized. This information for other types of intersections—e.g., three-leg, unsignalized—is currently unavailable but is required to evaluate such intersections by the traffic conflict technique. These values were obtained from data collected in Houston, Texas, using the appropriate procedure.

METHODOLOGY

The procedures detailed in *Traffic Conflict Techniques for Safety and Operations* [*Engineer's Guide* (*3*) and *Observer's Manual* (*4*)] were followed to conduct this study.

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Site Selection

Initially, four three-leg intersections at rural two-lane highways carrying between 7,500 and 12,500 vehicles per 11-hr day (7:00 a.m. to 6:00 p.m.) were chosen at the request of the Texas State Department of Highways and Public Transportation. These roadways had average speeds of 40 to 55 mph, and no left-turn lanes were provided. Figure 1 shows one of these intersections.

In order to create a data base for comparing these intersections, a sample of similar sites was needed. Additional three-leg, unsignalized intersections were sought to study for conflict behavior. Altogether, 10 three-leg, unsignalized intersections were located in the Houston area, some with four lanes on the main roadway but most with two. Two sites had medians allowing left-turn storage, whereas most others did not provide this capability. A description of all intersections is included with the results.

Observer Training

Four observers were used to collect the data. All were taken to the field to witness traffic conflicts and to classify and distinguish between the types of conflicts. Figure 2 shows a typical three-leg, unsignalized intersection with three approaches and approximate observer locations.

Figure 3 shows the four types of conflicts that may occur from the northbound approach. They are (a) opposing left turn; (b) right turn, same direction; (c) right turn from right; and (d) left turn from right.

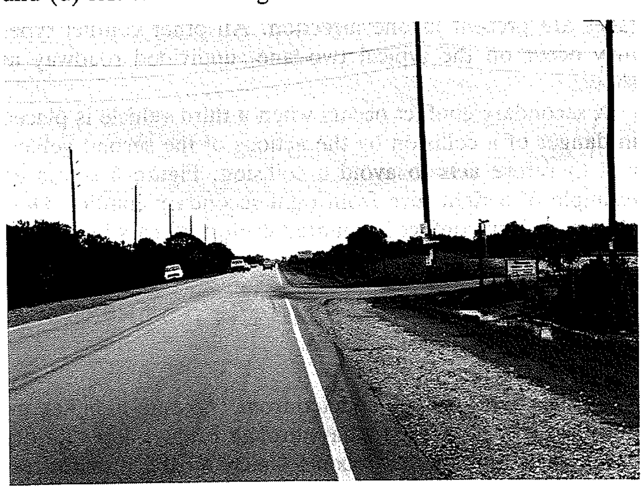


FIGURE 1 Three-leg, unsignalized intersection.

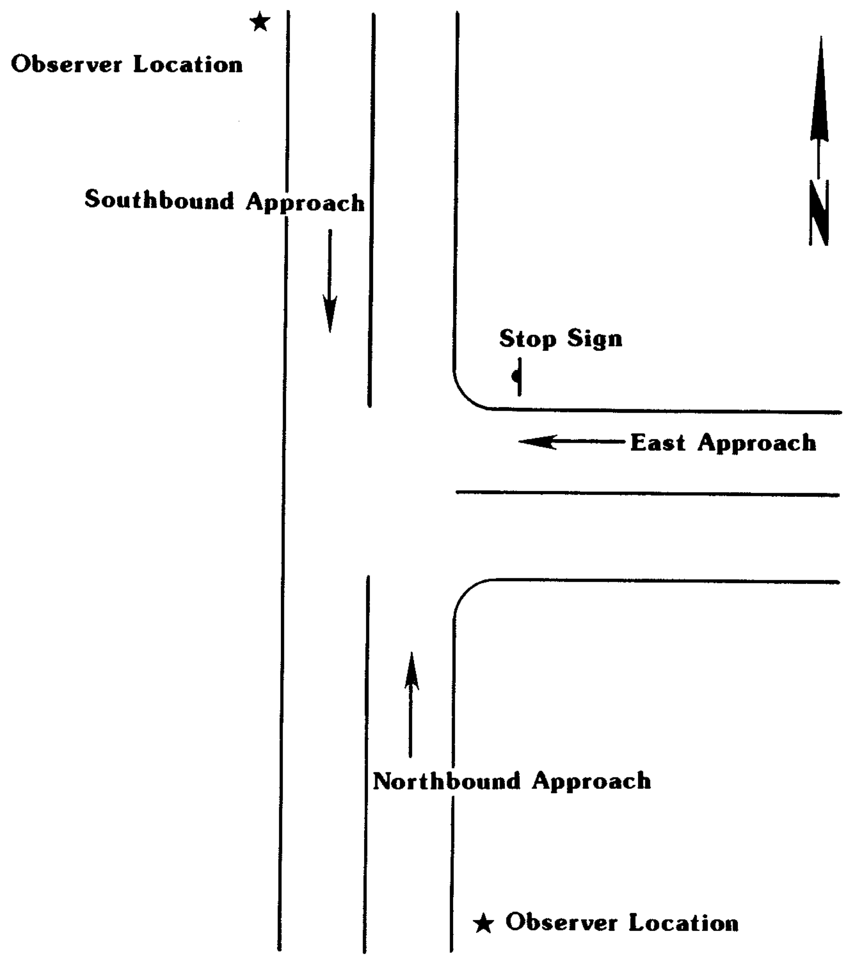


FIGURE 2 Typical three-leg, unsignalized intersection.

Figure 4 shows the three conflict types that may occur from the southbound approach: (a) left turn from left, (b) right turn from left, and (c) left turn, same direction.

Figure 5 shows the two conflict types that may occur from either direction: (a) slow vehicle, and (b) lane change. The lane change type conflict can occur only when two or more lanes are present in one direction. All other conflict types may occur on the typical two-lane, undivided roadway as shown.

A secondary conflict occurs when a third vehicle is placed in danger of a collision by the actions of the second vehicle and therefore acts to avoid a collision. Figure 6 shows an example of a right turn from right secondary conflict. Only one secondary conflict is counted even if all cars in the line of several cars put on their brakes.

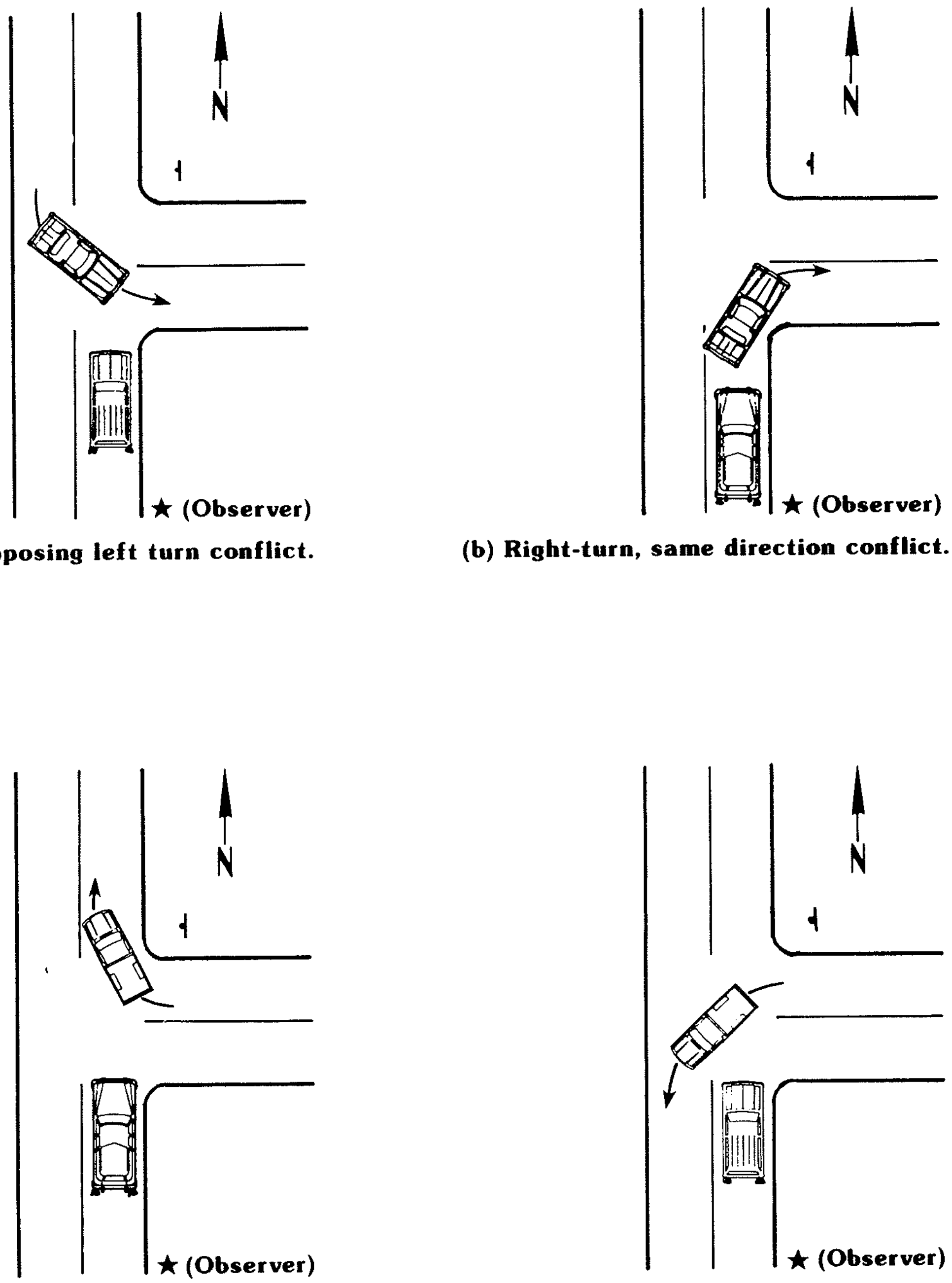
DATA COLLECTION

The daily counts were conducted from 7:00 a.m. to 6:00 p.m. during the weekdays (Monday through Friday) and with dry pavement conditions as recommended by the previous researchers. Two observers collected a full day of data at each intersection. Each observer witnessed traffic conflicts from one approach to the intersection and documented their data in 30-min increments. The observer locations, previously shown in Figure 2, varied from 100 to 300 ft from the intersection depending on the speed of the vehicles and the presence of ditches and shoulders. In addition to the conflicts, the observers counted approach volumes for the direction they were observing.

DATA ANALYSIS

The data were summarized for each intersection and daily conflict counts were estimated; data both for conflicts and secondary conflicts are presented in Table 1.

As indicated in Table 1, the number of conflicts at different intersections varies greatly. Several factors affect the operations at each intersection. Some roadway characteristics that may contribute to certain types of conflicts are (a) presence of exclusive left-turn lane, (b) presence of exclusive right-turn lane, (c) volume at minor approach, (d) width of roadway lanes, (e) restricted sight distance, and (f) excessive speeds. A brief description of the individual study site characteristics and environmental features for each intersection studied are as follows:



(a) Opposing left turn conflict.

(b) Right-turn, same direction conflict.

(c) Right-turn from right conflict.

(d) Left-turn from right conflict.

FIGURE 3 Traffic conflicts from the northbound approach.

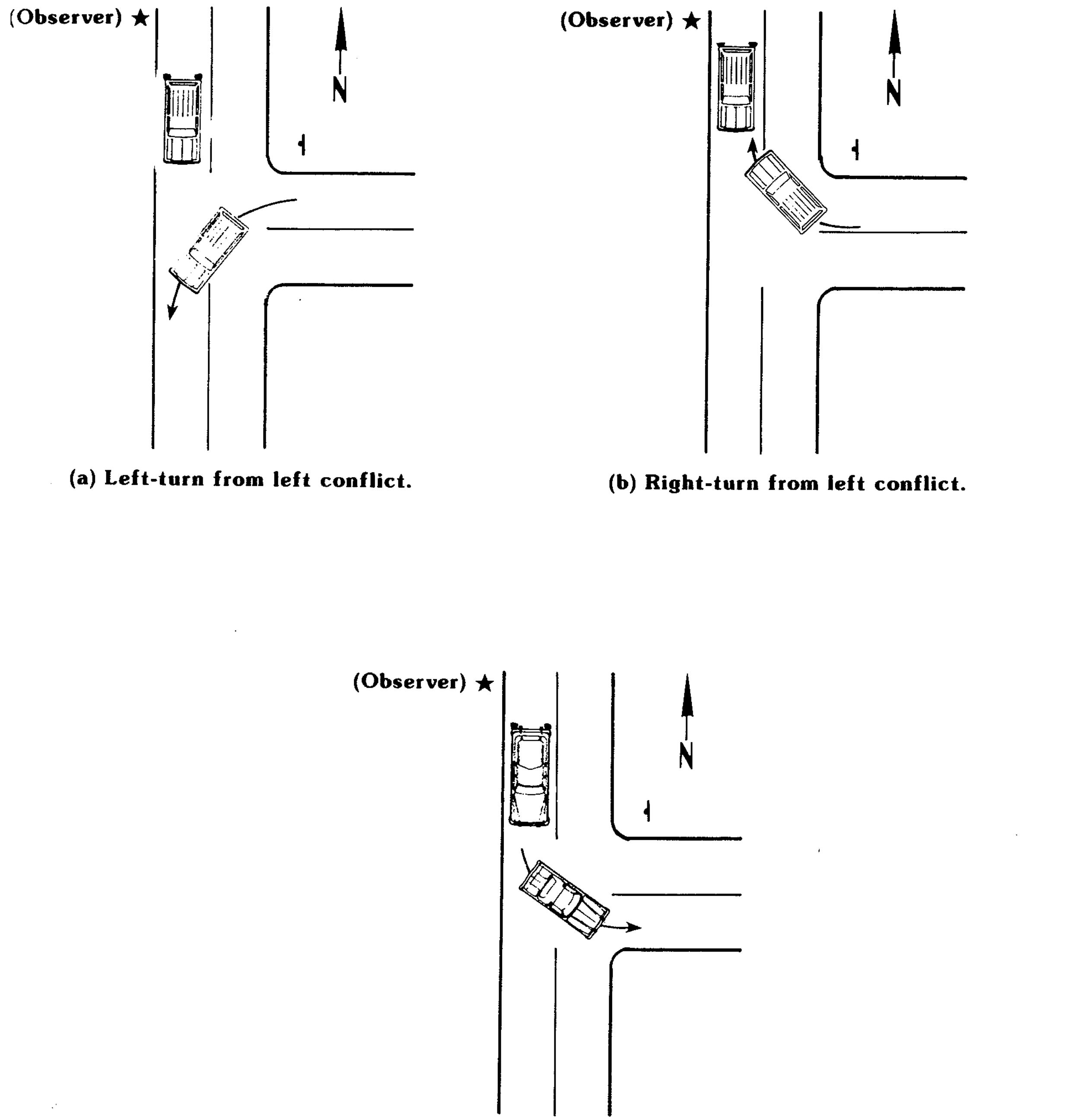
1. Franz at Elrod. Franz is a two-lane, undivided roadway with speeds between 35 and 45 mph. There are ditches on both sides of Franz with no shoulders. Elrod is a two-lane, undivided spine street to a residential community.

2. US-90 at Royalwood. US-90 is a four-lane, undivided highway with shoulders. The speeds in this rural area are approximately 45 to 55 mph. Royalwood is a two-lane, undivided street with a convenience store on the corner with driveways that lead to driver confusion.

3. NASA Road 1 at Lagoon. NASA Road 1 is a four-lane divided roadway with a left-turn lane, shoulders, and a wide median. The speeds are approximately 40 to 45 mph. Lagoon is a two-lane roadway at the entrance to a residential area.

4. NASA Road 1 at Forest Lake. NASA Road 1 is a four-lane, undivided roadway at this intersection with an exclusive left-turn lane provided for Forest Lake, shoulders on both sides, and speeds ranging from 35 to 45 mph. Forest Lake is a two-lane, divided entrance to a residential community. A signal is located approximately ¼ mi west of the intersection.

5. SH-105 at Highland Hollow. SH-105 is a two-lane undivided highway with average speeds of approximately 55 mph. There are gravel shoulders on both sides and a short right-



(a) Left-turn from left conflict.

(b) Right-turn from left conflict.

(c) Left-turn, same direction conflict.

FIGURE 4 Traffic conflicts from the southbound approach.

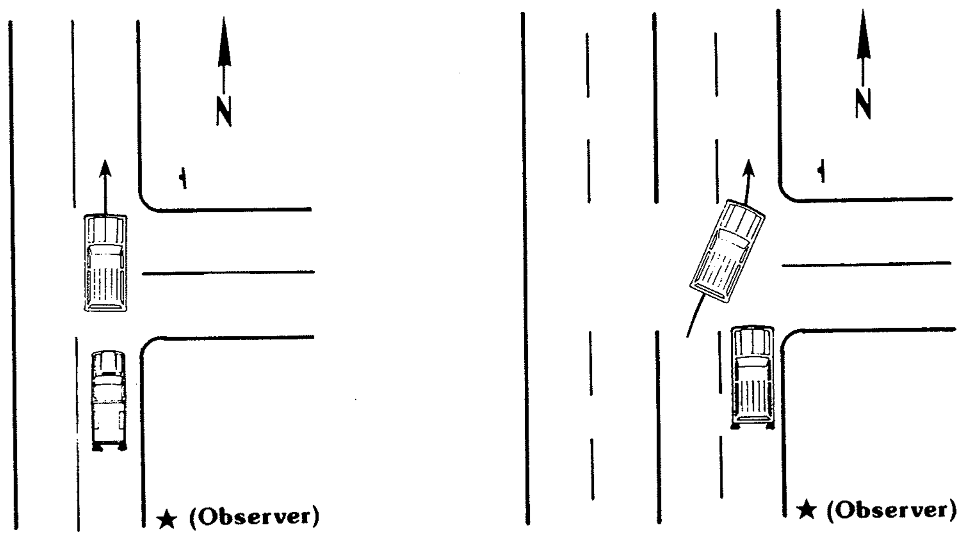
turn lane. Because the speeds are so high, this right-turn lane is too short to be effectively used. Highland Hollow is a two-lane undivided roadway entrance to a neighborhood.

6. FM-3345 at Quail Village. FM-3345 is a two-lane, undivided roadway with shoulders. Speeds in this area are approximately 35 to 45 mph. Quail Village is a two-lane divided entrance to a residential area.

7. FM-2234 at Blue Ridge. FM-2234 is a rural two-lane, undivided roadway with a right-turn lane and shoulders. The speeds are approximately 50 to 60 mph. Blue Ridge is a two-lane, undivided road and an industrial plant is located on the corner. Figure 7 shows a large truck attempting to make a left turn at this location.

8. Conrad Sauer at Westview. Conrad Sauer is a two-lane, undivided roadway with ditches close to the road and no shoulders. Westview is striped as a two-lane road at this intersection but turns into a four-lane road. There are many turns to and from Westview at the Conrad Sauer intersection. The area is residential and the speeds average about 35 mph.

9. Clay at Durban. Clay Road is a two-lane, undivided roadway with speeds between 35 and 45 mph. There are no shoulders and deep ditches are next to the road. Durban is a



(a) Slow-vehicle, same direction conflict.

(b) Lane-change conflict.

FIGURE 5 Traffic conflicts occurring from either approach.

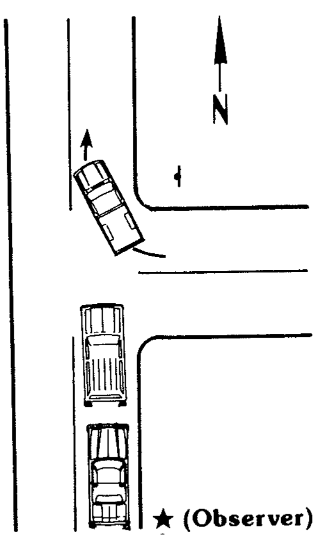


FIGURE 6 Right turn from right secondary conflict.

spine street to a residential community and is two lanes, divided at the intersection.

10. Campbell at Emnora. Campbell Road is a two-lane, undivided roadway with no shoulders. The average speed is approximately 35 mph and the area is residential. There is a narrow bridge on one approach that may influence driver behavior. Emnora is a two-lane road with some truck traffic. The intersection is so tight that turning 18-wheelers cause traffic to stop.

RESULTS

Previous results (*3*) for mean and abnormal conflict counts at four-leg, two-way stop, unsignalized intersections are presented in Table 2. These values represent data collected in the Kansas City area and at intersections with a volume of 2,500 to 10,000 vehicles per day.

Using the procedure detailed by Parker and Zegeer (*3*), the values presented in Table 3 for three-leg, unsignalized intersections were identified from the data collected in the Houston, Texas, area. The results presented in Table 3 include data collected for secondary conflicts. It should also be noted that the cross-traffic conflicts at four-leg intersections (Conflict Types 7 and 10 from Table 2) do not occur at three-leg intersections. These types of conflicts were explained by Parker and Zegeer (*3*).

The results presented in Table 3 for three-leg intersections demonstrate similarities to the results presented in Table 2 for four-leg intersections. The mean conflict count for the most frequently occurring conflict types (Conflict Type 1—left turn, same direction; Conflict Type 2—slow vehicle; and Conflict Type 4—right turn, same direction) exhibit similar values. In addition, the 90th- and 95th-percentile values for Conflict Types 1 and 4 are also relatively close. Overall, Tables 2 and 3 indicate that, from the data collected, the mean conflict counts at four- and three-leg intersections are similar, with slightly higher values identified for four-leg intersections.

Those tables with average and abnormally high percentile values can be used to evaluate individual intersections after conflict data have been collected. For example, Table 4 presents the comparison of the individual site SH-105 at Highland Hollow with the values identified for three-leg, unsignalized intersections.

Table 4 indicates that from the data collected, the slow vehicle and right-turn, same-direction, 90th-percentile values have been exceeded. A possible cause for both these high numbers of incidents may be the excessive speeds of some vehicles on the approaches. Also, the insufficient length of the right-turn lane could have contributed to the right-turn, same-direction conflicts. General countermeasures could be to reduce the speed limit or provide police enforcement of the speed limit. Increasing the length of the right-turn lane

TABLE 1 DAILY CONFLICT COUNTS BY STUDY SITE

Conflict Type	Location (See Legend Below)									
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
LT, Same Direction										
C	16	22	27	62	66	67	80	90	112	141
S&C	17	26	35	73	92	108	121	96	186	173
Slow Vehicle										
C	43	63	89	90	196	196	118	38	56	104
S&C	50	75	101	101	258	249	142	40	65	131
Lane Change										
C	0	5	20	8	0	0	0	0	0	0
S&C	0	5	21	9	0	0	0	0	0	0
RT, Same Direction										
C	92	39	35	24	115	25	4	28	123	28
S&C	121	46	42	29	160	29	5	30	155	34
Opposing LT										
C	0	8	2	20	8	5	4	10	9	9
S&C	0	8	2	20	9	7	4	10	12	9
LT from Left										
C	13	11	16	2	19	4	25	27	49	19
S&C	17	17	17	3	25	5	33	28	63	21
RT from Left										
C	0	0	0	0	0	0	1	2	0	7
S&C	0	0	0	0	0	0	1	2	0	8
LT from Right										
C	0	14	2	3	4	7	6	17	11	6
S&C	0	15	2	3	4	8	8	17	12	6
RT from Right										
C	2	15	2	36	1	19	9	14	6	23
S&C	2	17	2	38	1	25	13	14	6	29
1-4 Same Direction										
C	151	129	171	184	377	288	202	156	291	273
S&C	188	152	199	212	510	386	268	166	406	338

C = Conflict
S&C = Secondary Conflicts + Conflicts
LT = Left Turn
RT = Right Turn

Legend for Table 1

Intersection	Location	Road Type	Two-Way Approach 11-Hour Volume (Vehicles)
# 1	Franz @ Elrod	2U	4,000
# 2	US 90 @ Royalwood	4LU	8,800
# 3	NASA Road #1 @ Lagoon	4LD	18,700
# 4	NASA Road #1 @ Forest Lake	4LU	18,100
# 5	SH 105 @ Highland Hollow	2LU	8,300
# 6	FM 3345 @ Quail Village	2LU	12,200
# 7	FM 2234 @ Blue Ridge	2LU	8,500
# 8	Conrad Sauer @ Westview	2LU	3,800
# 9	Clay @ Durban	2LU	10,600
#10	Campbell @ Emnora	2LU	8,000

Note: 2U - 2 lane undivided

4LU - 4 lane undivided

4LD - 4 lane divided

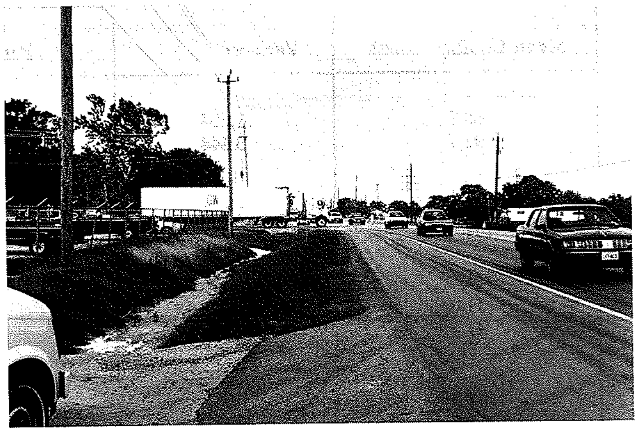


FIGURE 7 Example of three-leg, unsignalized left-turn conditions (FM-2234 at Blue Ridge).

TABLE 2 MEAN AND ABNORMAL DAILY CONFLICT COUNTS FOR FOUR-LEG, TWO-WAY-STOP, UNSIGNALIZED INTERSECTIONS

Conflict Type	Mean Conflict Count	Variance	Abnormally High Conflict Count	
			90th Percentile	95th Percentile
1. Left-Turn, Same Direction	70.6	1,005.0	110.0	130.0
2. Slow Vehicle	101.9	9,648.2	225.0	295.0
3. Lane Change	0.1	0.1	*	*
4. Right-Turn, Same Direction	57.9	2,197.3	120.0	150.0
5. Opposing Left-Turn	3.6	8.3	7.5	9.0
6. Left-Turn from Left	3.4	7.8	7.0	9.0
7. Cross-Traffic from Left	6.7	42.0	1.5	19.0
8. Right-Turn from Left	0.6	0.8	*	*
9. Left-Turn from Right	5.0	72.7	16.0	23.0
10. Cross-Traffic from Right	5.2	11.6	10.0	12.0
11. Right-Turn from Right	5.5	12.1	10.0	12.0
1-4 Same Direction	230.5	17,929.2	410.0	490.0
7+10 Through Cross-Traffic	11.9	75.2	24.0	29.0

Source: (3).

Note: o Conflict counts are the total number of conflicts per 11-hour day (7:00 A.M. to 6:00 P.M.) for the two approaches with right-of-way. The counts were obtained on weekdays, on dry pavement, and do not include secondary conflicts.

* Indicates this conflict type is so rare that any number observed at an intersection should be considered abnormal.

TABLE 3 MEAN AND ABNORMAL DAILY CONFLICT COUNTS FOR THREE-LEG, UNSIGNALIZED INTERSECTIONS

Conflict Type	Mean Conflict Count	Variance	Abnormally High Conflict Count	
			90th Percentile	95th Percentile
1. Left-Turn, Same Direction				
C	68.3	1,604	122.0	145.0
S&C	92.7	3,344	170.0	204.0
2. Slow Vehicle				
C	99.3	3,265	176.0	208.0
S&C	121.2	5,928	224.0	269.0
3. Lane Change				
C	11.0**	63	22.0	26.0
S&C	11.7**	69	23.0	28.0
4. Right-Turn, Same Direction				
C	51.3	1,781	107.0	134.0
S&C	65.1	3,281	140.0	178.0
5. Opposing Left-Turn				
C	7.5	30	15.0	18.0
S&C	8.1	31	16.0	19.0
6. Left-Turn from Left				
C	18.5	180	36.0	45.0
S&C	22.9	285	45.0	56.0
7. Right-Turn from Left				
C	1.0	5	*	*
S&C	1.1	6	*	*
8. Left-Turn from Right				
C	7.0	30	14.0	18.0
S&C	7.5	32	15.0	19.0
9. Right-Turn from Right				
C	12.7	124	27.0	35.0
S&C	14.7	161	31.0	40.0
1-4. Same Direction				
C	229.9	6,713	427.0	513.0
S&C	290.7	12,622	557.0	679.0

Note: o C = Conflict, S&C = Secondary Conflicts & Conflicts.
o **Only includes 4-lane roadways.
o Conflict counts are the total number of conflicts per 11-hour day (7:00 A.M. to 6:00 P.M.) for the two approaches with right of way. The counts were obtained on weekdays and on dry pavement.
o * Indicates this conflict type is so rare that any number observed at an intersection should be considered abnormal.

would allow the right-turning vehicles the chance to get over without having to slow down the through traffic.

The individual daily conflicts and descriptions of the study sites were given so further interpretation of the data could be performed more thoroughly. For instance, if a particular site undergoing investigation had similar characteristics to one of those included, the individual data could prove more helpful than a straight average. For further explanation of possible causes of abnormally high conflicts and general countermeasures for each conflict type, refer to the *Engineer's Guide* (*3*).

Figures 8–10 show graphically the individual site data for left-turn, same-direction conflict; slow-vehicle conflict; and right-turn, same-direction conflict; respectively. Refer to the legend of Table 1 for intersection names and roadway types. The mean, 90th-, and 95th-percentile values have been included on the graphs.

Figure 8 shows that Intersection 10 exceeds the 90th-percentile limit, which is abnormally high for this conflict type. There were a large number of vehicles turning left and there was no left-turn storage lane at this site. A left-turn lane could improve the situation.

Figure 9 shows that Intersections 5 and 6 exceed the abnormally high limit for the 90th percentiles for slow-vehicle conflicts. Excessive speeds of some vehicles at Intersection 5 (SH-105 at Highland Hollow) could be a contributing factor, as previously discussed. Some vehicles at Intersection 6 (FM-3345 at Quail Village) may also travel at excessive speeds leading to slow-vehicle traffic conflicts. However, it is more likely that the larger number of vehicles traveling through this intersection mainly contribute to the conflicts. The traffic volumes counted at Intersection 6 were the highest recorded for all the two-lane roadways studied.

Figure 10 shows that Intersections 5 and 9 exhibit abnormally high right-turn, same-direction conflicts. Providing a sufficiently long right-turn lane could help alleviate these high numbers of incidents.

TABLE 4 IDENTIFICATION OF ABNORMALLY HIGH CONFLICT PATTERNS (CONFLICTS ONLY)

	Daily Counts For Similar Locations		Daily Counts at SH 105 at Highland Hollow
Conflict Type	Mean Count	90th Percentile	
1. Left-Turn, Same Direction	68.3	122.0	66
2. Slow Vehicle	99.3	176.0	196**
3. Lane Change	11.0	22.0	0
4. Right-Turn, Same Direction	51.3	107.0	115**
5. Opposing Left-Turn	7.5	15.0	8
6. Left-Turn from Left	18.5	36.0	19
7. Right-Turn from Left	1.0	*	0
8. Left-Turn from Right	7.0	14.0	4
9. Right-Turn from Right	12.7	27.0	1
1-4. Same Direction	229.9	427.0	377

*Indicates this conflict type is so rare that any number observed at an intersection should be considered abnormal.
**Denotes abnormally high conflict pattern.

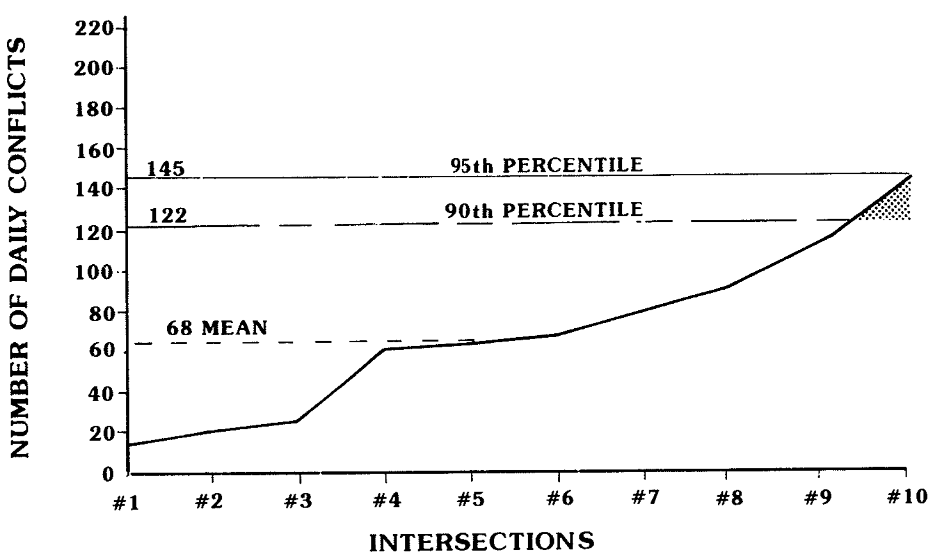


FIGURE 8 Left-turn, same-direction traffic conflicts.

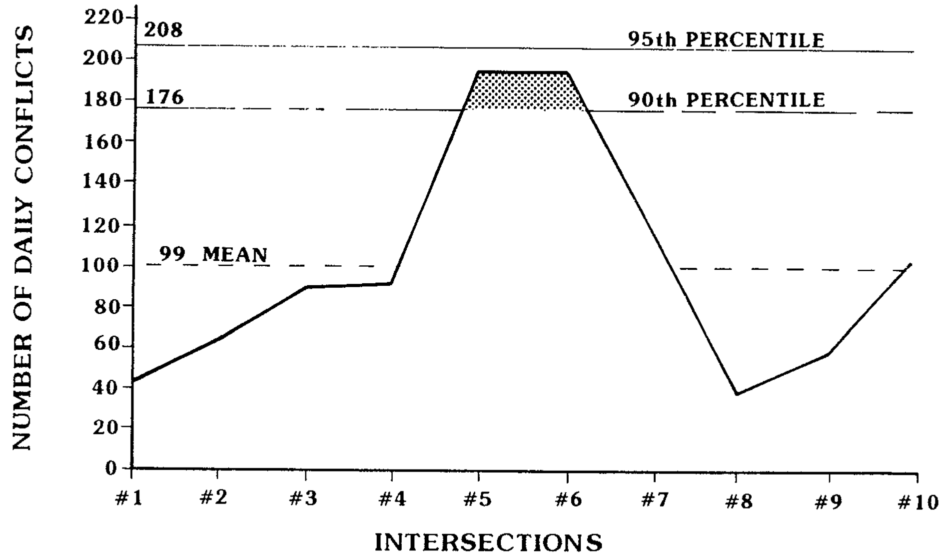


FIGURE 9 Slow-vehicle traffic conflicts.

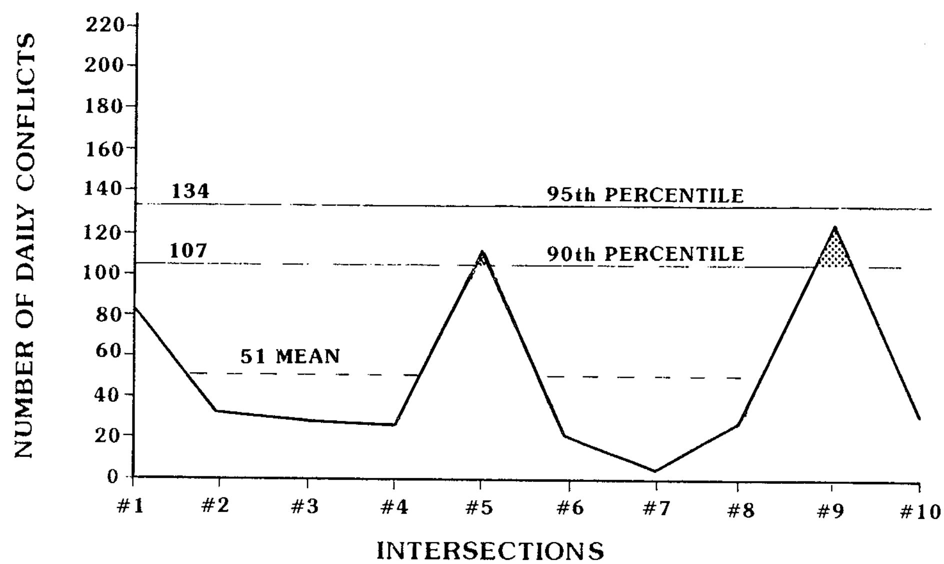


FIGURE 10 Right-turn, same-direction traffic conflicts.

SUMMARY AND CONCLUSIONS

A study was performed to determine the average and abnormally high conflict counts for a three-leg, unsignalized intersection. The results of this study may be used as a guideline when evaluating other three-leg, unsignalized intersections by the traffic conflict technique. *Traffic Conflict Techniques for Safety and Operations—Engineer's Guide* (*3*) should be obtained for further explanation of the technique. The results obtained are based on data collected in the Houston, Texas, area during daylight hours (7:00 a.m. to 6:00 p.m.), on weekdays (Monday through Friday), and with dry-pavement conditions. Other geographical locations may have varying driver behavior. Additionally, there may be environmental conditions that influence the data results in other regions.

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Publication of this paper sponsored by Committee on Methodology for Evaluating Highway Improvements.