Evaluation of Urban Intersections Using Traffic Conflict Measures

Mike E. Clayton
University of Kentucky

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MEMORANDUM TO: G. F. Kemper  
State Highway Engineer  
Chairman, Research Committee  

SUBJECT: Research Report No. 476; Evaluation of Urban Intersections Using Traffic Conflicts Measures; "KYP-76-81; HFR-PL-1(.3), Part III-B.

The report transmitted herewith issues from extra-ordinary circumstances explained by R. C. Deen in a memorandum included herewith.

Traffic conflicts and erratic maneuvers offer the best possibilities of identifying hazardous sites and in treating them in an analytical or diagnostic manner in the absence of accident histories and fatality-type statistics. Whereas some researchers and experts have argued that there is no relationship between accident incidence and conflicts, our intuitiveness prevails; and a series of reports will be forthcoming from this study. Warrants identifying potential hazards will be developed. This report, however, will be given limited distribution.

Respectfully submitted,

Jas. H. Havens  
Director of Research

gd  
Attachments  
cc's: Research Committee
MEMORANDUM TO: James H. Havens  
Director  
Division of Research  

FROM: Robert C. Deen  
Assistant Director  
Division of Research  


Traffic conflicts, erratic maneuvers, and near-miss accidents have been proposed as means of obtaining information concerning accident potentials on the highways. Mike Clayton, a senior civil engineering student at the University of Kentucky, has prepared this report for a special problems course at the University under my supervision. The effort represents observations at two sites in Lexington and an analysis of each. Since the Division of Research is currently involved in a number of studies of this type, including the two reported herein, it seemed to be appropriate to direct Mr. Clayton's activity and to issue his findings in a study report. The data collected will also be used as a part of the data bank for our research studies. The remedies and physical improvements proposed by the author are those seen by the traffic analyst and are not necessarily feasible or desirable from the standpoint of costs and benefits.

gd  
Attachment
The purpose of this report was to analyze two urban intersections using conflict data, erratic maneuver data, and near-miss accident data and to recommend site improvements, if necessary. The two intersections selected were Euclid Avenue at Woodland Avenue and New Circle Road at Woodhill Drive in Lexington. Data were taken using 11-hour observation periods.

Proposed improvements for the site on Euclid Avenue included adding dual left-turn lanes and three-phase signals or an extended multi-turn lane. At the New Circle site, a longer, more gradual right-turn lane and repositioning some of the signing are recommended. The conflict data recorded were found to be very useful in identifying the specific causes of the problems.
EVALUATION OF URBAN INTERSECTIONS USING TRAFFIC CONFLICTS MEASURES

KYP-76-81; HPR-PL-1(13), Part III-B

by

Mike E. Clayton
Senior Civil Engineering Student
University of Kentucky

advised by

Robert C. Deen
Assistant Director

Division of Research
Bureau of Highways
DEPARTMENT OF TRANSPORTATION
Commonwealth of Kentucky

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Bureau of Highways. This report does not constitute a standard, specification, or regulation.

August 1977
INTRODUCTION

Attempts to analyze or evaluate the relative safety of highway locations are often complicated when accident data are used. Accident records in many cases are incomplete and inaccurate, and several years of data are usually needed for a reliable sample. Accident diagrams do not always help the traffic engineer determine the causes of accident problems; thus, some appropriate highway improvements may not be recognized. Traffic conflicts may, therefore, be a better descriptor of potential hazards than short-term accident data.

A traffic conflict is an evasive action, such as braking or weaving, which is forced on a driver by an impending accident situation, or a traffic violation. Traffic conflicts are measures of accident potential and operational problems at a location. Conflict studies can be completed using objective criteria to obtain significant quantities of data in as little as one day of observation. Operational problems can then be determined and improvements made before accidents are allowed to occur.

Other measures of accident potential include erratic maneuvers and near-miss accidents. An erratic maneuver is any sudden, unexpected movement by a vehicle which could result in an accident. Examples of erratic maneuvers at intersections are U-turns, vehicles turning left from the right lane, and vehicles using the highway shoulder as a turning lane. A near-miss accident occurs when a collision between two or more vehicles is barely avoided due to a last-second movement or stop. Conflicts, erratic maneuvers, and near-miss accidents are all measures of driver confusion or disruption in traffic flow. Patterns of these occurrences provide the engineer with hints as to site deficiencies which need to be improved to reduce accident potential.

The purpose of this study was to analyze two urban intersections based on traffic conflicts, erratic maneuvers, and near-miss accidents and to propose improvements to reduce the dangers at each site. Another objective was to determine the value of these non-accident indicators in identifying specific problems at urban intersections.

TRAFFIC CONFLICTS

The Traffic Conflicts Technique (TCT) was developed by General Motors in 1967 (1). Approximately twenty specific types of conflicts were defined for measuring accident potential at intersections. Several state highway agencies including Ohio, Virginia, and Washington currently utilize modifications of the TCT for determining specific improvement needs at hazardous intersections (2, 3, 4). Traffic conflict counts are also utilized in Canada, Great Britain, and Sweden.

An advantage which makes the traffic conflicts technique adaptable to all intersections is that the types of conflicts listed on the data sheets (APPENDIX A) may be changed to accommodate other types of conflicts which are deemed important at a particular site. For example, an intersection may have a "run-red" problem. Then, one of the non-used categories may be crossed out and used as a run-red category.

The basic types of accidents at intersections may be classified as left-turn, weave, cross-traffic, red-light violation, and rear-end accidents. The corresponding conflict types were defined as follows by the General Motors study (1):

A left-turn conflict involves a vehicle crossing directly in front of an opposing through vehicle. The evasive action involves braking or weaving of the through vehicle (Figure 1).

![Figure 1. Left-Turn Conflict (1).](image)

The weave conflict, associated with a weave or sideswipe accident, is defined as a situation in which a vehicle changes lanes and merges into the path of another vehicle (Figure 2). The offended vehicle brakes or weaves to avoid collision. Weave conflicts can occur as a result of lane changes, turns from improper lanes, or turns into wrong lanes.
A cross-traffic conflict involves a vehicle crossing or turning into the path of a through, right-of-way vehicle, causing the through vehicle to brake or weave (Figure 3). Cross-traffic conflicts are generally observed at nonsignalized intersections where the cross-road vehicles are supposed to stop and give right of way to arterial traffic. Cross-traffic conflicts can also occur at signalized intersections having special signal-control phases, e.g., right-turn red-arrow sequences. There are three categories of cross-traffic conflicts: through vehicles that completely cross the arterial, left-turn cross-road vehicles that completely cross one direction of traffic and turn left into the path of a right-of-way vehicle, and right-turn cross-road vehicles that turn right into the path of a right-of-way vehicle.

A red-light violation conflict is defined as a situation in which a vehicle enters the intersection on a red signal. Vehicles that have entered the intersection legally and complete their movement after the signal changes are not considered violators. The three categories of red-light violators -- through vehicles, left-turn vehicles, and right-turn vehicles -- are considered separately because they appear to have different accident potentials. At intersections which have all-red phases, separate counts are made of red-light violators who enter the intersection after the all-red phase.

A rear-end conflict, in general, can be defined as a situation in which a vehicle stops unexpectedly and causes a following vehicle to take evasive action to avoid a rear-end collision. Left-turn and right-turn incidents are recorded separately so that initial causations of incidents may be noted. The third type involves a vehicle stopping or slowing in a through lane and causing a following, through vehicle to brake or weave (Figure 6). Vehicles approaching an apparently clear intersection on a green signal have been observed coming to a complete stop before proceeding through the intersection. This type of rear-end conflict can also be initiated by entrances beyond an intersection causing vehicles to back up into the intersection, slow trucks beyond the intersection, merging situations, disabled vehicles, emergency vehicles, general congestions, and traffic back-ups. The fourth type of rear-end conflict is a situation in which a vehicle slows or stops when involved in a traffic conflict and causes a following vehicle to take evasive action to avoid a rear-end collision (Figure 7). Left-turn conflicts, weave conflicts, and cross-traffic conflicts can produce "slow-for-traffic rear-end conflicts."
Figure 4. Stop-on-Amber Rear-End Conflict (1).

Figure 5. Slow-for-Turn Rear-End Conflict (1).

Figure 6. Slow-in-Through-Lane Rear-End Conflict (1).

Figure 7. Slow-for-Traffic-Conflict Rear-End Conflict (1).
ERRATIC MANEUVERS

The use of erratic maneuvers has been limited primarily to lane-drop locations, gore areas, and ramps on high-speed facilities. Specific types of erratic maneuvers were defined and used to evaluate traffic control devices at exit gore areas in a study by Taylor and McGee in 1973 (5). Counts were made in Kentucky to evaluate maintenance signing, raised pavement markers, and operational characteristics of lane drops (6, 7, 8).

Here the erratic maneuvers observed were rated on a severity scale of one to three, where a one was a routine erratic maneuver, a two was moderate case, and a three was considered serious. Next, the approximate time of maneuver was recorded along with the number of vehicles, vehicle direction, and a brief description of what happened. All maneuvers were then categorized by severity, type of probable accident, and the number of times it occurred. Diagrams of each maneuver were drawn to show how the erratic maneuver occurred. A copy of the data sheet is given in APPENDIX A.

NEAR-MISS ACCIDENTS

Very little work has been documented using counts of near-miss accidents to identify specific problems at a location. This is due to the limited occurrences of near-miss accidents and the greater reliance on subjectivity than with traffic conflicts or erratic maneuvers. Work in this area by Forbes (9) and Hayward (10) attempted to utilize near-miss accident data for evaluating problem intersections.

Near-miss accidents have been considered as predictors of accident-rate characteristics. The near-miss, loosely defined, is a traffic event which produces more than an ordinary amount of danger than a mere conflict. Near-misses would appear to be closely related to the accident pattern witnessed at a location and, therefore, could become an attractive alternative to accident histories. Near-misses have never been considered seriously as accident predictors because their detection and classification involve a great deal of judgement on the part of the observer. An event which looks dangerous to an observer who is a conservative or inexperienced driver may appear commonplace to an observer who drives very aggressively. Consequently, counts of near-miss events could vary substantially because of the differences in the personalities and driving experiences of the observers (10). A copy of the near-miss accident form is given in APPENDIX A.

PROCEDURE

Data were collected on Tuesday, May 10, 1977, at Site 1 (New Circle Road and Woodhill Drive); and data for Site 2 (Euclid Avenue and Woodland Avenue) were collected on Thursday, June 10, 1977. There were four observers at each location. All the observers had several hours of training in counting conflicts. Generally, one observer was responsible for the conflicts, erratic maneuvers, and near-misses on two of the approach legs; another observer counted traffic (volume data). Each set of approach legs were observed simultaneously for 15-minute periods. The fourth man alternated positions with the conflict and volume observers throughout the day. Each observer received a 15-minute break each hour. Lunch times were staggered to accommodate continuous observation of the intersection.

The conflict observers positioned themselves on the shoulder of the road approximately 100 to 300 feet (30 to 90 m) from the intersection, as shown in Figure 8. However, this was not always possible; at the Euclid and Woodland site, observers sat on chairs on the sidewalks to observe traffic, since there were no shoulders. The volume counter usually positioned himself very close to the intersection to provide a clear view of all lanes.

Figure 8. Brake-Light Criteria Observation (1).
NEW CIRCLE ROAD AT WOODHILL DRIVE

New Circle Road (KY 4) and Woodhill Drive intersect on the southeast side of Lexington. New Circle Road is a partially controlled, four-lane highway; Woodhill Drive is a two-lane, collector street. Both are adjacent to heavily-visited, urban shopping centers. Woodhill Drive is the main access to Woodhill Plaza and a rear exit to Lexington Mall. The average speed on New Circle Road for free-flowing conditions is approximately 40 mph (18 m/s). New Circle Road is a four-lane highway with left- and right-turn lanes. Woodhill Drive is a two-lane road; both lanes are used for through and turning traffic. Another lane is reserved for collecting right-turn traffic off of New Circle. Lanes are 12 feet (3.6 m) wide except for the 16-foot (4.9-m) wide collector lanes on Woodhill. A 20-foot (6.1-m) median separates traffic on New Circle; the median narrows to an 8-foot (2.4-m) width before the intersection. Woodhill’s west approach has a 20-foot (6.1-m) median to separate the collector lane and other lanes which is approximately 40 feet (12.2 m) long. There are 10-foot (3-m) shoulders on New Circle Road adjacent to the through lanes only; there are none on Woodhill Drive. Drainage includes a 4-foot (1.2-m) ditch which parallel to New Circle Road and 9 feet (2.7 m) away from the shoulder. This drains into concrete drainage inlets at each corner of the intersection. These facilities are approximately 10 feet (3.0 m) away from the intersection. Telephone poles are located only on the southbound approach of New Circle Road. There is also a southbound off ramp beyond Woodhill Drive; this channels traffic from New Circle onto Richmond Road.

The average annual daily traffic (AADT) for this intersection is approximately 35,000. As seen in Figure 9, the northbound volume is highest in the early morning and lowest during midday and in late afternoon. The southbound traffic is lowest in the morning and midday and highest in late afternoon. People travel toward the city in early morning and return home on the southbound approach.

The location was selected for conflict analysis because it was suspected of having a right-turn accident potential. Also, the analysis provided an evaluation of improvements made previously. A condition diagram of the intersection is given in APPENDIX B. Total volume is shown in Figure 10. Volumes of all 12 traffic movements in each hour are given in Table 1.

Figure 9. Hourly Volumes on New Circle Road.
Figure 10. Total Volumes on New Circle Road and Woodhill Drive.
Table 1. Hourly Volumes; New Circle-Woodhill Intersection

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EUCLID AND WOODLAND AVENUES

Euclid and Woodland Avenues intersect within a few blocks of the University of Kentucky and serve a considerable number of student motorists and pedestrians. Euclid Avenue is an arterial road; Woodland Avenue is considered a local road. The streets intersect at the junction of two small shopping areas. The average, free-flowing speed on both streets is approximately 25 to 30 mph (11 to 13 m/s).

Euclid Avenue has four lanes, two lanes in each direction, and a 4-foot (1.2-m) median which ends 10 feet (3 m) before the intersection. Woodland has only two lanes, but there are lanes reserved to collect right-turning traffic onto Euclid. Lane widths on Euclid Avenue are 12 feet (3.7 m); on Woodland, the two lanes used for through and left-turning vehicles are 10 feet (3.0 m) wide, and the right-turn lanes are 18 feet (5.5 m) wide. There are no shoulders adjacent to either street. Sidewalks vary in width from 4 to 6 feet (1.2 to 1.8 m). The only street drain is a curb inlet located to the north on the northbound approach of Euclid adjacent to University Plaza. There are also telephone poles very close to each corner of the intersection.

One major distinction of this intersection, especially on Euclid, is the closeness of homes and driveways. Entrances for University Plaza and to Shop and Save shopping centers are shown in APPENDIX B.

The average annual daily traffic for this intersection is about 16,000. As shown in Figures 11, 12, and 13, peaks occur at the expected rush hours, i.e. early morning, midday, and late afternoon. Figure 11 shows volume on the southbound approach; peaks occur at midday and late afternoon. The low points are at early morning and late afternoon. On the northbound approach (Figure 12), the only high peak occurs in the early morning because most drivers travel northbound toward town. After morning, through volume remains fairly constant (Figure 13). Volume data for this site are summarized in Table 2.
Figure 12. Hourly Volumes on Northbound Euclid Avenue.

Figure 13. Total Volumes on Woodland and Euclid Avenues.
Table 2. Hourly Volumes; Euclid-Woodland Intersection

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Total: 10,865
DATA ANALYSIS

NEW CIRCLE ROAD AT WOODHILL DRIVE

At the intersection of New Circle Road and Woodhill Drive, conflict data (see APPENDIX C for a conflicts diagram) were collected only for the southbound approach of New Circle. The total number of conflicts observed during the 11-hour test period was 895. Of these 895 conflicts, the most common types were congestion in intersection or traffic backup (451) (50.4 percent), shoulder used for right turn (124) (14 percent), slow for left turn (56) (6 percent), and slow for right turn (91) (10 percent). Other types of conflicts include weave conflicts, left turn from wrong lane, late-entry right turn, opposing left turn, run red light, right-turn accident, abrupt stop, previous conflicts, and pedestrian rear-end. A summary is shown in Table 3.
The conflicts accounting for more than half of the total were due to congestion in the intersection. The next most serious conflict (caused by a short right-turn lane) was caused by drivers using the shoulder as a right-turn lane. As traffic volumes increased, the number of drivers attempting to turn right increased, and both through lanes became congested as drivers were unable to get into the right-turn lane. Drivers then became impatient to turn right and began using the shoulder to get into the designated right-turn lane. The third serious conflict, very much related to the second, was slow for right turn. This was caused by people who wanted to get into the right-turn lane slowing to find an opening into the right-turn lane. Lastly, the slow-for-left-turn conflict caused basically the same conditions as noted previously for the right-turn lane.

The conflicts per 15 minutes were plotted in Figure 14 to see if any pattern resulted. Conflicts gradually increased throughout the day to its highest peak (39 conflicts) between 4:30 and 5:30 p.m. This is also shown in Figure 15 in which conflicts per hour were plotted against time of day.

A plot of volume per 15 minutes versus conflicts per 15 minutes, Figure 16, tests correlations between conflicts and volumes. The r-value was 0.72 (a good correlation).

In Figure 17, conflicts per 1000 vehicles was plotted against time of day. Peaks occurred at 10:30-11:30 a.m. and 1:30-2:30 p.m., which are not the peak rush hours. Although there were small peaks in conflicts during peak rush hours, they were not as high as in the non-peak rush hours. These data were then used to plot conflict rates per 1000 vehicles versus volumes per hour. Virtually no correlation was found between conflict rate and volume; the r-value was only 0.14.

Figure 14. Conflicts per 15 Minutes on New Circle Road and Woodhill Drive.
Figure 15. Conflicts per Hour on New Circle Road and Woodhill Drive.

Figure 16. Conflicts per 15 Minutes versus Volume per 15 Minutes on New Circle Road and Woodhill Drive.
At New Circle Road and Woodhill Drive, there were 31 erratic maneuvers; 21 were related to the right-turn lane. In the early morning hours, all right-turn erratic maneuvers involved drivers not knowing whether to go straight or turn right. The second category was turning late at the right-turn entrance; this was due either to drivers not knowing whether to go straight or turn right or to driver negligence. The last category came about as volumes increased; drivers swerved sharply in front of a right-turn vehicle already in the right lane. This was due again to inadequate space in the right-turn lane. All other maneuvers were very specific types, such as abrupt stops, turning sharply into the left lane, and a weave that resulted in an erratic maneuver. These maneuvers did not fit a pattern. A summary is given in Table 4, and a detailed description of each maneuver is given in APPENDIX D.

Three near-miss accidents were observed at the site.

Near-Miss Accident 1 was apparently due to the driver of Vehicle 1 not knowing if he wanted to go straight or turn left or not realizing there was a left-turn lane. When he was almost through the intersection, he must have realized he must turn left; and this is when Vehicle 1 saw the left-turn lane. The driver of Vehicle 1 slammed on his brakes and swerved sharply into the left-turn lane behind Vehicle 2, causing Vehicle 2 to be almost rear-ended.

Near-Miss Accident 2 involved a driver of Vehicle 2 who apparently did not know if he wanted to go straight through the intersection or turn right. When Vehicle 2 was almost through the intersection, the driver realized he had to turn right, and he saw the right-turn lane but swerved too sharply, almost side-swiping Vehicle 1.
In Near-Miss Accident 3, the driver of Vehicle 2 apparently thought he did not have enough time or space to slow down and let Vehicle 1 proceed in the right-turn lane. Vehicle 2 accelerated and tried to pass Vehicle 1 and at the same time make the right turn; Vehicle 1 almost side-swiped Vehicle 2.

EUCLID AND WOODLAND AVENUE

Conflicts per 15 minutes at Euclid and Woodland Avenues are summarized in Tables 5 and 6. There were 1,004 conflicts in the 11-hour test period, or 91.3 conflicts per hour; 622 or 62 percent were committed on the northbound approach. This high rate can be attributed to entrances to the University Plaza and Shop and Save on the northbound lane of Euclid. For the northbound approach, the hourly conflict rate was 56.5; on the southbound approach, the conflict rate was 34.7 per hour.

The most numerous types of conflicts for both approaches (see APPENDIX C for a conflicts digram) include brake-for-left-turn, slow-for-left-turn, slow-for-right-turn, congestion-in-the-intersection, and opposing-left-turn conflicts. The percentages for each type of conflict of each approach leg shown below:

<table>
<thead>
<tr>
<th>TYPE OF CONFlict</th>
<th>Percent</th>
<th>Southbound Approach</th>
<th>Northbound Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>87.9%</td>
<td>83.8%</td>
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<tr>
<td>Opposing left turn</td>
<td>3.7%</td>
<td>2.0%</td>
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<tr>
<td>Congestion in intersection</td>
<td>60.0%</td>
<td>53.0%</td>
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<tr>
<td>Slow for right turn</td>
<td>4.5%</td>
<td>9.0%</td>
<td></td>
</tr>
<tr>
<td>Slow for left turn</td>
<td>15.0%</td>
<td>14.3%</td>
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</tr>
<tr>
<td>Brake for left turn</td>
<td>4.7%</td>
<td>5.5%</td>
<td></td>
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Table 5. Conflicts on Southbound Euclid Avenue; Euclid-Woodland Intersection

<table>
<thead>
<tr>
<th>Time</th>
<th>Head-on</th>
<th>Other Conflicts</th>
<th>Right Turn</th>
<th>Left Turn</th>
<th>Right Turn from Opposite Lane</th>
<th>Left Turn from Opposite Lane</th>
<th>Head-on from Opposite Lane</th>
<th>Total Violations</th>
</tr>
</thead>
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<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

*Does not include head-on collisions.*

| Total       | 182     | 13              | 34              | 34              | 6                | 3               | 1               | 9               | 225             | 2               | 9               | 2               | 382             | 382             |
Table 6. Conflicts on Northbound Euclid Avenue; Euclid-Woodland Intersection

<table>
<thead>
<tr>
<th>Time</th>
<th>Conflicts</th>
</tr>
</thead>
<tbody>
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<td>7:00-8:00</td>
<td>WEAVE</td>
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<td>8:00-9:00</td>
<td>WEAVE</td>
</tr>
<tr>
<td>9:00-10:00</td>
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<td>12:00-1:00</td>
<td>BRAKE FOR</td>
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<td>BRAKE FOR</td>
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<td>3:00-4:00</td>
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<td>SLOW VEHIC</td>
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<td>5:00-6:00</td>
<td>CONGESTION</td>
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<td>TRAFFIC</td>
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<td>PEDESTRIAN</td>
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<td>9:00-10:00</td>
<td>15-MINUTE</td>
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<td>HOURLY</td>
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Note: The table includes various types of conflicts recorded during the specified time periods.
These five types account for more than 80 percent of the total conflicts. The most numerous conflict, congestion in the intersection, was caused partially by through drivers waiting for vehicles to turn left onto Woodland Avenue. The next most numerous conflict was slow for left turn; and here again, through vehicles were often slowed by vehicles turning left onto Woodland Avenue. The last two conflicts in the above list are also indirectly related to vehicles attempting to turn left onto Woodland Avenue, indicating that a left-turn lane might reduce the number of left-turn conflicts.

Plots of conflicts in each 15-minute period are given in Figure 18 (northbound approach for Euclid);

the highest peak, 31, occurred in the early morning hours; smaller peaks are at midday and 3:30-4:30 p.m.
The southbound Euclid approach (Figure 19) showed low conflicts that increased to a peak of 33 per 15 minutes between 4:30-5:30 p.m. The early northbound peak can be attributed to people going to work and the peak on the southbound approach to people going home. Also, the northbound approach was more traveled compared to the southbound approach, due to the closeness of the shopping entrances to the northbound approach. Conflicts per hour were also plotted in Figures 20 and 21, respectively.

Figure 18. Conflicts per 15 Minutes on Northbound Euclid Avenue.
Figure 19. Conflicts per 15 Minutes on Southbound Euclid Avenue.

Figure 20. Conflicts per Hour on Northbound Euclid Avenue.
In Figures 22 and 23, plots of conflicts per 15 minutes versus volume per 15 minutes for each approach were made. On the southbound approach shown in Figure 22, the best-fit equation of regression was \( y = 0.17x - 3.64 \), and the \( r \)-value was 0.81 (a good correlation). On the northbound approach (Figure 23), the \( r \)-value was 0.70, and the equation of the line was \( y = 0.11x + 3.46 \).

Conflicts per 1000 vehicles versus time of day were plotted for each approach. On the northbound approach (Figure 24), the only peak was between 12:30 and 1:30 p.m. This can be attributed to people turning into the University Plaza for lunch. Other than this, the conflict rates are fairly constant. On the southbound approach (Figure 25), the conflict rate gradually increased to a peak of 0.18 between 4:30 and 5:30 p.m. This can be attributed only to conflicts increasing as the volume increased.

Relationships between conflicts per 1000 vehicles and volume per hour were also found. However, \( r \)-values for the northbound and southbound approaches were 0.17 and 0.67, respectively. This indicates a possible correlation for the southbound approach only.

The number of erratic maneuvers at this intersection was small as shown in Table 7. Of these, the most numerous involved possible sideswipes and rear-end collisions. A detailed description of each erratic maneuver is given in APPENDIX D.

Only two near-miss accidents were observed at this site during the period. In Near-Miss Accident 1, a pickup truck was in the process of making a left turn from southbound Euclid onto Woodland and apparently did not see a motorcycle which was northbound. The motorcyclist thought the pickup would stop; however, when the cyclist saw the truck starting to make his turn, he was forced to brake and veer right, nearly overturning. Then the driver of the pickup braked, closely missing the cyclist. It seems that the pickup driver did not see the motorcyclist because he was not very alert. This near-miss was not caused by any geometric deficiency of the intersection.
Figure 22. Conflicts per 15 Minutes versus Volume per 15 Minutes on Southbound Euclid.

\[ y = 0.17x - 3.64 \]
\[ r = 0.81 \]

Figure 23. Conflicts per 15 Minutes versus Volume per 15 Minutes on Northbound Euclid.

\[ y = 0.11x + 3.46 \]
\[ r = 0.70 \]
Figure 24. Conflicts per 1000 Vehicles on Northbound Euclid.

Figure 25. Conflicts per 1000 Vehicles on Southbound Euclid.
New Circle Road at Woodhill Drive

There is definitely a right-turn problem at this site. Approximately 80 percent of the erratic maneuvers there are related to the right-turn lane. Until about 1:00 or 2:00 p.m., drivers have trouble deciding if they want to go left or right. This is evidenced by late right turns and swerves from the far lane to the right-turn lane. After 2:00 p.m., drivers have trouble getting into the right-turn lane; this is indicated by erratic maneuvers wherein one or two drivers swerve in front of a driver already proceeding to make a right turn. After 2:00 p.m., there is an increase in volume per hour, indicating that drivers have much less maneuvering time to get into the right lane. Also, conflicts per minute after 2:00 p.m. show an increase. This serves as another check that less time for maneuvering is available and consequently is causing more conflicts after 2:00 p.m. and more right-turn erratic maneuvers.

Another problem with the right-turn lane is that drivers who cannot see ahead of the intersection think that the right-turn lane leads directly to the off-ramp from New Circle to Richmond road. This can be seen by the type of erratic maneuvers in which drivers begin to make a right turn and then find this is not the off-ramp. They then swerve sharply out into the flow of through traffic. This problem could be corrected by placing advance destination signing adjacent to the right-turn lane on southbound New Circle before Woodhill. This could be seen by motorists and provide more time to decide if they want to proceed straight through or make the right turn.

The last conditions which seem to cause conflicts at this site have to do with geometric conditions. First, the radius of curvature of the right-turn lane from New Circle to Woodhill is too sharp. Some drivers make a very wide right turn to avoid this sharpness of the curb.

Based on the findings from the conflict data, the following improvements are recommended at the intersection of New Circle Road and Woodhill Drive:

1. Place advance destination signing adjacent to the right-turn lane on southbound New Circle Road before Woodhill Drive.
2. Lengthen the right-turn lane and make it more gradual from New Circle Road onto Woodhill Drive.
3. Ease the curvature of the curb from southbound New Circle Road to Woodhill Drive.

Euclid Avenue at Woodland Avenue

The intersection at Euclid and Woodland Avenues, based on conflict data, has a left-turn problem. In order for a car to turn left onto Woodland from either approach leg of Euclid, the left-turning car will block a lane of through traffic while waiting for a gap. Even then, it is difficult for the left-turn vehicle to make a turn when the light is green. Also, there are two small shopping areas which cause conflicts at the intersection on the southbound leg -- i.e., vehicles trying to turn left onto Euclid often come very close to cars turning off Euclid.

Due to the size of the lanes and the closeness of homes and business adjacent to Euclid, three improvements are suggested. The first concerns decreasing the width of each through lane of Euclid to provide for a left-turn lane. An alternative is a three-phase sequence of signaling for the intersection. One possible disadvantage of either of these proposals is the reduction in capacity for through traffic. Reduced widths of lanes at the intersection will reduce capacity as will the reduced green time per cycle, due to a three-phase signal. The third improvement involves construction of a multi-use turn lane, which would extend for several blocks along Euclid Avenue. This could serve as dual left-turn lanes at several intersections and provide storage for vehicles which turn left into businesses and private driveways. Although this proposal is probably the most expensive, it is likely to be the most attractive alternative.
REFERENCES


6. Cornette, D., Operational Characteristic of Lane Drops, Kentucky Department of Highways, Division of Research, August 1972.


APPENDIX A

DATA FORMS
<table>
<thead>
<tr>
<th>CONFLICTS DATA SHEET</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>START TIME (INITIAL)</strong></td>
</tr>
<tr>
<td><strong>C</strong> PROJECT NO.</td>
</tr>
<tr>
<td>Conflict Counts</td>
</tr>
<tr>
<td><strong>INTERSECTION</strong></td>
</tr>
<tr>
<td><strong>APPROACH NO.</strong></td>
</tr>
</tbody>
</table>

**Traffic Conflicts Data Sheet "C"**

District __, County _____________ (___)

Major Route _____________

Minor Route _____________

Route Design. _____________, Log Point _____________

Recorded By _____________

Comments _____________
<table>
<thead>
<tr>
<th>NUMBER</th>
<th>TIME</th>
<th>DIRECTION</th>
<th>NO. OF VEHICLES INVOLVED</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>2</td>
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<td>8</td>
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<td>9</td>
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<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**NEAR-MISS ACCIDENTS DATA SHEET**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NAME</td>
<td>2. AGE</td>
<td>3. SEX</td>
</tr>
<tr>
<td>4. DRIVING EXPERIENCE (YEARS)</td>
<td>5. OCCUPATION</td>
<td></td>
</tr>
<tr>
<td>6. LOCATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. VEHICLES INVOLVED (NUMBER &amp; YEAR/MAKE/TYPE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. TIME OF DAY</td>
<td>9. ESTIMATED SPEED</td>
<td></td>
</tr>
<tr>
<td>10. WEATHER CONDITIONS</td>
<td>11. LIGHT CONDITIONS</td>
<td></td>
</tr>
<tr>
<td>12. ROADWAY CHARACTER</td>
<td>13. ROADWAY SURFACE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. VEHICLE ACTION BEFORE NEAR-MISS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. APPARENT CONTRIBUTING FACTORS (HUMAN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. APPARENT CONTRIBUTING FACTORS (VEHICULAR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. APPARENT CONTRIBUTING FACTORS (ENVIRONMENTAL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. NEAR-MISS EXPLANATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. NEAR-MISS DIAGRAM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

CONDITION DIAGRAMS
APPENDIX C

CONFLICTS DIAGRAMS
A - Weave conflict
B - Late entry on right turn
C - Shoulder used for right
D - Right turn conflict
E - Abrupt stop
F - Slow for left turn
G - Slow for right turn
H - Previous conflict
I - Slow car or truck
J - Traffic backup
K - Run red
A - Weave Conflicts
B - Left from wrong lane
C - Opposing left turn
D - Run red
E - Brake for left turn
F - Slow for right turn from driveway
G - Slow for left turn
H - Slow for right turn
I - Previous traffic conflict
J - Congestion in intersection or traffic backup
L - Stalled vehicle
M - Pedestrian rear end
APPENDIX D

ERRATIC MANEUVERS
<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:02 a.m.</td>
<td>Bicyclist in the right of the right lane moved across all four lanes of traffic.</td>
</tr>
<tr>
<td>12:44 p.m.</td>
<td>Vehicle in left (inside) lane swerved into right lane and stopped.</td>
</tr>
<tr>
<td>4:40 p.m.</td>
<td>An auto backed from the University Plaza into northbound Euclid, causing a vehicle to brake and swerve into left lane, causing another vehicle to brake.</td>
</tr>
<tr>
<td>5:59 p.m.</td>
<td>Vehicle pulled from shopping center, made an U-turn, and then stopped in right lane.</td>
</tr>
<tr>
<td>6:18 p.m.</td>
<td>Bicyclist traveling on wrong side of street while dodging through vehicles.</td>
</tr>
<tr>
<td>6:13 p.m.</td>
<td>Pick-up truck backed from parking lot across two lanes of traffic.</td>
</tr>
</tbody>
</table>
### SOUTHBOUND EUCLID AVENUE AT WOODLAND AVENUE

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:22 p.m.</td>
<td>Bicyclist traveling on the median.</td>
</tr>
<tr>
<td>4:11 p.m.</td>
<td>Vehicle stopped in right lane to discharge passengers. A trailing vehicle braked and swerved.</td>
</tr>
<tr>
<td>3:28 p.m.</td>
<td>Vehicle backed from a driveway across two lanes, causing a through vehicle to brake and swerve around the backing vehicle.</td>
</tr>
</tbody>
</table>
### SOUTHBOUND NEW CIRCLE ROAD AT WOODHILL DRIVE

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:42 a.m.</td>
<td>Vehicle swerved sharply into left lane to clear green light.</td>
<td>2</td>
</tr>
<tr>
<td>7:49 a.m.</td>
<td>Vehicle crossed into left lane to make a left turn.</td>
<td>2</td>
</tr>
<tr>
<td>8:10 a.m.</td>
<td>Abrupt stop.</td>
<td>2</td>
</tr>
<tr>
<td>9:23 a.m.</td>
<td>Vehicle moved from right-turn lane into through-flow lane.</td>
<td>2</td>
</tr>
<tr>
<td>9:31 a.m.</td>
<td>Vehicle moved from left-turn lane to right-turn lane.</td>
<td>2</td>
</tr>
<tr>
<td>9:38 a.m.</td>
<td>Vehicle swerved partially into right-turn lane and back into through lane in front of a trailing vehicle.</td>
<td>2</td>
</tr>
</tbody>
</table>
Vehicle turned from eastbound lane into right, northbound lane and then into left northbound lane.

VEHICLE = 2

Vehicle made a very wide right-turn maneuver.

VEHICLE = 2

Vehicle backed at intersection after stopping.

VEHICLE = 2

Same as 9.

VEHICLE = 2

Vehicle turned into right-turn lane and then back into through lane.

VEHICLE = 2

Late right turn into path of a right-turning vehicle.

VEHICLE = 2
<table>
<thead>
<tr>
<th></th>
<th>13</th>
<th>11:53 a.m.</th>
<th></th>
<th>14</th>
<th>12:01 p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vehicle stopped at light, then tried to weave into the left lane.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEVERITY = 2</td>
<td>SEVERITY = 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>12:58 p.m.</td>
<td></td>
<td>16</td>
<td>12:45 p.m.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Same as 11.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Same as 11.</td>
<td></td>
</tr>
<tr>
<td>SEVERITY = 2</td>
<td>SEVERITY = 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>1:20 p.m.</td>
<td></td>
<td>18</td>
<td>1:20 p.m.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Same as 11.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Same as 11.</td>
<td></td>
</tr>
<tr>
<td>SEVERITY = 1</td>
<td>SEVERITY = 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Description</td>
<td>Severity</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>----------</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2:11 p.m.</td>
<td>Vehicle moved into right-turn lane immediately behind leading vehicle also moving into right-turn lane.</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:12 p.m.</td>
<td>Same as 11.</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:17 p.m.</td>
<td>Same as 11.</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:17 p.m.</td>
<td>Three vehicles turned into right-turn lane almost simultaneously, almost causing a multiple rear-end accident.</td>
<td>2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3:12 p.m.</td>
<td>Trailing vehicle uses shoulder as a right-turn lane immediately behind a leading vehicle moving into right-turn lane.</td>
<td>2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4:28 p.m.</td>
<td>Vehicle stopped on right-turn lane for 5 minutes, then moved across two lanes into left-turn lane.</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SOUTHBOUND NEW CIRCLE ROAD AT WOODHILL DRIVE

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>4:59 p.m.</td>
<td>Same as 11.</td>
</tr>
<tr>
<td>26</td>
<td>5:20 p.m.</td>
<td>Same as 11.</td>
</tr>
<tr>
<td>27</td>
<td>5:32 p.m.</td>
<td>Leading vehicle moved into right-turn lane late, immediately in front of trailing vehicle also moving into right-turn lane.</td>
</tr>
<tr>
<td>28</td>
<td>5:59 p.m.</td>
<td>Same as 11.</td>
</tr>
<tr>
<td>29</td>
<td>6:04 p.m.</td>
<td>Vehicle in left-turn lane crossed two through lanes into right-turn lane in front of two through vehicles.</td>
</tr>
<tr>
<td>30</td>
<td>6:14 p.m.</td>
<td>Two leading vehicles move into right-turn lane immediately in front of a trailing vehicle, also moving into the right-turn lane.</td>
</tr>
</tbody>
</table>
Vehicle in right-turn lane attempted to merge left into through lanes, but was unable to do so; vehicle then backed and made a right turn.

SEVERITY = 1