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ACCIDENT RATES AT INTERSECTIONS

by

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in cooperation with

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16. Abstract

The objectives of this study were to determine average accident rates for various categories of at-grade intersections and to identify intersections having high accident rates. This involved locating intersections of two or more state-maintained highways and determining the appropriate volumes to use as well as locating the accidents occurring at any given intersection.

A procedure was developed to allow for the identification of intersections having high or critical accident rates. A list of the intersections of two or more state-maintained roadways was developed. A total of 6,707 intersections were included in the file. Using county, route and milepoint information, accident and volume data were associated with each intersection. Accident rates were calculated for each intersection. The rates are in terms of accidents per million entering vehicles (ACC/MV). Statewide average and critical accident rates were calculated by functional classification. Intersections having critical accident rates were then identified using both the typical procedure and a procedure which accounted for the regression-to-the-mean bias.

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TABLE OF CONTENTS

INTRODUCTION

Accident rates on Kentucky highways have been calculated for highway sections in terms of accidents per 100 million vehicle miles and for spots in terms of accidents per million vehicles. Using this procedure, when analyzing rates at an intersection, the rates for a spot on one of the intersecting roadways had to be used. A more reliable analysis could be performed if accident rates were calculated specifically for various categories of intersections.

In order to specifically identify intersections that have a high-accident rate, it is necessary to have average rates for various types of intersections. In the current high-accident location identification process, average rates for intersections are not determined. Intersections must either be treated as a spot (0.3 mile in length) or identified as part of a longer section. This procedure uses accident and volume data for one of the intersecting roadways. A more accurate procedure would use numbers of accidents and accident rates considering all intersection approaches and total intersection volume.

Before average accident rates for various categories of at-grade intersections can be calculated, accurate accident and volume data must be obtained. The locations of intersections, as well as each accident, must be located so that an intersection-related accident can be assigned to the appropriate intersection. The procedure currently used to locate accidents involves associating a milepoint with the accident. The milepoint for the intersection must also be known to match with the milepoint for the accident. Also, a decision must be made concerning the length of road that will be associated with an intersection. Specifically, the range of milepoints on either side of the center of the intersection that should be assigned to the intersection must be determined.

A volume file exists for all state-maintained highways. For intersections of two or more state-maintained highways, the total volume at the intersection could be determined if the milepoint for the highways at the intersection is known. As with the accident data, this requires locating each intersection with a milepoint. No volume file exists for non-state maintained roadways.

The objectives of this study were to determine average accident rates for various categories of at-grade intersections and to identify intersections having high accident rates. This involved locating intersections of two or more state-maintained highways and determining the appropriate volumes to use as well as locating the accidents occurring at any given intersection. The procedure developed to obtain the objectives must be documented so that it may be used in the future to update the results of this study.

PROCEDURE

State-of-the-art Survey

A review of the literature was conducted to determine information available in the area of accident rates at intersections. A survey of the states was also performed to determine the current methodology used to identify high-accident locations or, specifically, high-accident intersections.

Accident Analysis

The procedure used to calculate accident rates by intersection involved three major steps. The first step was the identification of intersections of two or more state-maintained roadways. The county, route and milepoint for each intersecting roadway had to be determined at each intersection of two or more state-maintained roadways. A computer disk containing the information given on the statewide milepoint log was used as the base for the identification of intersections. The milepoint log was edited to exclude locations which did not involve a reference to an intersection. All intersections are not included in the milepoint log so county maps were used to add intersections. The list of intersections, by county, was later given to traffic engineers in each highway district in order to make modifications to ensure maximum accuracy. This list of intersections must be kept up-to-date in the future for the procedure to perform its function properly.

Only intersections of state-maintained highways could be included because accident locations are not identified off the state-maintained system and volume data are not available for non-state maintained roads. Also, intersections involving a ramp at an interchange were not included. This type of intersection could not be included because accidents could not be associated with a specific ramp and volume data were not available for specific ramps.

At each intersection, the number of intersection legs, or approaches, for each highway was also noted. The controlling factor in this process was the number of state-maintained approaches that came into an intersection. The number of legs could be either three or four. Following is an explanation of the various combinations. This classification was used in determining the volume assigned for each roadway. The 32/31 and 42/42 combinations are the two most common intersection classifications. The first number in the classification (3 or 4) refers to the number of state-maintained approaches at the intersection while the second number (1 or 2) is used to assign all or half of the volume of a route to the intersection.

32/31 This is a T-intersection with two roads intersecting. Typically, one route continues through the intersection while the other road either stops or starts at the intersection. The intersection could have four approaches but would be placed in this category when one approach was not state maintained. Both routes could continue through the intersection but the milepoint for one route would not increase until the two routes separated.

42/42	This would be a cross-intersection with two roads crossing each other and continuing on through the intersection.
31/31	There are three state-maintained approaches at the intersection. The route which continues through the intersection is one-way.
31/31/31	There are three state-maintained routes at the intersection where there are three state-maintained approaches.
42/41	Two roads cross each other and continue through the intersection such that there are four state-maintained approaches. One of the roads is one way.
41/41	Two one-way roads cross each other and continue through the intersection.
42/41/41	Three roads intersect with one continuing on both sides.
41/41/41	Three roads intersect with a one-way road continuing on both sides.

After identification of the intersections, the second step was to assign a traffic volume or annual average daily traffic (AADT) to each intersecting roadway. The milepoint for each road was determined using the milepoint log. This milepoint was then associated with a traffic volume by matching the county, route and milepoint to a file (the Historic file) containing traffic volumes for all state-maintained roadways. The Historic file is updated periodically. The most up-to-date file available at the time was used in the analysis. Either the total or one half of the traffic volume was assigned to a route. The intersection classifications indicated whether the total volume or one half of the volume was included. When the total AADT was used for a route, this route was a two-way road which continued through the intersection. One half of the AADT was used for one-way roads or for a route that did not continue through the intersection. The second number in the classification for a route was used to assign all the volume (when this number was a 2) or one half of the volume (when this number was a 1).

The third step was to associate accidents to the intersections. The intersecting roadways at each intersection were identified by county, route and milepoint. This information would allow accident data at this milepoint to be associated with the intersection. The milepoint is coded to the thousandth of a mile. The intersection accidents which should be associated with a given intersection would extend for a certain length on either side of the specific milepoint. Various distances were used to determine what should be used in the procedure. Ranges of plus or minus 0.05 mile, 0.10 mile and 0.15 mile were used for both urban and rural intersections. A range of 0.02 mile was also used for urban intersections.

Accident data were analyzed for the three-year period of 1989 through 1991. Using the directional analysis code, a subset of only intersection accidents was obtained. Accidents in the intersection subset for this three-year period were then associated with the various intersections of two or more state-maintained roadways. Total entering volume was used to calculate a rate for each intersection in terms of accidents per million entering vehicles (ACC/MV).

Each intersection was assigned a functional classification. The functional classification information was obtained from the same file (Historic file) which contains the traffic volumes. When the functional class on the intersecting roads at a given intersection did not match, the functional classification of the roadway with the highest traffic volume was used in the analysis. An analysis was then performed giving the statewide average accident rate (ACC/MV) for each functional classification. The critical accident rate for each functional classification was calculated. A critical number of accidents was also calculated for each functional classification. The following formula was used to calculate critical accident rates:

$$A_c = A_a + K(\mathrm{sqrt}(A_a/M)) + 1/(2M)$$

in which

A_c = critical accident rate,
A_a = average accident rate,
sqrt = square root,
K = constant related to level of statistical significance selected (a probability of 0.995 was used wherein K = 2.576), and
M = exposure (million vehicles).

To determine the critical number of accidents, the following formula was used:

$$N_c = N_a + K(\mathrm{sqrt}(N_a)) + 0.5$$

in which

N_c = critical number of accidents and
N_a = average number of accidents.

A ranking was obtained, by functional classification, of intersections having the highest accident rates. The intersection rates were also ranked using a computer program called BEATS (Bayesian Estimation of Accidents in Transportation Safety). This procedure was developed as part of a Federal Highway Administration report (Report No. FHWA-RD-90-091) by Texas Transportation Institute. This program has been used to correct for the regression-to-the-mean bias which causes problems in accident analysis.

A printout was also obtained, by county, summarizing the information for each intersection. The printout included the intersecting route numbers, number of intersection approaches, milepoint, functional classification, number of lanes, traffic volume, number of accidents and accident rate.

RESULTS

State-of-the-Art Survey

A literature search was conducted to determine past research which dealt with the calculation of accident rates at intersections. A survey of other states was also performed to obtain information concerning their current practice used to determine intersections with high accident rates. While there was a limited amount of information obtained from the review of literature, the survey of states revealed much more useful information. Responses were received from 36 states (73 percent). A brief summary of the response from each state is given in Appendix A.

Of the 36 responses, 14 states (39 percent) indicated they calculate accident rates for intersections using total entering volume. Statewide accident rates are then used to identify high-accident intersections. In some of the other states, accident rates were estimated for intersections using data for the major roadway. In other cases, high-accident intersections would be identified as a spot location in the identification procedure.

There were several methods used to classify intersections. The most common was to use rural or urban categories. Other methods used by more than one state were type or classification of highway, number of lanes, divided or undivided, and traffic control.

The length of road to be associated with the intersection varied. This length varied from using an approach length of 100 feet to using a spot of 0.3 mile. The most common method was to use a 0.1-mile spot.

The intersection accident rates are given in terms of accidents per million vehicles. Examples of some rates are given in the summaries in Appendix A.

Accident Analysis

~~The milepoint log was used, along with a review of county maps, to develop~~ a list of intersections. A list was prepared for each county. A preliminary list was distributed to each of the 12 highway districts to verify the accuracy of the intersection data.

A total of 6,705 intersections of two or more state-maintained roads were identified. The number in any county varied from 18 in Robertson County to 136 in Graves County. The variance by district was from 392 in District 12 to 885 in District 2.

An extensive analysis was conducted to determine the most accurate milepoint range to use. The objective was to select a range which would identify all accidents associated with an intersection but would not include accidents at adjacent intersections.

A subset of intersection accidents (as determined by the directional analysis code) was used as the source of accident information. For the three-year period of 1989 through 1991, there were 129,396 accidents identified as occurring at an intersection. This represented 30 percent of the total accidents in the state over this time period. When accidents without a route or milepoint were eliminated, the file contained 85,887 accidents. This represented 20 percent of all accidents and 66 percent of all accidents at intersections.

In order to determine the necessary accident and volume data, a milepoint had to be associated for each roadway at each intersection. The milepoint data should be available at intersections involving two or more state-maintained roadways. However, a large number of intersection accidents involve only non-state maintained roadways. Also, many intersection accidents on state-maintained roadways would not involve another state-maintained roadway. These intersections and the associated accidents could not be included in the analysis. Intersections where one approach was from a ramp from a limited access highway were not included since traffic volume information was not available for the ramps. It has also been estimated that about 10 percent of accidents on state-maintained roadways do not have a milepoint assigned. Accidents having no milepoint could not be used in the analysis. All of these factors reduced the number of useable accidents substantially.

The milepoint assigned to a roadway at a particular intersection came from the milepoint log and was given to the thousandth of a mile. An intersection would have an effect on accidents for a distance on either side of the middle of the intersection. The number of accidents within a milepoint range on either side of the specific milepoint for the intersection was identified. Ranges of plus or minus 0.05, 0.10 and 0.15 miles were used for both rural and urban intersections with plus or minus 0.02 mile also used for urban locations. Computer printouts of accidents occurring at and near several intersections were obtained to determine what range would be needed to identify accidents occurring at the intersection but not include accidents not associated with the intersection.

Of the total intersection accidents statewide, about 17 percent were associated with the 6,705 intersections when the 0.05-mile range was used. This percentage decreased to approximately 15 percent when a 0.02-mile range was used for urban locations. When only accidents having a given route and milepoint are considered, about 25 percent of the accidents in the intersection file were identified using the 0.05-mile range compared to about 23 percent when a 0.02-mile range was used for urban locations.

After review of the data, it was clear that the maximum range which should be used was 0.05 mile or about 250 feet on either side of the intersection. In urban areas this length could be a problem, so a length of 0.02 mile or about 100 feet on either side of the intersection was analyzed. When the distance between intersections is less than 500 feet, an accident could be assigned to an incorrect intersection using the 0.05-mile range. The large majority of accidents occurring at an intersection were found to be coded with the milepoint given in the milepoint log. This milepoint is given to the thousandth of a mile.

In order to obtain the most accurate information, the decision was made to use the 0.05-mile range for rural intersections and the 0.02-mile range for urban intersections. This resulted in associating 19,590 accidents with the 6,705 intersections over the three-year period of 1989 through 1991. While it would be possible to omit accidents occurring at an intersection using these ranges, the possibility of incorrectly assigning accidents to an intersection was minimized. The accuracy of assigning accidents to the intersections is dependent upon the accuracy of the coding of the appropriate milepoint and directional analysis code.

An analysis of the coding of accidents at a sample of 100 intersections is shown in Appendix B. The purpose for this analysis was to compare the data in the file used in this analysis with the Kentucky Accident Reporting System (KARS) data and to determine how accidents at intersections were being coded. The county, route and milepoint is given for each of these intersections. A comparison was made between: 1) the number of accidents associated with the intersection (using 0.02- and 0.05-mile ranges) from the file of intersection accidents (data for 0.02-mile range was only obtained for urban intersections) and 2) the number of accidents associated with the intersection at the exact milepoint and for the two milepoint ranges using KARS data.

The KARS data show that the majority of accidents (81 percent) identified with the 100 sample intersections were coded using the exact milepoint for the intersection. This analysis confirmed that there was no reason to expand the range beyond 0.05 mile for rural intersections and 0.02 mile for urban intersections. This analysis also confirmed the accuracy of the accident file used in this analysis. The accident file used in this analysis contained 99 percent of the accidents identified using the KARS data file. There were few differences between the number of accidents identified with intersections using the two sources of accident information. Of the 100 intersections, differences were found at eight intersections. The difference at four of the eight intersections was because of identical milepoints for one of the roads at two different intersections. This occurred as a result of two roads intersecting and continuing concurrently for a distance. The milepoints for the higher numbered road would not increase over this distance so, at the intersection where the roads separate, it would have the same milepoint as the intersection where the roads first met. When this occurs, the accidents can only be assigned to one of the intersections.

A sample of the information obtained for each intersection is given in Figure 1. Shown in this figure is a portion of a summary printout giving the information for the intersections in one county. Following are explanations of the information given in Figure 1. There are at least two lines per intersection since each line relates to one route.

Heading	Explanation
INT NO.	Each intersection of two or more state maintained roads was assigned a number (1-xx) for each county.
CO. NO.	County designation (001-120).
ROUTE NUMBER	Route number that is referenced to this intersection.
INTER. ROUTE	Route or routes that the preceding route intersects.
NO. LEGS	The number of state-maintained approaches at the intersection. This number may be 3 or 4 depending on the type of intersection.
AADT FAC.	The AADT factor determines whether all or one half of the volume is assigned to the intersection. This number may be 1 or 2 depending on the type of intersection.
MILEPT	Milepoint for route under route number heading (milepoint 003379 would be 3.379).

Heading	Explanation
AADT	Average daily traffic for route under route number heading.
FC	Functional classification for route under route number heading.
NO LNS.	Number of through lanes on route under route number heading.
INT AADT	All or one half of average daily traffic for route under route number heading depending on intersection characteristics. This volume is used in the accident rate calculation.
NO. ACC	The number of accidents for each year and the given time period within limits on either side of intersection (0.05 mile for rural intersections and 0.02 mile for urban intersections).
INT FC	The functional classification assigned to the intersection.
ACC RATE	Accident rate in terms of accidents per million entering vehicles (ACC/MV).

There are limitations on the accuracy of the results because of the procedure used to assign milepoints. For example, when one route intersects another route and then is concurrent with that route for a distance before departing, the milepoint for one of the routes will not increment while the two routes are concurrent. This results in one route having the same milepoint at two intersections. The logic used in the analysis would not allow an accident to be counted more than once. An accident will be assigned to the first intersection in which it is identified as being within the milepoint range. This means that an accident occurring at a milepoint on a route where the same milepoint is assigned to two intersections would be assigned to the first occurrence in the intersection file. There is no procedure available to determine at which of the two intersections the accident occurred. This same problem would occur on a one-way street where the same milepoint would be assigned to two intersections for one route. Another problem has been created when the milepoint on one street of a one-way couplet starts at zero.

Volume data were obtained from a file of volumes on state-maintained roads. In the few instances that a volume was not available for a given route at the intersection, the average volume for the functional classification of the intersection was used. This volume data is periodically updated. The file current at the time of the analysis was used. Some very low volumes were located in the file. These volumes were manually checked and replace with new volumes when appropriate.

An accident rate for each intersection was calculated. A statewide accident rate was calculated for each functional classification. These rates are summarized in Table 1. The accident rates varied from 0.21 ACC/MV for rural, local roadways to 0.78 ACC/MV for urban, principal arterials. The accident rate considering all intersections was 0.53 ACC/MV. The statewide accident rate was 0.38 ACC/MV for the 5,766 rural intersections and 0.72 ACC/MV for the 939 urban intersections. The number of accidents per intersection in the three-year period varied from 0.3 for intersections on rural minor collector and rural local highways to 17.8 for intersections on urban principal arterial highways. Considering all intersections, the average number of accidents per intersection was 2.9 for the three-year period. The average number of accidents per intersection was 1.4 for rural intersections compared to 12.5 for urban intersections. The critical number of accidents in the three-year period is also given in Table 1. The critical number ranged from two for intersections on rural minor collector and rural local highways to 29 for intersections on urban principal arterial highways.

Critical rates were also calculated for each functional classification. These rates are presented in Table 1 as well as the number of intersections having a rate above the critical. A level of significance of 0.995 was used in the statistical analysis. A total of 181 intersections (2.7 percent of all intersections) were identified as having a critical accident rate. Intersections having critical rates, classified by functional classification, are tabulated in Appendix C. Case studies are included in Appendix D for a few of the intersections listed in Appendix C. The accident histories at the intersections were summarized as part of the case study. The case studies were conducted as an additional check of the accuracy of the accident data.

One of the problems in the analysis of accident data is the regression-to-the-mean bias. An empirical Bayes method (EBEST) has been developed to adjust for this bias. A computer program called BEATS (Bayesian Estimation of Accidents in Transportation Safety) has been developed to perform this type of analysis. The BEATS program was used to rank the intersections included in this analysis. When ranking high hazard locations, this procedure provides a site estimate that incorporates the concept of the variability about the observed estimate and weights the estimates according to their exposure. The program was used to rank intersections by functional classification. The program would not function on the larger data sets. However, when intersections having no accidents were eliminated from the file, output was obtained from all functional classifications. Output from the program is included in Appendix E. One of the types of output from the program is a listing of the top 20 sites by expected rate. This is the output included in Appendix E (except for a couple of the classifications where only the top 10 sites were listed). In most of the functional classifications the rankings were similar to that determined when the intersections were ranked by accident rate. However, there were major differences in some of the classes.

SUMMARY

The objectives of this study were to determine average accident rates for various categories of at-grade intersections and to identify intersections having high or critical accident rates. This involved locating intersections of two or more state-maintained highways and determining the appropriate volumes to use as well as locating the accidents occurring at any given intersection.

A procedure was developed which will allow the identification of intersections having high or critical accident rates. The rates are in terms of accidents per million entering vehicles (ACC/MV). Average and critical rates were calculated for various classifications of intersections.

A list of the intersections of two or more state-maintained roadways was developed. A total of 6,705 intersections were included in the file. Using the county, route and milepoint information, accident and volume data were associated with each intersection. To obtain accident data, ranges of 0.05 mile in rural areas and 0.02 mile in urban areas were used. Accident rates were calculated for each intersection. Statewide average and critical accident rates were calculated by functional classification. Intersections having critical accident rates were then identified using both the typical procedure and a procedure which accounted for the regression-to-the-mean bias.

RECOMMENDATION

The procedure developed in this study should be used in the high-accident location process. The accident history at the identified intersections can then be investigated to determine what accident countermeasures should be implemented. A description of the various computer programs which must be used to implement this procedure is given in Appendix F.

The identification process is only as accurate as the input data. Corrections and additions should be made to maintain an up-to-date intersection file.

TABLE 1. SUMMARY OF ACCIDENT RATE DATA

FUNCTIONAL CLASSIFICATION	NUMBER OF INTERSECTIONS*	TOTAL ACCIDENTS**	ACCIDENT RATE***	ACCIDENTS PER INTERSECTION	CRITICAL RATE	NUMBER OF INT. HAVING CRITICAL ACCIDENT RATE	CRITICAL NUMBER (IN THREE YEARS)
			Rural				
Principal Arterial	488	1,560	0.35	3.2	1.39	22	8
Minor Arterial	886	1,911	0.39	2.2	1.86	17	6
Major Collector	2,603	3,781	0.42	1.5	2.41	41	5
Minor Collector	1,510	509	0.30	0.3	3.91	13	2
Local	279	79	0.21	0.3	3.10	7	2
			Urban				
Principal Arterial	396	7,057	0.78	17.8	1.68	41	29
Minor Arterial	440	4,412	0.68	10.0	1.74	37	19
Collector	94	281	0.45	3.0	1.83	3	8

* There were nine intersections in other functional classification codes.
** Accidents were for the three-year period of 1989 through 1991.
*** The accident rate is given in terms of accidents per million vehicles (ACC/MV).

INT NO.	CO NO.	ROUTE NUMBER	INTERSECTING ROUTE DESCRIPTION	NO LEG	NO APPR	MILEPT	AADT	FC	NO LN	INT AADT	NO ACC 89	NO ACC 90	NO ACC 91	TOTAL ACC		INT FC	ACC RATE
1	1	KY 0055	KY 900	3	2	003379	599	7	2	599	0	0	0	0			
1	1	KY 0900	KY 55	3	1	005409	428	8	2	214	0	0	0	0	0	7	0.000
2	1	KY 0055	KY 92	3	2	006184	1180	7	2	1180	0	0	0	0			
2	1	KY 0092	KY 55	3	1	000000	454	8	2	227	0	0	0	0	0	7	0.000
3	1	KY 0055	KY 704	3	2	009335	2100	7	2	2100	0	0	1	1			
3	1	KY 0704	KY 55	3	1	012778	1290	7	2	645	0	0	0	0	1	7	0.333
4	1	KY 0080	KY 55 SOUTH BOUND	3	1	0012282	8480	6	2	4240	3	1	5	9			
4	1	KY 0055	KY 80	3	2	010614	12900	6	2	12900	8	2	2	12	21	6	1.119
5	1	KY 0439	KY 55 IN COLUMBIA	4	1	001787	6470	8	2	3235	1	2	0	3			
5	1	KY 0055	KY 80 EASTBOUND	4	2	011170	13700	6	2	13700	11	4	7	22			
5	1	KY 0080	KY 55	4	1	0012282	8480	6	2	4240	0	0	0	0	25	6	1.078
6	1	KY 0206	KY 55 IN COLUMBIA	3	1	000000	4230	7	2	2115	0	0	0	0			
6	1	KY 0055	KY 206	3	2	011519	11300	6	2	11300	8	4	3	15	15	6	1.021
7	1	KY 0551	KY 55	3	1	000000	1090	7	2	545	0	0	0	0			
7	1	KY 0055	KY 551	3	2	012849	6220	6	2	6220	0	0	0	0	0	6	0.000
8	1	KY 1913	KY 55	3	1	000629	601	8	2	300	0	0	0	0			
8	1	KY 0055	KY 1913	3	2	018579	4000	6	2	4000	0	0	0	0	0	6	0.000
9	1	KY 0533	KY 61 S	3	1	0001828	144	8	2	72	0	0	0	0			
9	1	KY 0061	KY 533 WEST	3	2	001506	458	7	2	458	0	0	0	0	0	7	0.000
10	1	KY 0061	KY 533 EAST	3	2	001794	416	7	2	416	0	0	0	0			
10	1	KY 0533	KY 61 N AT BREEDING	3	1	0001828	144	8	2	72	0	0	0	0	0	7	0.000
11	1	KY 0061	KY 768 WEST	3	2	006665	946	7	2	946	0	0	0	0			
11	1	KY 0768	KY 61 NORTH	3	1	0017473	305	8	2	152	0	0	0	0	0	7	0.000
12	1	KY 0061	KY 768 EAST	3	2	007850	1140	7	2	1140	0	0	0	0			
12	1	KY 0768	KY 61 SOUTH	3	1	0017473	305	8	2	152	0	0	0	0	0	7	0.000
13	1	KY 0061	KY 80 WEST	3	2	012879	1360	7	2	1360	1	0	0	1			
13	1	KY 0080	KY 61 SOUTH	3	1	0011775	1030	7	2	515	2	3	3	8	9	7	4.384
14	1	KY 0061	KY 80 EAST	3	2	015248	4430	7	2	4430	1	4	3	8			
14	1	KY 0080	KY 61 NORTH	3	1	0011775	1030	7	2	515	0	0	0	0	8	7	1.477
15	1	KY 0439	KY 61	3	1	000000	898	8	2	449	0	0	0	0			
15	1	KY 0061	KY 439	3	2	016362	3600	6	2	3600	0	0	0	0	0	6	0.000
16	1	KY 0061	KY 768	3	1	021445	1930	6	2	965	0	0	0	0			
16	1	KY 0768	KY 61	3	2	000000	618	8	2	618	0	0	0	0	0	6	0.000
17	1	KY 0076	KY 206	3	2	003455	767	8	2	767	0	0	0	0			
17	1	KY 0206	KY 76 S	3	1	0011428	898	7	2	449	0	0	0	0	0	8	0.000
18	1	KY 0076	KY 206	3	2	006347	719	7	2	719	0	0	0	0			
18	1	KY 0206	KY 76 N	3	1	0011428	898	7	2	449	0	0	0	0	0	7	0.000
19	1	KY 1104	KY 76	3	1	000000	254	8	2	127	0	0	0	0			
19	1	KY 0076	KY 1104	3	2	010040	418	8	2	418	0	0	0	0	0	8	0.000
20	1	KY 0439	KY 767	3	2	001186	3370	8	2	3370	1	1	1	3			
20	1	KY 0767	KY 439	3	1	000000	3170	8	2	1585	0	0	0	0	3	8	0.553
21	1	KY 0551	KY 76 AT KNIFLEY	4	2	011941	844	7	2	844	1	0	0	1			
21	1	KY 0076	KY 551	4	2	012203	822	8	2	822	0	0	0	0	1	7	0.548
22	1	KY 0080	KY 768 EAST	3	2	002909	274	7	2	274	0	0	0	0			
22	1	KY 0768	KY 80 EAST	3	1	0012791	333	8	2	166	0	0	0	0	0	7	0.000
23	1	KY 0080	KY 768 WEST	3	2	003248	317	7	2	317	0	0	0	0			
23	1	KY 0768	KY 80 WEST	3	1	0012791	333	8	2	166	0	0	0	0	0	7	0.000
24	1	KY 0080	KY 959	3	2	008674	582	7	2	582	0	0	0	0			
24	1	KY 0959	KY 80	3	1	000000	215	9	2	107	0	0	0	0	0	7	0.000
25	1	KY 0080	KY 531	3	2	017794	2440	7	2	2440	0	0	0	0			
25	1	KY 0531	KY 80	3	1	000000	266	8	2	133	0	0	0	0	0	7	0.000
26	1	KY 0080	KY 1729	3	2	018545	2440	7	2	2440	0	0	0	0			
26	1	KY 1729	KY 80	3	1	000000	421	8	2	210	0	0	0	0	0	7	0.000
27	1	KY 0531	KY 206 AT CHRISTINE	3	1	005301	442	8	2	221	0	0	0	0			
27	1	KY 0206	KY 531	3	2	006606	1730	7	2	1730	0	0	0	0	0	7	0.000
28	1	KY 0055	KY 530	3	2	014949	4000	6	2	4000	0	0	0	0			
28	1	KY 0530	KY 55	3	1	000000	149	9	2	74	0	0	0	0	0	6	0.000
29	1	KY 0532	KY 61	3	1	002302	208	9	2	104	0	0	0	0			
29	1	KY 0061	KY 532	3	2	022426	1290	6	2	1290	0	0	0	0	0	6	0.000
30	1	KY 0551	KY 1742	3	2	014727	220	8	2	220	0	0	0	0			
30	1	KY 1742	KY 551	3	1	000000	220	8	2	110	0	0	0	0	0	8	0.000

Figure 1. County Intersection Summary

APPENDIX A

SUMMARY OF STATE SURVEY

Arkansas

The procedure used to identify high accident rate locations does not include a specific procedure to identify intersections that have a high accident rate.

Arizona

The procedure used to identify high hazard locations considers various types of roadway categories. Intersections are not specifically identified.

California

California has developed expected accident rates for various intersection groups with the base rate of accidents per million vehicles entering the intersection (ACC/MV). Accidents within the intersection as well as on each leg within a distance of typically 250 feet are included. To identify high accident intersections, the intersection type and expected rate are first identified. Using the expected rate, time, and volume data, the expected number of accidents is calculated. The number of accidents needed to be significantly high is calculated (using the expected number of accidents and a Poisson formula) and compared to the number of accidents which actually occurred. Expected rates are classified by intersection type (four-legged, multi-legged, offset, tee, y, and other), control type (none, stop and yield, four-way stop, four-way flashers, and signals), and area (rural, suburban, and urban). The base rate varied from 0.10 to 1.05 ACC/MV for the 30 categories.

Colorado

In calculating rates for urban intersections, only those accidents and volumes for the main intersecting roadways are considered. Rural spot locations are defined as highway sections no more than 1/4 mile in length. Urban spot locations are identified as intersections.

Connecticut

Accident rates are calculated for two types of locations. The types are spots (intersections with another highway or a segment between intersections less than 0.1 mile in length) and sections (segments between intersections greater than 0.1 mile in length or interchange areas or segments between interchange areas on expressways). Accident rates for intersections are given in terms of ACC/MV. A critical accident rate is determined for each location based on the average accident rate for various roadway categories. Major categories include urban or rural, number of lanes, and divided or undivided. Intersections with state roads, intersections with town roads, and signalized private drives are classified separately. Traffic volume at signalized intersections of Town Roads and commercial driveways includes 2,500 or 35 percent of the State highway volume, whichever is greater, as the ADT for the intersecting street. Accident rates are computed separately for intersections.

Delaware

There is no procedure to rate intersections by their accident severity. Intersections are rated as part of 0.3-mile spots along one of the intersecting roads. A minimum accident number of 24 during a three-year period is used.

Idaho

One type of high accident location is defined as an intersection related urban/rural spot (0.1 mile in length). Roadway types are divided by: rural or urban, access control, number of lanes, divided or undivided, and width. Three years of accident data are used. The statewide base accident rate for urban intersections was 0.72 accidents per million vehicles compared to 1.47 accidents per million vehicles for a rural intersection.

Florida

A node system is used to identify intersections. A spot location is 0.1 mile or less. There has been an attempt to access cross street traffic volumes but the results were not useable on a statewide basis. Average spot rates, in terms of accidents per million vehicles, were given by highway category, urban or rural, and divided or undivided roadway. Examples for rural highways are 1.48 ACC/MV for an undivided highway having less than three lanes, 1.10 ACC/MV for an undivided highway having four lanes, and 0.77 ACC/MV for a divided highway having four lanes. Examples for urban highways are 1.12 ACC/MV for undivided highways having less than three lanes, 0.99 ACC/MV for undivided highways with four lanes, and 0.74 for divided highway having four lanes.

Georgia

Intersections are identified separately from sections as high-accident locations. Average accident frequency, rate, and severity values are computed for eight intersection categories. These categories are based on rural or urban classification, whether the intersection is signalized or unsignalized, and whether the intersection is of two state routes or one state route with a non-state route. The accident rate for intersections does not consider all approaches. Only the main street volume is considered because the cross street volumes, in most cases, are not available.

Illinois

Intersections are analyzed separately from sections. Traffic volume information is available only for the state route so crossroad volumes are assigned to each intersection from a table based on the functional classification of the crossroad. Each intersection is separated into signalized and non-signalized with statewide averages being computed for various categories of intersections. Statewide averages are computed for accident frequency, rate, severity, and three year trend. Rates for segments with intersections are calculated using rural or urban classification, type of street (two way, one way, divided, bidirectional lanes, or freeway), and number of lanes. The segment length could vary from about 0.2 mile to one mile in length.

Indiana

At the present time, there is no system to link accident and traffic volume data. For intersections which are studied, an accident summary is obtained along with an ADT from a traffic count summary and a rate is calculated.

Iowa

A link-node system is used in the accident location system. Node numbers are assigned to intersections. The ranking of locations is based on number of intersections, value loss (dollars), and accident rate. For intersections, accident rates in terms of accidents per million entering vehicles are calculated for locations where traffic exposure data are available from automated files. Traffic exposure is not readily available for all locations. Locations without accident rates are given a ranking factor which gives them the highest priority ranking possible. Statewide accident rates varied from 0.8 to 1.0 ACC/MV when divided according to rural or urban classification and into the type of road (primary, secondary, rural, city street, or municipal).

Kansas

Spots are defined as 0.3 mile in length and are used to identify intersections. The spot would be for one highway with the traffic volume data from that roadway used. For rural, two-lane highways, the average accident rate for intersections is considered to be 0.4 to 0.5 ACC/MV.

Louisiana

Intersections in incorporated places are given individual milepoints to 0.01 mile and a code in the accident data base indicates whether the accident location is at an intersection. Locations having five or more accidents are subdivided by development (rural or urban), type (section, intersection, or spot), and type of roadway (two lane, four lane, four-lane divided, and freeway). Locations having five or more accidents and accident rates at least twice the average rate for its class are considered to be abnormal accident locations. Since most intersections only have volume data for the major state highway, the volume data for the major state highway at an intersection are used to calculate the accident rate for intersections. Accidents that occur on the approaches of the minor road within 100 feet of the intersection are included.

Maine

Intersections are identified by nodes in each county. Statewide average accident rates are calculated for nodes for various road types and urban/rural classification. Exposure is the number of entering vehicles. The rate for all signalized intersections was 0.90 ACC/MV. The rates for principal arterial, four-lane divided highways were 0.18 ACC/MV for urban nodes and 0.52 ACC/MV for rural nodes. The rates for principal arterial, two-lane highways were 0.22 ACC/MV for urban nodes and 0.17 for rural nodes.

Michigan

Accident rates are not used in the process of determining high-accident intersections. Accident and severity rates are used to determine how various types of urban and rural roadways compare between the various highway districts and statewide conditions. When identifying high-accident intersections, an effort is made to locate continuing correctable accident patterns over a three-year period. That pattern must meet or exceed a minimum threshold value of a particular accident type. For intersections, threshold values are given for angle, head-on or left-turn, and rear-end accidents as a function of ADT.

Minnesota

Computer software is used to locate high accident intersections. Accidents are totaled and rates are computed for each intersection with the capability available to group similar intersections with rates computed. Average or critical rates have not been established for the various intersection types. A study is currently used that looks at the 100 worst accident locations as ranked by accident rates. Accidents are given in terms of accidents per million vehicles on the approaches.

Mississippi

Accident rates in terms of accidents per million vehicles per day have been calculated periodically to determine high-accident intersections. The length of roadway used was 0.1 mile. Total entering volume was not used. Instead, the ADT of the lowest volume roadway was used. A list completed in 1984 was cut off at an accident rate of 20 accidents per million vehicles per day.

Missouri

One-tenth mile segments are used to identify high accident locations with rates given in terms of accidents per hundred million vehicle miles. There is no methodology for determining high-accident intersections based on the intersection accident rate formula per million entering vehicles.

Montana

Average or critical accident rates for intersections have not been developed because of the difficulty of determining the entering ADT. Intersections are identified to investigate based on the number of accidents at an intersection.

Nebraska

Intersections are included as a third classification oflocations in addition to spots and sections. Only intersections of two or more state highways are included since volume information is available. Each intersection is given a number and grouped by land use (rural or urban) and lane characteristics (interchange, one-way, four-lane, and two-lane). Statewide average intersection rates are calculated and locations which exceed the statewide average are considered high-accident locations. Some average intersection rates for the time period of July 1989 to June 1991 are as follows (rates in terms of ACC/MV): 0.56 for urban two-lane (121 sites); 0.27 for rural two-lane (535 sites); 1.12 for urban four-lane (60 sites); and 1.03 for rural four-lane (27 sites).

New Hampshire

Intersections are identified as high accident locations only as part of a larger section of road.

New Mexico

A procedure is used to develop a list of intersections having a high accident numbers. Intersections throughout the state where 15 or more accidents occurred in the latest available year and in one of the previous two years are identified. Accident rates are calculated based on the annual average daily entering vehicles. The locations are then prioritized according to the three-year average rate. The 1989 accident rate for the top ten prioritized intersections varied from 2.34 to 5.93 ACC/MV.

New York

There is a separate analysis of individual intersections which produces a listing of potentially hazardous intersections. An accident rate (ACC/MV) is calculated for an intersection and compared to the mean intersection rate for a similar intersection type.

Intersections having a significantly higher rate than the mean rate, which also meet a frequency threshold of accidents, are placed on the listing. For intersections where side road volumes are unknown, a volume estimation procedure is used. Intersections were classified into categories based on type (Y, T, four leg, or ramp), right-of-way control (signal, yield, stop, flashing device, or no control), and whether a left-turn lane was present. There were a total of 37,504 intersections on the file having an average overall accident rate of 0.29 ACC/MV and 1.41 accidents per intersection. The most common intersection type was a T intersection having stop sign control and no left-turn lane (16,811 sites) which had a rate of 0.21 ACC/MV and 0.76 accident per intersection. The four-way intersection having stop sign control and no left-turn lane (3,712 sites) had a rate of 0.48 ACC/MV and 1.42 accidents per intersection. The four-way intersection having traffic signal control and no left-turn lane (1,364 sites) had an accident rate of 0.87 ACC/MV and 6.13 accidents per intersection.

Nevada

No statewide intersection rates have been calculated. Studies are conducted on a case-by-case basis. Accident rates are expressed in terms of ACC/MV for intersections.

North Carolina

Intersections are identified separately from sections as high-accident locations. Numbers of accidents, in terms of equivalent property damage only (EPDO) accidents, and accident rates (given as EPDO accidents per 100 million entering vehicles) are used to identify high-accident locations. To obtain the number of EPDO accidents, fatal and class A injury accidents are multiplied by a factor of 64.0 and class B and class C injury accidents are multiplied by a factor of 19.1. Accidents within 500 feet for rural intersections and 100 feet for urban intersections are included. The accident warrants used for intersections accidents include: 1) an EPDO index of 400 in three years with 140 in the most recent year as well as 25 accidents in three years with 8 in the most recent year or 2) an EPDO index of 200 in the most recent year with at least 12 accidents. The EPDO accident rate must exceed 900 accidents per 100 million entering vehicles.

Ohio

Intersection accident rates are calculated using only the priority road volume because, for most intersections, the crossroad volume is not available.

Oregon

Intersections are not treated differently than any other segment of the highway system. Accidents are assigned to the major roadway where two roadways cross. No separate intersection list is maintained. Segments of 0.10 mile in rural areas and 0.05 mile in urban areas are used as a sliding window.

South Carolina

Accident rates at intersections are calculated using the sum of the entering volumes for the ADT. A distance of 250 feet from the intersection on each approach is used as the limit of the intersection. Intersections are grouped by the number of through lanes on each approach. Current statewide rates are 2.74 ACC/MV for one through lane on each approach and 1.75 for two through lanes on each approach.

Tennessee

Spots are identified as 0.1 mile in length. Volume data are used for one of the intersecting roadways with the other approach factored by the type highway and type of cross street. Examples of statewide rates for intersections are 0.19 ACC/MV for rural two-lane and 0.28 ACC/MV for urban two-lane.

Texas

Accident frequency is used to identify high-accident locations. Four lists of locations are annually given to each district office ranked by frequency of accidents, and intersection-related accidents are contained in one of those lists. There is a current project to develop a more effective procedure to identify and analyze high-accident locations.

Utah

Hazardous intersections are identified within a section of a road (normally 0.1 mile). Accident data are used in conjunction with the road inventory to obtain expected accident rates which are used for comparison with the actual rates occurring at intersections or sections of highways. Expected rates are classified by functional classification. Average right-angle accident rates are given for signalized intersections by functional classification.

Vermont

A listing of high-accident intersections is developed using accident rates at intersections compared to critical rates determined using statewide average intersection accident rates. The intersection rates are in terms of accidents per million vehicles (ACC/MV) and use the sum of ADT for all legs of the intersection divided by two. Statewide average intersection rates for the time period of 1986 through 1990 are 0.594 ACC/MV for FAP (federal aid primary) rural, 0.473 ACC/MV for FAP urban, 0.544 ACC/MV for FAS (federal aid secondary) rural, and 0.536 ACC/MV for FAU (federal aid urban).

Virginia

A procedure is currently used where spot locations having an average accident experience above a certain level are listed on an annual spot improvement list. A Highway and Traffic Records Information System is being developed (to be completed in 1992) which will involve assigning nodes to all intersections so that accidents and traffic volumes at intersections may be tabulated.

Washington

There is no procedure to specifically identify high accident intersections. Intersections are treated either as a spot or as part of a longer section, with traffic volumes for only the major roadway included.

West Virginia

A critical rate package is used for the identification of hazardous locations. However, statewide average rates, specifically for intersections, are not determined.

APPENDIX B

ACCIDENTS ASSOCIATED WITH SAMPLE INTERSECTIONS

(DIFFERENT MILEPOINT RANGES)

				COMPUTER PROGRAM		KARS		
COUNTY	INT	ROUTE	MP	.05	.02	EXACT	0.02	0.05
Bell	10	KY 74	16.148	33	33	33	33	33
		KY 2079	2.061	2	2	2	2	2
Breathitt	1	KY 15	7.722	6		5	6	6
		KY 476	11.446	0		0	0	0
Breathitt	3	KY 15	14.629	8		8	8	8
		KY 1812	0.000	0		0	0	0
		KY 1098	0.000	0		0	0	0
Breathitt	12	KY 15	18.465	6		5	5	6
		KY 30	14.830	0		0	0	0
Breathitt	7	KY 15	25.086	5		5	5	5
		KY 205	0.000	0		0	0	0
Caldwell	10	US 62	7.019	25	21	8	21	25
		KY 91	11.849	0	0	0	0	0
Calloway	14	US 641	8.633	14	14	13	14	14
		KY 121	14.075	4	2	2	2	4
Christian	11	US 41	14.786	42	42	42	42	42
		KY 1682	3.099	0	0	0	0	0
Christian	16	KY 91	0.679	11	11	11	11	11
		KY 1682	0.659	2	2	2	2	2
Christian	22	KY 115	1.239	13	12	12	12	13
		KY 911	1.835	0	0	0	0	0
Christian	26	US 68	10.137	30	28	26	28	30
		KY 1007	0.785	4	3	0	3	4
Christian	44	US 41	12.114	34	23	20	23	34
		US 41A	15.990	2	2	2	2	2
Christian	45	US 68	9.500	17	17	13	17	17
		KY 109	10.945	0	0	0	0	0
Christian	61	US 41	12.199	40	40	39	40	40
		KY 107	18.834	11	2	1	2	11
Christian	62	KY 107	18.640	38	23	23	23	31
		KY 272	10.965	0	0	0	0	0
Christian	71	US 41	12.636	26	26	25	26	26
		KY 2544	0.308	0	0	0	0	0
Christian	92	KY 107	19,844	22	21	21	22	22
		KY 507	0.000	1	1	1	1	1

				COMPUTER PROGRAM		KARS		
COUNTY	INT	ROUTE	MP	.05	.02	EXACT	0.02	0.05
Christian	94	US 41	11.025	30	30	30	30	30
		KY 380	3.613	0	0	0	0	0
Christian	97	KY 107	18.394	14	0	0	0	14
		KY 695	12.829	2	2	2	2	2
Christian	103	KY 272	9.416	21	20	20	20	21
		KY 380	0.000	0	0	0	0	0
Daviess	22	US 231	13.285	60	21	17	21	60
		KY 298	10.231	3	2	2	2	3
Daviess	25	KY 298	7.828	17	14	14	14	17
		KY 3143	0.926	0	0	0	0	0
Fayette	40	US 27	4.674	68	67	67	67	68
		KY 2333	0.000	0	1	0	0	0
Fayette	41	US 27	5.698	38	36	36	36	38
		KY 1974	13.174	1	1	1	1	1
Fayette	57	US 27	5.966	20	19	19	19	20
		US 68	6.189	4	2	2	2	4
Fayette	2	US 27	8.450	126	126	126	126	126
		KY 4	10.665	50	2	8	10	64
Fayette	54	US 27	6.491	3	2	2	2	3
		US 25	13.920	96	79	26	76	96
Fayette	48	US 25	0.000	3		3	3	3
		KY 2328	1.167	0		0	0	0
Fayette	42	KY 169	2.100	0		0	0	0
		KY 1974	0.000	2		2	2	2
		KY 1975	0.000	1		1	1	1
Floyd	56	US 23	16.798	78		13	78	78
		KY 1428	15.642	0		0	0	0
Floyd	19	KY 80	8.027	10		9	10	10
		KY 1210	0.000	0		0	0	0
Floyd	20	KY 80	8.579	13		13	13	13
		KY 122	8.496	0		0	0	0
Floyd	55	US 23	10.597	15		5	7	15
		KY 1428	6.216	0		0	0	0
Floyd	51	US 23	9.009	4		2	3	4
		KY 1426	14.271	0		0	0	0

				COMPUTER PROGRAM		KARS		
COUNTY	INT	ROUTE	MP	.05	.02	EXACT	0.02	0.05
Garrard	1	US 27	8.633	14	14	13	14	14
		KY 34	14.075	0	0	0	0	0
Graves	91	US 45	0.512	6		4	6	6
		KY 1283	0.074	0		0	0	0
Graves	41	US 45	7.466	6		2	2	6
		KY 339	12.334	0		0	0	0
Graves	28	KY 121	9.787	12	12	12	12	12
		KY 303	16.853	0	0	0	0	0
Graves	21	KY 94	17.180	7		7	7	7
		KY 97	6.850	0		0	0	0
Graves	20	KY 94	14.092	9		9	9	9
		KY 381	4.485	0		0	0	0
Hancock	21	US 60	1.933	9		9	9	9
		KY 657	7.569	0		0	0	0
Hancock	2	KY 69	12.816	5		5	5	5
		KY 1265	4.955	0		0	0	0
Hancock	6	KY 69	14.524	5		1	1	5
		KY 3101	0.944	0		0	0	0
Hardin	21	US 31W	15.049	43	43	42	43	43
		KY 210	0.000	0	0	0	0	0
Harlan	16	US 421	16.978	16		12	13	16
		KY 38	0.000	0		0	0	0
Henderson	39	KY 812	0.000	0		0	0	0
		KY 1078	6.132	2		1	1	2
Henderson	20	US 41A	15.832	58	56	56	56	58
		KY 351	0.000	1	1	1	1	1
Henderson	40	US 41	13.006	25	25	25	25	25
		KY 812	7.396	0	0	0	0	0
Hopkins	118	KY 1178	1.562	10	9	6	9	19
		KY 1581	0.000	0	0	0	0	0
Hopkins	30	US 41A	16.135	39	38	38	38	39
		KY 1751	0.000	0	0	0	0	0
		KY 281	0.000	0	0	0	0	0
Hopkins	22	US 41	11.708	8		6	8	8
		KY 138	0.000	0		0	0	0

				COMPUTER PROGRAM		KARS		
COUNTY	INT	ROUTE	MP	.05	.02	EXACT	0.02	0.05
Hopkins	6	KY 70	19.946	18	18	18	18	18
		KY 254	0.000	0	0	0	0	0
Hopkins	5	US 41A	14.711	22	20	20	20	22
		KY 262	4.753	0	0	0	0	0
		KY 70	19.000	0	0	0	0	0
Hopkins	4	US 41A	14.008	32	23	29	30	32
		KY70	18.653	2	0	0	1	2
Jefferson	98	US 31W	19.650	18	16	13	16	18
		US 150	0.741	0	0	0	0	0
Jessamine	6	KY 39	2.454	3		2	2	3
		KY 1268	0.000	0		0	0	0
Johnson	5	US 23	8.788	40		33	40	40
		US 460	8.347	0		0	0	0
		KY 40	8.724	5		0	0	5
Johnson	49	US 23	0.028	2		2	2	2
		KY 2381	0.000	1		1	1	1
Kenton	41	KY 177	9.174	3		3	3	3
		KY 1303	0.000	0		0	0	0
Kenton	3	KY 8	7.321	37	36	0	36	37
		KY 17	23.766	37	17	3	17	37
Kenton	4	KY 8	7.402	69	57	0	57	69
		KY 17	23.681	10	1	1	1	10
Lee	2	KY 11	4.115	8		0	0	0
		KY 1411	4.911	0		0	0	0
Letcher	9	US 119	17.551	7		7	7	7
		KY 15	0.000	4		4	4	4
McCreary	11	US 27	4.608	9		9	9	9
		KY 92	16.612	1		0	1	1
McLean	16	US 431	2.485	9		7	9	9
		KY 85	10.009	0		0	0	0
Madison	34	KY 595	12.771	4		4	4	4
		KY 1295	1.416	0		0	0	0
Magoffin	17	US 460	14.635	6		5	6	6
		KY 114	0.000	0		0	0	0

				COMPUTER PROGRAM		KARS		
COUNTY	INT	ROUTE	MP	.05	.02	EXACT	0.02	0.05
Martin	9	KY 40	9.148	5		5	5	5
		KY 645	4.682	0		0	0	0
Meade	20	US 60	8.692	13		10	13	13
		KY 144	28.655	1		1	1	1
Mercer	28	US 68	6.752	52	52	52	52	52
		US 127	4.402	0	0	0	0	0
Ohio	19	US 62	10.125	12		8	12	12
		KY 273	3.440	0		0	0	0
Perry	9	KY 15	13.269	9	9	8	9	9
		KY 15X	2.306	0	0	0	0	0
Perry	8	KY 15	11.119	18	18	18	18	18
		KY 15X	0.000	0	0	0	0	0
Perry	21	KY 15X	0.302	24	24	24	24	24
		KY 451	3.483	1	1	1	1	1
Perry	10	KY 15	15.968	8		8	8	8
		KY 267	1.981	0		0	0	0
Pike	44	US 23	27.491	12		12	12	12
		KY 1426	4.889	9		5	9	9
Pike	68	US 23	30.834	24		22	24	24
		US 119	0.000	3		3	3	3
Pike	74	KY 1460	5.116	0		3	3	3
		KY 1426	6.442	11		4	4	11
Pike	59	US 23	32.030	9		8	8	9
		KY 3227	0.000	0		1	1	1
Pike	56	US 23	34.014	6		5	6	6
		KY 2061	0.000	0		0	0	0
Powell	7	KY 11	15.638	24		23	24	24
		KY 213	7.576	4		3	3	4
Pulaski	4	KY 39	0.286	21	21	18	21	21
		KY 80B	1.087	8	8	7	8	8
Scott	51	US 62	6.901	31	31	30	31	31
		US 460	8.583	5	5	3	5	5
Scott	4	US 460	7.055	6		6	6	6
		KY 227	0.000	1		0	0	1

				COMPUTER PROGRAM		KARS		
COUNTY	INT	ROUTE	MP	.05	.02	EXACT	0.02	0.05
Scott	21	US 460	11.905	10		9	10	10
		KY922	3.121	0		0	0	0
Scott	30	US 62	8.413	13	13	13	13	13
		KY 1962	0.000	0	0	0	0	0
Scott	35	US 25	2.500	12	7	7	7	12
		KY 2341	0.329	0	0	0	0	0
Scott	50	US 25	3.920	55	54	51	54	55
		US 62	7.930	28	2	1	2	28
Scott	52	US 62	9.138	23	23	23	23	23
		US 460	8.582	0	0	3	5	5
Union	5	US 60	16.339	16		13	16	16
		KY 56	13.035	3		0	0	3
Union	10	US 60	5.671	11		11	11	11
		KY 109	1.536	0		0	0	0
Webster	7	KY 109	1.286	11		1	11	11
		KY 293	3.232	0		0	0	0
Webster	15	US 41A	1.194	13		13	13	13
		KY 120	6.723	0		0	0	0
Wolfe	4	KY 15	9.515	24		24	24	24
		KY 191	0.000	1		0	0	1
Wolfe	32	KY 191	0.250	12		0	11	12
		KY 2491	0.262	0		0	0	0
Woodford	4	US 62	7.046	20	19	19	19	20
		KY 33	13.799	10	10	10	10	10
Woodford	20	US 62	6.690	9	9	9	9	9
		KY 1964	9.745	0	0	0	0	0
Woodford	31	US 62	7.144	0	0	2	2	2
		US 60X	0.960	18	12	12	12	18
Woodford	33	US 60	9.385	58	58	58	58	58
		US 60X	1.790	11	4	2	4	11
Woodford	13	KY 1681	11.082	7		5	6	7
		KY 1967	9.010	0		0	0	0

APPENDIX C

INTERSECTIONS HAVING CRITICAL ACCIDENT RATES

(BY FUNCTIONAL CLASSIFICATION)

Rural, Principal Arterial

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Madison	US 25 - KY 627	22	4.21
Knox	US 25E - KY 1629	15	3.11
McCreary	KY 92 - US 27	10	2.89
Marshall	KY 80 - KY 1311	4	2.73
Wolfe	KY 15 - KY 191	25	2.61
Logan	US 68 - KY 3233	23	2.57
Lincoln	US 127 - KY 78	10	2.45
Lincoln	US 27 - US 150	43	2.25
Meade	US 60 - KY 144	14	2.22
Marshall	US 68 - KY 58 - KY 1462	10	1.99
Letcher	KY 15 - US 119	11	1.84
Bell	US 25E - KY 66	13	1.81
McCreary	US 27 - KY 592	11	1.75
Breckinridge	US 60 - KY 261	6	1.73
Pulaski	US 27 - KY 70	14	1.67
Trigg	US 68 - KY 139	17	1.61
Lincoln	US 27 - KY 1247	13	1.60
Garrard	US 27 - KY 39	20	1.56
Pulaski	KY 80 - KY 461	18	1.55
Marshall	US 68 - KY 80	6	1.50
Knox	US 25E - KY 312	34	1.48
Pulaski	US 27 - KY 635	11	1.44

Rural, Minor Arterial

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Pendleton	US 27 - KY 22	12	3.03
Marshall	US 641 - KY 408	20	2.93
Breckinridge	KY 737 - KY 259	4	2.41
Madison	US 421 - KY 1016	8	2.31
Meade	KY 1238 - KY 144	7	2.30
Carlisle	KY 121 - KY 307	6	2.34
Garrard	KY 52 - KY 1295	5	2.20
Scott	US 460 - KY 922	10	2.17
McLean	US 431 - KY 85	9	2.12
Jefferson	US 31E - KY 660	26	2.07
Jessamine	US 68 - KY 29	13	2.06
Madison	KY 595 - KY 1295	4	2.05
Ballard	KY 121 - KY 286	10	2.00
Harrison	US 27 - KY 982	9	1.97
Marshall	US 641 - KY 1824	12	1.95
Marshall	US 641 - KY 348	22	1.95
Graves	KY 121 - KY 940	7	1.87

Rural, Major Collector

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Graves	US 45 - KY 1283	21	9.05
Daviess	KY 456 - KY 56	17	7.94
Marshall	US 641 - KY 58	41	5.84
Trigg	KY 272 - KY 139	15	5.59
Calloway	KY 893 - KY 783	2	5.17
Laurel	KY 229 - KY 1189	23	4.83
Hardin	US 31W - KY 210	43	4.68
Graves	KY 381 - KY 94	9	4.60
Owen	KY 227 - KY 607	2	4.43
Adair	KY 61 - KY 80	9	4.38
Graves	US 45 - KY 1529	10	4.23
Grayson	KY 79 - KY 54	7	3.99
Fulton	KY 239 - KY 116	4	3.84
McCracken	KY 725 - KY 305	6	3.84
Graves	KY 97 - KY 94	7	3.83
Clay	KY 66 - KY 1850	2	3.66
Menifee	KY 2071 - KY 3341	1	3.58
Russell	KY 379 - KY 55	5	3.49
Woodford	KY 1967 - KY 1681	7	3.49
Metcalfe	KY 314 - KY 218	3	3.40
Elliott	KY 504 - KY 649	3	3.36
Anderson	KY 53 - KY 1291	3	3.36
Pulaski	KY 70 - KY 39	6	3.15
Crittenden	KY 91 - KY 135	1	2.99
Marshall	KY 58 - KY 1949	5	2.88
Meade	KY 228 - KY 1844	2	2.83
Owen	KY 22 - KY 355	3	2.82
Boyle	KY 34 - KY 300	8	2.77
Kenton	US 25 - KY 14	11	2.75
Hancock	KY 261 - KY 2124	2	2.73
Hardin	KY 84 - KY 1375	1	2.72
Graves	KY 94 - KY 303	5	2.71
Rockcastle	KY 70 - KY 3273	3	2.69
Hart	KY 728 - KY 357	1	2.69
Lawrence	KY 644 - KY 3	3	2.68
McCracken	US 62 - KY 286	6	2.65
Muhlenberg	KY 70 - KY 181	12	2.60
Shelby	KY 1779 - KY 395	5	2.53
Hardin	US 62 - KY 84	12	2.46
Bracken	KY 19 - KY 8	6	2.46
Bath	KY 1602 - KY 1325	1	2.42

Rural, Minor Collector

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Muhlenberg	KY 890 - KY 831	2	8.62
Warren	KY 626 - KY 1435	1	6.05
McLean	KY 593 - KY 136	1	6.01
Union	KY 950 - KY 758	2	5.64
Pulaski	KY 761 - KY 1664	2	5.64
Christian	KY 398 - KY 1348	1	5.54
Grayson	KY 1168 - KY 720	2	5.26
Daviess	KY 762 - KY 142	2	5.05
Jessamine	KY 39 - KY 1268	3	4.38
Henderson	KY 136 - KY 268	1	4.37
Hickman	KY 781 - KY 1529	1	4.13
Boyle	KY 37 - KY 243	2	3.99
Caldwell	KY 902 - KY 1077	1	3.97
Rural, Local			
Woodford	KY 1659 - KY 2331	3	8.08
Graves	KY 427 - KY 1374	1	7.08
Hickman	KY 575 - KY 1708	1	6.97
McLean	KY 798 - KY 2437	1	5.78
Trigg	KY 958 - KY 1507	2	5.15
Logan	KY 1038 - KY 1588	2	4.05
Adair	KY 901 - KY 1323	1	3.29

Urban, Principal Arterial

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Kenton	KY 8 EB - KY 17 NB	58	5.77
Kenton	KY 8 WB - KY 17 SB	53	5.39
Warren	US 68 - KY 1435	62	5.23
Daviess	US 60 - US 431	63	5.14
Daviess	US 60 - KY 2235	41	4.96
Daviess	US 231 - KY 2245	22	4.36
Warren	US 31W - KY 3225	90	4.25
Daviess	US 60 - KY 231	33	3.50
Bourbon	US 68 X - US 460	21	3.48
Taylor	KY 55 - KY 3183	15	3.13
Jefferson	US 150 - US 31W	38	3.08
Jefferson	KY 1065 - KY 1865	36	2.74
Kenton	KY 17 - KY 1120	34	2.73
Boyle	US 127 - US 150	54	2.72
Jefferson	KY 1931 - KY 2054	36	2.71
Jefferson	US 31E - KY 1020 - US 31W	62	2.69
Jefferson	US 60A - KY 1020	86	2.67
Fayette	US 68 - KY 1267	39	2.49
Daviess	US 231 - KY 298	23	2.39
Daviess	US 60 - KY 1467	26	2.35
Shelby	US 60 - KY 53	54	2.33
Jefferson	US 31W - US 150	16	2.27
Fayette	US 27 - KY 4	127	2.12
Boyle	US 127B - US 150 - US 127	39	2.10
Jefferson	US 60 - US 42	30	2.09
Fayette	US 27 - US25	81	2.08
Jefferson	US 31E - KY 2052	1	2.05
Jefferson	KY 61 - KY 1065	19	2.00
McCracken	US 45 - KY 1286	49	1.98
Christian	US 41 - KY 107	42	1.96
McCracken	US 60 - KY 998	26	1.95
Shelby	US 60 - KY 55	31	1.88
Henderson	US 41A - KY 351	57	1.82
Jefferson	KY 1020 - US 150	7	1.81
Christian	US 68 - KY 109	17	1.78
Mason	US 62 - KY 10	33	1.78
Warren	US 68 - KY 880	33	1.77
Fayette	US 27 - KY 2333	67	1.75
Mason	US 62 - US 68 - KY 1236	8	1.75
McCracken	US 60 - US 60X	44	1.73
McCracken	US 60 - KY 994	34	1.71

Urban, Minor Arterial

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Scott	US 460 - US 62	36	6.69
Jefferson	US 150 - KY 3054	18	5.86
Jefferson	KY 146 - KY 1699	54	3.56
Caldwell	US 62 - KY 91	21	3.44
Christian	US 41 - KY 2544	26	3.28
Christian	US 41 - KY 1682	42	3.25
Madison	KY 876 - KY 52	47	3.17
Fayette	KY 57 - KY 1970	11	3.02
Kenton	US 25 - KY 1303	73	2.86
Clark	KY 507 - KY 107	22	2.79
Mercer	US 68 - US 127	52	2.68
Campbell	US 27 - KY 8	23	2.52
Fayette	US 27 - KY 1974	37	2.47
Franklin	US 60 - KY 420	40	2.41
Kenton	KY 17 - KY 1303	26	2.41
Muhlenberg	KY 70 - KY 189	22	2.37
Christian	KY 91 - KY 1682	13	2.31
Kenton	KY 17 - KY 16	41	2.24
Christian	US 41 - KY 380	30	2.14
Campbell	US 27 - KY 8	19	2.10
Clark	KY 89 - KY 627	39	2.07
Bourbon	US 68X - KY 627	12	2.05
Christian	KY 272 - KY 107	23	2.04
Christian	KY 272 - KY 380	20	2.02
Jefferson	KY 155 - KY 1747	48	2.02
Boone	KY 18 - KY 3168	46	2.01
Caldwell	US 62 - KY 139	9	1.94
Scott	US 62 - US 25	56	1.92
Kenton	US 25 - KY 1072	49	1.90
Henderson	US 41 - KY 812	25	1.87
Woodford	US 62 - KY 33	29	1.87
Daviess	KY 298 - KY 3143	14	1.86
Bell	KY 74 - KY 2079	35	1.83
Warren	US 31W - KY 880	42	1.83
Christian	KY 109 - KY 1682	10	1.82
Daviess	US 231 - KY 298	23	1.79
Jefferson	KY 864 - KY 1631	33	1.76

Urban, Collector

County	Intersection	Number Accidents	Accident Rate (ACC/MV)
Kenton	KY 2044 - KY 2045	1	2.97
Christian	KY 115 - KY 911	12	2.62
Bell	KY 2079 - KY 2401	15	1.84

APPENDIX D

CASE STUDIES

As part of the process of verifying the data, detailed computer summaries of accident data were obtained for several intersections. Following is a summary of accident data, as given on the computer summaries, at various types of intersections identified as having critical accident rates.

Christian County (US 41 and KY 1682)

The accident rate at this intersection in Hopkinsville was 3.24 ACC/MV compared to a critical rate of 1.74 ACC/MV for its functional classification (urban minor arterial). There were 42 accidents during the three-year period. The intersection has four approaches with both roads having four lanes. The right-of-way is controlled by a traffic signal. The most common accident type was an angle accident (21) followed by rear-end accidents (15). The large majority of the angle accidents involved one vehicle turning left (17 accidents). In the majority of the rear-end accidents, one vehicle was stopped (8 accidents). The most common contributing factor was failure to yield the right of way (25 accidents). There was a high percentage of injury accidents (45 percent) which would be related to the high number of angle accidents. Twenty nine percent of the accidents occurred on a wet pavement with 19 percent during darkness.

Fayette County (US 27 and KY 4)

The accident rate at this intersection in Lexington was 2.12 ACC/MV compared to a critical rate of 1.68 ACC/MV for its functional classification (urban principal arterial). There were 136 accidents during the three-year period. The intersection has several lanes on each of its four approaches. The right-of-way is controlled by a traffic signal. Rear-end accidents were the most common type (82) followed by angle accidents (36) and same direction sideswipe accidents (10). In the majority of the rear-end accidents (51), one vehicle was stopped. An injury was involved in 20 percent of the accidents. The most common contributing factor was driver inattention (56 accidents) with following too close (18 accidents) next. Twenty percent of the accidents occurred on a wet pavement with 24 percent during darkness.

Graves County (KY 94 and KY 381)

The accident rate at this intersection in Lynnville was 4.60 ACC/MV compared to a critical rate of 2.41 ACC/MV for its functional classification (rural major collector). There were nine accidents during the three-year period. There are four approaches to the intersection with stop signs on the KY 381 approaches. An intersection beacon has been installed. Seven of the nine accidents were angle accidents. Four of the accidents (44 percent) involved an injury. None of the accidents were on a wet pavement and only two were during darkness. All of the accidents involved failure to yield the right of way.

Hardin County (US 31W and KY 210)

The accident rate at this intersection in Elizabethtown was 4.68 ACC/MV compared to a critical rate of 2.41 ACC/MV for its functional classification (rural major collector). There were 43 accidents during the three-year period. There are three approaches with a stop sign on the KY 210 approach. The most common accident type was an angle accident (22) with most involving a vehicle attempting to turn left. There were also 14 rear-end accidents and five opposing left turn accidents. Six of the accidents (14 percent) were injury accidents. Eighteen accidents (42 percent) were on a wet pavement and only two (5 percent) were during darkness. The most common contributing factor was failure to yield the right of way (25 accidents) followed by driver inattention (12 accidents).

Jessamine County (US 68 and KY 29)

The accident rate at this intersection near Nicholasville was 2.06 ACC/MV compared to the critical rate of 1.86 ACC/MV for its functional classification (rural minor arterial). There were 13 accidents during the three-year period. There are three approaches at the intersection with a stop sign on the KY 29 approach. The most common accident type was an angle accident (7) with most involving one vehicle turning left. There were also three single vehicle fixed-object accidents. Five of the accidents were injury accidents. Four accidents (31 percent) were on a wet pavement with four accidents during darkness. There was no pattern for contributing factors with three involving failure to yield right of way and two with improper passing and two with disregarding traffic control.

Kenton County (KY 8 and KY 17)

The intersection of these two highways in Covington provides an example of the problem occurring when two one-way roads intersect. Both roads are one way couplets through Covington. The KY 8 couplet is 4th and 5th Streets while the KY 17 couplet is Scott Street and Greenup Street. This results in four intersections of two one-way streets. The information given in the milepoint log allows the identification of two intersections with distinct milepoints. The rates for these two intersections were 5.77 and 5.39 ACC/MV compared to the critical rate of 1.68 ACC/MV for their functional classification (urban principal arterial). The rate for an individual intersection would be reduced if the data would allow the accidents to be assigned to each of the four intersections. There were a total of 111 accidents at these intersections over the three-year period. The most common accident type was angle accidents (55) followed by same direction sideswipe accidents (33) and rear-end accidents (19). Eighteen accidents (16 percent) involved an injury. There were 23 percent of the accidents on a wet pavement and 21 percent during darkness. The major contributing factors included driver inattention, disregarding a traffic control device, turning improperly, and failure to yield the right of way.

Madison County (US 25 and KY 627)

The accident rate at this intersection near Richmond was 4.21 ACC/MV compared to the critical rate of 1.39 ACC/MV for its functional classification (rural principal arterial). There were 22 accidents during the three-year period. There are three major approaches with right of way controlled by a stop sign on KY 627. There is a minor approach (KY 3055) opposite KY 627 which is also controlled by a stop sign. There is also an intersection beacon. The most common accident type was an angle collision with 15 accidents of this type. The majority of those accidents (8) involved both vehicles going straight through the intersection. Ten accidents (45 percent) involved an injury with another accident involving a fatality. Seven accidents (32 percent) were on a wet pavement and four accidents (18 percent) were during darkness. The most common contributing factor was failure to yield the right of way.

Scott County (US 25 and US 62)

The accident rate at this intersection in Georgetown was 1.92 ACC/MV compared to a critical rate of 1.74 ACC/MV for its functional classification (urban minor arterial). There were 55 accidents during the three-year period. There are four approaches with right of way controlled by a traffic signal. The most common accident types were angle accidents (27) with 14 rear-end accidents and five opposing left turn and same direction sideswipe accidents. Thirteen (24 percent) of the accidents were injury accidents. Eleven accidents (20 percent) were on a wet pavement and seven accidents (13 percent) were during darkness. The most common contributing factors were failure to yield the right of way (19 accidents), driver inattention (18 accidents) and disregarding the traffic controls (7 accidents).

Wolfe County (KY 15 and KY 191)

The accident rate at this intersection near Campton was 2.61 ACC/MV compared to a critical rate of 1.39 ACC/MV for its functional classification (rural principal arterial). There were 25 accidents at the intersection during the three-year study period. There are four approaches at the intersection with right of way controlled by a traffic signal. Over one-half of the accidents (13) were angle with failure to yield right of way the most common contributing factor (15 accidents). Almost one-half of the accidents (11) involved an injury. Twenty four percent of the accidents occurred on a wet pavement with 12 percent during darkness.

Woodford County (KY 1681 and KY 1967)

The accident rate at this intersection was 3.49 ACC/MV compared to the critical rate of 2.41 ACC/MV for its functional classification (rural major collector). There were seven accidents during the three-year period. There were three approaches at the intersection with right of way controlled by a stop sign. There were three angle, one rear end, one opposing left turn, one fixed object and one same direction sideswipe accident. Two accidents involved an injury. The most common contributing factor was failure to yield the right of way. There were no accidents during darkness while four (57 percent) were on a wet pavement.

APPENDIX E

RANKING OF INTERSECTIONS USING BEATS COMPUTER PROGRAM

Rural, Principal Arterial

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Madison	US 25 - KY 627*	1	1
Knox	US 25E - KY 1629*	2	2
Wolfe	KY 15 - KY 191*	3	5
Logan	US 68 - KY 3233*	4	6
Lincoln	US 27 - US 150*	5	8
McCreary	US 27 - KY 92*	6	3
Lincoln	US 127 - KY 78*	7	7
Meade	US 60 - KY 144*	8	9
Bell	US 25E - KY 66*	9	12
Marshall	US 68 - KY 58 - KY 1462*	10	10
Letcher	US 119 - KY 15*	11	11
Pulaski	US 27 - KY 70*	12	15
McCreary	US 27 - KY 592*	13	13
Marshall	KY 80 - KY 1311*	14	4
Trigg	US 68 - KY 139*	15	16
Garrard	US 27 - KY 39*	16	18
Knox	US 25E - KY 312*	17	21
Pulaski	KY 80 - KY 461*	18	19
Lincoln	US 27 - KY 1247*	19	17
Breckinridge	US 60 - KY 261*	20	14

* Has critical accident rate.

Rural, Minor Arterial

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Marshall	US 641 - KY 408*	1	2
Pendleton	US 27 - KY 22*	2	1
Jefferson	US 31E - KY 660*	3	10
Marshall	US 641 - KY 348*	4	16
Jessamine	US 68 - KY 29*	5	11
Larue	US 31E - KY 210	6	19
Scott	US 460 - KY 922*	7	8
Madison	US 421 - KY 1016*	8	4
Marshall	US 641 - KY 1824*	9	15
McLean	US 431 - KY 85*	10	9
Ballard	KY 121 - KY 286*	11	13
Meade	KY 144 - KY 1238*	12	5
Simpson	US 31W - KY 1008	13	24
Laurel	KY 192 - KY 363	14	28
Marshall	US 641 - KY 80	15	22
Harrison	US 27 - KY 982*	16	14
Rockcastle	US 25 - US 150	17	26
Wolfe	KY 191 - KY 2491	18	21
Carlisle	KY 121 - KY 307*	19	6
Marshall	US 641 - KY 1445	20	18

* Has critical accident rate.

Rural, Major Collector

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Marshall	US 641 - KY 58*	1	3
Graves	US 45 - KY 1283*	2	1
Hardin	US 31W - KY 210*	3	7
Daviess	KY 56 - KY 456*	4	2
Laurel	KY 229 - KY 1189*	5	6
Trigg	KY 139 - KY 272*	6	4
Floyd	US 23 - KY 1428	7	44
Graves	US 45 - KY 1529*	8	11
Graves	KY 94 - KY 381*	9	8
Adair	KY 80 - KY 61*	10	10
Boone	US 42 - KY 237	11	56
Kenton	US 25 - KY 14*	12	29
Muhlenberg	KY 70 - KY 181*	13	39
Grayson	KY 54 - KY 79*	14	12
Graves	KY 94 - KY 97*	15	15
Hardin	US 62 - KY 84*	16	39
Boone	US 25 - KY 338	17	62
Woodford	KY 1681 - KY 1967*	18	19
Bullitt	US 31E - KY 44	19	88
McCracken	KY 305 - KY 725	20	14

* Has critical accident rate.

Rural, Minor Collector

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Muhlenberg	KY 181 - KY 601	1	87
Muhlenberg	KY 175 - KY 181	2	32
McCracken	KY 348 - KY 994	3	25
Jessamine	KY 39 - KY 1268*	4	9
Todd	KY 171 - KY 507	5	31
Pulaski	KY 452 - KY 1247	6	37
Hardin	KY 222 - KY 1904	7	14
Henderson	KY 416 - KY 520	8	15
Hardin	KY 434 - KY 447	9	93
Fayette	KY 1927 - KY 1973	10	78
Graves	KY 339 - KY 1748	11	28
Knox	KY 233 - KY 1232	12	88
Muhlenberg	KY 831 - KY 890*	13	1
Woodford	KY 1659 - KY 1681	14	35
Harlan	KY 38 - KY 72	15	131
Jessamine	KY 39 - KY 1541	16	77
Fayette	KY 57 - KY 1973	17	79
McCracken	KY 999 - KY 1954	18	45
Pulaski	KY 761 - KY 1664*	19	5
Union	KY 758 - KY 950*	20	4

* Has critical accident rate.

Rural, Local

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Woodford	KY 1659 - KY 2331*	1	1
Trigg	KY 958 - KY 1507*	2	5
Logan	KY 1038 - KY 1588*	3	6
Wolfe	KY 2488 - KY 2491	4	9
McCracken	KY 1241 - KY 1288	5	16
Pulaski	KY 635 - KY 2309	6	14
Pike	US 23 - US 460	7	23
Graves	KY 427 - KY 1374*	8	2
Hickman	KY 575 - KY 1708*	9	3
McLean	KY 798 - KY 2437*	10	4
Laurel	KY 1376 - KY 3434	11	12
Estill	KY 1645 - KY 2461	12	20
Adair	KY 901 - KY 1323*	13	7
Caldwell	KY 278 - KY 1603	14	8
McCracken	KY 1014 -KY 1288	15	19
Calloway	KY 893 - KY 1836	16	10
Morgan	US 460 - KY 2496	17	21
Greenup	KY 2 - KY 2541	18	22
McCracken	KY 998 - KY 1286	19	24
Webster	KY 874 - KY 1340	20	11

* Has critical accident rate.

Urban, Principal Arterial

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Kenton	KY 8 - KY 17*	1	1
Kenton	KY 8 - KY 17*	2	2
Warren	US 68 - KY 1435*	3	3
Daviess	US 60 - US 431*	4	4
Daviess	US 60 - KY 2235*	5	5
Warren	US 31W - KY 3225*	6	7
Daviess	US 231 - KY 2245*	7	6
Daviess	US 60 - US 231*	8	8
Bourbon	US 68X - US 460*	9	9
Jefferson	US 31W - US 150*	10	11
Taylor	KY 55 - KY 3183*	11	10
Boyle	US 127 - US 150*	12	14
Jefferson	US 60A - KY 1020*	13	17
Jefferson	US 31E-US 31W-KY 1020*	14	16
Jefferson	KY 1065 - KY 1865*	15	12
Kenton	KY 17 - KY 1120*	16	13
Jefferson	KY 1931 - KY 2054*	17	15
Fayette	US 68 - KY 1267*	18	18
Shelby	US 60 - KY 53*	19	21
Daviess	US 231 - KY 298*	20	19

* Has critical accident rate.

Urban, Minor Arterial

County	Intersection	Ranking Using BEATS	Ranking Using Accident Rate
Scott	US 62 - US 460*	1	1
Jefferson	US 150 - KY 3064*	2	2
Jefferson	KY 146 - KY 1699*	3	3
Christian	US 41 - KY 1682*	4	6
Madison	KY 52 - KY 876*	5	7
Caldwell	US 62 - KY 91*	6	4
Christian	US 41 - KY 2544*	7	5
Kenton	US 25 - KY 1303*	8	9
Mercer	US 68 - KY 127	9	11
Christian	KY 107 - KY 507*	10	10
Fayette	KY 57 - KY 1970*	11	8
Fayette	US 27 - KY 1974*	12	13
Campbell	US 27 - KY 8*	13	12
Franklin	US 60 - KY 420*	14	14
Kenton	KY 17 - KY 1303*	15	15
Muhlenberg	KY 70 - KY 189*	16	16
Kenton	KY 17 - KY 16*	17	18
Christian	US 41 - KY 380*	18	19
Christian	KY 91 - KY 1682*	19	17
Clark	KY 89 - KY 627*	20	21

* Has critical accident rate.

Urban, Collector

County	Intersection	Ranking Using: BEATS	Ranking Using: Accident Rate
Christian	KY 115 - KY 911*	1	2
Bell	KY 2401 - KY 2079*	2	3
Campbell	KY 8 - KY 1998	3	4
Warren	KY 2158 - KY 2629	4	6
Boyd	KY 766 - KY 1134	5	7
Fayette	KY 1267 - KY 1966	6	5
Hopkins	KY 70 - KY 254	7	13
Greenup	KY 207 - KY 693	8	12
Jefferson	US 42 - KY 329	9	8
Kenton	KY 8 - KY 1072	10	14
Bell	KY 441 - KY 2396	11	15
Kenton	KY 8 - KY 371	12	9
Calloway	KY 821 - KY 822	13	18
Kenton	KY 2044 - KY 2045*	14	1
Pulaski	KY 1247 - KY 1577	15	19
Jefferson	KY 1447 - KY 2050	16	21
Boone	KY 2364 - KY 2367	17	20
Wayne	KY 1808 - KY 3106	18	10
Boone	KY 8 - KY 20	19	11
Pulaski	KY 2291 - KY 2292	20	17

* Has critical accident rate.

APPENDIX F

DESCRIPTION OF VARIOUS COMPUTER PROGRAMS NECESSARY TO IMPLEMENT THIS PROCEDURE

Following is a detailed explanation of the procedures involved in the development of the intersection accident file. Step by step instructions and descriptions are provided for the programs needed to complete the analysis of the intersection accident rates. The following steps are required in the order specified. It is important to follow in the order of the steps outlined because later programs operate on the output of earlier runs.

I. Modify intersections included in INTERSECTION FILE.

II. Add AADT and functional classification to Intersection File using INTHIST program.

III. Manually edit output from INTHIST program to correct any missing AADT or functional classification.

IV. Create an intersection accident subset for each year using the INTERACC program.

V. Match intersection accident subset with edited output from step III using program INTACRAT.

VI. Calculate intersection accident rates using the CALACRAT program.

VII. Determine a functional classification for each intersection using the INTTOTAC program.

VIII. Calculate average and critical accident rates by functional classification using the program FCCOUNT.

IX. Sort the Intersection Output file.

X. Print county intersection data.

XI. Download the output file from the INTTOTAC run.

XII. Calculate exposure for use in the BEATS program.

XIII. Use BEATS program to rank intersections.

Following is a description of how to perform the preceding steps.

I. Modify intersections included in INTERSECTION FILE:

Modifications may be made directly on the previous intersection file in order to update current intersection information. When appending or omitting intersections, the intersection numbers must be updated. It is important that the intersection numbers remain in a numeric sequence for each county. The intersection number is the descriptor which defines a unique intersection for the programs. The information needed to update the Intersection file includes county, intersection route number, milepoint, number of legs, and number of lanes.

II. Add AADT and functional classification to Intersection file using INTHIST program:

INTHIST is a fortran program written specifically to match the Historic file, which contains the traffic volume information, with the intersection file. This program updates current average annual daily traffic (AADT) and functional classification in the intersection file. The program places the AADT for the middle year of the three years being analyzed. For example, considering the years 1990, 1991 and 1992, the AADT will reflect 1991 volumes.

The Historic file is the most accurate traffic volume available with updates occurring annually. Current Historic files may be obtained from Kurt Godshall at the Kentucky Transportation Center in Lexington or from Ed Medina at the Division of Planning in Frankfort. It may be necessary to manually verify some of the volume data, specifically when very low volumes occur.

The program places an AADT and a functional classification for each leg of all intersections by matching on county, route and milepoint. The Historic file has a beginning and ending milepoint for each of its sections so a match is considered good when the intersection milepoint falls within the Historic file's beginning and ending milepoints. The Historic file's AADT is in an exponential format. For example, the number "1231" represents the value $123*10^1$ or 1,230. The program converts the numbers out of the exponential format into a standard format before placing them into the intersection file. A negative sign in the Historic file represents an estimated value so the absolute value is calculated.

III. Manually edit output from INTHIST program to correct any missing AADT or functional classification

In some cases, the INTHIST program will not find a match for an intersection record and, therefore, cannot place a current AADT or functional classification onto the record. Manual editing is required at this point to place a best estimate or functional class average on the record. This is a subjective procedure since a functional classification must be determined based on the highway type and urban/rural location.

There are two traffic volumes recorded in the Intersection file, a volume recorded in the highway segment and an intersection volume. The intersection volume is calculated using the number of approaches value in position 35. When the approach value is a 1, the intersection volume is half of the highway segment volume. When the approach value is a 2, the intersection volume is the same as the highway segment volume.

IV. Create an intersection accident subset using the INTERACC program

The SAS job INTERACC will create a single file containing three years of accident data. This program creates a subset of intersection accidents based on the directional analysis codes in positions 35 and 36 in the statewide accident tape. When the directional analysis codes are greater than 0 and less than or equal to 20, the accident is identified as an intersection accident. By using the INTERACC program, an intersection accident subset can be created. This decreases the run time and cost on job runs requiring this data set.

V. Match Intersection accident subset with edited output from step III using program INTACRAT.

The FORTRAN job INTACRAT matches the intersection accident subset file with the intersection milepoint file. The program uses the urban/rural designation to apply a range of plus or minus 0.02 mile for urban intersections and plus or minus 0.05 mile for rural intersections to the milepoint to find a match. The program determines the number of accidents for each intersection for each respective year and places the total at the end of each record.

VI. Calculate intersection accident rates with CALACRAT program

Each intersection is identified by at least two records in the Intersection file. This program totals up the accidents observed at each intersection and calculates an accident rate for each intersection. The following equation was used to calculate accident rates. $\left[\frac{total\ accidents*1000000}{AADT*365*3}\right]$ The equation gives an accident rate in terms of accidents per million vehicles (ACC/MV). The factors in the numerator represent total accidents and a factor of 1,000,000. The factors in the denominator represent the current AADT multiplied by 365 (number of days in a year) times a factor of three to represent the three years of data.

VII. Determine a functional classification for each intersection

In most cases, the intersecting highways have different functional classes. A functional classification must be determined for each intersection to complete the analysis. The program INTTOTAC will determine the functional class based on the traffic volume for each highway at the intersection. The functional classification for the intersection is defined as the functional classification for the highway having the highest traffic volume.

VIII. Calculate average and critical accident rates by functional classification using the program FCCOUNT.

This program creates a table displaying average accident rates, total accidents, million vehicles, number of intersections and critical accident rates for each functional classification. A check should be made to verify that none of the functional classifications are out of the accepted range. Some functional classes of zero and 99 have been detected in the data. These will have to be corrected since they are not valid functional classes.

In order to correct the non-valid functional class values, determine whether the road is in a rural or urban location and match a functional class to the section with regard to traffic volume.

IX. Sort the Intersection Output file

The sorting procedure is performed to determine which intersections, within each functional class, have an accident rate greater than the critical rates calculated in step VIII.

Since there are at least two records for each intersection, a standard sort procedure cannot be performed immediately. The program CONCAT must be run to concatenate the intersection records into one record and place the intersection functional class and accident rates in positions 369 through 370 and 373 through 378, respectively. A sort then may be performed on the output of the CONCAT run using the field 369 through 370 as the primary sort field and 373 through 378 as the secondary sort field. After sorting the file, the program RECAT must be run to put the sorted file back together.

The output of the RECAT program enables the determination of which intersections have accident rates greater than the calculated critical rates from the FCCOUNT run.

X. Print County Intersection Data

In order to get a printout for each county, the output from the INTTOTAC run should be used. By adding headers to the file and using carriage control, page breaks may be placed at every county.

XI. Download the output file from the INTTOTAC run

The ranking procedure is a PC based operation that uses the results of the previous job runs. Using any available communications software (ie, Kermit..), download the output file, INTTOTAC.OUT, to the PC level.

XII. Calculate exposure for use in the BEATS program

Exposure is the total number of vehicles that pass through an intersection in the three years being analyzed. The PC Fortran based program EXPOSURE will calculate the exposure for each intersection using the downloaded file INTTOTAC.OUT. The program creates a site identification number for each intersection, tallies all the accidents observed at each site, and attaches an exposure to the site identification. The site identification number is created using the county number and the intersection number. For example, the number 3405 represents county number 34 and intersection number 5.

The output from the EXPOSURE program must be modified to be read by the BEATS program. After running the EXPOSURE program, individual files for each functional class must be created. The exposure value must be divided by one million and the functional class value in the last column must be removed. The new files for each functional class should have the same format as the file TEST.DAT with is included with the BEATS program.

XI. Use BEATS Program to Rank Intersections

Researchers in the field of accident analysis have long been aware of the problems associated with drawing statistical inference on safety using accident data. One of the most serious problems is the regression-to-mean bias which occurs due to the non-random site selection process. The regression-to-mean bias is the phenomenon where the number of accidents at a high-accident location decreases even when no safety improvements are made. The BEATS program applies Baysian Estimation Methodology to account for the regression-to-mean bias.

Run the BEATS program for each of the functional class files. From the main menu, choose the F6 option, Ranking Data Analysis. When asked, type the name of the functional class exposure file and an output file. On the next menu, choose the option F2, to list the estimates for top rates. Repeat these procedures for each functional class file. The number of intersections in a functional classification may be too large for the the BEATS program to run. A solution to this problem is to delete all intersections where no accidents occurred during the study period. This will reduce the number of intersections to a level which can be handled by the BEATS program.

Program list

1. INTHIST.FORTRAN
   Fortran job that matches the Intersection file with the Historic file to get current traffic volumes.
2. INTERACC.JCL
   SAS job that creates an intersection accident subset from three years of accident data.
3. INTACRAT.FORTRAN
   Fortran job that matches the Intersection file with the intersection accident subset.
4. CALACRAT.FORTRAN
   Fortran job that computes the accident rates for each intersection.
5. INTTOTAC.FORTRAN
   Fortran job that determines the intersection functional class and writes it into the file in position 94.
6. FCCOUNT.FORTRAN
   Fortran job that produces a table of number of accidents, million vehicles, number of intersections, average accident rates and critical accident rates for each functional classification.
7. CONCAT.FORTRAN
   Fortran job that concatenates the Intersection file so that a sort may be run.
8. RECAT.FORTRAN
   Fortran job that takes the concatenated Intersection file back into its normal format.
9. EXPOSURE.EXE
   PC Fortran based program to calculate exposure at each site.
10. BEATS.EXE
   Baysian Estimation program to rank the sites by accident rate.