AUTO-UTILITY TRAILER COMBINATIONS ON RURAL HIGHWAYS IN KENTUCKY

by

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ABSTRACT

An analysis of accident records indicated that auto-utility trailer (A-UT) combinations are involved in a disproportionately high number of traffic mishaps. Locations which have a history of accidents involving A-UT vehicles indicated that differential crosswinds and unanticipated driving maneuvers contribute to the driver's loss of control. A-UT combinations contributed to the fatigue loss in pavement life approximately 50 percent as much as single-unit, two-axle, six-tire trucks (per vehicle). In general, this vehicle type constituted approximately three percent of the total traffic stream. Analysis of speed distributions indicated an equivalency factor for A-UT combinations equal to that for trucks for similar roadway types and topographical conditions.

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INTRODUCTION

The Kentucky Bureau of Highways has recently completed several studies characterizing traffic on highways within the state. The first of these studies *(1)* established a methodology for predicting the vehicular composition of the traffic stream as related to significant local variables. The methodology was needed to increase the accuracy of predictions of cumulative equivalent axleloads (EAL's). The validity of the proposed procedure depends upon the accuracy of vehicle classification and loadometer data used as inputs. A second study *(2)* was conducted to enhance the validity of the predictive technique of the first by providing data on the lateral distribution of traffic on four- and six-lane limited access facilities. An analysis of loadometer and classification data of traffic utilizing bridges spanning the Ohio River from Kentucky resulted in a proposed methodology *(3, 4, 5, 6)* by which the fatigue life of a bridge could be evaluated.

Present methods of classifying vehicle types do not segregate auto-utility trailer (A-UT) combinations. Traffic classification counts merely denote an auto-utility trailer combination as a passenger car. If a trailer is being pulled by a pickup truck, the combination is recorded as a single unit, two-axle, four-tire truck. In compliance with this practice, previous studies of traffic characteristics *(1, 2, 3, 4)* made no special notation of these vehicles. However, a surprisingly large number of automobiles pulling utility trailers was noted by the data collectors. Preliminary observations indicated that during peak periods of traffic flow up to ten percent of the total traffic stream was composed of A-UT combinations.

The present study, therefore, was conceived with the following objectives:

1. To establish the presence of A-UT combinations on certain rural Kentucky highways,
2. To ascertain the effect of A-UT combinations on capacity (level of service) for various

highway types and various dissimilar highway sections (in terms of number of equivalent autos),

3. To provide a basic data bank for denoting quantitative trends for this vehicle type in the future,
4. To examine the advisability of counting A-UT combinations separately in classification studies,
5. To consider the effect A-UT axleloads have on the total equivalent axleload accumulation, and
6. To investigate accidents involving A-UT vehicles.

ACCIDENT DATA AND ANALYSIS

Preliminary comparisons of accident involvement rates of A-UT combinations to percentages of this vehicle type in the traffic stream revealed a glaring disproportionality (Table 1). These data were obtained from toll roads records *(7)* and from available accident reports. Since these figures were valuable only for intuitive purposes, it was anticipated that a detailed analysis of accident records would provide additional information.

Extensive accident records of Kentucky highways were available for analysis. Table 2 summarizes the road-year data sets available. The geographical distribution of roadways investigated is shown in Figure 1.

Initially, A-UT accident trends were compared with those of accidents in general. The procedure involved examination of all single-vehicle accidents, accidents involving A-UT combinations, single-vehicle accidents involving A-UT combinations, and traffic volumes by means of a graphical representation of trends by hour of day, day of week, and month of year. Typical distributions of total traffic volume, total accident occurrence, total A-UT accidents, all single-vehicle accidents, and single-vehicle accidents involving A-UT combinations are shown in Figures 2 and 3. There was no marked difference (except for the smoothness of the curves as a function of sample size) in the hourly distributions of A-UT accidents relative to traffic volume distribution from the hourly distribution of all accidents. The same was true for single-vehicle accidents. During daylight hours, a greater percentage of single-vehicle A-UT accidents occurred than do single-vehicle accidents -- at night the opposite trends were evident. It was hypothesized that these trends were caused by the lower volume of A-UT traffic at night.

Typical accident and traffic volume distributions by day of the week are illustrated in Figures 4 and 5. Again, similarities were apparent. However, accident and volume distributions of A-UT traffic showed marked differences. Tuesday was the lightest day for A-UT traffic, yet Tuesday was the third highest day for A-UT accident occurrence. A similar situation existed for Friday; whereas for Saturday, the opposite was true. Thus A-UT traffic and A-UT accidents cannot be said to coincide to the degree that was exhibited for all traffic and all accidents. For all single-vehicle accidents, similarities with volume distributions were again evident. Once again, the greater-accident-than-volume condition for A-UT single-vehicle accidents prevailed for Tuesday and Friday; the opposite held true for Monday and Saturday. It may be concluded from these observations that the distribution by day of the week of all accidents, both single-vehicle and total, was not identical to that of similarly classed A-UT accidents.

Distributions of accidents and volumes by month are illustrated in Figures 6 and 7. Generally, A-UT accidents illustrated the same trends as all accidents. There were, however, some notable exceptions. The percentage of A-UT accidents increased markedly in April, while the percentage of all accidents dropped significantly. The trends then coincided until October, when A-UT accidents rose noticeably over a rather exaggerated September low. At the same time, all accidents decreased slightly from September to October. Again, in November, the percentage of A-UT accidents dropped perceptibly while the percentage of accidents in general increased slightly. Discounting exaggerations (again probably caused by small sample sizes), trends with respect to single-vehicle accident and single-vehicle A-UT accident distributions seemed to follow similar patterns with the exception of the previously noted differences for October and November. Volume of A-UT traffic (as a monthly percentage of the yearly total) increased significantly during the summer months; a corresponding increase in accident proportions was not observed. A relatively high percentage of A-UT accident occurrence during December and January was countered by the lowest number of A-UT vehicles during these two months. This suggests that A-UT accidents, like accidents in general, correlate rather highly with periods of inclement weather and reduced visibility. The distribution of single-vehicle A-UT accidents shows similar features to all A-UT accidents, but the increase in summer accidents corresponding to high summer volumes was more noticeable.

Another manner in which accidents involving A-UT combinations can be compared with other types of accidents is by distribution in space. It was hypothesized that any location at which the number of A-UT accidents was much greater than that of accidents in general could be analyzed for possible contributing factors. A typical spatial distribution of accident occurrences is shown in Figure 8. The methodology to select sites for detailed investigation initially identified all locations at which at least two A-UT accidents had been reported. Judgement was then employed to ascertain if the number of A-UT accidents represented a disproportionate percentage (60 percent or more) of the total number of accidents reported at that location. It was decided that, while specific accident records at each site could provide insight into probable causes of the problem, accident records would be best utliized as a supplement to on-the-site investigations.

One location was situated on a relatively steep vertical grade (downgrade) in relation to several relatively deep rock cuts. Crosswind conditions created by such cuts have been recognized to contribute to accidents. It was hypothesized that crosswinds would affect A-UT vehicles more than automobiles because of the increased surface area on which wind forces could act. Sudden steering reactions required when a vehicle is subjected to differential crosswind could add to the already difficult task of controlling an A-UT combination. Two other locations were similar to the first. Here, however, steep grades reduced the speeds of A-UT combinations, inducing other vehicles to overtake and pass. The passing of a vehicle also creates a wind loading on both the passing and passed vehicle. Thus these particular accident sites indicated that at least some A-UT accidents occur at locations where cuts induce crosswinds and(or) steep grades lead to wind currents from passing vehicles. These wind factors may be sufficient to affect A-UT vehicles while not necessarily affecting other traffic to such a deleterious extent. Another site involving a disproportionate number of A-UT combination accidents was a section of six-lane interstate roadway (three lanes in each direction) with relatively high traffic volumes. Informational signs depicting exit ramps and signs advising of gas, food, and lodging may precipitate weaving by all traffic and especially A-UT traffic. There was also a median crossover at this site; a waiting vehicle within the crossover could induce erratic maneuvers within the traffic stream and thus indirectly create a traffic conflict and(or) a collision. Therefore, the high rate of A-UT accidents at this site was probably induced by weaving maneuvers performed during high traffic volume conditions. At another site, the only indicative factor was a blank blue sign panel which previously was lettered *REST AREA 2 MILES.* It was not known if the sign message appeared at this site, but there is no subsequent rest area to warrant such a message. Had this sign been erected with such a message, weaving would have been induced. There does not appear to be any contributing conditions, other than some advanced directional signing and the overpass of a county road with its concomitant bridge piers. At a final location, nothing notable in the way of signing appeared in the southbound lanes; but in the northbound direction, several sign panels preliminary to an exit *(EXIT 1 MILE, GAS-FOOD-LODGING)* seemed to present a situation which could induce weaving. In addition, a combination of the cut profile and tree patterns adjacent to the roadway created a situation where wind could be a problem. There was also a crossover located in the area. Specific accident records did not indicate this crossover to be a problem. The primary problem at this site appeared to be a combination of wind and weaving.

A general purview of records of accidents involving A-UT combinations seemed to indicate the primary sources of trouble were trailer hitches becoming loosened while the vehicle was in motion and a general loss of control of the A-UT combination. There was nothing to indicate that loss of control could be solely attributed to conditions of wet weather. Situations seemed to indicate that more often loss of driver control resulted from wind gusts created by roadway topography or overtaking vehicles. Such situations are difficult if not impossible to correct through modification of the roadway. The apparent difficulty lies with the vehicle itself and not with any roadway disparity. Of course, roadway situations in deep cuts and steep grades which may contribute to a wind problem are the result of a desire for economic optimality. Possible elimination or reduction of such situations are necessarily a trade-off against the economic toll of accidents induced by such features. The important factor is that these situations can present problems and may be genuine causes of accidents.

As a final step in the accident analysis, frequency rates of A-UT accidents were compared with the rates of occurrence of all accidents. The common denominator of this analysis was the accident rate per 100 million vehicle-miles. To obtain reliable measures of such rates, accident records, ADT values, and roadway lengths were analyzed for all accidents. Similarly, rates were computed for A-UT accidents utilizing the number of A-UT accidents, the appropriate roadway length, and the volume of A-UT traffic. A-UT volumes were computed using data obtained from traffic classification counts and expanding this information with proper expansion factors. Using the volume of A-UT combinations was thought to be a more legitimate procedure than using total volumes and A-UT accidents.

Results of the analysis for ten sections of roadway are shown in Figure 9. The four toll roads are four-lane limited access highways with attendant toll facilities. US 41 and the three interstate roadways are four-lane limited access highways with no toll facilities. US 27 represents a two-lane rural highway, and US 60 depicts a four-lane, no-toll, no access control facility. For the toll roads, the ratio of A-UT rates to total accident rates had an unweighted mean value of 0.97. This was markedly different from the unweighted mean value (3.32) for the four toll-free, four-lane, limited-access facilities. This disparity could not be related with any statistical significance to levels of volume, median design, or accidents which occurred on toll facilities. Likewise, no correlation could be established with percentage of A-UT vehicles in the traffic stream. Consideration of density did not offer a solution. Finally, this situation was judged to be the result of data sample size. A closer examination of Figure 8 reveals several peculiarities which could most aptly be related to sample size. For instance, the two-lane section of US 27 had the lowest accident rate of all roads considered. This did not conform to intuitive reasoning, since US 27 carried a relatively dense traffic stream in the subject area. Furthermore, many A-UT accident rates were based on a single A-UT accident. Undoubtedly, larger sample sizes of accidents would provide better indications. In general, however, it can still be said that the frequency of A-UT accidents was greater than accidents involving automobiles alone. The unweighted combination of the statistics depicted in Figure 8 indicated that A-UT accidents occur at a rate 2.35 times greater than the occurrence of all accidents.

The final portion of the accident analysis was an attempt to compare severity rates of A-UT accidents with those of all accidents. Here again, data were very sparse, and meaningful relationships were difficult to develop. Figure 10 illustrates values obtained in the severe accident analysis. No attempt has been made to draw any conclusions from these limited data; they are presented for informational purposes only.

ANALYSIS OF WEIGHT DATA

To test the hypothesis that the A-UT combinations contribute significantly more to accumulated equivalent axleloads on a pavement structure than standard automobiles, it was proposed to obtain sample weights of A-UT vehicles. No records were available of any previous loadometer data on automobile-utility trailers in Kentucky. A literature search did not reveal any data acquired elsewhere. Principal determinants in selecting weighing sites were compatibility with accident data and availability of facilities for weighing vehicles. Extensive accident records were available for rural, limited access facilities in the state, both toll roads and interstate highways. Permanent loadometer stations had been constructed in conjunction with several interstate facilities, and three of these installations were in operation. The I-75 weigh station was located in Scott County, the I-64 weigh station was situated in Shelby County, and the weigh station on I 65 was located in Hardin County.

Weighing operations were conducted only during the 16-hour period between 6 a.m. and 10 p.m. during the summer of 1970. A-UT traffic between 10 p.m. and 6 a.m. did not appear to warrant the inclusion of this time period in the weighing operations. This decision was justified by the number of A-UT vehicles finally weighed on I 65 and I 75 (114 and 202, respectively). Thus, a statistically large sample of vehicles in each direction of travel was weighed. However, only 49 vehicles were weighed on I 64. Of these, 21 were eastbound vehicles and 28 were westbound. The relatively smaller number of vehicles weighed was partially attributable to the small daily traffic volumes on I 64 and because of less responsiveness on the part of A-UT combination drivers to enter the weigh station area. For each set of data, representing each A-UT combination weighed, axleloads, axle spacings, direction of travel, roadway name, and type of trailer being pulled were recorded.

It was desirable to separate the trailers into distinguishable categories so as to evaluate trends which might be evident for given trailer types. However, it was realized that to obtain statistically significant sample sizes there was a certain practical limit to the number of categories which could be used. As the number of categories increased, the size of each data subset necessarily decreased. Thus, it was decided to categorize the vehicles into three to six classes. A pilot study of vehicle classification was conducted prior to the collection of any data for use in the study for the purpose of establishing procedures and determining classification of trailers to be used in the actual data collection process.

The sample data were collected for approximately 2 hours on I 75. From this sample, it was decided that A-UT combinations should be classified as either house trailers, boat trailers (loaded or unloaded), or U-Haul type trailers. A fourth category was provided for other types of trailers which did not lend themselves to categorization in this manner. This classification system was utilized during the weighing operations. Later, it became apparent that the system needed revision due to the large number of trailers being recorded as miscellaneous types which could be classified as a specific type. With the exception of the relatively small amount of data acquired at the I 64 weigh station, the 16-hour weighing period provided statistically sufficient data sample sizes. At the I 64 weigh station, the gross number of vehicles weighed (49) was a significant sample size, but subdivisions of the data into smaller groupings reduced the size of samples below that generally regarded as being statistically large (i.e. 30).

The relationship between vehicle load and contribution to fatigue, whether the fatigue being considered involves structural metallic materials (as in bridge members) or asphaltic or portland cement concrete pavement substances, can best be analyzed by consideration of discrete loading distributions. The initial phase of weight data analysis was to calculate values of selected characteristics. Results of this analysis are summarized in Tables 3 and 4.

Since the principal intended use of the axle weight data was its application to pavement design techniques, decomposition of these data into subsets of vehicle type, road name, and direction of travel was a necessity if trends peculiar to a certain subset were to be identified *(1)*. However, if certain subsets could be examined with extraneous variables eliminated, the analysis could pinpoint more accurately the source of these trends. To determine whether or not certain aspects of data subsets were combinable, appropriate statistical tests were used to examine the equality of means and variances, the Smith-Satterthwaite t-test for equality of means and the F-test for equality of variances. Each of these statistical analyses was performed at the 95-percent level of confidence, with the $\alpha = .05$ region divided into two tails.

A rather arbitrary method was necessarily chosen to evaluate results of the statistical comparisons.

Four criteria were established. The first was the acceptable statistical combination of three of the four axleloads. The second was the acceptability of combining gross loads. The third examined the combinability of two of the three axleloadings. Statistical lumping of the wheel base was the final criterion. If three of the four criteria were satisfied, it was deemed sufficient evidence of the combinability of the statistical parameter under study. As a result of these tests, the only data lumping deemed proper was that of I 64 eastbound with I 64 westbound and that of I 65 northbound with that of I 65 southbound.

Pavement design philosophies embody a concept of failure by fatigue in both flexible and rigid pavements and recognize the fatigue-contributing equivalence of a certain number of passages of a standard axleload to a single passage of another weight. The passage of a sufficiently heavy axle contributes to a reduction in the remaining fatigue life. Thus, any unanticipated increase in the number of axleloads from any traffic source could theoretically decrease the useful life of the pavement. Since A-UT combinations are categorized merely as automobiles in traffic classification studies, trailer axles are not included in pavement design analyses. If the trailer axles should prove to be relatively heavy, then the damage to the pavement could be significant. When both car axles and trailer axles are considered in a cumulative fatigue analysis for flexible pavement design, the additional equivalent axleloads accumumated for a 20-year design period for a roadway with significant A-UT traffic was approximately five percent. A-UT combinations contributed to the fatigue loss in pavement life about 50 percent as much as single-unit, two-axle, six-tire trucks (per vehicle).

TRAFFIC COUNTS

Locations at which to conduct classification studies were restricted from both the aspect of compatibility with available accident records and facilities available for loadometer studies and of congruity with radar speed study information. Visual classification surveys were conducted in the vicinity of the three loadometer stations:

1. I 65 in Hardin County, approximately 0.75 miles (1.2 km) south of the loadometer stations where East Rhudes Creek Church Road is overpassed by I 65.
2. I 75 in Scott County, about 0.5 mile (0.8 km) north of the loadometer stations where KY 620 passes under the interstate.
3. I 64 in Shelby County, 1.3 miles (2.1 km) west of the interchange with KY 395 where Wentworth Road passes beneath I 64. This site is 3.4 miles (5.5 km) east of the loadometer stations on I 64, but there are no intervening exits to allow any change in the traffic stream.

Additional sites were selected to provide data from different classes of roads. One site was located on US 41 in Hopkins County at a point 0.6 mile (1.0 km) south of the US 41 - US 62 interchange where US 41 overpassed the old Nortonville-White Plains Road. Other locations selected were on US 27 in Jessamine County, 0.8 mile (1.3 km) south of the intersection with KY 981 at a roadside park, and on US 60 in Woodford County, 4.6 miles (7.4 km) south of the Fayette - Woodford County line. It was believed these six classification study locations, combined with information available from four toll roads, would provide necessary classification information for purposes of this study.

At each site, there was a physical limitation as to the number of varying types of information which could be obtained for each count. Some information desired included the lane distribution of total traffic and of A-UT traffic and information as to whether the automobiles had trailer hitches. During any one count period, distribution of traffic by lane or the separation of those vehicles having trailer hitches could be recorded, but not both. A count of cars with trailer hitches was an indicator of the potential of A-UT combinations on the roadway. At sites on I 64, I 65, US 27, US 60, US 41, and the short count on I 75, data concerning trailer hitches was recorded. For the week-long count on I 75, where determination of the presence of a trailer hitch during darkness was difficult, it was decided to record the lane distribution of automobiles and of A-UT combinations.

A long count (a staggered, week-long study which included each hour of the week) was conducted at the I 75 location in Scott County. Personnel limitations precluded a 24-hour per day, seven-day continuous count. The remaining counts, which were short, were conducted at locations on I 65, I 64, US 27, US 60, and US 41. The short counts were of 12-hours duration, conducted from 8:00 a.m. to 8:00 p.m. These data were supplemented by toll receipts data.

Prior to obtaining the classification information, a method to classify trailer types was chosen. An investigation of the licensing procedure in Kentucky indicated that only "house trailers" and the general class of "trailers" were licensed; a better stratification of trailer type information was needed. During initial counts, it was observed by data collectors that an unusually large number of miscellaneous trailers which could be classified separately as campers were being recorded.

Stratification of trailers by axle configuration was included because this is the type of data needed in an analysis of the effect of axleloads on the pavement. A systematic presentation of loadometer data would of necessity include those types of data needed for the computation of the average numbers of axles in various subsets. Distinction was made between those trailers having two axles closely spaced in tandem and those spaced similar to standard automobiles.

Table 5 indicated the average percentages of vehicle types for each of the six roadways at which classification information was obtained. This table also presents a weighted (by volume) average of all data and of data acquired at four-lane, controlled-access facilities. It can be seen that A-UT vehicles ranged from 1.12 percent of total traffic on US 27 to 4.24 percent on I 75; the weighted mean value was 2.47 percent on all roads and 3.00 percent on four-lane, controlled-access highways. Thus, the total weighted percentage of recreational vehicles on all roads was 3.48 percent and on all four-lane, limited-access facilities was 4.11 percent. The range was a low of 1.75 percent on I 64 to a high of 5.56 percent on I 75.

From data obtained for I 75, it was possible to determine the distribution of vehicle types by hour of day (Table 6) and by day of week (Table 7). An analysis of the percentage of A-UT traffic as a function of hour of day indicates a good correlation with traffic volume. Regression analysis indicated an equation of the form

$$y = 2.48 + .00148\ x,$$

where x is the hourly traffic volume and y is the percentage of A-UT traffic. The correlation coefficient of this equation is 0.85. The boundary lines within which 95 percent of the points fall are:

Lower: $y = 2.05 + .00107\ x$

Upper: $y = 2.91 + .00189\ x$

A similar attempt to relate percentages of A-UT vehicles to daily volumes did not produce any significant correlation. It was hypothesized that correlation with volume was significant when day of the week could be incorporated into the percentages, but when percentage as a function of volume is stratified by day of the week, no correlation was evident.

These regression models are presented for the purpose of illustrating trends rather than for the actual prediction of A-UT percentage. Correlation is high, but this does not necessarily mean that there is a causative relationship. The regression line was derived from volumes stratified by hour of the day; the real meaning of this correlation was that the increase in A-UT traffic during certain periods of time was proportionately greater than the increase in traffic in general. It was obvious this was true for certain days of the week, and the figures presented seem to indicate that this was also true for certain hours of the day.

An analysis was also performed to test the directional equality of vehicle percentages and volume percentages. At the 95-percent level of significance, the percentages of the four vehicle types and of volume were not significantly different by direction of travel.

Furthermore, an analysis was made of the percentage of non A-UT automobiles which had a trailer hitch (Table 8). The mean percentage of such vehicles was 9.09 and the standard deviation was 1.79. There was no statistically significant difference in the percentages of non A-UT vehicles with trailer hitches. The percentage of this type of vehicle indicated a potential for as much as 10 to 12 percent of the total traffic being A-UT vehicles.

Analysis of the percentage of A-UT vehicles in the shoulder lane of traffic revealed an unweighted mean percentage of 90.49 when the data were stratified by hour and 88.68 percent when categorized by day. Examination of the hourly percentages revealed that, except for the period between 4 a.m. and 5 a.m. when every A-UT vehicle was traveling in the shoulder lane, no particular hour had a statistically significant percentage differential. Similar analysis of percentages by day revealed no significant deviation. It may be concluded that approximately 90 percent of A-UT combinations travel in the shoulder lane. Hourly and daily distributions of the percentages of A-UT vehicles in the shoulder lane are shown in Tables 9 and 10.

The final analysis of traffic classification data was a summary of trailer types. A matrix of five trailer types and three axle configurations was used (Table 11). The distribution of trailer types is dominated by camper trailers; each of the other four trailer types share an approximately equal percentage of the total. Nearly four-fifths of all trailers had one axle and less than one percent had three axles. Camper trailers were the dominant type of one-axle and three-axle trailers but were the least dominant two-axle trailer. House trailers were the least prevalent one-axle trailer. With the exception of miscellaneous trailer types, house trailers were also the most prevalent two-axle trailer. There were no three-axle boat or U-Haul trailers observed. The largest single trailer type was the one-axle camper trailer.

There was one roadway section, I 75, at which the classification study extended to each hour of the week. It was hypothesized that a calculation could be made to determine the percentage of daily A-UT traffic which occurs during each hour of the day, and this information could be utilized to expand a 12-hour count to a full day's count. Similar calculations could then be made for day of the week. Information available from toll road collections could then be used to project the data from the month in which it was taken to the entire year.

There were several assumptions implicit in this numerical manipulation. The distribution by hour of the day was lumped for all days of the week. Therefore, the assumption was that the distribution does not vary within the week. There are several obvious instances in which this assumption is not valid. However, in general, it was felt that the hypothesis was true. Similarly, the assumption was implicit that the week during which the classification study was conducted was typical of every week of the year. Finally, the assumption was also made that the years for which toll data were acquired were typical. In addition, the assumption was implicit that distributions by hour and by day on I 75 were typical of that for other roads.

Table 12 lists the percentages of A-UT vehicles of the total volume for each hour of the day. It can be seen that the percentage occurring between 7 p.m. and 8 p.m. exceeds that during the hour 7 a.m. to 8 a.m. and that the percentage occurring between 8 a.m. and 9 a.m. and that occurring between 8 p.m. and 9 p.m. were not significantly different. Therefore, it can be concluded that the 8-8 shift for the 12-hour count was preferable to a 7-7 shift. The percentage of daily A-UT vehicles counted between 8 a.m. and 8 p.m. was 77.31. Tables 13 and 14 show similar distributions by day of week and month of year.

SPOT SPEEDS

The final phase of the study was to determine various spot-speed parameters for different vehicle types. It was felt this information could be used to determine auto-utility trailer combination equivalency factors to be utilized in capacity analyses. Furthermore, since accident potential on high-speed facilities increases as speed differentials increase, an analysis of speed differential trends might yield a correlation with accident records.

The choice of locations at which to conduct spot-speed studies was made in conjunction with appropriate criteria for other phases of the study. Specific criteria which were considered especially relevant to the collection of spot-speed information were relatively straight and level sections of roadway and appropriate possibilities for concealment of measuring apparatuses. The requirement that the roadway section be relatively straight and level was derived from the assumption that the most important aspect to be considered is the relative speed between A-UT combinations and autos, not the absolute speed of either.

At least 3 hours of data in each direction were obtained for each road. Spot speed was recorded for as many vehicles as possible. However, only the first vehicle of a platoon was recorded since this vehicle was the speed determinator of the queue. This limited the data which could be obtained on the two-lane roadway, US 27; however, the greater volume and multilane aspects of the other roads eased the effects of this restriction. Speeds were obtained for automobiles, A-UT vehicles, and trucks.

A statistical analysis of speed data indicated a statistically significant difference between speeds of A-UT combinations and of automobiles at each of the six test sites. Table 15 shows a parcel of information from a plot of the cumulative speed distributions of automobiles, trucks, and A-UT combinations for the six roadway sections. Use of the 85th percentile is consistent with the normal practice used to establish speed limits and gauge the normal running speed of the traffic stream. The 50th percentile is the median speed, a common measure of central tendency. The 15th percentile is used as a lower base for running-speed calculations, sometimes used as the speed below which allowance should not be made in the design of speed-influenced elements. It is also an appropriate statistical symmetry for the 85th-percentile speed.

Based on a symmetry analysis, i.e. a comparison of the difference between the 85th-percentile level and the 50th-percentile level with the difference between the 50th percentile and the 15th percentile, it can be said that automobiles were relatively symmetrical in their speed distribution, exhibiting a slightly greater tendency toward more dispersion among lower speeds. Trucks were not greatly skewed in their distribution, yet they exhibited a marked trend toward greater variance at lower speeds -- more so than automobiles. Speed distributions of A-UT vehicles exhibited the greatest variance in distribution in either direction, undoubtedly due to a smaller sample size. However, when the mean difference between upper and lower differentials was computed, the A-UT distribution was more heavily skewed downward than the distribution of either automobiles or trucks. By inference, the lower half of the A-UT speed distribution was more widely variant than those for automobiles or trucks, indicating that the lower half of the speed range was more extended for A-UT combinations.

Equivalency factors can be computed to a remarkable degree of accuracy from speed distributions *(8)*. The process used here to compute equivalency factors for A-UT combinations was to compare speed distributions of automobiles, trucks, and A-UT combinations. Using established factors for trucks as a base and the mean ratio between truck-auto differences and A-UT-auto differences as a multiplier, a related figure for A-UT combinations was calculated.

Speed-differential ratios for five percentile levels are listed for each road in Table 16. It can be seen that the mean on each of these roads was close to unity. Therefore, the automobile equivalency factor for A-UT combinations is essentially the same as the factor for trucks.

SUMMARY AND CONCLUSIONS

The purpose of the preceeding discussion has been to consider the influence of automobile-utility trailer (A-UT) combinations on several aspects of highway design and operation. The accident history of these vehicles, the influence of their axle weights on pavement design, the relative proportions of these vehicles in the traffic stream, the relative speed distributions of these vehicles and other vehicle types are factors which have never before been considered. The purpose of this discussion was not to provide an exhaustive treatise on any of these subject areas but merely to consider all four areas from a general viewpoint.

The following conclusions can be drawn from the results of the study:

1. Accidents involving A-UT combinations are disproportionately greater than the prevalence of these vehicles in the traffic stream.
2. Although the size of the data sample was small, several types of locations were pin-pointed which seemed to be problem areas for A-UT accidents.
3. Indications at these locations were that A-UT accidents are related to wind forces created either by passing maneuvers or cross sectional configurations or to weaving.
4. Trailer axles, while generally being heavier than automobile axles, are relatively light.
5. When both car axles and trailer axles are considered in a cumulative fatigue analysis for flexible pavement design, the additional equivalent axleloads accumulated for a roadway with significant A-UT percentage is approximately five percent.
6. Four-fifths of the A-UT combination trailers on the road are one-axle trailers.
7. The camper trailer is the most common type of trailer.
8. The speed distribution of A-UT combinations closely resembles that of trucks.
9. The automobile equivalency factor for A-UT combinations is approximately equal to that for trucks.

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6. Bruner III, R. J., *Fatigue Analysis of Central Bridge Deduced from Strain Gage Data and Probability Analysis,* Kentucky Department of Highways, February 1973.

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8. *Highway Capacity Manual,* **Special Report** 87, Highway Research Board, 1965.

TABLE 1

ACCIDENT INVOLVEMENT OF A-UT COMBINATIONS
ON SELECTED KENTUCKY HIGHWAYS
(1967 and 1968)

ROAD	PERCENT OF ACCIDENTS INVOLVING A-UT COMBINATIONS	PERCENT OF A-UT COMBINATIONS IN TRAFFIC STREAM	RATIO
Bluegrass Parkway	8.92	2.96	3.01
Kentucky Turnpike	5.72	2.66	2.15
Mountain Parkway	1.54	1.27	1.21
West Kentucky Parkway	4.24	3.85	1.10
US 41	1.23	2.02	0.61
US 27	5.26	1.12	4.70
US 60	2.86	1.26	2.26
I 64	4.47	1.16	3.85
I 65	10.51	2.80	3.75
I 75	8.38	4.21	1.99

TABLE 2

ACCIDENT DATA SETS

ROAD	YEAR	TYPE OF ACCIDENT RECORDS AVAILABLE
Bluegrass Parkway	1966	Median Accidents, X-Over, Fatalities
Bluegrass Parkway	1967	All Accidents
Bluegrass Parkway	1968	All Accidents
Kentucky Turnpike	1965	Median Accidents, X-Over, Fatalities
Kentucky Turnpike	1966	Median Accidents, X-Over, Fatalities
Kentucky Turnpike	1967	All Accidents
Kentucky Turnpike	1968	All Accidents
Mountain Parkway	1965	Median Accidents, X-Over, Fatalities
Mountain Parkway	1966	Median Accidents, X-Over, Fatalities
Mountain Parkway	1967	All Accidents
Mountain Parkway	1968	All Accidents
West Kentucky Parkway	1965	Median Accidents, X-Over, Fatalities
West Kentucky Parkway	1966	Median Accidents, X-Over, Fatalities
West Kentucky Parkway	1967	All Accidents
West Kentucky Parkway	1968	All Accidents
I 64[a]	1965	Median Accidents, X-Over, Fatalities
I 64[a]	1966	Median Accidents, X-Over, Fatalities
I 64[a]	1967	All Accidents
I 64[a]	1968	All Accidents
I 64[b]	1965	Median Accidents, X-Over, Fatalities
I 64[b]	1966	Median Accidents, X-Over, Fatalities
I 64[b]	1967	All Accidents
I 64[b]	1968	All Accidents
I 65[c]	1965	Median Accidents, X-Over, Fatalities
I 65[c]	1966	Median Accidents, X-Over, Fatalities
I 65[d]	1967	All Accidents
I 65[d]	1968	All Accidents
US 41[e]	1965	Median Accidents, X-Over, Fatalities
US 41[e]	1966	Median Accidents, X-Over, Fatalities
US 41[e]	1967	All Accidents
US 41[e]	1968	All Accidents
I 75[f]	1967	All Accidents
I 75[g]	1968	All Accidents
US 60, Woodford County	1968	All Accidents
US 27, Jessamine County	1968	All Accidents

[a]Montgomery, Clark, and Shelby Counties (all regular median)

[b]Shelby and Franklin Counties (irregular median)

[c]Hardin and Larue Counties

[d]Hardin, Larue, Hart, Warren, and Simpson Counties

[e]Limited Access Section in Hopkins County

[f]Grant County

[g]Madison, Scott, Kenton, Whitley, Grant, Boone and Rockcastle Counties

TABLE 3

SUMMARY OF A-UT AXLE WEIGHTS AND SPACINGS BY ROADWAY

		I 75		I 75 NORTHBOUND		I 75 SOUTHBOUND		I 65		I 65 NORTHBOUND		I 65 SOUTHBOUND		I 64		I 64 EASTBOUND		I 64 WESTBOUND	
		MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
1st AXLE WEIGHT	(lb)	2270	76	2233	465	2303	400	2338	341	2360	339	2325	344	2258	351	2301	94	2224	388
	(kg)	1030	34	1013	211	1045	181	1060	155	1070	154	1055	156	1024	159	1044	43	1009	176
2nd AXLE WEIGHT	(lb)	2697	112	2605	308	2778	337	2771	177	2725	588	2800	499	2579	485	2549	455	2603	515
	(kg)	1223	51	1182	140	1260	153	1251	80	1236	267	1270	226	1169	220	1156	206	1181	234
3rd AXLE WEIGHT	(lb)	1798	164	1871	214	1733	250	1893	352	1730	993	1995	524	1693	894	1742	1165	1654	820
	(kg)	815	74	849	97	786	113	859	160	785	450	905	238	768	406	790	528	750	372
4th AXLE WEIGHT	(lb)	1730	642	2360	781	1507	419	2088	669	2028	867	2112	617	1610	750	1100		1695	783
	(kg)	785	291	1070	354	684	190	947	303	920	393	958	280	730	340	499		769	355
GROSS LOAD	(lb)	6949	222	6856	148	7032	262	7325	314	7041	934	7502	507	6756	824	6643	1571	6845	1573
	(kg)	3152	101	3110	67	3190	119	3323	142	3194	424	3403	230	3064	374	3013	713	3105	714
1st AXLE SPACING	(ft)	9.9	0.6	9.8	0.7	9.9	0.5	10.0	0.6	9.9	0.6	10.0	0.6	10.0	0.5	10.1	0.4	10.0	0.6
	(m)	3.02	.18	2.99	.21	3.02	.15	3.05	.18	3.02	.18	3.05	.18	3.05	.15	3.08	.12	3.05	.18
2nd AXLE SPACING	(ft)	14.4	2.6	14.0	2.4	14.7	2.8	14.3	2.8	14.0	2.7	14.5	2.9	13.9	2.4	13.6	2.3	14.1	2.5
	(m)	4.39	.79	4.27	.73	4.48	.85	4.36	.85	4.27	.82	4.42	.88	4.24	.73	4.15	.70	4.30	.76
3rd AXLE SPACING	(ft)	2.5	0.4	2.4	0.6	2.5	0.4	3.2	1.6	3.1	0.2	3.3	2.0	2.8	0.2	2.8	0.4	2.8	0.1
	(m)	76	.12	.73	.18	.76	.12	.98	.49	.94	.06	1.01	.61	.85	.06	.85	.12	.85	.03
WHEEL BASE	(ft)	24.6	3.2	23.9	3.0	25.1	3.4	24.7	3.5	24.2	3.3	25.1	3.6	24.4	3.1	24.0	2.4	24.7	3.3
	(m)	7.50	.98	7.28	.91	7.65	1.04	7.53	1.07	7.38	1.01	7.65	1.10	7.44	.94	7.32	.73	7.53	1.01

TABLE 4

SUMMARY OF A-UT AXLE WEIGHTS AND SPACINGS BY TRAILER TYPE

		ALL DATA		ONE-AXLE TRAILERS		TWO-AXLE TRAILERS		BOAT TRAILERS		HOUSE TRAILERS		U-HAUL TYPE TRAILERS		MISC. TRAILER TYPES	
		MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
1st AXLE WEIGHT	(lb)	2290	118	2269	98	2417	337	2357	521	2459	407	2194	349	2193	334
	(kg)	1039	54	1029	44	1096	153	1069	236	1115	185	995	158	995	151
2nd AXLE WEIGHT	(lb)	2704	89	2657	136	3014	661	2788	371	2781	336	2538	505	2713	170
	(kg)	1227	40	1205	62	1367	300	1265	168	1261	152	1151	229	1231	77
3rd AXLE WEIGHT	(lb)	1814	117	1791	56	1878	649	1530	704	2906	394	1483	454	1366	298
	(kg)	823	53	812	25	852	294	694	319	1318	179	673	206	620	135
4th AXLE WEIGHT	(lb)	1847	681			1847	681	1483	418	2518	520	1807	647	1756	733
	(kg)	838	309			838	309	673	190	1142	236	820	293	797	362
GROSS LOAD	(lb)	7041	88	6713	123	9156	915	6992	665	8412	456	6453	464	6439	306
	(kg)	3194	40	3045	56	4153	415	3172	302	3816	207	2927	210	2921	139
1st AXLE SPACING	(ft)	9.9	0.6	9.9	0.6	10.3	0.4	10.0	0.9	10.1	0.4	9.8	0.6	9.9	0.5
	(m)	3.02	.18	3.02	.18	3.14	.12	3.05	.27	3.08	.12	2.99	.18	3.02	.15
2nd AXLE SPACING	(ft)	14.3	2.7	14.0	2.4	16.1	3.5	17.1	2.1	15.7	2.4	12.6	1.4	13.0	2.0
	(m)	4.36	.82	4.27	.73	4.91	1.07	5.21	.64	4.79	.73	3.84	.43	3.96	.61
3rd AXLE SPACING	(ft)	2.9	1.1			2.9	1.1	2.3	0.3	2.9	0.1	2.9	0.1	3.3	1.9
	(m)	.88	34			.88	.34	.70	.09	.88	.03	.88	.03	1.01	.58
WHEEL BASE	(ft)	24.6	3.3	23.8	2.6	29.3	3.3	27.7	2.8	26.2	3.1	22.8	2.3	23.3	2.6
	(m)	7.50	1.01	7.25	.79	8.93	1.01	8.44	.85	7.99	.94	6.95	.70	7.10	.79

TABLE 5

DISTRIBUTION OF VEHICLE TYPES

ROAD	PERCENTAGES OF AUTOS	A-UT	CAMPERS	TRUCKS	ADT *
I 75	85.21	4.21	1.32	9.23	22988
I 64	80.90	1.16	0.59	18.53	10586
I 65	77.85	2.80	1.13	18.22	9860
US 27	90.24	1.12	0.72	7.92	9740
US 41	79.43	2.02	1.14	17.41	8510
US 60	86.29	1.26	0.83	11.62	12000
WEIGHTED AVG.	83.59	2.47	1.01	12.93	12281
WEIGHTED AVG. (Four-Lane, Controlled Access)	81.72	3.00	1.11	14.17	12986

*Vehicles per day

TABLE 6

DISTRIBUTION OF VEHICLE TYPES ON I 75 BY HOUR OF DAY

HOUR	PERCENTAGES OF AUTOS	A-UT	CAMPERS	TRUCKS	AVERAGE VOLUME *
Midnight					
12-1	73.72	2.26	1.60	22.02	418
1-2	72.96	3.03	1.65	22.36	364
2-3	71.87	2.90	1.54	23.69	315
3-4	75.97	2.80	0.98	20.25	424
4-5	76.19	2.99	1.29	19.53	320
5-6	83.36	3.26	0.94	12.44	561
6-7	82.75	3.62	1.27	12.36	631
7-8	85.22	3.64	1.24	9.90	785
8-9	85.77	4.19	1.22	8.82	1043
9-10	86.59	4.70	0.98	7.73	1334
10-11	87.37	4.99	0.99	6.65	1481
11-12	87.12	4.95	1.22	6.71	1528
Noon					
12-1	87.64	4.68	1.12	6.56	1526
1-2	87.29	4.89	1.27	6.55	1517
2-3	87.91	4.86	1.33	5.90	1583
3-4	87.19	4.59	2.13	6.09	1639
4-5	88.10	3.93	1.44	6.53	1513
5-6	88.09	4.19	1.28	6.44	1316
6-7	87.11	3.87	1.46	7.56	1186
7-8	84.94	4.07	1.47	9.52	951
8-9	81.93	5.35	1.16	11.56	824
9-10	83.18	3.34	1.30	12.18	693
10-11	80.23	2.92	1.41	15.44	557
11-12	78.69	3.14	1.26	16.91	411
Midnight					

*Vehicles per hour

TABLE 7

DISTRIBUTION OF VEHICLE TYPES ON I 75 BY DAY OF WEEK

DAY	PERCENTAGES OF AUTOS	A-UT	CAMPERS	TRUCKS	VOLUME *
Sunday	90.21	3.98	1.20	4.61	32080
Monday	84.99	4.23	1.26	9.52	20878
Tuesday	81.99	3.57	1.14	13.30	17589
Wednesday	79.33	4.35	1.13	15.19	16842
Thursday	80.60	4.24	1.56	13.60	18369
Friday	85.34	4.18	1.20	9.28	24589
Saturday	87.92	4.87	1.64	5.57	39569

*Vehicles per day

TABLE 8

VEHICLES WITH TRAILER HITCHES

ROAD	PERCENT OF VEHICLES WITH TRAILER HITCH
US 41	9.68
US 27	11.31
I 65	8.16
I 64	7.22

Mean 9.09
Standard Deviation = 1.79

TABLE 9

A-UT TRAFFIC IN SHOULDER LANE BY HOUR

HOUR	PERCENT	HOUR	PERCENT
0-1	94.87	12-13	87.80
1-2	98.70	13-14	89.21
2-3	93.75	14-15	86.99
3-4	96.39	15-16	86.53
4-5	100.00	16-17	85.58
5-6	95.31	17-18	88.60
6-7	93.12	18-19	85.67
7-8	84.50	19-20	87.82
8-9	92.81	20-21	84.47
9-10	87.47	21-22	89.51
10-11	88.20	22-23	93.86
11-12	89.22	23-24	91.43

Mean = 90.49

Standard Deviation = 4.44

Largest deviation from mean is not significantly large.

TABLE 10

A-UT TRAFFIC IN SHOULDER LANE BY DAY

DAY	PERCENT
Sunday	87.39
Monday	90.93
Tuesday	91.08
Wednesday	86.90
Thursday	88.45
Friday	86.37
Saturday	89.66

Mean = 88.68

Standard Deviation = 1.91

T test indicates Monday, Tuesday, Wednesday, and Friday have significantly different percentages.

TABLE 11

TRAILER TYPE PERCENTAGES

TRAILER TYPE	ITEM	ONE-AXLE	TWO-AXLE	THREE-AXLE	SUMMATION
House	Mean	11.59	4.28	0.14	16.01
	Std Dev	6.04	3.60	0.40	8.80
Boat	Mean	17.54	2.31	0.00	19.85
	Std Dev	12.62	3.30	0.00	15.54
U-Haul	Mean	14.57	4.25	0.00	18.82
	Std Dev	8.42	4.95	0.00	11.82
Camper	Mean	23.89	0.59	0.53	25.00
	Std Dev	15.00	0.98	1.03	13.07
Other	Mean	13.01	7.05	0.26	20.32
	Std Dev	6.06	4.00	0.73	9.25
Summation	Mean	80.60	18.47	0.93	100.00
	Std Dev	8.28	7.99	1.43	

TABLE 12

HOURLY DISTRIBUTION OF A-UT TRAFFIC

HOUR	PERCENT OF TOTAL	HOUR	PERCENT OF TOTAL
Midnight-1	1.14	Noon-1	7.36
1-2	1.13	1-2	7.61
2-3	.94	2-3	7.88
3-4	1.22	3-4	7.73
4-5	.98	4-5	6.10
5-6	1.88	5-6	5.66
6-7	2.35	6-7	4.71
7-8	2.93	7-8	3.98
8-9	4.49	8-9	4.53
9-10	6.44	9-10	2.38
10-11	7.59	10-11	1.67
11-12	7.76	11-12	1.54

TABLE 13

DAILY DISTRIBUTION OF A-UT TRAFFIC

DAY	PERCENT OF TOTAL
Sunday	18.74
Monday	12.94
Tuesday	9.21
Wednesday	10.75
Thursday	11.43
Friday	15.07
Saturday	21.86

TABLE 14

MONTHLY DISTRIBUTION OF A-UT TRAFFIC

MONTH	PERCENT OF TOTAL
January	3.08
February	3.18
March	4.87
April	8.52
May	7.76
June	14.39
July	17.74
August	16.76
September	8.43
October	6.69
November	4.50
December	4.08

TABLE 15

SUMMARY OF VEHICULAR SPEEDS

ROAD	VEHICLE TYPE	85TH PERCENTILE SPEED (mph)	85TH PERCENTILE SPEED (m/s)	50TH PERCENTILE SPEED (mph)	50TH PERCENTILE SPEED (m/s)	15TH PERCENTILE SPEED (mph)	15TH PERCENTILE SPEED (m/s)
US 27	Autos	56	25.0	48	21.5	42	18.8
	Trucks	50	22.4	43	19.2	34	15.2
	A-UT's	49	21.9	43	19.2	38	17.0
US 60	Autos	65	29.1	59	26.4	53	23.7
	Trucks	60	26.8	54	24.1	47	21.0
	A-UT's	60	26.8	54	24.1	44	19.7
US 41	Autos	69	30.8	63	28.2	56	25.0
	Trucks	64	28.6	58	25.9	52	23.2
	A-UT's	61	27.3	57	25.5	44	19.7
I 65	Autos	70	31.3	64	28.6	58	25.9
	Trucks	63	28.2	59	26.4	54	24.1
	A-UT's	65	29.1	56	25.0	50	22.4
I 64	Autos	70	31.3	65	29.1	59	26.4
	Trucks	65	29.1	60	26.8	54	24.1
	A-UT's	64	28.6	58	25.9	54	24.1
I 75	Autos	72	32.2	66	29.5	61	27.3
	Trucks	62	27.7	58	25.9	52	23.2
	A-UT's	65	29.1	58	25.9	52	23.2

TABLE 16

SPOT SPEEDS AND RATIOS*

ROAD	VEHICLE	SPOT SPEEDS AT SELECTED PERCENTILES 10 (mph)	10 (m/s)	30 (mph)	30 (m/s)	50 (mph)	50 (m/s)	70 (mph)	70 (m/s)	90 (mph)	90 (m/s)	MEAN
US 27	Autos	41	18.3	44	19.7	48	21.5	52	23.3	57	25.5	
	Trucks	33	14.8	39	17.4	43	19.2	45	20.1	51	22.8	
	A-UT's	33	14.8	41	18.3	43	19.2	45	20.1	50	22.3	
	Ratio	1.00		.95		1.00		1.00		1.02		.99
US 41	Autos	54	24.1	59	26.4	63	28.2	66	29.5	71	31.7	
	Trucks	52	23.2	55	24.6	58	25.9	60	26.8	65	29.1	
	A-UT's	41	18.3	52	23.2	57	25.5	59	26.4	63	28.2	
	Ratio	1.27		1.08		1.02		1.02		1.03		1.08
US 60	Autos	51	22.8	57	25.5	59	26.4	64	28.6	66	29.5	
	Trucks	45	20.1	51	22.8	55	24.6	58	25.9	60	26.8	
	A-UT's	43	19.2	50	22.4	53	23.7	56	25.0	64	28.6	
	Ratio	1.05		1.02		1.04		1.04		.94		1.02
I 65	Autos	56	25.0	61	27.3	64	28.6	67	30.0	71	31.7	
	Trucks	53	23.7	56	25.0	59	26.4	61	27.3	64	28.6	
	A-UT's	49	21.9	53	23.7	55	24.6	60	26.8	65	29.1	
	Ratio	1.08		1.06		1.07		1.02		.98		1.04
I 75	Autos	59	26.4	64	28.6	66	29.5	69	30.8	73	32.6	
	Trucks	50	22.4	55	24.6	58	25.9	60	26.8	64	28.6	
	A-UT's	50	22.4	55	24.6	58	25.9	61	27.3	66	29.5	
	Ratio	1.00		1.00		1.00		.98		.97		.99
I 64	Autos	58	25.9	62	27.7	65	29.1	66	29.5	71	31.7	
	Trucks	53	23.7	58	25.9	60	26.8	63	28.2	65	29.1	
	A-UT's	54	24.1	56	25.0	58	25.9	60	26.8	65	29.1	
	Ratio	.98		1.04		1.03		1.05		1.00		1.02

*Ratio of Truck Spot Speed to A-UT Spot Speed

LIST OF FIGURES

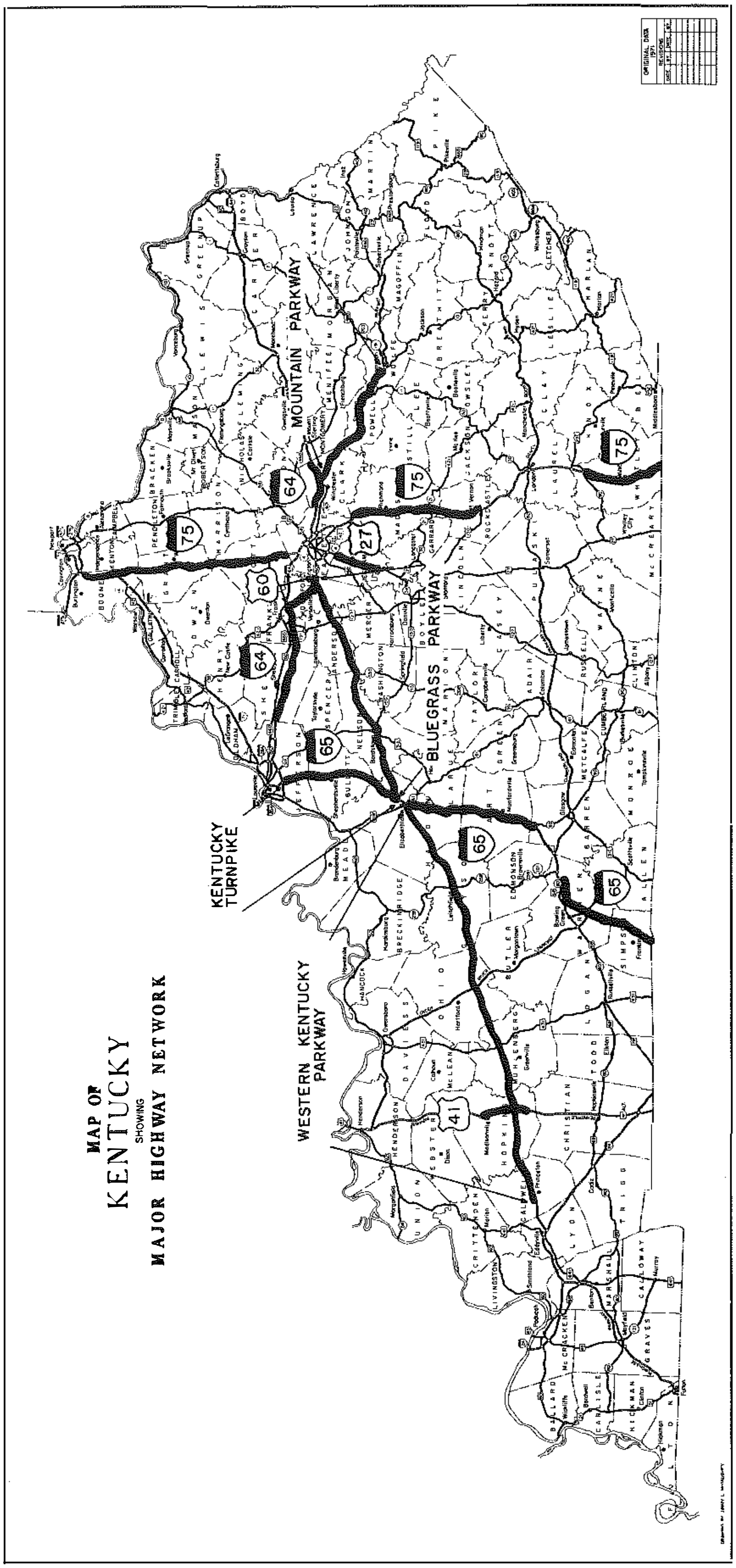

Figure 1. Geographical Distribution of Roadways Investigated.

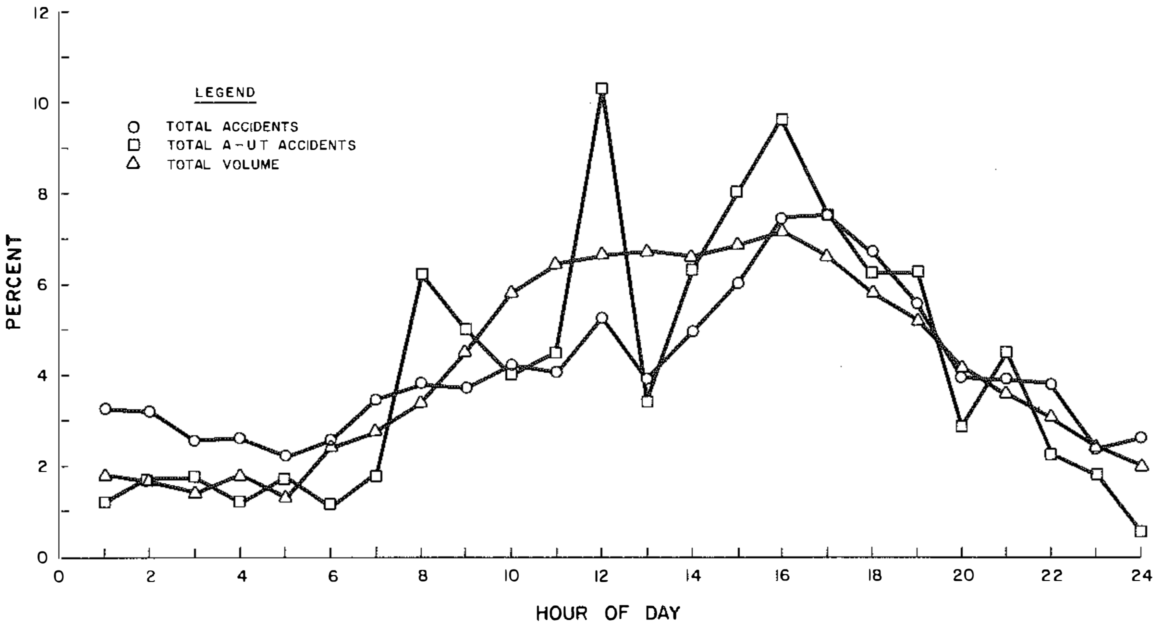

Figure 2. Accident and Volume Distributions by Hour of Day for I 75 (Scott County).

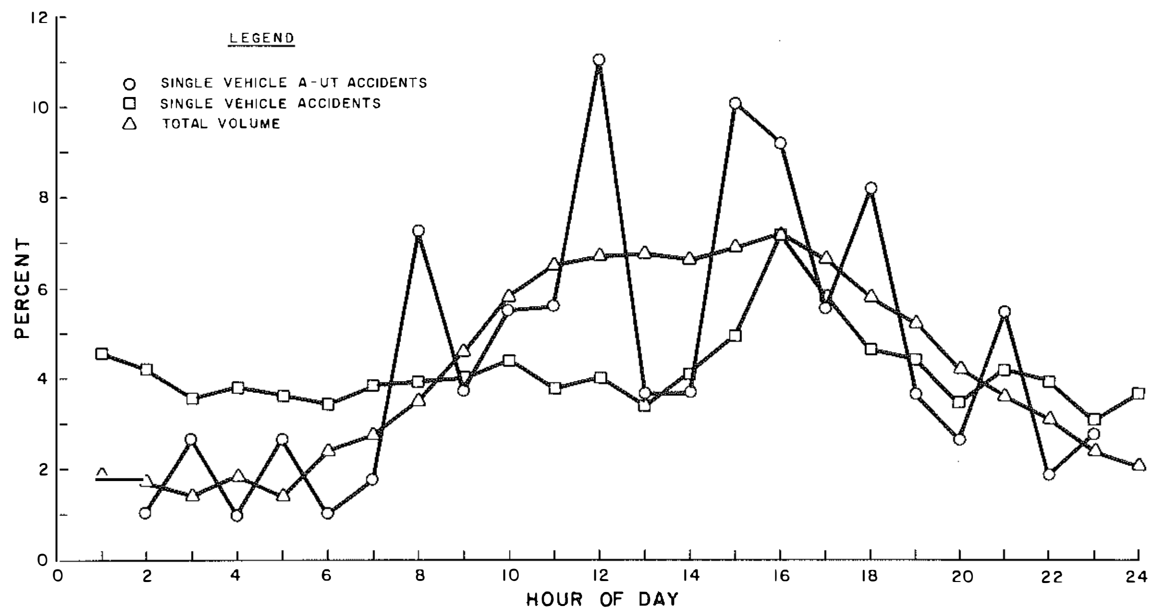

Figure 3. Accident and Volume Distributions by Hour of Day for I 75 (Scott County).

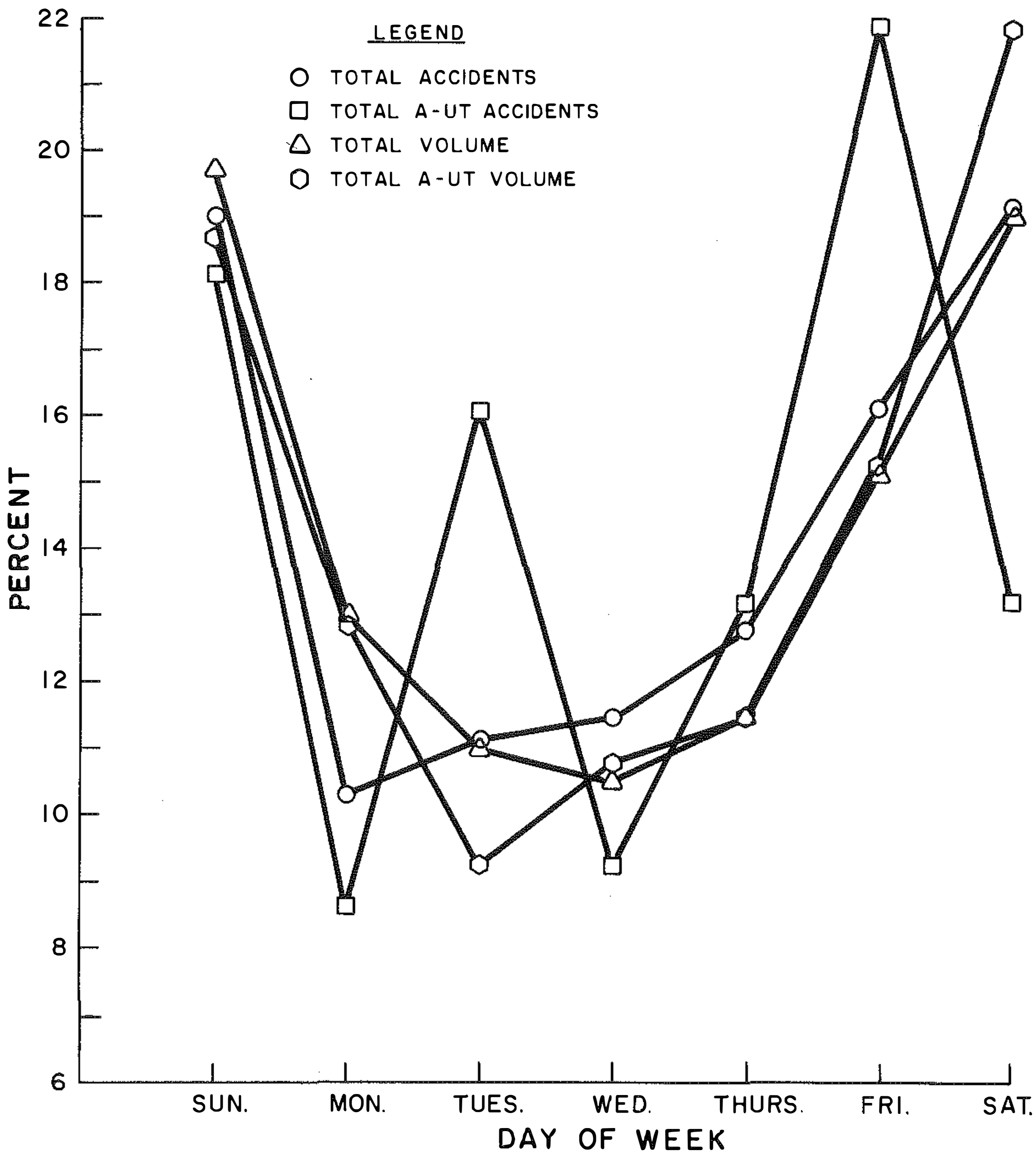

Figure 4. **Accident and Volume Distributions by Day of Week for I 75 (Scott County).**

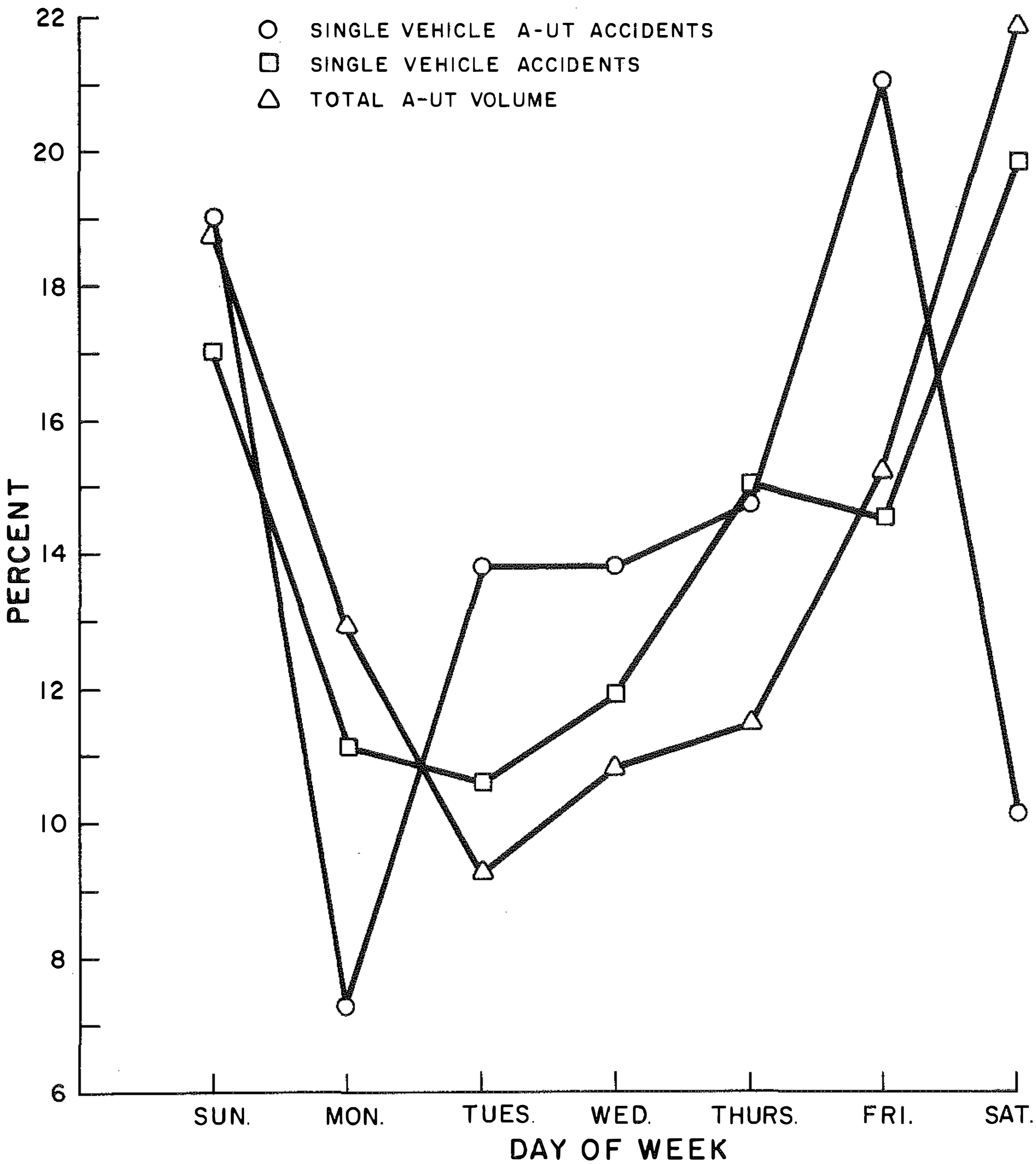

Figure 5. Accident and Volume Distributions by Day of Week for I 75 (Scott County).

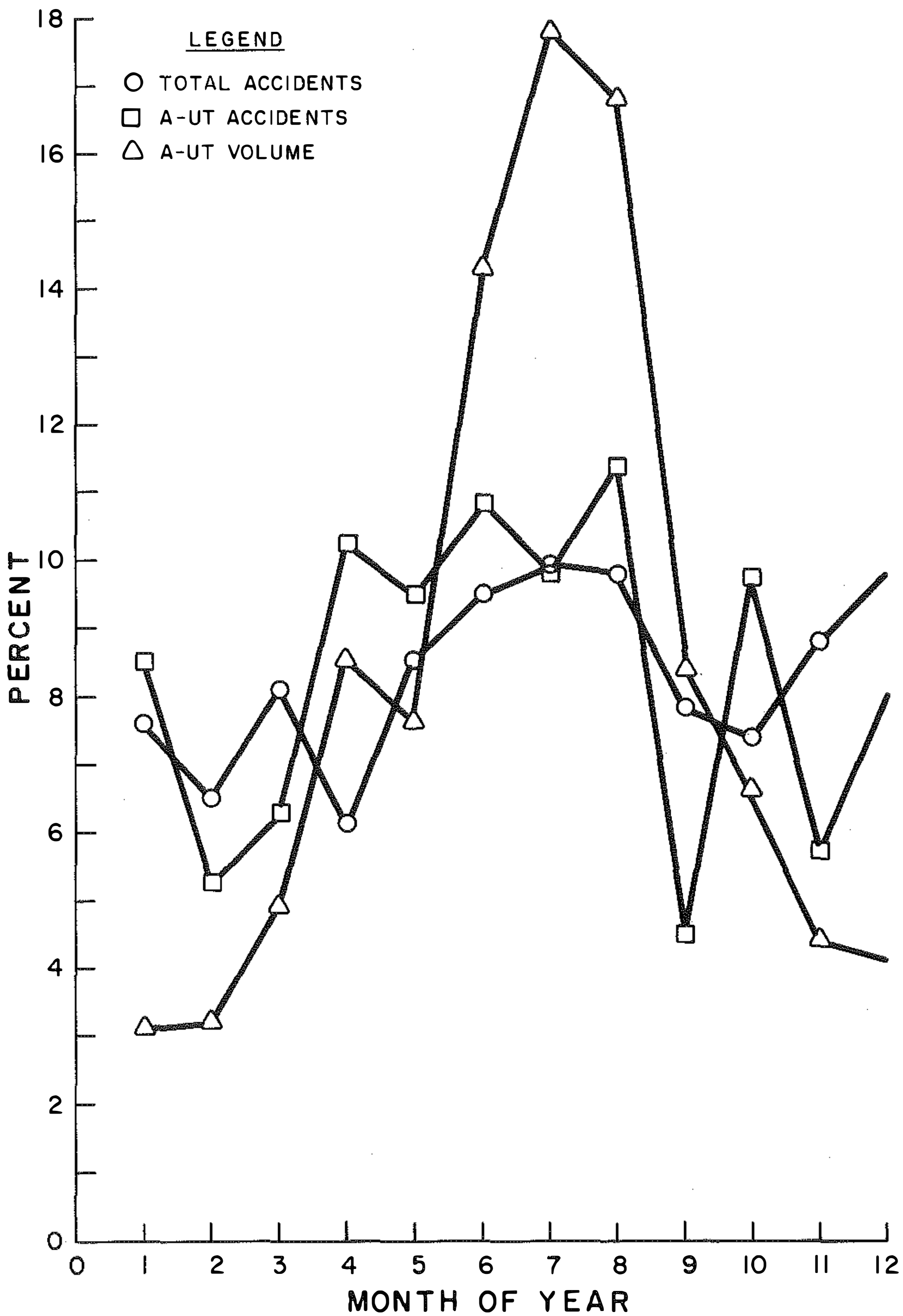

Figure 6. **Accident and Volume Distributions by Month of Year for I 75 (Scott County).**

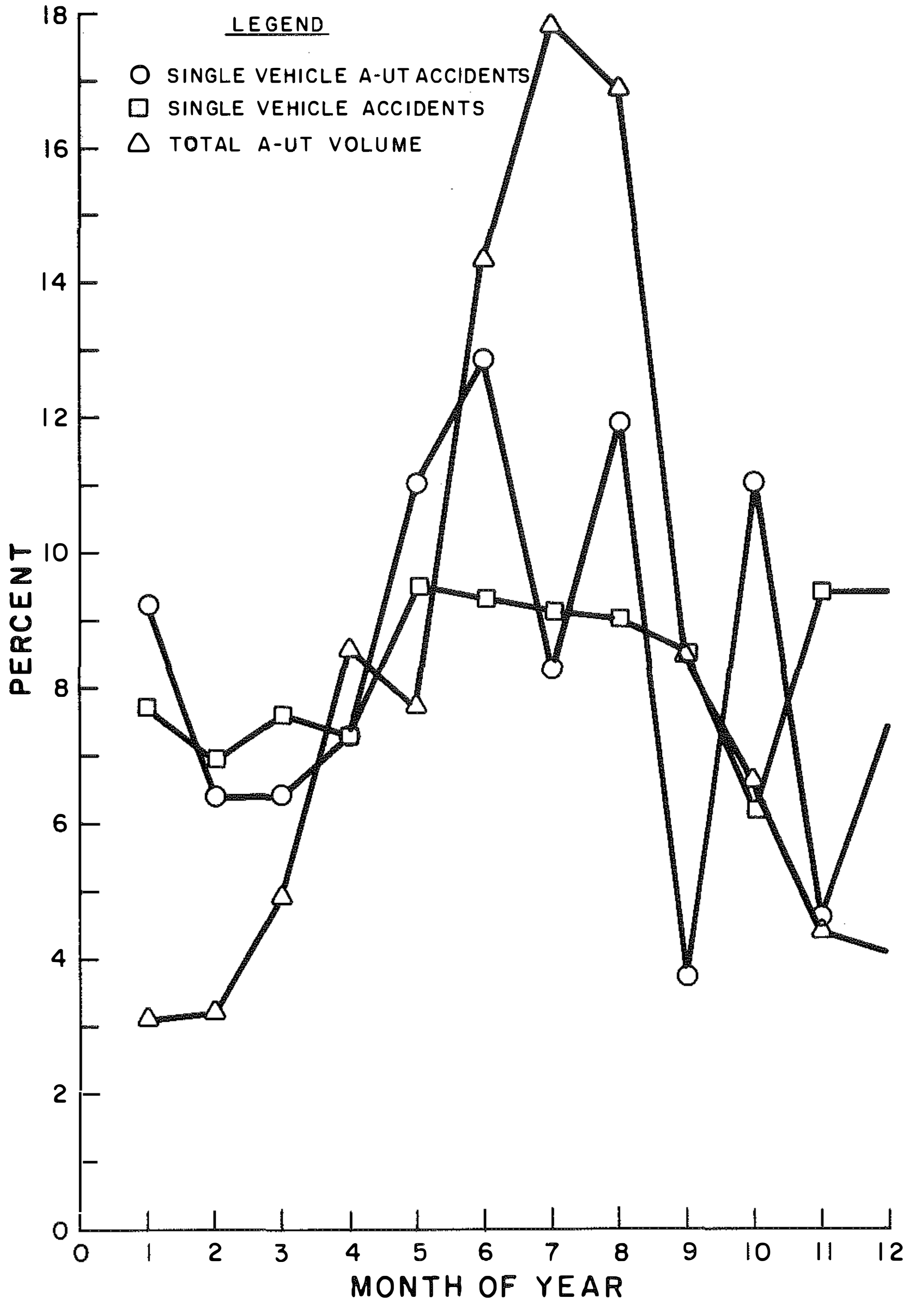

Figure 7. Accident and Volume Distributions by Month of Year for I 75 (Scott County).

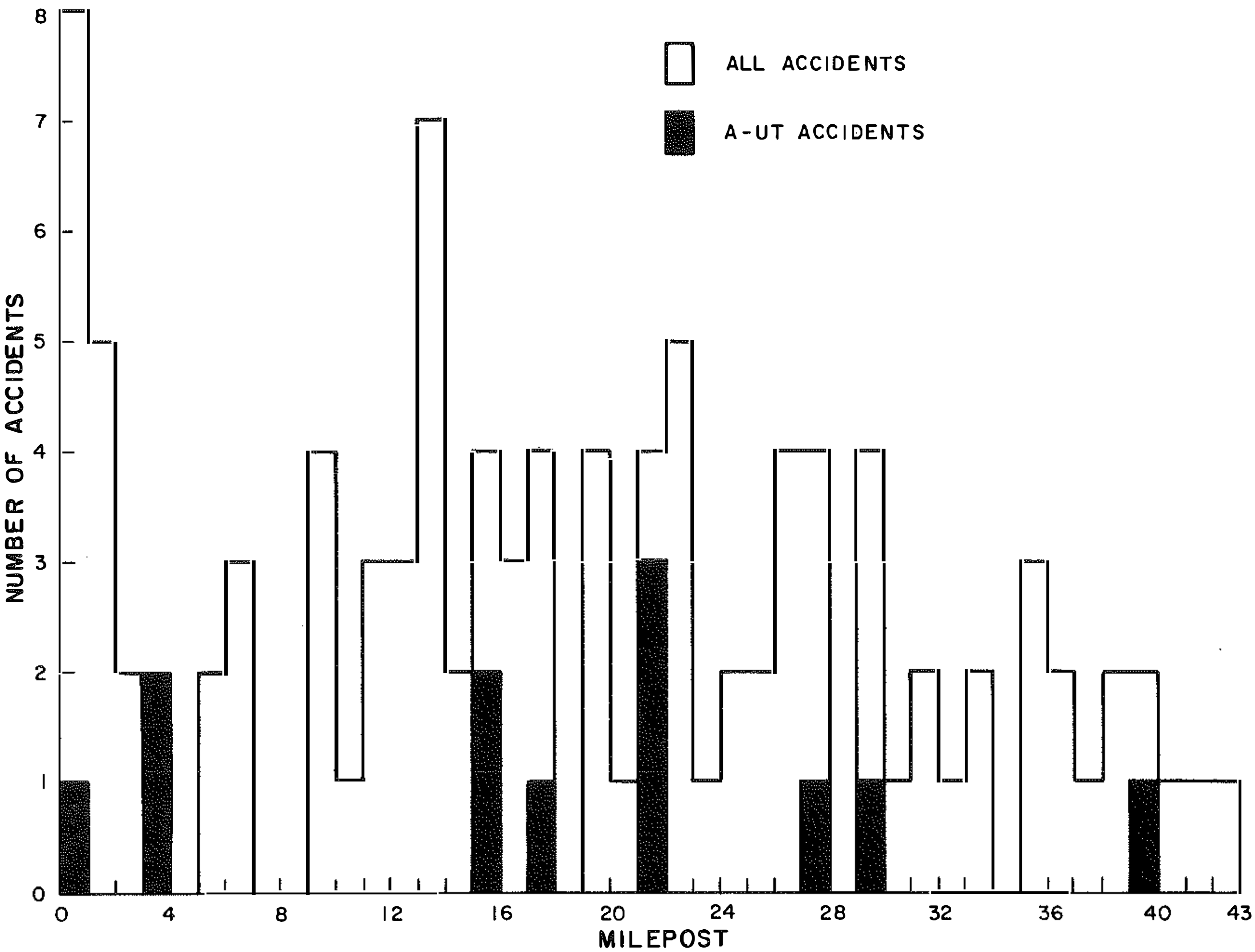

Figure 8. Spatial Distribution of Accidents on the Bluegrass Parkway.

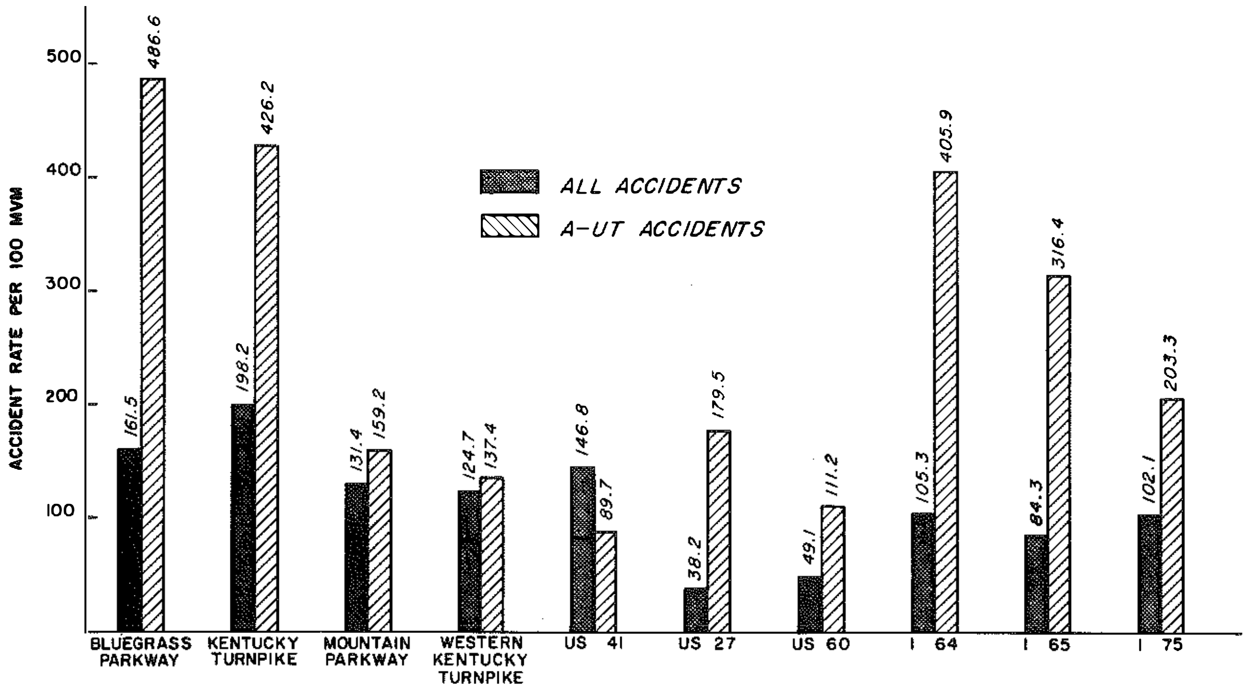

Figure 9. Summary of Accident Rates.

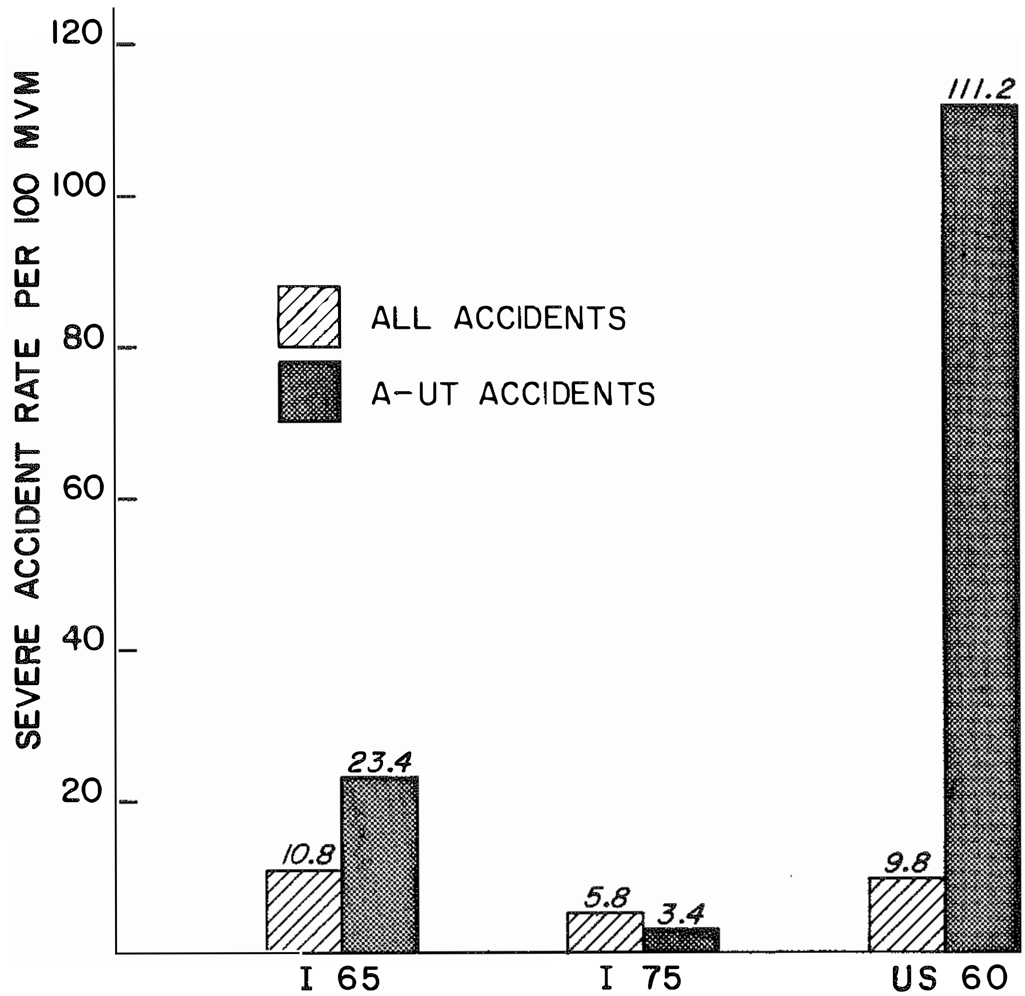

Figure 10. Summary of Severe Accident Rates.