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COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

MARTHA LAYNE COLLINS
GOVERNOR

March 11, 1987

Robert E. Johnson, P. E.
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40601

SUBJECT: Implementation Statement
Research Study KYHPR 85-108, Subtask 4, "Sampling Techniques for the Collection of Vehicle Classification Data"
Research Study KYHPR 86-112, "Sampling of Vehicle Classification Data"

Dear Mr. Johnson:

Results from this study will be used to support the current sampling procedures for the collection of vehicle classification data. Because of the limitations of analyzing data from only two toll stations for one year, it cannot be recommended that time periods shorter than the current 16-hour period be used for classification data collection. Historically, vehicle classification data collection has been concentrated on weekdays in the spring, summer, and fall. It is anticipated that this practice will continue until the use of automatic classification equipment becomes more widespread.

Very truly yours,

R. K. Capito, P. E.
State Highway Engineer

Technical Report Documentation Page

1. Report No. UKTRP-85-17	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Sampling Techniques for the Collection of Vehicle Classification Data		5. Report Date June 1985
		6. Performing Organization Code
7. Author(s) J. G. Pigman		8. Performing Organization Report No. UKTRP-85-17
9. Performing Organization Name and Address Kentucky Transportation Research Program College of Engineering University of Kentucky Lexington, Kentucky 40506-0043		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. KYHPR-85-108-4
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building Frankfort, Kentucky 40622		13. Type of Report and Period Covered Final
		14. Sponsoring Agency Code

15. Supplementary Notes
Study Title: Quick Response Studies
Prepared in cooperation with the Federal Highway Administration

16. Abstract

The question of what length of time is necessary to collect statistically reliable vehicle classification data is an important issue when manpower is limited. Varying local conditions may necessitate more classification data be collected at some locations than others. The use of short-term counts could produce significant savings. Supplementing manual counts with automatic classification equipment could reduce data collection costs and improve accuracy.

The objectives of this study were to review literature to determine the capabilities of automatic classfication equipment and to analyze toll road data in Kentucky to determine if short time periods may be used to represent the annual distribution of vehicle types.

Automatic classification equipment has been evaluated by others and there are systems available that can classify vehicles according to number of axles and wheelbase. Emphasis is being placed on the development of a more reliable and permanent axle counter by several companies.

Results from the analysis of vehicle classification data at two parkway toll stations indicate that specific 8-hour periods within the year are representative of the annual distribution of vehicle types. It was recommended that data collection efforts be concentrated on weekdays between 7:00 a.m. and 11:00 p.m. during all seasons of the year. Limitations were noted because the analysis included data from only two toll stations.

17. Key Words Vehicle classification, Sampling, Automatic classifications, Short-term counting		18. Distribution Statement Unlimited with Kentucky Transportation Cabinet approval	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 24	22. Price

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

Research Report
UKTRP-85-17

SAMPLING TECHNIQUES FOR THE COLLECTION OF VEHICLE CLASSIFICATION DATA

by

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Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

June 1985

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INTRODUCTION

The question of what length of time is necessary to collect statistically reliable vehicle classification data is an important issue when manpower is limited. Traditionally, it has been assumed that as much data as reasonably possible should be collected for all types of highway locations where classification data are required. Varying local conditions may necessitate more classification data be collected at some locations than others. Emphasis should be placed on stratification of local conditions (highway type, geographic area, volume group, etc.) such that statewide representation is obtained.

The capability of obtaining statistically reliable classification data by means of short-term counts could produce significant savings in terms of reduced manpower requirements. Supplementing manual counts with automatic classification equipment also could reduce data collection costs and possibly improve accuracy. Automatic classification equipment may be examined to determine if any type is sufficiently reliable to be used for supplementing manual classification data collection. These issues should be addressed as a means of obtaining more accurate and cost-effective vehicle classification data collection procedures.

VEHICLE CLASSIFICATION SAMPLING

Considerable work has been performed in the area of traffic volume sampling; however, very little has been done concerning vehicle classification sampling. In studies dealing with classification sampling, it is a common assumption that 24-hour surveys taken during each season of the year are representative of the full year of classification data.

A study was performed by the State Highway Department of Georgia in 1971 in an attempt to determine a sampling procedure that could be used to obtain manual classification counts with less total effort, but with an acceptable degree of accuracy (1). Loadometer data collected during four 24-hour periods were the source of data assumed to be representative of the full year. Sampling periods of 8 or 9 hours were compared to 24-hour totals. In neither case were the sampled hours consecutive, but were generally spread throughout the 24-hour period. Therefore, observers would still be required to be at a site for the entire 24-hour period. It was determined that a significant reduction in total sampling hours could be achieved by selecting periods that were representative of 24-hour totals. However, it was concluded that if a significant error occurred on just one project, then construction or maintenance costs due to over- or underdesign could quickly eliminate potential savings.

A study was performed by the Utah Department of Highways in 1974 to compare results from a 7-hour classification counting period (11:00 a.m. to 6:00 p.m.) to a 24-hour counting period (2). The 7-hour period was selected because analysis had shown that the degree of accuracy during that time period was not materially different from a 24-hour classification period. Types of vehicles included in the analysis were passenger cars, light trucks, heavy trucks, and light trailers. Results for 16 loadometer stations were analyzed, and the differences between vehicle classifications for a 7-hour period as compared to a 24-hour period were determined to be within an acceptable level of accuracy.

Hupp and Palombo reported that the Federal Highway Administration's Guide for Estimating Urban Vehicle Classification and Occupancy was an excellent how-to manual for vehicle classification studies (3). They found that the largest contribution of the guide was the short-count sampling approach which resulted in significant survey cost savings with no loss of accuracy. Sampling sites were stratified by functional class, area type, and volume group. Sample size was a function of the tolerance and level of confidence desired in the sample estimate and the variation in the parameter being estimated. It was suggested that short-count, data-collection techniques in 15-minute periods could be used to replace continuous counts throughout the hour. An example presented was the use of a single surveyor to cover one direction of travel of a six-lane freeway by collecting data for 15-minute periods from each of three lanes in one direction rather than having each of six lanes be surveyed throughout the hour.

A report prepared by the Colorado Department of Highways in 1984 outlined a traffic information inventory plan that would allow them to collect more data at a higher level of accuracy (4). The data collection effort was estimated to be reduced by approximately $200,000 per year when the program was fully implemented. A significant one-time cost for equipment purchase and loop installations would be incurred. The result would be an automated data collection procedure that would provide full area and system coverage of traffic volumes, vehicle and axle weights, vehicle classification, and vehicle speeds.

A detailed report on development of statewide traffic counting programs was prepared by Peat, Marwick, Mitchell, and Company in 1984 under contract with the Federal Highway Administration (5). The report included procedures for determining the number of vehicle classification stations and amount of data necessary to provide specified levels of precision. Considerable dependence was placed on use of FHWA's Highway Performance Monitoring System (HPMS) as the base from which sample locations should be selected. It was recommended that the sample locations be stratified by functional class and consider stratification into volume groups, area type, or other characteristics should conditions in an individual state warrant. To determine sample size for classification data, the user is required to specify a precision level and input data into an equation based on statistical sampling procedures. This sampling procedure musts be repeated for each vehicle classification sampling stratum. Sample locations may be chosed from the HPMS sample sections by either random sampling or sampling proportional to vehicle miles traveled. An additional recommendation was that vehicle classification counts be taken every three years on the same cycle used for volume counts. It was recommended that samples be taken in each season of the year, if possible. Seasonal variations could be accounted for by using Automatic Traffic Recorder Stations or by special vehicle classification studies.

The Peat, Marwick, Mitchell, and Company report also suggests that vehicle classification data be collected for 24 hours when automatic equipment is used and 16 hours when a manual count is being made with a 24-hour volume count. HPMS data from Arkansas, Iowa, Minnesota, Washington, and the city of Philadelphia showed considerable change in the traffic composition of night hours versus day hours. However, it was noted that the total volume of vehicles in night hours was usually so small compared to total daily volume that the increased percentage of night truck travel does not significantly affect percentages derived from 16-hour classification data. It was concluded that the increased precision in most locations resulting from night counts was too small to justify the cost of eight additional hours of manual counts.

A FHWA report titled "Traffic Monitoring Guide" was prepared in July 1984 and included recommendations for vehicle classification data collection (6). Many of the concepts in the Peat, Marwick, Mitchell and Company report (5) were adopted and expanded within FHWA's recommendations. In general, FHWA's recommendations for classification data collection included the following:

a) Classification counts should be taken over a three-year cycle at 300 to 420 locations, depending upon the number of urbanized areas within a state.
b) The monitoring period should be a minimum of 48 hours; however, 24-hour periods could be used until automatic classification equipment is available.
c) Classification counts should be made during each season to eliminate the need for factoring.

It was noted that a detailed discussion of the sample design for vehicle classification was not included in the report, but would be issued in 1985.

AUTOMATIC CLASSIFICATION EQUIPMENT

TYPES OF EQUIPMENT

Automatic classification equipment is generally of two types: 1) axle classifier and 2) length classifier. There are four basic components of vehicle classification equipment: 1) sensing devices, which provide an indication of a vehicle's presence; 2) detectors, which are the signal receiving unit; 3) recorders, which print or store the information received; and 4) processors, which manipulate data into various categories or perform calculations.

Axle Classifiers

Axle classifiers usually involve a pneumatic tube as the sensing device. Coaxial cables have been tested as sensing devices, but they are not in common use. The axle-sensing classifiers are the type of equipment most acceptable to state DOT's, because they classify vehicles in a manner similar to the manual counts currently taken. Some problems associated with axle classifiers are the inability to classify vehicles in slow-moving traffic and the ability to classify only one lane of traffic with each classifier. The problem of being able to collect data in only one lane is associated with the use of the pneumatic tube. Units using other types of axle sensing devices may count multiple lanes.

A study performed at the Maine Facility Laboratory evaluated automatic vehicle classifiers and determined that using road tubes as sensing devices resulted in a high degree of error (7). The Maine study determined that the pneumatic tube systems tended to misclassify vehicles having more than three axles. The error rate was between 10 and 20 percent and typically was due to underestimating the length or undercounting the number of axles.

The Maine study evaluated several types of automatic vehicle classifiers. One rated considerably higher than any other classifier was the axle-sensing device designed by the Transportation Road Research Laboratory (TRRL) in the United Kingdom. A 98.3 percent accuracy level was achieved with the TRRL vehicle classification equipment during the study.

Another system, not available for the Maine tests, is manufactured in Canada by IRD-CMI Dearborn. This system has 12 pressure sensors permanently placed in the pavement to detect axles and it has the capability of collecting data from multiple lanes. Recent advancements have permitted placing sensors into prepared pits in the pavement such that they can be used on a temporary basis and then replaced with a filler unit.

Other systems evaluated in the Maine study included units manufactured by Golden River, Streeter-Amet, Leupold and Stevens, Safetran Traffic Systems, Radian, and Redland Automation (Sarasota).

Lyles and Wyman, who were subcontractors on the Maine Facility Laboratory testing of classification equipment, noted the shortcomings of presently available equipment and recommended several areas for improvements (8). One of the more important recommendations was for development of a longer-lived axle sensor. They suggested that some derivation of the coaxial cable would be the most likely candidate and interfacing coaxial cables with existing systems would be a desirable feature. It was recommended that a standardized classification scheme be developed for use by the states and by FHWA. They also acknowledged that the system developed by the Transport and Road Research Laboratory met many of the desirable requirements and that development of the necessary hardware for accurate and practical equipment was within the capabilities of most manufacturers.

Length Classifiers

Classifiers using length to determine the type of vehicle rely on inductance loops. Length data gathered from loops cannot be used to determine number of axles and therefore cannot be used to classify vehicles into categories recommended by FHWA. Tests at the Maine

Facility showed that length classifiers using loops produced more accurate results than axle-sensing devices.

APPLICABILITY OF EQUIPMENT

Testing and evaluation of automatic classification equipment are underway by several states and other agencies. A thorough review of available equipment was performed as part of the Maine Facility study (7). Automatic classification equipment is presently being evaluated in New York and Florida and many other states are in the preliminary stages of evaluation.

Results from an evaluation of classification data reliability by Davies and Salter suggest that the accuracy of automatic equipment is presently a problem (9). However, the level of accuracy associated with automatic equipment was found to be more acceptable when evaluation of manually-collected data revealed similar inaccuracies. It was noted that manual counting may be a tedious process, which requires extended concentration that may not be an attribute of the type of employee typically assigned the task. Even where counts are properly conducted and well supervised, there is still considerable room for error and unreliable results.

Potential errors associated with manual classification counts and the labor-intensive efforts associated with the tasks indicate that more serious consideration should be given to automatic vehicle classification equipment. It does appear, that in order to classify into the vehicle-type categories specified by FHWA, axle-sensing classifier units rather than length classifiers will be required.

As a follow-up to the work performed at the Maine Facility Laboratory in 1982, another study was sponsored by the Federal Highway Administration to assess the capability of existing equipment to classify according to "Scheme F" (10). This scheme for classifying vehicles has been recommended by the Federal Highway Administration and is designed to include number of axles and wheelbase length as a means of classifying vehicles into 14 categories. "Scheme F" was evaluated and found to be workable as a classification scheme at more than 90 percent classification accuracy. Four systems are available and programmable to classify vehicles to the FHWA "Scheme F." Those systems evaluated included one that operates with inductance loops and magnetic axle counter (IRD-CMI Dearborn), one that operates with inductance loops and a pad-type axle counter (Golden River), and two that operate with pneumatic tubes (Streeter-Amet and G. K. Instrument). A fifth system (Sarasota) was tested, but it had only the capability to measure vehicle length. Included as an Appendix is a summary of available equipment that was presented in the Maine report (10) dated January 1985. The primary recommendation in that report was that emphasis should be placed on development of a low cost, permanent axle counter.

TOLL FACILITIES CLASSIFICATION DATA

At the present time, classification data are collected on an annual basis at all toll stations on the parkways in Kentucky. During Fiscal Year 1983-84, there were 28 stations in operation. Classification data are collected for the purpose of documenting the types of vehicles and revenue collected at each toll station. Because parkways are the only roads in Kentucky where annual classification data are available, they were selected for detailed analysis to determine whether short time periods may be used to represent the annual distribution of vehicle types.

ANALYSIS OF DATA

As a means of determining whether classification data collected over short time periods may be used to accurately represent the annual distribution of vehicle types, a sample of classification data from two toll stations was analyzed. The toll station at Lawrenceburg on the Bluegrass Parkway was selected to represent a location having a high volume of automobile traffic. The toll station at Slade on the Mountain Parkway was selected to represent a location having a high volume of trucks. However, further analysis of annual totals showed the two locations had similar percentages of automobiles and trucks.

Annual classification data for the Slade and Lawrenceburg toll stations were obtained from the Transportation Cabinet's Division of Toll Facilities for the period January 1, 1984, through December 30, 1984 (this included 366 days because it was a leap year). The sample period for comparing with the base period was restricted because data from Toll Facilities were only available in the form of totals for 8-hour shifts at each toll station. The three 8-hour shifts were as follows:

Shift 1 -- 7:00 a.m. to 3:00 p.m.,
Shift 2 -- 3:00 p.m. to 11:00 p.m., and
Shift 3 -- 11:00 p.m. to 7:00 a.m.

Data collected by the Division of Toll Facilities are classified into eight vehicle types based on the number of axles. Because some of the vehicle types represent a very small percentage of the traffic stream, it was determined that a useful analysis could be made by including only two-axle, four-tire vehicles and five-axle vehicles. The two-axle, four-tire vehicles and five-axle vehicles made up 80.99 and 7.51 percent, respectively, of the total at Slade for the data analyzed during Calendar Year 1984. Similarly, the two-axle, four-tire vehicles and five-axle vehicles made up 79.54 and 8.74 percent, respectively, at Lawrenceburg. These two vehicle types represented approximately 88 percent of the total traffic at each of the toll stations. Percentages of these two vehicle types at both toll stations for 1984 are shown in Table 1.

RESULTS

As noted previously, data were only available for 8-hour periods; therefore, the objective of determining short time periods representative of annual distributions was restricted to some multiple of eight hours for comparison with annual percentages. The first effort was directed at analyzing 8-hour periods for the entire year with secondary analysis of selected time periods within the year. For example, the average percentage of passenger cars at the Lawrenceburg toll station was found to be 79.54 percent for all 8-hour shifts during the year. All data entries representing each of the three shifts during the year were analyzed and it was found that the Shift 1 mean value of 80.70 percent was closer to the annual percentage of 79.54 percent. Similar, analysis was made for all shifts on weekdays and weekends. The results indicated Shift 2 on weekdays and Shift 3 on weekends, on the average, represented the annual distribution of passenger cars most accurately. The results of these analyses for passenger cars and other 4-tire vehicles are presented in Table 2. Other analyses were performed for 5-axle vehicles passing through the Lawrenceburg toll station and these results are presented in Table 3. The data indicate that Shift 1 was most representative of the annual distribution of 5-axle trucks when compared to all data entries for each of the three shifts and also when compared to weekday shifts. Shift 3 was nearest to the annual average on weekends.

Similar analyses using the Slade toll station data showed the annual average of passenger cars and other 4-tire vehicles was 80.99 percent (Table 4). When mean values for all data entries representing each of the three shifts were computed, the mean value nearest to the annual average was for Shift 1. Again it was found that Shift 1 was nearest the annual average when only weekdays were compared. During weekends at the Slade toll station, Shift 3 was found to be nearest the annual average.

The annual distribution of 5-axle trucks at Slade was a mean value of 7.51 percent for all time periods during the year. The pattern of distribution for 5-axle trucks was similar to that for passenger cars. Shift 1 on weekdays and Shift 3 on weekends were most representative of the annual average.

A more comprehensive approach to analyzing the data for passenger cars and 5-axle trucks was the preparation of tables cross-classified by shift, day of week, and season. Each table is a matrix of 84 cells with values representing the mean, standard deviation, and coefficient of variation within a cell. Presented in Table 6 is the matrix representing passenger cars and other 4-tire vehicles at the Lawrenceburg toll station. This table and others representing 5-axle trucks at Lawrenceburg (Table 7), passenger cars at Slade (Table 8), and 5-axle trucks at Slade (Table 9), are useful to demonstrate the process by which time periods most representative of the annual distribution of vehicle types can be selected.

Additional data are provided to assist in the selection of the most representative time period at the bottom of each of Tables 6 through 9. Presented is a subjectively derived set of limits for mean values which may be used as a guide in selecting the most representative time period. These limits include one-third of the 84 cells within the matrix and the values are centered around the annual average of a specific vehicle type at each toll station. For example, the range shown at the bottom of Table 6 includes mean values of 76.38 to 82.83. These data were obtained from a list of mean values in ascending order with 14 mean values less than the annual average and 14 mean values more than the annual average.

As noted previously, other statistical measures presented in Table 6 are the standard deviation and the coefficient of variation. The coefficient of variation represents both the mean and the standard deviation and is useful when comparing how one mean and its corresponding standard deviation compare to another. With reference to Table 6 again, the 28 cells in bold type and underlined are recommended as being most representative of the annual distribution of passenger cars and other 4-tire vehicles. In addition, the cells with the lowest coefficients of variation would be the best of the 28 cells previously selected as the most representative of the aannual distribution.

The data presented in Tables 6 through 9 indicate that the time periods most representative of the annual distribution are Shift 1 and Shift 2 on weekdays during all seasons of the year. For the data analyzed, Mondays had the most time periods included in the 28-cell range selected to be representative of the annual distribution. Tuesdays and Wednesdays were the next most representative days. Shift 2 on Friday was generally not very representative of the annual distribution.

SUMMARY AND RECOMMENDATIONS

An analysis of vehicle classification data at the Lawrenceburg toll station (Bluegrass Parkway) and the Slade toll station (Mountain Parkway) was made to determine if 8-hour periods could be used to accurately represent the annual distribution of vehicle types. Included were one year of data (Calendar Year 1984) from each of the toll stations. The analysis indicated that specific 8-hour periods within the year are representative of the annual distribution of vehicle types and that combining data from the same 8-hour period during the year generally improves the accuracy relative to the annual distribution. Tables were developed that show a matrix of mean values and standard deviations for percentages of vehicle types cross-classified by shift, day of week, and season. These tables provide a process by which time periods during the year can be selected such that they are representative of the annual distribution. Based on a known value for the annual percentage of a specific vehicle type and the range of means, standard deviations, and coefficient of variations presented in Tables 6 through 9, the most representative sampling periods can be selected.

It is clear that analysis of data from two toll stations for one year has limitations, and because of these limitations it cannot be recommended that shorter time periods be used for classification data collection. However, based on the available data, it does appear that classification data collection efforts should be concentrated on weekdays between 7:00 a.m. and 11:00 p.m. during all seasons of the year. The most obvious exception to this general recommendation was Shift 2 (3:00 p.m. to 11:00 p.m.) on Fridays which was not very representative of the annual distribution.

Additional research related to vehicle classification sampling is recommended. Limitations of using data from only two toll stations is apparent. The use of automatic classification equipment would enable expanded analysis of data for highway systems other than toll roads. In addition to other uses, permanent classification equipment on selected highways would permit examination of annual data and the result could be the determination of short-term periods that would be representative of the annual distribution of vehicle types.

Automatic classification equipment has been evaluated by others and there are systems available that can classify vehicles according to number of axles and wheelbase. Emphasis is being placed on the development of a more reliable and permanent axle counter by several companies. Consideration should be given to installation and evaluation of automatic classification equipment with the objective of system-wide coverage in the future.

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TABLE 1. SUMMARY OF VEHICLE TYPES: FY 1983-84

VEHICLE TYPE	LAWRENCEBURG PERCENT	SLADE PERCENT
Passenger Cars or Other Two-Axle, Four-Tire Vehicles	79.54	80.99
Five-Axle Truck (Any Combination)	8.74	7.51
Other Vehicles	11.72	11.50
Total	100.00	100.00

TABLE 2. STATISTICAL VALUES FOR PERCENTAGES OF PASSENGER CARS AND OTHER 4-TIRE VEHICLES AT LAWRENCEBURG (Calendar Year 1984)

NUMBER OF DATA ENTIRES	TIME PERIOD	SHIFT NUMBER	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
105	Weekends	1	90.33	8.62	9.55
99	Weekends	2	94.35	1.32	1.40
98	Weekends	3	82.02	7.34	8.95
260	Weekdays	1	76.81	5.36	6.97
254	Weekdays	2	82.07	4.13	4.97
250	Weekdays	3	67.41	7.34	10.89
365	All Days	1	80.70	8.90	11.03
353	All Days	2	86.24	6.22	7.21
348	All Days	3	71.53	9.85	13.78
1066		All Shifts	79.54	10.39	13.07

TABLE 3. STATISTICAL VALUES FOR PERCENTAGES OF 5-AXLE VEHICLES AT LAWRENCEBURG (Calendar Year 1984)

NUMBER OF DATA ENTIRES	TIME PERIOD	SHIFT NUMBER	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
105	Weekends	1	2.83	2.02	71.35
99	Weekends	2	1.61	0.67	41.33
98	Weekends	3	8.04	4.50	56.00
260	Weekdays	1	8.71	1.74	20.01
254	Weekdays	2	6.27	1.80	28.64
250	Weekdays	3	16.86	4.55	27.00
365	All Days	1	7.02	3.23	46.04
353	All Days	2	4.96	2.63	52.94
348	All Days	3	14.38	6.03	41.96
1066		All Shifts	8.74	5.82	66.60

TABLE 4. STATISTICAL VALUES FOR PERCENTAGES OF PASSENGER CARS AND OTHER 2-AXLE, 4-TIRE VEHICLES AT SLADE (Calendar Year 1984)

NUMBER OF DATA ENTIRES	TIME PERIOD	SHIFT NUMBER	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
105	Weekends	1	89.50	2.20	2.46
105	Weekends	2	91.17	1.68	1.84
105	Weekends	3	81.80	6.21	7.59
260	Weekdays	1	79.05	3.05	3.86
260	Weekdays	2	83.78	3.19	3.80
260	Weekdays	3	72.29	5.15	7.12
365	All Days	1	82.06	5.52	6.73
365	All Days	2	85.90	4.40	5.12
365	All Days	3	75.02	6.96	9.27
1095		All Shifts	80.99	7.28	8.99

TABLE 5. STATISTICAL VALUES FOR PERCENTAGES OF 5-AXLE VEHICLES AT SLADE (Calendar Year 1984)

NUMBER OF DATA ENTIRES	TIME PERIOD	SHIFT NUMBER	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
105	Weekends	1	2.54	0.69	27.21
105	Weekends	2	2.36	0.56	23.77
105	Weekends	3	7.57	3.75	49.53
260	Weekdays	1	7.35	1.42	19.33
260	Weekdays	2	6.03	1.58	26.25
260	Weekdays	3	13.21	3.20	24.20
365	All Days	1	5.97	2.52	42.17
365	All Days	2	4.98	2.16	43.35
365	All Days	3	11.59	4.22	36.42
1095		All Shifts	7.51	4.25	56.63

TABLE 6. CROSS-CLASSIFICATION MATRIX FOR PASSENGER CARS AND OTHER 4-TIRE VEHICLES AT LAWRENCEBURG

		SHIFT 1				SHIFT 2				SHIFT 3			
		SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER
	MEAN	91.78	94.40	90.31	95.46	95.01	94.41	95.31	94.66	74.90	77.45	76.85	74.12
SUN	STD DEV	12.24	0.81	13.01	1.25	1.20	0.81	0.65	1.59	5.95	2.59	3.60	5.09
	COEFF VAR	13.34	0.86	14.41	1.31	1.26	0.86	0.68	1.68	7.94	3.34	4.69	6.86
	MEAN	78.20	78.92	79.78	78.90	83.01	82.43	82.84	80.73	61.76	64.46	64.75	64.25
MON	STD DEV	8.77	2.32	4.61	5.81	4.22	1.55	4.11	5.67	7.76	2.96	3.77	11.88
	COEFF VAR	11.21	2.94	5.78	7.36	5.08	1.88	4.97	7.03	12.57	4.58	5.82	18.49
	MEAN	71.86	75.81	75.47	76.24	81.52	81.64	81.38	79.95	63.39	64.72	65.03	63.39
TUE	STD DEV	10.39	4.92	2.17	7.00	1.77	2.31	2.43	4.64	4.23	2.82	4.00	5.77
	COEFF VAR	14.46	6.49	2.87	9.18	2.17	2.83	2.99	5.80	6.67	4.36	6.15	9.11
	MEAN	74.20	77.08	76.31	75.21	81.39	82.27	81.69	79.05	61.72	67.38	67.08	62.64
WED	STD DEV	6.90	3.90	3.01	4.14	1.70	3.14	5.56	3.91	2.51	4.25	7.26	4.29
	COEFF VAR	9.30	5.06	3.94	5.51	2.09	3.81	6.80	4.94	4.07	6.31	10.83	6.85
	MEAN	76.22	77.02	77.53	75.27	82.87	82.86	84.14	80.62	65.43	68.11	67.21	62.99
THU	STD DEV	1.68	2.98	6.07	2.47	2.12	1.65	4.20	3.41	3.94	2.72	4.91	3.00
	COEFF VAR	2.20	3.87	7.83	3.28	2.55	1.99	4.99	4.23	6.02	4.00	7.30	4.76
	MEAN	77.42	78.12	78.34	78.27	88.62	87.98	89.40	86.93	76.39	80.48	80.30	74.78
FRI	STD DEV	8.02	3.95	6.16	2.89	0.96	1.06	1.90	2.02	3.70	4.17	4.19	7.00
	COEFF VAR	10.36	5.06	7.86	3.70	1.08	1.20	2.13	2.32	4.84	5.18	5.22	9.36
	MEAN	86.33	88.49	87.99	87.44	94.08	93.60	94.48	93.33	86.84	89.63	90.03	87.62
SAT	STD DEV	10.12	2.16	11.18	2.67	1.19	0.70	1.34	1.75	1.89	1.82	3.19	3.31
	COEFF VAR	11.72	2.44	12.70	3.06	1.27	0.74	1.42	1.88	2.18	2.03	3.54	3.77

Annual average percentage of passenger cars and other 4-tire vehicles at Lawrenceburg = 79.54

Range of mean values representative of the annual distribution = 76.38-82.83

TABLE 7. CROSS-CLASSIFICATION MATRIX FOR 5-AXLE TRUCKS AT LAWRENCEBURG

		SHIFT 1				SHIFT 2				SHIFT 3			
		SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER
	MEAN	1.64	0.96	1.47	1.45	1.47	1.37	1.12	2.06	12.46	11.26	11.14	12.74
SUN	STD DEV	1.95	0.23	2.12	0.29	0.43	0.28	0.29	0.60	2.48	1.40	2.52	2.08
	COEFF VAR	119.02	23.39	144.67	19.96	29.39	20.60	25.66	29.04	19.92	12.45	22.61	16.30
	MEAN	7.85	7.98	7.17	8.64	6.51	6.69	6.27	8.20	19.62	19.30	18.47	18.82
MON	STD DEV	2.13	1.38	2.18	2.26	1.97	0.75	1.90	2.72	5.14	2.68	5.33	6.59
	COEFF VAR	27.19	17.31	30.42	26.11	30.21	11.22	30.26	33.22	26.20	13.89	28.87	35.02
	MEAN	9.42	8.45	9.26	9.76	7.04	6.57	6.54	8.01	19.22	19.15	17.05	18.73
TUE	STD DEV	1.24	1.98	1.15	2.76	0.85	1.12	1.04	2.14	2.79	3.45	4.33	4.35
	COEFF VAR	13.16	23.46	12.44	28.25	12.05	17.12	15.86	26.70	14.54	18.02	25.36	23.21
	MEAN	9.97	8.81	8.46	10.33	6.95	6.28	6.11	8.59	20.01	17.28	16.31	17.89
WED	STD DEV	2.37	1.55	1.80	1.57	0.85	1.20	1.29	2.00	1.68	2.98	3.41	3.13
	COEFF VAR	23.78	17.60	21.23	15.19	12.19	19.07	21.09	23.30	8.40	17.22	20.90	17.49
	MEAN	9.26	8.60	7.83	9.75	6.26	6.05	5.39	7.70	17.30	17.16	17.53	20.36
THU	STD DEV	1.05	1.28	2.05	1.12	1.19	0.73	1.70	1.75	3.41	1.77	2.96	1.59
	COEFF VAR	11.32	14.90	26.12	11.49	19.03	11.99	31.51	22.81	19.73	10.31	16.90	7.80
	MEAN	8.19	7.94	7.84	8.84	3.94	3.80	3.42	5.23	11.75	9.49	9.42	12.51
FRI	STD DEV	1.10	0.89	1.30	1.38	0.56	0.44	0.91	1.05	2.37	2.51	3.05	3.97
	COEFF VAR	13.46	11.18	16.54	15.58	14.12	11.64	26.69	20.00	20.14	26.42	32.45	31.71
	MEAN	4.53	4.17	3.19	5.30	1.43	1.41	1.35	2.52	4.17	2.82	3.18	5.66
SAT	STD DEV	1.40	1.06	1.53	1.22	0.37	0.33	0.91	0.85	1.39	0.83	2.44	2.25
	COEFF VAR	30.89	25.43	47.89	23.09	25.98	23.40	67.50	33.75	33.34	29.48	76.78	39.64

Annual average percentage of 5-axle trucks at Lawrenceburg = 8.74

Range of mean values representative of the annual distribution = 7.69-11.74

TABLE 8. CROSS-CLASSIFICATION MATRIX FOR PASSENGER CARS AND OTHER 4-TIRE VEHICLES AT SLADE

		SHIFT 1				SHIFT 2				SHIFT 3			
		SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER
SUN	MEAN	89.80	88.97	90.67	91.87	91.11	90.48	91.56	92.41	74.86	**78.36**	77.11	76.45
	STD DEV	1.91	1.76	1.69	2.35	2.00	0.88	1.35	1.93	3.65	3.31	4.01	5.58
	COEFF VAR	2.13	1.98	1.86	2.56	2.19	0.97	1.47	2.09	4.87	4.23	5.20	7.31
MON	MEAN	**79.38**	**80.32**	**79.51**	**80.71**	**82.46**	**83.24**	83.60	83.62	69.34	71.29	70.57	73.72
	STD DEV	2.80	0.98	3.62	5.44	2.19	1.36	2.73	5.61	2.20	1.65	2.00	8.08
	COEFF VAR	3.53	1.22	4.55	6.74	2.66	1.63	3.27	6.71	3.17	2.32	2.83	10.96
TUE	MEAN	77.02	78.13	77.35	**78.34**	**81.37**	**82.35**	**82.01**	**82.35**	66.69	71.32	70.60	71.12
	STD DEV	1.18	0.69	1.29	6.03	1.21	1.57	1.31	3.76	1.80	2.32	3.18	4.27
	COEFF VAR	1.53	0.89	1.66	7.69	1.49	1.91	1.60	4.57	2.70	3.26	4.50	6.01
WED	MEAN	77.51	**78.62**	77.61	77.10	**81.82**	**83.14**	**82.87**	**81.63**	67.89	71.15	70.33	69.51
	STD DEV	1.65	2.55	2.28	3.42	1.65	2.28	3.03	3.73	1.89	3.26	5.31	2.12
	COEFF VAR	2.13	3.24	2.94	4.43	2.02	2.75	3.66	4.57	2.79	4.59	7.56	3.05
THU	MEAN	78.02	**79.31**	**79.62**	78.11	**83.33**	83.56	84.43	**82.56**	70.48	72.42	71.77	69.15
	STD DEV	1.06	1.58	4.83	2.65	1.09	1.01	3.66	2.72	4.06	1.65	3.80	3.28
	COEFF VAR	1.36	2.00	6.07	3.39	1.30	1.21	4.33	3.29	5.77	2.28	5.30	4.74
FRI	MEAN	**80.47**	**81.24**	**81.63**	**80.97**	87.63	86.83	88.56	88.17	78.07	**80.72**	**79.93**	**79.45**
	STD DEV	2.00	1.40	2.32	2.26	1.20	1.44	1.07	2.19	2.66	1.20	5.58	4.33
	COEFF VAR	2.49	1.72	2.84	2.79	1.37	1.66	1.21	2.49	3.41	1.49	6.98	5.45
SAT	MEAN	88.32	87.66	89.56	88.96	90.38	90.01	91.59	91.69	85.92	86.24	87.61	88.28
	STD DEV	2.05	1.39	1.65	2.16	2.22	0.95	1.13	1.52	2.09	2.46	1.91	2.13
	COEFF VAR	2.32	1.59	1.84	2.43	2.46	1.05	1.24	1.66	2.43	2.85	2.18	2.42

Annual average percentage of passenger cars and other 4-tire vehicles at Slade = 80.99

Range of mean values representative of the annual distribution = 78.34-83.33

TABLE 9. CROSS-CLASSIFICATION MATRIX FOR 5-AXLE TRUCKS AT SLADE

		SHIFT 1				SHIFT 2				SHIFT 3			
		SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER	SPRING	SUMMER	FALL	WINTER
	MEAN	2.24	1.96	2.05	2.60	2.55	2.18	2.36	2.87	11.83	9.58	10.68	11.10
SUN	STD DEV	0.51	0.33	0.47	0.82	0.60	0.20	0.63	0.83	2.35	1.29	2.20	3.06
	COEFF VAR	22.65	17.07	22.90	31.35	23.53	9.26	26.85	28.80	19.85	13.43	20.56	27.61
	MEAN	6.87	6.43	7.13	7.06	6.66	5.78	6.35	6.75	15.22	13.50	15.03	13.28
MON	STD DEV	1.74	0.39	1.56	2.38	1.37	0.52	1.39	2.53	1.37	0.85	1.30	4.17
	COEFF VAR	25.25	6.06	21.82	33.71	20.56	9.01	21.90	37.48	8.97	6.28	8.67	31.40
	MEAN	7.97	7.17	8.01	8.07	7.07	6.23	7.05	7.37	16.52	13.45	14.91	14.28
TUE	STD DEV	0.85	0.42	0.69	2.47	0.52	0.90	0.61	1.74	1.09	1.78	2.59	2.51
	COEFF VAR	10.66	5.91	8.62	30.57	7.29	14.53	8.59	23.64	6.58	13.22	17.35	17.55
	MEAN	7.76	7.05	8.13	8.69	6.87	5.92	6.64	7.64	15.73	13.38	14.91	15.42
WED	STD DEV	0.65	1.29	0.84	1.57	0.88	0.91	1.18	1.69	1.43	1.33	2.79	1.19
	COEFF VAR	8.42	18.35	10.36	18.09	12.87	15.30	17.76	22.12	9.11	9.96	18.73	7.69
	MEAN	7.90	7.11	7.34	8.50	6.08	5.52	5.79	7.15	14.25	12.38	13.66	15.26
THU	STD DEV	0.90	0.74	1.86	1.41	0.64	0.48	1.47	1.46	2.04	1.12	2.48	1.60
	COEFF VAR	11.37	10.40	25.34	16.58	10.50	8.63	25.34	20.46	14.30	9.01	18.13	10.51
	MEAN	6.32	5.93	6.40	7.30	3.92	3.66	3.77	4.57	8.62	7.19	8.03	9.37
FRI	STD DEV	1.05	0.55	1.18	0.90	0.48	0.37	0.43	0.91	0.95	0.75	1.49	1.65
	COEFF VAR	16.65	9.19	18.49	12.34	12.24	10.20	11.48	19.99	11.01	10.42	18.62	17.59
	MEAN	2.76	2.66	2.50	3.55	2.20	2.07	1.94	2.67	4.59	3.90	3.92	4.66
SAT	STD DEV	0.43	0.35	0.54	0.81	0.35	0.33	0.28	0.51	0.94	1.04	0.90	0.60
	COEFF VAR	15.65	13.12	21.70	22.83	16.11	16.11	14.35	19.27	20.51	26.57	22.87	12.90

Annual average percentage of 5-axle trucks at Slade = 7.51

Range of mean values representative of the annual distribution = 5.93-10.68

APPENDIX

SUMMARY OF AVAILABLE VEHICLE CLASSIFICATION EQUIPMENT

Source: Wyman, J. H.; Braley, G. A.; and Stevens, R. I.; "Field Evaluation of FHWA Vehicle Classification Categories - MDOT," FHWA Contract DTFH-71-80-54-ME-03, Maine Department of Transportation, December 1984.

SUMMARY OF RESULTS FROM VEHICLE CLASSIFICATION EQUIPMENT EVALUATION

1. I. R. D. -- A permanent year round system using two loops and a axle counter. Provides classification to "Scheme F." Printout available for each vehicle in real time as well as retaining data for summaries and telemetry to a central headquarters. In proof test, run classified 91.2 percent correctly. In volume, field run counted 99.86 percent of 8,100 vehicles passing the sensor. A quality unit in the $25,000 class.

2. Golden-River -- A semi-permanent system for clear road, seasonal use only. Two loops and a capacitance-pad axle counter provide input data. Data collected to "Scheme E." May be programmed by manufacturer for "Scheme F." Rear time printout of each vehicle available, but not simultaneously with data storage or telemetering. On proof run classified correctly 95.9 percent of vehicles and in volume run, missed 13 percent of vehicles out of 9,345. The missed vehicles were either in a slow queue or a wheel had missed the pad. A quality unit is in the $25,000 class.

3. Streeter-Amet -- A portable system using road tubes, on proof testing, correctly classified 93.5 percent of vehicles. In the volume run, it operated for nine 24-hour periods with two road tube failures. Comparisons with G. K. Instrument system is the only qualitative measure possible. A relatively inexpensive unit for portable data collection that operated satisfactorily.

4. G.K. Instrument System -- This is a portable system also using road tubes. It successfully classified 95.5 percent of vehicles on proof testing. On volume testing, it was compared with the Streeter-Amet system for volume check. Except for the road-tube failure, operation appears reasonable. Also a relatively inexpensive unit and acceptable short-term portable use.

5. Sarasota System -- This system operates on two loops and therefore classifies according to vehicle length only. The electronics system operated successfully without failure during the test period.