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FLEET ACCIDENT EVALUATION OF FMVSS 121

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16. Abstract

The Interim Report presents preliminary results based on the first year of the fleet monitoring program to evaluate the safety impact of FMVSS 121. Mileage, accidents, and brake system maintenance are being collected on a national sample of vehicles. The fleets and vehicles were selected from manufacturers' sales lists for the production period January 1974 through January 1976 using probability-based sampling techniques. A complete description of the sample design is included.

An important finding at the mid-point of the study is that the sales of pre-standard vehicles in 1974 and early 1975 involved proportionately more tractors in large "for hire" fleets, while the sales of post-standard vehicles in 1975 and early 1976 involved proportionately more straight trucks in small private fleets. These differences are adjusted for in the computation of accident rates since they directly affect the exposure of the vehicles.

Preliminary results indicate that the adjusted accident rate is slightly lower (19%) for the post-standard vehicles. However, brake system maintenance on the post-standard vehicles occurs more frequently (35%). These results are not statistically significant.

The final section of the report describes work-in-progress including supplemental data collection on injury and fatal accidents.

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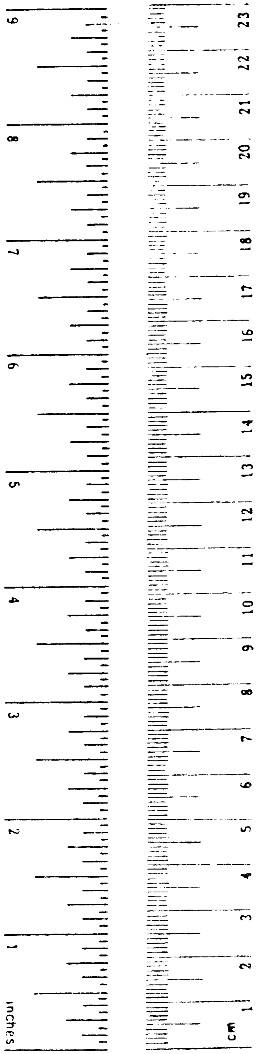
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

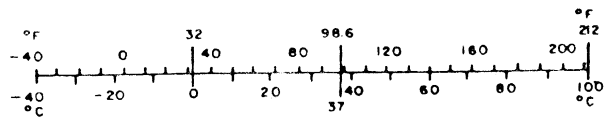
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This report contains preliminary results. As such, certain qualifications are in order which the reader must be aware of. The objective of this study is to quantify the actual safety benefits of FMVSS-121 using rigorous statistical techniques. The data base for this evaluation is being gathered over a two year period. These tabulations are based on preliminary data files containing the available information after one year of data collection.

The sample design for this study is based upon knowledge of the purchasers of 1974 and 1975 air-braked vehicles. This information was graciously provided by the following manufacturers:

Chrysler (Dodge)
Ford
Freightliner
General Motors (GMC, Chevrolet)
International Harvester
Mack
White

A statistically sound study could not have been employed without their assistance.

For the selected vehicles, information on the mileage, maintenance, and accidents is obtained from existing company or owner records. This information could not be collected without the cooperation and assistance provided by the nearly 500 owners of trucks participating in the study. The identities of these companies and individuals must be kept confidential in keeping with the Privacy Act of 1974. However, the trucking industry is to be commended for their understanding, cooperation, and patience in this evaluation of the 121 standard.

While this study is predicated on the cooperation of the truck manufacturers and owners, the findings and opinions presented in this report are solely those of the authors.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table Page

1. INTRODUCTION

The overall objective of this study is to quantify the safety impact of Federal Motor Vehicle Safety Standard No. 121, Air Brake Systems. The major data collection activity involves a national sample of vehicles whose mileage, accidents, and brake system maintenance are being monitored over a two-year period. This report is based on preliminary data files containing information from the first half of the study--calendar year 1976. The purpose of this report is to describe the progress to date and illustrate the kind of results which will be available at the end of the program.

This introductory chapter has three sections. Section 1.1 presents a brief overview of the project and describes the current status. Results from the analysis of the preliminary data files are summarized in Section 1.2. The final section, Section 1.3, describes the organization of the report. The purpose of this chapter is to provide the reader with a summary of the findings and a brief description of the information contained in the remaining chapters.

1.1 Overview

Primary objectives involve a comparison of property damage, injury, and fatal accident rates for pre- and post-standard vehicles. Secondary objectives address maintenance and operational experiences. Three data sources are utilized to meet these objectives as shown in Figure 1.1. The major effort is the monitoring of a national sample of fleets (and vehicles) which were selected using probability-based sampling techniques. Information on exposure (mileage), accidents, and brake system maintenance is being recorded over a two-year period on these vehicles.

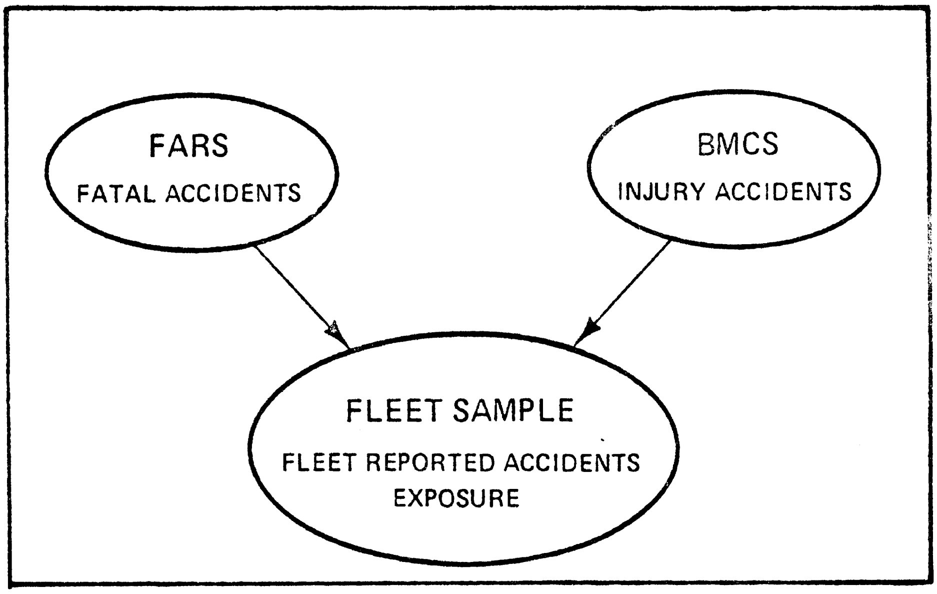


FIGURE 1.1 -- DATA SOURCES

In order for the analysis to include appreciable numbers of injury and fatal accidents, supplemental data are being incorporated from two sources. First, a census of all fatal accidents occurring in the 48 contiguous states plus the District of Columbia, involving late-model (1974 or newer) air-braked trucks, is being obtained through the NHTSA Fatal Accident Reporting System (FARS). Additional information on these accidents is being collected by telephone interview. Secondly, injury accidents reported to the Bureau of Motor Carrier Safety (BMCS) by Authorized Carriers (Common and Contract) will also be incorporated. Additional information on these accidents is being obtained by mail. Exposure data obtained through the fleet monitoring activity will allow calculation of accident rates for property damage, injury, and fatal accidents.

The importance of the fleet and vehicle selection procedures used for the monitoring program cannot be overemphasized. They are central to the value of the results generated. To extrapolate to a larger population of vehicles in use, it is necessary to employ a probability-based method of selecting the fleets and vehicles to be studied. The first step was to obtain sales lists from the major manufacturers of air-braked trucks. Vehicles for study were selected from these lists in such a way that the probability of selection is known for every vehicle. The sampling design involved three major steps: the selection of 36 geographic areas of the country, the selection of 554 truck owners located within the selected areas, and the selection of 5,398 vehicles within the selected fleets.

To obtain sufficient study vehicles manufactured before and after FMVSS 121 went into effect (March, 1975), the production period chosen was January, 1974 through January, 1976. During that period, an estimated 246,000 pre-standard vehicles and 100,000 post-standard vehicles were produced. Manufacturers providing sales data for the sampling frame accounted for about 90% of the production of air-braked vehicles. Table 1.1 shows the sampling frame in relation to total production.

TABLE 1.1

SAMPLING FRAME

	PRE-STANDARD	POST-STANDARD
ESTIMATED PRODUCTION 1/74 - 1/76	246,000	100,000
PARTICIPATING MANUFACTURERS	213,000	90,000
SAMPLING FRAME	185,000	42,000

No more than 42,000 post-standard vehicles could be included in the sampling frame because of the time-lag between the listing of the vehicle under "factory sales" and the updating of the manufacturers' warranty files, which were the source of data for the sampling frame.

Figure 1.2 shows the 36 selected geographic areas.

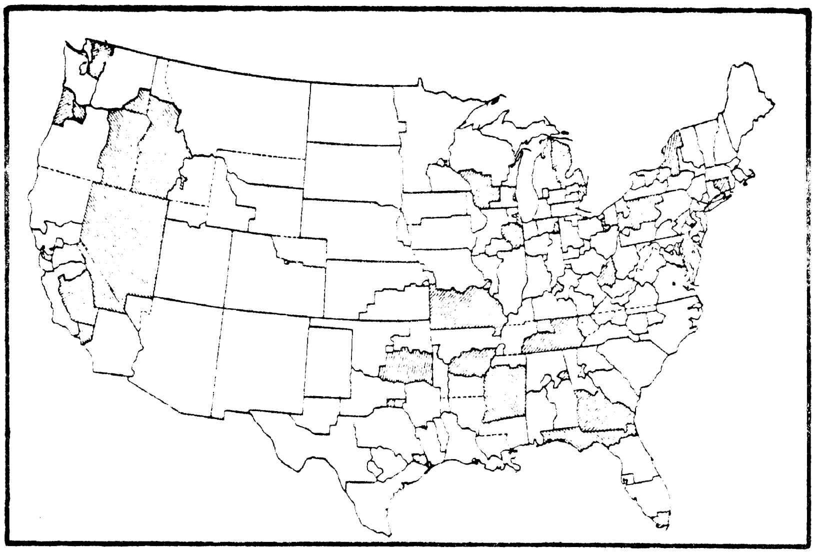


FIGURE 1.2 -- SELECTED AREAS

These are areas where the vehicle records are maintained, not necessarily the areas of vehicle operation. The sample design is presented in detail in Chapter 2.

During implementation, Task 2, the selected fleets were visited to secure cooperation and initiate data collection. Table 1.2 shows the number of fleets currently in the study, classified by fleet size and carrier type.

TABLE 1.2

STUDY FLEETS

FLEET SIZE	PRIVATE	FOR HIRE
SMALL (1-49)	250	62
MEDIUM (50-399)	84	27
LARGE (400+)	9	10
UNKNOWN	27	5
TOTAL	370	104

The fleet size is the total number of air-braked vehicles owned. While 474 fleets are currently participating, only 382 of these were among those originally selected. Nearly 100 additional fleets are being visited in our continuing efforts to monitor the selected vehicles, even though the current owner may not be the purchaser indicated on the manufacturers' lists. The magnitude of this problem is indicated by the fact that during implementation over 800 owners were visited in our attempts to secure data collection on vehicles which our records indicated were owned by a total of 554 companies or individuals. The vehicle selection procedures require that every effort be made to locate the selected vehicle regardless of the current owner. Vehicle substitutions cannot be made for the convenience of data collection.

Table 1.3 shows the number of currently participating vehicles by brake type and vehicle type.

TABLE 1.3

STUDY VEHICLES

VEHICLE TYPE	BRAKE TYPE	
	PRE	POST
STRAIGHT TRUCK	360	634
TRACTOR	986	576
SCHOOL BUS	146	475
TOTAL	1492	1685

Data collection in the fleet monitoring program is accomplished by locally-based personnel employed by HSRI. Descriptive information on the companies and vehicles was obtained during the initial visit. Fleets are then revisited quarterly to update the mileage, maintenance, and accident information. Data forms are subsequently forwarded to HSRI for processing. Implementation of the fleet monitoring program is described in more detail in Chapter 3.

1.2 Preliminary Results

The preliminary nature of these results must be emphasized. Data collection is incomplete. Because of the preliminary nature of the data and the analyses, resolution of the study questions cannot be expected. These results are presented to determine if the statistics computed are adequate to address the study objectives.

In all of the tabulations presented, the data have been weighted in proportion to the inverse of the vehicle selection probabilities, so that the statistics computed apply to the vehicle population defined by the sampling frame. The accuracy of these estimates is measured by the 95% confidence intervals computed. Statistically, this means that prior to the experiment the probability that the true mean would be outside the interval is only one in twenty. Basically, the width of the interval is determined by the variation in the statistic and the amount of data (sample size).

1.2.1 Exposure. A major finding at this point is that there are significant differences between the pre- and post-standard vehicles in terms of owners, types of vehicles, and usage. For example, 20% of the pre-standard vehicles were purchased by large fleets (400 or more air-braked power units), while only 9% of the post-standard vehicles were purchased by large fleets. With respect to carrier type, "for hire" fleets purchased 40% of the pre-standard vehicles while only purchasing 18% of the post-standard vehicles. Straight trucks increased from 13% of the pre-standard vehicles to 46% of the post-standard. Finally, the usual trip was in the "local" area for 43% of the pre-standard vehicles and 54% of the post-standard.

These differences reflect changes in the sales of air-braked trucks during the years 1974-1975. Large fleets may have "over-bought" pre-standard vehicles to avoid purchasing the more expensive 121-equipped trucks. And as large fleets tend to buy tractors that are commonly used in intercity trips, these differences would be explained. Furthermore, the trucking industry experienced an economic slump in late 1975, which may have affected purchasing by the "for hire" fleets more than the private fleets.

The observed differences in the composition of the pre- and post-standard groups of vehicles are important because they directly influence the exposure (mileage) of the vehicles. Distributions of total mileage are shown in the next four figures (Figures 1.3 through 1.6).

The mileage distribution by fleet size is shown in Figure 1.3. The role of large fleets should be noted in particular.

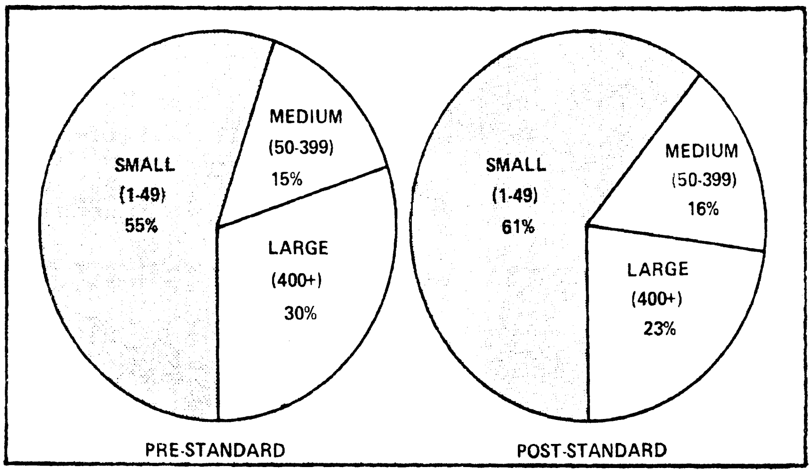


FIGURE 1.3 -- MILEAGE DISTRIBUTION BY FLEET SIZE

Large fleets accounted for only 0.5% of all owners in the sampling frame, but contained from 9% to 20% of the vehicles. In this figure, it can be seen that they account for 20% to 30% of the total mileage. Notice that the proportion of total mileage is appreciably less for the post-standard vehicles, reflecting the smaller proportion of vehicles in this category.

The mileage distribution by carrier type is shown in Figure 1.4. The proportion of total mileage accumulated by vehicles in "for hire" fleets changes from 54% to 37%. The "for hire" fleets tend to be larger and to accumulate more mileage per vehicle.

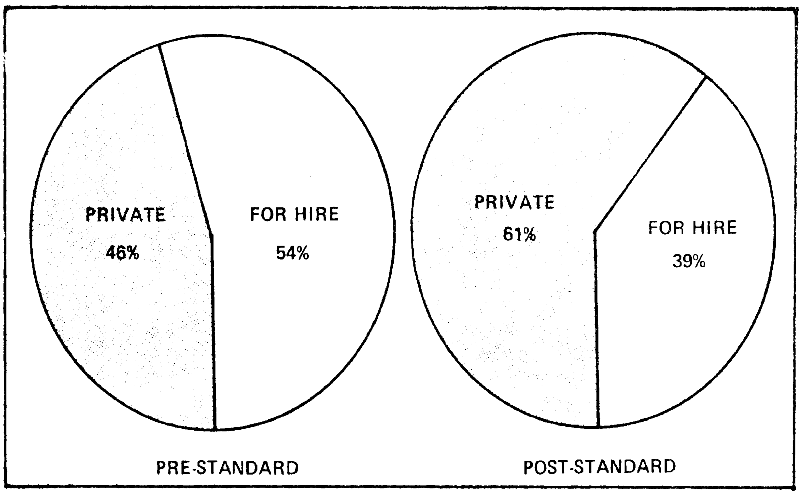


FIGURE 1.4 -- MILEAGE DISTRIBUTION BY CARRIER TYPE

The mileage distribution by vehicle type is shown in Figure 1.5. Notice that the pre-standard tractors account for 82% of the mileage accumulated by pre-standard vehicles in the sampling frame, and that this proportion drops to 64% for the post-standard vehicles.

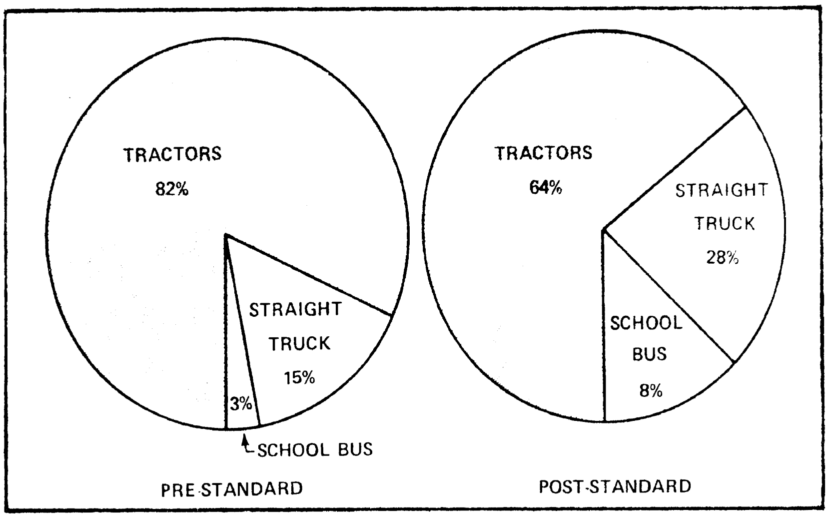


FIGURE 1.5 -- MILEAGE DISTRIBUTION BY VEHICLE TYPE

Similar differences are shown in the mileage distribution by usual trip distance , Figure 1.6.

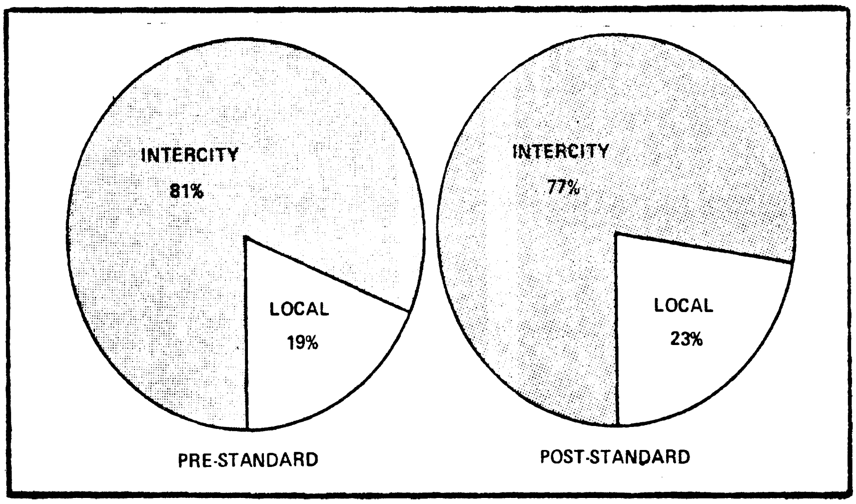


FIGURE 1.6 -- MILEAGE DISTRIBUTION BY TRIP DISTANCE

These figures illustrate that the exposure of pre- and post-standard vehicles is not the same. The differences arise from differences in the composition of the two groups. The pre-standard group contains more tractors in large for-hire fleets, while the post-standard group contains more straight trucks in small private fleets. These two groups cannot be compared unless the results are adjusted to some common exposure distribution. The exposure distribution shown in Table 1.4 is the average of the distributions for the pre- and post-standard vehicles, and is the distribution used in comparing the accident rates in the next section.

TABLE 1.4

AVERAGE MILEAGE DISTRIBUTION

	LOCAL	INTERCITY	TOTAL
STRAIGHT TRUCK	8.1	13.5	21.6
TRACTOR	7.5	65.7	73.2
SCHOOL BUS	4.9	0.3	5.2
TOTAL	20.5	79.5	100.0

1.2.2 Accident Rates. Figures 1.11 through 1.13 present the result of analyses of 1976 accident data for pre- and post-standard vehicles. The numbers represent the average number of accidents per 100 million vehicle miles; the bands are 95% confidence intervals that reflect the accuracy of the estimate. Overall, the rates are somewhat lower than were expected, reflecting variations in reporting discussed in Chapter 3.

Accident rates are presented by vehicle type in Figure 1.7.

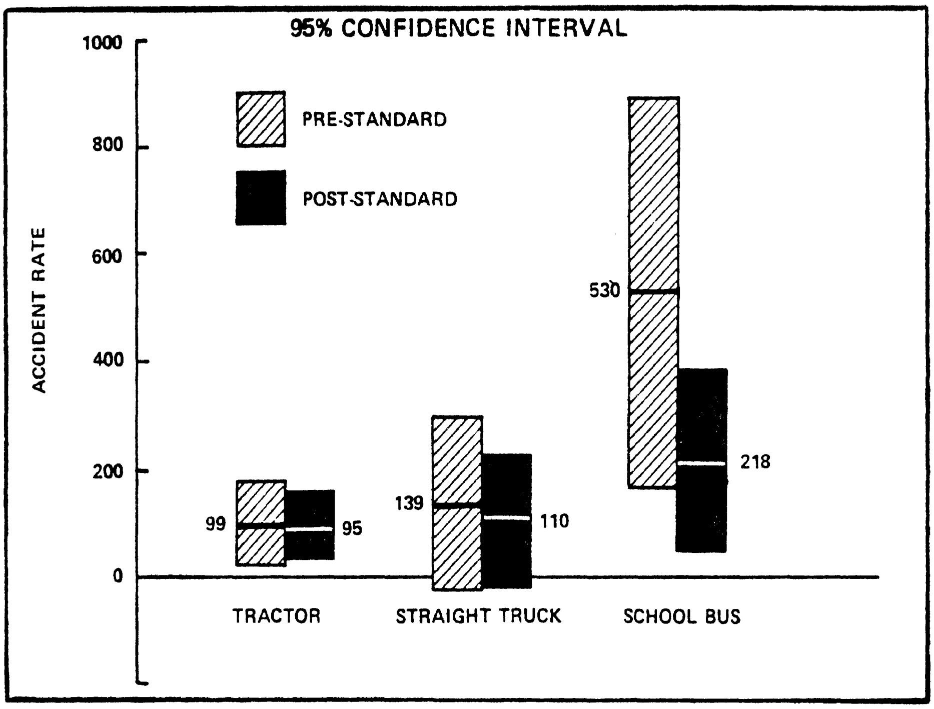


FIGURE 1.7 -- ACCIDENT RATE BY VEHICLE TYPE

The percent changes are: tractors down 4%, straight trucks down 21%, and school buses down 59%. These results are based on a total of only 268 accidents, and only about 84 of these accidents involved straight trucks or school buses. Accident reporting was only partially complete for the school buses, which may explain the high accident rate observed for this pre-standard vehicle type.

Post-standard tractors show only a 4% reduction in accident rate. However, the mix of pre- and post-standard equipment on combination vehicles has not yet been taken into account. So far, it would appear that post-standard tractors are pulling pre-standard trailers most of the time. Information is being gathered which will allow accident rates to be computed separately for the various combinations of pre- and post-standard equipment on combination vehicles.

Figure 1.8 shows that the accident rate is up by 17% in the local trip distance category, and down 35% in the intercity category. Since tractors are used predominately in intercity trips, these results prevent the formulation of any strong conclusions.

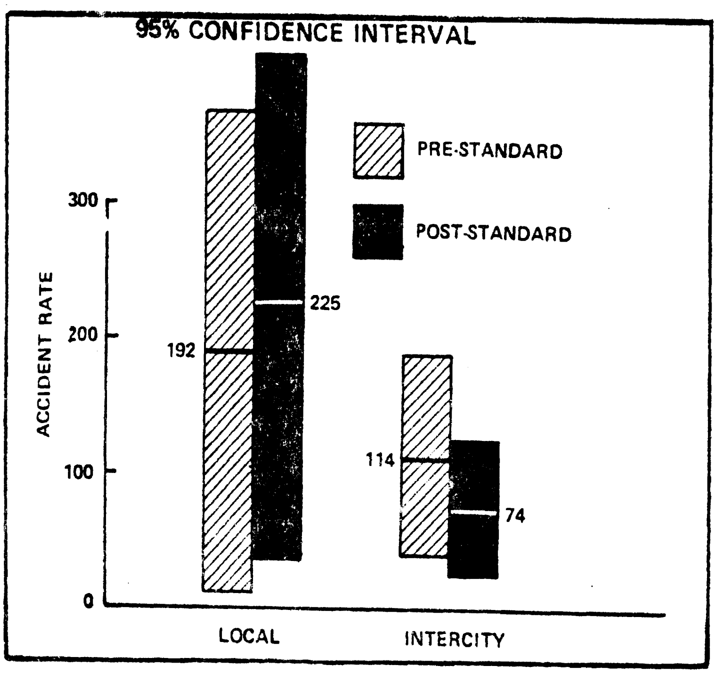


FIGURE 1.8 -- ACCIDENT RATE BY TRIP DISTANCE

Figure 1.9 shows the overall comparison of accident rates for the pre- and post-standard vehicles. The overall rate for the post-standard vehicles is 19% lower. The difference in these two accident rates is 25 accidents per hundred million vehicle miles.

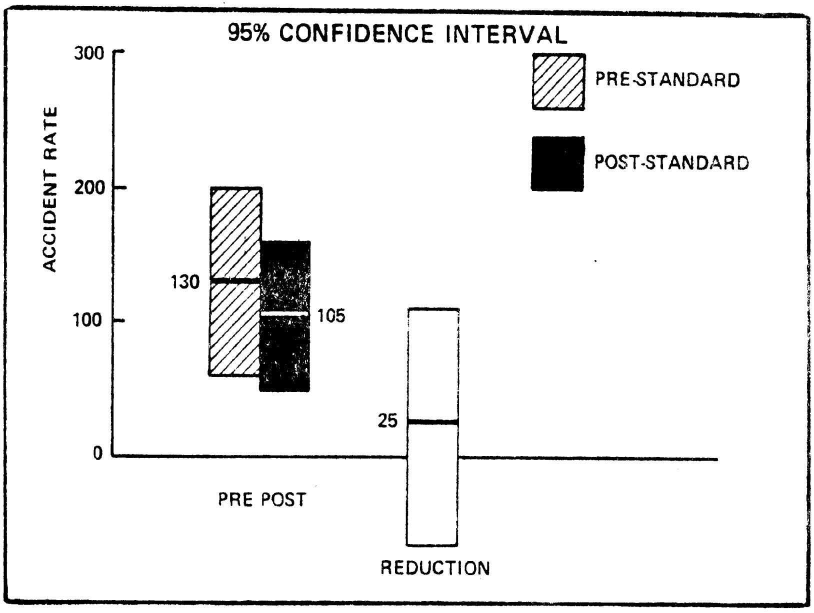


FIGURE 1.9 -- OVERALL ACCIDENT RATE

Note that a zero difference lies well within the confidence interval shown. Thus, statistically, there is no evidence at this point to support the hypothesis that 121-equipped vehicles have different accident rates than pre-standard vehicles. One must keep in mind, however, that these interim findings have several weaknesses: these data are not complete; participating companies vary in their reporting thresholds on accidents; the accident sample size is small; and the exposure information has not yet been classified into the various combinations of 121 equipment on tractor-trailer units. All of those problems are being addressed during the oncoming portion of the study.

1.2.3 Brake System Maintenance. Figures 1.10 through 1.13 illustrate the results of analyses of the maintenance experience of the monitored vehicles. While the differences between pre- and post-standard vehicles are not statistically significant, they are quite large.

Table 1.5 shows the average odometer readings as of January, 1977 for the study vehicles. Note the low mileage on the 121-equipped straight trucks and school buses.

TABLE 1.5

MEAN ODOMETER READING
JANUARY 1977
BY VEHICLE TYPE

VEHICLE TYPE	PRE-STANDARD	POST-STANDARD
TRACTOR	211,200	122,750
STRAIGHT TRUCK	43,548	21,470
SCHOOL BUS	25,401	14,003

Figure 1.10 shows the maintenance data analyzed by computing the interval in miles between maintenance entries. The first column in the figure shows a computation restricted to entries involving the same component. The second column shows entries for any component in the same major group of components. The third column represents intervals between each successive entry in the maintenance record. In all three columns, the intervals for 121 tractors are markedly shorter. Note that preventive maintenance has been excluded from these computations.

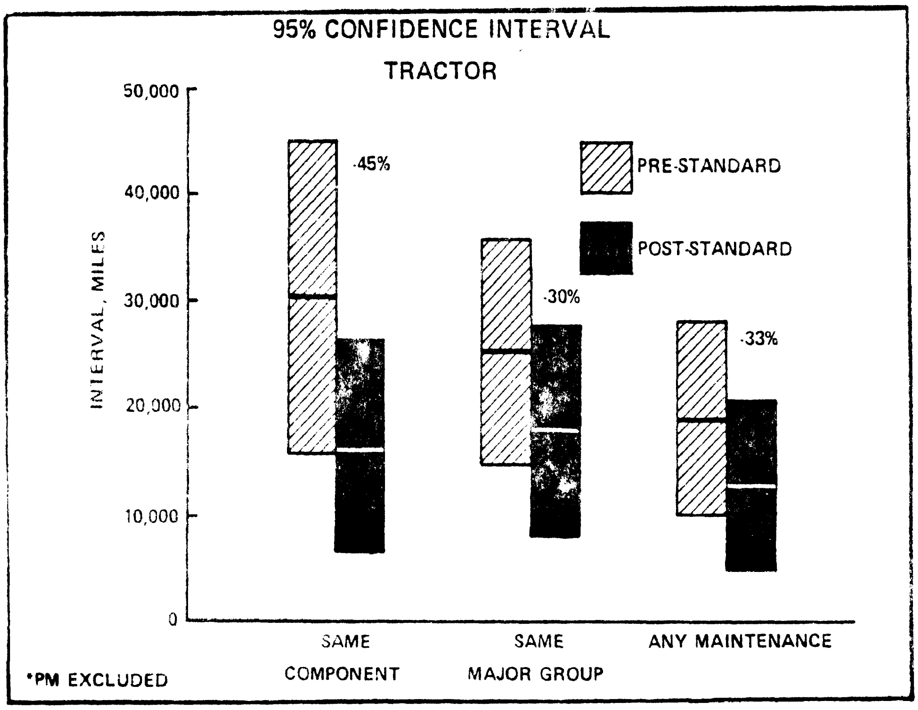


FIGURE 1.10 -- MEAN MAINTENANCE INTERVAL: TRACTORS

Figure 1.11 shows similar results for straight trucks. Note that while the tractors had maintenance intervals of 20,000 to 40,000 miles, the straight truck intervals are 5,000 to 10,000 miles. In general, maintenance intervals vary with usage, so that the same kind of exposure problems that occur in comparing accident rates also apply to the comparison of maintenance data.

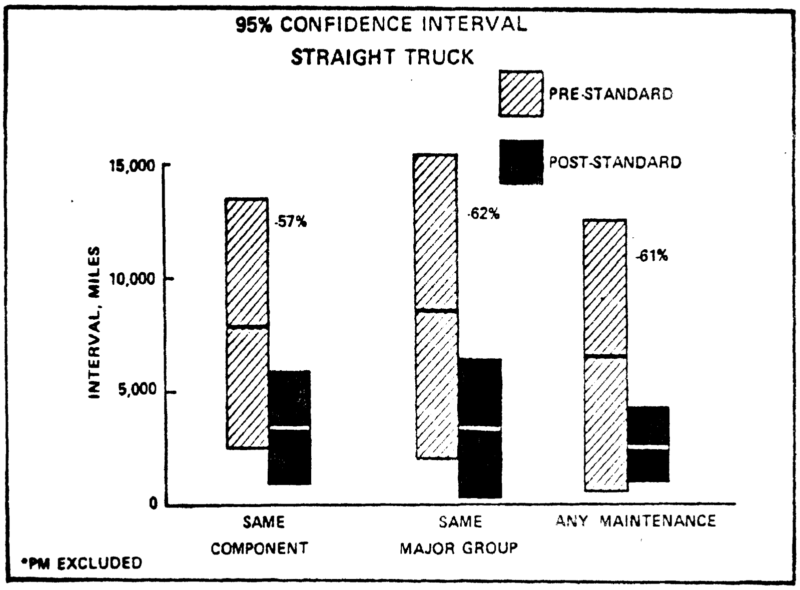


FIGURE 1.11 -- MEAN MAINTENANCE INTERVAL: STRAIGHT TRUCKS

Similar results are shown for school buses in Figure 1.12.

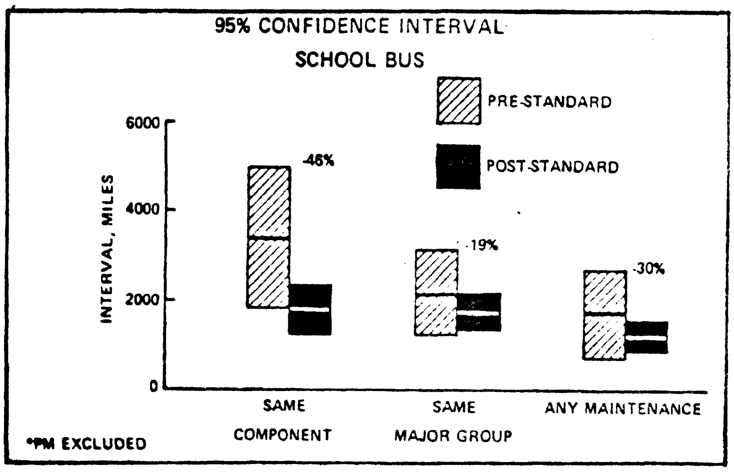


FIGURE 1.12 -- MEAN MAINTENANCE INTERVAL: SCHOOL BUSES

Figure 1.13 shows that air generation is the only major component group to show a longer interval (by 11%) for the 121 intercity tractors. Note also that the maintenance interval on the anti-skid components is only about 20,000 miles.

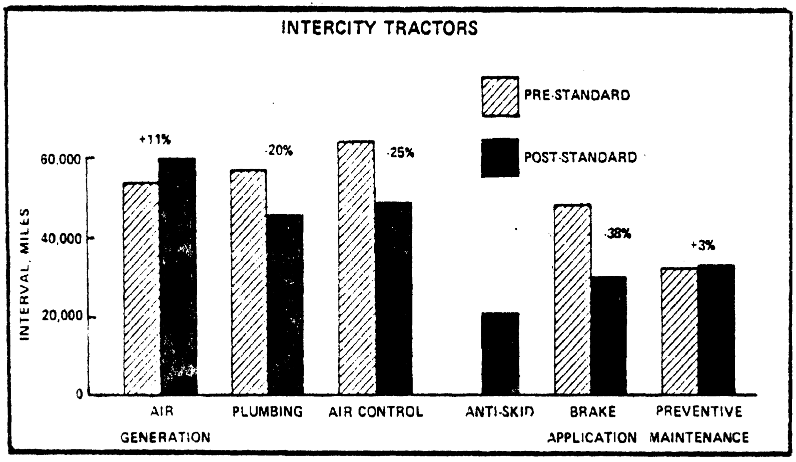


FIGURE 1.13 -- MEAN MILES TO FIRST OCCURRENCE BY MAJOR COMPONENT GROUP

The differences in maintenance intervals shown in Figure 1.10 through 1.13 are not statistically significant. However, they are substantial and, based on the confidence intervals shown, are likely to become statistically significant with the addition of the second year of data.

1.2.4 Summary. One of the purposes of the interim report is to provide all interested parties with a better idea of the study design, the problems associated with acquiring consistent and reliable field data, and the methods being employed to assure a fair and accurate comparison of pre- and post-121 vehicles. The results to date are sufficient to illustrate how pre- and post-standard vehicles in the sampling frame differ in their ownership, types, and exposure.

The mid-point findings show that 121-equipped vehicles have slightly lower accident rates and appreciably higher maintenance rates than non-121 vehicles, but neither of those differences is statistically significant.

Many of the problems in the present analysis are being addressed. A trip survey is being conducted to determine the proportion of mileage accumulated by tractor-trailers with the various mixes of pre- and post-standard brakes. The results of this survey should shed some light on the accident experience of the combination units. At the end of the program, supplementary data on injury and fatal accidents will be available from the follow-up of BMCS and FARS accidents currently in progress. More information on these tasks is presented in Chapter 7. Finally, the fleet monitoring program is being expanded to obtain early-life brake system maintenance data on the pre-standard vehicles, and to initiate data collection on post-Notice 7 vehicles. The additional maintenance data will allow a comparison of maintenance experience over the complete history of both pre- and post-standard vehicles. The addition of post-Notice 7 vehicles will allow an evaluation to be made of the effect of this most recent modification in the standard. Many of the criticisms of the early 121 vehicles were addressed with the Notice 7 modifications.

1.3 Report Organization

Section 1.1 provided an overview of the study design. This information is discussed more fully in the "Plan of Work and Methodology" written at the end of Task 1. Details were not available at that time on the sampling frame and the sample design. Chapter 2 of this report is provided to supply a detailed description of this work. Task 2 was the implementation of the fleet sample. The procedures used and resulting response rates are discussed in Chapter 3.

Preliminary results are presented in Chapters 4 through 6.

Descriptive information on the trucks and their owners are discussed in Chapter 4. Mileage, accidents, and accident rates are presented in Chapter 5. Chapter 6 presents the results of analysis of brake system maintenance data.

Finally, the supplemental data collection activities currently in progress are briefly described in Chapter 7. These activities include the trip survey, fatal accident follow-up, BMCS accident follow-up, the addition of early-life brake system maintenance data on the pre-standard vehicles, and initiation of data collection on post-Notice 7 vehicles.

2. SAMPLE DESIGN

The goal of the sample design was to obtain two national probability samples of trucks, one of air-braked trucks meeting the 121 standard and one of air-braked trucks which did not meet this standard. Since the purpose of the study was to compare the accident experience of the two samples, it was considered important for the two to be as much alike on other relevant variables as possible. Unfortunately (from the point of view of this comparative study), after February 28, 1975, virtually all air-braked vehicles manufactured in the United States for domestic use had to conform to the new 121 standard, so it was not possible to match the two samples exactly in terms of vehicle age and miles driven. However, it was decided to draw the pre-standard sample only from trucks manufactured after January 1, 1974, so that the two samples would be as similar as possible in regard to the age and usage of the sample vehicles.

Thus, the basic plan was to obtain samples of air-braked trucks manufactured in 1974 and 1975 and to study the effectiveness of their brake performance during two years of use, 1976 and 1977. Since expensive field contacts would be required with the owners of most of the sampled vehicles, it was considered necessary to cluster the sample by geographic area and by company to the maximum feasible extent. The following sections will detail the four steps involved in drawing these two samples by a multi-stage, stratified, clustered, controlled probability design: development of the frame, creation and selection of the primary sampling units (PSU's), selection of fleets within the selected PSU's, and selection of sample vehicles with the selected fleets. These sections are followed by a short section on sampling weights.

2.1 Frame Development

Not surprisingly, there are no single master lists of air-braked trucks manufacturered in 1974 and 1975 readily available in the public domain. The closest approximation to this is the TRINC tape developed commercially by Dun and Bradstreet, Inc. using available information from state motor vehicle registration files assembled by R. L. Polk and Reuben Donnelly. However, these data do not include the state of Oklahoma, are months or years behind in many other states, are often inaccurate, are admittedly incomplete, and are quite expensive. In addition, it is usually not possible to distinguish air-braked vehicles from hydraulic-braked vehicles in these records, and, since the date of first registration is almost always considerably different from the date of manufacture, it is not possible to distinguish clearly pre-standard vehicles from vehicles meeting the 121 brake standard.

Due to these problems with the Polk-Donnelly data, information was requested directly from the major truck manufacturing companies which jointly account for about 95% of United States on-road truck production. Over the next few months seven of these companies provided the computerized data necessary to the development of national frames of pre- and post-standard vehicles. Two companies, Peterbilt and Kenworth (subsidiaries of Paccar) which account for about 6% of total U.S. production were willing to cooperate but were unable to provide computerized data. They offered to obtain the needed data from their files or to let HSRI staff have access to the files, but this was deemed too time consuming and expensive.

Five companies, Ford, General Motors (separately for Chevrolet and GMC), Mack, Chrysler, and International Harvester, provided computer tapes which had separate listings of their pre- and post-standard 1974 and 1975 (and some early 1976) air-braked vehicles including VIN number and the name and address of the purchaser.

White Motor Company provided similar data in computer printout form in alphabetical order by purchaser, including its Autocar and Western Star divisions, but it did not provide the computer tape itself. Freightliner provided its data on computer tape already aggregated by purchasing company. This tape listed the numbers of pre- and post-standard vehicles purchased by each company, but it did not include vehicle VIN numbers. This was the ideal form into which all the vehicle data from the other manufacturers had to be transformed in order to draw the sample of participating companies.

In most cases the data source for these company lists was the company purchase or warranty record files. Thus, if the purchaser's name had not been received or the warranty not registered, the vehicle might not be included in the manufacturer's list. These lists were received between January and April 1976, and a few vehicles manufacturered in early 1976 were included. However, since, as expected, there was often a substantial delay between purchase and the adding of the warranty information to the warranty file, many of the post-standard vehicles manufactured in 1975 were not included in these lists.

This data collection procedure placed the responsibility on the manufacturers to determine which of their vehicles were pre-standard and which were post-standard, and subsequent field follow-up with the selected study vehicles shows that this distinction was generally accurate. Specific instructions were not given for buses built on truck chasis (i.e., school buses), but these were generally included. Buses built on other than a commercial chasis (i.e., intercity, transit, and suburban) were excluded. Vehicles sold to purchasers outside of the contiguous United States were excluded by all the manufacturers. These lists from the seven companies provided data on 185,183 pre-standard vehicles and only 43,043 post-standard vehicles. The latter figure was later reduced to 42,301 when it was discovered that one large order to a domestic firm was used entirely for export.

Table 2.1 shows the distribution of the listed vehicles by manufacturer. International Harvester was the largest seller of both pre-standard and post-standard vehicles, while Ford ranked second in both types of listings. Together they account for well over half of the vehicles in the sampling frame.

Unfortunately, it is difficult to obtain good published data on air-braked vehicles manufactured during the study periods for comparison with the vehicle lists provided by the manufacturers. Data published by the Motor Vehicle Manufacturers Association concerning trucks and buses sold each month categorize vehicles by weight class rather than by whether or not they have air brakes.

Table 2.2 provides some comparison data by manufacturer on the estimated numbers of air-braked trucks and buses which were produced from January 1974 through February 1975 and from March 1975 through January 1976. These estimates were obtained by assuming that 15% of Class 6 vehicles (19,501-26,000 lbs. GVWR), 85% of Class 7 vehicles (26,001-33,000 lbs. GVWR), and 100% of Class 8 vehicles (over 33,000 lbs. GVWR) were air-braked vehicles. These estimates are admittedly rough and probably vary from manufacturer to manufacturer. They probably also lead to underestimation of the numbers of air-braked buses. It should be noted that the estimates in Table 2.2 include transit and intercity buses as well as school buses. The two tables agree in showing International Harvester and Ford as the leading manufacturers of air-braked vehicles in both period, and the other manufacturers have roughly similar rankings in both tables for both periods.

The estimates in Table 2.2 suggest that the seven manufacturers included in this study produced at least 87% of the pre-standard vehicles and 90% of the post-standard vehicles during

TABLE 2.1

NUMBER OF PRE-STANDARD AND POST-STANDARD VEHICLES IN THE SAMPLING FRAME BY MANUFACTURER

Manufacturer	PRE-STANDARD VEHICLES			POST-STANDARD VEHICLES		
	Number of Purchasers	Number of Vehicles	Percent of Vehicles	Number of Purchasers	Number of Vehicles	Percent of Vehicles
Chevrolet	11,700	19,173	10.4	2,522	3,880	9.2
Dodge	260	493	0.3	30	42	0.1
Ford	20,162	45,299	24.5	5,783	13,702	32.4
Freightliner	5,894	15,066	8.1	1,139	2,795	6.6
GMC	10,281	20,210	10.9	1,867	3,728	8.8
International Harvester	26,541	58,655	31.7	4,563	14,301	33.8
Mack	5,146	15,388	8.3	604	2,248	5.3
White	3,757	10,899	5.9	652	1,605	3.8
TOTAL	83,741	185,183	100.1	17,160	42,301	100.0

TABLE 2.2

ESTIMATES OF AIR-BRAKED PRE-STANDARD AND POST-STANDARD TRUCKS AND BUSES BY MANUFACTURER, BASED ON FACTORY SALES DATA* FOR TWO PERIODS

Manufacturer	PRE-STANDARD VEHICLES (Jan. 1974-Feb. 1975)		POST-STANDARD VEHICLES (March 1975-Jan. 1976)	
	Number	Percent	Number	Percent
TRUCKS:				
Chevrolet	16,643	6.8	8,134	8.1
Diamond Reo	4,296	1.8	286	0.3
Dodge	6,767	2.8	1,319	1.3
Duplex	208	0.1	158	0.2
Ford	45,165	18.4	20,087	20.1
FWD	633	0.3	125	0.1
GMC	22,648	9.2	8,620	8.6
Intl Harvester	54,558	22.3	24,469	24.5
Mack	30,239	12.3	12,221	12.2
White†	28,746	11.7	8,900	8.9
Others†	24,385	10.0	2,134	7.1
SUB-TOTAL	234,288	95.7	91,453	91.5
BUSES:				
Chevrolet	659	0.3	748	0.8
Ford	1,799	0.7	843	0.9
GMC	2,982	1.2	2,078	2.1
Intl Harvester	2,269	0.9	2,294	2.3
Others	2,871	1.2	2,515	2.5
SUB-TOTAL	10,580	4.3	8,478	8.5
TOTAL	244,868	100.0	99,931	100.0
Participating Manufacturers† (excl "Others")	212,475	86.8	89,713	89.8

*These figures include trucks and buses manufacturered in the U.S. for domestic sale and trucks and buses manufactured in Canada and imported to the U.S. They were published in monthly reports by the Statistics Department of the Motor Vehicle Manufacturers Association of the United States. The estimates of air-braked vehicles are based on a 15% rate for Class 6, an 85% rate for Class 7, and a 100% rate for Class 8 vehicles.

†Some Freightliner trucks are included in the White data, and some are included in the "Others" category.

these two production periods. When it is considered that the Freightliner vehicles are split between White and the "Others" category and that the "Other" bus manufacturers produced mainly transit and intercity buses, then it seems likely that well over 90% of the vehicles of interest were produced by the seven participating manufacturers. Thus, the coverage of manufacturers seems high enough that there is little likelihood of significant bias from excluding Paccar and a few smaller manufacturers from the study.

Unfortunately, the estimates in Table 2.2 also suggest that the frame lists are somewhat low, not only for the post-standard vehicles as expected, but also for the pre-standard vehicles. The pre-standard lists seem particularly deficient for Mack and Dodge vehicles. Since in Table 2.2 some Freightliner vehicles are included in White production and some are included in the "Other" category, it is difficult to judge the completeness of the White and Freightliner lists. Of course, all of the manufacturers appear low in their post-standard lists, although again Mack and Dodge seem particularly low. It is hoped that there are not any significant differences between each manufacturer's vehicles which are included in the frame lists and those which were left off, and that the somewhat uneven coverage of vehicles of different manufacturers will not seriously affect the basic goal of developing two samples of pre-standard and post-standard vehicles whose experience with the two different types of air-brakes can be carefully compared.

As mentioned above, it was necessary to transform the 14 vehicle listings into 14 purchaser listings in order to draw an efficient sample of purchasers. Much of this aggregation task was carried out by special computer programs which assigned a common purchaser identification number to vehicles with the same purchaser name and address on one manufacturer's list. However, this task also involved a considerable amount of rather tedious clerical work due to many situations in which there were small differences in name and/or address for what appeared to be the same purchaser in one manufacturer's listing. This iterative process of combining vehicles into purchaser fleets from one manufacturer led to the creations of two new files, one containing 83,741 manufacturer-specific purchasers of pre-standard vehicles and one containing 17,161 manufacturer-specific purchasers of post-standard vehicle. The degree of overlap due to the same purchaser's buying both pre-standard and post-standard vehicles was not determined until after the selection of the primary sampling units. The fleet size distributions for the two files are shown in Table 2.3.

2.2 PSU Creation and Selection

In order to develop an efficient sample design, considerable statistical information on the population to be studied and the variables involved is required. Such information is not available for the trucking industry. A sample design also allows control to be exerted on aspects of data collection which influence cost. Methodologically, this study constitutes a major step forward in attempting to quantify the actual safety benefits of a Federal Motor Vehicle Safety Standard using rigorous statistical sampling techniques. Cost control is an important consideration anytime endeavors with a high degree of uncertainty are attempted. Initial estimates indicated data collection costs could be in excess of one million dollars. A major objective of the sample design was to reduce these costs.

The geographic area over which data collection must take place was identified as a major cost factor. This situation was addressed by using a design in which the first stage involves the selection of specific geographic areas within which data collection will be carried out. From a sampling point of view a large number

TABLE 2.3

INITIAL PURCHASER FLEET SIZE DISTRIBUTIONS FOR
PRE-STANDARD AND POST-STANDARD VEHICLES
(MANUFACTURER-SPECIFIC)

BRAKE TYPE:		NUMBER OF VEHICLES PURCHASED FROM A SINGLE MANUFACTURER							
		1	2-3	4-5	6-10	11-20	21-50	51+	Total
PRE-STANDARD VEHICLES	Fleets: N	62,299	13,932	3,181	2,499	1,039	564	227	83,741
	%	74.4	16.6	3.8	3.0	1.2	0.7	0.3	100.0
	Vehicles: N	62,299	31,482	13,889	18,701	14,886	16,935	26,991	185,183
	%	33.6	17.0	7.5	10.1	8.0	9.1	14.6	99.9
	Mean Size	1.00	2.26	4.37	7.48	14.33	30.03	118.9	2.21
POST-STANDARD VEHICLES	Fleets: N	11,868	3,251	858	689	284	166	44	17,160
	%	69.2	18.9	5.0	4.0	1.7	1.0	0.3	100.0
	Vehicles: N	11,868	7,387	3,745	5,194	4,025	5,231	4,851	42,301
	%	28.1	17.5	8.9	12.3	9.5	12.4	11.5	100.2
	Mean Size	1.00	2.27	4.36	7.54	14.17	31.51	110.3	2.47

NOTE: The numbers for pre-standard vehicles and fleets may be slightly inaccurate in the three largest size categories due to a computer printing problem.

of such areas is desirable. Cost considerations dictated a maximum of 36 areas for data collection.

The county unit provided the most appropriate geographic basis for the creation of primary sampling units (PSU's). PSU's consisted of one or more whole counties or independent cities. Using counties as units within primary areas permitted stratification by variables published on the county level, whereas zip codes do not have a simple geographical base. Therefore, it was necessary to add a county identification number to each record in the purchaser fleet files, and for this purpose the five-digit state and county code provided in Federal Information Processing System (FIPS) standards was used. A program for converting postal service zip codes to FIPS county codes was prepared and this process was carried out by computer for purchasers whose zip codes were recorded in the purchaser fleet files. Unfortunately, this recording was neither complete nor always accurate, and a large clerical effort was also associated with the task of looking up communities in a zip code directory, checking county assignments to the wrong state, etc. Only 0.6% of the post-standard vehicle purchasers with 0.8% of the post-standard vehicles could not be assigned a county code, but 3.0% of the pre-standard vehicle purchasers with 5.4% of the pre-standard vehicles lacked sufficient information for a county assignment and had to be ignored in the subsequent sampling processes.

Once the FIPS codes were added to the fleet records, the next task was to aggregate the purchaser fleet data by the 3106 counties and independent cities in the contiguous United States. Data entered on each county record included the FIPS code, the county name, the number of pre-standard fleets and vehicles, the number of post-standard fleets and vehicles, the total numbers of fleets and vehicles, the numbers of fleets with 11-50 vehicles, the numbers of fleets with 50+ vehicles, the 1974 county population, and the 1972 county retail gasoline sales.

In then further aggregating the counties and independent cities into PSU's only two of these numbers were used, the number of post-standard vehicles and the number of fleets containing 11 or more post-standard vehicles. In forming the PSU's the minimal size was taken to be at least two fleets with more than 10 post-standard vehicles <u>or</u> at least 200 total post-standard vehicles. Considering the 4.2 to 1 ratio of pre-standard vehicles to post-standard vehicles in the two sample frames, it was thought more important to exert direct control on the sample size for the post-standard vehicles. The relationship of pre- and post-standard vehicle counts was relied on to maintain control on the sample size for the pre-standard vehicles.

The actual process of PSU formation was a large and time-consuming manual task. Outline maps of each of the states were obtained and the two criterion numbers plus the FIPS code were entered for each of the 3,106 counties and independent cities. Then lines were drawn delineating counties and groups of counties which met one or both of the minimum criteria and which were as geographically compact and centered around one major city as feasible. Not surprisingly, there proved to be many vast rural areas containing very few post-standard trucks, and these areas had to be formed into very large PSU's. A total of 187 PSU's were formed. Twenty-five of these contained only one county or independent city, but the average was 16.7 counties, and the largest PSU in terms of number of counties contained 83. Where feasible these PSU's were formed within state boundaries, but 20 were composed of parts of two or more states, including one with parts from five states. The number of large (11+) post-standard purchases in a PSU varied from none (14 PSU's) to 19 (Los Angeles), while the number of post-standard vehicles varied from 99 to 1,042.

The name and FIPS county code for the major county in each PSU were used as the name and identification code for that PSU.

Also, the number of component counties and three stratification characteristics (explained below) were determined for each PSU. These numbers were coded and keypunched into a new complete county file, which indicated to which PSU each county was assigned, and this new file was matched with the old file to add the PSU identification number, the number of counties, and the stratification information to the old county file. Data from this file were then aggregated into a new file containing the 187 PSU's, 36 of which were subsequently selected for the national sample by a controlled probability selection procedure.

The probability of selection of each PSU was directly related to its proportion of the total national listing of post-standard trucks. However, before determining these probabilities, adjustments were made to two sets of PSU's. There were four PSU's which had fewer than 132 post-standard vehicles, and in these PSU's this number was arbitrarily increased to 132. These were Monterey, California (99); San Joaquin, California (107); Allen, Indiana (114); and Erie, Pennsylvania (122). The other adjustment involved halving the numbers of post-standard vehicles in the 15 PSU's with no large (11+) purchases of post-standard vehicles and in the 32 PSU's with only one such fleet. This was done in order to reduce the expected number of large-area PSU's to be selected, because the widely dispersed fleets in these PSU's were expected to make for particularly expensive field data collection costs. By these adjustments the effective total number of post-standard vehicles in the 187 PSU's was reduced from 41,974 to 37,308. Thus the average number of post-standard vehicles per selected PSU was 1,036.111, and the initial selection probability for each PSU was this number divided into the adjusted number of post-standard vehicles in the PSU.

In order to apply the Groves-Hess Controlled Selection Computer Program (CONSEL) the 187 PSU probabilities were further aggregated into a 120-cell matrix using the three previously-coded stratification variables. The first stratification variable was region, and it used the four major regions of the Census Bureau: (1) Northeast; (2) North Central; (3) South; and (4) West. States included in each of these regions are shown in Figure 2.1. The second was a three-category urbanicity variable defined as follows:

1. PSU with at least 60% of total population living in SMSA's and one SMSA county population over 400,000.

2. PSU with at least 60% of total population living in SMSA's and no SMSA county population over 400,000.

3. PSU with less than 60% of population in SMSA's.

The third stratification variable was a ten-category geographic size and post-standard vehicle concentration code defined below, with the number of PSU's in each category shown to the right.

1.	Under 50 mile radius, no large (11+) fleets	N = 1
2.	Over 50 mile radius, no large fleets	N = 14
3.	Under 50 mile radius, one large fleet	N = 9
4.	Over 50 mile radius, one large fleet	N = 23
5.	Under 50 mile radius, two large fleets	N = 30
6.	Over 50 mile radius, two large fleets	N = 53
7.	Under 50 mile radius, three large fleets	N = 16
8.	Over 50 mile radius, three large fleets	N = 6
9.	Four to six large fleets	N = 23
10.	Seven to nineteen large fleets	N = 12

The probability matrix consisted of a combined 12-category region-urbanicity row variable and the ten-category size column variable. However, only 63 of the 120 cells were actually occupied by one or more of the 187 PSU's. These probabilities were summed in each cell and across cells to obtain the row and column marginals. In order to pair selected PSU's in the calculation of sampling error, <u>even</u> numbers of PSU's were selected in each region. Accordingly, it was decided to choose exactly six PSU's each from the Northeast and

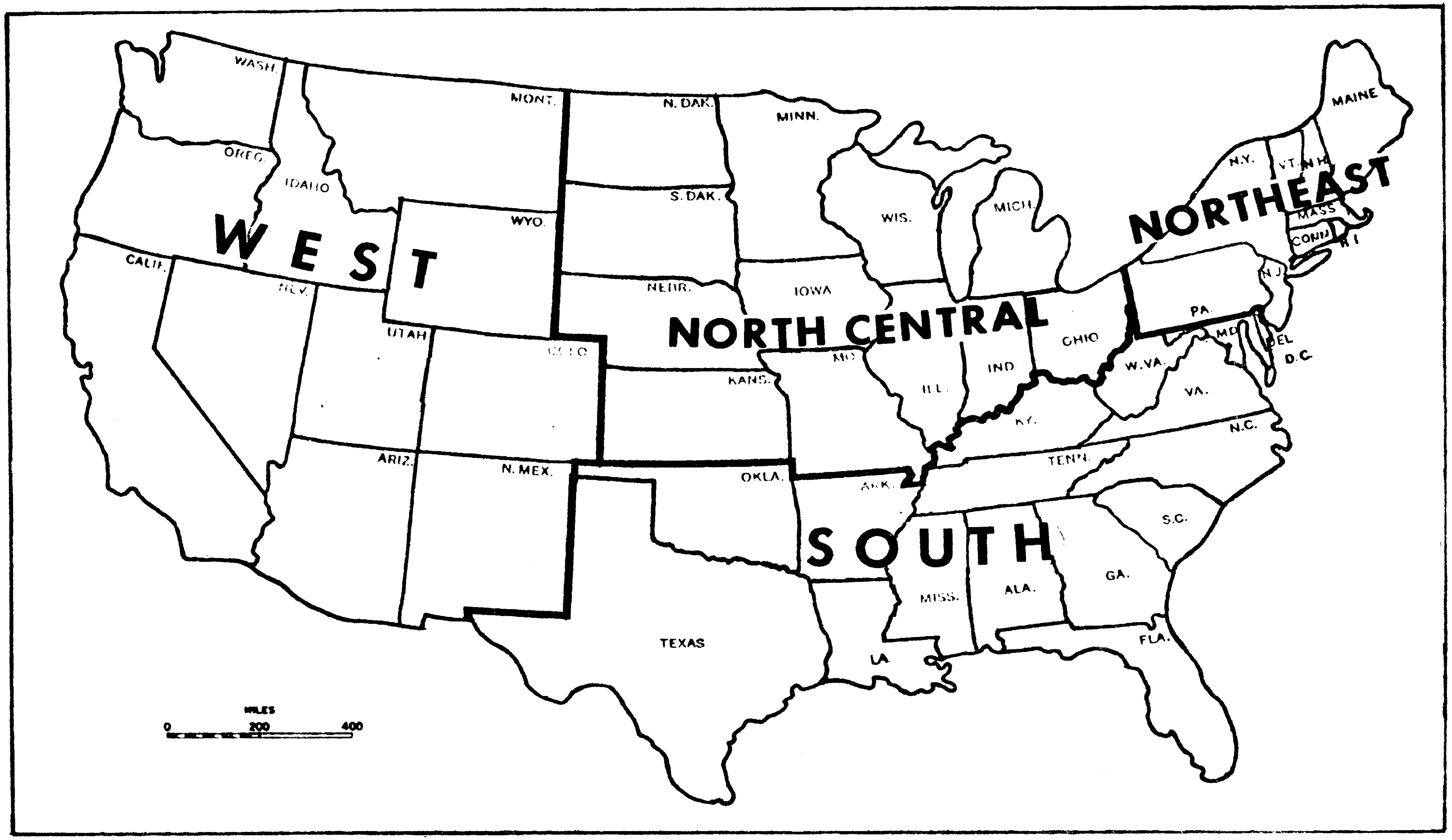


FIGURE 2.1 -- UNITED STATES REGIONAL MAP

West and twelve PSU's each from the North Central region and from the South. Wtihin each region the number of selections from each urbanicity type was also set at an integer number. This led to an adjustment in the cell probabilities in each row by the constant factor necessary to make the sum of the cell probabilities in each row exactly equal to these desired integer row marginals. The adjusted input matrix to the CONSEL program is shown in Table 2.4, along with the adjustment factors used in each row. Naturally these same adjustment factors also affected all of the individual PSU selection probabilities for PSU's within each row (region-urbanicity stratum).

The output from the CONSEL program was a listing of a number of possible patterns of allocation of 36 PSU's to the 63 occupied cells in the matrix. Each listed pattern had a probability weight associated with it, and these weights cumulated to 10,000. A random number between 1 and 10,000 was chosen from a random number table (3944), and this resulted in the choice of allocation pattern 6 which is shown in Table 2.5.

Thus the 36 PSU's were to be selected from the 27 non-empty cells of Pattern 6. If a chosen stratum was composed of more than one PSU, a further selection process was required to select the particular PSU(s) to represent that cell in the national sample. As a preliminary step the numbers of post-standard vehicles for the PSU's in each selected cell were cumulated for all the PSU's in that cell in order to permit a random choice among eligible PSU's in proportion to other PSU's number of post-standard vehicles. The cell PSU selections were then made in the following manner.

1. If there was only one PSU in a one-selection stratum or if there were only two PSU's in a two-selection stratum, these PSU's were of course selected with certainty.

2. If all of the PSU's in a selected stratum were from the same state, the choice among these PSU's was made by a controlled

TABLE 2.4

INPUT MATRIX OF ADJUSTED SELECTION PROBABILITIES FOR 120 STRATA, WITH ADJUSTMENT FACTORS USED TO CHANGE THE ORIGINAL MATRIX

REGION: URBANICITY	SIZE CATEGORY										TOTAL	ADJUSTMENT FACTOR
	1	2	3	4	5	6	7	8	9	10		
NORTHEAST: 1	0.1013	0.0	0.2699	0.0	0.4367	0.1723	1.1699	0.2082	0.4496	1.1921	4.0000	0.95449
2	0.0	0.0	0.0793	0.0	0.4211	0.2632	0.2364	0.0	0.0	0.0	1.0000	0.79026
3	0.0	0.0817	0.0	0.1600	0.2953	0.4630	0.0	0.0	0.0	0.0	1.0000	0.88183
NORTHCENTRAL: 1	0.0	0.0	0.0	0.0	1.1380	0.0	0.8548	0.0	1.8513	2.1559	6.0000	1.11133
2	0.0	0.0	0.0957	0.0951	1.1034	0.2054	0.1329	0.0	0.3675	0.0	2.0000	1.04314
3	0.0	0.6768	0.1779	0.2755	0.3731	2.1510	0.0	0.3457	0.0	0.0	4.0000	0.94516
SOUTH: 1	0.0	0.0	0.0889	0.0729	0.8874	0.2824	0.1877	0.1581	2.1510	1.1716	5.0000	0.92593
2	0.0	0.2586	0.0	0.0	0.1260	0.9457	0.1229	0.0	0.5468	0.0	2.0000	0.80583
3	0.0	0.2025	0.0933	1.1617	0.0	3.1277	0.0	0.0	0.1739	0.0	5.0000	1.00640
WEST: 1	0.0	0.0	0.0	0.0	0.2097	1.2609	0.4315	0.0	0.5396	1.5583	4.0000	1.12042
2	0.0	0.0	0.0	0.1650	0.2682	0.4327	0.0	0.1341	0.0	0.0	1.0000	1.05241
3	0.0	0.1610	0.0	0.5542	0.0	0.2848	0.0	0.0	0.0	0.0	1.0000	2.03583
TOTAL	0.1013	1.3806	0.8050	2.4844	5.2589	9.5891	3.1361	1.0870	6.0797	6.0779	36.0000	---

TABLE 2.5

PSU ALLOCATION PATTERN 6, SHOWING THE NUMBER OF PSUs TO BE SELECTED FROM EACH OF 120 STRATA

Region: Urbanicity	SIZE CATEGORY										TOTAL
	1	2	3	4	5	6	7	8	9	0	
NORTHEAST: 1	0	0	1	0	0	0	1	0	1	1	4
2	0	0	0	0	0	1	0	0	0	0	1
3	0	1	0	0	0	0	0	0	0	0	1
NORTH CENTRAL: 1	0	0	0	0	1	0	1	0	2	2	6
2	0	0	0	0	1	0	1	0	0	0	2
3	0	0	0	0	1	3	0	0	0	0	4
SOUTH: 1	0	0	0	0	1	0	0	1	2	1	5
2	0	0	0	0	0	1	0	0	1	0	2
3	0	1	0	1	0	3	0	0	0	0	5
WEST: 1	0	0	0	0	0	2	0	0	0	2	4
2	0	0	0	0	1	0	0	0	0	0	1
3	0	0	0	1	0	0	0	0	0	0	1
TOTAL	0	2	1	2	5	10	3	1	6	6	36

probability procedure such that each PSU's chance of selection was equal to its proportion of the total stratum number of post-standard vehicles.

3. For the remaining selected strata within each region a new Controlled Selection process was used to allocate the selections among the various states in the region. In the Northeast this involved a 4 x 5 matrix using one-decimal place probabilities to allocate four selections among four strata. Seven possible patterns were generated, and Pattern 2 was randomly chosen. In the North Central region a 7 x 10 matrix using one-decimal place probabilities was input into the CONSEL program in order to allocate 11 selections among 7 strata. Ten possible patterns were generated, and Pattern 2 was chosen by random number. In the South an 8 x 17 matrix using two-decimal place probabilities was utilized to allocate 11 selections among 9 strata. Twenty-four possible patterns were generated, and Pattern 8 was selected by random number. This resulted in selections being spread among ten states, but 6 of the 7 non-chosen states are part of the South Atlantic sub-region. In the West it was apparent that the four non-determined selections were sure to be spread among three or four states, so the controlled selection program was not used. There the choice in each stratum was made by random number, and in the two-selection stratum the stratum was divided in half and the same random number was used with each half.

4. For the strata entered in the CONSEL program the chosen pattern determined which states within a stratum were to be allocated a PSU. If there was only one PSU from that state in a stratum, then that PSU was automatically chosen. If there was more than one PSU from that state in the stratum, then a choice was made among them by means of the random number procedure.

The 36 chosen PSU's are shown on the map in Figure 2.2 and

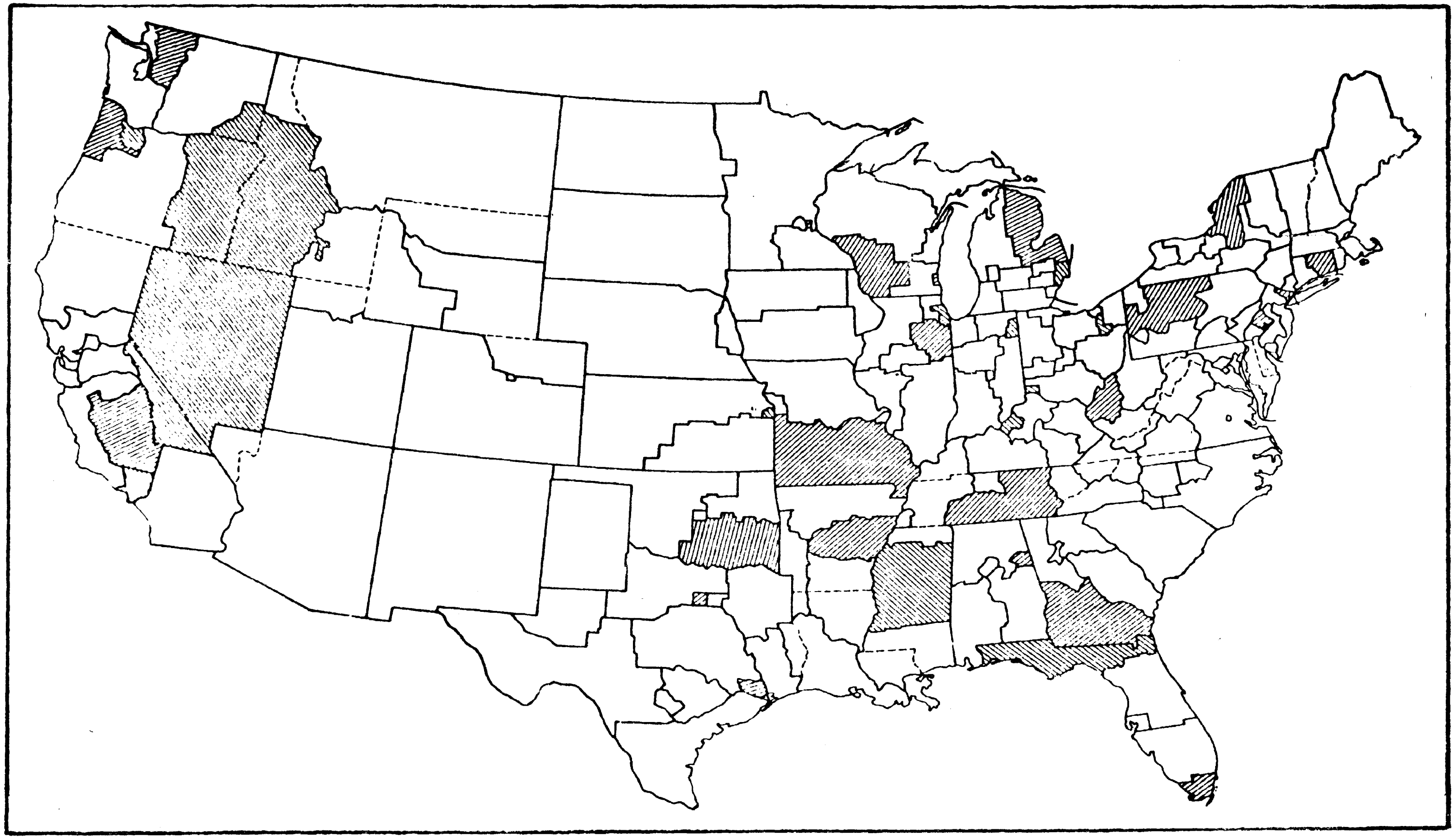


FIGURE 2.2 -- MAP OF THE 187 POTENTIAL PSU'S WITH THE 36 SELECTED PSU'S SHADED IN GRAY

are listed in Table 2.6 with their individual selection probabilities, numbers of pre- and post-standard vehicles, etc. Nine of the selected PSU's consisted of only one county, while one large selected PSU contained 61 counties (Southern Missouri), and the average was 13.2. Only 6 of the 47 PSU's whose probabilities were reduced due to lack of large post-standard fleets were selected in the sample.

The selected PSU's compose 19.3% of all of the PSU's and contain 15.3% of the counties and independent cities and 21.8% of the population of the contiguous United States. As can be seen in the bottom row of Table 2.6, they contain very similar percentages of the total county-determined pre- and post-standard vehicles, 24.5% and 25.0%. So the first stage in the sampling process reduced the number of vehicles eligible for selection in the study to about one quarter of the original master frame.

2.3 Fleet Selection

Before choosing particular purchaser fleets for participation in the evaluation study, a further consolidation of the year-specific and manufacturer-specific purchaser lists was carried out in the 36 selected PSU's. This consolidation was aimed at making it more likely that both pre- and post-standard vehicles would be chosen from the same purchaser, thus reducing field contact costs, than if the purchaser selections had been made from the uncombined lists.

The consolidation procedure involved creating a new file for each PSU which listed all of the purchases from the various manufacturers' lists of either pre- or post-standard vehicles. These new files were printed and the lists were checked visually for more than one instance of the same purchaser. When the records showed two or more purchases by the same purchaser, a correction card was made which combined all the purchase data for one purchaser into a single record. This consolidation process was

TABLE 2.6

PRE-STANDARD AND POST-STANDARD VEHICLES AND SELECTION PROBABILITIES
IN THE 36 SELECTED PSUs COMPARED TO ALL PSUs

Area Number	Area Name	Number of Counties	Pre-standard Purch.	Pre-standard Vehs.	Post-standard Purch.	Post-standard Vehs.	Total Purch.	Total Vehs.	Post-standard Large (11+) Purchasers	Adjusted Post-standard Vehicles	Selection Probability
01	Paterson, New Jersey	3	463	1361	119	200	582	1561	1	95	.0917
02	Hartford, Connecticut	5	311	592	93	223	404	815	3	213	.2055
03	Norristown, Pennsylvania	2	383	852	95	232	478	1084	4	221	.2133
04	Philadelphia, Pennsylvania	1	269	1052	80	481	349	1533	10	459	.4429
11	Upstate New York	6	286	484	67	132	353	616	2	104	.1004
12	Northwest Pennsylvania	18	963	1379	153	192	1116	1571	0	85	.0820
21	Akron, Ohio	2	385	1800	91	225	476	2025	2	250	.2412
22	Milwaukee, Wisconsin	1	281	846	54	182	335	1028	3	202	.1949
23	Mt. Clemens, Michigan	2	231	645	63	186	294	831	4	207	.1997
24	Cincinnati, Ohio	1	236	882	72	255	308	1137	5	283	.2731
25	Chicago, Illinois	1	1324	3905	249	634	1573	4539	8	705	.6803
26	St. Paul, Minnesota	1	226	882	72	255	308	1137	5	283	.3040
31	Olathe, Kansas	1	71	743	7	347	78	1090	2	362	.3493
32	Fort Wayne, Indiana	2	197	1282	28	114	225	1396	3	138	.1332
41	Kankakee, Illinois	8	365	507	60	169	425	676	2	160	.1544
42	Saginaw, Michigan	19	488	814	84	286	572	1100	2	270	.2605
43	Southern Missouri	61	865	1330	131	210	996	1540	2	198	.1911
44	Madison, Wisconsin	16	481	989	99	205	580	1194	2	194	.1872
51	Louisville, Kentucky	5	249	523	67	148	316	671	2	137	.1322

TABLE 2.6--Continued

Area Number	Area Name	Number of Counties	Pre-standard Purch.	Pre-standard Vehs.	Post-standard Purch.	Post-standard Vehs.	Total Purch.	Total Vehs.	Post-standard Large (11+) Purchasers	Adjusted Post-standard Vehicles	Selection Probability
52	North Florida	25	605	1523	89	177	694	1700	3	164	.1583
53	Miami, Florida	2	310	4154	67	1042	377	5196	4	965	.9312
54	Fort Worth, Texas	1	296	724	77	271	373	995	6	251	.2422
55	Houston, Texas	1	975	2625	229	710	1204	3335	10	657	.6340
61	Charleston, West Virginia	11	265	440	83	179	348	619	2	144	.1390
62	Anniston, Alabama	2	105	501	51	272	156	773	5	219	.2113
71	South Georgia	60	469	837	90	214	559	1051	0	108	.1042
72	Little Rock, Arkansas	19	599	952	100	206	699	1158	1	104	.1004
73	Central Mississippi	49	909	1529	122	179	1031	1708	2	180	.1737
74	Southeast Oklahoma	26	311	639	48	174	359	813	2	175	.1689
75	Chattanooga, Tennessee	47	559	946	102	171	661	1117	2	172	.1660
81	Fresno, California	4	496	885	114	194	610	1079	2	217	.2094
82	Seattle, Washington	6	317	564	111	214	428	778	2	240	.2316
83	Los Angeles, California	1	1237	3184	252	882	1489	4066	19	988	.9534
84	Portland, Oregon	2	358	1203	133	559	491	1762	9	626	.6041
91	Salem, Oregon	9	263	527	46	132	309	659	2	139	.1341
92	Idaho-Nevada	55	519	731	109	201	628	932	1	206	.1988
	36 Selected PSUs	475	16667	42911	3473	10481	20140	53392	137	10153	--
	All PUSs	3106	81244	175210	17055	41974	98299	217184	480	37307	--
	Selected PUSs: % of Total	15.3	20.5	24.5	20.4	25.0	20.5	24.6	28.1	27.2	--

carried out in each of the 36 selected PSU's, and, as shown in Table 2.7, it resulted in a 20.3% reduction in the number of purchaser fleets available for selection in the 36 PSU's--from 20,240 to 16,051. This consolidation process also provided a fairly thorough checking of the vehicle and purchaser assignments in the 36 PSU's, and this resulted in some changes in the number of eligible vehicles in most of the PSU's. Overall the number of pre-standard vehicles in the 36 PSU's changed from 42,911 to 44,381, a 3.4% increase; while the number of post-standard vehicles changed from 10,481 to 10,109, a 3.5% decrease.

Table 2.7 also demonstrates that only a small proportion of the purchaser fleets were joint fleets containing both pre- and post-standard vehicles. Over four fifths of the listed fleets in the 36 PSU's contained only pre-standard vehicles, while about one eighth contained only post-standard vehicles, and only 7.2% contained both types of vehicles. These joint fleets, and also large sized fleets, were substantially over-sampled to reduce field costs. Table 2.8 shows the distribution of all fleets and vehicles in the 36 PSU's in 16 different cells of a matrix based on four size categories of the number of pre-standard vehicles in a fleet and on four size categories of the number of post-standard vehicles in the fleet.

This distribution matrix was used to try out different sets of cell selection probabilities with the goal of determining a set of cell probabilities which would provide a sufficient number of study vehicles from a limited number of fleets with "too large" a difference between the largest and smallest probabilities in the set. The final set of cell selection probabilities decided upon is shown in Table 2.9. These probabilities provide that most joint fleets be selected with twice the probabilities of post-standard only fleets containing similar numbers of post-standard vehicles, and within the joint fleets, large joint fleets (Cells 7-8, 10-12) have twenty times as large a chance of selection as

TABLE 2.7

EFFECT OF COMBINING PRE-STANDARD AND POST-STANDARD PURCHASES ACROSS MANUFACTURERS AND DISTRITUION OF PRE- ONLY, POST- ONLY, AND JOINT PRE- AND POST- FLEETS, BY PSU

AREA NUMBER	AREA NAME	UNCOMBINED PURCHASERS	COMBINED PURCHASERS	PERCENT REDUCTION	PRE- ONLY FLEETS		POST- ONLY FLEETS		JOINT FLEETS	
					N	%	N	%	N	%
01	Paterson, New Jersey	582	485	16.7	378	77.9	73	15.1	34	7.0
02	Hartford, Connecticut	404	310	23.3	228	73.5	48	15.5	34	11.0
03	Norristown, Pennsylvania	478	384	19.7	297	77.3	54	14.1	33	8.6
04	Philadelphia, Pennsylvania	349	225	35.5	158	70.2	42	18.7	25	11.1
11	Upstate New York	353	307	13.0	243	79.2	39	12.7	25	8.1
12	Northwest Pennsylvania	1116	961	13.9	810	84.3	105	10.9	46	4.8
21	Akron, Ohio	476	351	26.3	273	77.8	34	9.7	44	12.5
22	Milwaukee, Wisconsin	335	227	47.6	182	80.2	20	8.8	25	11.0
23	Mt. Clemens, Michigan	294	209	40.7	155	74.2	25	12.0	29	13.9
24	Cincinnati, Ohio	308	242	21.4	176	72.7	49	20.2	17	7.0
25	Chicago, Illinois	1573	1145	27.2	922	80.5	130	11.4	93	8.1
26	St. Paul, Minnesota	264	156	40.9	122	78.2	16	10.3	18	11.5
31	Olathe, Kansas	78	64	21.9	57	89.1	5	7.8	2	3.1
32	Fort Wayne, Indiana	225	150	50.0	125	83.3	11	7.3	14	9.3
41	Kankakee, Illinois	425	358	15.8	299	83.5	36	10.1	23	6.4
42	Saginaw, Michigan	572	464	18.9	388	83.6	42	9.1	34	7.3
43	Southern Missouri	996	887	12.3	759	85.6	86	9.7	42	4.7
44	Madison, Wisconsin	580	462	25.5	368	79.7	65	14.1	29	6.3
51	Louisville, Kentucky	316	241	23.7	179	74.3	32	13.3	30	12.4
52	North Florida	694	557	19.7	475	85.3	50	9.0	32	5.7
53	Miami, Florida	377	230	39.0	181	78.7	26	11.3	23	10.0
54	Fort Worth, Texas	373	279	25.2	217	77.8	38	13.6	24	8.6
55	Houston, Texas	1204	918	23.8	716	78.0	126	13.7	76	8.3
61	Charleston, West Virginia	348	268	23.0	194	72.4	42	15.7	32	11.9
62	Anniston, Alabama	156	124	20.5	73	58.9	29	23.4	22	17.7
71	South Georgia	559	440	21.3	356	80.9	38	8.6	46	10.5
72	Little Rock, Arkansas	699	606	13.3	514	84.8	64	10.6	28	4.6
73	Central Mississippi	1031	868	15.8	751	86.5	69	7.9	48	5.5
74	Southeast Oklahoma	359	318	11.4	273	85.8	34	10.7	11	3.5
75	Chattanooga, Tennessee	661	579	12.4	482	83.2	68	11.7	29	5.0
81	Fresno, California	610	536	12.1	426	79.5	83	15.5	27	5.0
82	Seattle, Washington	428	359	16.1	264	73.5	69	19.2	26	7.2
83	Los Angeles, California	1489	1142	23.3	920	80.6	142	12.4	80	7.0
84	Portland, Oregon	491	400	18.5	273	68.3	105	26.3	22	5.5
91	Salem, Oregon	309	268	13.3	224	83.6	36	13.4	8	3.0
92	Idaho-Nevada	628	531	15.4	425	80.0	79	14.9	27	5.1
	TOTAL	20140	16051	20.3	12883	80.3	2010	12.5	1158	7.2

TABLE 2.8

DISTRIBUTION OF ELIGIBLE FLEETS AND VEHICLES IN THE 36 SELECTED PSU'S IN RELATION TO FOUR SIZE CATEGORIES OF PRE-STANDARD AND POST-STANDARD VEHICLES, WITH PERCENTAGES IN ITALICS

Number of Pre-Standard Vehicles in Fleet		Number of Post-Standard Vehicles in Fleet: 0	1-5		6-50	51+	TOTAL
0			CELL 5		CELL 9	CELL 13	
	Fleets		1917 *(11.9)*		91 *(0.6)*	2 *(0.0)*	2010 *(12.5)*
	Pre-Vehicles		--		--	--	--
	Pre-Mean		--		--	--	--
	Post-Vehicles		2567 *(25.4)*		976 *(9.7)*	256 *(9.7)*	3799 *(37.6)*
	Post-Mean		1.34		10.73	123.00	1.89
1-5		CELL 2	CELL 17*	CELL 6*	CELL 10	CELL 14	
	Fleets	12189 *(75.9)*	591 *(3.7)*	142 *(0.9)*	45 *(0.3)*	1 *(0.0)*	12968 *(80.8)*
	Pre-Vehicles	16942 *(38.2)*	1000 *(2.3)*	562 *(1.3)*	132 *(0.3)*	1 *(0.0)*	18637 *(42.0)*
	Pre-Mean	1.39	1.69	3.25	2.93	1.00	1.44
	Post-Vehicles	--	797 *(7.9)*	425 *(4.2)*	490 *(4.8)*	56 *(0.6)*	1768 *(17.5)*
	Post-Mean	--	1.35	2.99	10.89	56.00	0.14
6-50		CELL 3	CELL 7		CELL 11	CELL 15	
	Fleets	660 *(4.1)*	196 *(1.2)*		138 *(0.9)*	2 *(0.0)*	996 *(6.2)*
	Pre-Vehicles	7722 *(17.4)*	2690 *(6.1)*		2409 *(5.4)*	63 *(0.1)*	12884 *(29.0)*
	Pre-Mean	11.70	13.72		17.46	81.50	12.94
	Post-Vehicles	--	517 *(5.1)*		1787 *(17.7)*	127 *(1.3)*	2431 *(24.0)*
	Post-Mean	--	2.64		12.95	63.60	2.44
51+		CELL 4	CELL 8		CELL 12	CELL 16	
	Fleets	34 *(0.2)*	13 *(0.1)*		21 *(0.1)*	9 *(0.1)*	77 *(0.5)*
	Pre-Vehicles	4079 *(9.2)*	1459 *(3.3)*		2394 *(5.4)*	4928 *(11.1)*	12860 *(29.0)*
	Pre-Mean	119.97	112.23		114.00	547.56	167.01
	Post-Vehicles	--	36 *(0.4)*		493 *(4.9)*	1582 *(15.6)*	2111 *(20.9)*
	Post-Mean	--	2.77		23.48	175.78	27.42
TOTAL	Fleets	12883 *(80.3)*	2859 *(17.8)*		295 *(1.8)*	14 *(0.1)*	16051 *(100.0)*
	Pre-Vehicles	28743 *(64.8)*	5711 *(12.9)*		4935 *(11.1)*	4992 *(11.2)*	44381 *(100.0)*
	Pre-Mean	2.23	2.00		16.73	356.57	2.76
	Post-Vehicles	--	4342 *(43.0)*		3741 *(37.1)*	2021 *(20.0)*	10109 *(100.0)*
	Post-Mean	--	1.52		12.70	144.36	0.63

*Cell 17 contains joint fleets with between one and five pre-standard vehicles and between one and five post-standard vehicles and which have a total size of 2, 3, 4, or 5. Cell 6 contains similar fleets whose total size is 6, 7, 8, 9, or 10.

TABLE 2.9

FLEET SELECTION PROBABILITIES USED IN THE SELECTION OF FLEETS FROM DIFFERENT FLEET SIZE CELLS IN THE 36 PSUs

NUMBER OF PRE-STANDARD VEHICLES IN FLEET	NUMBER OF POST-STANDARD VEHICLES IN FLEET: 0	1-5	6-50	51+
0		CELL 5 $\frac{.00661}{P_i}$	CELL 9 $\frac{.0661}{P_i}$	CELL 13 $\frac{N_2}{50} \times \frac{.0661}{P_i}$
1-5	CELL 2 $\frac{.00661}{3.82\ P_i}$	CELL 17* $\frac{.00661}{P_i}$ / CELL 6* $\frac{.0661}{P_i}$	CELL 10 $\frac{.1322}{P_i}$	CELL 14 $\frac{N_2}{50} \times \frac{.1322}{P_i}$
6-50	CELL 3 $\frac{.0661}{3.82\ P_i}$	CELL 7 $\frac{.1322}{P_i}$	CELL 11 $\frac{.1322}{P_i}$	CELL 15 $\frac{N_2}{50} \times \frac{.1322}{P_i}$
51+	CELL 4 $\frac{N_2}{50} \times \frac{.0661}{3.82\ P_i}$	CELL 8 $\frac{.1322}{P_i}$	CELL 12 $\frac{.1322}{P_i}$	CELL 16 $\frac{N_2}{50} \times \frac{.1322}{P_i}$

P_i = Probability of selection of the PSU (see Table 2.6).
N_1 = Number of Pre-Standard vehicles in the fleet.
N_2 = Number of Post-Standard vehicles in the fleet.

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*Cell 17 contains joint fleets with between one and five pre-standard vehicles and between one and five post-standard vehicles and which have a total size of 2-5. Cell 6 contains similar fleets whose total size is 6-10.

that of very small joint fleets (Cell 17). Also, due to the much larger number of pre-standard only fleets compared to post-standard only fleets, and due to the desire to choose roughly equal numbers of pre- and post-standard vehicles for inclusion in the study, post-standard only fleets were given a selection probability 3.82 times as great as similar-sized pre-standard only fleets. It will be noted that for Cells 2-3, 5-12, and 17 the probabilities within one PSU are constant for all fleets assigned to a particular cell. However, for pre-standard only fleets containing more than 50 vehicles (Cell 4) and for all fleets containing more than 50 post-standard vehicles (Cells 13-16) the selection probability is fleet-specific, depending on the size of N_1 and N_2 respectively.

Before applying these probabilities in Table 2.9 to the actual selection of fleets, the fleets within each PSU list were sorted in the following manner. First, all fleets with no post-standard vehicles were sorted in ascending order by number of pre-standard vehicles. Then all fleets with one post-standard vehicles were sorted in descending order by number of pre-standard vehicles. Then all fleets with two post-standard vehicles were sorted in ascending order by number of pre-standard vehicles. This process was continued, alternating descending and ascending order for number of pre-standard vehicles while always ascending on number of post-standard vehicles, until the entire list of fleets had been ordered. Then the individual selection probability for each fleet on the list was determined (on the basis of its cell selection probability but treating P_i as a constant .1322), and these individual probabilities were cumulated throughout the entire list. Finally, the selection interval was determined for each PSU by dividing .1322 into the PSU selection probability; a random number less than this interval was found; the fleet whose cumulative total first included this random number was chosen as the first selection; the PSU interval was added to the random start number in order to choose the fleet whose cumulative total first included this second number; and this process of adding the PSU interval and selecting the appropriate fleets based on the cumulative totals was continued throughout the PSU fleet list.

It should be noted that due to a programming error the purchaser identification number was partially or completely destroyed on the PSU fleet listing on which the selections were made. For some selected fleets the purchaser name and address fields were also blank on this listing. In these cases it was necessary to go back to the PSU initial combined purchaser list and to seek a purchaser with the same numbers of pre- and post-standard vehicles as the unidentified selected fleet. If there was more than one purchaser who matched the selected fleet on these numbers, then a random choice was made among these matching candidates.

This process resulted in the selection of 554 purchaser fleets in the 36 PSU's, an average of about 15 per PSU. However, the variation in number of selected fleets was very large, from only two in Olathe, Kansas, to 43 in Northwest Pennsylvania. There were three selected fleets which were so large that their cumulative totals included two selection numbers. There were also five PSU's where some fleets were double-selected because the PSU selection probability was less than .1322, resulting in an interval of less than 1.00. Since all fleets in Cells 7 and 8, and 10 to 16 had selection probabilities of 1.00 or more, it is not surprising that 17 fleets in these five PSU's ended up being double-selected and their vehicles are weighted accordingly in the data analysis.

2.4 Vehicle Selection

For fleets with from 1 to 50 post-standard vehicles (Cells 5-12 and 17) the vehicle selection process was quite straightforward. It involved simply selecting all post-standard vehicles and 1/3.82 of the pre-standard vehicles in these fleets. Similarly for pre-standard only fleets with from 1 to 50 vehicles (Cells 2 and 3) all vehicles in these fleets were automatically selected (the 3.82 factor having been applied to the original fleet selection).

However, for fleets with more than 50 post-standard vehicles (Cells 13-16) and for pre-standard only fleets with more than 50 vehicles (Cell 4) individual vehicle selection probabilities had to be worked out in relation to the numbers of eligible vehicles. This was because it was considered desirable in these large fleets to try to limit the number of selected vehicles of one type to about 50 in order not to place too great a burden on the selected company and also so as to not concentrate the study vehicles too much in a few large fleets. Accordingly, in these large fleets a selection interval was determined individually for each fleet which would provide 50 post-standard vehicles (50 pre-standard vehicles for Cell 4), and this same interval was multiplied by 3.82 for the selection of pre-standard vehicles from fleets in Cells 14-16. These cell vehicle selection probabilities are summarized in Table 2.10.

For the three very large double-selected fleets the vehicle selection probabilities were doubled to $\frac{100}{(N_2)(3.82)}$ and $\frac{100}{N_2}$ rather than doubling the weight of each selected vehicle. This led to the selection of 105 pre-standard and 100 post-standard vehicles from the biggest company. However, this doubling of the vehicle selection probabilities could not be applied to the 17 double-selected fleets in the five PSU's with a selection probability less than .1322, because in these fleets all of the post-standard vehicles were already selected with certainty. Thus the vehicles in these fleets are double-weighted.

In order to determine the VIN numbers of the eligible vehicles in the selected fleets, it was necessary to go back to the manufacturers' model-specific lists. The uncombined purchaser list for each PSU was studied to obtain the individual manufacturers'

TABLE 2.10

PRE-STANDARD AND POST-STANDARD VEHICLE SELECTION PROBABILITIES
USED IN THE SELECTION OF VEHICLES FROM SELECTED FLEETS
FROM DIFFERENT FLEET SIZE CELLS IN THE 36 PSU'S

NUMBER OF PRE-STANDARD VEHICLES IN FLEET		NUMBER OF POST-STANDARD VEHICLES IN FLEET: 0	1-5	6-50	51+
0	Pre-Standard Vehicles		CELL 5 --	CELL 9 --	CELL 13 --
	Post-Standard Vehicles		1.00	1.00	$\frac{50}{N_2}$
1-5	Pre-Standard Vehicles	CELL 2 1.00	CELL 17* $\frac{1}{3.82}$ ¦ CELL 6* $\frac{1}{3.82}$	CELL 10 $\frac{1}{3.82}$	CELL 14 $\frac{50}{(N_2)(3.82)}$
	Post-Standard Vehicles	--	1.0 ¦ 1.00	1.00	$\frac{50}{N_2}$
6-50	Pre-Standard Vehicles	CELL 3 1.0	CELL 7 $\frac{1}{3.82}$	CELL 11 $\frac{1}{3.82}$	CELL 15 $\frac{50}{(N_2)(3.82)}$
	Post-Standard Vehicles	--	1.00	1.00	$\frac{50}{N_2}$
51+	Pre-Standard Vehicles	CELL 4 $\frac{50}{N_1}$	CELL 8 $\frac{1}{3.82}$	CELL 12 $\frac{1}{3.82}$	CELL 16 $\frac{50}{(N_2)(3.82)}$
	Post-Standard Vehicles	--	1.00	1.00	$\frac{50}{N_2}$

N_1 = Number of Pre-Standard Vehicles in the fleet.
N_2 = Number of Post-Standard Vehicles in the fleet.

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*Cell 17 contains joint fleets with between one and five pre-standard vehicles and between one and five post-standard vehicles and which have a total size of 2-5. Cell 6 contains similar fleets whose total size is 6-10.

components of the vehicle totals for the selected fleets, and these components were listed by purchaser identification number on a separate form for each fleet. Then the vehicles belonging to these particular purchasers were retrieved from the manufacturers' vehicle tapes on a computer listing. These tape listings, or the White computer printout, were then used to select the appropriate fraction of pre- and post-standard vehicles depending on the cell location of the particular fleet. When a fractional selection of a particular vehicle list was to be made, a systematic selection procedure was followed by making the first selection on the basis of a random number less than the interval and then consecutively adding the interval to make the next selection until the eligible vehicle list was exhausted. The VIN numbers of the selected vehicles were then transcribed onto a form for use in contacts with the selected purchasers. In the case of selected purchasers of Freightliner vehicles a list of these purchasers had to be sent to Freightliner in order to obtain the VIN numbers of the eligible vehicles, since Freightliner had only provided aggregated purchaser data to HSRI initially.

This vehicle selection procedure resulted in the selection of 2,690 pre-standard and 2,708 post-standard vehicles from the 554 selected purchaser fleets in the 36 selected PSU's. A comparison of the numbers of eligible fleets and vehicles and actually selected fleets and vehicles in each PSU is given in Table 2.11. The distribution of the selected fleets and vehicles by cell in the fleet size matrix is given in Table 2.12. It can be seen that about 59% (unweighted) of the selected pre-standard vehicles and 88% of the selected post-standard vehicles come from the 53% of the fleets which are joint (Cells 6-8, 10-12, 14-17), while 51% of the selected pre-standard vehicles and 34% of the selected post-standard vehicles come from the 7% of the fleets which have at least 51 vehicles of one type (Cells 4, 8, 12-16).

TABLE 2.11

ELIGIBLE FLEETS AND VEHICLES AND SELECTED FLEETS AND VEHICLES IN THE 36 PSUs

Area Number	Area Name	Eligible Fleets	Total Eligible Vehicles	Mean No. of Vehicles	Selected Fleets	Eligible Veh. in Selected Fleets	Mean No. of Eligible Vehicles	Selected Vehicles Pre-	Selected Vehicles Post-	Selected Vehicles Total
01	Paterson, New Jersey	485	1589	3.28	31	635	20.48	221	88	309
02	Hartford, Connecticut	310	833	2.69	11	186	16.91	26	82	108
03	Norristown, Pennsylvania	384	1177	3.07	18	314	17.44	100	84	184
04	Philadelphia, Pennsylvania	225	1588	7.06	8	517	64.63	112	92	204
11	Upstate New York	307	637	2.07	16	143	8.94	36	42	78
12	Northwest Pennsylvania	961	1762	1.83	43	347	8.07	123	41	164
21	Akron, Ohio	351	2036	5.80	18	891	41.5	123	65	188
22	Milwaukee, Wisconsin	227	1038	4.57	15	450	30.00	95	69	164
23	Mt. Clemens, Michigan	209	745	3.56	14	285	20.36	55	85	140
24	Cincinnati, Ohio	242	1171	4.84	9	106	11.78	17	61	78
25	Chicago, Illinois	1145	4966	4.34	17	382	22.47	120	99	219
26	St. Paul, Minnesota	156	1279	8.20	7	299	42.71	38	94	132
31	Olathe, Kansas	64	1099	17.17	2	877	438.50	71	100	171
32	Fort Wayne, Indiana	150	1391	9.27	15	875	58.33	185	76	261
41	Kankakee, Illinois	358	654	1.83	11	157	14.27	25	64	89
42	Saginaw, Michigan	464	1008	2.17	15	122	8.13	28	48	76
43	Southern Missouri	887	1570	1.77	17	241	14.18	63	57	120
44	Madison, Wisconsin	462	1195	2.59	14	438	31.29	114	93	207
51	Louisville, Kentucky	241	755	3.13	23	319	13.87	78	91	169
52	North Florida	557	1686	3.03	22	528	24.00	154	68	222
53	Miami, Florida	230	5259	22.87	4	4115	1028.80	120	114	234
54	Fort Worth, Texas	279	1058	3.79	12	264	22.00	54	112	166
55	Houston, Texas	918	3274	3.57	14	254	18.14	80	83	163
61	Charleston, West Virginia	268	629	2.35	18	179	9.94	29	86	115
62	Anniston, Alabama	124	773	6.23	17	269	15.82	45	128	173
71	South Georgia	440	1051	2.39	33	306	9.27	74	93	167
73	Central Mississippi	868	1734	2.00	22	177	8.05	66	35	101
74	Southeast Oklahoma	318	826	2.60	7	361	51.57	64	109	173
75	Chattanooga, Tennessee	579	1145	1.98	20	182	9.10	54	58	112
81	Fresno, California	536	1089	2.03	11	63	5.73	17	28	45
82	Seattle, Washington	359	789	2.20	10	90	9.00	25	33	58
83	Los Angeles, California	1142	4181	3.66	10	211	21.10	81	59	140
84	Portland, Oregon	400	1795	4.49	7	521	74.43	71	79	150
91	Salem, Oregon	268	604	2.25	8	154	19.25	49	72	121
92	Idaho-Nevada	531	946	1.78	12	106	8.83	26	34	60
	Total 36 PSUs	**16051**	**54490**	**3.39**	**554**	**15595**	**28.15**	**2690**	**2708**	**5398**

TABLE 2.12

DISTRIBUTION OF SELECTED FLEETS AND VEHICLES (UNWEIGHTED AND WEIGHTED) IN THE 36 SELECTED PSU'S IN RELATION TO FLEET SIZE CELL, WITH PERCENTAGES IN *ITALICS*

NUMBER OF PRE-STANDARD VEHICLES IN FLEET		NUMBER OF POST-STANDARD VEHICLES IN FLEET: 0	1-5		6-50	51+	TOTAL
0			CELL 5		CELL 9	CELL 13	
	Fleets: Unwtd.		64 *(11.6)*		24 *(4.3)*	0	88 *(15.9)*
	Wtd.		1280 *(11.3)*		48 *(0.4)*	0	1328 *(11.7)*
	Pre Vehs: Unwtd.		0		0	0	0
	Wtd.		0		0	0	0
	Post Vehs: Unwtd.		82 *(3.0)*		249 *(9,2)*	0	331 *(12.2)*
	Wtd.		1640 *(29.9)*		498 *(9.1)*	0	2138 *(38.9)*
1-5		CELL 2	CELL 17*	CELL 6*	CELL 10	CELL 14	
	Fleets: Unwtd.	111 *(20.6)*	27 *(4.9)*	42 *(7.6)*	19 *(3.4)*	0	202 *(36.5)*
	Wtd.	8709 *(77.0)*	540 *(4.8)*	84 *(0.7)*	21 *(0.2)*	0	9354 *(87.7)*
	Pre Vehs: Unwtd.	152 *(5.7)*	14 *(0.5)*	40 *(1.5)*	17 *(0.6)*	0	223 *(8.3)*
	Wtd.	3040 *(44.1)*	280 *(4.1)*	80 *(1.2)*	18 *(0.3)*	0	3148 *(49.6)*
	Post Vehs: Unwtd.	0	41 *(1.5)*	125 *(4.6)*	163 *(6.0)*	0	329 *(12.1)*
	Wtd.	0	820 *(14.9)*	250 *(4.6)*	177 *(3.2)*	0	1247 *(22.7)*
6-50		CELL 3	CELL 7		CELL 11	CELL 15	
	Fleets: Unwtd.	50 *(9.0)*	107 *(19.3)*		70 *(12.6)*	1 *(0.2)*	228 *(41.2)*
	Wtd.	390 *(3.4)*	117 *(1.0)*		73 *(0.6)*	1 *(0.1)*	581 *(5.1)*
	Pre Vehs: Unwtd.	505 *(18.8)*	334 *(12.4)*		253 *(9.4)*	2 *(0.1)*	1094 *(40.7)*
	Wtd.	1010 *(14.6)*	370 *(5.4)*		267 *(3.9)*	2 *(0.03)*	1649 *(23.9)*
	Post Vehs: Unwtd.	0	380 *(10.3)*		844 *(31.2)*	50 *(1.8)*	1174 *(43.4)*
	Wtd.	0	308 *(5.6)*		871 *(15.9)*	50 *(0.9)*	1229 *(22.4)*
51+		CELL 4	CELL 8		CELL 12	CELL 16	
	Fleets: Unwtd.	9 *(1.6)*	8 *(1.4)*		12 *(2.2)*	7 *(1.3)*	36 *(6.5)*
	Wtd.	27 *(0.2)*	9 *(0.1)*		12 *(0.1)*	3 *(0.1)*	511 *(0.5)*
	Pre Vehs: Unwtd.	440 *(16.4)*	268 *(10.0)*		342 *(12.7)*	323 *(12.0)*	1373 *(51.0)*
	Wtd.	880 *(12.8)*	288 *(5.3)*		342 *(5.0)*	323 *(4.7)*	1833 *(26.6)*
	Post Vehs: Unwtd.	0	20 *(0.7)*		354 *(13.1)*	500 *(18.5)*	874 *(32.3)*
	Wtd.	0	22 *(0.4)*		354 *(6.5)*	500 *(9.1)*	876 *(16.0)*
TOTAL	Fleets: Unwtd.	173 *(31.2)*	248 *(44.8)*		125 *(22.6)*	8 *(1.4)*	554
	Wtd.	9127 *(80.6)*	2030 *(17.9)*		154 *(1.3)*	4 *(0.2)*	11314
	Pre Vehs: Unwtd.	1097 *(40.8)*	656 *(24.4)*		612 *(22.8)*	325 *(12.1)*	2690
	Wtd.	4930 *(71.5)*	1018 *(14.8)*		627 *(9.1)*	325 *(4.7)*	6895
	Post Vehs: Unwtd.	0	548 *(20.2)*		1610 *(59.5)*	550 *(20.3)*	2708
	Wtd.	0	3040 *(55.4)*		1900 *(34.6)*	550 *(10.0)*	5490

*Cell 17 contains joint fleets with between one and five pre-standard vehicles and between one and five post-standard vehicles and which have a total size of 2, 3, 4, or 5. Cell 6 contains similar fleets whose total size is 6-10.

2.5 Resulting Sampling Weights

If it were not for the different constant factors included in the fleet selection probabilities in the different cells, the sample design would be almost a completely self-weighting one. However, as noted earlier, these constant factors varied as much as 20 to 1 among the different cells of the fleet size matrix, and accordingly different weighting factors must be used in the analysis of vehicles selected from fleets located in the different cells. These weight values by cell are shown in Table 2.13.

These same weights can be used in the analysis of both the sample of pre-standard vehicles and of the sample of post-standard vehicles. Pre-standard vehicles always have 1/3.82 of the selection probability of post-standard vehicles from the same cell, but this factor does not need to be taken into account because the two samples are expected to always be analyzed separately.

In addition to the weights shown in Table 2.13, there are 67 pre-standard vehicles and 71 post-standard vehicles from the 17 double selected fleets in the Patterson, New Jersey, Upstate New York, Northwest Pennsylvania, South Georgia, and Little Rock, Arkansas PSU's which have weights of 2 instead of 1. Taking these into account and applying the weights of Table 2.13 to the numbers of vehicles selected by cell in Table 2.12, one obtains weighted values of 6,895 for the pre-standard vehicle sample and of 5,490 for the post-standard vehicle sample.

Although the sampling procedures were developed in order to obtain weighted national samples of pre-standard and post-standard vehicles, they can also be used to produce a weighted national sample of initial purchasers of 1974 and 1975 air-braked vehicles. As can be seen in Table 2.14 for Cells 5-12 and 17 the initial purchase weights are the same as the vehicle weights (including the 17 double-selected fleets), and for Cells 2 and 3

TABLE 2.13

SAMPLING WEIGHTS FOR VEHICLES SELECTED FROM FLEETS IN THE DIFFERENT FLEET SIZE CELLS

NUMBER OF PRE-STANDARD VEHICLES IN FLEET	NUMBER OF POST-STANDARD VEHICLES IN FLEET: 0	1-5	6-20	51+
0		CELL 5 20	CELL 9 2	CELL 13 2
1-5	CELL 2 20	CELL 17* 20 / CELL 6* 2	CELL 10† 1	CELL 14 1
6-50	CELL 3 2	CELL 7† 1	CELL 11† 1	CELL 15 1
51+	CELL 4 2	CELL 8† 1	CELL 12 1	CELL 16 1

*Cell 17 contains joint fleets with between one and five pre-standard vehicles and between one and five post-standard vehicles and which have a total size of 2-5. Cell 6 contains similar fleets whose total size is 6-10.

†Vehicles in Cells 7, 8, 10, and 11 from the seventeen double-selected fleets are weighted 2.

TABLE 2.14

SAMPLING WEIGHTS FOR SELECTED INITIAL PURCHASERS
IN THE DIFFERENT FLEET SIZE CELLS

NUMBER OF PRE-STANDARD VEHICLES IN FLEET	NUMBER OF POST-STANDARD VEHICLES IN FLEET: 0	1-5	6-50	51+
0		CELL 5 20	CELL 9 2	CELL 13 $2 \times \frac{50}{N_2}$
1-5	CELL 2 76.4	CELL 17* 20 CELL 6* 2	CELL 10† 1	CELL 14 $\frac{50}{N_2}$
6-50	CELL 3 7.64	CELL 7† 1	CELL 11† 1	CELL 14 $\frac{50}{N_2}$
51+	CELL 4 $2.64 \times \frac{50}{N_2}$	CELL 8† 1	CELL 12 1	CELL 16 $\frac{50}{N_2}$

N_1 = Number of Pre-Standard vehicles in fleet.
N_2 = Number of Post-Standard vehicles in fleet.

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*Cell 17 contains joint fleets with between one and five pre-standard vehicles and between one and five post-standard vehicles and which have a total size of 2-5. Cell 6 contains similar fleets whose total size is 6-10.

†In Cells 7, 8, 10, and 11 the seventeen double-selected fleets are weighted two.

the purchaser weights are just 3.82 times the vehicle weights. However, for the selected large fleets in Cells 4 and 13-16, specific individual weights are calculated using the actual numbers of pre-standard or post-standard vehicles purchased. Use of these weights results in a weighted value of 11,295 for the national sample of initial purchasers of 1974 and 1975 air-braked trucks and buses.

The large weighting factors applied to some vehicles sometimes permit variation in just a few vehicles to have a rather large effect on the sample results. Table 2.15 presents data on the frequencies of the different weight categories in the total sample. It can be seen that although only small proportions of the vehicles have weights of 20, these vehicles account for close to half of the total weighted sample values in both the pre-standard and post-standard vehicle samples.

TABLE 2.15

DISTRIBUTION OF PRE-STANDARD AND POST-STANDARD VEHICLES IN THE THREE WEIGHT CATEGORIES FOR ALL KNOWN ELIGIBLE VEHICLES

Type of Vehicle	Wtd = 1		Wtd = 2		Wtd = 20		TOTAL	
	N	%	N	%	N	%	N	%
PRE-STANDARD:								
Unwtd.	1457	55.1	1022	38.6	166	6.3	2645	100.0
Wtd.	1457	21.4	2044	30.0	3320	48.7	6821	100.1
POST-STANDARD:								
Unwtd.	2103	79.1	432	16.3	123	4.6	2658	100.0
Wtd.	2103	38.8	864	15.9	2460	45.3	5427	100.0

3. IMPLEMENTATION

This chapter documents the work performed under Task II, Implementation. The sample design described in Chapter 2 resulted in the selection of 554 fleets located in 36 geographic areas. The 36 areas contained an average of approximately thirteen counties per area. The objective of this task was to secure the cooperation of the owners and/or users of the selected vehicles. Included was the training of locally based personnel to carry out the ongoing data collection activity. The major problem encountered involved vehicles located outside the selected geographic areas.

The material in this chapter is organized into five sections. The first section, 3.1, describes the data collection system. The implementation methods, including training of personnel, data forms, and the Data Collection Handbook, are described in the second section, 3.2. Problems encountered and the resulting response rate are discussed in Section 3.3 Section 3.4 presents a description of the fleets and vehicles which are currently participating in the study. The last section, 3.5, describes data reduction including coding, editing, and file building.

3.1 Data Collection Methodology

The data collection system was implemented in August, 1976, with the goal of collecting timely, accurate data to fulfill the analysis requirements.

Basically, the plan was to establish contact by telephone with the owners of the vehicles and to arrange for a visit to the site of the vehicle and its owner. Such an initial visit was to be followed by subsequent quarterly visits over a period of 18 months to record certain data on a continuing basis.

The objective of the first data collection visit was to establish face to face contact with the vehicle owner (and the vehicle, if possible), explain the project, and secure his cooperation. During this initial visit the following information was to be collected:

Fleet Description (Type of Fleet, What Hauled, Where, Dispatch Practices)

Vehicle Description (Type of Vehicle, Cargo, Brakes, Use)

Accident Information (Accidents Prior to Visit)

Exposure Information (Usual Trip Distance, etc.)

Maintenance Information (General Inspection and Maintenance Practices and Brake System Related Maintenance)

The data forms for recording this information are explained in detail in Section 3.2. On a quarterly basis following the initial visit, the owner was to be re-contacted to obtain updated information on mileage, accidents, and brake system maintenance.

The data collection plan was implemented by developing and training a staff of HSRI field managers to carry out the initial visits to the 36 data collection regions, as it was considered most economical to implement the data collection on a regional basis. Arrangements were made with a national temporary help organization to provide field data collection personnel in each region served by its offices. This field data collection person was then responsible for periodically contacting the selected vehicle owners or lessees to record the continuing data.

Each field manager was given responsibility for implementing the study with a number of regions. Prior to or during his visit to a region he would telephone the purchasers of the selected vehicles and arrange for personal visits. Simultaneously, the temporary help office would be contacted and a local field data collection person would be assigned to the field manager. Armed with a set of appointments, the field manager would journey to the region and make contact with the field data collector. The field manager would spend approximately a half day training the field data collector in his tasks, and then the two would proceed to the first data collection appointment. After describing the purpose of the project and securing the cooperation of the owner, the field manager and field data collector would seek to complete the necessary data forms and elements. Usually the field manager would conduct the interview and complete the company description data form. Either or both the field manager and field data collector would then complete the vehicle description(s) and ascertain the location of the maintenance records and accident reports. After all data were collected (or arranged for later collection if not available at that appointment), the field manager would arrange for the next quarterly visit by the field data collector, and the two would then depart for the next company. Just after leaving the company the field manager would complete his Field Manager Report Form summarizing the status of the visit. Such a scenario would be repeated for each selected company in the region, and for each region assigned to a particular field manager.

Once a region was implemented, the field manager would make arrangements for the repeat quarterly visits with the field data collector. Any problems that might arise on the repeat visit were to be handled by telephone and/or letter whenever possible. If complications arose which could not be handled in this manner, then a repeat visit by the field manager or a visit by an HSRI project staff person would be required.

Following each quarterly visit, the field data collector was to return the forms by mail to HSRI for processing.

The field data collection staff was also available for special studies and surveys, since data forms and instructions could easily be supplied to them for the collection of additional types of data on subsequent quarterly visits.

3.2 Data Forms, Handbook, and Training

This section presents a brief description of the data collection materials organized under their respective headings.

3.2.1 Data Forms. The data elements necessary to operate a survey can be classified into these groups:

1. Analysis Variables
2. Sample Definition
3. Data Collection and Control

Group One elements are those items necessary to satisfy the analytical needs for testing the study hypotheses.

Group Two elements are those necessary to define and construct the sample and to allow for expansion of the sample results to the study population.

Group Three elements are those housekeeping and bookkeeping items necessary to maintain the records and monitor data collection in an orderly fashion.

HSRI developed a number of data forms for recording data specific to certain hypothesis/analysis requirements and also forms especially designed for the sample definition and data collection and control needs. It should be noted that certain items (particularly data collection and control elements) are necessary on all forms. Therefore, certain elements are repeated on forms to permit accurate record keeping.

The following is a list of the data forms, followed by a brief explanation of each with an indication of the form's primary function: (1) Analysis Variables, (2) Sample Definition, and

(3) Data Collection and Control. The specific data forms are located in Appendix B.

Reference Card: To permit an economy of data form reproduction, certain code tables were reproduced on a separate card to be used in conjunction with several data forms. These code tables were too large to be economically reproduced on each data form.

Fleet and Vehicle Selection Record: To record for each selected purchaser the name and address, the basic fleet selection criterion and source (manufacturer), and the numbers of pre- and post-standard vehicles from the manufacturers' lists. Data element Type 2.

Study Vehicle Inventory: To list out the specific selected study vehicles from the manufacturers' lists and permit recording additional basic identification information about the vehicles. Data element Type 2.

Cooperation and Disclosure Statement: Required to provide the selected purchasers with information about the survey and solicit their informed consent and participation.

Company Description: To record the complete and specific name of the company, names of contacts within the company, and information about the company's operations, organization, cargo, vehicle maintenance and inspection facilities and practices, and total fleet inventory. Data elements Types 1 and 3.

Company Description--Copy: To reproduce the company name and contact information for retention by the field data collector.

Company Visit Log: To record the frequency and nature of each visit and/or contact with a company. Data element Type 3.

Vehicle Description: To record specific data concerning each study vehicle in a fleet. Major data elements include weight class, truck and body style, axle and brake configuration by axle, and general exposure information. Data element Type 1.

Vehicle Maintenance and Mileage History: To record two groups of information: (1) brake system maintenance, and (2) vehicular mileage. The brake system maintenance data provides for a chronology of repairs to the brake system including date, mileage, component, work performed, 121 status, repair time, etc. The vehicle mileage is a quarter by quarter recording of the cumulative mileage and the source of the mileage reading. Data element Type 1.

HSRI Accident Report: To record specific information about accidents occurring to study vehicles. An accident is defined as any incident occurring to a vehicle which results in the expenditure of effort or dollars to correct--whether in hours of down time or crash damage repair. Major data elements include accident location information, trip information, cargo and loading, special conditions, vehicle description and composition, accident loss type, and a narrative description of the collision factors. Data element Type 1.

Vehicle Record Contact Log: To record the number and types of contacts with specific vehicle records. Data element Type 3.

Field Manager Report: To keep track of the status of the contact with a particular fleet during the initial fleet contact and to provide for the recording of the impressions of the field manager following his initial visit to a fleet. Data element Type 3.

Trip Information Survey: To record data on trip distance and tractor and trailer brake type on randomly selected units and days. Data element Type 1.

3.2.2 Handbook. To assist in the training of the data collectors in the understanding and use of the data forms a comprehensive data collection handbook was prepared. The purpose of the book was to serve both as a training aid and a reference document once data collection had begun. Major sections in the book include: Project Description; Truck Brakes Simplified (how trucks and brakes work); An Example of a Trucking Company (a discussion of the organization of a typical trucking company); Data Collection Forms--Description and Use; Data Collection and Related Information; and A Set of Data Forms. This booklet was distributed to all field managers and field data collection personnel as a reference document.

3.2.3 Training. The training of the field staff was conducted in two phases. First the staff of field managers was assembled prior to the implementation of the data collection and briefed on all aspects of the data collection, the project purposes and goals, and University policies and procedures. Secondly, each field manager trained the field data collector in each region assigned to him.

The training for the field manager staff included seminars on the structure of the trucking industry, on methods of contacting trucking companies and obtaining cooperation, on understanding of specific data elements, and on use and completion of the data forms. This latter point included a thorough explanation of each data form and a completion exercise at HSRI followed by field visits to several area trucking companies.

In the field, the field manager met with the field data collection person for the region and spent approximately a half day training him or her in the use of the data forms prior to any visits to trucking companies. While at the trucking companies, the field manager monitored the completion of the forms as an additional training effort.

Continued contact was maintained with the field data collectors both to monitor the quality of the data and to answer questions concerning data collection.

3.3 Response Rate

This section describes the problems encountered during implementation, and the resulting response rate. The problems encountered can be grouped into two general categories: locating the vehicles and their records, and securing cooperation. The most serious problems fall into the first category. Information on response rates is presented following a discussion of the reasons for non-response. Finally, our assessment of data quality is presented.

Fleets and vehicles were selected based on the purchaser's address as provided by the manufacturers. In many cases the vehicles, or more to the point, their records, were not available at that address. This situation was anticipated for large fleets with many remote terminals. Most of these fleets are Authorized Carriers and have very good central record systems. Major difficulties arose when governmental purchasers, body builders, or lessors were selected. States often made large purchases of vehicles for use by their highway departments or public schools. These vehicles would subsequently be distributed across the state. In such cases, records are usually maintained where the vehicle is used. In several cases it has been necessary for data collection personnel to travel throughout the state in order to monitor the selected vehicles. In the absence of a system of central records, the quality and completeness of the records maintained at the remote locations was often found lacking. A similar situation involving vehicles and their records located at remote sites was encountered in some medium-sized private fleets.

The situation was much more difficult when the selected fleet was a body builder or lessor. The normal situation for a body builder is that all of the vehicles he purchases will subsequently be sold. Body builders were often reluctant to reveal the names of their customers. Several stated that they did not keep records of their sales! Lessors were also reluctant to reveal the names of customers. In a few instances the field personnel were lucky. In one area a lessor would not supply customer names for a large purchase of vehicles. In subsequent conversations with other selected fleets a particular school district was mentioned frequently because they had replaced their entire fleet with long-term lease vehicles recently. Our field person was advised that if he was interested in 121 "problems" he should visit this school district. On making the visit he found the vehicles he had been unable to locate through the lessor. Since the school district was having problems, they were more than willing to cooperate. Such good fortune was unusual.

In the absence of such a fortuitous location method, vehicles were sometimes located by requesting a search of registration records by the state Department of Motor Vehicles. Of course, for this to be successful, it is necessary to at least know the state in which the vehicle is registered. Also not all states will permit the use of their registration records for such a purpose.

In other cases, vehicles were not at the expected location because delivery had been cancelled or they had been subsequently sold. When delivery was not taken the vehicles would sometimes go to a local dealer for sale. While the dealers, in most cases, were willing to provide new purchasers names, the additional field work required was sometimes staggering. Vehicles which were returned to a dealer in Wisconsin were found as far away as Maine, North Dakota, and Alabama.

Each time vehicles were found to be owned by someone other than the selected original purchaser, a "sub-fleet" was created to identify the actual owner. A total of 554 purchasers of vehicles were originally selected. Over 250 additional "sub-fleets" were visited because vehicles were found to be owned or operated by someone other than the purchaser listed by the manufacturer. Of the 480 currently active fleets, 124 are "sub-fleets." Many are located outside the original geographic areas.

Even when the selected vehicles were still being operated by the original purchasers in the selected geographic areas, there were often problems encountered in securing the cooperation of their owners. One must keep in mind that quarterly collection of brake system maintenance, mileage, and accident data impose a significant burden on the participating fleets even though project personnel are provided to record the information. In general, small fleets and municipal fleets were most cooperative. In the larger fleets the decision to participate was often shifted from one individual to another which necessitated several contacts and some time delay. In some companies the decision was referred to their legal staff who generally would determine that participation was "not in the best interests of the company." This determination took several months in many cases.

Authorized Carriers tended to be more cooperative than private carriers. They seemed more knowledgeable about matters that influence the trucking industry as a whole. These companies are the most visible element of the trucking industry, and seem to be aware that, for many people, they represent the trucking industry. In a private company the trucking operation is usually only a small part of the overall operation, often viewed as a service division. Private companies do not always see themselves as part of the trucking industry even though they may operate 200-300 vehicles. As a consequence of this view, they seem to be less interested in the problems facing the trucking industry than Authorized Carriers.

As mentioned, cooperation was most difficult to secure from the body builders and leasing companies. Here our interest was in their customers. In general, these companies felt it would be "bad business" to allow our people to contact their customers. Lessors were often willing to provide data on the vehicles from their own records, but often requested that no contact be made with the lessees.

Cooperation was also influenced by the quality and detail of the records maintained by the company. The large Authorized Carriers usually have sophisticated systems of central records. These records were found to be generally complete and data collection posed no serious problems in these companies once the decision to participate in the study was obtained. This was often not the case in the private fleets. While accident reports usually are kept at a central location, maintenance records are often kept only at the major domicile of the vehicle, or with the vehicle, and mileage may be available at either location. Again, the fact that "trucking" is not the major business of the private firm seems to be reflected in the sophistication of the fleet operation, especially for the medium and small size fleets. Data collection is much more difficult and poses a greater inconvenience for the fleet operator in these cases. Thus, the private fleet operator is somewhat more likely to choose not to participate.

To summarize the implementation problems, vehicles located outside the selected fleets and areas are responsible for much of the reduction in sample size. While selected owners sometimes were not willing to participate, this problem was secondary. In categorizing the problems by the type of fleet selected, body builders and leasing companies posed far and away the most difficulty through the combination of reluctance to cooperate and dispersed vehicles. Some governmental fleets posed nearly equal problems with respect to dispersed vehicles or records. The governmental purchasers, however, were usually most helpful in trying to meet our data needs, sometimes to the point of keeping additional records for this project. Implementation went most smoothly in the Authorized

Carriers. Records were usually complete and easily accessible, and the fleet operators were usually willing to cooperate. Private fleets tended to have less complete records which were sometimes difficult to access. Perhaps for this reason, private fleets were somewhat less willing to cooperate.

Another product of the implementation process is the identification of vehicles which are not part of the desired population. These are referred to as "non-sample" units. In this study the desired population was restricted to vehicles operating in the contiguous United States during the study period. Vehicles known to have been manufactured for export were excluded from the original sample frame. However, some domestically sold vehicles are subsequently exported, and other vehicles may become inoperable due to accidents, fires, etc. From contacts with personnel at the selected fleets it was learned that 45 selected pre-standard vehicles and 50 selected post-standard vehicles were not operating in the contiguous United States after January 1, 1976. Most of these vehicles had been shipped overseas, but a few had been scrapped due to accidents, fires, etc. These vehicles are considered non-sample units, and thus the numbers of eligible selected vehicles have been reduced to 2,645 pre-standard and 2,658 post-standard trucks and buses. In five of the selected fleets all of the selected vehicles were "non-sample" units, and thus the total number of eligible fleets has been reduced to 549.

In establishing the desired sample sizes for this study it had been difficult to estimate what kind of response rate to expect because no study of this sort had ever been carried out in the trucking industry before. It was hoped to obtain participation by 66% of the 554 selected fleets or 365 fleets, and it was hoped to be able to study 72% of the 5,398 selected vehicles or 3,887 vehicles. In regard to fleets, the HSRI project staff has been able to achieve its response rate goal. At least one selected vehicle is currently participating in the study from 382 of the 549 still-eligible selected fleets, for a resulting fleet response rate of 69.6%. The total active sample of 480 fleets and sub-fleets currently includes 356 original purchasers operating at least some of their purchased vehicles themselves. The remaining 124 active fleets are owners or lessees who obtained their selected vehicles from 32 of these purchasers, or from 10 purchasers who are not currently participating with their own selected vehicles, or from 16 original purchasers who did not retain any of their selected vehicles themselves. However, it is not possible to calculate a response rate for this total of 480 separate currently participating operators of selected vehicles because it is not known to how many sub-fleets non-participating purchasers have sent their selected vehicles.

As can be seen in Table 3.1, the current response rate for vehicles is considerably lower than had been hoped for, about 56% for the pre-standard sample and about 67% for the post-standard sample. Overall the current weighted selected vehicle response rate is 61.3%. HSRI field staff are continuing to work on obtaining participation from reluctant fleets and on tracing missing or sold vehicles, and it is anticipated that the final weighted vehicle response rate will be at least 68%. The lower response rate for the pre-standard vehicles reflects the greater likelihood that such vehicles are no longer with their original purchaser and thus are more difficult to locate.

The effect of non-response must be considered when interpreting the result of any survey. An evaluation of this effect requires information on the characteristics of the non-response group. If the characteristics of the non-response group are different from the responding group, then the sample results will be biased. The amount of bias is a function of the size of the difference and the size of the non-response group. Unfortunately,

TABLE 3.1

UNWEIGHTED AND WEIGHTED RESPONSE RATES FOR THE
PRE-STANDARD AND POST-STANDARD VEHICLE SAMPLES

Vehicles	Eligible Sample	Participating Sample	Participating Response Rate	Daily Mileage Info Sample	Daily Mileage Response Rate
PRE-STANDARD:					
N	2645	1492	56.4	1099	41.6
Wtd N	6821	3853	56.5	2630	38.6
POST-STANDARD:					
N	2658	1685	63.4	1175	44.2
Wtd N	5427	3655	67.3	2482	45.7
TOTAL:					
N	5303	3177	59.9	2274	42.9
Wtd N	12248	7508	61.3	5112	41.7

almost nothing is known of the vehicles which could not be located. In Chapter 4, distributions by manufacturer and GVWR class are compared for the responding vehicles and the total population. The fact that these distributions are comparable implies that the non-responding vehicles should have similar characteristics. Further work will be directed towards obtaining information on the non-responding vehicles. At this point, the reader should be cautioned that the magnitude of the non-response in this study has the potential to bias the observed results if the experiences of the non-response vehicles are appreciably different from those of the responding vehicles.

A final area of concern at the completion of the implementation phase is the overall quality of the data collected. Our present assessment is provided in the following paragraphs.

Mileage data are accurate and complete. Odometer readings are usually recorded in maintenance or other company records. Maintenance information is more difficult to obtain. Monitoring of maintenance data has only been established for about 70% of the study vehicles. For these vehicles, the identification of the component repaired and the type of work performed is nearly always adequate. However, we find that the records available to us do not always include minor work like adjustments, nor do they include warranty work. The exclusion of some minor work in some of the records being monitored does not seem to be a serious problem. Records on warranty work, however, are almost never kept by the truck owner. Our efforts to collect this information from dealers when they are identified is seldom successful. In general, warranty work is not included in the maintenance data collected. Another problem is that we are not able to verify the operational status of the brake system. We have found that owners nearly always respond that the system is 100% operational with no modifications (except for bus owners who have been directed to disconnect components). We have no other means of assessing operational status.

The number of accident reports received is only about 1/5 the expected number. While the original estimate was little more than a guess, large variations in the apparent reporting threshold have been observed from fleet to fleet. Some fleets do keep records on even the most minor accidents which may involve only down time and no property damage, while others say they keep records on only BMCS reportable accidents ($2,000 property or any injury). In general, fleets which were expected to have higher accident rates (straight trucks in local driving environments) often have the poorest records. This situation is not expected to bias the comparison of pre- and post-standard vehicles (the majority of the fleets have both types). Finally, in those fleets with maintenance records, we find that collision damage is usually indicated. This provides what would seem to be a fairly good notification of accident involvement.

3.4 Study Vehicles and Fleets

This section presents descriptive information on the vehicles and fleets currently participating in the study. Sampling weights have not been taken into account in the preparation of these tabulations. Similar tables using the sampling weights are shown in Chapter 4. Table 3.2 shows the number of study vehicles by brake type in each exposure category. These categories are defined by the following variables and levels:

	Variable	Levels
1.	Vehicle Type	Straight Truck, Tractor, and School Bus
2.	Trip Length	Local, Intercity
3.	Fleet Size, i.e. All Power Units	Small (1-49); Large (50+)
4.	Carrier Type	Private; For Hire

TABLE 3.2

UNWEIGHTED DISTRIBUTION OF STUDY VEHICLES BY EXPOSURE CELL

PRE-STANDARD VEHICLES:

Fleet Size	Carrier Type	Straight Trk		Tractor		School Bus		TOTAL
		Local	Inter-City	Local	Inter-City	Local	Inter-City	
Small (1-49)	Private	61	30	24	107	62	3	287
	For Hire	33	16	6	44	5	4	108
Large (50+)	Private	69	56	18	140	62	3	348
	For Hire	1	14	151	476	1	0	643
Missing Data	Private	53	27	8	11	6	0	105
	For Hire	0	0	0	1	0	0	1
	TOTAL	217	143	207	779	136	10	1492

POST-STANDARD VEHICLES:

Fleet Size	Carrier Type	Straight Trk		Tractor		School Bus		TOTAL
		Local	Inter-City	Local	Inter-City	Local	Inter-City	
Small (1-49)	Private	108	65	33	107	154	6	473
	For Hire	7	11	13	19	27	4	81
Large (50+)	Private	147	170	33	28	248	4	630
	For Hire	7	13	54	265	12	1	352
Missing Data	Private	31	69	6	17	19	0	142
	For Hire	6	0	0	1	0	0	7
	TOTAL	306	328	139	437	460	15	1685

Considerable variation exists in the number of vehicles per cell. Sampling control could only be exerted on the number of vehicles per purchaser and the brake type (pre- and post-standard). Distribution across the other exposure variables was left to chance. Small numbers of vehicles in these cells basically reflect a low frequency of occurrence. For example, there are very few "For Hire" school bus fleets, and as a consequence, very few study vehicles fall in this category. Table 3.3 shows the unweighted percentage distribution of study vehicles for the same exposure categories.

In Chapter 5, accident rates are computed for 6 exposure cells defined by the intervals of vehicle type and trip distance. The unweighted numbers and percentages of study vehicles in these cells are shown in Table 3.4. The percentages for each vehicle type are quite different for the pre- and post-standard vehicles. Approximately 66% of the pre-standard vehicles are tractors while only 34% of the post-standard vehicles are tractors. School buses account for about 10% of the pre-standard vehicles and 28% of the post-standard vehicles. These differences presumably reflect a difference in the sales pattern for the pre- and post-standard vehicles.

Table 3.5 shows the unweighted distribution of study vehicles by the size of the fleet the vehicle is located in. Fleet size is determined by the total number of air-braked power units owned by the fleet. These distributions are fairly comparable with roughly equal numbers of vehicles in the three size categories. It must be remembered that this unweighted distribution is greatly influenced by the sample design since small purchases of vehicles were under-sampled and large purchases were over-sampled.

Table 3.6 shows the breakdown of study vehicles by whether they are located in private or "for hire" fleets. Approximately

TABLE 3.3

UNWEIGHTED PERCENT DISTRIBUTION OF STUDY VEHICLES
BY EXPOSURE CELL

PRE-STANDARD VEHICLES:

Fleet Size	Carrier Type	Straight Trk Local %	Straight Trk Inter-City %	Tractor Local %	Tractor Inter-City %	School Bus Local %	School Bus Inter-City %	TOTAL %
Small (1-49)	Private	4.1	2.0	1.6	7.1	4.2	0.2	19.2
	For Hire	2.2	1.1	0.4	3.0	0.3	0.3	7.2
Large (50+)	Private	4.6	3.7	1.2	9.3	4.2	0.2	23.3
	For Hire	0.1	0.9	10.1	31.9	0.1	0.0	43.2
Missing Data	Private	3.6	1.8	0.5	0.8	0.4	0.0	7.0
	For Hire	0.0	0.0	0.0	0.1	0.0	0.0	0.1
	TOTAL	14.5	9.6	13.9	52.2	9.1	0.7	100.0

POST-STANDARD VEHICLES:

Fleet Size	Carrier Type	Straight Trk Local %	Straight Trk Inter-City %	Tractor Local %	Tractor Inter-City %	School Bus Local %	School Bus Inter-City %	TOTAL %
Small (1-49)	Private	6.4	3.9	2.0	6.4	9.1	0.4	28.1
	For Hire	0.4	0.7	0.8	1.1	1.6	0.2	4.8
Large (50+)	Private	8.7	10.1	2.0	1.6	14.7	0.2	37.4
	For Hire	0.4	0.8	3.2	15.7	0.7	0.1	20.9
Missing Data	Private	1.8	4.1	0.4	1.0	1.1	0.0	8.4
	For Hire	0.4	0.0	0.0	0.1	0.0	0.0	0.4
	TOTAL	18.2	19.5	8.2	25.9	27.3	0.9	100.0

TABLE 3.4

UNWEIGHTED DISTRIBUTION OF STUDY VEHICLES
BY EXPOSURE--6 CELLS

PRE-STANDARD VEHICLES:

Vehicle Type	Local		Inter-City		TOTAL	
	Freq	%	Freq	%	Freq	%
Straight Truck	217	14.5	143	9.6	360	24.1
Tractor	207	13.9	779	52.2	986	66.1
School Bus	136	9.1	10	0.7	146	9.8
TOTAL	560	37.5	932	62.5	1492	100.0

POST-STANDARD VEHICLES:

Vehicle Type	Local		Inter-City		TOTAL	
	Freq	%	Freq	%	Freq	%
Straight Truck	306	18.2	328	19.5	634	37.6
Tractor	139	8.2	437	25.9	576	34.2
School Bus	460	27.3	15	0.9	475	28.2
TOTAL	905	53.7	780	46.3	1685	100.0

TABLE 3.5

UNWEIGHTED DISTRIBUTION OF STUDY VEHICLES
BY FLEET SIZE

Fleet Size	PRE-STANDARD VEHICLES		POST-STANDARD VEHICLES	
	Frequency	Percent	Frequency	Percent
Small (1-49)	395	26.5	554	32.9
Medium (50-399)	378	25.4	646	38.4
Large (400+)	539	36.1	336	19.9
Missing Data	180	12.0	149	8.8
TOTAL	1492	100.0	1685	100.0

TABLE 3.6

UNWEIGHTED DISTRIBUTION OF STUDY VEHICLES
BY CARRIER TYPE

Carrier Type	PRE-STANDARD VEHICLES		POST-STANDARD VEHICLES	
	Frequency	Percent	Frequency	Percent
Private	740	49.6	1245	73.9
For Hire	752	50.4	440	26.1
TOTAL	1492	100.0	1685	100.0

50% of the pre-standard vehicles are in private fleets while nearly 74% of the post-standard vehicles are in private fleets. Again, this distribution is influenced by changes in the sales patterns.

The previous tables all presented distributions of vehicles. Comparable tables will now be presented describing the fleets those vehicles are located in. Table 3.7 shows the unweighted distribution of fleets by exposure category as defined by typical trip length, fleet size, and carrier type. (No attempt was made to characterize fleets by brake type or vehicle type since many have vehicles of more than one type.) Nearly 52% of the fleets indicated that their typical trip was within the local vicinity. Although most of these fleets are small, the previous tables indicated that 38% of the pre-standard and 54% of the post-standard vehicles are typically involved in local trips.

An unweighted breakdown of the study fleets by carrier type is shown in Table 3.8. Approximately 78% are private and 22% "for hire." The unweighted distribution of the study fleets by fleet size is shown in Table 3.9. Small fleets constitute nearly 66% of the study fleets, while large fleets are 4%. In making these preliminary tabulations it was discovered that missing data existed on fleet size in nearly 7% of the study fleets. Complete information will be obtained on subsequent company visits in these cases. The small fleet size category is shown in more detail in Table 3.10. One objective of the study design was to include owner-operators and small fleets in the evaluation. Of course, total fleet size was not known, only the number of new vehicles purchased since January, 1974. From the unweighted distribution in Table 3.10 it is evident that appreciable numbers of single-vehicle owner-operators (39) and other small fleets are currently participating in the study. These small fleets which compose 66% of the study fleets include about 33% of the study vehicles.

TABLE 3.7

UNWEIGHTED DISTRIBUTION OF STUDY FLEETS
BY EXPOSURE CATEGORY

Fleet Size	Carrier Type	USUAL TRIP LENGTH						TOTAL	
		Local		Inter-City					
				< 200 Mi.		> 200 Mi.			
		Freq	%	Freq	%	Freq	%	Freq	%
Small (1-49)	Private	145	30.6	67	14.1	38	8.0	250	52.1
	For Hire	25	5.3	18	3.8	19	4.0	62	13.1
Medium (50-399)	Private	53	11.2	16	3.4	15	3.2	84	17.7
	For Hire	3	0.6	17	3.6	7	1.5	27	5.7
Large (400+)	Private	5	1.1	3	0.6	1	0.2	9	1.9
	For Hire	1	0.2	2	0.4	7	1.5	10	2.1
Missing Data	Private	12	2.5	10	2.1	5	1.1	27	5.7
	For Hire	2	0.4	0	0.0	3	0.6	5	1.1
	TOTAL	246	51.9	133	28.1	95	20.0	474	100.0

TABLE 3.8

UNWEIGHTED DISTRIBUTION OF STUDY FLEETS
BY CARRIER TYPE

Carrier Type	Frequency	Percent
PRIVATE	370	78.1
FOR HIRE		
Common	67	14.1
Contract	31	6.5
Exempt	6	1.3
TOTAL	474	100.0

TABLE 3.9

UNWEIGHTED DISTRIBUTION OF STUDY FLEETS
BY FLEET SIZE*

Fleet Size	Frequency	Percent
Small (1-49)	312	65.8
Medium (50-399)	111	23.4
Large (400+)	19	4.0
Missing Data	32	6.8
TOTAL	474	100.0

*Number of air-braked power units.

TABLE 3.10

UNWEIGHTED DISTRIBUTION OF STUDY FLEETS
BY FLEET SIZE* FOR SMALL FLEETS

Fleet Size	Frequency	Percent
1	39	8.2
2	25	5.3
3	15	3.2
4	16	3.4
5	15	3.2
6-10	46	9.7
11-20	63	13.3
21-30	42	8.9
31-49	51	10.8
TOTAL	312	65.8

*Number of air-braked power units.

3.5 Data Processing

As data collection implementation continued, data began flowing into HSRI. Systems were established to keep track of the data, monitor its quality, reduce it to machine readable form, and create data files suitable for analysis. The following sections describe the various activities.

3.5.1 Data Form Receipt and Storage. At the beginning of the data collection phase, a filing system was set up to receive and store the data forms. Thirty-seven file drawers were set up (one for each area plus a miscellaneous drawer) with a file pocket for each fleet. Within each file pocket was space for the Company Description forms and for each vehicle.

As the various data forms arrived, they were screened for legibility and filed in the appropriate folder. Any notes or comments received from the field (either via the data form or from the field manager) were also filed.

Two record systems were established to keep track of each area's data collection progress. A manual record notebook for each area was prepared to keep a written record of the status of the area. Also a computer based file (Fleet and Vehicle Status File) was established whereby a data card was begun for each fleet and vehicle which achieved active status. This system allowed for checking in each form, tracking its coding through the file-build process, and permitting automatic summaries of the status of each data form. Summaries were prepared showing which fleet, vehicle, and data forms had been completed and which were yet to be begun or completed.

Once edited and coded, each data form was returned to its folder for permanent storage.

3.4.2 Data Quality Monitoring. Steps were taken to insure the quality of the data as it flowed into HSRI. The data forms, as they arrived for filing were reviewed by HSRI staff. This purpose was two-fold. First, the data forms from the initial visit were scanned as to completeness and consistency of the data, and each fleet contact was reviewed by HSRI staff and the field manager to evaluate the data source, to monitor the quality, and to provide for follow-up of any problem during the implementation. As additional data forms were received from the quarterly visits, each was scanned before filing.

As a part of the data reduction process, each form was edited prior to coding. The editing process consisted of reviewing a fleet folder (containing all vehicles) for consistency across the fleet and within the region. Legibility, completeness of response, and consistency of response were the primary factors reviewed. Where errors, omissions, or discrepancies were noted, they were corrected either by reference to other information or by re-contacting the field manager or field data collector. Data quality control pervaded all aspects of the record keeping and data reduction phases, and efforts in each phase are described in that section. However, a conscious effort was undertaken to review each data form as a separate effort.

3.5.3 Data Reduction. After each data form had been edited it was reduced to a machine readable form through a coding process. Coding forms were prepared to serve as the vehicle between the data form and the key entry process. Each data form had a corresponding coding form (or several forms) upon which the desired codes were entered. Below is a list of the forms and their use.

Coding Form	Use
FLEET SELECTION CRITERION	Record fleet selection/vehicle selection parameters and basic fleet identification and size information
FIELD MANAGER REPORT	Code the Field Manager Report data

COMPANY DESCRIPTION	Code the Company Description data
VEHICLE DESCRIPTION	Code the Vehicle Description data
MILEAGE CODING FORM #1	Code the quarterly mileage for the first three quarters to provide immediate mileage information
MAINTENANCE AND MILEAGE	Code the maintenance data, quarters 4-6 mileage, and any previous mileages not recorded on the Mileage Coding Form #1
ACCIDENT COUNT DATA FILE	Code the accident date and type for all incoming accidents to provide a count of accidents
HSRI ACCIDENT REPORT	Code all relevant information concerning each accident

A majority of the data entries have their code table printed on the form. Where tables were long or repeated, often reference cards were prepared for easy use by the coders. Often the editing and coding were performed at the same time and were done by area, again to enhance quality control and to make the most efficient use of staff time.

The first groups of forms to be coded were the Company, Fleet, Field Manager, and Fleet Selection forms by area. Then the Mileage Coding Form #1 and Vehicle Description forms were completed followed by a coding of the maintenance data and accident count files. The accident form was the last to be coded on a batch basis. Subsequent data coding exercises followed the same batch processing.

Following the coding of each type or group of data forms, the coding forms were keypunched onto punched cards.

3.5.4 File Building. As each data form was keypunched it was accumulated in a file until sufficient like cards were available for the file building process.

This data file building process consisted of four distinct operations: (1) error checking, (2) file construction, (3) error checking, and (4) file combination.

(1) Error Checking: Special purpose computer programs were prepared for each data form to provide for a check on the code values. The common checks were for incorrect value ranges and for consistency checks. Also some relational checks were made. Typical errors included out of range codes, missing entries, inconsistent coding among similar data items, and improper relationships between variables. The errors were listed out along with case number to facilitate tracking and correcting the errors. Once detected in this manner the errors were corrected. Discovered coding errors were less than .5%.

(2) File Construction: The file construction consisted of feeding the data into the HSRI SR Computer Data Analysis System for formatting and building into a usable data analysis file. One file for each coding form was created. The process included generating the desired variables (dictionary) and specifying the data values to be included. This is largely a machine process yielding a data file, a dictionary, and an error list. Errors were again tracked down and corrected.

(3) Error Checking: Error checking was again undertaken, this time utilizing the power of the computer and a built data set to check for relational type errors and consistency. For example, if a vehicle is equipped with 121 brakes, then all brake related questions should reflect this. Errors were discovered and corrected. Following this exercise, several complete and corrected data files existed. They were:

1. Fleet File
2. Vehicle File
3. Mileage File
4. Accident Count File
5. Maintenance File
6. Accident File*
7. Trip Information File*

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*As of the interim report, these files had not been created.

(4) File Combination: To provide for usable data files, several data files were created out of these single files. The following describes each file.

1. *FLEET FILE* -- containing Fleet Analysis variables for 480 fleets, one record per fleet, and information on the selected fleets as obtained from three data forms.

Form FS: Fleet and Vehicle Selection Record describing fleet selection and sampling parameters as well as the fleet sampling frame totals and the selected fleet sample sizes.

Form FM: Field Manager Report detailing the status of the fleet contacts and data collection implementation and giving the field manager's impression of the fleet.

Form CD: Company Description providing information about the organization and operation of the company, its maintenance practices, and fleet size.

2. *VEHICLE FILE* -- containing descriptive information on 3,188 vehicles, one record per vehicle, and descriptive information about each vehicle in the fleet. Included is information concerning the vehicle make, model, body style, typical use, and brake information by axle.

3. *THE COMBINED ANALYSIS FILE* -- containing selected Fleet and Vehicle analysis variables as well as the Mileage and Accident Count variables, one record per vehicle in which there is any associated mileage entry. Total entries = 2,613. The Combined Fleet and Truck Analysis File is a combination of four data files which permit speedy access to descriptive information about the sample of fleets, their associated vehicles, accumulated mileage and accident frequency. The four sub-files (consisting of only active fleets and vehicles) which make up the Combined Analysis File are:

a. Fleet Analysis File
b. Vehicle Analysis File
c. Mileage File
d. Accident Count File

Sub-files *(a)* and *(b)* above are subsets of variables from the Fleet and Vehicle Analysis Files respectively and permit a description of the sample fleets and sample vehicles. The Mileage File contains information concerning the mileage accumulated by each vehicle for the study period. The Accident Count File contains notations as to when an accident occurred and the type of accident. The Combined Analysis File provides a description of the vehicles' exposure and can be used to compute accident rates (accidents per hundred million vehicle miles).

4. *MAINTENANCE FILE* -- containing selected Fleet and Vehicle variables as well as the Maintenance Variables, one record per maintenance entry. Total entries = 8,308. The Maintenance File is composed of two sub-files.

a. Selected Combined File Variables
b. The Maintenance File

Certain variables which describe the vehicle, its company and operation were selected from the Combined File and coupled to the Complete Maintenance Activity File. Each maintenance activity is listed as a separate record.

5. *SPECIAL COMBINED FILE* -- containing all vehicles from the Fleet File, the Vehicle File, and all accidents reported for all vehicles whether vehicle mileage is available or not, one record per vehicle. Total entries = 3,188.

A document describing each analysis data file with associated information was prepared for use in analyzing the study data. Contained in this booklet are the following: (a) Five Variable Lists, (b) A Set of Code Tables, (c) A Set of Data Forms Keyed to the Fleet and Vehicle Analysis Files, (d) A Julian Day-Gregorian Day Conversion Table, and (e) Marginal Distributions with Means for Each Data File (except the Special Combined File).

4. DESCRIPTION OF THE SAMPLING FRAME

This section presents descriptive statistics on the vehicles and purchasers included in the sampling frame. Since the purchasers and vehicles were selected with known probabilities, the collected sample data provide a basis for a description of the segment of the trucking industry included in the sampling frame. As described in Chapter 2, this frame consisted of 175,210 pre-standard vehicles and 41,974 post-standard vehicles produced by seven major manufacturers and sold to 98,299 purchasers between January, 1974 and February, 1976 (Table 2.6). Taken in total, these statistics portray a striking picture of the changes in the sales and use of air-braked trucks during the period of implementation of FMVSS 121.

The statistics presented are computed by weighting the observations for each study vehicle by its sampling weight. The sampling weight is proportional to the inverse of the vehicle selection probability. Ninety-five percent confidence intervals are also computed to show the accuracy of these statistics. This interval is computed as $\pm$ 2 times the standard error. The size of the standard error depends on the size of the sample, the characteristics of the sample design (stratification, clustering, etc.), and the extent of homogeneity in the distribution of the variable of interest among the primary sampling areas. The statistical meaning of the 95% confidence interval is that, prior to the data collection, the odds are only one in twenty that the true value of the statistic will fall outside the computed confidence interval.

In general, the sampling errors (and confidence intervals) computed from the preliminary data files are quite large considering the sample sizes involved. Analysis of the sampling errors for a number of vehicle characteristics indicates that these errors are two to four times the error expected in a simple random sample. This result is due to the considerable homogeneity of the vehicle characteristics found within fleets and areas. The effect of this observed homogeneity is increased by the relatively small number (36) of primary sample units (geographic areas).

The reader should also be reminded that the confidence intervals presented do not take into account any possible non-response error. This error will be negligible if the characteristics of the non-responding vehicles are not appreciably different from those of the participating vehicles. This topic was discussed in more detail in Section 3.3.

Descriptive statistics on the vehicles are presented in Section 4.1. Descriptive statistics on the purchasers of these vehicles are presented in Section 4.2.

4.1 Description of the Vehicles

This section presents descriptive information on the vehicles in the sampling frame. Data elements for these tabulations come from the Vehicle Description Form described in Section 3.2 and shown in Appendix B. The statistics presented delineate significant differences in the types of vehicles and their use.

The initial tables presented are an attempt to compare data published in other sources which describe the total sampling frame with estimates computed from the sample. This information is followed by descriptive information which compares the vehicles in the pre- and post-standard sampling frames.

If some descriptive information is available for both the sample and the total sampling frame, one can then check for possible bias in the sample by comparison. One such comparison involves the vehicle manufacturer. The results of this comparison for both the pre- and post-standard samples are shown in Table 4.1. This

TABLE 4.1

COMPARISON OF MANUFACTURER PROPORTIONS FOR THE WHOLE FRAME
AND THE ACTIVE SAMPLE VEHICLES

Manufacturer	PRE-STANDARD VEHICLES			POST-STANDARD VEHICLES		
	Frame %	Active Unwtd. Sample %	Active Wtd. Sample %	Frame %	Active Unwtd. Sample %	Active Wtd. Sample %
Chevrolet	10.4	4.0	5.4 (± 2.8)	9.2	5.5	11.1 (± 7.0)
Dodge	0.3	0.0	0.0	0.1	0.1	0.03
Ford	24.5	23.9	26.5 (± 8.0)	32.4	46.3	44.8 (±10.0)
Freightliner	8.1	3.1	4.7 (± 4.8)	6.6	2.4	5.6 (± 5.8)
GMC	10.9	9.1	10.2 (± 5.0)	8.8	5.2	7.0 (± 3.2)
Intl Harvester	31.7	36.7	35.3 (±10.4)	33.8	35.8	26.4 (± 5.4)
Mack	8.3	10.6	10.1 (± 4.4)	5.3	2.4	1.3 (± 1.4)
White	5.9	12.5	7.7 (± 5.6)	3.8	2.0	2.2 (± 2.6)
Auto Car	--	0.0	0.0	--	0.1	0.5 (± 1.0)
White Western	--	0.2	0.1 (± 0.2)	--	0.3	1.2 (± 2.4)
N, WTD N		1492	3852		1686	3656

comparison shows some differences between the frame and sample percentages for the different manufacturers, especially between the frame percentages and the unweighted sample percentages. However, as would be expected, the use of the sample weights tends to reduce most of the sample and frame differences to amounts that are within the sampling error.

Another comparison is provided by Table 4.2 in which the estimated total factory sales of pre- and post-standard vehicles in Classes 6, 7, and 8 are compared with the weighted distributions of the active pre- and post-standard samples in these three classes. In this comparison both samples appear to be somewhat lower than would be expected in Class 8, but whether this is a real bias or an artifact of inadequate estimation formulae for determining factory sales of air-braked vehicles cannot be ascertained. In any event, both the factory sales and the sample data agree in indicating a post-standard decline in average GVWR for air-braked vehicles.

The major objective of this study is a comparison of accident rates (accidents per one hundred million vehicle miles) for the pre- and post-standard vehicles to determine the safety impact of FMVSS 121. However, other factors such as the driving environment also influence the accident rate for any vehicle. The comparison between pre- and post-standard vehicles will only be valid insofar as these exposure variables are controlled for in the analysis. The analysis approach for this study is to categorize the exposure (mileage) by the various types of vehicle usage. Adjustments will have to be applied if the populations of pre- and post-standard vehicles are distributed differently across the exposure categories. A direct comparison cannot be made if the usage is not the same. For this reason, the exposure distribution of the pre- and post-standard vehicles in the sampling frame is of central interest.

TABLE 4.2

WEIGHT CLASS COMPARISON OF WEIGHTED GROSS VEHICLE PROPORTIONS FOR THE ACTIVE SAMPLES OF PRE-STANDARD AND POST-STANDARD VEHICLES AND FACTORY SALES ESTIMATES ON AIR-BRAKED VEHICLES*

WEIGHT CLASS	PRE-STANDARD VEHICLES			POST-STANDARD VEHICLES		
	Study Vehicles		Factory Sales	Study Vehicles		Factory Sales
	%	CI	%	%	CI	%
Class 6 *(19,501-26,000#)*	16.3	(±6.6)	14.6	24.9	(±10.0)	19.9
Class 7 *(26,001-33,000#)*	18.0	(±6.4)	13.0	26.5	(± 9.6)	17.7
Class 8 *(Over 33,000#)*	65.7	(±7.0)	72.4	48.6	(± 9.6)	62.4

*See Table 2.2 for an explanation of these estimates.

The exposure categories are defined by four variables. These variables and their levels are:

	Variable	Levels
1	Vehicle Type	Straight Truck, Tractor, School Bus
2	Trip Distance	Local, Intercity
3	Fleet Size	Small (1-49), Large (50+), Unknown
4	Carrier Type	Private, For Hire

The fleet size variable is based upon the total number of air-braked units. A third category is shown for this variable to include the 6-8% missing data which is present in the preliminary data files used to produce these tabulations. There are almost no missing data on the other three exposure variables. The proportions of pre- and post-standard vehicles in the exposure categories defined by these variables are shown in Table 4.3.

Combining the data in Table 4.3, the proportions of pre-standard and post-standard vehicles in the basic six exposure cells defined by vehicle type and trip distance are shown in Table 4.4. Appreciable differences can be seen in these proportions for the pre- and post-standard vehicles. These differences and the 95% confidence values associated with them are shown in Table 4.5 where it can quickly be seen that tractors make up a significantly larger proportion of the pre-standard population than of the post-standard population. A possible explanation for these differences in the type of vehicle purchased before and after the standard may be the reluctance of some fleets to purchase the 121-equipped vehicle. The large, over-the-road fleets would have been most inclined to alter their purchases, and best able financially to do so. Small fleets and municipal fleets may have been less likely to do so. In fact, in early 1975, as the effective date of the standard approached, industry publications reported that large fleets were "over-buying" pre-standard 1974 and 1975 vehicles, presumably to avoid purchasing the 121 units. If the

TABLE 4.3

WEIGHTED PROPORTIONS OF VEHICLES

PRE-STANDARD:

Fleet Size	Carrier Type	Straight Truck		Tractor		School Bus		TOTAL
		Local	Inter-City	Local	Inter-City	Local	Inter-City	
Small (1-49)	Private	11.0%	3.4%	5.3%	12.0%	8.5%	1.6%	56.0%
	For Hire	3.5	4.5	0.2	5.9	0.1	0.1	
Large (50+)	Private	2.4	2.1	0.4	7.7	1.9	0.6	35.3
	For Hire	0.1	0.4	5.9	18.1	0.1	0.0	
Unknown	Private	2.0	1.7	1.2	1.3	0.2	0.0	8.8
	For Hire	0.0	0.0	0.0	0.0	0.0	0.0	
	TOTAL	19.0	12.1	13.0	43.0	10.8	2.3	100.1

N = 1,492 WTD N = 3,852

POST-STANDARD:

Fleet Size	Carrier Type	Straight Truck		Tractor		School Bus		TOTAL
		Local	Inter-City	Local	Inter-City	Local	Inter-City	
Small (1-49)	Private	17.2%	10.6%	3.8%	11.1%	9.7%	0.7%	60.9%
	For Hire	1.8	1.6	0.9	2.5	0.9	0.1	
Large (50+)	Private	6.7	5.1	1.0	2.5	7.4	0.1	33.0
	For Hire	0.2	0.4	1.5	7.8	0.3	0.1	
Unknown	Private	0.8	1.9	1.2	1.5	0.5	0.0	6.3
	For Hire	0.3	0.0	0.0	0.1	0.0	0.0	
	TOTAL	27.0	19.6	8.4	25.5	18.8	1.0	100.2

N = 1,685 WTD N = 3,655

TABLE 4.4

WEIGHTED PROPORTIONS OF VEHICLES--6 EXPOSURE CELLS
(95% CONFIDENCE INTERVAL)

Vehicle Type	Local		Intercity		TOTAL	
	%	CI	%	CI	%	CI
PRE-STANDARD:						
Straight Truck	19.0	(±4.6)	12.0	(±4.6)	31.0	(±7.0)
Tractor	13.1	(±6.4)	42.9	(±10.2)	56.0	(±11.0)
Bus	10.7	(±6.6)	2.2	(±3.0)	13.0	(±8.0)
TOTAL	42.8	(±8.6)	57.2	(±8.6)	100.0	
POST-STANDARD:						
Straight Truck	27.1	(±8.8)	19.5	(±7.0)	46.6	(±9.8)
Tractor	8.3	(±5.8)	25.3	(±6.6)	33.6	(±8.4)
Bus	18.9	(±7.2)	0.9	(±0.6)	19.8	(±7.4)
TOTAL	54.3	(±7.2)	45.7	(±7.2)	100.0	

Pre-Standard N = 1492 WTD N = 3853
Post-Standard N = 1685 WTD N = 3655

TABLE 4.5

WEIGHTED DIFFERENCES IN THE PROPORTIONS OF
PRE- AND POST-STANDARD VEHICLES--
6 EXPOSURE CELLS

(95% CONFIDENCE INTERVAL)

Vehicle Type	Local		Intercity		TOTAL	
	%	CI	%	CI	%	CI
Straight Truck	8.2	(±10.2)	7.5	(±6.2)	15.6	(±12.8)
Tractor	-4.8	(±5.4)	-17.6	(±14.0)	-22.4	(±14.4)
School Bus	8.1	(±5.8)	--	--	6.8	(±7.2)
TOTAL	11.5	(±11.8)	-11.5	(±11.8)		

over-buying was more prevalent in the large over-the-road fleets, the distribution of vehicle type would be altered since these fleets purchase tractors primarily. The proportion of vehicles used for intercity trips would, of course, also be influenced. This trend was aided by an economic slump which the trucking industry experienced in 1975.

Weighted distributions of vehicles by fleet size are shown in Table 4.6. The difference in the proportions of pre- and post-standard vehicles located in small, medium, and large fleets is only statistically significant for the medium size fleets. The weighted proportions of vehicles located in "private" and "for hire" fleets is shown in Table 4.7. The differences in these proportions for pre- and post-standard vehicles are statistically significant at the 95% level. The greater proportion of pre-standard vehicles in "for hire" fleets is consistent with the over-buying of large over-the-road fleets since these are mostly "for hire."

Table 4.8 and 4.9 present two other kinds of descriptive information about the pre-standard and post-standard vehicles broken down by vehicle type. These are gross vehicle weight rating and cab style. In regard to GVWR, air-braked tractors and buses have about the same distributions both before and after the implementation of the 121 standard, with most tractors in Class 8 and most buses in Class 6. However, for straight trucks there appears to be a substantial decline in average GVWR in the post-standard period. This and the proportionate increase in straight truck purchases in the post-standard period undoubtedly account for the overall decline in Class 8 vehicles noted in Table 4.2.

In regard to cab style, the post-standard tractors seem substantially more likely than the pre-standard tractors to have a cab-over or tilt cab styling with or without a sleeper (50.8% cab-over style for the post-standard tractors and 34.3% for the

TABLE 4.6

WEIGHTED PROPORTIONS AND DIFFERENCES OF PRE- AND POST-STANDARD VEHICLES BY FLEET SIZE

(95% CONFIDENCE INTERVAL)

Brake Type	FLEET SIZE						
	Small (1-49)		Medium (50-399)		Large (400+)		Unknown
	%	CI	%	CI	%	CI	%
Pre-Standard	56.0	(±9.8)	15.4	(±4.4)	19.9	(±8.2)	8.7
Post-Standard	60.8	(±9.0)	23.4	(±7.0)	9.4	(±8.2)	9.4
Difference	4.9	(±13.2)	8.1	(±7.6)	-10.6	(±11.6)	--

TABLE 4.7

WEIGHTED PROPORTIONS AND DIFFERENCES OF PRE- AND POST-STANDARD VEHICLES BY CARRIER TYPE

(95% CONFIDENCE INTERVAL)

Brake Type	CARRIER TYPE			
	Private		For Hire	
	%	CI	%	CI
Pre-Standard	60.3	(±11.2)	39.7	(±11.2)
Post-Standard	81.6	(±7.2)	18.4	(±7.2)
Difference	21.4	(±14.8)	-21.4	(±14.8)

TABLE 4.8

GVWR WEIGHTED PROPORTIONS BY VEHICLE TYPE
(95% CONFIDENCE INTERVAL)

PRE-STANDARD VEHICLES:

Weight Class	Straight Trucks	Tractors	Buses	All Vehicles
Class 5 < 19,000#	5.2 (±4.0)	1.4 (±2.2)	4.0 (±8.0)	2.9 (±1.6)
Class 6 19,001-26,000#	14.5 (±8.0)	2.4 (±3.8)	76.2 (±27.8)	15.7 (±6.6)
Class 7 26,001-33,000#	29.2 (±9.4)	10.1 (±6.8)	19.8 (±25.4)	17.3 (±6.4)
Class 8 > 33,000#	49.0 (±10.4)	85.8 (±8.4)	0.0	63.2 (±7.0)
Unknown	2.2 (±3.4)	0.2 (±0.4)	0.0	0.8 (±1.0)
TOTAL	100.1	99.9	100.0	99.9

POST-STANDARD VEHICLES:

Weight Class	Straight Trucks	Tractors	Buses	All Vehicles
Class 5 < 19,000#	2.5 (±3.4)	0.6 (±1.2)	3.3 (±5.4)	2.0 (±1.8)
Class 6 19,001-26,000#	18.2 (±10.0)	3.8 (±4.8)	74.0 (±22.0)	24.4 (±10.0)
Class 7 26,001-33,000#	39.6 (±14.2)	8.8 (±6.2)	22.4 (±19.4)	25.9 (±9.6)
Class 8 > 33,000#	39.3 (±15.8)	86.7 (±8.2)	0.0	47.5 (±9.6)
Unknown	0.3 (±0.4)	0.2 (±0.2)	0.0	0.2 (±0.2)
TOTAL	99.9	100.1	99.7	100.0

TABLE 4.9

CAB STYLE WEIGHTED PROPORTIONS BY VEHICLE TYPE

(95% CONFIDENCE INTERVAL)

PRE-STANDARD VEHICLES:

Cab Style	Straight Trucks	Tractors	Buses	All Vehicles
Conventional or Long Conventional	65.9 (±13.0)	48.2 (±13.2)	100.0	60.4 (±9.4)
Short Conventional	6.6 (±7.2)	17.5 (±12.0)		11.9 (±7.4)
Cab Over or Tilt Cab	26.8 (±12.6)	12.3 (±6.0)		15.2 (±5.0)
Cab Over or Tilt Cab with Sleeper	0.7 (±1.0)	22.0 (±10.0)		12.6 (±6.3)
TOTAL	100.0	100.0	100.0	100.1

POST-STANDARD VEHICLES:

Cab Style	Straight Trucks	Tractors	Buses	All Vehicles
Conventional or Long Conventional	75.3 (±13.8)	35.9 (±14.4)	100.0	66.9 (±9.4)
Short Conventional	15.5 (±12.2)	13.3 (±11.4)		11.7 (±7.2)
Cab Over or Tilt Cab	9.1 (±6.8)	32.1 (±19.2)		15.0 (±7.0)
Cab Over or Tilt Cab with Sleeper	0.1 (±0.2)	18.7 (±14.2)		6.3 (±5.1)
TOTAL	100.0	100.0	100.0	99.9

pre-standard tractors). The post-standard straight trucks are considerably less likely to have such cab styling than the pre-standard straight trucks (9.2% cab-over style for the post-standard straight trucks and 27.5% for the pre-standard straight trucks). This latter difference seems consistent with the decline in average size of the post-standard straight trucks.

Two other tables of interest concern the post-standard vehicles only. Table 4.10 presents data on the current operational status of the 121 brakes. This shows that the brakes have been modified on only about 5% of the post-standard straight trucks and tractors, but the brakes have been modified on about one-half of the post-standard buses. By far, the most frequent modification involves disconnecting the anti-lock system, a modification which was oficially authorized for buses by NHTSA in January 1976. Only 0.5% of the pre-standard vehicles are reported to have modified their original brakes by the addition of an anti-lock system.

Table 4.11 shows the distribution of the 121 anti-lock system in the post-standard sample among six major system manufacturers. On the basis of these sample findings it appears that Kelsey-Hayes and Eaton tend to dominate the market.

4.2 Description of the Purchasers

This section provides a description of the purchasers of the trucks on the manufacturers' sales lists. The descriptive information obtained for the study fleets is weighted in proportion to the inverse of the selection probability for each fleet. Several qualifications must accompany these results. First, these results do not necessarily describe the population of all owners of air-braked vehicles. These results only describe the fleets (or individuals) who purchased air-braked vehicles produced during the period January 1, 1974-February 1, 1976. As discussed in Chapter 2, only about half of the vehicles manufactured after the

TABLE 4.10

OPERATIONAL STATUS OF BRAKES ON REAR-MOST AXLE
OF POST-STANDARD TRUCKS AND BUSES

(95% CONFIDENCE INTERVAL)

Brake Status	Trucks	Buses	All Vehicles
As Originally Equipped	95.1 (±5.8)	49.4 (±20.2)	86.0 (±7.8)
Anti-Lock Disconnected	4.6 (±5.8)	37.8 (±14.0)	11.2 (±5.6)
Some Other Modification	0.1 (±0.2)	11.3 (±21.8)	2.4 (±4.6)
Both Disconnected Anti-Lock & Another Modification	0.2 (±0.4)	1.2 (± 2.0)	0.4 (±0.4)

TABLE 4.11

ANTI-LOCK MANUFACTURERS FOR POST-STANDARD TRUCKS AND BUSES

(95% CONFIDENCE INTERVAL)

Anti-Lock Manufacturers	Trucks	Buses	All Vehicles
A.C.	14.8 (± 6.4)	13.2 (±14.8)	14.5 (± 7.0)
Bendix	5.4 (± 6.2)	3.6 (± 4.4)	5.0 (± 4.6)
Eaton	36.2 (± 9.4)	28.6 (±11.8)	34.6 (± 9.2)
Kelsey-Hayes	37.1 (±10.4)	53.4 (±22.8)	40.5 (±10.0)
Rockwell	1.7 (± 2.2)	1.3 (± 1.8)	1.6 (± 1.6)
Wagner	4.8 (± 6.0)	0.0 (--)	3.8 (± 3.6)

121 standard took effect had names of purchasers listed in the manufacturers' records at the time the lists were obtained. This condition further limits the population of owners from which the sample was drawn.

A second qualification arises from the sampling approach used. The objective was to obtain a sample of trucks, not fleets. Fleets only represent clusters of vehicles for data collection purposes. Rather than try to obtain a uniform sample of fleets, the sample design called for large fleets to be over-sampled (selected with higher probabilities). It also called for fleets with both pre- and post-standard vehicles to be over-sampled as compared with fleets which purchased only pre-standard or only post-standard vehicles. This was done because data collection costs per vehicle are lower in a larger fleet. The effect of these factors is that the confidence intervals tend to be larger for the fleet statistics than for the vehicle statistics because the design was not tailored to these estimates.

Another qualification addresses additional fleets ("sub-fleets") which are included in the study. These additional fleets arise when selected vehicles are found to be located in fleets other than the selected fleet. This occurs when the vehicle is sold, or when the selected "fleet" is a body-builder or lessor. Of 554 fleets originally selected, 356 are participating and included in the preliminary data files. Descriptive information on 124 additional "sub-fleets" is also included in the preliminary files. However, only 26 of the sub-fleets are included in the descriptive statistics presented. These 26 sub-fleets represent the 16 selected purchasers who are not participating with the selected vehicles which they retained and the 10 selected purchasers who have not retained any of their selected vehicles. The remaining 98 sub-fleets are not included in these tables because their probabilities of selection, and therefore their sample weights, are not known since they were not directly selected during the sampling process.

At this point it should also be recalled that names and addresses were obtained for nearly four times as many pre-standard as post-standard vehicles. Sampling probabilities were chosen to yield approximately equal sample sizes from each group. However, these results are weighted by the inverse of the selection probabilities, and therefore are estimates for the original total population of listed purchasers during the 25-month period. This population contains approximately four times as many purchasers of pre-standard vehicles as post-standard vehicles. Thus, the purchaser weights vary from a high of 76.4 for Cell 2 fleets to .207 for the largest participating Cell 16 fleet.

Table 4.12 presents the weighted distribution of fleets by exposure category. Three exposure variables are shown, typical trip distance, fleet size, and ICC status. Fleets are not dichotomized by brake status, since most selected fleets which purchased 121-equipped vehicles also had purchased pre-standard vehicles. Nearly one-half of the fleets indicated that their typical trip was within the local vicinity, and only 16% indicated that their typical trip was intercity and a one-way distance greater than 200 miles.

Overall distributions by fleet size and carrier type are shown in Tables 4.13 and 4.14 respectively. Fleet size categories are based on the total number of air-braked power units owned by the company. On this basis, 85% of the fleets have less than 50 vehicles and only 0.5% have more than 400 air-braked power units. Table 4.14 indicates that about 74% of the fleets are private. The 95% confidence interval on this statistic is 64%-84%. Only 8.9% of the fleets reported that they were operating divisions of a larger corporation.

TABLE 4.12

WEIGHTED DISTRIBUTION OF FLEETS BY EXPOSURE CATEGORY
(95% CONFIDENCE INTERVAL)

FLEET SIZE	LOCAL	INTERCITY		TOTAL
		<200 Miles	>200 Miles	
Small (1-49):				
Private	34.3 (±10.6)	21.4 (±7.2)	6.7 (±5.4)	62.3 (±10.8)
For Hire	5.9 (± 5.0)	10.4 (±7.8)	6.8 (±4.4)	23.1 (± 9.4)
Medium (50-399):				
Private	2.7 (± 2.6)	2.6 (±3.2)	0.8 (±0.8)	6.0 (± 4.6)
For Hire	0.0 --	0.8 (±0.4)	0.4 (±0.4)	1.3 (± 0.6)
Large (400+):				
Private	0.1 (± 0.1)	0.0 --	0.0 --	0.1 (± 0.2)
For Hire	0.1 (± 0.2)	0.1 (±0.2)	0.2 (±0.2)	0.4 (± 0.4)
Unknown:				
Private	1.7 (± 1.6)	2.7 (±3.2)	1.2 (±2.4)	5.6 (± 5.2)
For Hire	1.2 (± 2.4)	0.0 --	0.0 --	1.2 (± 2.4)
TOTAL	45.9 (±10.6)	38.1 (±11.0)	16.0 (±7.2)	100.0 --

N = 376 WTD N = 6542

TABLE 4.13

WEIGHTED DISTRIBUTION OF FLEETS BY FLEET SIZE
(95% CONFIDENCE INTERVAL)

Fleet Size	Weighted Distribution	
	%	CI
Small (1-49)	85.4	(±6.2)
Medium (50-399)	7.3	(±4.8)
Large (400+)	0.5	(±0.4)
Unknown	6.8	--
TOTAL	100.0	--

N = 376 WTD N = 6542

TABLE 4.14

WEIGHTED DISTRIBUTION OF FLEETS BY CARRIER TYPE
(95% CONFIDENCE INTERVAL)

Carrier Type	Weighted Distribution	
	%	CI
Private	74.1	(±9.6)
For Hire	25.9	(±9.6)
Common	*14.9*	*(±5.4)*
Contract	*7.5*	*(±6.4)*
Exempt	*3.5*	*(±4.0)*
TOTAL	100.0	

N = 376 WTD N = 6542

While, in general, the confidence intervals on these statistics are large, it is important to realize that a very large proportion of the fleets included in the sampling frame are small, private fleets (62% ± 11%). The large, "for hire" fleets are only 0.5% of the total number of fleets. However, these fleets have approximately one quarter of the pre-standard vehicles and one-tenth of the post-standard vehicles.

Information on driver assignment practices is given in Table 4.15. The majority of companies (62%) assign vehicles to a particular driver. However, in approximately 20% the driver may be assigned to any vehicle on a given day. The final 17% are owner-operators.

Table 4.16 presents additional information on the geographic aspects of the sample fleets' operations. While Table 4.12 showed that 46% of the fleets considered their average trip to be a local one, Table 4.16 shows that 60% of the fleets at least sometimes make local trips. About one-sixth operate both locally and intra-state, and 6% operate locally, intra-state, and inter-state. About two-fifths travel only in the local area or commercial zone, and a further 30% do not customarily travel between states.

In regard to type of cargo carried, almost three-quarters of the fleets (73%) said they carried specialized cargo of various kinds. About one-sixth (17.4%) said they carried general commodities, 5.6% reported carrying primarily exempt commodities, and 3% were not cargo carrying vehicles (cranes, fire trucks, etc.). Two-thirds of the fleets report that their trucks generally travel back home empty, while 22.3% are company loaded.

One item of special interest in regard to 121 brakes is the company policy toward the coupling of 121-braked trailers with non-121-braked tractors and vice versa. Of the 70 fleets which reported owning both post-standard tractors and post-standard

TABLE 4.15

WEIGHTED DISTRIBUTION OF FLEETS BY
GENERAL DRIVER ASSIGNMENT POLICY

(95% CONFIDENCE INTERVAL)

Driver Assignment	Weighted Distribution	
	%	CI
COMPANY CONTROLLED		
Assignment Seat	61.5	(±7.6)
Slip Seat	19.8	(±5.6)
Not Specified	1.3	(±2.2)
OWNER/OPERATOR	17.4	(±7.8)

N = 376 WTD N = 6542

TABLE 4.16

WEIGHTED DISTRIBUTION OF FLEETS BY
GEOGRAPHIC AREA OF OPERATION

(95% CONFIDENCE INTERVAL)

Geographic Area of Operation	Weighted Distribution	
	%	CI
Local Only	34.6	(±10.8)
Commercial Zone Only	4.7	(±6.0)
Intra-State Only	11.7	(±7.6)
Inter-State Only	13.5	(±7.0)
Local and Intra-State	17.4	(±8.6)
Local and Inter-State	1.8	(±2.6)
Local & Intra-State & Inter-State	6.0	(±2.8)
Commercial Zone and Intra-State	2.4	(±3.2)
Commercial Zone and Inter-State	0.1	(±0.2)
Commercial Zone & Intra-State & Inter-State	0.1	(±0.1)
Intra-State and Inter-State	7.8	(±6.0)
TOTAL	100.1	
Total Local	59.8	(±13.8)
Total Commercial Zone	7.2	(±8.4)
Total Intra-State	45.3	(±9.6)
Total Inter-State	29.2	(±10.6)

N = 376 WTD N = 6542

trailers at the time of implementation, only 21% said it was company policy <u>not</u> to couple pre-standard trailers to post-standard tractors and vice versa. The confidence value for this statistic is a large 24.8, but still it is likely that very large numbers of mixed tractor-trailer brake combinations are currently in operation.

Table 4.17 provides information on reported pre-trip and post-trip inspection practices. About one-tenth of the fleets report no regular pre-trip inspection and three-tenths report no regular post-trip inspection. Only a few fleets use a check lane inspection procedure, but about one-fifth use a pre-trip check list and one-ninth use a post-trip vehicle condition report. For most fleets the burden of these inspections is primarily on the driver with the driver visual check being the most common form of pre-trip inspection and the driver oral report being the most common post-trip inspection practice.

In regard to periodic inspection practices, 36% of the fleets report regular visual inspections and 45% report regular written inspections, but 19% report not following any regular periodic inspection practice. For fleets which report practicing periodic inspection, 14.9% use company officials, 66.9% use company maintenance staff, and 18.2% use an outside repair service to conduct the inspections.

Turning to periodic maintenance of their vehicles, Table 4.18 indicates that a similar percentage of fleets (18.5%) do not practice regular periodic maintenance. Almost two-thirds of the fleets report performing their own mechanical work on their vehicles, but only one-fifth of the fleets which do their own mechanical work and have post-standard vehicles report being equipped to diagnose problems with post-standard brakes. An even smaller proportion, 14.7%, report that their mechanics have had special training in dealing with the 121 brake system. The primary sources

TABLE 4.17

WEIGHTED DISTRIBUTION OF FLEETS BY INSPECTION PRACTICES
(95% CONFIDENCE INTERVAL)

Inspection Practices	Weighted Distribution	
	%	CI
PRE-TRIP INSPECTION:		
Check Lane	1.6	(±2.2)
Check List	21.7	(±7.2)
Driver Visual Check	66.4	(±7.6)
None	10.3	(±4.0)
POST-TRIP INSPECTION:		
Check Lane	0.5	(±0.6)
Vehicle Condition Report	11.2	(±6.8)
Other Driver Written Report	23.2	(±7.4)
Driver Oral Report	35.4	(±8.2)
Combination of Methods	0.1	(±0.1)
None	29.6	(±8.8)

N = 376 WTD N = 6541

TABLE 4.18

WEIGHTED DISTRIBUTION OF FLEETS BY MAINTENANCE PRACTICES
(95% CONFIDENCE INTERVAL)

Maintenance Practice	Base N		Wtd. Distrib.	
	Unwtd.	Wtd.	%	CI
1. Carry Out Regular Periodic Maintenance	375	6541	81.5	(±9.6)
2. Perform Own Mechanical Work	375	6541	63.7	(±6.0)
3. Perform Own Mechanical Work and Have Post-Standard Tractors or Trailers	375	6541	36.2	(±5.0)
4. Equipped to Diagnose 121 Brake Problems (based on Category 3)	247	2368	19.2	(±11.8)
5. Special Training to Mechanics on 121 Brakes (based on Category 3)	247	2368	14.7	(±10.8)
6. Source of Special 121 Brake Training (based on Category 5):				
a. Truck Company Course	100	354	6.5	(±8.2)
b. Supplier Course	100	354	20.6	(±16.4)
c. Manufacturer Course	100	354	29.3	(±22.0)
d. On-the-Job Training	100	354	9.2	(±12.0)
e. Dealer Training	100	354	0.6	(±1.2)
f. Source Unknown to Respondent	100	354	33.9	(±32.4)

of such special training as had been received were supplier or manufacturer courses. Large fleets were much more likely to have 121 diagnosis facilities and special training than were small fleets, but it is apparent that there was still a substantial need for upgrading of 121 brake system maintenance capabilities 18 months after the effective date of the 121 standard.

5. MILEAGE, ACCIDENTS, AND ACCIDENT RATES

Over 100 million vehicle miles have been monitored during the first year of data collection, 1976. The information obtained has been processed and stored in computerized data files. Table 5.1 provides an overview of the number of vehicles, days, and miles which provide the basis for these preliminary mileage and accident figures. These data represent the first year of a two year data collection effort. Mileage information presented in Section 5.1 includes average miles per day and distributions of total mileage broken down by exposure category. The corresponding accident counts for each exposure category are presented in Section 5.2, and accident rates (number of accidents per hundred million vehicle-miles) are presented in Section 5.3.

5.1 Mileage

For each vehicle, the mileage is computed by subtracting the odometer reading at the beginning of the monitoring period from the odometer reading at the end of the monitoring period. The number of days is computed by subtracting the respective Julian dates. Mileage information is not complete for all vehicles and all quarters for 1976 in the data files used in these computations. All available information was utilized including, in some cases, mileages for the first quarter of 1977. Overall, the mileage analyzed represents an average of about ten months exposure for each vehicle.

An average daily mileage is computed for each vehicle. Every calendar day is included in the denominator on this division so that this figure is influenced by the amount of time the vehicle is out of service as well as the average traveling speed when the vehicle is in service. Vehicles are then grouped by exposure category and the mean miles per day is computed for each category by brake type. The exposure variables used and their levels are listed below:

Variable	Levels
1. Vehicle Type	Straight Truck, Tractor, School Bus
2. Trip Distance	Local, Intercity
3. Carrier Type	Private, For Hire
4. Fleet Size, i.e. All Power Units	Small (1-49); Large (50+)

These four variables define 24 categories within which comparisons can be made by brake type. The use of the exposure categories arises from the assumption that factors other than the presence of 121 brakes on the vehicle influence that vehicle's accident rate. In particular, different usage environments represent different risks of accident involvement. The use of these exposure categories is an attempt to control for the major confounding factors which influence the accident rates above and beyond the effect of the 121 brakes. Many other variables may be hypothesized as influencing accident rates. However, sample size limitations preclude inclusion of any additional categories. The intent of the study is to control for these additional factors in the selection of the vehicles. Vehicles for study were selected from adjacent production years (1974, 1975) to minimize differences in vehicle age. Data collection is conducted over the same calendar years for both pre- and post-standard vehicles to eliminate year-to-year and seasonal variations. Finally, about 50% of the pre-standard vehicles are located in the same fleets as the post-standard vehicles making the usage of these vehicles even more comparable.

Table 5.1 presents average daily mileages by brake type for each of the 24 exposure categories. In computing the means, the observation for each vehicle is weighted by the relative sampling weight for that vehicle. The source of these weights

TABLE 5.1

VEHICLES, DAYS, AND MILES MONITORED BY VEHICLE TYPE

Brake Type	No. Vehicles	Days	Vehicle Miles
STRAIGHT TRUCK:			
Pre-Standard	248	74,693	4,086,196
Post-Standard	343	88,979	4,805,281
TRACTOR:			
Pre-Standard	726	234,582	56,831,230
Post-Standard	478	138,837	36,148,458
SCHOOL BUS:			
Pre-Standard	125	37,492	1,275,095
Post-Standard	353	102,445	3,658,721
TOTAL			
Pre-Standard	1099	346,767	62,195,521
Post-Standard	1174	330,261	44,612,460
GRAND TOTAL	2273	667,028	106,807,481

was discussed in Chapter 2. Also shown for each cell is the raw (unweighted) number of study vehicles and the weighted number of vehicles upon which the mean was computed. Because the fleet size variable was unknown for some fleets at the time these data files were built, a third category is included in this table for these vehicles. There are no missing data in these files on any of the other exposure variables. When the fleet size categories are combined, the missing data category is included.

The unweighted cell sizes in Table 5.2 range from 0 vehicles (large for-hire fleets of school buses) to 359 (large for-hire fleets of intercity tractors). The average daily mileage ranges from 20.1 miles/day to 304.3 miles/day. Appreciable differences are shown in some exposure cells for the pre- and post-standard vehicles. However, the same general trends across exposure categories seem to prevail.

To increase cell sizes for computation of accident rates, exposure is aggregated into the 6 cells defined by vehicle type and trip distance. Table 5.3 shows the result of this aggregation on average daily mileage by brake type. In addition to the weighted cell means, Table 5.3 also shows 95% confidence intervals as plus or minus twice the sample error. As in Chapter 4, sample errors are high due to the homogeneity of the sample clusters. Consequently, the differences shown between the pre- and post-standard vehicles are not statistically significant.

Table 5.2 has also been aggregated to compare the usage of the pre- and post-standard vehicles against each of the exposure variables separately. These comparisons are shown in Tables 5.4 through 5.7. For Table 5.4, the Intercity Trip Distance category has been further divided into intercity trips with a one-way distance less than 200 miles and intercity trips with a one-way distance greater than 200 miles. Also, the fleet size variable has been expanded from two to three levels for Table 5.6. Confidence

TABLE 5.2

WEIGHTED MEAN MILES/DAY BY BRAKE TYPE--24 EXPOSURE CELLS

PRE-STANDARD VEHICLES:

Fleet Size	Carrier Type	STRAIGHT TRUCK Local N	WTD N	Mi/Day	STRAIGHT TRUCK Intercity N	WTD N	Mi/Day	TRACTOR Local N	WTD N	Mi/Day	TRACTOR Intercity N	WTD N	Mi/Day	SCHOOL BUS Local N	WTD N	Mi/Day	SCHOOL BUS Intercity N	WTD N	Mi/Day
Small (1-49)	Private	34	181	38.0	19	99	78.5	12	148	216.2	81	369	197.2	53	273	36.6	0	0	0
	For Hire	20	91	70.4	11	128	191.3	3	3	58.4	36	156	202.5	4	4	52.1	4	4	44.2
Large (50+)	Private	57	81	20.7	38	62	87.2	4	4	123.6	94	118	231.6	55	66	34.6	3	22	20.1
	For Hire	0	0	0	14	14	62.3	132	209	57.4	359	491	304.3	0	0	0	0	0	0
Missing Data	Private	41	63	33.0	14	14	41.1	1	1	28.9	4	23	103.1	6	6	32.6	0	0	0
	For Hire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POST-STANDARD VEHICLES:

Fleet Size	Carrier Type	STRAIGHT TRUCK Local N	WTD N	Mi/Day	STRAIGHT TRUCK Intercity N	WTD N	Mi/Day	TRACTOR Local N	WTD N	Mi/Day	TRACTOR Intercity N	WTD N	Mi/Day	SCHOOL BUS Local N	WTD N	Mi/Day	SCHOOL BUS Intercity N	WTD N	Mi/Day
Small (1-49)	Private	69	505	52.7	31	248	116.6	29	98	46.9	90	305	250.6	119	264	51.2	5	5	36.0
	For Hire	4	26	82.1	7	13	128.3	4	4	30.0	17	69	236.1	14	14	51.2	4	4	66.5
Large (50+)	Private	11	208	32.1	77	83	72.2	19	19	101.9	18	18	193.8	190	205	37.5	4	4	20.9
	For Hire	3	3	37.9	13	13	35.7	45	45	73.9	239	252	329.8	0	0	0	0	0	0
Missing Data	Private	12	12	23.7	16	33	49.3	0	0	0	16	54	152.1	17	17	41.3	0	0	0
	For Hire	0	0	0	0	0	0	0	0	0	1	2	258.8	0	0	0	0	0	0

Pre-Standard N = 1174
Pre-Standard WTD N = 2506

Post-Standard N = 1049
Post-Standard WTD N = 2630

TABLE 5.3

WEIGHTED MEAN MILES/DAY BY BRAKE TYPE--6 EXPOSURE CELLS
(95% CONFIDENCE INTERVAL)

Vehicle Type	Usual Trip Length			
	Local		Intercity	
	Miles/Day	CI	Miles/Day	CI
STRAIGHT TRUCK:				
Pre-Standard	41.0	(±20.9)	123.4	(±67.2)
Post-Standard	47.6	(±14.8)	101.4	(±59.3)
TRACTOR:				
Pre-Standard	122.5	(±77.9)	245.0	(±62.6)
Post-Standard	60.1	(±20.3)	275.0	(±57.8)
SCHOOL BUS:				
Pre-Standard	36.3	(±12.5)	23.8	(± 9.2)
Post-Standard	45.2	(±21.5)	40.7	(±22.1)

N = 2273 WTD N = 5136

TABLE 5.4

WEIGHTED MEAN MILES/DAY BY BRAKE TYPE AND USUAL TRIP LENGTH
(95% CONFIDENCE INTERVAL)

Brake Type	Usual Trip Length					
	Local		Intercity			
			< 200 Miles		> 200 Miles	
	Mi/Day	CI	Mi/Day	CI	Mi/Day	CI
Pre-Standard	65.9	(±24.5)	133.1	(±38.5)	268.7	(±79.8)
Post-Standard	48.2	(±10.9)	115.8	(±22.0)	299.8	(±61.2)

N = 2273 WTD N = 5136

TABLE 5.5

WEIGHTED MEAN MILES/DAY BY BRAKE TYPE AND VEHICLE TYPE
(95% CONFIDENCE INTERVAL)

Brake Type	Vehicle Type					
	Straight Trk		Tractor		School Bus	
	Mi/Day	CI	Mi/Day	CI	Mi/Day	CI
Pre-Standard	76.6	(±36.6)	215.6	(±54.8)	35.0	(±12.0)
Post-Standard	65.4	(±25.7)	233.8	(±62.4)	45.1	(±20.9)

N = 2273 WTD N = 5136

TABLE 5.6

WEIGHTED MEAN MILES/DAY BY BRAKE TYPE AND FLEET SIZE
(95% CONFIDENCE INTERVAL)

Brake Type	Fleet Size					
	Small (1-40)		Medium (50-399)		Large (400+)	
	Mi/Day	CI	Mi/Day	CI	Mi/Day	CI
Pre-Standard	132.2	(±45.2)	127.3	(±30.5)	203.7	(±100.5)
Post-Standard	112.8	(±28.0)	76.3	(±40.1)	270.9	(±165.9)

N = 2073 WTD N = 4856

TABLE 5.7

WEIGHTED MEAN MILES/DAY BY BRAKE TYPE AND CARRIER TYPE
(95% CONFIDENCE INTERVAL)

Brake Type	Carrier Type			
	Private		For Hire	
	Miles/Day	CI	Miles/Day	CI
Pre-Standard	112.1	(±41.3)	204.8	(±68.3)
Post-Standard	90.3	(±19.6)	254.3	(±90.8)

N = 2273 WTD N = 5136

intervals are indicated on each of these tables. In general, the average daily mileage is similar for the pre- and post-standard vehicles across each of the exposure variables.

A percentage distribution of total mileage by brake type for the 24 exposure cells is shown in Table 5.8. This distribution was computed by multiplying the mean daily mileage for each cell by the weighted proportion of study vehicles in that cell. The result of that calculation was then normalized to produce a table sum of 100% for the pre-standard and 100% for the post-standard. Table 5.9 shows the result when the exposure distribution is collapsed to 6 cells. This tabulation illustrates some apparent differences in the pre- and post-standard samples of vehicles. The post-standard tractors account for a lower percentage (64% vs. 82%) of the total mileage than the pre-standard tractors. This difference is primarily due to a smaller proportion of tractors in the post-standard sample, since the average daily mileages are comparable.

The distribution of mileage for the pre- and post-standard vehicles can also be compared across fleet size and carrier type as shown in Tables 5.10 and 5.11, respectively. Notice that the proportion of the total mileage accumulated by vehicles in large fleets is less for the post-standard vehicles (22.9% vs. 30.2%), reflecting the smaller proportion of vehicles in this category. The percentage of mileage accumulated in private fleets is 30% higher for the post-standard vehicles. This result is consistent with the higher proportion of straight trucks and school buses in the post-standard sample.

Since the mileage distribution shown in Table 5.9 shows significant differences between the pre- and post-standard vehicles, an average of the two was computed for use when the individual cell accident rates are combined to produce overall rates. This distribution is shown in Table 5.12.

TABLE 5.8

WEIGHTED PERCENT DISTRIBUTION OF MILEAGE
BY BRAKE TYPE--24 EXPOSURE CELLS*

PRE-STANDARD VEHICLES:

Fleet Size	Carrier Type	Straight Trk		Tractor		School Bus		TOTAL
		Local	Inter-City	Local	Inter-City	Local	Inter-City	
Small (1-49)	Private	2.7	1.8	7.5	15.5	2.0	0.4	29.9
	For Hire	1.6	5.7	0.1	7.9	0.0	0.0	15.3
Large (50+)	Private	0.3	1.2	0.3	11.7	0.4	0.1	14.0
	For Hire	0.0	0.2	2.2	36.2	0.0	0.0	38.6
Missing Data	Private	0.4	0.5	0.2	0.9	0.0	0.0	2.0
	For Hire	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	TOTAL	5.0	9.4	10.3	72.2	2.4	0.5	99.8

POST-STANDARD VEHICLES:

Fleet Size	Carrier Type	Straight Trk		Tractor		School Bus		TOTAL
		Local	Inter-City	Local	Inter-City	Local	Inter-City	
Small (1-49)	Private	8.1	11.0	1.6	24.7	4.4	0.2	50.0
	For Hire	1.3	1.8	0.2	5.2	0.4	0.1	9.0
Large (50+)	Private	1.9	3.3	0.9	4.3	2.5	0.0	12.9
	For Hire	0.1	0.1	1.0	22.9	0.1	0.0	24.2
Missing Data	Private	0.2	0.8	0.3	2.0	0.2	0.0	3.5
	For Hire	0.1	0.0	0.0	0.2	0.0	0.0	0.3
	TOTAL	11.7	17.0	4.0	59.3	7.6	0.3	99.9

*WTD Mean Miles/Day x WTD Proportions of Vehicles.

TABLE 5.9

WEIGHTED DISTRIBUTION OF MILEAGE
BY BRAKE TYPE--6 EXPOSURE CELLS*

PRE-STANDARD VEHICLES:

Vehicle Type	Usual Trip Length		TOTAL
	Local	Intercity	
Straight Truck	5.2	10.0	15.2
Tractor	10.8	71.1	81.9
School Bus	2.6	0.3	2.9
TOTAL	18.6	81.4	100.0

POST-STANDARD VEHICLES:

Vehicle Type	Usual Trip Length		TOTAL
	Local	Intercity	
Straight Truck	11.0	17.0	28.0
Tractor	4.2	60.2	64.4
School Bus	7.2	0.3	7.6
TOTAL	22.5	77.5	1.0

*WTD Mean Miles/Day x WTD Proportions of Vehicles.

TABLE 5.10

WEIGHTED DISTRIBUTION OF MILEAGE
BY BRAKE TYPE AND FLEET SIZE*

Brake Type	FLEET SIZE Small (1-49)	Medium (50-399)	Large (400+)	TOTAL
Pre-Standard	55.2	14.6	30.2	100.0
Post-Standard	61.0	16.1	22.9	100.0

*WTD Mean Miles/Day x WTD Proportions of Vehicles.

TABLE 5.11

WEIGHTED DISTRIBUTION OF MILEAGE
BY BRAKE TYPE AND CARRIER TYPE*

Brake Type	CARRIER TYPE Private	For Hire	TOTAL
Pre-Standard	45.5	54.5	100.0
Post-Standard	60.9	39.1	100.0

*WTD Mean Miles/Day x WTD Proportions of Vehicles.

TABLE 5.12

AVERAGE DISTRIBUTION OF WEIGHTED MILEAGE FOR PRE- AND
POST-STANDARD VEHICLES--6 EXPOSURE CELLS

Vehicle Type	USUAL TRIP LENGTH Local	Intercity	TOTAL
Straight Truck	8.1	13.5	21.6
Tractor	7.5	65.7	73.2
School Bus	4.9	0.3	5.2
TOTAL	20.5	79.5	100.0

5.2 <u>Accidents</u>

Accidents involving study vehicles were also grouped according to the exposure category of the vehicle. All accidents, no matter how minor, are included in this tabulation. Variations in the reporting threshold from fleet to fleet will influence the number of accidents received. The only accidents which have been excluded are those in which the study vehicle was parked. Table 5.13 shows weighted counts of 1976 accidents by brake type and exposure cell along with the weighted total number of study vehicles in each cell. Unweighted data are shown in Table 5.14.

A more stringent approach is to only count those accidents which fall within the mileage data currently in the file. In this approach the accident is not included in the count unless the mileage information is complete for the accident date. Using this approach, weighted and unweighted counts of accidents, vehicles, and mileage by brake type for 6 exposure cells are shown in Tables 5.15 and 5.16, respectively. Nearly 40% fewer accidents are included in this tabulation.

5.3 <u>Accident Rates</u>

Accident rates expressed as number of accidents per million vehicle miles are obtained directly from Table 5.15 by division. The results of this division are shown in Table 5.17 along with the associated 95% confidence intervals. Statistically, the probability was one in twenty that the true mean would fall outside the interval <u>prior to the experiment</u>. The confidence limits on the accident rates are very large. While this has also been the case on the previous statistics presented, it is informative to note the source of this variation. For the proportions presented in Chapter 4, the design effect was very high, multiplying the standard error (and the confidence interval) by factors of 3 or 4. This was also the situation for the average daily mileages, although

TABLE 5.13

WEIGHTED COUNTS OF 1976 ACCIDENTS AND VEHICLES
BY BRAKE TYPE--6 EXPOSURE CELLS

Brake Type	USUAL TRIP LENGTH			
	Local		Intercity	
	Accidents	Vehicles	Accidents	Vehicles
STRAIGHT TRUCK:				
Pre-Standard	37	730	47	463
Post-Standard	42	991	8	712
TRACTOR:				
Pre-Standard	25	504	145	1655
Post-Standard	14	303	76	926
SCHOOL BUS:				
Pre-Standard	4	414	60	86
Post-Standard	25	689	1	34

WTD N of Accidents = 441
WTD N of Vehicles = 7480

TABLE 5.14

UNWEIGHTED COUNTS OF 1976 ACCIDENTS AND VEHICLES BY BRAKE TYPE--6 EXPOSURE CELLS

Brake Type	USUAL TRIP LENGTH			
	Local		Intercity	
	Accidents	Vehicles	Accidents	Vehicles
STRAIGHT TRUCK:				
Pre-Standard	18	217	4	143
Post-Standard	21	306	8	328
TRACTOR:				
Pre-Standard	25	207	93	779
Post-Standard	14	139	52	437
SCHOOL BUS:				
Pre-Standard	4	136	3	10
Post-Standard	25	460	1	15

Number of Accidents = 268
Number of Vehicles = 3,176

TABLE 5.15

WEIGHTED COUNTS OF ACCIDENTS, VEHICLES, AND MILEAGE
BY BRAKE TYPE FROM MONITORED MILES
AND ACCIDENTS--6 EXPOSURE CELLS

Brake Type	Usual Trip Length					
	Local			Intercity		
	No. Acc.	No. Veh.	100 Million Vehicle Mi.	No. Acc.	No. Veh.	100 Million Vehicle Mi.
STRAIGHT TRUCK:						
Pre-Standard	12	416	0.054756	5	317	0.130315
Post-Standard	9	754	0.112813	3	373	0.068869
TRACTOR:						
Pre-Standard	13	365	0.148346	65	1157	0.951814
Post-Standard	6	166	0.031989	36	700	0.523341
SCHOOL BUS:						
Pre-Standard	24	349	0.034484	0	26	0.002093
Post-Standard	20	501	0.064076	0	13	0.001597

WTD N of Accidents = 193
WTD N of Vehicles = 5136

TABLE 5.16

UNWEIGHTED COUNTS OF ACCIDENTS, VEHICLES, AND MILEAGE
BY BRAKE TYPE FROM MONITORED MILES
AND ACCIDENTS--6 EXPOSURE CELLS

Brake Type	Usual Trip Length					
	Local			Intercity		
	No. Acc.	No. Veh.	100 Million Vehicle Mi.	No. Acc.	No. Veh.	100 Million Vehicle Mi.
STRAIGHT TRUCK:						
Pre-Standard	12	152	0.016041	5	96	0.024821
Post-Standard	9	199	0.018464	3	144	0.029589
TRACTOR:						
Pre-Standard	13	152	0.027669	51	574	0.540673
Post-Standard	6	97	0.022035	36	381	0.339450
SCHOOL BUS:						
Pre-Standard	5	118	0.011996	0	7	0.000755
Post-Standard	20	341	0.034990	0	13	0.001597

UNWTD. N of Accidents = 160
UNWTD. N of Vehicles = 2273

in many cases, the design effect factor was somewhat lower for the average mileages. However, for the accident rates, the design effect is very low, in some cases even less than 1, thus producing sampling errors which are not greatly different from those that would be expected in a simple random sample design. Unfortunately however, the variation in accident rates is so high that the confidence intervals are still very large in spite of the very good effect of the sample design. As a result, the differences in accident rates shown in Table 5.17 are not statistically significant. While in some cases the differences are numerically large, they are all well within the range of expected random variation, given the high observed variance of this statistic.

For comparison, accident rates were computed which included all accidents received which occurred in 1976. The exposure (mileage) for this computation is obtained by multiplying the average daily mileage for the exposure cell by the number of study vehicles in the cell. This product is then multiplied by 366 days, and used as the denominator in the rate calculation. The results of this computation are shown in Table 5.18 along with the associated 95% confidence intervals. Not only do the magnitudes of the rates differ appreciably, but the difference between pre- and post-standard vehicles reverses for local school buses and intercity tractors. These variations may be due to the small cell counts on accidents. Recall that Tables 5.17 and 5.18 are based on only 160 and 268 accidents, respectively. Confidence intervals are large as in the previous table so that all the observed differences are well wtihin the range of random variation.

For the final comparison, accident rates are combined across all exposure categories to provide an overall comparison of pre- and post-standard vehicles. Accident rates for the individual cells are weighted using the average exposure distribution shown in Table 5.12. This computation is a direct adjustment, and

TABLE 5.17

WEIGHTED ACCIDENT RATES* BY BRAKE TYPE
FROM MONITORED MILES--6 EXPOSURE CELLS

(95% CONFIDENCE INTERVAL)

Brake Type	Usual Trip Length			
	Local		Intercity	
	Rate	CI	Rate	CI
STRAIGHT TRUCK:				
Pre-Standard	219	(±417)	38	(±31)
Post-Standard	80	(±172)	44	(±60)
TRACTOR:				
Pre-Standard	88	(±214)	68	(±51)
Post-Standard	188	(±335)	73	(±48)
SCHOOL BUS:				
Pre-Standard	696	(±714)	--	
Post-Standard	312	(±350)	--	

*Accidents per 100 million vehicle miles.

TABLE 5.18

WEIGHTED ACCIDENT RATES* BY BRAKE TYPE
FROM ESTIMATED MILEAGE** FOR 1976--
6 EXPOSURE CELLS

Brake Type	USUAL TRIP LENGTH			
	Local		Intercity	
	Rate	CI	Rate	CI
STRAIGHT TRUCK:				
Pre-Standard	338	(±418)	19	(±21)
Post-Standard	243	(±328)	30	(±36)
TRACTOR:				
Pre-Standard	111	(±174)	98	(±85)
Post-Standard	210	(±348)	82	(±61)
SCHOOL BUS:				
Pre-Standard	73	(±83)	8000	(±6140)
Post-Standard	219	(±178)	197	(±462)

*Accidents per 100 million vehicle miles.

**Computed from all 1976 fleet reported accidents, all study vehicles, and mean miles/day by exposure cell.

the variance is computed as in a linear combination. The combined rate, R, and its variance are computed as:

$$R = \sum_{i=1}^{n} e_i \; r_i$$

$$\mathrm{Var}\,(R) = \sum_{i=1}^{n} e_i^2 \; \mathrm{Var}\,(r_i)$$

where: the e_i and r_i are the mileage proportions and accident rates for the individual exposure cells,

and: $$\sum_{i=1}^{n} e_i = 1$$

The results of this combination are shown by brake type and vehicle type in Tables 5.19 and 5.20 using the rates from the monitored and estimated miles respectively. The difference in accident rates and its 95% confidence interval is also shown. Table 5.21 shows the combined rates by brake type and usual trip distance using the rates from estimated miles.

An overall reduction in the combined accident rates for post-standard vehicles of 19% is shown by both methods of calculation. However, a zero difference is well within the 95% confidence limits. Statistically, there is no evidence to support the hypothesis that 121 equipped vehicles have different accident rates than pre-standard vehicles.

Looking at the accident rates by vehicle type one should note that the post-standard tractors show a slight <u>increase</u> in Table 5.19 and a slight <u>decrease</u> in Table 5.20. Considering the anti-skid, one might have expected combination vehicles to have the greatest reduction. Sample size and reporting threshold are

TABLE 5.19

COMBINED WEIGHTED ACCIDENT RATES* FROM MONITORED MILES
BY BRAKE TYPE AND VEHICLE TYPE

(95% CONFIDENCE INTERVAL)

Brake Type	Vehicle Type						All Vehicles	
	Straight Trk		Tractor		School Bus			
	Rate	CI	Rate	CI	Rate	CI	Rate	CI
Pre-Standard	106	(±158)	70	(±51)	656	(±714)	108	(±63)
Post-Standard	58	(±75)	81	(±55)	294	(±350)	87	(±47)
Difference	48	(±175)	-11	(±75)	362	(±795)	21	(±79)

TABLE 5.20

COMBINED WEIGHTED ACCIDENT RATES* FROM ESTIMATED MILEAGES**
BY BRAKE TYPE AND VEHICLE TYPE

(95% CONFIDENCE INTERVAL)

Brake Type	Vehicle Type						All Vehicles	
	Straight Trk		Tractor		School Bus			
	Rate	CI	Rate	CI	Rate	CI	Rate	CI
Pre-Standard	139	(±157)	99	(±78)	530	(±363)	130	(±69)
Post-Standard	110	(±125)	95	(±65)	218	(±170)	105	(±55)
Difference	29	(±201)	4	(±102)	312	(±401)	25	(±88)

TABLE 5.21

COMBINED WEIGHTED ACCIDENT RATES* FROM ESTIMATED MILEAGES**
BY BRAKE TYPE AND USUAL TRIP LENGTH

(95% CONFIDENCE INTERVAL)

Brake Type	Usual Trip Length			
	Local		Intercity	
	Rate	CI	Rate	CI
Pre-Standard	192	(±178)	114	(±74)
Post-Standard	225	(±187)	74	(±51)

*Accidents per 100 million vehicle miles.

**Computed from all 1976 fleet reported accidents, all vehicles, and mean miles/day.

much less of a problem for this group. Possible explanations are:

1. The mix of 121 equipment on tractor and trailer has not yet been taken into account. A trip survey is in progress to determine the exposure of the various combinations. However, the proportion of mileage accumulated by combination units completely equipped with 121 is expected to be only 10% to 15%. This fact reduces the expected benefits somewhat.

2. The 121 systems may not be 100% operational all the time. The incidence of improper anti-skid functioning or improper slack adjustment is not known.

3. The major benefit may come from the general upgrading of the brake system rather than the anti-skid.

Looking at the combined accident rates by Usual Trip Distance and Brake Type as shown in Table 5.21, one also sees variations. The rate is up 17% in the Local Trip category and down 35% in the Intercity category. Since the tractors are used in predominately intercity trips, these results prevent the formulation of any strong conclusions.

At this point it is appropriate to repeat some of the qualifications which should be kept in mind. These results are based on preliminary data files; data collection is incomplete. Records are more difficult to obtain from some fleets causing the degree of completeness to vary from fleet to fleet while data collection is in process. A uniform accident reporting threshold has not been incorporated for these calculations. The observed variations in reporting threshold may influence the results. Exposure information which defines the mileage that 121-equipped tractors accumulate while pulling 121-equipped trailers is not yet available. All of these problems will be more adequately addressed at the end of the study.

6. BRAKE SYSTEM MAINTENANCE

Brake system maintenance records are being collected to determine whether there is a difference in the level of maintenance effort for the post-standard vehicles as compared to the pre-standard vehicles. The information is taken from existing records maintained by the company or truck owner. Field data collection personnel transcribe all brake system maintenance entries including the date, mileage, and repair time. In coding this information, the part of the brake system worked on is identified by a code defining the major component group and the sub-system. This code table is shown in Table 6.1. The type of work performed is coded using Table 6.2.

For analysis, the resulting information is file-built. This file is then merged with the company and vehicle description information. Two analyses are presented here. The basic computation is a determination of the interval (in miles) between successive maintenance entries. This computation can also be restricted to entries which are similar, such as those involving the exact same component or those involving the same major component group. Comparisons are then based on means of the computed intervals. The results of this kind of analysis are presented in Section 6.1.

The second analysis looks at the number of maintenance labor hours on a per mile basis. This analysis is directed towards the variation in maintenance as the vehicle ages. The average number of labor hours per mile is computed in 25,000 mile increments of the odometer reading. Of course, considerably more data are required to provide this level of detail. Preliminary results using this approach are presented in Section 6.2.

TABLE 6.1

BRAKE SUB-SYSTEM CODES

MAJOR GROUP CODE

100	Air Generation and Storage
200	Plumbing and Miscellaneous
300	Air Control--Valves
400	Anti-Wheel Lock (Electrical, Electronic)
500	Brake Application
600	Trouble
700	Periodic Maintenance of Vehicle and Brake System
800	Unspecified, Unknown, or Unrecognizable
900	No Maintenance Accomplished or Reported During Reporting Period

* * *

COMPONENTS

100 Air Generation and Storage (Air System)

- 101 Compressor
- 102 Reservoir (Wet, Dry, Protected, etc.), Tank
- 103 Check Valve
- 104 Air Pressure Gauge
- 105 Governor
- 106 Low Air Warning
- 107 Drain Valve (Cock)--Manual or Automatic
- 108 Pressure Relief Valve (Safety Valve)
- 109 Air Filters and Additive Devices (Alcohol Evaporator, Dryer, Water Separator, etc.)

200 Plumbing and Miscellaneous

- 201 Air Lines (Rigid and Semi-Rigid)
- 202 Flexible Hoses--Chassis
- 203 Stop Light Switch
- 204 Glad Hands (Tractor-Trailer Airline Connector)
- 206 Trailer Connection Hoses
- 207 Air Hose (Unspecified)

300 Air Control

- 301 Brake Valve (Main Foot Control)
- 302 Hand Control Valve (Trailer)
- 303 Tractor Protection Valve and Control (Break-Away Valve)
- 304 Relay Valve (Wheel Lock Control Modulator)

TABLE 6.1--Continued

305 Quick Release Valve
306 Spring Brake (Parking) Control Valve
307 Limiting Valve and Control
308 Proportioning Valve and Control (Modulator, Front-to-Rear Proportioning)
309 Tractor (Only) Parking Control Valve (306 Preferred)
310 Trailer Supply Valve
311 Inversion Valve
312 Valve (No Further Description)

400 Anti-Wheel Lock (Unspecified or Total)

401 Wheel Speed Sensor
402 Exciter Ring
403 Warning Light
404 Miscellaneous Wiring
405 Computer, Anti-Wheel Lock, Including Fuses
406 RFI Filter

500 Brake Application

501 Brake Actuator (Brake Chamber, Including Plunger, Piston and Cylinder)
502 Cam, Wedge
503 Diaphragm (Pancake)
504 Slack Adjuster--Manual or Automatic
505 Push Rod
506 Spring Brake Chamber (Emergency Brake Chamber)
507 Drum
508 Brake Shoes, Lining, Block
509 Retractor Springs
510 Brakes (Complete System or Not Specified)
511 Wheel (Oil) Seals
512 Backing Plate, Spider, Rollers, Miscellaneous Parts

600 Trouble

601 Brakes Locked
602 No Brakes
603 Air Leak (Not Further Qualified)

700 Periodic Maintenance of Vehicle and Brake System

800 Unspecified, Unknown, or Unrecognizable

900 No Maintenance Accomplished or Reported During Reporting Period

TABLE 6.2

WORK ACCOMPLISHED CODES

01	Adjust, Calibrate, Tune-Up
02	Balance
03	Charge
04	Clean
05	Disconnect
06	Drain, Bleed, Flush, Backflush
07	Exchange, Replace
08	Inspect
09	Install (where a similar item was not previously present)
10	Lubricate
11	Modify
12	Overhaul, Rebuild
13	P.M. -- A, B, C, D
14	Reline (Brakes), Refurbish (Valve Seats), Replace (Seat Gaskets)
15	Remove and Not Replace
16	Repack (Pack), Reseal
17	Turn, Resurface, Rebore
18	Ignored
19	Noted
20	Repaired (Use a more precise term, if possible.)
21	Checked (No further mention of repairs or replacement)
22	Work Not Stated but Done (Use where parts are stated but no work or action is listed.)
23	Free, Unstick, Release, Thaw
50	No Maintenance Accomplished or Reported During Reporting Period

Efforts have also been made to apply standard failure analysis techniques to the maintenance data. Here, the fraction of vehicles which have experienced a "failure" (or maintenance entry) is computed as a function of the number of miles since the last "failure" (entry). This distribution may be described as a simple exponential function, or this function may be modified with a constant which provides for an increasing or decreasing failure rate with mileage (Weibull function). Difficulties have been encountered in applying this approach in the context of a probability based sample and computing variances. However, efforts will continue to develop the necessary software.

The preliminary data file used contained 8,308 records on 2,450 vehicles. Each record is a separate maintenance entry. The maintenance entries were distributed by vehicle type as follows: 21% straight trucks, 63% tractors, and 16% buses. Approximately 54% of the entries involve 121-equipped vehicles. The average number of entries per vehicle is 3.4. Missing data rates for selected variables are as follows:

Date	0.6%
Mileage	33.0%
Labor Hours	12.0%
Component	0.3%
Work Performed	0.3%

In addition, 14% of the entries simply indicated that no brake system maintenance had been performed. The missing data rate on mileage is particularly troublesome. Apparently, this information is not available from the records kept by the company or owner. Field data collection personnel will be instructed to direct their attention to this problem in the hope that some improvement can be made. Since the quarterly mileage information is being obtained on these vehicles, it will also be possible to estimate the mileage for each maintenance entry from the date.

The mileage accumulated by the study vehicles as of January, 1977 is shown in Table 6.3 by vehicle and brake type. The large difference in annual mileage between tractors and straight trucks is reflected in these figures. Weighted distributions of major component group and work accomplished for pre- and post-standard vehicles are shown in Tables 6.4 and 6.5, respectively. The proportion of "air generation" and "brake application" entries decreased for the post-standard vehicles while the proportion of "air control," "anti-skid," and "preventive maintenance" increased. Looking at the distribution of type of work performed shown in Table 6.5, one sees little difference between the pre- and post-standard vehicles.

At this point a general problem in interpreting the maintenance data should be mentioned. The type and frequency of maintenance work is influenced by the driving environment the vehicle is used in. For example, stop and go city driving increases the frequency of brake adjustments and relinings. Maintenance results should be computed separately for each driving environment just as the accident rates were. For the preliminary report, maintenance results are presented separately for each vehicle type based on the observation that most straight trucks are used in local driving environments and most tractors are used in intercity driving environments.

6.1 Maintenance Intervals

The maintenance entries for each vehicle are listed sequentially according to the date and mileage. Maintenance intervals are computed by subtracting the odometer readings for selected entries. For example, if the maintenance activity of interest is the "relining of the brake shoes," then the maintenance records are searched and whenever two or more entries of this type are found for a vehicle, mileage intervals are computed by subtracting the odometer readings for the successive entries. The preliminary data files did not contain enough entries to provide stable estimates

TABLE 6.3

UNWEIGHTED MEAN ODOMETER READING JANUARY, 1977
BY VEHICLE AND BRAKE TYPE

Vehicle Type	Brake Type	
	Pre-Standard	Post-Standard
Straight Truck	43,548	21,470
Tractor	211,200	122,750
School Bus	25,401	14,003

TABLE 6.4

WEIGHTED DISTRIBUTION OF MAJOR COMPONENT GROUP
FOR PRE- AND POST-STANDARD VEHICLES

Major Component Group	Brake Type	
	Pre-Standard	Post-Standard
Air Generation	8.0%	4.9%
Plumbing, Misc.	5.0	6.1
Air Control	3.0	6.1
Anti-Skid	0.1	11.9
Brake Application	54.1	34.7
"Trouble"	3.5	3.3
P.M.	3.6	9.5
No Work	22.2	22.4
Unknown	0.6	1.2
TOTAL	100.1%	100.1%

TABLE 6.5

WEIGHTED DISTRIBUTION OF WORK ACCOMPLISHED
FOR PRE- AND POST-STANDARD VEHICLES

Work Accomplished	Brake Type	
	Pre-Standard	Post-Standard
Adjust	26.0%	22.7%
Disconnect, Modify, Charge, Clean, Lub	0.0	2.8
Free Drain	2.9	3.2
Replace	13.3	13.6
Inspect	0.9	1.3
Install	0.2	1.5
Overhaul	0.7	0.4
Preventive Maintenance (PM)	3.6	9.5
Reline	6.4	0.9
Repaired	8.2	9.5
Noted	7.5	7.0
Unspecified	7.8	4.7
No Entry	22.3	22.4
Unknown	0.3	0.4
TOTAL	100.1%	99.9%

of the interval for specific activities like "relining of the brake shoes." For this reason, entries were selected for interval computation by using only the brake sub-system codes, which were shown in Table 6.1. Intervals were computed using three different criteria. The most selective criterion required that the maintenance entries have the same sub-system code, like "brake shoe." The type of work performed was not examined; it could have been a "relining" or an "inspection." Intervals were also computed using a more relaxed criterion which only required that the component involved belong to the same major component groups as defined by the "100" level codes in Table 6.1. Finally, the most relaxed criterion was the computation of intervals between each successive maintenance entry, regardless of the component code.

The first group of results presented in this section are the mean, or average, value for these intervals computed separately for tractors, straight trucks, and school buses. Intervals were weighted in proportion to the inverse of the selection probability for the vehicle, and 95% confidence intervals were computed. The mean maintenance interval is computed separately for the pre- and post-standard vehicles. In addition, the reduction is computed by subtracting the interval for the post-standard vehicles from that for the pre-standard. A 95% confidence interval is also computed for this reduction.

These results are shown for tractors in Table 6.6, straight trucks in Table 6.7, and school buses in Table 6.8. The reduction in the brake system maintenance intervals shown in these tables is not statistically significant. However, the magnitude of the reduction is sizeable ranging from 10% to 60%. Reductions are shown regardless of whether the computation of intervals is restricted to the same component, components of the same major group, or any maintenance entry. As would be expected, the intervals between successive entries are shorter than those between entries relating to a specific component.

TABLE 6.6

WEIGHTED MEAN MAINTENANCE INTERVAL FOR TRACTORS BY BRAKE TYPE
(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
SAME COMPONENT:				
Pre-Standard	234	393	29,750	(±13,498)
Post-Standard	189	254	22,602	(±12,890)
Reduction			7,147	(±17,768)
% Reduction			24.0%	
SAME MAJOR GROUP:				
Pre-Standard	278	465	25,063	(±10,318)
Post-Standard	199	284	22,230	(±12,236)
Reduction			2,833	(±15,032)
% Reduction			11.3%	
ANY MAINTENANCE:				
Pre-Standard	337	566	18,277	(±8,666)
Post-Standard	249	437	12,576	(±7,256)
Reduction			5,701	(±11,364)
% Reduction			31.2%	

TABLE 6.7

WEIGHTED MEAN MAINTENANCE INTERVAL FOR STRAIGHT TRUCKS BY BRAKE TYPE

(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
SAME COMPONENT:				
Pre-Standard	64	169	7,888	(±5,460)
Post-Standard	66	80	4,192	(±2,710)
Reduction			3,696	(±5,164)
% Reduction			46.9%	
SAME MAJOR GROUP:				
Pre-Standard	69	175	8,669	(±6,654)
Post-Standard	76	129	3,801	(±2,928)
Reduction			4,868	(±6,774)
% Reduction			56.2%	
ANY MAINTENANCE:				
Pre-Standard	89	234	6,568	(±5,942)
Post-Standard	127	344	2,631	(±14,350)
Reduction			3,937	(±6,032)
% Reduction			59.9%	

TABLE 6.8

WEIGHTED MEAN MAINTENANCE INTERVAL FOR SCHOOL BUSES
BY BRAKE TYPE

(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
SAME COMPONENT:				
Pre-Standard	13	14	3,333	(±1,544)
Post-Standard	95	157	2,009	(±608)
Reduction			1,324	(±1,806)
% Reduction			39.7%	
SAME MAJOR GROUP:				
Pre-Standard	20	21	2,180	(±908)
Post-Standard	106	168	1,960	(±452)
Reduction			220	(±898)
% Reduction			10.1%	
ANY MAINTENANCE:				
Pre-Standard	31	35	1,773	(±992)
Post-Standard	137	222	1,260	(±292)
Reduction			512	(±958)
% Reduction			28.9%	

These three tables illustrate that the post-standard vehicles have shorter intervals between brake system maintenance entries for all three vehicle types: tractors, straight trucks, and school buses. One should also note the relative magnitudes of the intervals for the three vehicle types. For the tractors the intervals are about 25,000 miles; for the straight trucks, 5,000 miles; and for the school buses, 2,000 miles. These intervals are presumably influenced by the type of service, such as the amount of stop and go driving and the presence of contaminants like dust or mud. Indeed, these comparisons are only valid to the degree that the pre- and post-standard vehicles of each type are involved in the same type of service, at least as far as the maintenance is concerned. The exposure data discussed in the previous chapter did indicate that straight trucks and school buses are used predominately in local trips while the tractors are used primarily in intercity trips.

The maintenance intervals shown in these tables indicate that the post-standard vehicles receive maintenance 30% to 40% more frequently than the pre-standard vehicles. The influence of preventive maintenance on this finding is addressed in the next group of tables. Since the frequency of preventive maintenance is primarily set by company policy, differences here might not necessarily reflect the requirements of the brake system. All maintenance interval calculations were repeated after excluding all maintenance entries involving preventive maintenance. These results are shown in Tables 6.9 through 6.11 for tractors, straight trucks, and school buses, respectively. The intervals themselves are slightly larger, and the reductions are slightly larger. However, the reductions are still not quite statistically significant as can be seen by the fact that the 95% confidence intervals shown exceed the mean. The confidence interval is formed by the mean plus or minus two times the standard error. For a reduction or a difference to be significant, zero must lie outside the interval

TABLE 6.9

WEIGHTED MEAN MAINTENANCE INTERVAL FOR TRACTORS
EXCLUDING PREVENTIVE MAINTENANCE BY BRAKE TYPE

(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
SAME COMPONENT:				
Pre-Standard	217	368	30,484	(±14,184)
Post-Standard	99	154	16,695	(± 9,980)
Reduction			13,788	(±17,040)
% Reduction			45.2%	
SAME MAJOR GROUP:				
Pre-Standard	261	440	25,400	(±10,800)
Post-Standard	119	194	17,862	(± 9,944)
Reduction			7,538	(±14,420)
% Reduction			29.7%	
ANY MAINTENANCE:				
Pre-Standard	326	549	19,051	(± 8,962)
Post-Standard	199	374	12,863	(± 8,106)
Reduction			6,188	(11,684)
% Reduction			32.5%	

TABLE 6.10

WEIGHTED MEAN MAINTENANCE INTERVAL FOR STRAIGHT TRUCKS EXCLUDING PREVENTIVE MAINTENANCE BY BRAKE TYPE

(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
SAME COMPONENT:				
Pre-Standard	63	168	7,925	(±5,482)
Post-Standard	54	66	3,424	(±2,488)
Reduction			4,501	(±5,056)
% Reduction			56.8%	
SAME MAJOR GROUP:				
Pre-Standard	68	174	8,709	(±6,682)
Post-Standard	64	115	3,313	(±3,134)
Reduction			5,396	(±6,916)
% Reduction			62.0%	
ANY MAINTENANCE:				
Pre-Standard	88	233	6,598	(±5,960)
Post-Standard	114	310	2,593	(±1,594)
Reduction			4,005	(±6,086)
% Reduction			60.7%	

TABLE 6.11

WEIGHTED MEAN MAINTENANCE INTERVAL FOR SCHOOL BUSES EXCLUDING PREVENTIVE MAINTENANCE BY BRAKE TYPE

(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
SAME COMPONENT:				
Pre-Standard	13	14	3,437	(±1,552)
Post-Standard	86	144	1,839	(±592)
Reduction			1,598	(±1,778)
% Reduction			46.5%	
SAME MAJOR GROUP:				
Pre-Standard	20	21	2,210	(±946)
Post-Standard	97	155	1,798	(±406)
Reduction			412	(±1,084)
% Reduction			18.6%	
ANY MAINTENANCE:				
Pre-Standard	31	35	1,743	(±996)
Post-Standard	126	207	1,226	(±318)
Reduction			517	(±964)
% Reduction			29.7%	

formed. This, of course, cannot happen anytime two times the standard deviation exceeds the mean.

To compute an overall result for all vehicle types, the maintenance intervals were combined in the same manner as the accident rates in the previous chapter. A linear combination of the results for the three vehicle types was computed using the proportions of Table 5.12, the average exposure distribution, as weights. This adjusts the results to a common mixture of the three vehicle types. The overall percent reduction ranges from 33% to 46%, but the reduction is still not statistically significant, as is shown in Table 6.12.

Time to failure is sometimes modeled with an exponential function. Often observation has not gone on long enough to observe two failures in all units under observation. If the objective is a comparison of failure rates, rather than a determination of the magnitude of the rate, then one may define an arbitrary starting point and treat the time from this point to the first failure as an estimate of the time to failure. Comparisons of rates based on these intervals will not be biased. This approach was applied to the maintenance data by thinking of "maintenance rates" rather than failure rates. In this way it is appropriate to compute an interval for each entry. The first results with this approach are shown in Table 6.13. The reduction in interval for the post-standard vehicles is comparable with the previous results, and the number of intervals (sample size) is greater. However, these results are also not statistically significant because the variance increased somewhat.

This computation was also repeated excluding preventive maintenance entries. The result is shown in Table 6.14. Results are similar for the tractors and school buses. However, straight trucks show a 33% <u>increase</u> rather than a reduction. An examination of this result reveals that the pre-standard interval decreased

TABLE 6.12

WEIGHTED MEAN MAINTENANCE INTERVAL FOR ALL VEHICLES EXCLUDING PREVENTIVE MAINTENANCE BY BRAKE TYPE

(95% CONFIDENCE INTERVAL)

Method	Interval	CI
SAME COMPONENT:		
Pre-Standard	24,205	(±10,450)
Post-Standard	13,056	(± 7,325)
Reduction	11,149	(±12,762)
% Reduction	46.1%	
SAME MAJOR GROUP:		
Pre-Standard	20,589	(± 8,036)
Post-Standard	13,884	(± 7,310)
Reduction	6,705	(±10,863)
% Reduction	32.6%	
ANY MAINTENANCE:		
Pre-Standard	15,461	(± 6,686)
Post-Standard	10,040	(± 5,944)
Reduction	5,421	(± 8,946)
% Reduction	35.1%	

TABLE 6.13

WEIGHTED MEAN MAINTENANCE INTERVAL INCLUDING MILES TO FIRST OCCURRENCE BY VEHICLE TYPE

(95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
TRACTOR:				
Pre-Standard	412	708	41,512	(±17,950)
Post-Standard	289	534	22,314	(± 9,444)
Reduction			19,198	(±20,086)
% Reduction			46.2%	
STRAIGHT TRUCK:				
Pre-Standard	120	328	14,860	(±12,710)
Post-Standard	184	619	10,325	(± 3,802)
Reduction			4,535	(±13,508)
% Reduction			30.5%	
SCHOOL BUS:				
Pre-Standard	45	148	6,999	(± 3,618)
Post-Standard	178	268	3,280	(± 1,044)
Reduction			3,719	(± 3,470)
% Reduction			53.1%	

TABLE 6.14

WEIGHTED MEAN MAINTENANCE INTERVAL INCLUDING MILES TO FIRST OCCURRENCE EXCLUDING PREVENTIVE MAINTENANCE BY VEHICLE TYPE (95% CONFIDENCE INTERVAL)

Method	N	WTD N	Interval	CI
TRACTOR:				
Pre-Standard	401	691	42,356	(±18,276)
Post-Standard	264	503	24,888	(±13,658)
Reduction			17,468	(±22,140)
% Reduction			41.2%	
STRAIGHT TRUCK:				
Pre-Standard	118	288	8,180	(±5,556)
Post-Standard	170	545	10,912	(±4,190)
Reduction			-2,733	(±7,004)
% Reduction			-33.4%	
SCHOOL BUS:				
Pre-Standard	44	146	6,983	(±3,658)
Post-Standard	172	258	3,316	(±1,070)
Reduction			3,667	(±3,544)
% Reduction			52.5%	

drastically due to the exclusion of only two intervals which had weights of 20. These data will be reviewed as the maintenance records are updated. The small sample sizes in the preliminary data files are subject to this kind of inconsistency.

Finally, mean maintenance intervals were computed for each major component group and brake type. These results are shown in Table 6.15. Intervals computed from the mileage to the first entry were included to increase the number of intervals for comparison. All major component groups show reductions in the maintenance interval with the exception of "air generation" which shows an 11% increase and "preventive maintenance" which shows almost no difference. In addition, maintenance entries involving the anti-skid system have a mean interval approximately one-half of the other intervals for pre- or post-standard vehicles.

In summary, the computation of maintenance intervals produced no statistically significant findings using the preliminary data files. However, large differences were found in almost every instance. If these trends continue in the remainder of the data to be collected, one would expect most of these results to become statistically significant.

6.2 Labor Hours Per Mile

The objective in this analysis is to address the variation in maintenance as a function of vehicle age as reflected by the odometer reading. This analysis is made in terms of the number of labor hours of brake system maintenance on a per mile basis without regard to the component or type of work performed. The odometer readings were categorized into 25,000 mile increments. The total number of labor hours for each of these increments was obtained by summing the entries in each, and the rate was computed by dividing by 25,000 miles. The results of this computation are shown in Tables 6.16 through 6.18 for intercity tractors, straight trucks,

TABLE 6.15

WEIGHTED MEAN MAINTENANCE INTERVAL INCLUDING MILES TO FIRST OCCURRENCE BY MAJOR COMPONENT GROUP FOR INTERCITY TRACTORS

(95% CONFIDENCE INTERVAL)

Major Component	N	WTD N	Interval	CI
AIR GENERATION:				
Pre-Standard	80	130	54,252	(± 6,630)
Post-Standard	55	58	60,144	(±10,180)
REDUCTION			-5,891	(± 9,690)
% REDUCTION			-10.9%	
PLUMBING:				
Pre-Standard	44	49	56,793	(±36,650)
Post-Standard	36	59	45,415	(±39,268)
REDUCTION			11,378	(±37,404)
% REDUCTION			20.0%	
AIR CONTROL:				
Pre-Standard	39	47	64,320	(±19,294)
Post-Standard	43	67	48,092	(±44,026)
REDUCTION			16,228	(±39,260)
% REDUCTION			25.2%	
ANTI-SKID:				
Pre-Standard	--	--	--	--
Post-Standard	26	88	20,432	(±15,162)
REDUCTION			--	--
% REDUCTION			--	--
BRAKE APPLICATION:				
Pre-Standard	321	532	47,662	(±22,580)
Post-Standard	90	186	29,610	(±14,862)
REDUCTION			18,052	(±26,366)
% REDUCTION			37.9%	
P.M.				
Pre-Standard	57	67	31,316	(±9,910)
Post-Standard	123	132	32,156	(±4,964)
REDUCTION			- 840	(±6,564)
% REDUCTION			-2.7%	

TABLE 6.16

WEIGHTED BRAKE SYSTEM MAINTENANCE INCREMENTAL LABOR HOURS PER MILE FOR INTERCITY TRACTORS

Mileage Increment	Pre-Standard		Post-Standard	
	UNWTD No. Vehicles	Rate	UNWTD No. Vehicles	Rate
25,000	14	.000099	29	.000155
50,000	40	.000116	61	.000098
75,000	59	.000093	72	.000081
100,000	70	.000078	109	.000117
125,000	74	.000087	104	.000091
150,000	72	.000094	103	.000142
175,000	69	.000086	94	.000113
200,000	61	.000133	80	.000165
225,000	65	.000090	42	.000141
250,000	57	.000111	9	.000228
275,000	68	.000065		
300,000	68	.000073		
325,000	81	.000098		
350,000	78	.000066		
375,000	65	.000092		
400,000	64	.000075		
425,000	51	.000074		
450,000	40	.000133		
475,000	15	.000120		

Average Over 225,000 Miles:
Pre-Standard = .000097
Post-Standard = .000123

Increase = 26%

TABLE 6.17

WEIGHTED BRAKE SYSTEM MAINTENANCE INCREMENTAL LABOR HOURS PER MILE FOR STRAIGHT TRUCKS

Mileage Increment	Pre-Standard		Post-Standard	
	UNWTD No. Vehicles	Rate	UNWTD No. Vehicles	Rate
25,000	80	.000104	112	.000140
50,000	14	.000093	16	.000191

TABLE 6.18

WEIGHTED BRAKE SYSTEM MAINTENANCE INCREMENTAL LABOR HOURS PER MILE FOR SCHOOL BUSES

Mileage Increment	Pre-Standard		Post-Standard	
	UNWTD No. Vehicles	Rate	UNWTD No. Vehicles	Rate
25,000	22	.000177	144	.000207
50,000	23	.000121	8	.000051

and school buses, respectively. For each increment of 25,000 miles, the unweighted number of vehicles with maintenance entries in that period are shown along with number of labor hours per mile for pre- and post-standard vehicles. These rates are shown graphically for intercity tractors in Figure 6.1.

Averaging over the first 225,000 miles, the post-standard intercity tractors show a 26% increase in the number of labor hours of brake system maintenance on a per mile basis. Problems arose in this analysis when the influence of preventive maintenance was removed. Excluding the preventive maintenance, the post-standard intercity tractors show a 25% decrease in the incremental labor rate. This result is shown in Table 6.19 and Figure 6.2. Further checking revealed that in some fleets, including one large fleet, the number of labor hours recorded reflected all preventive maintenance instead of just brake system preventive maintenance. Other fleets show no preventive maintenance. These problems preclude any meaningful results in this area. A clarification will be sent to all field staff to address these problems.

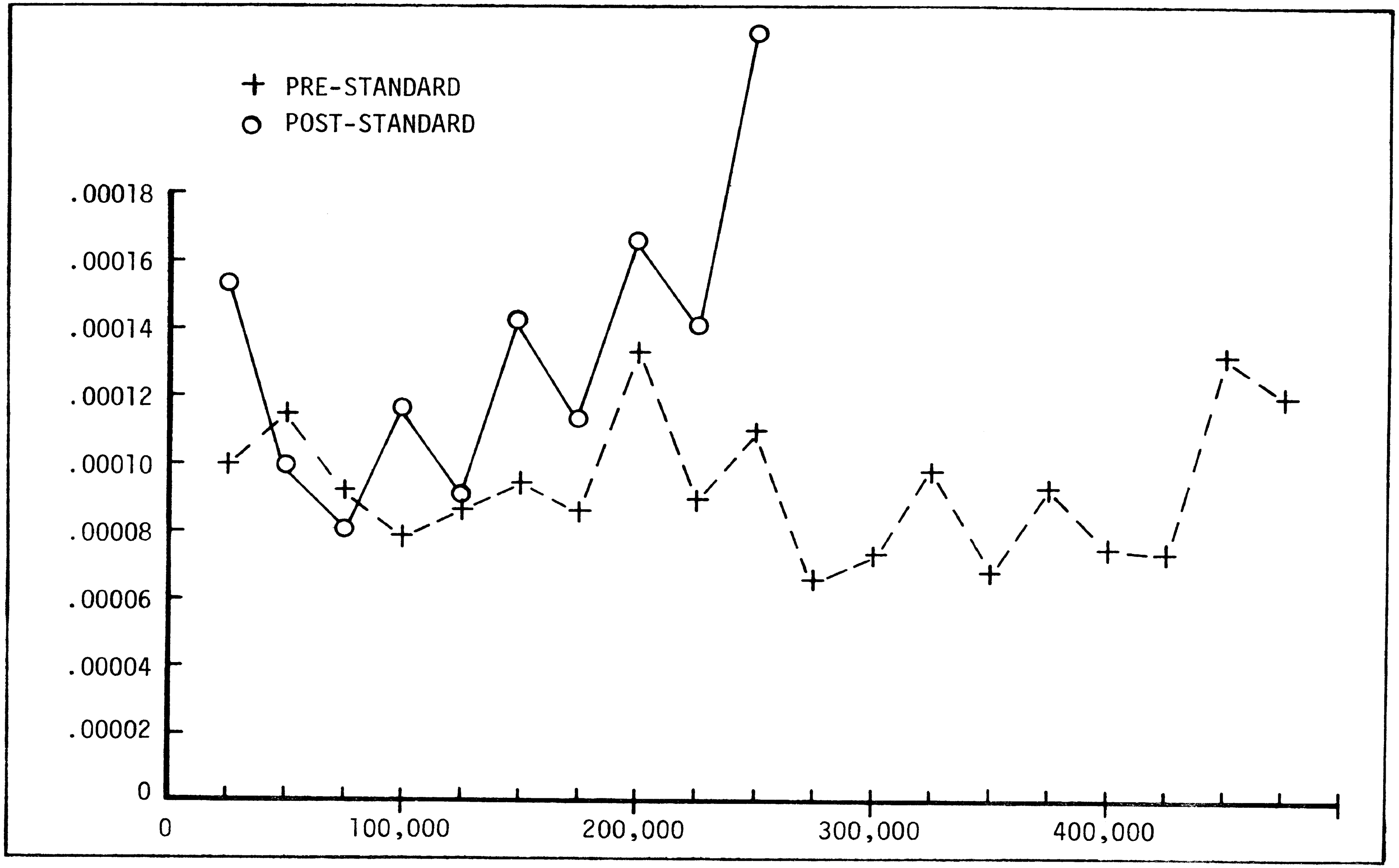

FIGURE 6.1 -- Weighted Brake System Maintenance Incremental Labor Hours Per Mile for Intercity Tractors Only

TABLE 6.19

WEIGHTED BRAKE SYSTEM MAINTENANCE INCREMENTAL LABOR HOURS
PER MILE EXCLUDING PREVENTIVE MAINTENANCE
FOR INTERCITY TRACTORS

Mileage Increment	Pre-Standard		Post-Standard	
	UNWTD No. Vehicles	Rate	UNWTD No. Vehicles	Rate
25,000	13	.000096	27	.000157
50,000	37	.000100	47	.000081
75,000	53	.000085	50	.000057
100,000	68	.000074	68	.000076
125,000	74	.000087	67	.000044
150,000	70	.000092	70	.000034
175,000	66	.000076	58	.000043
200,000	57	.000118	40	.000034
225,000	58	.000059	23	.000062
250,000	51	.000079	5	.000058

Average Over 225,000 Miles:

Pre-Standard = .000088
Post-Standard = .000065

Decrease = 25%

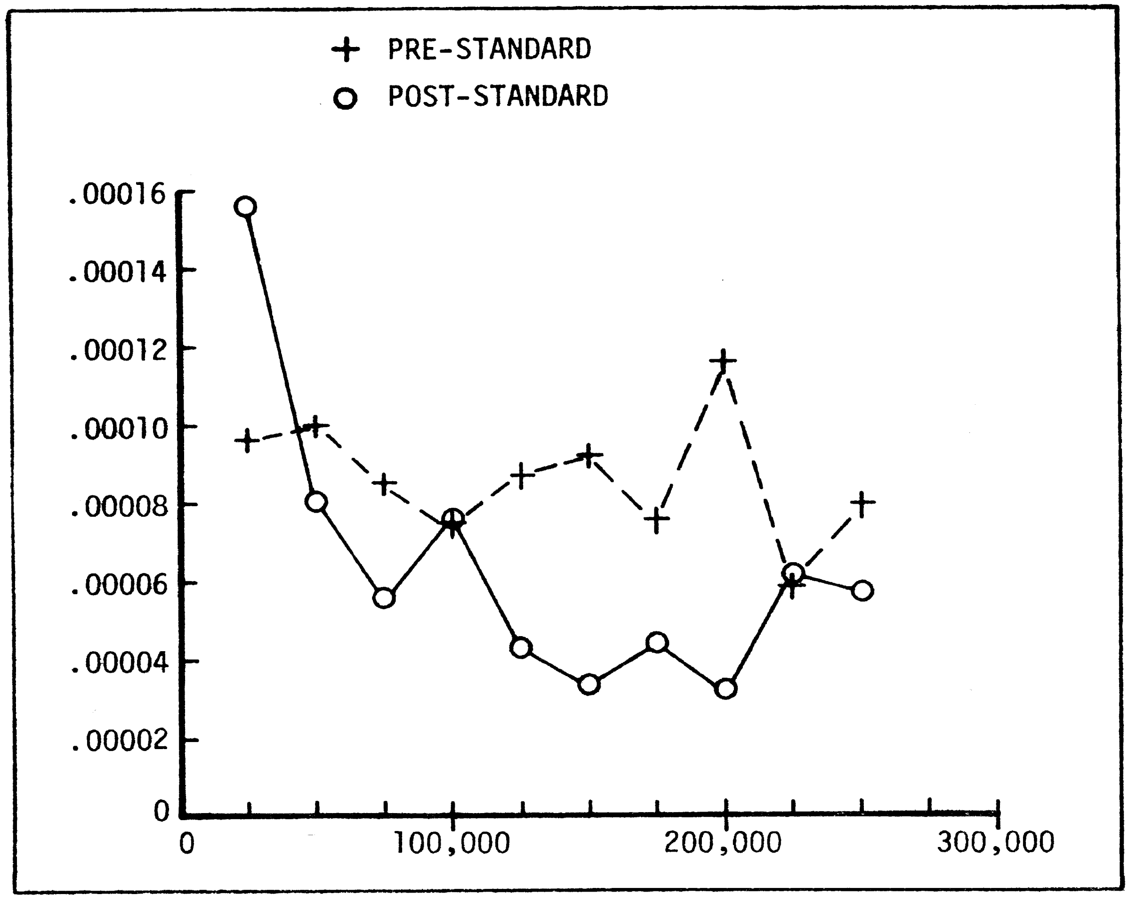

FIGURE 6.2 -- Weighted Brake System Maintenance Incremental Labor Hours Per Mile Excluding Preventive Maintenance for Intercity Tractors Only

7. SUPPLEMENTARY DATA

This chapter describes work currently in progress, or planned, which will contribute significantly to the final results. Included are the follow-up activities on fatal and injury accidents which are described in Sections 7.1 and 7.2, respectively. The Trip Information Survey which is designed to provide more detailed exposure data is discussed in Section 7.3. The final section, Section 7.4, describes recent modifications made in the fleet monitoring program. These modifications address the collection of additional brake system maintenance data on the pre-standard vehicles prior to the beginning of the current study period, and the addition of post-Notice 7 vehicles to the program.

7.1 Fatal Accidents

The objective in this task is to study all fatal accidents involving late-model (1974 or newer) air-braked trucks. The exposure data collected from the national sample of vehicles in the fleet monitoring program will allow calculation of accident rates for fatal accidents (number of fatal accidents per hundred million vehicle miles). Notification on these fatal accidents is provided by the NHTSA Fatal Accident Reporting System (FARS). After notification, the next step is to obtain copies of the state police reports. Arrangements have been made with all but eight states for forwarding of the police reports to HSRI. Approximately 9% of the fatal truck accidents occurred in these eight states. Several of these states have privacy laws which prevent them from releasing the information. In the remaining problem states the storage systems for the reports are such that retrieval is difficult. It is hoped that these problems will be worked out.

The information on the police reports, which will be available through the FARS data files, is not sufficient to carry out the desired analysis. In particular, the type of brakes is not recorded. Information on the exposure variables for the accident trip is also needed. To get this information, HSRI is conducting a follow-up on each of the fatal accidents by telephone interview. This effort requires contact to be made with the owner or driver in order to get the additional information. The basic information sought is the vehicle configuration and the brake type and operational status for each unit. Exposure information includes the carrier type and fleet size (number of air-braked power units), and the one-way distance for the accident trip. Copies of the data forms are in Appendix C.

The expected number of 1976 FARS accidents involving 1974 or newer air-braked trucks was approximately 1,100. The number of reports received for follow-up was expected to be about 1,000 due to privacy and access problems in some states. Successful completion of the follow-up was expected on about 70% of these, or 700 completed interviews. About an equal number of interviews on 1977 cases is anticipated.

A listing of eligible cases from a preliminary 1976 FARS data file contained 904 cases. This preliminary file was estimated to be 85% complete. As of June, 1977, a total of 862 eligible 1976 cases and 235 1977 cases had been received from the states. Of these, 758 were also on the 1976 FARS listing. Follow-up interviews had been completed on 609 1976 cases and 69 1977 cases. The telephone interview has been successful for about 75% of the cases. In the remaining 25%, either a telephone number cannot be obtained or the contact is not completed. In these cases a self-explanatory version of the form is mailed out. Response to these mailings is currently less than 50%. The total completion is currently expected to be 80% to 85%.

Of the 678 completed interviews, 536 have been key-punched and file-built. Some preliminary tabulations have been prepared from this file, and are presented in Tables 7.1 through 7.7. The distribution by model year is shown in Table 7.1. The follow-up has revealed about 5% of the vehicles to be earlier than 1974 model year. The distribution by brake type is shown in Table 7.2. About 22% are 121-equipped. Follow-up indicates that about 7% of the vehicles are not air-braked. These are reflected in both the "other" and the "missing data" categories in this table.

Private fleets own the vehicles involved in 44% of the fatal accidents. Vehicles in "for hire" fleets make up the remaining 56%. However, missing data is currently 13% on this variable. This category is shown in Table 7.3 along with the breakdown of the "for hire" fleets into Common, Contract, and Exempt.

The distribution of vehicle configurations is in Table 7.4. The most frequent configuration is the tractor-semitrailer which is involved in 77% of the fatal accidents. The various mixes of pre- and post-standard brakes on these units are shown in Table 7.5. Sixty-seven percent are equipped with pre-standard brakes on both tractor and semi-trailer. Combination units fully equipped with the 121 brakes are involved in about 8% of the fatal accidents. The mixture of 121 brakes on the tractor and non-121 brakes on the trailer occurs four times as frequently as its opposite.

The frequency of the various types of collisions is shown in Table 7.6 by brake type. There is little difference in the distributions for the pre- and post-standard vehicles. Notice that in rear-end collisions, the truck is the striking vehicle about as often as it is the struck vehicle. In the angle (or intersection) collisions, the truck is the striking vehicle approximately twice as often as the other vehicle. However, in these collisions, the striking vehicle is not necessarily at fault. These accidents commonly occur when the other vehicle pulls into the right-of-way of the truck, and the truck is unable to stop.

TABLE 7.1

DISTRIBUTION BY MODEL YEAR
FATAL ACCIDENTS

Model Year	N	%
1974	228	42.5
1975	171	31.9
1976	101	18.8
1977	11	2.1
Other	25	4.7
TOTAL	536	100.0

TABLE 7.2

DISTRIBUTION BY BRAKE TYPE
FATAL ACCIDENTS

Brake Type	N	%
Pre-Standard	333	62.1
Post-Standard	116	21.6
Other	9	1.7
Unknown	15	2.8
Missing Data	63	11.8
TOTAL	536	100.0

TABLE 7.3

DISTRIBUTION BY CARRIER TYPE
FATAL ACCIDENTS

Carrier Type	N	%
Private	205	38.2
For Hire		
Common	168	31.3
Contract	63	11.8
Exempt	30	5.6
Unknown	2	0.4
Missing Data	68	12.7
TOTAL	536	100.0

TABLE 7.4

DISTRIBUTION OF VEHICLE CONFIGURATION
FATAL ACCIDENTS

Configuration	N	%
Straight Truck	74	13.8
Bobtail	14	2.6
Tractor-Semitrailer	413	77.1
Tractor-Double Trailer	24	4.5
Straight Truck-Full Trailer	3	0.6
Other	3	0.6
Unknown	5	0.9
TOTAL	536	100.1

TABLE 7.5

BRAKE TYPE BY UNIT
TRACTOR-SEMITRAILER COMBINATIONS
FATAL ACCIDENTS

Semi-Trailer	Tractor				TOTAL	
	Pre-Standard		Post-Standard			
	N	%	N	%	N	%
Pre-Standard	258	67.4	74	19.3	332	86.7
Post-Standard	21	5.5	30	7.8	51	13.3
TOTAL	279	72.8	104	27.2	383	100.0

TABLE 7.6

COLLISION TYPE BY BRAKE TYPE
FATAL ACCIDENTS

Collision Type	Brake Type			
	Pre-Standard		Post-Standard	
	N	%	N	%
Single Vehicle	37	11.3	17	14.7
Head-On	84	25.7	32	27.6
Rear-End				
Truck Striking	23	7.0	11	9.5
Other Striking	28	8.6	11	9.5
Angle				
Truck Striking	62	19.0	21	18.1
Other Striking	31	9.5	10	8.6
Side Swipe	12	3.7	5	4.3
Other	33	10.1	6	5.2
Unknown	17	5.2	3	2.6
TOTAL	327	100.1	116	100.1

The frequency of involvement in these collisions is about the same for the pre- and post-standard vehicles.

The frequency of jackknifing in these fatal accidents is addressed in Table 7.7. No jackknifing is reported in over 75% of the accidents involving combination vehicles. Of the jackknifes reported, a little over two-thirds of them are post-impact events. These frequencies have not been broken down by brake type yet.

Fatal accident involvement on a per mile basis has not yet been computed. Currently we are studying the problem of adjusting the coverage of the sampling frame to correspond with the number of 1974 and 1975 vehicles on the road (registered). These results will be completed at the end of the study.

7.2 Injury Accidents

Supplemental information on injury accidents will be obtained from the Bureau of Motor Carrier Safety (BMCS) accident reports. Additional information also must be obtained for these accidents on the brake type and operational status and the exposure category for the accident trip. Data forms will be mailed to the carriers to collect this information. These forms are in Appendix D.

The use of BMCS reported accidents will be limited to injury accidents reported by Authorized Carriers (Common and Contract) involving 1974 or newer vehicles. Only air-braked vehicles will be used for analysis, but these cannot be identified until after the follow-up. The sub-set of accidents for follow-up numbers about 4,000 for 1976. These have been received from BMCS on magnetic tape.

The Authorized Carriers have been selected for analysis of injury accidents because their exposure can be determined from

Table 7.7

JACKKNIFING OF COMBINATION VEHICLES
FATAL ACCIDENTS

Jackknife?	N	%
No	335	76.1
Yes		
Pre-Impact	20	4.5
Post-Impact	35	8.0
Unknown	50	11.4
TOTAL	440	100.0

the fleet monitoring program. The carrier type is known for all fleets in the monitoring program, and their exposure can be determined separately. Combination of the exposure data with the BMCS accident data will allow the involvement in injury accidents to be determined on a per mile basis.

Results are not available from this activity at this time. A computerized mailing of the supplemental data forms is being implemented.

7.3 Trip Information Survey (TIS)

In order to obtain better information about how the pre- and post-standard vehicles are actually used, the original vehicle description data will be supplemented with a survey concerning vehicle use on specific randomly-selected dates. A brief questionnaire was designed to answer four questions:

1. Was the unit in service?
2. Approximately how many miles were driven on the survey date?
3. What is the breakdown of the mileage by trip distance (local, short-haul, long-haul)?
4. For the "most pulled" trailer, what is the brake type and operational status?

A sample data form is contained in Appendix B.

In order to get information on the variation in trip distance for a single vehicle, as well as the variation in trip distance from vehicle to vehicle, only one-fourth of the vehicles were selected for the trip survey. Each selected vehicle, however, is to be surveyed on four dates.

The trip survey spans the period from June 27, 1977 through December 31, 1977. This period is divided into four 47 day intervals as shown below.

Period	Dates
1	June 27 - August 12
2	August 13 - September 28
3	September 29 - November 14
4	November 15 - December 31

Each selected vehicle was assigned one sample date code numbered from 1 to 47, and this code indicated the four dates in 1977 that the vehicle was to be surveyed, each date being 47 days from the previous one. A 47 day period is a good one from the point of view of maximizing the spread of vehicles across weekends and different weekdays. It should result in two-sevenths of the vehicles being sampled twice on weekdays and twice on weekends, four-sevenths of the vehicles being sampled three times on weekdays and once on weekends, and one-seventh of the vehicles being sampled on weekdays only. The sample date codes and dates are shown in Table 7.8

In selecting the vehicle sub-sample for the Trip Information Survey it was considered desirable to obtain approximately equal numbers of vehicles from each of the six major exposure categories based on brake type and usual trip length. The six categories, their full sample N's, their TIS sample N's, and their sampling fractions are shown in Table 7.9, along with the systematic selection interval and the chosen random start number.

Prior to selection, each of the six groups was sorted on three other exposure variables: vehicle type, carrier type, and fleet size. Within each group, the vehicles were arranged in an alternating ascending-descending pattern on these three variables. Specifically, the sequence went:

Private, Straight Trucks
- Small
- Medium
- Large
- Unknown

For Hire, Straight Trucks
- Unknown
- Large
- Medium
- Small

TABLE 7.8

TRIP INFORMATION SURVEY SAMPLE DATES

Sample Date Code	Period 1	Period 2	Period 3	Period 4
1	June 27	Aug. 13	Sept. 29	Nov. 15
2	June 28	Aug. 14	Sept. 30	Nov. 16
3	June 29	Aug. 15	Oct. 1	Nov. 17
4	June 30	Aug. 16	Oct. 2	Nov. 18
5	July 1	Aug. 17	Oct. 3	Nov. 19
6	July 2	Aug. 18	Oct. 4	Nov. 20
7	July 4	Aug. 19	Oct. 5	Nov. 21
8	July 4	Aug. 20	Oct. 6	Nov. 22
9	July 5	Aug. 21	Oct. 7	Nov. 23
10	July 6	Aug. 22	Oct. 8	Nov. 24
11	July 7	Aug. 23	Oct. 9	Nov. 25
12	July 8	Aug. 24	Oct. 10	Nov. 26
13	July 9	Aug. 25	Oct. 11	Nov. 27
14	July 10	Aug. 26	Oct. 12	Nov. 28
15	July 11	Aug. 27	Oct. 13	Nov. 29
16	July 12	Aug. 28	Oct. 14	Nov. 30
17	July 13	Aug. 29	Oct. 15	Dec. 1
18	July 14	Aug. 30	Oct. 16	Dec. 2
19	July 15	Aug. 31	Oct. 17	Dec. 3
20	July 16	Sept. 1	Oct. 18	Dec. 4
21	July 17	Sept. 2	Oct. 19	Dec. 5
22	July 18	Sept. 3	Oct. 20	Dec. 6
23	July 19	Sept. 4	Oct. 21	Dec. 7
24	July 20	Sept. 5	Oct. 22	Dec. 8
25	July 21	Sept. 6	Oct. 23	Dec. 9
26	July 22	Sept. 7	Oct. 24	Dec. 10
27	July 23	Sept. 8	Oct. 25	Dec. 11
28	July 24	Sept. 9	Oct. 26	Dec. 12
29	July 25	Sept. 10	Oct. 27	Dec. 13
30	July 26	Sept. 11	Oct. 28	Dec. 14
31	July 27	Sept. 12	Oct. 29	Dec. 15
32	July 28	Sept. 13	Oct. 30	Dec. 16
33	July 29	Sept. 14	Oct. 31	Dec. 17
34	July 30	Sept. 15	Nov. 1	Dec. 18
35	July 31	Sept. 16	Nov. 2	Dec. 19
36	Aug. 1	Sept. 17	Nov. 3	Dec. 20
37	Aug. 2	Sept. 18	Nov. 4	Dec. 21
38	Aug. 3	Sept. 19	Nov. 5	Dec. 22
39	Aug. 4	Sept. 20	Nov. 6	Dec. 23
40	Aug. 5	Sept. 21	Nov. 7	Dec. 24
41	Aug. 6	Sept. 22	Nov. 8	Dec. 25
42	Aug. 7	Sept. 23	Nov. 9	Dec. 26
43	Aug. 8	Sept. 24	Nov. 10	Dec. 27
44	Aug. 9	Sept. 25	Nov. 11	Dec. 28
45	Aug. 10	Sept. 26	Nov. 12	Dec. 29
46	Aug. 11	Sept. 27	Nov. 13	Dec. 30
47	Aug. 12	Sept. 28	Nov. 14	Dec. 31

TABLE 7.9

EXPOSURE GROUPS FOR THE TIS SAMPLE

Exposure Groups	Full Sample N	TIS Sample N	Sampling Fraction	Random Start	Interval
Pre-Standard					
Local	560	134	.2381	1.7	4.2
Short Haul	290	132	.4545	1.3	2.2
Long Haul	642	134	.2083	4.4	4.8
Post-Standard					
Local	905	133	.1471	4.5	6.8
Short Haul	427	133	.3125	0.6	3.2
Long Haul	353	131	.3704	2.4	2.7
TOTAL	3177	797			

For Hire, Tractors
- Small
- Medium
- Large
- Unknown

Private, Tractors
- Unknown
- Large
- Medium
- Small

Private, Buses
- Small
- Medium
- Large
- Unknown

For Hire, Buses
- Unknown
- Large
- Medium
- Small

Then each of these groups was further sorted in PSU order to ensure spreading the trip information survey among the different geographic areas as evenly as possible. For each group, the appropriate sampling fraction and systematic selection interval was calculated (shown in Table 7.9), a random number less than this interval was chosen (also shown in Table 7.9), and a special FORTRAN program was used to select the 797 vehicles from the sorted files.

The next procedure involved the selection of a sample date code for each selected vehicle. In order to ensure that adjacent selected vehicles (which would often be from the same selected fleet) were not assigned adjacent survey dates, the sample date codes were arranged in the following sequence:

1
25
13
37
2
26
14
38

.
.
.
46
11
35
23
47
12
36
24

For each of the six groups of selected vehicles, a random start number between 1 and 47 was chosen as the sample date code for the first vehicle in the group. Then the following sample date code in sequence was assigned to the second vehicle, etc., continuing to the end of the sequence and then to the beginning of the sequence as many times as necessary to assign a sample date code to each selected vehicle in the group.

This completed the vehicle and date selection process. A special form was created for each selected vehicle listing its identification, sample dates, and exposure stratum. This form also provided space for keeping a record of all attempts to obtain the TIS information for the selected sample dates. These forms were then assigned among a staff of five HSRI telephone interviewers with each interviewer being responsible for obtaining the TIS information on the selected dates for all selected vehicles in one group of PSU's.

The results of this survey will allow exposure to be more accurately categorized with respect to trip distance. These results will be used to adjust the distributions obtained using the information in the vehicle description form. These results are also intended to allow the mileage accumulated by tractors to be partitioned by the brake type of the trailer. Since the accident data are already capable of partitioning on the brake type of both tractor and trailer, the addition of this information in the exposure data makes the calculation of accident rates as a function of both tractor and trailer brake type possible. This information should provide sound results on the relative performance of the various mixes of brake type on combination vehicles.

7.4 Modifications to the Fleet Monitoring Program

Two modifications to the fleet monitoring program are described in this section. The first is the collection of additional brake system maintenance data for the period of time the vehicles were in service prior to the beginning of the present data collection period (January 1976). The second is the addition of post-Notice 7 vehicles to the monitoring program.

While the original study was designed to provide a comparison of brake system maintenance experience during the study period, it is also desirable to plot maintenance effort as a function of vehicle age (odometer reading). This comparison requires maintenance data from the point the vehicle was first put into service. For the pre-standard vehicles, this period is approximately 18 months prior to the beginning of the present data collection period. This additional data should greatly enhance the analysis of vehicle maintenance.

On March 1, 1976, FMVSS No. 121 was modified appreciably (Notice 7). These modifications were expected to resolve many of the problems experienced with the early vehicles. This task includes the selection, implementation, monitoring, coding, analysis, and reporting on the accidents, mileage, and maintenance experience of approximately 1,000 post-Notice 7 vehicles. These vehicles will be randomly selected from the new vehicle purchases in 1977 by the fleets currently participating in the study. School buses will not be added, since their exemption extended through this year. Selection probabilities will be determined on a fleet by fleet basis depending on the number of post-Notice 7 vehicles available for study and the willingness of the owner to increase his participation. All study fleets will be contacted for implementation of this task.

It will not be possible to extrapolate the results from these vehicles to the population of all 1977 vehicles as is being done with the vehicles currently in the program. However, these vehicles will allow a comparison within the fleets currently in the study. The population described will be that composed of all vehicles purchased by study fleets in 1977. Since data collection is scheduled to end December 31, 1977, vehicles which have not been put into service by October 1, 1977 will not be included.

APPENDICES

APPENDIX A

LETTER TO MANUFACTURERS

(Address List Attached)

DRAFT

Dear :

As I am sure you know, we are evaluating the effectiveness of Federal Motor Vehicle Safety Standard (FMVSS) No. 121, Air Brake Systems, in preventing truck accidents. In carrying out this project we very much need the cooperation of truck manufacturers. It is our desire to gather data on the "real-world" experience of vehicles complying with FMVSS No. 121 as quickly as possible. To do this we must locate the owners of these vehicles. We hope to be able to do this through the manufacturers' sales records.

We would very much like to have your company cooperate with us, if at all possible. We believe it is to our mutual advantage to evaluate the effects of FMVSS No. 121 in a systematic and comprehensive fashion. A key element in such an evaluation is the determination of nationally representative effects. To satisfy this requirement, a statistically defensible sampling plan must be followed. In order to implement such a plan, the total population of owners of FMVSS No. 121-equipped vehicles must be known, in addition to a suitable control population such as the purchasers of new vehicles in a comparable period 12 months previous. This situation makes the cooperation of every manufacturer essential to ensure the validity of any results which may be obtained.

The University of Michigan Highway Safety Research Institute is presently participating in this project under National Highway Traffic Safety Administration Contract No. DOT-HS-6-01286, "Fleet Accident Evaluation of FMVSS 121." Could you please designate a liaison in your organization that our Contractor may contact in regards to our program and discuss our needs with you.

We are most hopeful that you will help us on this project. We want it to be as complete and objective as possible so that we will have a fair evaluation of the cost/benefits of the standard.

Sincerely,

James B. Gregory
Administrator

CONCURRENCES	
RTG. SYMBOL	
INITIALS/SIG.	
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RTG. SYMBOL	
INITIALS/SIG.	
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INITIALS/SIG.	
DATE	

Form DOT F 1320.65 (4-67)

OFFICIAL FILE COPY

Truck Manufacturers

Mr. Brooks McCormick
President
International Harvester Company
401 N. Michigan Avenue
Chicago, Illinois 60611

Mr. Lee A. Iacocca
President
Ford Motor Company
The American Road
Dearborn, Michigan 48121

Mr. H. J. Nave
President
Mack Trucks, Inc.
2100 Mack Blvd.
Allentown, Pennsylvania 18105

Mr. Elliott M. Estes
President
General Motors Corporation
767 Fifth Avenue
New York, New York 10009

Mr. Kenneth W. Self
President
Freightliner Corporation
2525 S. W. 3rd Avenue
Portland, Oregon 97201

Mr. S. E. Knudson
President
White Motor Corporation
100 Erieview Plaza
Cleveland, Ohio 44114

Mr. W. N. Gross
General Manager
Kenworth Truck Company
8801 E. Marginal Way S.
Seattle, Washington 98124

Mr. Robert A. Holmstrom
General Manager
Peterbilt Motors Company
38801 Cherry Street
Newark, California 94560

Mr. E. A. Cafiero
President
Chrysler Corporation
341 Massachusetts Avenue
Detroit, Michigan 48231

APPENDIX B

FLEET MONITORING PROGRAM DATA FORMS

Area No. ________

Fleet No. ________

PSU Prob. ________

Weight ________

Cell ________

FLEET AND VEHICLE SELECTION RECORD

Company Name ____

Address ____

____

	Pre-121	Post-121
Combined List No. ________________	______	______
Manufacturer's List No. ________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
________________	______	______
Frame Totals	______	______
Sample Totals	______	______

A.	I.D.________________
B.	Fleet Name__________
C.	Date________________

STUDY VEHICLE INVENTORY

Power Units Only

lodel 'ear	Vehicle I.D. (VIN)	Make Model	Unit Numbers		Cargo Body Style *	121 Brakes**		Trip Info. Date
			St. Truck	Tractor		YES	NO	

*See reference card, Table 1.

** At time of initial purchase (original equipment)

8/76

R

HIGHWAY SAFETY RESEARCH INSTITUTE
Institute of Science and Technology
Huron Parkway and Baxter Road
Ann Arbor, Michigan 48109

THE UNIVERSITY OF MICHIGAN

REQUIRED STATEMENT CONCERNING COOPERATION AND DISCLOSURE

The Highway Safety Research Institute of The University of Michigan is conducting a study entitled "Fleet Accident Evaluation of FMVSS 121." This study is sponsored and funded by the National Highway Traffic Safety Administration, U.S. Department of Transportation under contract number DOT-HS-6-01286.

This project is authorized by law -- the National Traffic and Motor Vehicle Safety Act of 1966 (PL-89-563) and the Highway Safety Act of 1966 (PL-89-564). While you are NOT required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate, and timely. If you agree to cooperate, you will be asked all questions. You may, at any time, refuse to answer any or all questions and to discontinue participation in the project.

The Highway Safety Research Institute will keep the names and identities of all individuals and companies who furnish information on truck usage for this study strictly confidential. Such information will not be disclosed unless the Institute is required to do so by court order.

Only summary statistics (without personal or corporate identification) will be reported. The opinions, findings, and conclusions expressed in all reports concerning this project will be those of The University of Michigan and not necessarily those of the National Highway Traffic Safety Administration.

It is the sincere desire of The University to obtain the best data possible. In the interests of safety and efficient company operation we are asking for your continued cooperation in this most important evaluation of FMVSS 121.

If you have any questions, please do not hesitate to contact:

Kenneth L. Campbell, Ph.D.
Project Director
Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109
(313) 764-0248

HSRI 7/76-1

Table 1 = Cargo Body Style

Tractor
51 Fifth Wheel and Dromedary
52 Fifth Wheel Only
53 Fifth Wheel and Added Device
54 Fifth Wheel and Auto Carrier
55 Other Hitch: *Specify on Data Form*
56 Other Hitch and Added Device

Straight Truck or Trailer
1 Chassis Only
2 Beverage
3 Dump
4 Fire Truck
5 Flat Bed Container
6 Flat Bed with Added Device
7 Flat Bed--Other
8 Flat (Low Boy)
9 Gondola (Grain, Hopper)
10 Garbage
11 Mixer--Cement
12 Pole *(Trailer only)*
13 Van--Conventional
14 Van--High Cube
15 Van--Refrigerated
16 Van--Furniture (Moving)
17 Van--Open Top
18 Wrecker *(Straight truck only)*
19 Automobile Carrier
20 Tanker--Liquid
21 Tanker--Bulk Dry
22 Cattle Rack--Livestock
23 Utility (Telephone, etc.)
24 Boom or Crane
25 Other: *Specify on data form*
26 Various

Table 2 = Anti-Lock Mfg.

Anti-Lock

1 AC
2 Bendix
3 Eaton
4 Goodrich
5 Kelsey-Hayes
6 Rockwell
7 Wagner
8 Removed
9 Not Applicable

Table 3 = 121 Status

1 Operational (original equipment)
2 Brake system modified (not inc. Anti-lock)
3 Anti-lock not operational
4 Brake system modified and anti-lock not operational
5 Not applicable

Table 4 = Model Year Codes

4 1974, Pre 121
5a 1975, Pre 121
5b 1975, Post 121
6 1976, Post 121
7 1977, Post 121
9 Other

Table 5 = Accident Events

A. Pre-Collision and Post Collision Factors

Ran-off-Road	Skidding
Load Shift	Trailer Swing
Load Spill	Vehicle Collapse
Fire	Jack Knife
Explosion	Braking
Rollaway	Turning
Separation of Units (Breakaway)	Unknown

B. Collision Factors

Non-Collision: Case vehicle as a single vehicle.

Overturn	Roll Away
Ran-off-Road	Separation of Units (Breakaway)
Load Shift	Skidding
Load Spill	Trailer Swing
Fire	Vehicle Collapse
Explosion	Jack Knife
	Unknown

Collision with Moving or Fixed Object*

Head-on (Crossed center line, into fixed object, etc.)
Rear-end (into leading vehicle or by following vehicle)
Side-swipe--same direction
Side-swipe--opposite direction
Other
Unknown

Intersection Type--
Front
Middle
Rear
Unknown

*Indicate which vehicle is the striking vehicle.

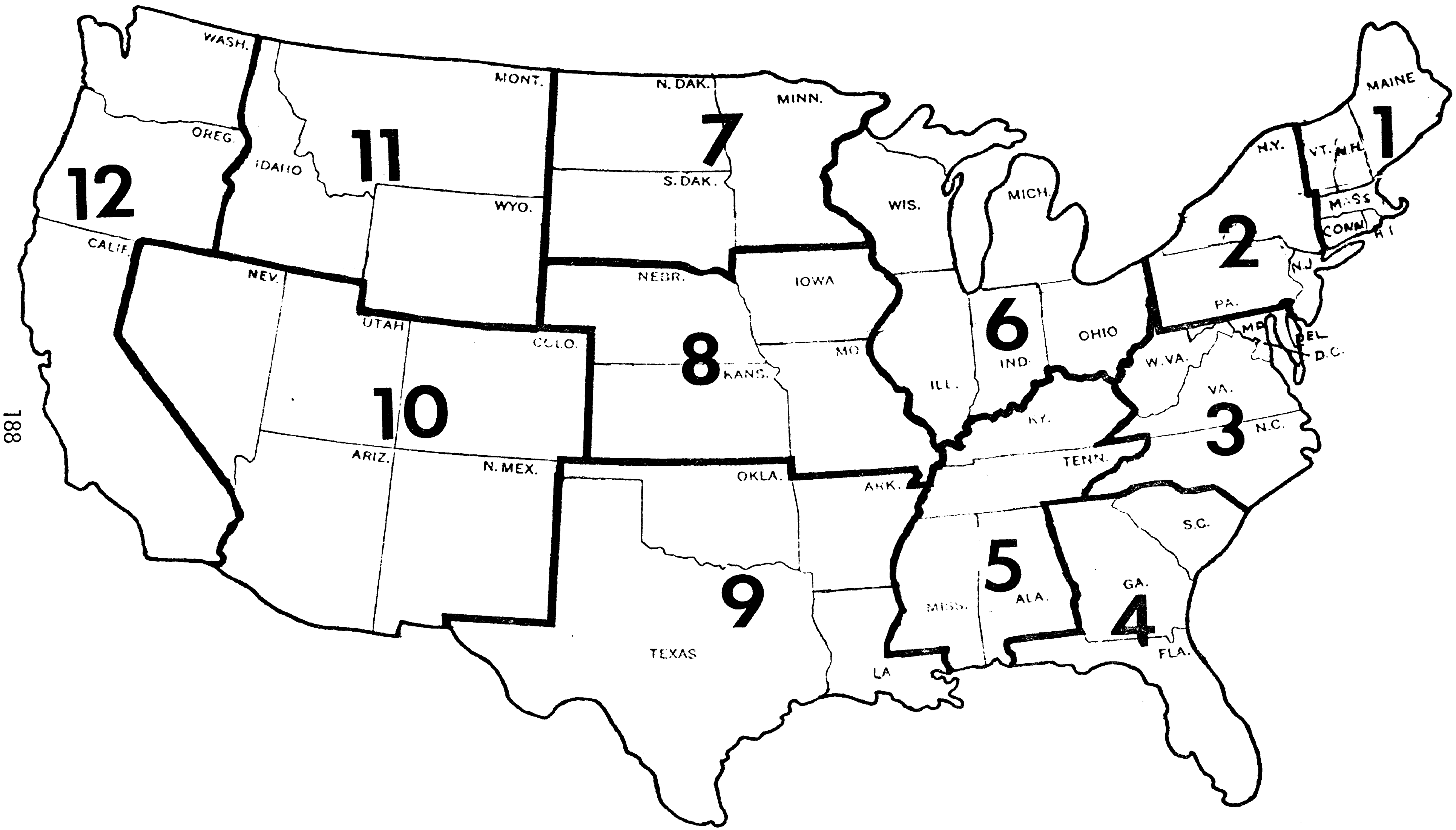
C. Object Contacted

Fixed Object:	Moving Object:
Parked vehicle--Car, small truck, lg. trk.	Pedestrian
Post, pole, tree, etc.	Bicycle type
Pier, bridge, abutment, etc.	Motorcycle
Building (large)	Car
Loading Dock	Bus--School, intercity
Earth Embankment--ditch hillside, etc.	Truck--Small, large (straight or articulated)
Median Barrier--steel or concrete	Railroad Train
Curb	Construction Equipment--noncargo carrying
Guardrail	Animal
Fallen Objects	Trailer
	Farm Vehicle
	Recreational Vehicle (Not a motor vehicle)

Table 6 = Brake System
1 Non 121 equipped
2 Non 121 equipped but with anti-lock system
3 121 equipped
4 Not equipped (none)
5 Not applicable

Table 7

Geographic Regions of the U.S.



MP - 6/76-1

Highway Safety Research Institute
The University of Michigan

A.	I.D. ________
B.	Fleet Name ________
C.	Date ____/____/____

COMPANY DESCRIPTION OR
OPERATING DIVISION INFORMATION

Complete page 1 in duplicate--return original to HSRI. Retain copy in company folder.

1. ( ) Company or Owner-Operator

2. ( ) Operating Division*

Division Name ________________________

Address ________________________

City ________________ State________ Zip______

Telephone No. ______ ____________

Corporate Name ________________________

* *

3. Names -- Company or Division

Major Contact ____________ Title ________ Phone ________

Maintenance ________________________ Phone ________

Dispatch ________________________ Phone ________

Accident Records ________________________ Phone ________

Driver Logs ________________________ Phone ________

Safety ________________________ Phone ________

Other: ____________; ____________ Phone ________

* * * * * * * * * *

*If corporate contact needed, give name and address of corporation:

Name ________________________

Address ________________________

City________________ State________ Zip______

Contact ________________ Telephone ______ ________

* * * * *

Disclosure statement given to:

Name ________________________

Title ________________ *Date* ____/____/____

CD-6/76-4

(OVER)

OPERATIONS

4. Basic Organization -- *Check one*

Private: ( )
For Hire: ( ) Common, ( ) Contract, ( ) Exempt

5. Authority -- *Check all that apply*

( ) Commercial Zone
( ) Intra-State: ______________ (State), PSC Number ______________
( ) Inter-State: ICC Number ______________
( ) None

6. Geographic Area of Operations

Region -- *Check all that apply*
( ) Local → ( ) Check if Commercial Zone ONLY
( ) Intra-State Only: ______________ (State)
( ) Inter-State: T7 Region(s)____,____,____,____,____,____,____
( ) Check if more than six regions

7. Average Trip Length -- *Check one*

( ) Local, ( ) Less than 200 mi. one way, ( ) More than 200 mi. one way

TYPE OF CARGO

8. General Classification

( ) General Commodities, ( ) Specialized Cargo, ( ) Exempt Commodities

9. Specific Cargo Transported or Hauled on a Regular Basis:

( ) ______________________________
( ) Mixed Cargo -- less than truck load (LTL) or truck load (TL) quantities of general freight

DISPATCH POLICY

10. Driver-Vehicle -- *Check all that apply*

( ) Company Controlled: → ( ) Slip Seat, ( ) Assigned Seat
( ) Owner-Operator

11. Unit Coupling Policy -- *Check one only*

( ) Straight Truck Only
( ) No Mixing of 121 and non-121 tractors and trailers
( ) Mixed

12. Backhaul

( ) Empty
( ) Loaded: → ( ) Company Load, ( ) Broker Load

COMPANY MAINTENANCE AND INSPECTION FACILITIES AND PRACTICES

Trip Inspection -- *Check one for each item*

13. Pre-Trip

( ) Checklane or Safety Lane
( ) Driver Checklist
( ) Driver Visual
( ) No Inspection

14. Post-Trip

( ) Checklane or Safety Lane
( ) Driver Vehicle Condition Report (FMCSR or equivalent)
( ) Other Written Driver Report
( ) Oral
( ) No Report

15. Periodic Inspection -- Does your company have a system of periodic inspection?

( ) Yes
( ) No

16. Are periodic inspections made by your:

( ) Company officials (if no maintenance staff)
( ) Maintenance Staff
( ) Repair Service (garage or dealer) if you have no maintenance staff.

17. Form of Inspection

( ) Visual, ( ) Written -- Checklist, etc.

18. What are the inspection intervals?

( ) Only as noted (Irregular)
( ) Periodic (Regular)--Define Basic Inspection Periods: ______________

Maintenance

19. Do you have a system of periodic maintenance?

( ) Yes
( ) No

20. What are the maintenance intervals?

( ) Periodic--Define basic period: ______________
( ) Periodic and combined with inspection

21. Do you do your own mechanical work?

( ) No
( ) Yes -- Own service staff

22. Is your maintenance facility equipped to diagnose & repair 121 brake systems?

( ) No
( ) Yes, capable of diagnostic repair, (tools & training)
( ) Don't Know

23. Have any of your mechanics received special training on repairing 121 systems?

( ) No
( ) Don't Know
( ) Yes -- Where ______________

Fleet Inventory

	Company Owned and Lease	Straight Truck Air Brake	Tractor Air Brake	Trailer Air Brake
24.	1974 & Pre-121 Vehicles			
25.	"121" Vehicles			
26.	Older Vehicles			

Highway Safety Research Institute
The University of Michigan

A. I.D. ______________
B. Fleet Name ______________
C. Date ____/____/____

COMPANY DESCRIPTION OR
OPERATING DIVISION INFORMATION

FOLDER COPY

Complete page 1 in duplicate--return original to HSRI. Retain copy in company folder.

1. ( ) Company or Owner-Operator

2. ( ) Operating Division*

   Division Name ______________________________

   Address ______________________________

   City ____________________ State __________ Zip ______

   Telephone No. ______ ____________

   Corporate Name ______________________________

* *

3. Names -- Company or Division

   Major Contact ______________ Title ________ Phone ________

   Maintenance ______________________ Phone ________

   Dispatch ______________________ Phone ________

   Accident Records ______________________ Phone ________

   Driver Logs ______________________ Phone ________

   Safety ______________________ Phone ________

   Other: ______________; ______________ Phone ________

* * * * * * * * * *

*If corporate contact needed, give name and address of corporation:

Name ______________________________

Address ______________________________

City ____________________ State __________ Zip ______

Contact ____________________ Telephone ______ ________

COPY

CD-6/76-4 C

Highway Safety Research Institute
The University of Michigan

COMPANY VISIT LOG

Record ALL visits--scheduled and completed.

Date	Reason for Visit	Y	N	By	Comments

Codes for Reasons:

1. Initial visit
2. Complete company description
3. Modify company description
4. Periodic visit for completing necessary forms. Specify forms completed as:

   TI--Trip Information
   A--Accident report
   MM--Mainyenance and Mileage Report
5. Complete work previously started.
6. Call back for periodic visit (reason 4).
7. Other visit: Specify above.

SPECIAL INSTRUCTIONS

F

Highway Safety Research Institute
The University of Michigan

A. I.D. ____________
B. Fleet Name ____________
C. Date ____________

VEHICLE DESCRIPTION

__Vehicle__

1. Make ____________________
2. Model ____________________
3. VIN or Manufacturers Vehicle No. ____________ → 4.(D) Company Unit No. ________
5. Model Year: ________

__Style__

6. Vehicle Style
( ) Straight Truck
( ) Tractor

7. Cab Style
( ) Conventional or Long Conventional
( ) Short Conventional
( ) Cab over or tilt cab
( ) Cab over or tilt cab with sleeper

8. Cargo body style T1 ________

9. GVWR (Gross Vehicle Weight Rating)

Range	Class
( ) less than 19000#	5
( ) 19000#-26000#	6
( ) 26001#-33000#	7
( ) greater than 33000#	8
( ) Unknown	

__Axle & Brake Configuration by Axle__

	Front	Rear 5	Rear 4	Rear 3	Rear 2	Rear 1
10. Equipped with axle?		( )	( )	( )	( )	( )
11. Brake System T6	___	___	___	___	___	___
12. Operational T3	___	___	___	___	___	___
13. Liftable axle		( )	( )	( )	( )	( )
14. Anti-lock Mfg. T2	___	___	___	___	___	___

__General Exposure Category__

15. Region
( ) Local → ( ) Check if ommercial zone ONLY
( ) Intra-State Only:
( ) Inter-State:
→
16. Usual Trip Length
( ) Less than 200 mi. one way
( ) More than 200 mi. one way

See form HSRI 7/76-1 for statement concerning cooperation and disclosure.

Highway Safety Research Institute
The University of Michigan

A.	I.D. ____________
B.	Fleet Name ____________
C.	Date ___/___/___
D.	Unit No. ____________

SURVEY VEHICLE MILEAGE AND
MAINTENANCE HISTORY

NOTE: Make a copy of this form. Retain the original in the field folder. Send the copy to HSRI. After each visit, update the field folder copy and send the new entries to HSRI.

MAINTENANCE

Maintain a chronology of repairs affecting the braking system.

Begin with January, 1976 entries.

Date	Mileage	Maintenance Entries	121 Status (T3)	Repair Time (Hours)	Reason for Maintenance: Routine Maint.	Driver Report	Accident

MILEAGE

Record the mileage for this vehicle at each quarterly visit. Note the date the reading was taken and the source of the reading.

Quarter	Jan,76	1 Aug-Oct,76	2 Nov-Jan,77	3 Feb-Apr,77	4 May-Jul,77	5 Aug-Oct,77	6 Nov-Dec,77
Date							
Mileage							
Source							

SOURCE: 1 = Maintenance Record; 2 = Inspection Record; 3 = Odometer; 4 = Other:__________ (Over) F

VEHICLE RECORD CONTACT LOG

Note date and check appropriate column(s) when reviewing records.

	By	Date	Vehicle Desc.	Trip Information	Accident report	Maint. record	Comments
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							
21.							
22.							

Highway Safety Research Institute
The University of Michigan

A.	I.D. ____________
B.	Fleet Name ____________
C.	Date ____________
D.	Unit No. ____________

FORM A
HSRI ACCIDENT REPORT

Name and Location

1. Carrier — Name ____________ Address ____________
City ____________ State ____________ Zip ________
Contact ____________ Telephone No. ______ ____________

2. Driver — Name ____________ Address ____________
City ____________ State ____________ Zip ________
Telephone No. ______ ____________

3. Date of Accident ____/____/____ 4. Place of Accident: City or Town ____________
County ____________ State ________

5. Reported to: (*Obtain copies of all available reports.*)
( ) Company: Report No. ____________
( ) Local Police: Department ________, State ____________ Report No. ____________
( ) State Police: State ____________, Report No. ____________
( ) Public Regulatory Agency: State ____________ Report No. ____________
( ) Bureau of Motor Carrier Safety: Report No. ____________

Trip Information

6. Areas of Operation: ( ) Local → ( ) Check if commercial zone ONLY
( ) Intra-State only:
( ) Inter-State: } → 7. Intended Trip Length: ( ) Less than 200 mi. one way
( ) More than 200 mi. one way

Cargo & Loading

8. Specific Cargo Transported or Hauled:
( ) ____________
( ) Mixed Cargo -- Less than Truck Load (LTL) quantities of general freight
( ) Empty → ( ) Empty

9. Loading:
( ) Full on Basis of Cargo: ( ) Weight
( ) Volume
( ) Partial
( ) Empty

Special Conditions

10. Vehicle Mechanical Defect -- General Category
( ) No Defect
( ) Other Defect: ____________

Brakes: ( ) Inoperative
( ) Worn
( ) Red Light On, Cause Unknown
( ) Locked
( ) Misadjusted
( ) Failure following Repair
( ) Air Supply
( ) Unspecified
( ) Other ____________

11. Road Surface Condition at the time of the accident:
( ) Dry
( ) Wet
( ) Snow/Ice
( ) Other: ____________
( ) Unknown

Vehicle Description and Composition

	Straight Truck ( )	Tractor ( )	Semi Trailer ( )	Conv. Dolly ( )	Semi Trailer ( )	Full Trailer ( )
12. Brake System (T6)	____	____	____	____	____	____
13. Operational (T3)	____	____	____	____	____	____
14. Unit No. *	________	________	________	________	________	________
15. Make	________	________	________	________	________	________
16. Model	________	________	________	________	________	________
17. Model Year (T4)	________	________	________	________	________	________
18. Cargo Body Style (T1)	________	________	________		________	________

19. For Power Unit, VIN (Vehicle Identification Number): ____________

*Use company unit number and our suffix: C = Company Owner, or O = Owned by Other.

See Form HSRI-7/76-1 for statement concerning cooperation and disclosure.

A-6/76-4

(OVER) F

Accident Loss Type

20. GENERAL LOSS TYPE -- For Accident: ( ) Property Damage, ( ) Injury, ( ) Fatal

21. OCCUPANTS AND INJURIES BY VEHICLE

For the study vehicle only, indicate: Total Occupants_____, Total Injured_____, Total Killed _____

For all other vehicles and any pedestrians involved, indicate:
Total Occupants & Pedestrians________, Total Injured________, Total Killed________

22. DOLLAR LOSS -- For Damage Only:

	$0	$1-$500	$501-$1000	$1000-$2000	$2001+
Total for Accident	( )	( )	( )	( )	( )
For Trucking Co.	( )	( )	( )	( )	( )

23. DOWN TIME: Time truck out of service due to accident and repairs.

( ) None
( ) Less than 4 Hours
( ) 4 - 24 Hours
( ) 24 Hours - 1 Week
( ) More than 1 Week
( ) Vehicle not put back into service

Narrative: Describe briefly how the accident occurred and include scene diagrams where appropriate. Use additional paper if space is not sufficient.

25. PRE-COLLISION: *Describe.*

Did anything unusual occur to the vehicle before the accident? (Note any pre-collision factor as listed on Table 5a of the reference card.) Indicate significant events.

26. COLLISION: *Describe. (Include the type of collision, number of vehicles involved and indicate the objects contacted -- see Table 5b and Table 5c.)*

27. POST-COLLISION: *(List any post-crash events which occured to the vehicle. See Table 5a.)*

→ Note: OMIT this section if police type report(s) are included with this submission.

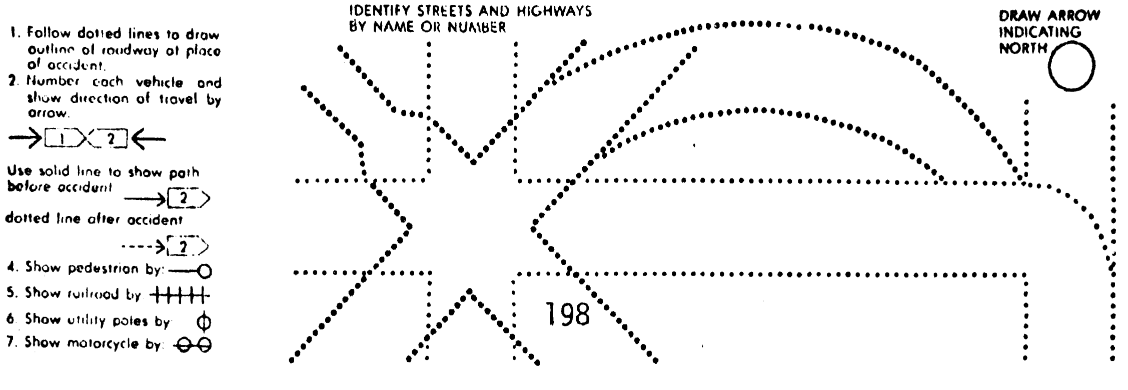
28. Location of Accident: ( ) Private Property: ________________________________
Parking Lot, Loading Dock, etc. & Name of Private Property

( ) Street or Highway____________________ ( ) at intersection with ____________________
( ) __________ Feet/Miles N S E W of Intersection with ____________________

29. Describe the location where the accident occurred.

30. Other Relevant Information -- Describe any other information deemed relevant, road condition, etc.

31. Scene Diagram: *(Using dotted diagram as guide and heavy pencil or pen, indicate actual roadway situation at accident scene. Then use symbols below to show what happened, the path taken by involved vehicles, and their final resting place.)*



Highway Safety Research Institute
The University of Michigan

A. I.D.________________
B. Fleet Name________________
C. Date________________
Field Mgr.________________

FIELD MANAGER REPORT

Company Name________________________________

STATUS:

1. Contacted?
   - ( ) No → Stopped: *(Indicate reason below)*
     - ( ) No or wrong address in our files
     - ( ) Cannot locate by telephone or personal visit
     - ( ) Other:________________________
   - ( ) Yes

2. Interviewed?
   - ( ) No → Stopped: *(Indicate reason below)*
     - ( ) Could not contact responsible party
     - ( ) Other:________________________
   - ( ) Yes

3. Interview Result
   - ( ) Stopped: Check reason
     - ( ) Unwilling to cooperate: Reason________________
       ____
     - ( ) Vehicles not available:* Reason ________________
       ____
     - ( ) Not in trucking business*
     - ( ) Other________________________________
       ____
   - ( ) Field visit OK → → → → complete other side of page →

---

* and NOTE: If one, several or all of the vehicles are not available, determine where they can be found.

____

____

____

IV-7/76-3 R

4. Willing to Cooperate
   ( ) Enthuastic
   ( ) Willing
   ( ) OK but some hesitation
   ( ) Unwilling
   ( ) Refusal

5. Does the potential for future field data collection problems exist with the company or any of its employees?
   ( ) No
   ( ) Yes: Explain ______________________________

   ____

   ____

6. Company bias toward 121
   ( ) Strongly in favor of 121
   ( ) Mildly in favor of 121
   ( ) Neutral
   ( ) Mildly against 121
   ( ) Strongly against 121

7. Facility Rating -- What type of periodic inspection and maintenance system exists in terms of getting the job done?

   Inspection

   ( ) Adequate -- pre-trip, post-trip written records, etc.
   ( ) Marginal -- post-trip only
   ( ) Inadequate -- cursory visual
   ( ) No inspection

   Maintenance

   ( ) Adequate -- periodic, with records, etc.
   ( ) Marginal -- some semblance of periodic system
   ( ) Inadequate -- fix it only when we find it
   ( ) No maintenance -- repairs only when it breaks down

STOPPED: Date ______________

( ) Unwilling to continue cooperation: Reason ______________________________

( ) Vehicle(s) not available: Reason ______________________________

NOTE where the vehicle(s) have gone ______________________________

( ) Quit business

( ) Other: ______________________________

Area	____
Fleet	____
Vehicle	____
Stratum	____
Sample Date Code	____

TRIP INFORMATION SURVEY (TIS)

Selected Vehicle Summary Form

UNIT NO. __________

Company Name ______________________ Total TIS Vehicles ______

Location ______________________ Phone ____ ________

Brake Type __________ Modifications: ______________________

Body Type ______________ Usual Trip Length ______________

Initial Information Notes: ______________________

Call Records

Period	Date	Time	Phone No.	Contact(s)	Result	Intv.
PERIOD 1 Sample Date: ________ Day of Week:____						
PERIOD 2 Sample Date: ________ Day of Week:____						
PERIOD 3 Sample Date: ________ Day of Week:____						
PERIOD 4 Sample Date: ________ Day of Week:____						

RESULT CODE: CI = Complete Info.; PI = Partial Info.; NI = No Info.; NA = No Answer; DN = Different No.; CA = Call Again; OTHER = Make a note on reverse side.

Date	CONTACT NOTES: PERIOD 1

Date	CONTACT NOTES: PERIOD 2

Date	CONTACT NOTES: PERIOD 3

Date	CONTACT NOTES: PERIOD 4

FORM TI
1977 Trip Information Survey

Telephone Interview Form

Company ______________________________

Phone ____________________ Unit No. __________

Vehicle I.D.____________	(03-11)
Survey Period____________	(12)
Stratum____________	(13-17)
Sample Date Code____________	(18-19)
Sample Date____________	(20-23)
Sample Day of Week________	(24)

(1=Mon; 2=Tues; 3=Wed; 4=Thurs; 5=Fri; 6=Sat; 7=Sun)

1. *Use Vehicle Description to verify, as necessary (year, make, 121 status, etc.)*
Was Unit Number ______________ in use on ____________? [Col 25]

[ ] 2 No

a. Was it being serviced, or not scheduled for use? [Col 26]

[ ] 3 Don't Know
[ ] 2 Wasn't Scheduled } *To End.*
[ ] 1 Being Serviced

b. Did this servicing involve the brakes at all? [Col 27]

[ ] 3 Don't Know
[ ] 2 No, not the brakes } *To End.*
[ ] 1 Yes

c. Was the reason for servicing a breakdown or failure in the brake system? [Col 28]

[ ] 3 Don't Know
[ ] 2 No } *To End.*
[ ] 1 Yes

d. What was the nature of the brake problem? ______________

____

____

[ ] 3 Don't Know
[ ] 4 Other *(Example: Vehicle sold, scrapped, etc.)* Specify: ________

____ *(To End.)*

[ ] 1 Yes

2. Approximately how many miles was Unit Number ____________ driven on ________ from midnight to midnight?

Specify number of miles: ______________ [Col 29-32]

Source: [ ] 1 Records [Col 33]
[ ] 2 Estimate
[ ] 3 Not Sure

3. Was all of this mileage driven on (local/short haul/long haul) trips?
If so, enter total mileage on appropriate line.
If not, enter a breakdown of mileages between categories.

a. Local:__________________ Miles [Col 34-37]
In or around the area in which the vehicle is based.

b. Short Haul:______________ Miles [Col 38-41]
A trip to another area less than 200 miles away.

c. Long Haul:_______________ Miles [Col 42-45]
A trip to another area more than 200 miles away.

NOTE: IF VEHICLE IS A BUS, GO TO END OF FORM!

4. a. Did Unit ________________ pull any trailers on _______________? [Col 46]

[ ] 3 Don't Know } *To End.*
[ ] 2 No }
[ ] 1 Yes

b. Was it a single bottom or double bottom? [Col 47]

[ ] 3 Don't Know
[ ] 1 Single--*Describe the most used trailer.*
[ ] 2 Double--*Describe the first and second trailer.*

SINGLE OR FIRST TRAILER:	SECOND TRAILER (IN DOUBLE):
c. Was it a 121 trailer? [Col 48] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes	f. Was it a 121 trailer? [Col 51] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes
d. If Yes, was the brake modified? [Col 49] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes	g. If Yes, was the brake modified? [Col 52] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes
e. If Yes, was the modified part the anti-skid? [Col 50] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes	h. If Yes, was the modified part the anti-skid? [Col 53] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes

* * END * *

Number of Calls _______ [Col 54]
Number of useful respondents ____ [Col 55]
Interviewer ______________
Interview Date ______________ [Col 56-59]

Interview Status (Before Key Punch) [Col 60]

[ ] 1 Complete Information
[ ] 2 Partial Information
[ ] 3 No Information

APPENDIX C

FATAL ACCIDENT FOLLOW-UP DATA FORMS

HIGHWAY SAFETY RESEARCH INSTITUTE
Institute of Science and Technology
Huron Parkway and Baxter Road
Ann Arbor, Michigan 48109

THE UNIVERSITY OF MICHIGAN

As you know from our recent telephone conversation, the Highway Safety Research Institute of The University of Michigan is collecting information about accidents which involved late model air-braked trucks. This study is sponsored by the U.S. Department of Transportation as part of its program for improving the safety of truck operations. An article explaining how the study will be used to evaluate the federal air-brake regulation (FMVSS-121) is enclosed along with a confidentiality statement. I sincerely hope you will be able to help us.

I fully understand your reluctance to discuss an accident over the phone. However, you will see from our questionnaire that we are interested in your truck and its brakes, rather than details of the accident or who was at fault. We would like you to answer the questions regardless of whether braking was involved in the accident.

Please take a few minutes to fill our our questionnaire and mail it in the enclosed stamped envelope. In the interest of highway safety and efficient truck operation, we ask for your cooperation in this important evaluation of FMVSS-121.

Sincerely,

Enclosures

HIGHWAY SAFETY RESEARCH INSTITUTE
Institute of Science and Technology
Huron Parkway and Baxter Road
Ann Arbor, Michigan 48109

THE UNIVERSITY OF MICHIGAN

The Highway Safety Research Institute of The University of Michigan is collecting information on accidents involving late model air-braked trucks. The study is sponsored by the U.S. Department of Transportation and will be used to evaluate the federal air-brake regulation (FMVSS-121) for heavy trucks. We would very much appreciate your help.

Because we have been unable to reach you by telephone, I am sending you our questionnaire and some information about our study. Also enclosed, you will find a confidentiality statement and a self-addressed stamped envelope.

The accident we are seeking information about is identified on the first page of the questionnaire. As you will see from the questions asked, we are interested in your truck, rather than details of the accident. We would like you to answer the questions regardless of whether braking was involved in the accident and regardless of whether your truck has 121 brakes.

We sincerely hope you will take a few minutes to fill out and mail this questionnaire. Your cooperation will be greatly appreciated by everyone concerned with truck safety.

If you have any questions concerning this study, or if it would be more convenient for you to provide this needed information over the phone, please call me collect at (313) 763-1276.

Sincerely,

Enclosures

HEAVY TRUCK ACCIDENT QUESTIONNAIRE

Instructions:

Please look over items A-E for errors or missing information and make any corrections necessary.

I. (These items have been copied from police reports secured from state and local authorities.)

A. Name of Driver ____________________

B. Place Accident Occurred ____________________, State ________

C. Date Accident Occurred ____________________
Month Day Year

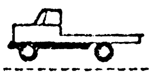
D. Vehicle Manufacturer ____________________

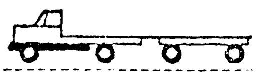
E. Vehicle Model Year ____________
(Note: If the model year of the vehicle is before 1974 do not answer any of the questions, and please return this form in the enclosed envelope.)

II. Continue now with Questions 1-14. Answer each question about the truck according to its condition <u>at the time of the accident</u>.

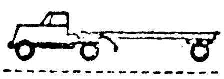
---

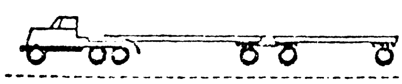
1. Check the box which corresponds to the <u>Vehicle Combination</u>. Choose only one.

☐  Straight Truck Only

☐  Straight Truck and Full Trailer

☐  Tractor Only (Bobtail)

☐  Tractor and Semi Trailer

☐  Tractor, Semi Trailer and Full Trailer (Doubles)

☐ Other (specify): ____________________

☐ Unknown

2. What type of brakes did the truck have?

[ ] Air

[ ] Air/hydraulic

[ ] Non-Air

[ ] Unknown

3. What was the Gross Vehicle Weight Rating of the truck?

[ ] 26,000 lbs. or over (Class 7, 8, Heavy-Heavy)

[ ] Under 26,000 lbs. (Class 3-6, Light Heavy)

[ ] Unknown

4. Write in the code number describing the type of brakes for each unit of the vehicle combination.

Power* Unit	1st trailer (if any)	2nd trailer (if any)
[ ]	[ ]	[ ]

1. Conventional Air Brake (non FMVSS 121)
2. Conventional Air Brake but with anti-lock system
3. FMVSS-121 air brake system
4. Not equipped with brakes
5. Electric brakes
6. Other brake system

5. Write in the code number describing the brake status of the brake system on each unit of the vehicle combination.

Power* Unit	1st trailer (if any)	2nd trailer (if any)
[ ]	[ ]	[ ]

*tractor or straight truck

For units with conventional air brakes

1. Operational as originally equipped
2. Brake system modified
3. Brake system not operational

For units with FMVSS 121 air brakes

4. Operational as originally equipped
5. Brake system modified
6. Anti-lock removed
7. Brake system not operational

For units with other brake systems

8. Operational 9. Not operational

6. How many air-braked trucks are in your fleet?

[ ] 1
[ ] 2-5
[ ] 6-50
[ ] 50+
[ ] Unknown

7. What was the intended area of operation for the trip on which the accident occurred?

[ ] Local
[ ] Within the State
[ ] Interstate
[ ] Unknown

8. What was the intended length of the driver's trip on the day of the accident (one way)?

[ ] Less than 200 miles

[ ] Greater than 200 miles

[ ] Unknown

9. What type of carrier was this vehicle?

[ ] Private

[ ] For Hire → What type?
[ ] Contract
[ ] Common
[ ] Exempt (Agricultural Commodity)
[ ] Exempt (Commercial Zone)
[ ] Unknown

10. Did the vehicle jacknife?

[ ] No

[ ] Yes, before impact

[ ] Yes, after initial impact

[ ] Unknown

11. What type of cab did the truck have?

[ ] Conventional

[ ] Tilt (Cab-over)

[ ] Unknown

12. Did the cab have a sleeper?

[ ] Yes

[ ] No

[ ] Unknown

13. What cargo was being transported at the time of the accident?

[ ] Specify: ____________________

[ ] Truck was empty

14. Comments: ____________________

____

____

____

Thank you for your cooperation--please mail this form in the enclosed stamped envelope, or send it to:

Heavy Truck Brake Study
Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109

FMVSS 121 FATAL ACCIDENT DATA FORM

I. ADMINISTRATIVE

State ___ ___ FARS ___ ___ ___ ___ (1-6)

Accident Date ___ ___/___ ___/___ ___ (7-12)
YR MO DY

Interview Complete ___ ___/___ ___/___ ___ (13-18)
YR MO DY

Vehicle/Interviewer Code _____ _____ (19-20)

Interviewee (21):

1 ( ) Owner
2 ( ) Driver
3 ( ) Owner/Driver
4 ( ) Other: ____________________
8 ( ) N/A, No interviewee

Final Status (22-30):

	Yes=1	No=2
Police Reports:		
Readable	( )	( )
Complete	( )	( )
Follow-up:		
Initiated	( )	( )
Phone #	( )	( )
Contacted	( )	( )
Cooperated	( )	( )
Mailed	( )	( )
Returned	( )	( )
Completed	( )	( )

II. VEHICLE DATA VALIDATION

Vehicle Manufacturer (31-32)

01 ( ) Ford
02 ( ) GM
03 ( ) Dodge
04 ( ) Mack
05 ( ) Peterbilt
06 ( ) Kenworth
07 ( ) White
08 ( ) International
09 ( ) Brockway
10 ( ) Diamond Reo
11 ( ) Chevy
12 ( ) Freightliner
13 ( ) Auto Car
14 ( ) White Western
__ ( ) See List
99 ( ) Unknown

Model Year ____ ____ (33-34)

Weight (35)

1 ( ) Under 26,000 (Class 3-6, L-H)
2 ( ) Over 26,000 (Class 7,8, H-H)
9 ( ) Definitely Unknown

Vehicle Configuration (36)

1 ( ) Bobtail Tractor
2 ( ) Straight
3 ( ) Tractor, Semi
4 ( ) Tractor, Semi, Full
5 ( ) Straight, Full
8 ( ) Other: ____________________
9 ( ) Unknown

Power Unit Brakes (37)

1 ( ) Air
2 ( ) Non-air
9 ( ) Unknown

III. EXPOSURE INFORMATION

Fleet Size (# Airbraked Power Units) (38)

1 ( ) 1
2 ( ) 2-5
3 ( ) 6-50
4 ( ) 50+
9 ( ) Unknown

Area of Operation of Truck (39)

1 ( ) Local
2 ( ) Intrastate
3 ( ) Interstate
9 ( ) Unknown

Intended Length of Accident Trip (one-way) (40)

1 ( ) Over 200 miles
2 ( ) Under 200 miles
9 ( ) Unknown

Carrier Type (41)

1 ( ) Private (not for hire)
2 ( ) For Hire
3 ( ) Authorized (ICC)
4 ( ) Contract
5 ( ) Common
6 ( ) Exempt
7 ( ) Cargo (e.g., Farm)
8 ( ) Area (e.g., Local)
9 ( ) Unknown

IV. SUPPLEMENTAL INFORMATION

Jackknife Condition (42)

1 ( ) Vehicle did not
2 ( ) Prior to impact
3 ( ) After initial impact
9 ( ) Unknown

Cab (43)

1 ( ) Conventional
2 ( ) Tilt
9 ( ) Unknown

Sleeper (44)

1 ( ) Yes
2 ( ) No
9 ( ) Unknown

Cargo ____________________

___ ___ ___ ___ ___ (45-49)

COMMENTS:

V. AIR BRAKE SYSTEM

BRAKE TYPE		BRAKE STATUS
(50) ______	Power Unit	______ ______ (51,52)
(53) ______	Trailer 1	______ ______ (54,55)
(56) ______	Trailer 2	______ ______ (57,58)

1. Conventional Air Brake (non FMVSS 121)
2. Conventional Air Brake but with anti-lock system
3. FMVSS-121 air brake system
4. Not equipped with brakes
5. Electric brakes
6. Other brake system
8. Not Applicable
9. Unknown

01. operational as originally equipped
02. not equipped
88. Not Applicable

For units with conventional air brakes:

03. Brake system modified
04. Brake system removed
05. Brake system not operational
88. Not Applicabl

For

[illegible]
anti-lock not operational (if so equipped)
08. Brake system modified and anti-lock not operational
09. Brake system removed
10. Anti-lock system only removed
88. Not Applicable

Accident Type (59) ____________________

1. Single
2. Head-on
3. Rear; OV→T
4. Rear; T→OV
5. Angle;
5. Angle; OV→T
6. Angle; T→OV
7. Sideswipe
8. Other ____________________
9. Unknown

APPENDIX D

INJURY ACCIDENT FOLLOW-UP DATA FORMS

HIGHWAY SAFETY RESEARCH INSTITUTE
Institute of Science and Technology
Huron Parkway and Baxter Road
Ann Arbor, Michigan . 48105

THE UNIVERSITY OF MICHIGAN

November 10, 1976

Dear

The Highway Safety Research Institute of The University of Michigan is conducting a study entitled "Fleet Accident Evaluation of FMVSS 121." This study is sponsored and funded by the National Highway Traffic Safety Administration, U.S. Department of Transportation under contract number DOT-HS-6-01286.

The purpose of this study is to determine what effect (if any) the imposition of Federal Motor Vehicle Safety Standard number 121, Air Brake Systems (FMVSS-121) has had on reducing the number of accidents involving trucks equipped with this new (anti-skid) brake system.

The Bureau of Motor Carrier Safety (BMCS) in cooperation with the National Highway Traffic Safety Administration has provided to us a copy of the BMCS Accident Report (form MCS-50T) indicating that one of your vehicles was involved recently in an accident. While form MCS-50T provides much information about the accident, a few additional, important pieces of data concerning the truck's brake system must be known before our analysis can be completed. Therefore please take a few minutes and complete the enclosed supplemental data form and return it in tne enclosed, self-addressed envelope. (No additional postage is required).

This project is authorized by law--the National Traffic and Motor Vehicle Safety Act of 1966 (PL-89-563) and the Highway Safety Act of 1966 (PL-89-564). While you are NOT required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate and timely.

The Highway Safety Research Institute will keep the names and identities of all individuals and companies who furnish information for this study strictly confidential. Such information will not be disclosed unless the Institute is required to do so by judicial process.

Only summary statistics (without personal or corporate identification) will be reported. The opinions, findings, and conclusions expressed in all reports concerning this project will be those of The University of Michigan and not necessarily those of the National Highway Traffic Safety Administration.

It is the sincere desire of The University of Michigan to obtain the best data possible. In the interests of highway safety and efficient company operation we are asking for your continued cooperation in this most important evaluation of FMVSS 121.

For the University of Michigan

For the Bureau of Motor Carrier Safety

vld

Enclosures

HSRI - BMCS Truck Accident Data Supplement

Instructions:

(1) Review items 1-5 for errors or omissions. These items have been copied from the Bureau of Motor Carrier Safety Motor Carrier Accident Report, Form MCS-50T. Note any corrections or changes necessary.

(2) Refer to item 6 and answer accordingly. Follow the instructions given in item 6. Complete the additional items requested and return the questionnaire--as instructed.

(3) A self addressed, stamped envelope is provided for your convenience. A prompt reply will be appreciated.

1. Name of Carrier ______________________________

2. Address ______________________________

____

3. Place Accident Occurred:

Street or Highway ______________________________

City ______________ State ______________ Zip ______________

4. Date Accident Occurred ______________________________
mo day year

5. Description of Involved Power Unit (truck or tractor)

Make ______________________________

Model ______________________________

Model Year ______________

* *

6. Indicate the type of brake system on the truck or truck-tractor.

( ) Hydraulic Brake System including Vacuum Assisted Hydraulic and Air Assisted Hydraulic (power) brakes

Skip to item 14

( ) Air Brake System including Air-Mechanical and Air-Hydraulic brakes

7. What specific cargo was being transported at the time of the accident?

( ) ____________________
( ) empty

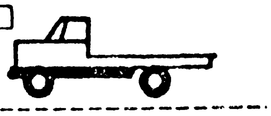
8. What was the quantity of cargo on the vehicle?

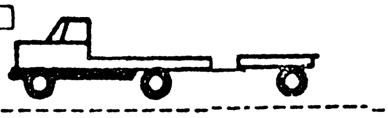
( ) full load on the basis of cargo weight
( ) full load on the basis of cargo volume
( ) partial load
( ) empty

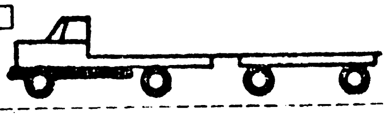
9. Indicate the length of time the power unit (truck or truck-tractor) was out-of-service due to the accident and repair necessary to place it back into service.

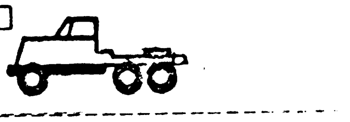
( ) a. None
( ) b. Less than 4 hours
( ) c. 4-24 hours
( ) d. 24 hours - 1 week
( ) e. More than 1 week
( ) f. Truck not put back into service

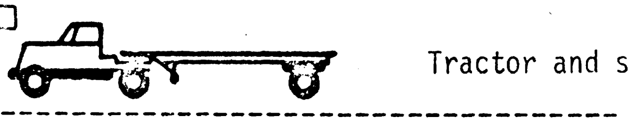
10. Check the box which corresponds to the vehicle combination at the time of the accident. Choose only one.

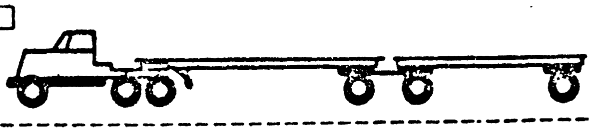
☐  Straight truck only

☐  Straight truck and utility trailer (or mobile equipment)

☐  Straight truck and Full Trailer

☐  Tractor only

☐  Tractor and semi-trailer

☐  Tractor, semi-trailer and Full Trailer (or semi and dolly) "Doubles"

☐ Other vehicle combination
Describe ______________________________

11. Write in the code number corresponding to the type of brakes for each Unit of the vehicle combination (marked above).

Power Unit	1st trailer (if any)	2nd trailer (if any)
☐	☐	☐

1. Conventional Air Brake (non FMVSS 121)
2. Conventional Air Brake but with anti-lock system
3. FMVSS-121 air brake system
4. Not equipped with brakes
5. Electric brakes
6. Other brake system

12. Write in the code number corresponding to the operational status of the brake system on each Unit of the vehicle combination

Power Unit	1st trailer (if any)	2nd trailer (if any)
☐	☐	☐

codes for operational status:
1. operational as originally equipped
2. not equipped

For units with conventional air brakes:
3. Brake system modified
4. Brake system removed
5. Brake system not operational

For units with FMVSS 121 air brakes
6. brake system modified (not including anti-lock)
7. anti-lock not operational (if so equipped)
8. brake system modified and anti-lock not operational
9. brake system removed
10. anti lock system only removed

13. Indicate any brake system defect or failure of the brake system at the time of the accident. Check all applicable defects and/or failures as listed below:

( ) a. No brake defect noted
( ) b. Brake linings worn
( ) c. Anti-lock red light on, cause unknown
( ) d. Anti-lock computer failure
( ) e. Brakes locked
( ) f. Brakes failed to release
( ) g. Parking brake frozen due to ice in lining
( ) h. Improper or faulty material/assembly of parts
( ) i. Bad adjustment
( ) j. Breakage of parts
( ) k. Grease on lining
( ) l. Cracked or heat checked brake drums
( ) m. Ice in lines or valves
( ) n. Failure of compressor
( ) o. Failure of booster
( ) p. Failure of compressor relay valve
( ) q. Failure of check valve
( ) r. Failure of brake chamber backing plate
( ) s. Metal tubing rubber or other flexible hose leaking, broken, kinked, cramped or restricted.
( ) y. Other (specify) ______________________________

14. Please place the questionnaire in the enclosed self-addressed, stamped envelope and mail. Thank you for your cooperation.