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FLEET ACCIDENT EVALUATION OF FMVSS 121

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16. Abstract The report presents the final results of a four-year project to evaluate the safety impact of FMVSS 121. The study focuses on the experience of 1974-1977 model year vehicles during the calendar years 1976-1978. National estimates of fatal and injury accident involvement rates (number of involvements per hundred million vehicle miles) are developed for pre- and post-standard vehicles in various exposure categories. Many approximations and assumptions were necessary to carry out this analysis with the available data. The influence of these factors must be taken into account when interpreting results.

National samples of vehicles were selected from manufacturers' sales lists for exposure surveys. The data collected included descriptive information on the company and vehicle, mileage, and type of use. The NHTSA Fatal Accident Reporting System (FARS) provides information on all fatal accidents. These data were supplemented by telephone interviews. Injury level accident data were obtained from the Bureau of Motor Carrier Safety.

The authors conclude that this study provides no evidence of a substantial safety benefit for post-standard vehicles. It is recommended that future evaluation programs be expanded to include limited pilot, or demonstration, programs and planning of the national impact evaluation <u>prior</u> to implementation of the countermeasure.

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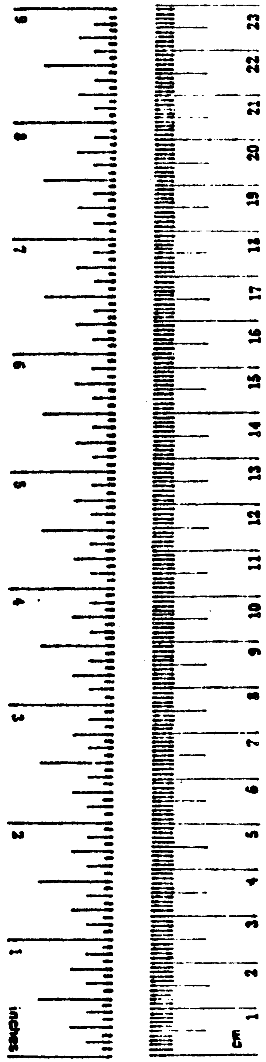
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

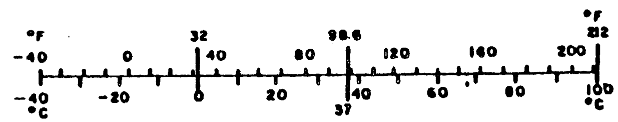
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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



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

Statistically sound methods could not have been employed without their cooperation.

Similarly, the information could not have been gathered without the cooperation of the truck owners participating in the study. The identities of these companies and individuals must be kept confidential in keeping with the Privacy Act. However, their cooperation and patience is sincerely appreciated.

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

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SECTION 1

SUMMARY

The National Highway Traffic Safety Administration implemented Federal Motor Vehicle Safety Standard No. 121, Air Brake Systems, on January 1, 1975 for trailers and on March 1, 1975 for power units. The performance requirements of this standard substantially upgraded air brake systems, focusing on stopping distance without wheel lockup. Truck manufacturers chose to meet these requirements with computerized wheel anti-lock controls. These changes were expected to produce substantial improvements in the overall accident experience of air-braked vehicles.

The objective of this study was to provide national estimates of the safety impact of FMVSS 121. This report presents the final results of a project which has lasted over four years, including nearly three years of data collection. This section of the report summarizes results, conclusions, and recommendations.

1.1 Study Design and Data Sources

This study combined data from many sources. Some existing data sources were used, some supplementary data collection augmented existing data sources, and some new data collection programs were developed and implemented. An overview of the study design is shown in Figure 1.1. The exposure data sources will be described first since they are most numerous and interrelated. A fundamental decision at the outset was to quantify the safety impact of FMVSS No. 121 in terms of accident involvement rates, or involvements per hundred million vehicle miles. These are the units for the involvement rates presented throughout the report. The critical data need became the mileage, or exposure, of the vehicles. The major effort of this study was focused on collection of the necessary exposure data.

The development of the exposure projections is illustrated in the center section of Figure 1.1. The most important design feature was the emphasis placed on development of statistically defensible national estimates. Probability-based methods were used to select the vehicles for the exposure surveys. In order to carry out these procedures, a sampling frame is necessary. The sampling frames used were sales lists supplied by most of the manufacturers of air-braked trucks. As shown in Figure 1.1, the selection of vehicles for the fleet monitoring program was made from manufacturers' sales lists for the 1974 and 1975 production years. Some 1976 vehicles were included. Manufacturers' sales lists for model year 1977 were used for the selection of vehicles for the second exposure survey conducted in 1978. These are post-Notice 7 vehicles. Notice 7 relaxed the stopping distance requirements of the standard. These vehicles were added in order to monitor the effect of this major change in FMVSS 121.

The original fleet monitoring program sought descriptive information on the company and the vehicle, quarterly mileage readings, brake system maintenance data, and information on all accidents the selected vehicles were involved in. Personal visits were made to collect the data. At the end of the two year data collection period, serious under-reporting problems were present for the maintenance and accident information. These data were judged to be unsuitable for national estimates. However, there was sufficient basis to believe that the descriptive and mileage information was sound. A supplemental "trip survey" in which information was obtained by phone on the use of the selected vehicles on specific randomly selected days

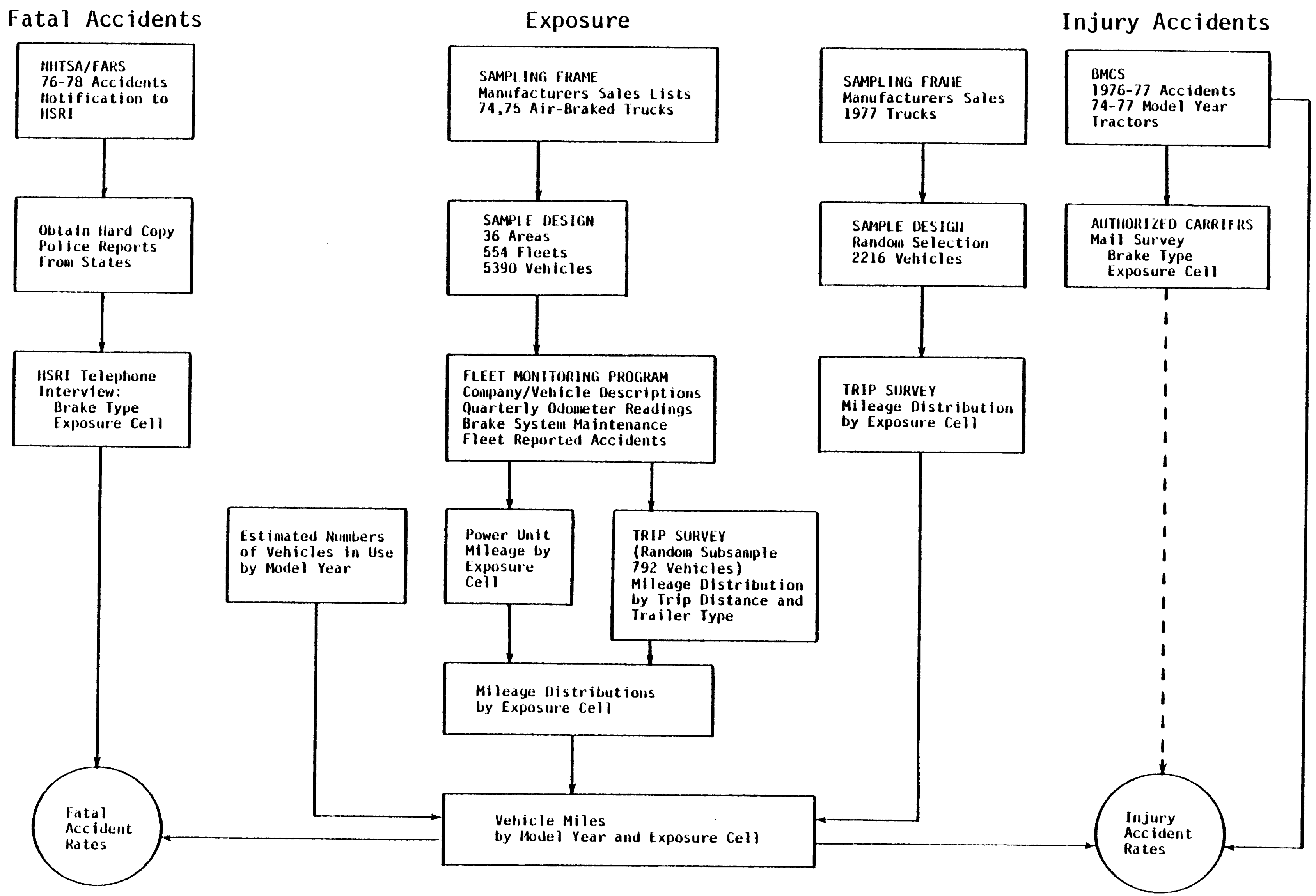

FIGURE 1.1 STUDY DESIGN

provided information on the distribution of mileage by trip distance and trailer type.

Because of the problems of accident reporting in the fleet monitoring program, the survey of post-Notice 7 vehicles was limited to descriptive information and exposure. The trip survey procedure was used.

These exposure data collection programs provided estimates of the average daily mileage for vehicles in various exposure categories. The last step was the extrapolation to the total number of vehicles in use. Estimates of the total number of vehicles in use were derived from factory sales data.

Next, the accident data shown on Figure 1.1 will be reviewed. Here, two data sources were used, the NHTSA Fatal Accident Reporting System (FARS) and the Bureau of Motor Carrier Safety (BMCS) accident files. Under FARS, uniform data on all fatal accidents are coded by analysts in each state. All interstate carriers are required to file an accident report with BMCS on any accident involving death, injury, or $2,000 property damage. Supplemental data collection was planned for both of these sources to obtain information on the brake type of both tractor and trailer as well as the exposure category. Telephone interviews were used to supplement the FARS data. A mail survey was tried for the BMCS cases. Unfortunately, the response to the mail survey was so low that the results were not useful.

The analysis consisted of partitioning the exposure and accident data into common categories of vehicle use. Accident rates were then computed within the various exposure categories. The resulting information on the differences in involvement rates associated with the exposure categories provides useful general information on the accident experience and use of heavy trucks. While this study does have the ability to identify differences in accident involvement rates for various types and uses of vehicles, it does not have the ability to identify the reasons for these differences. For example, tractors are found to have higher fatal involvement rates in both local and intercity use than do straight trucks. The reason(s) for this difference is not known. It could be due to differences in the operating environments not adequately controlled for in "local versus intercity" use categories, driver differences, or vehicle characteristics. Statistical findings such as these should be interpreted as indications of the need for further research to identify true causes and/or possible countermeasures.

The time periods spanned by the various data collection programs are illustrated in Figure 1.2. Notice that BMCS accident files were available only for 1976 and 1977. The trip survey for 1974 and 1975 model year vehicles was conducted from mid-1977 until mid-1978. The survey of post-Notice 7 vehicles covered the last four months of 1978. With this overview of the study as background, summary results are presented next. The material summarized in the next three sections is a condensation of the more complete discussion presented in Section 7.

1.2 Results

Before presenting the results, a brief review of the strengths and weaknesses of the data base is in order. The major strength of the exposure data base is the probability-based selection methods used. Table 1.1 summarizes the sample sizes, response rates, sampling frame totals, and frame coverage by model year. The "frame total" is the total number of vehicles in the sampling frame while the "frame coverage" is this total divided by the number of vehicles in the population the frame was intended to cover. While the response rates leave room for improvement, they are quite good considering that such techniques have not been applied to heavy truck accident research before. For

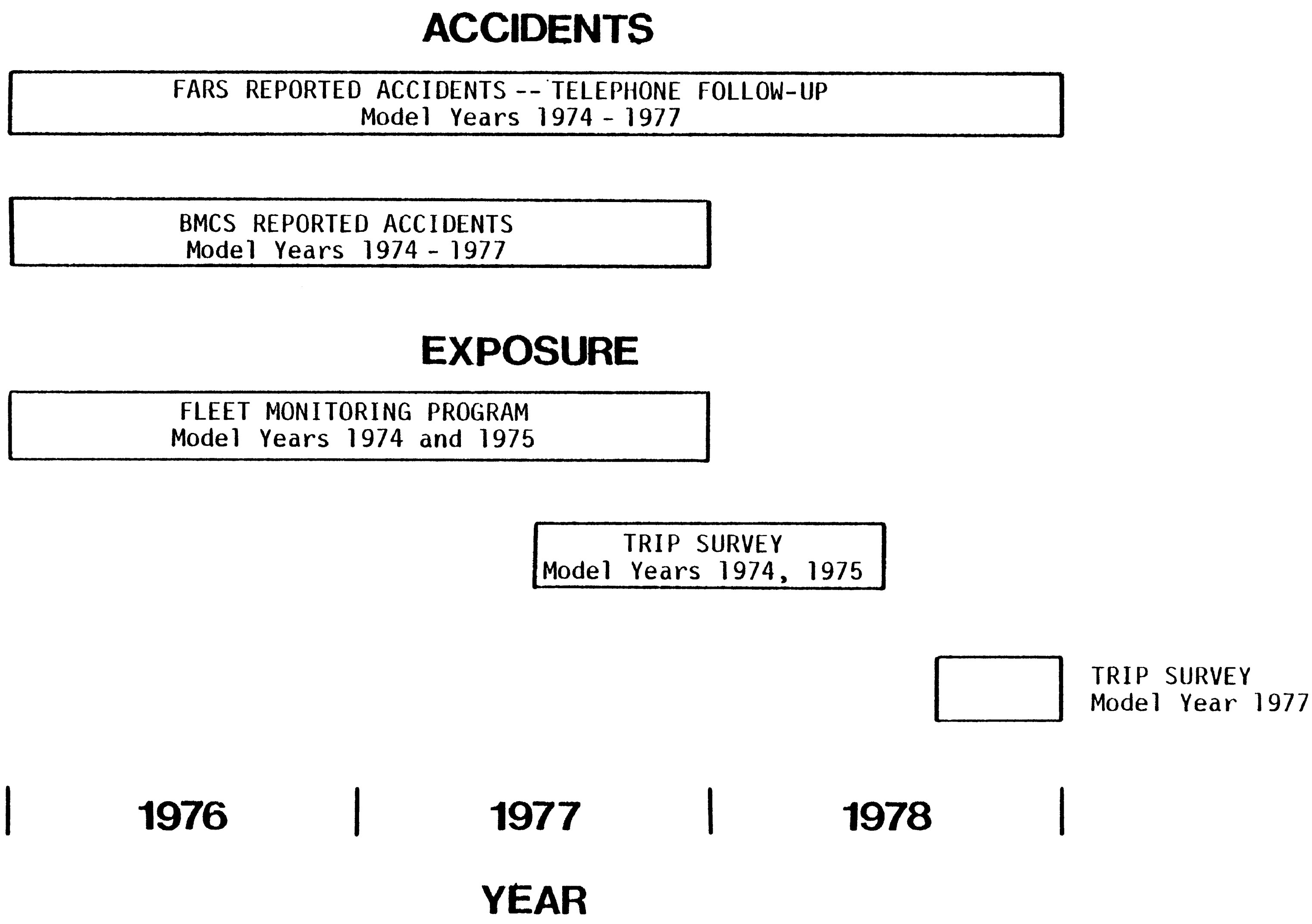

FIGURE 1.2 DATA SOURCES

the post-standard 1975 model year vehicles, the response is nearly 70%. This table also shows the minimal coverage of the 1976 model year. The fleet monitoring program was initiated early in this model year. By the time the program was expanded, the post-Notice 7 (model year 1977) vehicles were the focal point. Indeed, the sample size, response rate, and frame coverage for the survey of 1977 model-year vehicles are quite good. This is a reflection of the experience gained in the original fleet monitoring program.

TABLE 1.1

Exposure Survey Response Rates
and Frame Coverage by Model Year

Model Year	Participating Sample	Response Rate	Frame Total	Frame Coverage
1974	1,191	63.1	144,813	67.1
1975 Pre	283	63.1	40,370	55.7
1975 Post	1,065	69.8	36,083	50.5
1975 Total	1,348	68.3	76,453	53.1
1976	253	69.8	6,218	5.0
1977	1,444	68.0	142,983	82.0

The use of probability-based selection methods provides a statistical basis for projection from the sample to the larger population the sample is drawn from. This is the essential difference between anecdotal and survey information. If the elements for observation (vehicles) are not selected using probability-based methods, then the resulting information is anecdotal in nature. Results of an anecdotal nature provide no statistical basis for generalization (extrapolation) beyond the elements (vehicles) actually observed.

The use of probability-based selection methods also allows the precision of the estimates to be computed. These are shown as 95% confidence intervals on most of the results--the smaller the interval, the more precise the estimate. Many of the confidence intervals on the results from the fleet monitoring program are larger than one would like, 25%-50% of the mean. The high variances in this program are primarily the result of post-sample stratification for analysis, which produced subsets which were not well distributed across the primary sampling units. While this outcome is disappointing, one should keep in mind that variance estimates could not have been made if probability-based selection procedures had not been used.

The confidence intervals estimate the magnitude of the random variations present in the data. Another possible source of error is systematic error, or bias. Systematic error can be quantified only by comparison of independent data sources. In some cases such comparisons were possible (FARS data and survey mileages). For example, the model year distribution in the fatal accident survey data was forced to match the distribution in the parent FARS file. Because this study breaks much new ground in the analysis of the accident experience of heavy trucks, many assumptions and approximations are without verification. Every effort has been made to trace anomalous results to possible data problems. However, the possibility remains that some of the results presented are influenced by unknown systematic errors, and consequently do not reflect the true situation. Questions of this nature can only be resolved by further research.

The essential feature of the analysis is the incorporation of the exposure, or control, variables. The preliminary findings revealed that the pre- and post-standard groups of vehicles differed in their composition and use. The exposure variables are used to partition the data into common categories of use before rates are compared.

Mileage distributions by trip distance and trailer type were derived from the trip surveys. An important shortcoming here is in the estimation of the mileage distribution for pre- and post-standard trailers. While these surveys covered the calendar years of interest fairly well (see Figure 1.2), not all model years were surveyed in each calendar year. It was expected that data on the post-standard 1975 model year power units would accurately represent the 1976 power units with regard to the use of pre- and post-standard trailers. However, the proportions by trailer brake type from the accident data (discussed in Section 5) indicate a strong tendency for new model year equipment to be coupled. This being the case, the exposure data on trailer brake type is quite limited when only the model years and calendar years surveyed are applicable.

The major difficulty in the exposure projections is the estimation of the number of vehicles in use. This topic is discussed extensively in Section 4. The necessary information is not available from registration data. Consequently, a number of assumptions and adjustments must be made in working from factory sales. Some analysis of the sensitivity of the results to these assumptions is presented, but even this may not adequately quantify the uncertainty of this information.

These qualifications must be considered when interpreting the figures presented in the various tables. In particular, the comparison of pre- and post-standard vehicles is seriously limited. Throughout the report the various assumptions and approximations are discussed. This information must be used to temper one's interpretation of the results presented.

Having highlighted the strengths and weaknesses of the data, summary results will be presented next in two sub-sections. The first describes general findings on the types of air-braked trucks, their use, and their accident experience. Substantial differences are found in the involvement rates computed for the various exposure categories. This information may be of more long-term value than the comparative results on the pre- and post-standard vehicles presented in the second sub-section.

1.2.1 Exposure Categories. The first general results to be described are the differences in use and accident experience of straight trucks as compared to tractors. As one might expect, straight trucks are typically operated in local trips by small, non-Authorized carriers.[1] On the other hand, tractors are operated primarily by large Authorized and large private carriers on intercity trips. The average tractor accumulates almost four times the annual mileage of the average straight truck. Table 1.2 summarizes the fatal accident experience of straight trucks and tractors by trip distance. All rates presented in this report are computed as vehicle involvements per hundred million vehicle miles. Also shown in the tables is twice the standard error of the statistics. A 95% confidence interval is obtained by adding and subtracting this value from the statistic. Involvement rates for tractors are double those of straight trucks in both local and intercity use. All the differences on this table are statistically

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[1]Authorized carriers are the major class subject to Interstate Commerce Commission regulations. This class is comprised of the Common and Contract carriers. Non-Authorized refers to those carriers that are not ICC Common or Contract carriers. In general, the ICC economic regulations apply to interstate "for-hire" carriers. Interstate non-Authorized, i.e., not "for-hire," carriers are frequently referred to as "private" carriers. These carriers haul their own goods, and are not for-hire. Carriers that operate locally or intrastate are also

significant. Because of the large differences in the use and accident experience of straight trucks and tractors, vehicle type is the single, most important control variable. This distinction is important to the comparison of pre- and post-standard vehicles, because the proportion of all air-braked vehicles that were straight trucks as compared to tractors varied appreciably from model year to model year.

TABLE 1.2

Summary of Fatal Involvement Rates
by Vehicle Type and Trip Distance:
Aggregate of Model Years 1974-1977 and
Calendar Years 1976-1978*

Trip Distance	Straight Truck		Tractor	
	Rate	95% C.I.	Rate	95% C.I.
Local	4.0	±0.4	11.1	±2.1
Intercity	3.3	±0.7	6.8	±0.6
ALL	3.7	±0.5	7.2	±0.5

*All differences significant at .06 level or less.

Additional exposure categories were examined for intercity tractor use. These variables addressed trailer type (bobtail, single, or double), carrier type, and fleet size. Involvement rates for these exposure categories are summarized in Table 1.3. Involvement rates are shown for both fatal and injury accidents. Except for the comparison by carrier type, the injury involvement rates are restricted to Authorized carriers only.

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generally non-Authorized, regardless of whether they are for-hire or not.

TABLE 1.3

Summary of Involvement Rates
for Tractors by Exposure Category:
Intercity Use Only, Model Years 1974-1977 Combined

Exposure Variable and Levels	Fatal (Cal. Yrs. 76-78)		Injury (Cal. Yrs. 76-77)	
	Rate	95% C.I.	Rate	95% C.I.
Trailer Type				
Bobtail	90.0	±44.5	913.5	±1032.3
Trailer	6.8	± 0.7	53.5	± 18.3
Difference	83.2	±44.5	*860.0	±1032.7
Single	6.5	±0.6	47.9	±11.9
Double	9.5	±1.1	126.3	±25.7
Difference	-3.0	±1.3	-78.4	±28.3
Carrier Type				
Authorized	6.7	±1.2	45.9	±11.1
Non-Auth Interstate	6.2	±1.1	18.0	± 4.3
Difference	*0.5	±1.6	27.9	±11.9
Fleet Size				
Small	10.4	±1.4		
Large	4.6	±0.7		
Difference	5.8	±1.6		

*Differences significant at .05 level except when marked with asterisk.

The involvement rates for bobtail use are 13 to 20 times those for combination vehicles. However, the confidence intervals are very large because bobtail use is so infrequent (only 0.5% of the tractor mileage). In addition, there is some likelihood that bobtail mileage is underestimated. Even assuming considerable underestimation, the bobtails seem clearly over-involved in accidents. Double trailers also seem to be over-involved in comparison to single trailers, although not nearly to the extent of the bobtail category.

With regard to carrier type, the fatal involvement rates do not show any significant difference. However, the non-Authorized interstate carriers appear to have a much reduced injury accident involvement rate. This is believed to be a reflection of under-reporting to BMCS on the part of non-Authorized interstate carriers. This topic is discussed further in Section 6.

Differences in the involvement rates are also shown for large fleets as compared to small fleets. In particular, the vehicles in small fleets have more than double the fatal involvement rate of intercity tractors operated by large fleets. Fleet size is measured in the number of air-braked power units, small being 49 or less, and large being 50 or more.

A final comparison by cab style of the tractor is shown in Table 1.4. The cabover-style tractors have a fatal involvement rate 67% higher than that for conventional-cab tractors. This comparison is also limited to intercity use. Even more striking is the result when only accidents which resulted in death to the truck driver are used. Now the cabover-style tractor has a fatality rate slightly more than double that of the conventional cab tractor. These results are also highly significant.

This discussion has focused on differences in the accident experience associated with the various exposure categories. As such, it is necessary background for the comparison of pre- and post-standard vehicles presented next.

1.2.2 Comparison of Pre- and Post-Standard Vehicles. Results are presented separately for straight trucks and tractors in light of the previous results showing substantial differences in the use and accident experience of these two distinct vehicle types. A final tabulation addresses the jackknife experience of tractors on intercity trips. All tabulations in this section are presented by

TABLE 1.4

Fatal Involvement Rates by Cab Style:
Aggregate of Model Years 1974-1977 and
Calendar Years 1976-1978,
Intercity Use Only*

Cab Style	Fatal		Driver Fatal	
	Rate	95% C.I.	Rate	95% C.I.
Conventional	5.1	±0.9	0.65	±0.15
Cabover	8.5	±1.0	1.48	±0.26
Difference	-3.4	±1.3	-0.83	±0.30

*Differences significant at .001 level.

model year. All 1974 and the majority of 1975 model year air-braked vehicles are pre-standard. Efforts to split the 1975 model year were not successful. Model year 1977 vehicles are post-Notice 7.

Table 1.5 summarizes the fatal involvement rates (involvements per hundred million vehicle miles) for straight trucks. The data shown are an aggregate of the calendar years 1976-1978. Sufficient information is not available in the BMCS files to estimate injury involvement rates for straight trucks. Exposure data were particularly weak for the 1976 model year straight trucks. For this reason an average of daily mileage across model year was used in place of the actual survey data for the 1976 model year in this table. The 1974 model year is taken as a baseline in the computation of the percent change in the involvement rate for each successive model year.

The percent change in the involvement rates is seen to be somewhat mixed, but generally increasing. These results

TABLE 1.5

Summary of Fatal Involvement Rates
for Straight Trucks by Model Year:
Aggregate of Calendar Years 1976-1978

Model Year	Rate	95% C.I.	Percent Change*
1974	3.3	±0.9	0
1975	2.8	±0.5	-15
1976**	3.9	±0.9	+18
1977	4.6	±0.4	+39

*Base model year is 1974.

**Survey data replaced with an average of the daily mileages across model year.

were found to be somewhat sensitive to the method used to estimate exposure.

A summary of involvement rates for tractors is shown in Table 1.6. Here, results for both fatal and injury involvements are available. The fatal involvement rates are an aggregate of data from calendar years 1976-1978, while the injury accident involvement rates are derived from an aggregate of data from calendar years 1976-1977. Again, the percent change is computed using the 1974 model year as a baseline.

As with the straight trucks, the percent change is somewhat mixed, but generally increasing for the newer model years. These results were also found to be somewhat sensitive to the method used to estimate exposure. A notable exception is the 1977 tractors, which show a slight reduction. It is worth noting that the 1977 straight trucks showed the sharpest <u>increase</u>. The MVMA-supplied data on the percentage of tractors in each production year showed a

TABLE 1.6

Summary of Involvement Rates
for Tractors by Model Year

Model Year	Fatal Involvements (Cal. Years 1976-1978)			Injury Involvements (Cal. Years 1976-1977)		
	Rate	95% C.I.	Percent Change*	Rate	95% C.I.	Percent Change*
1974	6.6	±0.7	0	47.4	±12.5	0
1975	8.2	±0.8	+24	68.3	±29.9	+44
1976	8.5	±3.0	+29	57.2	±54.4	+21
1977	6.2	±0.2	-6	56.6	± 4.3	+19

*Base model year is 1974.

higher proportion of tractors for production year 1977 (67%) than for any of the previous three years. If this figure were slightly high, the straight truck rate would decrease and the tractor rate would increase. However, the survey of 1977 model year vehicles indicated that 77% were tractors! This kind of problem emphasizes the importance of the estimates of total numbers of vehicles in use.

A serious problem was encountered in our efforts to estimate involvement rates for the various combinations of brake type (pre/post) on tractor and trailer. Surveys of trailer use were conducted during most of the time period under study. However, not all model years were surveyed in each calendar year. Subsequent analysis of the <u>accident</u> data suggests that the use of new trailers is strongly related to the tractor model year. A complete discussion of this problem is presented in Section 5. The survey data are quite limited when restricted to the calendar year <u>and</u> model year surveyed. These results are very mixed. In general there seems to be no strong indication of under- or over-involvement related to trailer brake type. Tabulations of these results are presented in Table 7.11.

Jackknife accidents were of particular interest, since it was felt that this particular type of accident might show the most dramatic improvements for the post-standard vehicles. For a complete analysis, brake type of both tractor and trailer is needed. As suggested in previous discussion, the attempt to determine exposure by trailer brake type was not detailed enough. Consequently, the tabulation is presented here by model year of tractor only. Summary results are presented in Table 1.7. For the fatal involvements, only pre-impact jackknifes were included on the presumption that post-impact jackknifing is not amenable to vehicle handling countermeasures. In tabulating jackknifes from the BMCS file, accidents involving property damage only ($2,000 or more) were included. Jackknifing is a separate accident type in the BMCS file. Two types of statistic are shown in Table 1.7. First, the jackknifes are shown as a percent of all accidents under the column labeled "percent." No exposure data are involved in this computation. Next, the "rate" for jackknifes is computed as the number of jackknife accidents per hundred million vehicle miles. The confidence interval for the rate is also shown.

Looking at Table 1.7, the trends in the fatal involvements and the BMCS-reported involvements are strikingly consistent. Perhaps the most important result is that jackknifing as a pre-impact or primary non-collision event occurs in only 4%-7% of the fatal and BMCS-reported accidents. Jackknifes generally increase as a percent of all accidents and as a rate for the 1975 and 1976 model years, dropping for the 1977 model year. The percentage of BMCS-reported jackknifes shows a 29% reduction, from 5.5% for the 1974 model year to 3.9% for the 1977 model year. The rate of BMCS-reported jackknifes decreases 15% for the

TABLE 1.7

Summary of Jackknife Accidents:
Intercity Use Only

Power Unit Model Year	Fatal Involvements (Cal. Years 1976-1978)			BMCS-Reported Involvements (Cal. Years 1976-1977)		
	Percent	Rate	95% C.I.	Percent	Rate	95% C.I.
1974	3.7	0.225	±0.032	5.5	3.33	±0.92
1975	4.8	0.371	±0.045	6.7	5.60	±2.54
1976	5.0	0.393	±0.153	5.4	3.91	±3.98
1977	3.7	0.204	±0.007	3.9	2.83	±0.22

1977 model year power unit. For the most part, the differences in jackknife involvement rates are not statistically significant. This difference is also of little practical significance, since the 29% decrease represents only 1.6% of all accidents.

1.3 Conclusions

Many approximations and assumptions were necessary to carry out this analysis with the available data. These qualifications must be taken into account when interpreting the results. The authors conclude that this study provides no evidence of a substantial safety benefit for post-standard vehicles. However, the results are not sufficient to support the conclusion that involvement rates are higher for post-standard vehicles either.

Possible explanations for the observed failure of FMVSS 121 to produce the expected safety benefits were also reviewed. Maintenance and reliability problems were widespread in the early 121-equipped vehicles. These problems resulted in inoperable anti-lock systems on large proportions of the 121-equipped tractors and trailers. There is another important aspect of the problem revealed here. Improper brake adjustment was found to have been a prevailing maintenance problem before FMVSS 121 was introduced. The knowledge available now of pre-existing maintenance problems and practices in the trucking industry would suggest that the introduction of a more complex brake system would aggravate such problems as improper brake adjustment. But these problems do not seem sufficient to completely explain the observed lack of safety benefit.

The estimation of expected benefits for FMVSS 121 was also reviewed. Available information suggests that only a small proportion (10%-20%) of all large truck accidents are amenable to brake-related countermeasures. For example, the frequency of pre-impact jackknifing in injury or fatal accidents was found to be only 4%-7%. This problem is compounded when the braking performance requirements focus on the reduction of stopping distances, as is the case with FMVSS 121. A recent HSRI submission to the docket in response to the newly proposed air brake regulation, FMVSS 130, points out that requiring brake systems to be designed to achieve shorter wheels-unlocked stopping distances results in reductions in vehicle stability.[2]

It is concluded that it was unrealistic to expect FMVSS 121 to have produced substantial reductions in overall accident rates. This topic is discussed further in Section 7.3.3.

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[2]Response to Advanced Notice of Proposed Rulemaking, Air Brake Systems, Report No. UM-HSRI-79-32 (Ann Arbor: The University of Michigan, Highway Safety Research Institute, 1979).

1.4 Recommendations

The cost of nearly four years of FMVSS 121 is well over $1 billion, even when NHTSA's lower estimate is used.[3] Everyone would like to bring about improvements in highway safety as quickly as possible, especially where heavy trucks are concerned. The mixture of cars and heavy trucks on the same roads is perhaps our most serious highway safety problem. When vehicles of such disparate size collide, the consequences are most grim for the occupants of the smaller vehicle. The trucking industry has prospered on the interstate highway system. Yet the cost in human lives of moving goods by truck is greater than for any other transportation mode.[4]

However, the nation's economic resources need to be carefully applied to the task of improving highway safety. In an understatement, the Council on Wage and Price Stability concludes:

> "The overall public interest will not be well served if the proposed safety standards are unduly expensive or are written to preclude gains in safety by less expensive means."[5]

The problems of accident causation are so complex that it is extremely difficult to ensure that any change will have its intended effect. Consequently, it seems imperative to pursue countermeasure development in a cautious and

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[3]Economic Impact of FMVSS No. 121, Air Brake Systems: A "Quick Look" Evaluation (Washington, D.C.: National Highway Traffic Safety Administration, April 1975.)

[4]See James O'Day in response to Item IIID--Impacts on Highway and Motor Carrier Safety, of the Department of Transportation "Notice 79-10: Truck Size and Weight Study," Federal Register 44:10 (June 5, 1979), pp. 32344-32346, prepared for the Motor Vehicle Manufacturers Association.

[5]George C. Eads, Statement to the National Highway Traffic Safety Administration Public Meeting on Air Brake Systems--Standard No. 121 (Washington, D.C.: Council on Wage and Price Stability, 30 October 1975).

deliberate manner. These recommendations are presented in the hope that they will reduce the problems associated with the implementation and evaluation of future countermeasures.

First, the authors wish to underscore the need for rigorous, independent evaluation of the national impact of Federal Motor Vehicle Safety Standards. FMVSS 121 was expected to produce substantial safety benefits in return for a substantial economic investment. This study concludes that such benefits were not realized. This fact alone demonstrates the continuing need to evaluate Federal Motor Vehicle Safety Standards. Although many difficult problems hampered this program to evaluate FMVSS 121, the reader should not be tempted to conclude that national impact evaluations in the highway safety area are not feasible. The knowledge gained in this program should materially aid the planning of future countermeasure evaluation programs.

In our view, the experience gained in this evaluation of FMVSS 121 suggests that future countermeasure evaluation programs would be enhanced if they were initiated well before implementation of the countermeasure. During this period, limited pilot programs could be conducted to determine whether the proposed countermeasure can, in fact, influence the accident experience of equipped vehicles in a specific, controlled environment. Such a pilot program could also provide information on the types and proportion of all accidents able to be influenced by the countermeasure. The objective here is not to determine the national impact, but rather to demonstrate that the countermeasure does alter the accident experience of the vehicles in a specific, controlled, real-world trial.

In addition to these demonstration programs, a plan for the national impact evaluation should also be developed prior to implementation of the countermeasure. Major problems in the design of a national impact evaluation are the identification of vehicles affected by the countermeasure and the establishment of control groups. These problems are usually central considerations in constructing the sampling frame. Development of a plan for the national impact evaluation prior to implementation would provide more options in dealing with these problems. Convenient ways of "tagging" vehicles with the countermeasures might be employed. Knowledge of the implementation schedule for the countermeasure could enhance the definition of more suitable control groups. Considerations such as these might even make a phased introduction more attractive.

These additions to the evaluation phase will be costly and time-consuming. However, they appear to be necessary safeguards in the pursuit of improved highway safety. The authors hope that these recommendations will reduce the problems associated with the implementation and evaluation of future highway safety countermeasures. This material is discussed more fully in Section 7.1.3.

1.5 Report Organization

The detailed description of the various data collection programs, the analysis, and results are presented in Sections 2 through 6. Sections 2 through 4 describe the development of the exposure projections. Section 2 is a summary of the final results of the fleet monitoring program with the emphasis on the exposure data. The survey of 1977 model year vehicles is described in Section 3. Section 4 presents the estimation of the number of vehicles in use and the estimation of total mileage using the results of Sections 2 and 3. The resulting exposure projections are combined with data on fatal accident involvements in Section 5 to produce the involvement rates. Similarly, Section 6 presents injury accident involvement rates based on accidents reported to the Bureau of Motor Carrier Safety and the exposure projections for the carriers which report.

Finally, a complete discussion of the findings is presented in Section 7. This discussion is organized in three topical areas. First discussed are the strengths and weaknesses of the data bases in relation to the features of the study design so that future studies may benefit from this experience. Next are summarized the general findings on the composition, use, and accident experience of the population of late-model air-braked vehicles. These findings are also expected to be useful to any future studies of the accident experience of heavy trucks. Finally, the safety impact of FMVSS 121 is addressed. This discussion begins with a summary of the salient results, followed by a statement of conclusions.

SECTION 2

FLEET MONITORING PROGRAM

The fleet monitoring program formed a substantial part of the initial phase of the study. Air-braked vehicles manufactured in 1974 and 1975 were selected and monitored through the fleets that purchased them. Two samples, one of pre-standard, one of post-standard vehicles, were selected. The two samples were of roughly equal size so that the two groups would have approximately equal overall sampling variances.

The selected vehicles were then monitored over a two-year period, from January 1976 through December 1977. Data were collected in a number of areas. Initially a description of the purchaser and of the vehicle was obtained. Then at various intervals over the two-year period, information was collected on odometer readings, brake maintenance work performed in the interim, and any accidents that might have occurred. It was hoped to provide conclusions on relative maintenance costs (per mile) of pre- and post-standard vehicles and on their relative accident rates. However, as will be indicated later, it was only on the odometer readings that any kind of adequate response rate was obtained. These odometer readings have subsequently been used to estimate accident rates for the pre- and post-standard vehicles by using two federal accident collection systems, the Fatal Accident Reporting System (FARS) of the National Highway Traffic Safety Administration, and the truck accident data collection conducted by the Bureau of Motor Carrier Safety (BMCS).

Subsequently a subgroup of vehicles was selected for a Trip Information Survey (TIS). Each of the vehicles in this subgroup was surveyed at various pre-selected dates to determine how many miles it had put on in a twenty-four hour period and what kind of trailer, if any, it had pulled. This part of the study was intended to provide information on the breakdown of mileage between local and intercity trips and on the usage of various types of trailers--single or double, pre-standard or post-standard.

This section will initially discuss the sample design and the response rates and will then turn to a description of the vehicles and fleets selected for the study, concentrating on the areas for which the information collected is sufficient to support conclusions. Next, there will be a discussion of the data collected on vehicle use: annual mileage and the results of the trip survey. Finally, there will be an assessment of the fleet program and a discussion of some of the problems encountered in data collection, with an explanation in particular of why it is believed that the maintenance and accident data collected from the fleets are unreliable.

2.1 Sample Design and Response Rates[4]

One of the principal goals in choosing the sample design was to control data collection costs. It was therefore decided to cluster the sample by geographic area and by fleet, so that information on a large number of vehicles could be collected with as few field visits and as few field personnel as possible. For this purpose a three-stage sampling procedure was utilized: first the country

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[4] A more complete and more technical discussion of the sample design is to be found in Section 2 of Kenneth L. Campbell and Arthur C. Wolfe, Fleet Accident Evaluation of FMVSS 121: Interim Report, Report No. UM-HSRI-77-35 (Ann Arbor: The University of Michigan, Highway Safety Research Institute, October 1977), pp. 19-55.

was divided into primary sampling units (PSU's) and some of the PSU's were selected; next fleets were selected within the chosen PSU's; and finally vehicles were selected for each selected fleet.

In the forming of PSU's, one of the criteria was that purchasers within the PSU should have obtained a minimum number of post-standard vehicles. Since the ratio of pre-standard to post-standard vehicles in the sample frames was 4.4 to 1, this ensured that each PSU would contain both pre-standard and post-standard vehicles that were eligible for selection.

Similarly in the second stage, the selection of purchasers, the probability of selecting fleets that had obtained both types of vehicles was increased with the aim of reducing field contact costs. Thus, when the third stage was reached, in most cases a simple selection could be made in each fleet of a certain proportion of pre-standard vehicles and a certain proportion of post-standard vehicles.

2.1.1 The Sampling Frame. Computerized information listing air-braked vehicles manufactured in 1974 and 1975 plus a few 1976's was obtained from eight manufacturers: Ford, Chevrolet, GMC, International Harvester, Mack, Chrysler, White, and Freightliner. These lists indicated whether vehicles were pre- or post-standard, and gave the names and addresses of the purchasers and the vehicle identification numbers (VIN). Buses built on truck chassis (i.e., school buses) were generally included; other buses were excluded. Vehicles exported and those sold in Puerto Rico and Alaska were excluded.

A total of 185,183 pre-standard vehicles were included in these lists; the figure for post-standard vehicles was only 42,301 (hence the 4.4 to 1 ratio). The principal group of vehicles not included in the sampling frame was those manufactured by Paccar (Peterbilt and Kenworth)--Paccar was unable to provide computerized lists--but even so, over 90%

of eligible vehicles were produced by the 8 manufacturers. In addition, manufacturers were not able to supply names and addresses for all vehicles. In particular, the manufacturer warranty files frequently did not contain the purchaser's name and address for the most recently purchased vehicles. Estimates of the number of air-braked vehicles manufactured, based on factory sales data published by the Motor Vehicle Manufacturers Association (MVMA), indicate that names and addresses were supplied for about 64% of the pre-standard and 50% of the post-standard vehicles. Coverage was quite uniform by manufacturer, except for Mack in the pre-standard lists. Systematic bias from the omission of these vehicles from the sampling frames seems unlikely.

2.1.2 PSU Creation and Selection. To hold collection costs to a reasonable level, while maintaining adequate representation, the actual number of geographic areas was limited to thirty-six. To divide the country into PSU's, prior to selection of the thirty-six, the purchaser lists were first aggregated by county into 187 PSU's, with each PSU containing at least two fleets with more than 10 post-standard vehicles each or at least 200 total post-standard vehicles. Throughout the process of selecting PSU's, as in the whole sampling procedure, the main concern was the number of post-standard vehicles. Because there were far fewer of them, it was necessary to ensure that each PSU contained a minimum number, and it was thought more important to control for their sample size, relying on the overall ratio between the two types of vehicle to ensure that approximately the right number of pre-standard vehicles would be selected.

Once the 187 PSU's had been formed they were stratified by region, degree of urbanization, geographic size and by how many large purchasers of post-standard vehicles they contained. The purpose here was to select a sample of PSU's that was representative for all of these factors. A number of possible combinations of PSU's fitted the desired stratification. One pattern was selected at random, and further random selections were made where more than one PSU was still eligible for selection in a stratum where only a single PSU was wanted.

This process produced the 36 selected PSU's which in total contained 24.5% of eligible pre-standard vehicles and 25% of eligible post-standard vehicles. The sample was now one quarter of the original master frame, with the overall ratio between pre- and post-standard vehicles maintained.

2.1.3 Fleet Selection. For the fleet selection within the 36 PSU's, the main considerations were to select as many fleets as possible that had purchased both types of vehicles (to limit data collection costs) and to finish with a vehicle selection that would provide roughly equal numbers of the two vehicle types. This latter consideration meant that fleets that had obtained only post-standard vehicles were given a selection probability 3.82 times as great as pre-standard only fleets. (The 3.82 ratio was used, rather than the overall 4.4 ratio of pre to post, because purchasers of post-standard vehicles were being over-sampled so that more post-standard vehicles were likely to be selected.)

These criteria meant that certain fleets would be over-sampled and others under-sampled. This would be corrected for analysis by attaching sampling weights: thus the very small fleets which were given only one twentieth the selection probability of the large fleets would be assigned weights of twenty in analysis. If a simple random selection had been made, twenty of these very small fleets would probably have been selected for every one selected by this process. By attaching a weight of twenty (i.e., multiplying every variable for this fleet by a factor of twenty) this single fleet would represent all twenty.

However, it is also desirable to keep the largest weights as small as possible--so that one single, possibly variant, case cannot affect the conclusions too much. With this in mind joint fleets were given twice the selection probabilities of post-standard-only fleets containing similar numbers of post-standard vehicles; and within the joint fleets, the larger ones were given a probability twenty times as large as the very small ones.

With the probabilities for fleet selection within the PSU's chosen, a random selection of fleets was made, taking into account the probability of selection of the PSU within which the fleet fell--so that a fleet of a given type within PSU 1 would have a chance of being selected only half as great as a similar fleet within PSU 2, if the selection probability for PSU 2 was twice that for PSU 1.

This process resulted in the selection of 554 purchasers in the 36 PSU's. Some fleets (17) ended up being selected twice because there were very few eligible fleets in their PSU's, and their vehicles were subsequently weighted accordingly.

2.1.4 Vehicle Selection. The third and final step in the sampling was the selection of study vehicles. Here again the goal was the selection of equal numbers of pre- and post-standard vehicles. So the ratio of 3.82 to 1 was again applied: post-standard vehicles were given selection probabilities 3.82 times as great as pre-standard vehicles. With a few adjustments this ratio was applied throughout the vehicle selection which was carried out through a random selection of vehicles purchased by the 554 selected fleets (vehicles were identified by VIN numbers). Two samples were drawn, one each for the two types of vehicles, producing two national samples of vehicles, one pre-standard, the other post-standard. The procedure resulted in the selection of 2,690 pre-standard and 2,708 post-standard vehicles. These numbers were later reduced to

2,615 and 2,650 respectively, because some vehicles turned out to have been exported, while others did not have the type of brakes that the manufacturer records indicated.

The distribution of the eligible selected vehicles by their sampling weights is given in Table 2.1.

TABLE 2.1

Distribution of Pre-Standard and Post-Standard Vehicles in the Three Weight Categories for All Known Eligible Vehicles

Type of Vehicle	Wt=1		Wt=2		Wt=20		TOTAL	
	N	%	N	%	N	%	N	%
Pre-Standard								
Unwtd.	1434	54.9	1019	39.0	162	6.2	2615	100.1
Wtd.	1434	21.4	2038	30.4	3240	48.3	6712	100.1
Post-Standard								
Unwtd.	2100	79.2	430	16.2	120	4.5	2650	99.9
Wtd.	2100	39.2	860	16.1	2400	44.8	5358	100.1

2.1.5 Response Rate. As already indicated a number of vehicles turned out, after the selection process, not to have been eligible for selection. Besides the vehicles exported or those with anomalous brake types, there were a number of vehicles that had been scrapped after accidents or fires. These non-sample vehicles have been dropped from the totals of eligible vehicles in calculating response rates.

Among the eligible vehicles, the main problem was locating them. Sometimes the purchaser could simply not be found; often the vehicles had been sold to some government (local, state or federal) and it was difficult to establish which department was the final user. Other vehicle purchasers turned out to be body builders or dealers who subsequently sold the vehicles. Many purchasers were lessors who did not operate the vehicles themselves. Frequently the initial purchaser could be contacted but, in spite of extensive effort, we were unable to locate the operator of the vehicle.

In addition many of the purchasers contacted proved reluctant to provide information--understandably because of the substantial burden in providing all the information the study required. Others did not keep records that provided adequate information for the study. A number, including some fleets of substantial size, initially promised cooperation but subsequently failed to provide the needed information. A few large fleets with computerized record keeping indicated that it would be easier for them to provide all the requested information at the end of the study, but, when the time came, sent nothing in spite of repeated reminders.

The vehicles which were used in the final data analysis were those for which adequate descriptive information had been obtained at both the vehicle and fleet level and for which at least two odometer readings had been obtained, preferably for dates at least six months apart. These "responding" vehicles are those used in the calculation of Table 2.2.

The final vehicle response rate (unweighted) was 63.1% for pre-standard vehicles, 69.8% for post-standard. Overall the unweighted response rate was 66.5%. The lower response rate for the older, pre-standard, vehicles reflects the greater likelihood that these were no longer with their original owner and so were more difficult to locate.

These response rates were unfortunately somewhat lower than had been hoped for, but in assessing them the crucial question is whether there was any systematic bias to the study of the type that would occur if the non-responding group had characteristics significantly different from the responding group. Tables 2.3 and 2.4 give distributions by

TABLE 2.2

Unweighted and Weighted Response Rates for the Pre-Standard and Post-Standard Vehicle Samples

Vehicles	Eligible Sample	Participating Sample	Participating Response Rate
Pre-Standard			
N	2,615	1,651	63.1
Wtd N	6,712	4,084	60.8
Post-Standard			
N	2,650	1,849	69.8
Wtd N	5,358	3,829	71.5
TOTAL			
N	5,265	3,500	66.5
Wtd N	12,070	7,913	65.6

manufacturer and GVWR class for the study vehicles, and estimates of these distributions for the total population. They show the possible extent of bias along the make and vehicle size dimensions.

Table 2.3 shows that when the sampling weights are applied the sample proportions by manufacturer are very similar to those of the original sampling frame. Particularly for the post-standard vehicles, the differences between samples and frame are well within the sampling errors. This indicates that the three-stage sampling procedure did not systematically alter the distribution of vehicles by manufacturer.

Table 2.4 looks not at the relationship between sampling frame and active sample vehicles, but at that between factory sales and the active sample vehicles. Thus if bias had occurred in deciding which vehicles were eligible for sampling, such bias would tend to show in the table. The estimates of factory sales are derived from monthly reports of the Statistics Department of the Motor

TABLE 2.3

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 %
Ford	24.5	24.0	26.5 (±6.8)	32.4	45.8	45.7 (±10.1)
GMC	10.9	11.8	11.7 (±5.2)	8.8	4.9	6.4 (± 2.8)
Chevrolet	10.4	4.2	5.8 (±3.1)	9.2	5.6	10.3 (± 8.4)
White	5.9	10.8	7.4 (±5.3)	3.8	1.6	1.9 (± 2.5)
Autocar	---	0.0	0.0 (±0.0)	---	0.1	0.5 (± 1.1)
White Western	---	0.2	0.1 (±0.2)	---	0.3	1.1 (± 2.2)
Freightliner	8.1	3.5	4.4 (±4.5)	6.6	2.6	5.6 (± 6.0)
Mack	8.3	9.7	10.9 (±5.3)	5.3	2.1	1.2 (± 1.2)
International	31.7	35.7	33.2 (±9.4)	33.8	37.0	27.2 (± 4.7)

*In the frame percentages, Autocar and White Western are included within the figures for White.

**Pre-Standard Vehicles: N=1,651; Wtd N=4,084.

***Post-Standard Vehicles: N=1,849; Wtd N=3,829.

TABLE 2.4

Comparison of Factory Sales Estimates of Air-Braked Vehicles by GVWR Class with Weighted Proportions from the Sample

Weight Class	Pre-Standard			Post-Standard		
	Factory Sales	Study Vehicles		Factory Sales	Study Vehicles	
	%	%	C.I.	%	%	C.I.
Class 6 (19,501-26,000 lbs.)	14.6	17.1	±5.1	19.9	26.8	±7.6
Class 7 (26,001-33,000 lbs.)	13.0	16.4	±5.6	17.7	24.9	±8.6
Class 8 (Over 33,000 lbs.)	72.4	66.5	±6.4	62.4	48.3	±7.6

Vehicle Manufacturers Association of the United States. They include trucks and buses manufactured in the U.S. for domestic sale and those manufactured in Canada for export to the U.S. The proportion of air-braked vehicles is estimated at 15% for Class 6, 85% for Class 7 and 100% for Class 8.

The table appears to show that the samples were deficient in the heavy, Class 8, vehicles, particularly in the case of the post-standard vehicles. However, this might be the result of faulty estimation of the proportion of air-braked vehicles for each weight class. In addition most of the differences are once again within the sampling errors.

2.2 Description of Vehicles and Fleets

This sub-section will examine the study vehicles and study fleets, concentrating in particular on the variables that were used in analyzing daily mileage for the purpose of calculating accident exposure. First some indication is given of how the raw unweighted numbers of vehicles and fleets are distributed across various exposure categories. Next there is a more detailed discussion of the weighted distributions across the exposure categories. It is, of course, those weighted distributions that were used in analysis; they provide estimates of the characteristics of the sampling frame. The sub-section ends with a discussion of the weighted distributions of daily mileage, taken from odometer readings. These daily mileage estimates are the basis for the exposure figures used in the calculation of the accident rates for 1974 and 1975 vehicles reported in Sections 5 and 6.

2.2.1 Unweighted Distribution of Vehicles. Tables 2.5 and 2.6 show how the straight trucks and tractors in the study were distributed by model year, fleet size class, carrier type, and area of operation of the vehicle. The 708 school buses on which information was obtained are omitted from these and subsequent tables. These school buses were exempted from the 121 Standard in January 1976 and they were selected inadvertently.

Tables 2.5 and 2.6 reveal how the sampling strategy affected the selected vehicles. These tables show how the study vehicles were distributed by fleet size, carrier type, and area of operation. Because large fleets were over-sampled, the vehicles, and particularly the tractors, tend to be in large fleets. Another effect of this over-selection is that the tractors in Authorized carriers are somewhat over-represented too.

The two types of vehicles are, however, not distributed similarly between straight trucks and tractors: the proportion of straight trucks was substantially higher among post-standard vehicles, probably because the large Authorized carriers were not purchasing their normal quota of tractors. Thus the numbers of pre- and post-standard straight trucks are not equal; nor are those of the two types of tractors.

2.2.2 Unweighted Distribution of Fleets. The results of the sampling strategy at the fleet level are indicated in Table 2.7. More than a quarter of the selected fleets owned fifty or more air-braked power units, far more than would have been the case with a simple random sample. Table 2.8 shows how the fleets are distributed by carrier type. The Authorized fleets are not a particularly large proportion of the study fleets, but they include a large proportion of the study vehicles, because a far greater percentage of the Authorized fleets are in the large fleet category than is the case with the non-Authorized fleets.

Tables 2.9 and 2.10 show how the study fleets were distributed across fleet size. Once again the raw, unweighted data are presented. Although large fleets were over-sampled, a substantial number of small fleets were nonetheless selected. As Table 2.10 makes clear, these small fleets included 53 owner-operators and 97 other fleets

TABLE 2.5

Unweighted Distribution of Straight Trucks by Exposure Category

Model Year	Small Fleets (1-49)				Large Fleets (50+)				TOTAL
	Authorized		Non-Authorized		Authorized		Non-Authorized		
	Local	Inter-city	Local	Inter-city	Local	Inter-city	Local	Inter-city	
1974	1	9	102	31	0	13	44	51	251
1975 Pre	0	1	33	13	0	0	46	30	123
1975 Post	6	7	111	75	1	1	156	187	544
1976	0	0	29	6	0	0	34	58	127
TOTAL	7	17	275	125	1	14	280	326	1,045

TABLE 2.6

Unweighted Distribution of Tractors
by Exposure Category

Model Year	Small Fleets (1-49)				Large Fleets (50+)				TOTAL
	Authorized		Non-Authorized		Authorized		Non-Authorized		
	Local	Inter-city	Local	Inter-city	Local	Inter-city	Local	Inter-city	
1974	4	38	14	92	152	462	24	154	940
1975 Pre	8	4	13	36	6	61	5	27	160
1975 Post	29	16	26	123	27	186	32	82	521
1976	0	1	8	11	26	53	1	26	126
TOTAL	41	59	61	262	211	762	62	289	1,747

with 5 or fewer vehicles. Large fleets were by no means selected to the exclusion of owner-operators and other small fleets.

TABLE 2.7

Unweighted Distribution of Fleets by Exposure Category

Fleet Size/ Carrier Type	Fleet Area of Operation		TOTAL
	Intrastate	Interstate	
Small (1-49)			
Authorized	10	32	42
Non-Authorized	278	101	379
Large (50+)			
Authorized	4	33	37
Non-Authorized	72	47	119
TOTAL	364	213	577

TABLE 2.8

Unweighted Distribution of Fleets by Carrier Type

Carrier Type	Frequency
Authorized	
Common	64
Contract	15
Non-Authorized	
Exempt	13
Private	457
Lease	28
TOTAL	577

TABLE 2.9

Unweighted Distribution of Fleets by Fleet Size*

Fleet Size	Frequency
Small (1-49)	421
Medium (50-399)	133
Large (400+)	23
TOTAL	577

*Number of air-braked power units.

TABLE 2.10

Unweighted Distribution of Small Fleets by Fleet Size*

Fleet Size	Frequency
1	53
2	33
3	22
4	24
5	18
6-10	60
11-20	85
21-30	47
31-49	58
Unknown	21
TOTAL	421

*Number of air-braked power units.

2.2.3 Description of the Sampling Frame: Vehicles. This sub-section presents descriptive statistics on the vehicles in the sampling frame. To give the estimates, vehicles are weighted by the inverse of their sampling probability. For most statistics 95% confidence intervals have been compiled. The larger the confidence interval, the poorer the job the sample has done of estimating the true population figure. The confidence interval was computed at ±2 times the standard error. If one takes 100 samples of a fixed size from a population and calculates 95% confidence intervals for each sample, 95 out of the 100 confidence intervals generated will encompass the true population mean. It is desirable to make confidence intervals as small as possible so that the true population mean can be estimated with greater precision. One way to do this is to increase the size of the sample.

In interpreting the data, one important thing to watch for is whether differences between subgroups are statistically significant. Statistical significance is achieved when the confidence intervals of the subgroups for a certain characteristic do not overlap. Thus, if from a sample of African animals, it was found that the mean height of elephants was 8 feet ± 4 feet (i.e., a range of 4 to 12 feet), while that of giraffes was 16 feet ± 3 feet (i.e., a range of 13 to 19 feet), one would conclude that elephants and giraffes had differences in height that were statistically significant.

Tables 2.11 and 2.12 give estimates of the proportions of straight trucks and tractors in various exposure categories: fleet size, carrier type, and vehicle area of operation. There are clear fluctuations from year to year, with some tendency for the 1974 vehicles to be distributed similarly to the 1976 vehicles. The Authorized carriers operate only a small proportion of the straight trucks but a

TABLE 2.11

Weighted Proportions of Straight Trucks
by Exposure Category*

Model Year	Small Fleets (1-49)				Large Fleets (50+)				TOTAL		
	Authorized		Non-Authorized		Authorized		Non-Authorized				
	Local %	Inter-city %	Local %	Inter-city %	Local %	Inter-city %	Local %	Inter-city %	%	N	Wtd. N
1974	0.1	9.0	58.8	14.6	0.0	1.7	8.8	7.1	100.1	251	776
1975 Pre	0.0	5.4	38.7	29.8	0.0	0.0	12.4	13.7	100.0	123	372
1975 Post	0.8	2.1	38.9	26.9	0.1	0.1	17.9	13.3	100.1	544	1478
1976	0.0	0.0	52.2	10.1	0.0	0.0	13.8	23.9	100.0	127	247

*N=1,045; Wtd N=2,873.

TABLE 2.12

Weighted Proportions of Tractors
by Exposure Category*

Model Year	Small Fleets (1-49)				Large Fleets (50+)				TOTAL		
	Authorized		Non-Authorized		Authorized		Non-Authorized				
	Local %	Inter-city %	Local %	Inter-city %	Local %	Inter-city %	Local %	Inter-city %	%	N	Wtd. N
1974	0.2	9.7	9.4	22.3	12.1	34.7	1.4	10.2	100.0	940	1995
1975 Pre	3.3	6.5	19.3	25.6	1.5	29.3	1.3	13.3	100.1	160	399
1975 Post	2.8	4.7	10.9	43.5	2.6	18.8	3.0	13.7	100.0	521	1052
1976	0.0	1.1	14.4	27.7	13.8	28.7	0.5	13.8	100.0	126	188

*N=1,747; Wtd N=3,234.

large proportion of the tractors. The straights operate mainly locally, the tractors mainly intercity.

The same variables are presented one by one in Tables 2.13 through 2.18. Tables 2.13 and 2.14 show the distribution of vehicles by fleet size. Straight trucks are mostly owned by small fleets, though this is less the case for the later model years. Tractors are roughly equally distributed between the two fleet size categories, except in the first post-standard model year. In that year, as is shown also in Table 2.16, the large Authorized carriers held off purchasing. Tables 2.15 and 2.16 show that the carrier type distribution is very different for straight trucks and tractors. There are very few straight trucks in Authorized fleets, but roughly half the tractors are operated by Authorized carriers. In the later model years the number of straight trucks purchased by the Authorized carriers was minuscule. For area of operation in Tables 2.17 and 2.18 the picture is as might be predicted. Most tractors operate intercity, most straight trucks locally. Again the 1975 post-standard tractors are somewhat out of line, presumably for the same reason as before.

The proportions of cabovers and conventional cabs are presented in Tables 2.19 and 2.20, first for all tractors, then for tractors in Authorized fleets only. The figures for the 1976 model year appear unreliable. The year to year fluctuations are not statistically significant, and the large drop in the proportion of cabovers from 1974 to 1975 pre-standard may be attributable to sampling variance.

One of the questions asked in the fleet study for each post-standard vehicle was whether the brake system had been modified and/or the anti-lock had been disabled. The response was that 98.2% of the straight trucks and 94.3% of the tractors (weighted figures) were operating with the full brake system as originally equipped. One percent of the straight trucks and 5.5% of the tractors had, according to

TABLE 2.13

Weighted Proportions of Straight Trucks by Fleet Size

Model Year	Small (1-49)		Large (50+)		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	82.5	± 8.9	17.5	± 8.9	100.0	251	776
1975 Pre	73.9	±21.4	26.1	±21.4	100.0	123	372
1975 Post	68.7	±12.9	31.3	±12.9	100.0	544	1478
1976	62.4	±27.7	37.7	±27.7	100.1	127	247

NOTE: The coefficient of variation of the denominator (CVD) is greater than .15 for all cells. When the CVD exceeds .15 confidence intervals are underestimated (as the CVD approaches .2 the variance is underestimated by 12%-24% and the confidence interval by 6%-11%). In general, the CVD exceeded .15 when the 1975 pre-standard vehicles were split from the 1974 model year vehicles, and when the 1976 vehicles were split from the 1975 post-standard vehicles. The computed confidence intervals are generally large enough to prevent statistically significant findings even though the variance may be underestimated. Aggregate comparisons across model year were not prone to this problem. For more information see Leslie Kish, Survey Sampling (New York: John Wiley Sons, 1965), p. 207.

the survey, their anti-lock disconnected. This information was mostly collected in the first six months of the fleet study between September 1976 and February 1977, and does not cover modifications and disconnects that were made later. Even so, it is clear that many respondents, believing it was illegal to tamper with the 121 system, were reluctant to inform us of any modifications. The figures, as they stand, are not credible. The percentage of anti-locks reported as removed was even lower than the percentage of disconnects.

Table 2.21 shows the distribution of post-standard vehicles by anti-lock manufacturer.

TABLE 2.14

Weighted Proportions of Tractors by Fleet Size*

Model Year	Small (1-49)		Large (50+)		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	41.6	±11.3	58.4	±11.3	100.0	940	1995
1975 Pre	54.6	±25.9	45.4	±25.9	100.0	160	399
1975 Post	61.9	±22.9	38.1	±22.9	100.0	521	1052
1976	43.1	±35.5	56.9	±35.5	100.0	126	188

*CVD >.15 for all cells.

TABLE 2.15

Weighted Proportions of Straight Trucks by Carrier Type*

Model Year	Authorized		Non-Authorized		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	10.8	±9.8	89.2	±9.8	100.0	251	776
1975 Pre	5.4	±9.3	94.6	±9.3	100.0	123	372
1975 Post	3.0	±3.6	97.0	±3.6	100.0	544	1478
1976	0.0	±0.0	100.0	±0.0	100.0	127	247

*CVD >.15 for all cells.

TABLE 2.16

Weighted Proportions of Tractors
by Carrier Type*

Model Year	Authorized		Non-Authorized		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	56.8	±13.9	43.2	±13.9	100.0	940	1995
1975 Pre	40.6	±31.1	59.4	±31.1	100.0	160	399
1975 Post	28.8	±17.5	71.2	±17.5	100.0	521	1052
1976	43.6	±37.7	56.4	±37.7	100.0	126	188

*CVD >.15 for all cells.

TABLE 2.17

Weighted Proportions of Straight Trucks
by Area of Operation*

Model Year	Local		Intercity		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	67.7	±14.5	32.4	±14.5	100.1	251	776
1975 Pre	51.1	±28.0	48.9	±28.0	100.0	123	372
1975 Post	57.7	±14.2	42.4	±14.2	100.1	544	1478
1976	66.0	±32.3	34.0	±32.3	100.0	127	247

*CVD >.15 for all cells.

TABLE 2.18

Weighted Proportions of Tractors
by Area of Operation*

Model Year	Local		Intercity		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	23.1	±12.5	76.9	±12.5	100.0	940	1995
1975 Pre	25.3	±23.3	74.7	±23.3	100.0	160	399
1975 Post	19.3	±11.9	80.7	±11.9	100.0	521	1052
1976	28.7	±27.3	71.3	±27.3	100.0	126	188

*CVD >.15 for all cells.

TABLE 2.19

Weighted Proportions of Tractors
by Cab Style*

Model Year	Cabover		Conventional		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	41.8	±12.7	58.3	±12.7	100.1	940	1995
1975 Pre	22.1	±15.7	77.9	±15.7	100.0	160	399
1975 Post	56.9	±14.6	43.1	±14.6	100.0	521	1052
1976	37.8	±32.4	62.2	±32.4	100.0	126	188

*CVD >.15 for all cells.

TABLE 2.20

Weighted Proportions of Tractors in
Authorized Fleets by Cab Style*

Model Year	Cabover		Conventional		TOTAL	N	Wtd. N
	%	C.I.	%	C.I.			
1974	40.8	±18.4	59.2	±18.4	100.0	656	1133
1975 Pre	17.3	±27.4	82.7	±27.4	100.0	79	162
1975 Post	69.3	±28.4	30.7	±28.4	100.0	258	303
1976	8.5	±19.0	91.5	±19.0	100.0	80	82

*CVD >.15 for all cells.

Table 2.21

Weighted Proportions of Post-Standard Vehicles
by Anti-Lock Manufacturer*

Anti-Lock Manufacturer	Straight Trucks		Tractors	
	%	C.I.	%	C.I.
AC	15.4	±7.5	9.0	± 7.2
Bendix	6.4	±8.8	1.1	± 2.0
Eaton	31.2	±9.4	29.3	±15.2
Kelsey-Hayes	34.8	±10.4	39.8	±13.4
Rockwell	1.1	±2.2	3.4	± 4.3
Wagner	0.2	±0.3	11.0	±10.0
Unknown	10.8	±9.6	6.3	±5.6
Anti-lock removed	0.1	±0.1	0.2	±0.3
TOTAL	100.0	----	100.1	----

*CVD >.15 for all straight truck cells.

2.2.4 Description of the Sampling Frame: Fleets. In assessing the characteristics of the fleets in the sampling frame, two provisos are necessary. The first is that the estimates do not describe all fleets, but merely those fleets that purchased air-braked vehicles produced between January 1, 1974 and February 1976. The second is that the object of the sampling was to obtain a sample of vehicles not of fleets. Large fleets and fleets that purchased both pre- and post-standard vehicles were over-sampled to reduce data collection costs. The effect of both these factors is to increase the confidence intervals for the fleet data as compared to the vehicle data.

In the following tables the fleets are weighted by the inverse of their selection probability. Section 2 of Fleet Accident Evaluation of FMVSS 121: Interim Report discusses these probabilities and the resulting weights in more detail.

Table 2.22 presents the distribution of fleets by size, carrier type, and area of operation. Almost three quarters of the fleets in the sampling frame operate only intrastate. The table also indicates that over three quarters (76.8%) of the fleets are in the small, non-Authorized category. The large Authorized carriers were only 1.6% of the purchasers.

Tables 2.23 and 2.24 present one-way distributions of the fleets by carrier type and by fleet size. The Authorized carriers, small and large, formed only 10.6% of the purchasers. The private carriers were far and away the largest category. It should be noted that the "lease" carriers are those companies that purchased vehicles purely for either long- or short-term lease to other operators, so that their vehicles were split up among carriers of various types.

The fleet size distribution shows the fleets distributed by number of air-braked power units owned. As might be expected, the small fleets, those with less than 50

TABLE 2.22

Weighted Proportions of Fleets
by Exposure Category*

Fleet Size/ Carrier Type	Fleet Area of Operation			
	Intrastate		Interstate	
	%	C.I.	%	C.I.
Small (1-49)				
Authorized	4.7	±4.5	9.3	±6.6
Non-Authorized	63.0	±12.9	13.8	±7.9
Large (50+)				
Authorized	0.2	±0.2	1.4	±0.5
Non-Authorized	4.1	±.3.	3.6	±2.8
TOTAL	72.0	±10.4	28.0	±10.4

*N=577; Wtd N=7,065.

TABLE 2.23

Weighted Proportions of Fleets
by Carrier Type

Carrier Type	%	C.I.	N	Wtd. N
Authorized				
Common	11.3	±6.4	64	798
Contract	4.3	±4.2	15	301
Non-Authorized				
Exempt	6.0	±6.2	13	421
Private	77.7	±8.8	457	5,488
Lease	0.8	±0.5	28	58
TOTAL	100.1	----	577	7,066

TABLE 2.24

Weighted Proportions of Fleets
by Fleet Size

Fleet Size	%	C.I.	N	Wtd. N
Small (1-49)	90.7	±4.2	421	6,410
Medium (50-399)	8.6	±4.3	133	610
Large (400+)	0.6	±0.5	23	45
TOTAL	99.9	----	577	7,065

power units, predominate. The very large fleets, those with 400 or more power units, constitute less than 1 percent of the purchasers.

Unfortunately many of the confidence intervals in Table 2.23 are so large that the found proportions of fleets in the Common, Contract, and Exempt categories may be considerably different from their true proportions in the population of fleet owners.

2.3 Mileage

This sub-section reports the estimates of daily mileage for various categories of vehicles that were obtained from odometer readings on the study vehicles. These estimates were used in calculating accident rates for vehicles included in the FARS and BMCS accident reporting systems. The daily mileage estimates had to be subsetted into various categories--local versus intercity miles, miles pulling pre-standard trailers versus miles pulling post-standard trailers, miles pulling single trailers versus miles pulling double trailers--and for this categorization estimates taken from Trip Information Survey (TIS) were used.

2.3.1 Estimates of Daily Mileage from Odometer Readings. At quarterly intervals during the two-year study period the fleets reported odometer readings on the study vehicles. From these readings the total mileage accumulated was computed for each study vehicle. Only vehicles for which there was sufficient information to compute a two-year mileage figure were included in the analysis files. Other vehicles were counted as non-responding cases.

These two-year mileages were then divided by the number of days in the two-year period to give the estimates of daily mileage presented in Tables 2.25 and 2.26. The tables show that the tractors put on much greater mileage than the straight trucks. Some inter-model-year variation is noticeable, though most is not statistically significant. The figure for the 1976 straight trucks is particularly and inexplicably low. Overall the confidence intervals are rather large.

TABLE 2.25

Straight Trucks:
Miles Per Day by Model Year*

Model Year	Mean	C.I.	N	Wtd. N
1974	64.8	±29.4	251	776
1975 Pre	79.7	±39.5	123	372
1975 Post	67.6	±20.0	544	1,478
1976	32.8	±13.5	127	247

*CVD >.15 for all cells.

The next few tables show the daily mileages for the tractors, broken down by various categories. In Table 2.27 are presented the figures for tractors by carrier type. For

TABLE 2.26

Tractors:
Miles Per Day by Model Year*

Model Year	Mean	C.I.	N	Wtd. N
1974	209.1	±42.5	938	1,995
1975 Pre	180.5	±44.9	160	399
1975 Post	216.4	±52.1	521	1,052
1976	178.6	±107.4	126	188

*CVD >.15 for all cells.

each model year the first line gives the mean daily mileage per vehicle and the confidence interval associated with it; the second line gives the percentage of all daily mileage for that model year put on by the vehicles in that cell with confidence intervals. Thus each of the 1,131 1974 tractors that are estimated to be in Authorized fleets averaged 230 miles per day. As a group these 1,131 tractors put on 62% of the mileage of all the sampled 1974 tractors, with the non-Authorized tractors putting on the other 38%. Once again some inter-model-year variations are noticeable, though they are not statistically significant.

For the 1975 post-standard model year the proportion of total mileage put on by the Authorized carriers was substantially less than for the other model years. Here one can see the effect of the postponing of the purchase of new vehicles by the Authorized carriers because of the economic downturn and apprehension about the 121 system.

Tables 2.28 and 2.29 show the same types of distributions for fleet size and cab style. The 1975 post-standard tractors in small fleets put on a greater proportion of total mileage than the other model years in

TABLE 2.27

Tractors:
Miles Per Day by Carrier Type*

Model Year	Authorized Carriers				Non-Authorized Carriers			
	Mean	C.I.	N	Wtd. N	Mean	C.I.	N	Wtd. N
1974								
Miles	229.6	± 59.7	654	1,131	182.5	±55.5	284	862
Percent	62.3	± 17.0			37.7	±17.0		
1975 Pre								
Miles	214.0	± 82.8	79	162	157.6	±55.3	81	237
Percent	48.1	± 35.2			51.9	±35.2		
1975 Post								
Miles	267.5	±113.9	258	303	195.8	±33.3	263	749
Percent	35.6	± 26.3			64.4	±26.3		
1976								
Miles	244.0	±166.0	80	82	128.0	±72.9	46	106
Percent	59.6	± 47.1			40.4	±47.1		

*CVD >.15 for all cells.

TABLE 2.28

Tractors:
Miles Per Day by Fleet Size*

Model Year	Small (1-49)				Large (50+)			
	Mean	C.I.	N	Wtd. N	Mean	C.I.	N	Wtd. N
1974								
Miles	187.4	±57.7	148	830	224.8	±58.3	790	1163
Percent	37.3	±15.1			62.7	±15.1		
1975								
Miles	150.6	±57.8	61	218	216.5	±75.5	99	181
Percent	45.6	±30.8			54.4	±30.8		
1975 Post								
Miles	208.3	±45.3	194	651	229.7	±107.7	327	401
Percent	59.6	± 30.2			40.5	±30.2		
1976								
Miles	94.5	±44.8	20	81	242.3	±130.7	106	107
Percent	22.8	± 29.7			77.2	±29.7		

*CVD >.15 for all cells.

TABLE 2.29

Tractors:
Miles Per Day by Cab Style*

Model Year	Cabovers				Conventionals			
	Mean	C.I.	N	Wtd. N	Mean	C.I.	N	Wtd. N
1974								
Miles	258.2	±46.5	410	833	174.1	±56.3	528	1,160
Percent	51.6	±15.9			48.4	±15.9		
1975 Pre								
Miles	222.1	±29.8	43	88	168.7	±59.4	117	311
Percent	27.1	±22.2			72.9	±22.2		
1975 Post								
Miles	243.9	±73.9	318	599	180.0	±35.6	203	453
Percent	64.2	±17.9			35.8	±17.9		
1976								
Miles	129.1	±103.6	31	71	208.6	±144.2	95	117
Percent	27.3	±36.3			72.7	±36.3		

*CVD >.15 for all cells.

small fleets. This can probably be ascribed once again to the postponement of purchasing by the Authorized carriers. The figures for the 1976 model year with their small N's are probably unreliable. Table 2.29 shows that the mean daily mileage by cab style is generally stable across model year, with the cabovers generally putting on more mileage, presumably because they tend to be in intercity operation. It is not clear why there are so few cabovers, and hence such a small proportion of total mileage, in the 1975 pre-standard model year. The figures for the 1976 model year are once again somewhat unreliable.

2.3.2 Proportions of Daily Mileage from The Trip Survey. During 1977 a subsample of one fourth of the vehicles for which there was some descriptive information at that time was selected for a trip survey. Each of the 780 vehicles in this subsample was randomly assigned a sample date code between 1 and 47. The calendar period from June 27, 1977 through December 31, 1977 was divided into four survey periods of 47 days each. A vehicle that was selected for sample date code 1 was surveyed on the first day in each of the periods--namely June 27, August 13, September 29, and November 15. Subsequently another four survey periods of the same length were added, but each vehicle was only surveyed in one half of these last four periods, either in periods 5 and 7 or in periods 6 and 8.

For each survey date and for each survey vehicle the following questions were asked:

1. Was the unit in service on the survey date?
2. If yes, how many miles did the unit run on the sample date?
3. How was the mileage broken down between local, short-haul, and long-haul trips?
4. If the unit pulled any trailers did it pull one or two?
5. Was the "most-pulled" trailer pre- or post-standard?

From the responses to the trip survey it is possible to calculate for various types of vehicle what percentage of total mileage was put on in local trips and what percentage was put on in intercity trips. Similarly for the tractors it was possible to calculate what proportions of mileage were put on pulling no trailer, one trailer, and two trailers, and what proportions were put on pulling a first trailer that was pre-standard and a first trailer that was post-standard. The resulting proportions are in Tables 2.30 and 2.31.

TABLE 2.30

Trip Survey Proportions of Mileage
by Vehicle Type and Trip Distance*

121 Status	Usual Trip Length*	Vehicle Type	Local %	Local C.I.	Intercity %	Intercity C.I.	N
Pre	Local	Straight	87.1	±9.2	12.9	±9.2	228
Pre	Local	Tractor	66.2	±11.5	33.8	±11.5	98
Pre	<200	Straight	38.3	±10.9	61.7	±10.9	510
Pre	<200	Tractor	6.3	±2.4	93.7	±2.4	188
Pre	>200	Straight	23.6	±34.8	76.4	±34.8	52
Pre	>200	Tractor	2.4	±1.5	97.6	±1.5	324
Post	Local	Straight	84.6	±11.5	15.4	±11.5	237
Post	Local	Tractor	78.7	±15.9	21.3	±15.9	192
Post	<200	Straight	41.0	±8.1	59.0	±8.1	251
Post	<200	Tractor	5.8	±3.0	94.2	±3.0	401
Post	>200	Straight	6.2	±6.0	93.8	±6.0	16
Post	>200	Tractor	0.3	±0.3	99.7	±0.3	278

*From Vehicle Description.

For the interim report the categories used in the calculation of proportions of daily mileage by trip distance, were taken not from the trip survey (which had not then been carried out) but from the vehicle description. If a purchaser told us that a vehicle operated mainly locally

TABLE 2.31

Tractors:
Trip Survey Proportions of Intercity Mileage
by Vehicle Type and Trailer Type*

121 Status	Usual Trip Length*	Trailer Type				
		None	Pre	Post	Single	Double
Pre	Local	0.0	83.2	16.8	96.2	3.8
Pre	<200	0.0	85.7	14.3	95.3	4.7
Pre	>200	0.0	81.0	19.0	99.6	0.4
Post	Local	0.0	100.0	0.0	39.8	60.2
Post	<200	0.0	65.7	34.3	88.9	11.1
Post	>200	0.4	76.8	22.8	99.6	0.0

*From Vehicle Description.

then all that vehicle's mileage was put in the local category; similarly, if a purchaser told us that a vehicle operated mainly intercity then all that vehicle's mileage was put in the intercity category. However an analysis of the trip survey file indicated that many of the "local" vehicles did quite a few intercity trips. Because these trips were longer than the local trips, quite often a substantial proportion of their total mileage was put on in intercity trips. It was therefore decided to calculate the proportions from the trip survey presented in Table 2.30 and apply the proportions for each category to the odometer mileage for each vehicle in that category. Thus, for a pre-standard local straight truck, 87.1% of its miles per day would be ascribed to the local category, 12.9% to the intercity category.

Similarly, after intercity mileages had been calculated, the trailer type proportions presented in Table 2.31 were applied to the intercity mileage for each tractor in the study. The results of applying these proportions to the odometer readings are presented in the next sub-section.

2.3.3 Results of Applying the Trip Survey Proportions to the Odometer Mileages. Tables 2.32 to 2.35 show the proportions of daily mileage by model year and various other categories, after the trip survey proportions have been applied to each vehicle's total daily mileage. In Tables 2.32 and 2.33 the mileages are split between local and intercity trips, first for straight trucks then for tractors. In Tables 2.34 and 2.35 the intercity mileage for tractors is further split by trailer type and number of trailers.

TABLE 2.32

Straight Trucks:
Proportions of Miles Per Day by Trip Distance*

Model Year	Local Trips		Intercity Trips		N
	%	C.I.	%	C.I.	
1974	56.5	±13.1	43.5	±13.1	251
1975 Pre	54.6	±16.3	45.4	±16.3	123
1975 Post	52.3	±14.5	47.7	±14.5	544
1976	64.8	±18.2	35.2	±18.2	127

*CVD >.15 for all cells.

There are some substantial variations by model year such as the elevated proportion of local mileage for the 1975 pre-standard tractors in Table 2.33. This figure, based on a small N, is however not very reliable. Perhaps the most notable result is shown in Table 2.34. This table shows that the post-standard tractors are more likely to be coupled to a post-standard trailer than are the pre-standard

TABLE 2.33

Tractors:
Proportions of Miles Per Day by Trip Distance*

Model Year	Local Trips		Intercity Trips		N
	%	C.I.	%	C.I.	
1974	9.3	±4.8	90.7	±4.8	938
1975 Pre	16.8	±18.6	83.2	±18.6	160
1975 Post	8.4	±5.7	91.6	±5.7	521
1976	5.8	±7.0	94.2	±7.0	126

*CVD >.15 for all cells.

TABLE 2.34

Tractors:
Proportions of Intercity Miles Per Day
by Trailer Type*

Model Year	Bobtail		Pre-Standard		Post-Standard		N
	%	C.I.	%	C.I.	%	C.I.	
1974	0.0	±0.0	82.0	±0.6	18.0	±0.6	938
1975 Pre	0.0	±0.0	82.2	±0.7	17.8	±0.7	160
1975 Post	0.3	±0.1	74.5	±1.9	25.3	±1.9	521
1976	0.3	±0.1	74.6	±2.7	25.1	±2.8	126

*CVD >.15 for all cells.

tractors. When the purchasers were asked whether they had a deliberate policy of coupling like tractor to like trailer, they generally responded that they had no such policy. The

TABLE 2.35

Tractors:
Proportions of Intercity Miles Per Day
by Number of Trailers*

Model Year	Bobtail		Single		Double		N
	%	C.I.	%	C.I.	%	C.I.	
1974	0.0	±0.0	98.7	±0.5	1.3	±0.5	938
1975 Pre	0.0	±0.0	98.4	±0.7	1.6	±0.7	160
1975 Post	0.3	±0.1	95.7	±2.3	4.0	±2.3	521
1976	0.3	±0.1	96.5	±3.7	3.2	±3.8	126

*CVD >.15 for all cells.

inference must be, therefore, that the purchasers of post-standard tractors were also likely to be purchasers of post-standard trailers. According to Table 2.35, there is also some tendency for the later model vehicles to be coupled more often to double trailers.

2.4 Discussion of Results

This sub-section seeks to assess the quality of the data. It will look at response rates and give an evaluation of them. It will look at areas in the data collection, in particular the fleet accident and maintenance information, and explain why it is believed they are unreliable. And it will look at the problems in estimating population figures from the sample data, examining the generally large confidence intervals that are computed when making these estimates.

2.4.1 Response Rates. The overall fleet study response rates have already been discussed (see sub-section 2.2.5 above). These response rates, although lower than had been hoped, were by no means unsatisfactory. Adequate descriptive information and at least two odometer readings were collected for around two-thirds of all eligible vehicles. Table 2.3 indicated that the responding vehicles represented the sample frame in a generally accurate manner. Systematic bias in the results would appear unlikely. However, a higher response rate would have produced smaller confidence intervals and so would have resulted in more accurate estimations of population parameters.

Table 2.36 presents the response rate for the trip survey conducted on a sub-sample of the fleet vehicles. The table excludes the school buses which were included in the survey for the first four periods but which were excluded in analysis because of their exemption from the 121 Standard. Because each vehicle was only surveyed in two out of the last four periods the number eligible is half that for the first four periods.

TABLE 2.36

Trip Survey Response Rate:
Straight Trucks and Tractors Only

Period	Eligible	Responding	Response Rate
1	670	503	75.1%
2	670	497	74.2%
3	670	479	71.5%
4	670	485	72.4%
All (1-4)	2,680	1,964	73.3%
5	335	218	65.1%
6	335	203	60.6%
7	335	201	60.0%
8	335	208	62.1%
All (5-8)	1,340	830	61.9%
OVERALL	4,020	2,794	69.5%

The 670 vehicles selected were taken from fleets that were, at the time, cooperating with the study. An extremely high response rate was therefore expected. As can be seen from the table, the response rate turned out to be high, but not overwhelming. There is one mitigating factor here. At the time the trip survey vehicles were selected the collection of the fleet study data was by no means complete. Vehicles for which a vehicle description had been obtained were counted as "responding" vehicles and were therefore eligible for inclusion in the trip survey sub-sample. Subsequently when it proved impossible to collect odometer readings on some of these vehicles they were dropped from the study (i.e., counted as non-responses). So vehicles which had been dropped from the main analysis file as non-responses were included in the trip survey file, and it is presumably these vehicles that caused many of the data collection problems. Another large part of the non-response is attributable to a couple of large fleets which, after promising trip survey data, did not send them in.

The response rate for the last four periods is appreciably lower than that for the first four periods. When the trip survey began the vehicle operators were informed it would only last for four periods. Some of them seem to have felt they had done their duty at the end of the first four periods.

2.4.2 Assessment of the Exposure Estimates. Beyond the initial fleet and vehicle descriptive information, the odometer readings were the easiest data to collect. The trucking companies did not consider them to be sensitive information and so released them willingly. Many companies record odometer readings when they conduct periodic maintenance, and therefore had precise figures available in their books. Finally such readings are inherently self checking: they increase from reading to reading and one can even predict, after the first two readings, the size of subsequent readings. New odometers are the only explanation for readings that are lower than ones taken at an earlier date, and odometer replacements are recorded in vehicle maintenance files. It is therefore believed that the odometer readings and the daily mileage figures computed from them are extremely reliable. Errors are likely only from deficiencies in the sampling.

It was hoped that the trip survey data, and the proportions of daily mileage computed from them, could be almost as reliable. A relatively easy method exists for checking whether this is in fact the case: it is possible to compute daily mileage estimates from the trip survey (as was done from the 1978 trip survey discussed in Section 3) and to compare these estimates with the daily mileages computed from the odometer readings. Table 2.37 presents such a comparison. The table shows that the estimates from the trip survey are generally lower than the odometer figures, particularly for the long-haul tractors. There are a number of possible explanations: one is that the fleets generally report "as the crow flies" mileages in the trip survey, excluding pick-up and delivery at each end; another is that some fleets that drive faster than the speed limit or exceed legal driving times are reluctant to report mileages that might indicate violation of the law.

The fleet data are probably not affected severely by this underestimation. Only the proportioning of total mileage between local and intercity trips is taken from the trip survey; total mileage came from odometer readings. However, the study of the post-Notice 7 vehicles, carried out in 1978, relied on the trip survey to provide figures for total mileage. In that study the exposure for the intercity tractors may be underestimated, and accident rates therefore overestimated.

TABLE 2.37

Comparison of Average Daily Mileage from Odometer Information and Trip Survey

Vehicle Category	Odometer Mileage			Trip Survey Mileage		
	N	MPD	C.I.	N	MPD	C.I.
PRE-STANDARD						
Straight Truck:						
Local	202	32.4	±3.9	237	35.3	±6.2
< 200	98	60.3	±13.9	251	52.3	±11.5
> 200	34	137.4	±37.2	16	51.9	±45.8
Tractor:						
Local	208	64.6	±7.0	192	57.1	±9.8
< 200	182	178.2	±14.0	401	162.1	±17.4
> 200	631	270.3	±10.3	278	239.0	±29.4
POST-STANDARD						
Straight Truck:						
Local	324	37.0	±3.7	228	35.6	±6.6
< 200	289	56.1	±6.4	510	48.5	±7.6
> 200	28	160.9	±41.5	52	154.5	±52.1
Tractor:						
Local	141	67.2	±8.8	98	67.3	±15.6
< 200	117	175.8	±20.4	188	121.6	±21.0
> 200	346	318.3	±11.7	324	254.2	±25.9

2.4.3 The Problems with the Fleet Accident and Maintenance Data. When the fleet study was first planned, two of the main components were intended to be the computing of accident and maintenance rates for the study vehicles in order to compare the experience of pre- and post-standard vehicles. However, the accident and maintenance data turned out to be the most problematic parts of the study. The two will be dealt with in turn here.

Figures published elsewhere had given, prior to the study, some indication of what accident rates to expect for vehicles in various exposure categories. Thus the fleets participating in the National Fleet Safety Contest between

1971 and 1973 reported an average accident rate of 3.06 accidents per million miles for intercity trucks in Common carriers and 13.7 accidents per million miles for trucks owned by city governments. The figures from the same source for the 1975 to 1977 period are 2.91 and 12.99 respectively.[7] As only fleets with good safety records are likely to enter such a contest, these figures must be at the low end of the range for each category. Most fleets could be expected to have higher rates.

When the accident rates for the study fleets were tabulated it became clear that there were large differences in completeness of reporting. Some large Common carriers reported accident rates for their intercity tractors that were very much in line with the predicted levels. For example the rate for one large carrier turned out to be 3.09 accidents per million miles for pre-standard intercity tractors and 3.20 accidents per million miles for post-standard intercity tractors. Other Common carriers, however, reported rates for intercity tractors that were so low as to strain credibility: 0.34, for example, or 0.75 or 1.32. An examination of the accident data on a case by case basis for one fleet showed that we had received reports on only those accidents that met the BMCS threshold, (any injury accident or more than $2000 in property damage). Minor accidents were left out entirely, yet the same company later released figures indicating a far greater number of accidents.

The tabulation of rates for municipal fleets revealed similar variations in data quality. One large city had 42.6 accidents per million miles for its pre-standard trucks and

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[7]National Safety Council, Fleet Accident Rates, 1974 Edition (Chicago: National Safety Council, 1974), pp. 26-7; and National Safety Council, Accident Facts, 1978 Edition (Chicago: National Safety Council, 1978), p. 64.

39.0 for its post-standard trucks. Another had a rate of 120.4 for its pre-standard trucks.

Many fleets, fearing damage to their reputations if data were leaked, were clearly reluctant to report all their accidents. Others found the collection of the data to be too much of a burden on their time. But whatever the reasons the data were clearly too unreliable to perform their intended purpose: the assessment of the safety impact of the 121 Standard. It was therefore decided to use the FARS and BMCS data sets exclusively in comparing accident rates for pre- and post-standard vehicles.

The maintenance data were intended to provide an assessment of the costs of the 121 system just as the accident data were intended to test potential benefits. The unit of measurement here would be intervals between services on brake components, with intervals measured in miles and results computed for various operating environments. But once again data collection problems were severe. For one third of all maintenance entries in the data files no mileage at the time of maintenance was reported. This made the computing of intervals between services extremely difficult. Also large inter-fleet variations in data quality were noticeable. For many vehicles no brake maintenance at all was reported in the two-year study period. Other vehicles listed only major brake work, while yet another group listed periodic maintenance at regular intervals. Some, but not all, of this variation may be attributable to differences in maintenance policies between fleets, as vehicles are sometimes driven for as much as two years without maintenance.

Yet even the deficient data that were collected would lead one to the conclusion that maintenance intervals were substantially smaller on the post-standard vehicles, i.e., that they required much more servicing on brake components. None of the figures were statistically significant but they all pointed the same way. For tractors the maintenance interval between services on any component of the brake system was 31% lower for the post-standard vehicles. For straight trucks the interval was 60% lower. And these figures were close to being significant at the 95% confidence level.

2.4.4 Variance. As stated earlier a sampling procedure should be designed to result in confidence intervals that are as low as possible. A large confidence interval produces an estimate of a population parameter that has a wide range; a small confidence interval produces a much smaller range and hence a much more precise estimate. 1000 vehicles ±50 is clearly more useful than 1000 vehicles ±200.

The most straightforward way to achieve small confidence intervals is to take a simple random sample of a large size. Cluster sampling, as used in the fleet study where vehicles were clustered by PSU and by fleet, can produce confidence intervals even smaller than random sampling if the sampling strata correspond to the analysis strata. If however, as in the current study, the data are stratified after the fact (i.e., only in analysis) large confidence intervals are likely. If the strata are not homogeneously distributed across clusters, confidence intervals will further increase. This was the case here where, for example, the straight trucks were not distributed evenly across PSU's.

The high sampling variances are therefore directly attributable to the desire to control the cost of the study. Two ways of reducing them offered themselves. The first was to carry out a pilot study prior to the main project. This would have permitted all stratification to be carried out prior to sampling. The second would have been to take a simple random sample of the type used in assessing the post-Notice 7 vehicles in 1978.

SECTION 3

1978 TRIP SURVEY

On March 1,1976 NHTSA published a major amendment to FMVSS 121 which became known as "Notice 7." This amendment relaxed the stopping distance requirement from 245 feet to 293 feet on dry pavement from 60 mph. It was hoped that this modification would allow the front axle brakes to be de-powered on most vehicles so that anti-lock could be eliminated on the front axle. The objective of the 1978 Trip Survey was to collect descriptive information and exposure data on the first year of production of "post-Notice 7" vehicles. Accident experience would be derived from the FARS and BMCS files. No maintenance data were collected.

In general, this survey was patterned after the Trip Survey conducted as part of the fleet monitoring program described in the previous section, except that a new sample of post-Notice 7 vehicles was selected. The first sub-section of this section describes the sampling frame and sample design, survey methods, and response rates. Descriptive statistics on the types of vehicles and owners found in the survey are presented in the second sub-section. Mileage distributions and average daily mileage results are included in the third, and final, sub-section of this section.

3.1 Method

For the 1978 Trip Survey, a random sample of 2,166 vehicles was selected from manufacturers' sales lists containing 142,983 model year 1977 vehicles. The survey was conducted by telephone during the last four months of 1978. Each vehicle was surveyed on two randomly selected dates (spaced 60 days apart). On the initial call, descriptive information on the company and the vehicle were requested, in addition to information on the use of the vehicle on the survey date. Usage information comprised five basic questions:

1. Was the unit in service on the survey date?

2. If yes, how many miles did the unit run on the sample date?

3. How was the mileage broken down between local, short-haul, and long-haul trips?

4. If the unit pulled any trailers, did it pull one or two?

5. Was the "most-pulled" trailer pre- or post-standard?

Additional detail on the sampling frame, sample design, survey method, and response rates are provided in the remainder of this sub-section.

Although Notice 7 was published in March of 1976, truck manufacturers did not make appreciable modifications to the vehicles until the start of the 1977 model year (approximately November 1976). For this reason the survey of post-Notice 7 vehicles was focused on the 1977 model year. All of the truck manufacturers which supplied sales lists for the previous survey also agreed to supply similar information for this survey (except Chrysler which had stopped producing heavy trucks in 1975). In addition, Paccar (Kenworth and Peterbilt), which had been unable to provide the computerized data required for the complex sampling approach used in the first survey, provided hard copy lists of VIN numbers for the survey of post-Notice 7 vehicles. Because this design entailed only a simple random sample, Paccar vehicles were selected without the aid of a computer. The selected VIN's were returned to Paccar where purchasers' names and addresses were obtained from company files and sent to HSRI. Paccar's participation raised the coverage of the sampling frame from approximately 90% for the fleet monitoring program, to essentially 100% for the survey of post-Notice 7 vehicles. The percentage quoted is the percentage of total heavy truck factory sales accounted for by the participating manufacturers.

Even though nearly all manufacturers participated, names and addresses were not obtained for all vehicles produced. Table 3.1 shows adjusted factory sales by manufacturer for the 12 month period, November 1976 through October 1977. The adjustments were applied to factory sales by Weight Class in an attempt to estimate sales of only air-braked vehicles and are described in more detail in the next section. Table 3.2 shows the number of eligible vehicles in the sampling frame by manufacturer. Ineligible vehicles for selection were those missing a purchaser name and address or vehicles sold outside the contiguous 48 states. Overall, the sampling frame covers 79% of the total adjusted factory sales. Coverage is fairly uniform by manufacturer, although it is somewhat lower for International Harvester (65%). Freightliner, Kenworth, and Peterbilt are not identified individually in the factory sales data published by the Motor Vehicle Manufacturers' Association.

Information requirements were extensive in the fleet monitoring program, requiring personal visits to the carrier in order to achieve a reasonable response rate. The complex sample design employed in this program arose from the need to limit travel costs. However, the Trip Survey conducted as part of the original program showed that limited exposure information could be obtained in a telephone survey. The most important design feature of the 1978 Trip Survey, then, is its reliance on the telephone interview for data collection. With the requirement for personal visits eliminated, a simple random sample can be used. The selection process is, of course, vastly simplified for a

TABLE 3.1

Adjusted Factory Sales of Air-Braked Vehicles by Manufacturer for 1977*

Manufacturer	Adjusted Factory Sales	Percent
Chevrolet	9,386	5.2
Ford	38,160	21.0
GMC	20,026	11.0
Intl. Harvester	41,318	22.7
Mack	25,598	14.1
White**	20,447	11.2
Others***	27,075	14.9
TOTAL	182,010	100.1

*Based on Motor Vehicle Manufacturers Association (MVMA) sales data (November 1976 through October 1977).

**Includes Freightliner.

***Includes Peterbilt, Kenworth, and Others.

TABLE 3.2

Sampling Frame Totals and Selected Vehicles by Manufacturer

Manufacturer	Eligible Vehicles	Percent	Selected Vehicles
Chevrolet	7,116	5.0	108
Ford	29,770	20.8	451
Freightliner	8,020	5.6	121
GMC	16,539	11.9	251
Intl. Harvester	27,024	18.9	410
Mack	19,016	13.3	288
Peterbilt	9,117	6.4	138
Kenworth	13,345	9.3	202
White	13,036	9.1	197
TOTAL	142,983	100.0	2,166

simple random sample, and the sampling error is reduced in comparison to the sample design used for the fleet monitoring program.

An interval selection procedure with a random start was used. With the interval equal to 66, a total of 2,166 vehicles were selected. The number of vehicles selected from each manufacturer's list is shown in the last column of Table 3.2. Table 3.3 shows the random starts used for each manufacturer for both the vehicle selection and the assignment of the survey "date code."

TABLE 3.3

Random Starts for the Selection of Vehicles
and Assignment of Date Codes

Manufacturer	Random Start	
	Vehicle Selection	Date Code
Chevrolet	54	11
Ford	51	33
Freightliner	48	9
GMC	33	18
Intl. Harvester	19	21
Mack	28	53
Paccar	56	35
White	54	8

The survey covered a 120 day period beginning September 11, 1978 and ending January 8, 1979. The survey was divided into two 60 day periods, and each vehicle was surveyed once in each period. The "date codes" (1-60) correspond to the first 60 days of the survey. These date codes were randomly assigned to each vehicle at the time of selection in the following manner. Since several trucks are frequently purchased in a single order by large companies, it is likely that vehicles adjacent to one another on the manufacturers' sales lists may have been purchased by the same company. The date codes were put in the order shown in the listing below so that adjacent vehicles would not be assigned consecutive date codes. For each manufacturer, the date code for the first vehicle selected was determined by selecting a number from 1 to 60 from a random number table. Date codes for each successive vehicle selection were assigned by entering the sequence shown below at the date code initially selected and continuing through the sequence as many times as necessary. The survey date in the second period was then 60 days from the first survey date for each vehicle. The starting date code for each manufacturer is also shown in Table 3.3.

Column 1	Column 2	Column 3	Column 4
1	49	23	42
31	5	53	27
16	35	9	57
46	20	39	13
2	50	24	43
32	6	54	28
17	36	10	58
47	21	40	14
3	51	25	44
33	7	55	29
18	37	11	59
48	22	41	15
4	52	26	45
34	8	56	30
19	38	12	60

Survey information was collected by telephone. Calls were placed as close as possible to the survey date. In a large company, the dispatcher was usually best able to provide the requested information. On the initial contact the VIN was checked and the company unit number obtained. Descriptive information on the vehicle and the owner was recorded as well as the information on vehicle usage on the survey date. Arrangements were then made to obtain the vehicle use information once again in 60 days. Data forms are shown in Figures 3.1 and 3.2.

1977

COMPANY - VEHICLE

DESCRIPTION

Selection Number __ __ __ __ (Col. 1

Sample Date Code __ __ (Col. 5

Company Name ________________

Company Unit Number ________________

VEHICLE DATA VALIDATION

Vehicle Manufacturer (Col. 8-9)

01 [ ] Chevy
02 [ ] Ford
03 [ ] Freightliner
04 [ ] GM
05 [ ] International
06 [ ] Mack
07 [ ] Peterbilt
08 [ ] Kenworth
09 [ ] White
10 [ ] Auto Car
11 [ ] Western Star

Model Year __ __ (Col. 10-11)

STYLE

Vehicle Style (Col. 12)

1 [ ] Straight Truck
2 [ ] Tractor
8 [ ] Unknown

Cab Style (Col. 13)

1 [ ] Conventional or Long Conventional
2 [ ] Short Conventional
3 [ ] Cab Over or Tilt Cab
4 [ ] Cab Over or Tilt Cab with Sleeper
8 [ ] Unknown

Cargo Body Style (See Table Below) __ __ (Col. 14-15)

Straight Truck

01 Chassis Only
02 Beverage
03 Dump
04 Fire Truck
05 Flat Bed Container
06 Flat Bed with Added Device
07 Flat Bed—Other
08 Flat (Low Boy)
09 Gondola (Grain, Hopper)
10 Garbage
11 Mixer—Cement
13 Van—Conventional
14 Van—High Cube
15 Van—Refrigerated
16 Van—Furniture (Moving)
17 Van—Open Top
18 Wrecker
19 Automobile Carrier
20 Tanker—Liquid
21 Tanker—Bulk Dry
22 Cattle Rack—Livestock
23 Utility (Telephone, etc.)
24 Boom or Crane
25 Other: ________

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: ________
56 Other Hitch and Added Device

98 Unknown

AXLE AND BRAKE CONFIGURATION

Number of Rear Axles (Col. 16)

1 [ ] One
2 [ ] Two
3 [ ] Three or More
8 [ ] Unknown

Antilock Manufacturer (Col. 17)

1 [ ] AC
2 [ ] Bendix
3 [ ] Eaton
4 [ ] Goodrich
5 [ ] Kelsey Hayes
6 [ ] Rockwell
7 [ ] Wagner
8 [ ] Unknown

Has the brake system been modified? (Col. 18

1 [ ] Yes
2 [ ] No
8 [ ] Unknown

If yes, was the modified part the antilock? (Col. 19.

1 [ ] Yes
2 [ ] No
8 [ ] Unknown

Is the front axle equipped with antilock? (Col. 20

1 [ ] Yes
2 [ ] No
8 [ ] Unknown

GENERAL EXPOSURE

Carrier Type (Col. 21)

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

Fleet Size (# Airbraked Power Units) (Col. 22)

1 [ ] 1
2 [ ] 2-5
3 [ ] 6-49
4 [ ] 50-399
5 [ ] 400+
8 [ ] Unknown

Usual Area of Operation of Truck (Col. 23)

1 [ ] Local
2 [ ] Intrastate
3 [ ] Interstate
8 [ ] Unknown

If Intra. or Inter., Usual Trip Length (Col. 24)

1 [ ] Less than 200 miles one way
2 [ ] More than 200 miles one way
8 [ ] Unknown

VEHICLE STATUS (Col. 25)

1 [ ] Cooperation
2 [ ] Cooperation, but unable to provide TI
3 [ ] Refusal
4 [ ] Cannot Locate
5 [ ] Non-Sample Vehicle (e.g., outside of cont. USA, bus, mfg. under exempt., destroyed prior to TI date, etc.)
6 [ ] Other: ________

FIGURE 3.1 COMPANY AND VEHICLE DESCRIPTION FORM

1977 VEHICLE
TRIP INFORMATION SURVEY

Selection No. ____ ____ ____ ____	[1-4]
Survey Period ____	[5]
Sample Date Code ____ ____	[6-7]
Sample Date ____ ____ ____ ____	[8-11]
Sample Day of Week ____	[12]

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

Company Name ______________________

Company Unit Number ______________

1. Was Unit in use? [Col 14]

[ ] 2 No

a. Was it being serviced, or not scheduled for use? [Col 15]

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

b. Did this servicing involve the brakes at all? [Col 16]

[ ] 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 17]

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

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

____

____

[ ] 1 Yes

2. Approximately how many miles was Unit driven from midnight to midnight?

Specify number of miles: ______________ [Col 18-21]

Source: [ ] 1 Records [Col 22]
[ ] 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 23-26]
In or around the area in which the vehicle is based.

b. Short Haul: ______________ Miles [Col 27-30]
A trip to another area less than 200 miles away.

c. Long Haul: ______________ Miles [Col 31-34]
A trip to another area more than 200 miles away.

4. a. Did Unit pull any trailers? [Col 35]

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

b. Was it a single bottom or double bottom? [Col 36]

[ ] 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 37] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes	f. Was it a 121 trailer? [Col 40] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes
d. If Yes, was the brake modified? [Col 38] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes	g. If Yes, was the brake modified? [Col 41] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes
e. If Yes, was the modified part the anti-skid? [Col 39] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes	h. If Yes, was the modified part the anti-skid? [Col 42] [ ] 3 Don't Know [ ] 2 No [ ] 1 Yes

• • END • •

FIGURE 3.2 TRIP INFORMATION SURVEY FORM

Of the 2,166 vehicles selected, 47 (2.2%) were found to be "non-sample" vehicles. The term "non-sample" means that these vehicles were not part of the intended population. The intended population in this case was model year 1977 121-equipped vehicles sold within the 48 contiguous states. For the most part, vehicles not meeting these requirements were eliminated from the manufacturers' sales lists before the selections were made. A few slipped through, however. A description of the non-sample vehicles is provided below.

Non-Sample Categories	Vehicles
Located outside the U.S.	21
Auto carrier (exempt from FMVSS 121)	10
Destroyed prior to survey	7
Glider kit	4
Other (test vehicle, demo, etc.)	5
TOTAL	47

Nearly half are vehicles which were registered outside the contiguous 48 states, mostly in Canada. Most of these vehicles had original sales addresses within the U.S., but were subsequently transferred to a Canadian location. The next largest category is auto carriers which are exempt from the standard. Apparently these vehicles had not been excluded in some of the sales lists. Overall, the number of non-sample vehicles is very small and indicates that the sampling frame was indeed quite clean. The primary credit goes to the manufacturers who supplied the sales lists.

In general the response rate was better for the descriptive information than for the information on vehicle use, as might have been expected. For example, vehicle type (straight truck or tractor) was obtained for slightly over 80% of the sample. Non-response on this question is basically refusal. Some descriptive items could be determined from the VIN. Consequently, cab style is known for 96.5% of the sample vehicles. Going to the questions on usage, whether or not the vehicle was in service on the survey date was ascertained for 68% of the vehicle (62% of the survey dates). While this response rate is not as high as one might like, it is as good as that obtained in the fleet monitoring program (66%) where personal visits were used. Very little prior research of this type has been attempted in the trucking industry. In general, these response rates are thought to be quite good in light of the independence and diversity of the trucking industry.

Complete results from this survey are presented in the remaining two sub-sections of this section. Descriptive statistics on the vehicles and owners are presented in the next sub-section, while mileage distributions and average daily mileages are covered in the last sub-section.

3.2 Descriptive Statistics

Company and vehicle description forms were keypunched for all selected vehicles and entered into a MIDAS[a] data file regardless of whether the interview was completed or not. A "completion status" was recorded on the form (and in the computer file). Some data elements like number of rear axles or cab style could be determined from the VIN. For completed interviews survey data were checked with these. When the interview could not be completed, the available information from the VIN was entered as survey responses. The resulting data file is a "vehicle" file in that each record corresponds to a single sampled vehicle. The numbers (and percentages) presented in this sub-section are the numbers (and percentages) of the sampled vehicles responding to the various categories of each question. The percentage of vehicles in the sample providing a particular response is

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[a]Michigan Interactive Data Analysis System. See Daniel J. Fox and Kenneth E. Guire, Documentation for MIDAS, 3rd ed. (Ann Arbor: The University of Michigan Statistical Research Laboratory, September 1976.)

an estimate of the percentage of vehicles in the total sampling frame which would be expected to respond in the same fashion. The accuracy of this estimate is a function of the sample size and the magnitude of the proportion, and is presented as a "confidence interval." A 95% confidence interval means that if the process were repeated 100 times (draw 100 samples and compute 100 confidence intervals), then the true population value would be included in the calculated interval for 95 of the 100 samples.

For a simple random sample, the variance of a proportion, p, is given by:

$$Var(p) = p(1-p)/(n-1)$$

The standard error in p is given by the square root of the variance, and the 95% confidence interval has been computed as ±twice the standard error for these tabulations. Percentages are obtained by multiplying both the proportion and its confidence interval by 100.

The primary variables of interest here are the exposure, or control, variables for the computation of accident rates. It is recognized that many factors influence the overall accident rate for any group of vehicles. The following factors have been included in this study, and are referred to as "exposure variables."

Variable	Levels
1. Vehicle Type	Straight Truck, Tractor
2. Area of Operation	Local, Intrastate, Interstate
3. Carrier Type	Authorized, Non-Authorized
4. Fleet Size	Small (1-49), Large (50+)
5. Trip Distance	Local, <200 Miles, >200 Miles

Both accidents and vehicle mileage will be grouped using the categories formed by these variables. Accident rates will then be computed within the various categories.

The first results of interest, then, are the proportions of vehicles which are found in the various exposure categories. A major finding of the fleet monitoring program was that these proportions varied significantly when comparing the 1974 model year to the post-standard 1975 model year trucks. Table 3.4 presents a complete tabulation of proportions for the questions on the Company and Vehicle Description Form in the survey of 1977 model year 121-equipped trucks. Results are shown separately for straight trucks and tractors, as well as the combined results. Ninety-five percent confidence intervals are shown for all percentages. The "missing data" or "unknown" responses are also included for each question.

The first general observation to make in reviewing Table 3.4 is that the confidence intervals are very good (2%-4%). In this respect the simple random sample used for this survey represents a considerable improvement over the fleet monitoring program. Perhaps the first variable worth commenting on is vehicle type which simply tells whether the vehicle is a straight truck or tractor. This information was not available from the VIN or the manufacturers' records. Missing data (unknown) on this variable, then, is basically the result of nonresponse or refusal. For this question, the response rate is slightly over 80%, which is quite good. However, proceeding through this table, one observes that the response drops on some of the questions, in particular those relating to the anti-lock equipment. First, it is worth noting that cab style was determined for over 97% of the selected vehicles. The reason for this phenomenal response is that cab style could be determined from all of the manufacturers' VIN's except one, as will be shown in Table 3.5. For this variable, interview information was checked with the VIN data, and when the interview could not be completed, the VIN information was entered in its place.

TABLE 3.4

Descriptive Statistics:
1977 Model Year Air-Braked Vehicles

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
1. Manufacturer									
Chevrolet	44	11.5	±3.3	25	1.9	±0.7	97	4.6	±0.9
Ford	118	31.0	±4.7	197	15.0	±2.0	447	21.1	±1.7
Freightliner	2	.5	±0.7	107	8.1	±1.5	109	5.1	±0.9
GMC	41	10.8	±3.2	163	12.4	±1.8	250	11.8	±1.4
IHC	87	22.8	±4.3	219	16.6	±2.1	407	19.2	±1.7
Mack	62	16.3	±3.8	219	16.6	±2.1	286	13.5	±1.5
Peterbilt	3	.8	±0.9	94	7.1	±1.4	137	6.4	±1.0
Kenworth	7	1.8	±1.4	133	10.1	±1.7	198	9.3	±1.3
White	6	1.6	±1.3	154	11.7	±1.8	164	7.7	±1.2
Autocar	7	1.8	±1.4	5	.4	±0.3	15	.7	±0.4
Western Star	4	1.0	±1.0	1	.1	±0.1	9	.4	±0.3
2. Model Year									
1977	331	97.1	±1.8	1022	92.2	±1.6	1360	93.4	±1.3
1978	10	2.9	±1.8	86	7.8	±1.6	96	6.6	±1.3
Unknown	40	10.5	--	209	15.9	--	663	31.3	--
3. Vehicle Type									
Straight Truck							381	22.4	±2.0
Tractor							1317	77.6	±2.0
Unknown							421	19.9	
4. Cab Style									
Conventional	285	74.8	±4.4	527	40.6	±2.7	967	47.3	±2.2
Short Conventional	48	12.6	±3.4	108	8.3	±1.5	251	12.3	±1.4
Cabover	46	12.1	±3.3	251	19.3	±2.2	409	20.0	±1.7
Cabover w/Sleeper	2	.5	±0.7	412	31.7	±2.6	418	20.4	±1.8
Unknown	--	--	--	19	1.4	--	74	3.5	--

TABLE 3.4--Continued

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
5. Cargo Body Style									
Beverage	12	3.4	±1.9						
Dump	118	33.8	±5.0						
Fire Truck	8	2.3	±1.6						
Flatbed	42	12.3	±3.5						
Garbage	38	10.8	±3.3						
Mixer	39	11.1	±3.4						
Van--Conventional	19	5.4	±2.4						
Van--Refrigerated	10	2.8	±1.7						
Van--Furniture	3	.9	±1.0						
Tanker	22	6.3	±2.6						
Utility	9	2.6	±1.7						
Boom/Crane	2	.6	±0.8						
Other	27	7.7	±2.9						
Unknown	32	8.4	--						
6. Rear Axle									
One	156	42.6	±5.1	251	20.4	±2.3	509	26.5	±2.0
Two	186	50.8	±5.2	940	76.3	±2.4	1345	70.1	±2.1
Three or more	24	6.6	±2.6	41	3.3	±1.0	65	3.4	±0.8
Unknown	15	3.9	--	85	6.4	--	200	9.4	--
7. Antilock Mfg.									
A.C.	9	11.8	±7.5	31	7.4	±2.5	40	8.0	±2.4
Bendix	12	15.8	±8.4	20	4.7	±1.5	32	6.4	±2.2
Eaton	20	26.3	±10.2	141	33.5	±4.6	162	32.5	±4.2
Goodrich	3	3.9	±4.5	29	6.9	±2.5	32	6.4	±2.2
Kelsey Hayes	25	32.9	±10.8	139	33.0	±4.6	165	33.1	±4.2
Rockwell	7	9.2	±6.7	24	5.7	±2.3	31	6.2	±2.2
Wagner				34	8.0	±2.7	34	6.8	±2.3
Other				3	.7	±0.8	3	.6	±0.7
Unknown	305	80.0	--	896	68.0	--	1620	76.5	--
8. Brake Modified									
Yes	24	7.1	±2.8	65	6.2	±1.5	89	6.4	±1.3
No	314	92.8	±2.8	982	93.8	±1.5	1298	93.6	±1.3
Unknown	43	11.3	--	270	20.5	--	732	34.5	--

TABLE 3.4--Continued

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
9. Antilock Modified									
Yes	20	100	±0.0	47	90.4	±8.3	67	93.1	±6.0
No				5	9.6	±8.3	5	6.9	±6.0
Unknown	4	16.7	--	13	20.0	--	17	19.1	--
10. Front Axle Antilock									
Yes	135	53.4	±6.3	483	55.0	±3.4	620	54.7	±3.0
No	118	46.6	±6.3	395	45.0	±3.4	514	45.3	±3.0
Unknown	128	33.6	--	439	33.3	--	985	46.6	--
11. Carrier Type									
Non-Authorized	331	90.4	±3.1	564	48.1	±2.9	929	58.5	±2.5
Authorized	27	7.4	±2.7	572	48.8	±2.9	612	38.5	±2.4
Exempt	8	2.2	±1.5	37	3.2	±1.0	48	3.0	±0.9
Unknown	15	3.9	--	144	10.9	--	530	25.0	--
12. Fleet Size									
1	21	5.9	±2.5	61	5.2	±1.3	82	5.2	±1.1
2-5	61	17.2	±4.0	130	11.1	±1.8	192	12.3	±1.7
6-49	160	45.2	±5.3	312	26.7	±2.6	476	30.4	±2.3
50-399	85	24.0	±4.5	287	24.5	±2.5	375	23.9	±2.2
400+	27	7.6	±2.8	380	32.5	±2.7	442	28.2	±2.3
Unknown	27	7.1	--	147	11.2	--	552	26.1	--
13. Area of Operation									
Local	265	73.0	±5.0	165	14.4	±2.1	432	28.5	±2.3
Intrastate	75	21.0	±4.0	210	18.3	±2.3	286	18.9	±2.0
Interstate	22	6.0	±3.0	774	67.4	±2.8	799	52.7	±2.6
Unknown	19	5.0	--	168	12.8	--	602	28.4	--
14. Trip Length									
Local	265	74.0	±5.0	165	14.9	±2.1	432	29.0	±2.0
<200 Miles	79	22.0	±4.0	221	19.9	±2.4	301	20.0	±2.0
>200 Miles	12	3.0	±2.0	723	65.2	±2.9	737	50.0	±3.0
Unknown	6	1.7	--	40	3.5	--	649	30.6	--

Continuing with Table 3.4, the distribution of cargo body styles for straight trucks is shown next. Dump truck is the single largest category at almost 33%. The worst response comes on the question on anti-lock manufacturer where missing data is 76.5%. Only 6.4% of the owners said that the brake system had been modified. Of these, over 93% said that the modified component was the anti-lock. Owners also indicated that about 55% of the vehicles had anti-lock on the front axle. However, non-response on this question is 47%. The last four questions provide one-way distributions on the remaining four exposure variables. Non-response on these variables increased to 25%-30%.

The distribution of cab style by manufacturer is shown in Table 3.5. Cab style, as noted earlier, could be determined from the VIN for all manufacturers except Peterbilt. The only cab style data for this manufacturer comes from the survey, while the others represent a combination of survey and VIN information.

Table 3.6 shows a three-way distribution of area of operation, carrier type, and fleet size for straight trucks. Fleet size is measured by the number of air-braked power units owned. The primary observation to be made from this table is that nearly half (47%) of the straight trucks are operated by small non-Authorized carriers in primarily local use. Two-way distributions for each combination of these three variables are shown in Tables 3.7 through 3.9.

Tables 3.10 through 3.13 present the same information for tractors. Here one sees that about 67% of the tractors operate interstate, and that they are split about 50-50 between Authorized and non-Authorized carriers. The reader should keep in mind that this survey was conducted one year after the end of sales for this model year. In general, one would expect larger proportions of the tractors to be in local pick-up and delivery operations as the vehicles become older. Looking at Table 3.11, one finds that 52.3% of the

TABLE 3.5

Cab Style by Manufacturer

CAB STYLE	Vehicle Manufacturer									TOTAL
	CHEVROLET	FORD	FREIGHTLINER	GMC	IHC	MACK	PETERBILT	KENWORTH	WHITE	
Conventional	77	216	17	129	149	199	15	70	95	967
Total %	3.6	10.2	.8	6.1	7.0	9.4	.7	3.3	4.5	45.6
Row %	8.0	22.3	1.8	13.3	15.4	20.6	1.6	7.2	9.8	
Column %	79.4	48.3	15.6	51.6	36.6	69.6	10.9	35.4	50.5	
Short Conventional	7	131	0	13	49	30	0	1	20	251
Total %	.3	6.2		.6	2.3	1.4		.0	.9	11.8
Row %	2.8	52.2		5.2	19.5	12.0		.4	8.0	
Column %	7.2	29.3		5.2	12.0	10.5		.5	10.6	
Cabover	6	74	21	58	109	25	7	66	43	409
Total %	.3	3.5	1.0	2.7	5.1	1.2	.3	3.1	2.0	19.3
Row %	1.5	18.1	5.1	14.2	26.7	6.1	1.7	16.1	10.5	
Column %	6.2	16.6	19.3	23.2	26.8	8.7	5.1	33.3	22.9	
Cabover w/Sleeper	7	14	71	43	100	32	60	61	30	418
Total %	.3	.7	3.4	2.0	4.7	1.5	2.8	2.9	1.4	19.7
Row %	1.7	3.3	17.0	10.3	23.9	7.7	14.4	14.6	7.1	
Column %	7.2	3.1	65.1	17.2	24.6	11.2	43.8	30.8	16.0	
Unknown	0	12	0	7	0	0	55	0	0	74
Total %		.6		.3			2.6			3.5
Row %		16.2		9.5			74.3			
Column %		2.7		2.8			40.1			
TOTAL	97	447	199	250	407	286	137	198	188	2119
Percent	4.6	21.1	5.1	11.8	19.2	13.5	6.5	9.3	8.9	100.0

TABLE 3.6

Distribution of Straight Trucks by Area of Operation, Carrier Type, and Fleet Size

Carrier Type and Fleet Size	Area of Operation									TOTAL		
	Local			Intrastate			Interstate					
	N	%	C.I.	N	%	C.I.	N	%	C.I.	N	%	C.I.
Authorized												
Small (1-49)	10	2.9	±1.8	8	2.3	±1.6	3	0.9	±1.0	21	6.0	±2.6
Large (50+)	3	0.9	±1.0	1	0.3	±0.6	1	0.3	±0.6	5	1.4	±1.3
All Authorized	13	3.7	±2.0	9	2.6	±1.7	4	1.1	±1.1	26	7.5	±2.8
Non-Authorized												
Small (1-49)	164	47.1	±5.4	43	12.4	±3.5	11	3.2	±1.9	218	62.6	±5.2
Large (50 +)	76	21.8	±4.4	21	6.0	±2.6	7	2.0	±1.5	104	29.9	±4.9
All Non-Authorized	240	69.0	±5.0	64	18.4	±4.2	18	5.2	±2.4	322	92.5	±2.8
TOTAL	253	72.7	±4.8	73	21.0	±4.4	22	6.3	±2.6	348	100.0	--

TABLE 3.7

Straight Trucks:
Area of Operation by Carrier Type

Carrier Type	Area of Operation									TOTAL		
	Local			Intrastate			Interstate					
	N	%	C.I.	N	%	C.I.	N	%	C.I.	N	%	C.I.
Other	244	68.0	±4.9	63	17.5	±4.0	17	4.7	±2.2	324	90.3	±3.1
Authorized	14	3.9	±2.0	9	2.5	±1.7	4	1.1	±1.1	27	7.5	±2.8
Exempt	5	1.4	±1.2	2	0.6	±0.8	1	0.3	±0.6	8	2.2	±1.6
TOTAL	263	73.3	±4.7	74	20.6	±4.3	22	6.1	±2.5	359	100.0	--

TABLE 3.8

Straight Trucks:
Area of Operation by Fleet Size

Fleet Size	Area of Operation									TOTAL		
	Local			Intrastate			Interstate			N	%	C.I.
	N	%	C.I.	N	%	C.I.	N	%	C.I.			
1	15	4.3	±2.2	5	1.4	±1.3	1	0.3	±0.6	21	6.0	±2.5
2-5	47	13.4	±3.7	12	3.4	±1.9	2	0.6	±0.8	61	17.4	±4.1
6-49	113	32.3	±5.0	35	10.0	±3.2	11	3.1	±1.9	159	45.4	±5.3
50-399	60	17.1	±4.0	18	5.1	±2.4	7	2.0	±1.5	85	24.3	±4.6
400+	19	5.4	±2.4	4	1.1	±1.1	1	0.3	±0.6	24	6.8	±2.7
TOTAL	254	72.6	±4.8	74	21.1	±4.4	22	6.3	±2.6	350	100.0	--

TABLE 3.9

Straight Trucks:
Carrier Type by Fleet Size

Fleet Size	Carrier Type									TOTAL		
	Other			Authorized			Exempt					
	N	%	C.I.	N	%	C.I.	N	%	C.I.	N	%	C.I.
1	18	5.1	±2.4	2	0.6	±0.8				20	5.7	±2.5
2-5	57	16.2	±3.9	3	0.9	±1.0	1	0.3	±0.6	61	17.3	±4.0
6-49	138	39.2	±5.2	16	4.5	±2.2	5	1.4	±1.3	159	45.2	±5.3
50-399	81	23.0	±4.5	4	1.1	±1.1				85	24.1	±4.6
400+	26	7.4	±2.8	1	0.3	±0.6				27	7.7	±2.8
TOTAL	320	90.9	±3.1	26	7.4	±2.8	6	1.7	±1.4	352	100.0	--

TABLE 3.10

Tractors:
Area of Operation by Carrier Type and Fleet Size

Carrier Type and Fleet Size	Area of Operation									TOTAL		
	Local			Intrastate			Interstate					
	N	%	C.I.	N	%	C.I.	N	%	C.I.	N	%	C.I.
Authorized												
Small (1-49)	17	1.5	±0.7	45	4.0	±1.2	121	10.7	±1.8	183	16.2	±2.2
Large (50+)	56	5.0	±1.3	37	3.3	±1.1	279	24.8	±2.6	372	33.0	±2.8
All Authorized	73	6.5	±1.5	82	7.3	±1.5	400	35.5	±2.9	555	49.2	±3.0
Non-Authorized												
Small (1-49)	59	5.2	±1.3	84	7.5	±1.6	170	15.1	±2.1	313	27.8	±2.7
Large (50+)	31	2.8	±1.0	41	3.6	±1.1	187	16.6	±2.2	259	23.0	±2.5
All Non-Authorized	90	8.0	±1.6	125	11.1	±1.9	357	31.7	±2.8	572	50.8	±3.0
TOTAL	163	14.5	±2.1	207	18.4	±2.3	757	67.2	±2.8	1127	100.0	--

TABLE 3.11

Tractors:
Area of Operation by Carrier Type

Carrier Type	Area of Operation									TOTAL		
	Local			Intrastate			Interstate			N	%	C.I.
	N	%	C.I.	N	%	C.I.	N	%	C.I.			
Other	89	7.8	±1.6	119	10.5	±1.8	335	29.5	±2.7	543	47.8	±3.0
Authorized	73	6.4	±1.5	83	7.3	±1.5	401	35.3	±2.8	557	49.0	±3.0
Exempt	2	0.2	±0.2	7	0.6	±0.5	28	2.5	±0.9	37	3.3	±1.1
TOTAL	164	14.4	±2.1	209	18.4	±2.3	764	67.2	±2.8	1137	100.1	--

TABLE 3.12

Tractors:
Area of Operation by Fleet Size

Fleet Size	Area of Operation									TOTAL		
	Local			Intrastate			Interstate			N	%	C.I.
	N	%	C.I.	N	%	C.I.	N	%	C.I.			
1	5	0.4	±0.4	17	1.5	±0.7	38	3.3	±1.1	60	5.3	±1.3
2-5	20	1.8	±0.8	38	3.3	±1.1	72	6.3	±1.4	130	11.5	±1.9
6-49	52	4.6	±1.2	75	6.6	±1.5	184	16.2	±2.2	311	27.4	±2.6
50-399	27	2.4	±0.9	43	3.8	±1.1	211	18.6	±2.3	281	24.8	±2.6
400+	60	5.3	±1.3	35	3.1	±1.0	258	22.7	±2.5	353	31.1	±2.7
TOTAL	164	14.4	±2.1	208	18.3	±2.3	763	67.2	±2.8	1135	100.0	--

TABLE 3.13

Tractors:
Carrier Type by Fleet Size

Fleet Size	Carrier Type									TOTAL		
	Other			Authorized			Exempt					
	N	%	C.I.	N	%	C.I.	N	%	C.I.	N	%	C.I.
1	21	1.8	±0.8	33	2.8	±1.0	6	0.5	±0.4	60	5.2	±1.3
2-5	81	7.0	±1.5	35	3.0	±1.0	11	0.9	±0.6	127	10.9	±1.8
6-49	182	15.7	±2.1	116	10.0	±1.8	12	1.0	±0.6	310	26.7	±2.6
50-399	134	11.6	±1.9	144	12.4	±1.9	6	0.5	±0.4	284	24.5	±2.5
400+	135	11.6	±1.9	242	20.9	±2.4	2	0.2	±0.2	379	32.7	±2.8
TOTAL	553	47.7	±2.9	570	49.1	±2.9	37	3.2	±1.0	1160	100.0	--

tractors are operated by ICC regulated carriers (Authorized plus Exempt on this table), and that another 29.5% of the vehicles operated by non-regulated carriers are used in interstate operations. Adding these two, one would estimate that a little over 80% of the tractors should be reporting accidents to the Bureau of Motor Carrier Safety (BMCS).

Table 3.12 shows that about 31% of the tractors are operated by carriers with 400 or more air-braked power units. Looking at the relation of carrier type to fleet size shown in Table 3.13, one finds that the Authorized Carriers have nearly twice as many vehicles in the largest fleet size category as the "other" category on carrier type.

3.3 Mileage

Results in this sub-section come from the 1978 Trip Survey File. Information on vehicle use was requested on each of two randomly selected days for each survey vehicle. The number of trip surveys attempted, then, was twice the number of selected vehicles (2 x 2166 = 4332). The first results presented are simply the percent distribution of responses to the trip survey questions. These are shown in Table 3.14. As for the descriptive information, the responses are shown separately for straight trucks and tractors. Notice that the sample design distributed the surveys equally among the days of the week. The response rate quoted in Section 3.1 was based on the answer to the question on whether the selected vehicle was in use on the selected date. From Table 3.14, one sees that a total of 2,642 valid responses were obtained out of 4,236 surveys (here the non-sample vehicles have been omitted) for a 62% response rate. Some vehicles responded on only one of the survey dates so that responses were obtained from 68% of the selected vehicles (1,444). The 95% confidence intervals shown in Table 3.14 (and 3.15) were computed in the same manner as in Section 3.2.

TABLE 3.14

Responses From The Trip Survey File

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
1. Period									
One	342	49.9	±3.8	1095	49.9	±2.1	1456	49.9	±1.9
Two	344	50.1	±3.8	1097	50.1	±2.1	1459	50.1	±1.9
2. Day of Week									
Monday	106	15.5	±2.8	334	15.3	±1.5	444	15.3	±1.3
Tuesday	109	15.9	±2.8	321	14.7	±1.5	436	15.0	±1.3
Wednesday	91	13.3	±2.6	305	13.9	±1.5	407	14.0	±1.3
Thursday	99	14.5	±2.7	343	15.7	±1.6	446	15.3	±1.3
Friday	88	12.8	±2.6	303	13.8	±1.5	396	13.6	±1.3
Saturday	105	15.3	±2.8	293	13.4	±1.5	404	13.9	±1.3
Sunday	87	12.7	±2.5	291	13.3	±1.5	379	13.0	±1.3
3. In Use									
Yes	395	61.9	±3.8	1442	72.5	±2.0	1842	69.7	±1.8
No	243	38.1	±3.8	547	27.5	±2.0	800	30.3	±1.8
Unknown	48	7.0	--	203	9.3	--	273	94.	--
4. Not Used									
Being Serviced	8	3.8	±2.7	58	12.3	±3.0	67	9.8	±2.3
Not Scheduled	201	96.2	±2.7	412	87.7	±3.0	615	90.2	±2.3
Unknown	34	14.0	--	74	13.6	--	115	14.3	--
5. Brakes Serviced									
Yes	3	42.9	±40.4	6	12.0	±9.3	9	15.8	±9.7
No	4	57.1	±40.4	44	88.0	±9.3	48	84.2	±9.7
Unknown	1	12.5	--	6	10.7	--	8	12.3	--
6. Brake Failure									
Yes	3	100.0	±0.0	3	50.0	±44.7	6	66.8	±3.3
No				3	50.0	±44.7	3	33.3	±3.3
7. Mileage Source									
Records	92	26.4	±4.7	486	39.0	±2.8	578	36.2	±2.4
Estimate	257	73.6	±4.7	761	61.0	±2.8	1020	63.8	±2.4
Unknown	33	8.6	--	144	10.4	--	180	10.1	--

TABLE 3.14--Continued

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
8. Trailers									
Yes	22	5.7	±2.3	1424	99.5	±.4			
No	367	94.3	±2.3	7	.5	±.4			
Unknown	6	1.5	--	11	.8	--			
9. Single/Double									
Single				1325	93.6	±1.3			
Double				86	6.2	±1.3			
Unknown				13	.9	--			
10. First Trailer 121									
Yes				589	52.9	±3.0			
No				524	47.1	±3.0			
Unknown				311	21.8	--			
11. Trailer 1 Brake Modified									
Yes				40	11.0	±3.3			
No				323	89.0	±3.3			
Unknown				226	38.4	--			
12. Trailer 1 Anti-Skid Modified									
Yes				33	91.7	±9.3			
No				3	8.3	±9.3			
Unknown				4	10.0	--			
13. Trailer 2 121									
Yes				21	46.7	±15.0			
No				24	53.3	±15.0			
Unknown				41	47.7	--			
14. Trailer 2 Brake Modified									
Yes				0	0.0	--			
No				17	100.0	±0.0			
Unknown				4	19.0	--			

TABLE 3.14--Continued

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
15. Vehicle Type									
Straight Truck							686	23.8	±1.6
Tractor							2192	76.2	±1.6
Unknown							37	1.3	--
16. Manufacturer									
Chevrolet	86	12.6	±2.5	40	1.8	±0.6	130	4.5	±0.8
Ford	215	31.3	±3.5	362	16.5	±1.6	585	20.1	±1.5
Freightliner	4	.6	±0.6	158	7.2	±1.1	162	5.6	±0.9
GM	73	10.6	±2.4	275	12.5	±1.4	351	12.0	±1.2
IHC	162	23.6	±3.2	414	18.9	±1.7	590	20.2	±1.5
Mack	94	13.7	±2.6	302	13.8	±1.5	396	13.6	±1.3
Peterbilt	6	.9	±.7	167	7.6	±1.1	177	6.1	±.9
Kenworth	14	2.0	±1.1	248	11.3	±1.4	264	9.1	±1.1
White	12	1.7	±1.0	220	10.0	±1.3	234	8.0	±1.0
Autocar	14	2.0	±1.1	6	.3	±0.2	20	.7	±0.3
Western Star	6	.9	--	--	--	--	6	.2	±0.2
17. Cab Style									
Conventional	510	74.3	±3.3	890	41.1	±2.1	1410	48.9	±1.7
Short Conventional	88	12.8	±2.6	181	8.4	±1.2	278	9.6	±1.1
Cabover	84	12.2	±2.5	369	17.0	±1.6	464	16.1	±1.4
Cabover w/Sleeper	4	.6	±0.6	725	33.5	±2.0	734	25.4	±1.6
Unknown				27	1.2	--	29	1.0	--
18. Rear Axle									
One	286	43.4	±3.9	437	21.0	±1.8	736	26.5	±1.7
Two	338	51.3	±3.9	1574	75.5	±1.9	1929	69.6	±1.8
Three or more	35	5.3	±1.7	73	3.5	±.8	108	3.9	±.7
Unknown	27	3.9	--	108	4.9	--	142	49	--

TABLE 3.14--Continued

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
19. Antilock Mfg.									
A.C.	16	11.3	±5.3	60	7.5	±1.9	76	8.1	±1.8
Bendix	24	16.9	±6.3	40	5.0	±1.5	64	6.8	±1.6
Eaton	39	27.5	±7.5	268	33.7	±3.4	309	32.9	±3.1
Goodrich	6	4.2	±3.4	57	7.2	±1.8	63	6.7	±1.6
Kelsey Hayes	43	30.3	±7.7	257	32.3	±3.3	300	31.9	±3.0
Rockwell	14	9.9	±5.0	45	5.7	±1.6	59	6.3	±1.6
Wagner				64	8.0	±1.9	64	6.8	±1.6
Other				5	.6	±0.6	5	.5	±0.5
Unknown	544	79.3	--	1396	63.7	--	1975	67.7	--
20. Brakes Modified									
Yes	45	7.0	±2.0	122	6.2	±1.1	167	6.4	±1.0
No	595	93.0	±2.0	1856	93.8	±1.1	2455	93.6	±1.0
Unknown	46	6.7	--	214	9.8	--	293	10.1	--
21. Antilock Modified									
Yes	37	100.0	±0.0	90	90.0	±6.0	127	92.7	±4.5
No				10	10.0	±6.0	10	7.3	±4.5
Unknown	8	17.8	--	22	18.0	--	30	18.0	--
22. Carrier Type									
Private	618	90.6	±2.2	1034	47.9	±2.2	1659	58.2	±1.8
For Hire	48	7.0	±2.0	1053	48.8	±2.2	1101	38.6	±1.8
Exempt	16	2.3	±1.2	71	3.3	±.8	91	3.2	±0.7
Unknown	4	.6	--				64	2.2	--
23. Fleet Size									
1	40	6.0	±1.8	111	5.1	±1.0	151	5.3	±0.8
2-5	119	17.9	±3.0	244	11.3	±1.4	365	12.9	±1.3
6-49	300	45.2	±3.9	595	27.6	±1.9	897	31.7	±1.7
50-399	163	24.5	±3.3	547	25.4	±1.9	710	25.1	±1.6
400+	42	6.3	±1.9	659	30.6	±2.0	708	25.0	±1.6
Unknown	22	3.2	--	36	1.6	--	84	2.9	--

TABLE 3.14--Continued

VARIABLE	STRAIGHT TRUCK			TRACTOR			TOTAL		
	N	%	95% C.I.	N	%	95% C.I.	N	%	95% C.I.
24. Area of Operation									
Local	493	72.3	±3.4	307	14.2	±1.5	801	28.1	±1.7
Intrastate	149	21.8	±3.2	404	18.7	±1.7	553	19.4	±1.5
Interstate	40	5.9	±1.8	1451	67.1	±2.0	1495	52.5	±1.9
Unknown	4	.6	--	30	1.4	--	66	2.3	--
25. Trip Length									
Local	493	73.6	±3.4	307	14.7	±1.5	801	29.0	±1.7
Less than 200	157	23.4	±3.3	424	20.3	±1.8	581	21.0	±1.5
More than 200	20	3.0	±1.3	1359	65.0	±2.1	1383	50.0	±1.9
Unknown	12	1.8	--	72	3.3	--	84	2.9	--
26. Cargo Body Style									
Beverage	24	3.8	±1.5						
Dump	214	33.5	±3.7						
Fire Truck	16	2.5	±1.2						
Flatbed	76	11.9	±2.6						
Garbage	76	11.9	±2.6						
Mixer	71	11.1	±2.5						
Van--Conventional	37	5.8	±1.9						
Van--Refrigerated	18	2.8	±1.3						
Van--Furniture	6	.9	±0.8						
Tanker	40	6.3	±1.9						
Utility	18	2.8	±1.3						
Boom/Crane	4	.6	±0.6						
Other	38	6.0	±1.9						
Unknown	42	6.2	--						

Overall, about 70% of the vehicles were in service with the remaining 30% not in service. Of the vehicles not in service, about 10% were in for maintenance. On about 16% of these the maintenance involved the brake system, and in 67% of these, the reason for the maintenance was a brake system breakdown or failure.

The mileage data are not shown in this table. However, it should be noted that the mileage was estimated by the respondent (rather than coming from records) the majority of the time (64%). The next series of questions addressed the pulling of trailers. As would be expected, straight trucks seldom pulled trailers (6% of the surveys), and tractors seldom run bobtail (0.5% of the surveys). Double bottoms (two trailers) were indicated on only 6% of the surveys. The statistic which is markedly changed from the previous trip survey is the frequency with which the trailer was equipped with 121 brakes. In this survey, the trailer was equipped with 121 brakes on 53% of the surveys. Trailer brakes had been modified 11% of the time, and in over 90% of the cases the modified part was the anti-lock. It is more or less presumed that the "modification" was to disconnect the system.

The remainder of the data shown are the descriptive information on the power unit which was merged from the Company and Vehicle Description File so that the trip survey information could be categorized using these variables. Since the response rate is somewhat lower, the question arises whether the group of vehicles which were able to supply the vehicle use data are any different in composition than those supplying only the descriptive information on the company and vehicle. A comparison of the distributions in Table 3.4 with the same variables in Table 3.14 shows essentially no important differences. For example, the percentage of straight trucks is 22.4% in Table 3.4 and 23.8% in Table 3.14.

Table 3.15 shows the percentage of vehicles in use by day of the week separately for straight trucks and tractors. From this table one can see that tractors are used more on the weekends than straight trucks, as would be expected.

TABLE 3.15

Percent of Vehicles "In-Service" by Day of Week and Vehicle Type

Day of Week	Vehicle Type					
	Straight Truck			Tractor		
	N	%	C.I.	N	%	C.I.
Monday	101	77.2	±8.4	304	83.6	±4.3
Tuesday	105	74.3	±8.6	295	84.7	±4.2
Wednesday	84	76.2	±9.4	269	87.4	±4.1
Thursday	92	78.3	±8.6	299	81.6	±4.5
Friday	80	81.3	±8.8	281	81.5	±4.6
Saturday	96	33.3	±9.7	274	46.4	±6.0
Sunday	79	6.3	±5.5	265	38.5	±6.0
ALL	637	61.9	±3.8	1987	72.5	±2.0

The next two Tables, 3.16 and 3.17, show average daily mileages for the various categories formed by the exposure variables, area of operation, carrier type, and fleet size. Here, the variance in the miles per day, mpd, is computed using the common equation shown below.

$$\mathrm{Var(mpd)} = \sum_{i=1}^{n}(y_i - y)^2/(n - 1)$$

The variance of the mean mpd is obtained by dividing the result given by the equation above by n, the sample size. The 95% confidence interval on the mean is then computed as twice the square root of its variance. (The expression for the variance of a proportion given in the previous sub-section is obtained by simplification of the above expression based on the fact that, for a proportion, the variable only takes on the values 0 and 1.)

Looking at Table 3.16, the overall average daily mileage for straight trucks is 76.5 miles per day with a 95% confidence interval of ±7.9 miles per day based on 638 surveys. In other words, on each survey date we inquired about the mileage for the 24-hour period. If the vehicle was not in use a mileage of 0 was entered. The results shown were obtained by simply averaging the daily mileage totals for all straight trucks. The confidence intervals become larger as the number of surveys in any particular category becomes small. Again, these confidence intervals are appreciably better than those obtained in the fleet monitoring program. Average daily mileage does not vary from one category to another very much, except for the variation shown for the three levels on area of operation. No appreciable differences are shown with regard to fleet size or carrier type.

The overall average daily mileage for tractors is 273.7 mpd with a confidence interval of ±11.2 mpd based on 1,980 surveys. Tractor mileage also does not seem to vary much with carrier type or fleet size. As with the straight trucks, appreciable variation is shown with area of operation as would be expected.

In addition to the total mileage for the 24-hour period, interviewers also inquired about the number of miles accumulated on the survey date in each of three trip distance categories, local trips, trips with a one-way distance less than 200 miles, and trips with a one-way distance more than 200 miles. In this way the total mileage for the day could be allocated among the three levels of trip distance. Trip distance is the primary exposure variable. The next sequence of tables, 3.18 through 3.25, all present distributions of mileage by trip distance versus the other exposure variables.

TABLE 3.16

Average Daily Mileage for Straight Trucks by Area of Operation, Carrier Type, and Fleet Size

Carrier Type and Fleet Size	Area of Operation									All Areas of Operation		
	Local			Intrastate			Interstate					
	N	MPD	C.I.	N	MPD	C.I.	N	MPD	C.I.	N	MPD	C.I.
Authorized												
Small (1-49)	17	65.5	±40.3	13	73.1	±47.1	6	103.3	±101.5	36	74.6	±29.9
Large (50 +)	5	90.0	±80.0	2	50.0	±100.0				7	78.6	±61.2
All Authorized	22	71.1	±35.4	15	70.0	±42.2	6	103.3	±101.5	43	75.2	±26.7
Non-Authorized												
Small (1-49)	292	63.5	±10.3	81	115.0	±27.9	20	186.2	±81.2	395	81.0	±10.8
Large (50+)	128	61.0	±13.1	39	90.7	±34.5	11	105.5	±70.5	178	70.3	±12.9
All Non-Authorized	435	62.2	±8.0	122	106.1	±21.7	31	157.6	±59.0	592	76.6	±8.3
ALL STRAIGHT TRUCKS	459	62.5	±7.8	138	102.3	±19.7	37	148.8	±52.0	638	76.5	±7.9

TABLE 3.17

Average Daily Mileage for Tractors by Area of Operation, Carrier Type, and Fleet Size

Carrier Type and Fleet Size	Area of Operation									All Areas of Operation		
	Local			Intrastate			Interstate					
	N	MPD	C.I.	N	MPD	C.I.	N	MPD	C.I.	N	MPD	C.I.
Authorized												
Small (1-49)	30	149.2	±56.7	78	220.8	±49.6	203	318.4	±38.4	313	275.8	±29.2
Large (50 +)	95	54.8	±12.0	65	242.2	±58.2	474	335.0	±23.5	640	282.1	±20.1
All Authorized	125	77.5	±17.8	145	230.7	±37.5	678	330.6	±20.1	956	280.4	±16.5
Non-Authorized												
Small (1-49)	111	133.3	±32.7	148	202.7	±30.1	285	323.7	±29.4	544	251.9	±19.8
Large (50 +)	50	116.1	±44.8	70	224.7	±45.5	322	328.2	±30.5	446	288.1	±24.6
All Non-Authorized	163	126.9	±26.2	220	208.9	±24.9	615	328.0	±21.1	1002	269.1	±15.5
ALL TRACTORS	289	105.1	±16.9	367	217.3	±21.0	1307	328.5	±14.4	1980	273.7	±11.2

Table 3.18 shows the overall distribution of mileage by trip distance for tractors and straight trucks. A percent distribution of mileage is shown as the second row of the table which can be seen to sum to 100 at the right margin. Also shown is a breakdown of the average miles per day by trip distance. For example, straight trucks are found to put on 57.3% of their total mileage in "local" trips. When this percentage is multiplied by the total average daily mileage of 76.5 mpd, the figure shown, 43.8 mpd, is obtained. The "average" straight truck, then, may be thought of as putting on each day, 43.8 miles in local trips, 26.7 miles in trips with a one-way distance less than 200 miles, and 5.9 miles in trips with a one-way distance more than 200 miles, for a total average daily mileage of 76.5 miles. The "intercity" trip distance category is simply the sum of the "less than 200 miles" and the "more than 200 miles" categories. Overall, this table shows that straight trucks put on 43% of their mileage in intercity trips, while tractors put on 96% of their mileage in intercity trips.

Confidence intervals on the mpd figures in these two tables are computed as shown by the previous equation. Confidence intervals on the percentages must be computed as a ratio of the total miles in a particular trip distance category divided by the total mileage for all trip distance categories. A general equation for the standard errors of functions of random variables is given in Kendall and Stuart[1] as shown below.

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[1]Maurice G. Kendall and Allan Stuart, The Advanced Theory of Statistics, 3rd ed., Vol. 1 (New York, N.Y.: Hafner Publishing Co., 1969).

TABLE 3.18

Mileage by Trip Distance and Vehicle Type

Vehicle Type	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
Straight Truck	638										
Miles/Day		43.8	±5.3	26.7	±6.3	5.9	±3.8	32.6	±7.2	76.5	±7.9
Percent		57.3	±6.7	35.0	±6.6	7.7	±4.7	42.7	±6.7	100.0	--
Tractor	1980										
Miles/Day		11.9	±2.0	44.7	±4.9	217.7	±12.2	261.8	±11.6	273.7	±11.2
Percent		4.3	±0.8	16.3	±1.9	79.3	±2.0	95.7	±0.8	100.1	--

$$Var[g(x)] = \sum_{i=1}^{k}[g_i'(\theta)]^2 + \sum_{i \neq j = 1}^{k}\sum g_i'(\theta)\ g_j'(\theta)\ cov(x_i, x_j)$$

where $g(x)$ is a function $g(x_1, x_2, \ldots x_k)$,

and x_i has mean θ_i,

and $g'(\theta)$ is $\partial g/\partial x_i$ evaluated at $\theta_1, \theta_2, \ldots \theta_k$.

This equation for the variance of the function $g(x)$ is an approximation obtained by taking the terms of the Taylor expansion of $g(x)$ shown below.

$$g(x) = g(\theta) + \sum g_i'(\theta)\ (x_i - \theta)$$

For a ratio of population totals, $g(x) = x_1/x_2$ where x_1 and x_2 are population totals. Using the expression from Kendall and Stuart, the variance of a ratio of population totals can be shown to be given by:

$$Var(x_1/x_2) = (x_1/x_2)^2\ [Var(x_1/x_1^2 + var(x_2)/x_2^2 - 2cov(x_1, x_2)/x_1^2\ x_2^2]$$

Notice that the covariance term must be computed for this expression. As before, the 95% confidence interval is computed as twice the square root of the variance.

Tables 3.19 through 3.21 show distributions of mileage by trip distance versus carrier type, fleet size, and area of operation respectively. Only area of operation, Table 3.21, appreciably influences the distribution of mileage by trip distance.

Table 3.22 shows the distribution of trip distance by cab style for tractors. Cabover tractors are shown to put on a higher percentage of their total mileage (88.8% versus 65.7%) in long haul trips (more than 200 miles one-way distance). Also, the average daily mileage for the cabovers is nearly 50% higher than the conventional cab vehicles

Tables 3.23 to 3.25 show the distribution of mileage by trip distance versus carrier type, fleet size, and area of operation for tractors. A result similar to that for straight trucks is observed.

TABLE 3.19

Straight Trucks:
Mileage Apportioned by Trip Distance and Carrier Type

Carrier Type	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
Other	578										
Miles/Day		44.3	±5.6	25.6	±6.6	6.0	±4.1	31.5	±7.6	75.8	±8.4
Percent		58.4	±7.2	33.7	±7.0	7.9	±5.1	41.6	±7.2	100.0	
Authorized	43										
Miles/Day		35.4	±20.3	39.8	±23.8	0.0	--	39.8	±23.8	75.2	±26.7
Percent		47.1	±23.3	52.9	±23.3	0.0	--	52.9	±23.3	100.0	
Exempt	14										
Miles/Day		46.4	±42.5	40.7	±44.6	21.4	±42.9	62.1	±57.3	108.6	±57.6
Percent		42.8	±37.2	37.5	±36.9	19.7	±35.3	57.2	±37.2	100.0	
ALL STRAIGHT TRUCKS	638										
Miles/Day		43.8	±5.3	26.7	±6.3	5.9	±3.8	32.6	±7.2	76.5	±7.9
Percent		57.3	±6.7	35.0	±6.6	7.7	±4.7	42.7	±6.7	100.0	

TABLE 3.20

Straight Trucks:
Mileage Apportioned by Trip Distance and Fleet Size

Fleet Size	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
1	37										
Miles/Day		31.9	±17.5	35.4	±28.9	0.0	--	35.4	±28.9	67.4	±29.8
Percent		47.4	±27.2	52.6	±27.2	0.0	--	52.6	±27.2	100.1	
2-5	111										
Miles/Day		48.3	±14.3	16.8	±10.9	0.0	--	16.8	±10.9	65.1	±16.3
Percent		74.1	±14.6	25.9	±14.6	0.0	--	25.9	±14.6	100.0	
5-49	289										
Miles/Day		43.3	±8.0	32.8	±10.9	11.9	±8.1	44.7	±13.2	88.0	±13.5
Percent		49.2	±9.6	37.3	±9.8	13.5	±8.4	50.8	±9.6	100.0	
50-399	146										
Miles/Day		47.8	±11.7	24.9	±11.5	0.0	--	24.9	±11.5	72.7	±14.3
Percent		65.8	±12.9	34.2	±12.9	0.0	--	34.2	±12.9	100.0	
400+	39										
Miles/Day		38.2	±16.5	15.6	±18.4	9.0	±17.9	24.6	±25.2	62.8	±26.6
Percent		60.9	±28.6	24.9	±25.3	14.3	±25.6	39.1	±28.6	100.0	
ALL STRAIGHT TRUCKS	638										
Miles/Day		43.8	±5.3	26.7	±6.3	5.9	±3.8	32.6	±7.2	76.5	±7.9
Percent		57.3	±6.7	35.0	±6.6	7.7	±4.7	42.7	±6.7	100.0	

TABLE 3.21

Straight Trucks:
Mileage Apportioned by Trip Distance and Area of Operation

Area of Operation	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
Local	459										
Miles/Day		51.5	±3.7	9.2	±2.5	1.7	±1.4	11.0	±2.9	62.5	±4.4
Percent		82.4	±4.1	14.8	±3.7	2.8	±2.2	17.6	±4.1	100.0	
Intrastate	138										
Miles/Day		24.6	±9.1	72.3	±19.6	5.4	±7.7	77.7	±20.5	102.3	±19.7
Percent		24.0	±9.4	70.7	±11.0	5.3	±7.3	76.0	±9.4	100.0	
Interstate	37										
Miles/Day		24.2	±17.6	77.0	±40.8	47.6	±46.7	124.6	±55.1	148.8	±52
Percent		16.3	±13.2	51.7	±24.1	32.0	±25.2	83.7	±13.2	100.0	
ALL STRAIGHT TRUCKS	638										
Miles/Day		43.8	±5.3	26.7	±6.3	5.9	±3.8	32.6	±7.2	76.5	±7.9
Percent		57.3	±6.7	35.0	±6.6	7.7	±4.7	42.7	±6.7	100.0	

TABLE 3.22

Tractors:
Mileage Apportioned by Trip Distance and Cab Style

Cab Style	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
Conventional	989										
Miles/Day		19.0	±3.4	56.9	±7.8	145.7	±14.4	202.7	±14.1	221.7	±13.4
Percent		8.6	±1.7	25.7	±3.5	65.7	±3.8	91.4	±1.7	100.0	
Cabover	970										
Miles/Day		4.5	±2.1	32.1	±6.0	287.6	±18.9	319.7	±17.8	324.2	±17.6
Percent		1.4	±0.6	9.9	±1.9	88.7	±2.0	98.6	±0.6	100.0	

TABLE 3.23

Tractors:
Mileage Apportioned by Trip Distance and Carrier Type

Carrier Type	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
Other	941										
Miles/Day		14.4	±3.4	52.3	±7.6	195.2	±17.1	247.5	±16.2	261.90	±15.6
Percent		5.5	±1.4	20.0	±3.0	74.5	±3.3	94.5	±1.4	100.0	
Authorized	956										
Miles/Day		9.7	±2.5	37.9	±6.7	232.8	±17.8	270.7	±17.0	280.4	±16.5
Percent		3.5	±0.9	13.5	±2.5	83.0	±2.7	96.5	±0.9	100.0	
Exempt	61										
Miles/Day		10.8	±8.6	36.9	±21.5	332.5	±87.2	369.4	±80.1	380.1	±77.2
Percent		2.8	±2.5	9.7	±6.4	87.5	±7.1	97.2	±2.5	100.0	
ALL TRACTORS	1980										
Miles/Day		11.9	±2.0	44.7	±4.9	217.7	±12.2	261.8	±11.6	273.7	±11.2
Percent		4.3	±0.8	16.3	±1.9	79.3	±2.0	95.7	±0.8	100.0	

TABLE 3.24

Tractors:
Mileage Apportioned by Trip Distance and Fleet Size

Fleet Size	N	Trip Distance								TOTAL	
		Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity ALL			
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
1	97										
Miles/Day		12.9	±10.1	45.5	±21.9	241.1	±59.6	286.7	±55.8	299.6	±54.3
Percent		4.3	±3.5	15.2	±7.8	80.5	±8.8	95.7	±3.5	100.0	
2-5	220										
Miles/Day		14.9	±7.7	71.3	±17.8	193.5	±35.9	264.8	±33.2	279.6	±31.9
Percent		5.3	±2.9	25.5	±6.8	69.2	±7.3	94.7	±2.9		
6-49	549										
Miles/Day		13.6	±4.4	47.8	±9.0	184.3	±22.0	232.1	±20.9	245.7	±20.3
Percent		5.6	±1.9	19.4	±3.9	75.0	±4.3	94.4	±1.9	100.0	
50-399	493										
Miles/Day		8.5	±3.5	47.5	±9.9	217.5	±25.2	265.0	±23.8	273.5	±23.3
Percent		3.1	±1.3	17.4	±3.8	79.5	±4.1	96.9	±1.3	100.0	
400+	597										
Miles/Day		11.5	±3.0	30.1	±8.2	251.4	±22.5	281.5	±21.7	293.0	±20.9
Percent		3.9	±1.1	10.3	±2.8	85.8	±3.1	96.1	±1.1	100.0	
ALL TRACTORS	1980										
Miles/Day		11.9	±2.0	44.7	±4.9	217.7	±12.2	261.8	±11.6	273.7	±11.2
Percent		4.3	±0.8	16.3	±1.9	79.3	±2.0	95.7	±0.8	100.0	

TABLE 3.25

Tractors:
Mileage Apportioned by Trip Distance and Area of Operation

Area of Operation	N	Trip Distance: Local		Trip Distance: Intercity (<200 Miles)		Trip Distance: Intercity (>200 Miles)		Trip Distance: Intercity ALL		TOTAL	
		Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.	Mean	C.I.
Local	289										
Miles/Day		48.2	±9.1	24.7	±8.8	32.1	±14.9	56.8	±16.7	105.1	±16.9
Percent		45.9	±9.6	23.6	±7.9	30.5	±11.0	54.1	±9.6	100.0	
Intrastate	367										
Miles/Day		14.2	±5.5	117.7	±16.8	85.4	±20.2	203.2	±21.7	217.3	±21.0
Percent		6.5	±2.6	54.2	±7.2	39.3	±7.3	93.5	±2.6	100.0	
Interstate	1307										
Miles/Day		3.3	±1.4	28.4	±4.8	296.8	±15.5	325.2	±14.6	328.5	±14.4
Percent		1.0	±0.4	8.6	±1.5	90.3	±1.6	99.0	±0.4		
ALL TRACTORS	1980										
Miles/Day		11.9	±2.0	44.7	±4.9	217.7	±12.2	261.8	±11.6	273.7	±11.2
Percent		4.3	±0.8	16.3	±1.9	79.3	±2.0	95.7	±0.8	100.1	

The last series of tables in this section address the distribution of mileage by trailer type. Table 3.26 shows the use of trailers by straight trucks. Overall, trailers are pulled for only 10% of the vehicle's total mileage. A similar distribution is shown for tractors, but including the trip distance variable in Table 3.27. Bobtail mileage is shown to be only 0.4% of the total intercity mileage.

TABLE 3.26

Straight Trucks:
Percent Miles by Trailer Use
(N=389)

Trailer Use	Percent Miles	95% C.I.
No Trailer	89.8	±4.8
Trailer	10.2	±4.8
TOTAL	100.0	--

Information on the type and number of trailers pulled is shown in Tables 3.28 and 3.29. Table 3.28 indicates that, for tractors, 58.3% of the intercity trailer mileage is accumulated while pulling a trailer equipped with 121 brakes. This figure is substantially higher than the 21.5% obtained in the earlier Trip Survey for post-standard 1975 tractors. In Table 3.29, slightly less than 7% of the intercity trailer mileage is attributed to doubles (two trailers).

The last two tables present distributions of the total intercity daily mileage for tractor by the type of trailer pulled. The total mpd at the bottom of Table 3.30 is the overall intercity mpd for tractors taken from Table 3.23. As was done with trip distance, this total is then

TABLE 3.27

Tractors:
Percent Distribution of Mileage by Trailer Use and Trip Distance*

Trailer Use	Trip Distance								TOTAL	
	Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity (ALL)			
	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.
No Trailer	0.6	±0.9	0.7	±1.0	0.3	±0.4	0.4	±0.3	0.4	±0.3
Trailer	99.4	±0.9	99.3	±1.0	99.7	±0.4	99.6	±0.3	99.6	±0.3
TOTAL	100.0		100.0		100.0		100.0		100.0	

*N=1,422.

TABLE 3.28

Tractors:
Percent Distribution of Mileage by Trailer Brake Type and Trip Distance*

Trailer Brake Type	Trip Distance								TOTAL	
	Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity (ALL)			
	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.
Pre-Standard	59.0	±10.3	54.8	±6.6	39.0	±4.0	41.7	±3.5	42.5	±3.4
Post-Standard	41.0	±10.3	45.2	±6.7	61.0	±4.0	58.3	±3.5	57.5	±3.4
TOTAL	100.0		100.0		100.0		100.0		100.0	

*N=1,110.

TABLE 3.29

Tractors:
Percent Distribution of Mileage by Number of Trailers and Trip Distance*

Number of Trailers	Trip Distance								TOTAL	
	Local		Intercity (<200 Miles)		Intercity (>200 Miles)		Intercity (ALL)			
	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.	Percent Miles	C.I.
One Trailer	91.2	±6.3	94.4	±3.0	93.0	±1.8	93.3	±1.6	93.2	±1.5
Two Trailers	8.8	±6.3	5.6	±3.0	7.0	±1.8	6.7	±1.6	6.8	±1.5
TOTAL	100.0		100.0		100.0		100.0		100.0	

*N=1,403.

distributed among the three trailer types shown. The bobtail (no trailer) mpd is obtained by multiplying the percentage of intercity miles bobtail from Table 3.27 by the total intercity mpd for tractors. The mpd with a pre-standard trailer, shown in Table 3.31, is a product of the percent trailer miles intercity from Table 3.27, the percent pre-standard trailer miles intercity (given a trailer was pulled) from Table 3.28, and the total intercity mpd for tractors from Table 3.23. The equation from Kendall and Stuart referenced earlier can also be used to develop the variance expression for these statistics. This expression includes terms for the variance of each of the five terms involved (numerator and denominator for the two ratios) and 20 covariance terms.

TABLE 3.30

Tractors:
Average Daily Mileage in Intercity Trips
by Number of Trailers

Number of Trailers	Miles Per Day	C.I.
None (Bobtail)	1.1	±1.0
One Trailer (Single)	243.3	±12.0
Two Trailers (Double)	17.5	±4.4
TOTAL	261.8	±11.6

TABLE 3.31

Tractors:
Average Daily Mileage in Intercity Trips
by Trailer Type

Trailer Type	Miles Per Day	C.I.
None (Bobtail)	1.1	±1.0
Pre-Standard	108.7	±11.4
Post-Standard	152.0	±14.4
TOTAL	261.8	±11.6

This formulation of the exposure data simplifies the variance estimation for the total vehicle miles which is the topic of the next section.

SECTION 4

EXPOSURE PROJECTIONS

The previous two sections have described the collection of data on the average daily mileage for 1974-1977 model year vehicles during the calendar years 1976-1978 in various exposure categories. The objective of this work is to produce national exposure estimates in vehicle miles which are compatible with the accident information collected through the NHTSA Fatal Accident Reporting System (FARS) and the Bureau of Motor Carrier Safety. Estimates of the number of vehicles in service for each model year in each calendar year are needed in order to use the data from the previous sections to estimate the national exposure of pre- and post-standard vehicles.

Unfortunately, the information necessary to provide a direct answer to this problem is not currently available. Published statistics do not distinguish air-braked trucks from the large numbers of lighter trucks. Furthermore, truck model years are not well defined, which turns out to be the most troublesome aspect of this problem.

The R.L. Polk Company publishes the number of "new registrations" by calendar month and by weight class. However, this tabulation does not currently include the model year of the vehicle. Similarly, the Motor Vehicle Manufacturers Association (MVMA) publishes factory sales by calendar month and weight class. Historically, the model year of a truck has not been identified by the manufacturer as is done with passenger cars in the Vehicle Identification Number (VIN). Each state has procedures for assigning a model year for registration purposes. Usually the model year is taken to be the calendar year at either the time of registration, the time of sale, or time at which the vehicle was delivered to the dealer. For trucks, then, model year is really only defined in the state registration files!

The first part of this section attempts to estimate the number of vehicles in service by model year using factory sales data and various assumptions on the time lag between production and registration. Supplementary statistics supplied by the MVMA allow the estimation of air-braked trucks and tractors in these data. This sub-section concludes with estimates of the number of air-braked straight trucks and tractors by model year and calendar year.

In the next section, 4.2, estimates of total vehicle miles are computed using the numbers of vehicles in use and the average daily mileage estimates from the previous sections. Confidence intervals are also computed. In the last sub-section, the sensitivity of the vehicle miles figures is examined.

4.1 Vehicles in Use

The primary data source used in this sub-section is the MVMA monthly statistics which tabulate factory sales by weight class. Specifically, the "Domestic Sales" plus the "Canadian Exports to the U.S." were used. Several problems have to be dealt with before factory sales can be used to estimate the number of vehicles in service. The desired vehicle population for this study is, of course, air-braked vehicles. Since vehicles equipped with air-brakes are not identified in any of the available tabulations, weight class is used as a surrogate. A first approximation is to take all Class 7 and 8 vehicles (GVWR >26,000 pounds). For the 1978 Interim Report, this estimation was refined to 15% of Class 6, plus 85% of Class 7, plus 100% of Class 8. In an effort to improve upon this approximation, NHTSA requested information from the MVMA on the number of air-braked vehicles produced during 1974-1978. Additionally, they requested that straight trucks and tractors be tabulated separately. This breakdown had previously been shown to be most critical to the exposure estimation. MVMA responded with the information in Table 4.1. The accompanying letter, which is reproduced in Appendix A, stipulated that MVMA was not able to perform audit procedures, and that the individual manufacturers advised that direct tabulations were not possible so that subjective estimates were necessary in some cases.

The monthly statistics published by MVMA were used to provide the total number of vehicles produced in each calendar year, shown in Table 4.2. By dividing the MVMA supplied figures shown in Table 4.1 by the figures in Table 4.2, the percent of each weight class which is air-braked can be computed. This result is shown in Table 4.3. There are some small inconsistencies which show up in the percentages for Class 8, in particular the total of 113% for the 1975 calendar year.

Also taken from the MVMA supplementary statistics shown in Table 4.1, are the percentage of air-braked vehicles which are tractors in each calendar year. This information is repeated in Table 4.4. These results are somewhat different from the percentages obtained from the surveys which were described in Sections 2 and 3 of this report. For example, 72% of the 1974 model year vehicles in the Fleet Monitoring Program were tractors, while 47% of the 1975 model year vehicles in this program were tractors. In the survey of 1977 model year vehicles, nearly 77% of the vehicles were found to be tractors. It is not clear what biases may be operating, but the MVMA percentages will be used for this analysis.

The percentages of air-braked vehicles by weight class, Table 4.3, and the percentage of tractors, Table 4.4, were

TABLE 4.1

MVMA-Supplied Air-Braked Truck/Tractor Summary*
(G.V.W.R. in Lbs.)

Model Year	TRUCKS				TRACTORS				TOTAL			
	19,501-26,000	26,001-33,000	33,001 & Over	Total	19,501-26,000	26,001-33,000	33,001 & Over	Total	19,501-26,000	26,001-33,000	33,001 & Over	Total
1974	25,726	14,689	46,656	87,071	8,182	12,182	102,779	123,143	33,908	26,871	149,435	210,214
1975	19,892	12,857	29,711	62,397	6,581	7,600	48,729	62,910	26,410	20,457	78,440	125,307
1976	13,240	10,863	26,556	50,659	3,967	5,995	70,453	80,415	17,207	16,858	97,009	131,074
1977	14,475	13,057	34,188	61,720	5,408	10,398	110,413	126,219	19,883	23,455	144,601	187,939
1978	14,436	15,686	39,898	70,020	5,299	9,557	114,970	129,826	19,735	25,243	154,868	199,846

*Above data subject to stipulations outlined in the February 14, 1979 letter to Mr. Harry Close (see Appendix A).

TABLE 4.2

Factory Sales by Weight Class and Calendar Year
for U.S. Domestic and Canadian Exports to U.S.

Calendar Year	Weight Class		
	6	7	8
1974	183,540	31,063	158,320
1975	117,510	22,761	69,032
1976	119,990	21,461	99,057
1977	132,170	31,518	146,800

Source: MVMA monthly production statistics.

TABLE 4.3

Percent Air-Braked Vehicles by Weight Class
and Calendar Year

Calendar Year	Weight Class		
	6	7	8
1974	18.5	86.5	94.4
1975	22.5	89.9	113.6
1976	14.3	78.6	97.9
1977	15.0	74.4	98.5

used to adjust the monthly factory sales figures. This adjustment produced a monthly tabulation of air-braked factory sales separately for tractors and straight trucks. This result is presented in Table 4.5 beginning with January 1974 and ending with December 1977. This same adjustment

TABLE 4.4

Percent Tractors by Calendar Year

Calendar Year	Percent Tractors
1974	58.6
1975	50.2
1976	61.4
1977	67.2

was applied to the monthly registration data, except that a two-month lag between production and registration was assumed. This result is presented in Table 4.6. A plot of the adjusted factory sales data and the adjusted new registrations by month is shown in Figure 4.1. The result is not particularly satisfying. Early in 1974, production exceeded registrations. During 1975 production dropped way off, and registrations now exceeded production. Industry publications during this time period generally described rising factory inventories during 1974 coupled with "over-buying" on the part of some large fleets, which frequently involved placing multiple orders with several manufacturers. Delivery was not always taken on all of the orders placed. The stage would seem to have been set for substantial drops in production in 1975. Indeed, factory sales show a sharp decline which began in late 1974 and continued through 1975 before leveling off at the end of the year. This situation is also due, in part, to a depressed economic condition in the trucking industry in mid-1975. Registrations, however, continued strongly until nearly the end of 1975 before dropping off also. This delay in the decline of registrations is thought to be due to a lag in the purchasing and subsequent registration of the substantial inventories of pre-standard vehicles which were produced.

TABLE 4.5: Adjusted Monthly Factory Sales

Month		Adj. Total	Tractors	Straight Trks.
1974	January	19190.0	11246.0	7944.9
	February	17798.0	10430.0	7368.4
	March	21181.0	12412.0	8768.7
	April	19122.0	11206.0	7916.7
	May	19136.0	11214.0	7922.4
	June	17137.0	10042.0	7094.8
	July	16929.0	9920.5	7008.7
	August	15651.0	9171.4	6479.4
	September	17664.0	10351.0	7312.9
	October	19678.0	11531.0	8146.6
	November	14079.0	8250.5	5828.8
	December	12708.0	7446.6	5260.9
1975	January	12386.0	6217.9	6168.4
	February	13572.0	6813.2	6759.0
	March	12973.0	6512.6	6460.7
	April	11688.0	5867.3	5820.5
	May	10840.0	5441.5	5398.2
	June	9840.4	4939.9	4900.5
	July	9108.1	4572.2	4535.8
	August	7679.5	3855.1	3824.4
	September	9357.4	4697.4	4660.0
	October	10846.0	5444.8	5401.4
	November	7971.3	4001.6	3969.7
	December	9060.8	4548.5	4512.3
1976	January	7236.5	4443.2	2793.3
	February	8155.1	5007.2	3147.9
	March	10994.0	6750.2	4243.6
	April	11266.0	6917.1	4348.5
	May	11418.0	7010.4	4407.2
	June	12246.0	7518.9	4726.9
	July	11042.0	6779.6	4262.1
	August	11471.0	7043.2	4427.8
	September	11793.0	7240.9	4552.1
	October	11889.0	7299.6	4589.0
	November	11135.0	6836.8	4298.0
	December	12360.0	7589.3	4771.1
1977	January	12373.0	8314.4	4058.2
	February	12355.0	8302.9	4052.6
	March	16823.0	11305.0	5518.0
	April	15860.0	10658.0	5202.2
	May	16852.0	11324.0	5527.3
	June	18319.0	12310.0	6008.7
	July	14639.0	9837.2	4801.5
	August	15573.0	10465.0	5107.8
	September	17233.0	11581.0	5652.6
	October	18487.0	12424.0	6063.9
	November	15024.0	10096.0	4927.9
	December	14334.0	9632.3	4701.5

TABLE 4.6: Adjusted Monthly New Registrations

Month		Adj. Total	Tractors	Straight Trks.
1974	January	17011.0	9968.3	7042.5
	February	13424.0	7866.4	5557.5
	March	15202.0	8908.1	6293.4
	April	16304.0	9554.0	6749.7
	May	16191.0	9487.7	6702.9
	June	15144.0	8874.6	6269.8
	July	16968.0	9943.0	7024.6
	August	18301.0	10725.0	7576.8
	September	16345.0	9578.4	6767.0
	October	18586.0	10891.0	7694.4
	November	13393.0	7848.5	5544.9
	December	16429.0	9627.6	6801.8
1975	January	13843.0	8112.0	5731.0
	February	10262.0	6013.3	4248.3
	March	13104.0	6578.3	6525.8
	April	12106.0	6077.1	6028.6
	May	13998.0	7027.2	6971.2
	June	13628.0	6841.1	6786.6
	July	14143.0	7099.7	7043.1
	August	16008.0	8036.2	7972.2
	September	16632.0	8349.4	8282.8
	October	16176.0	8120.1	8055.4
	November	11599.0	5822.8	5776.5
	December	13839.0	6947.2	6891.8
1976	January	10479.0	5260.3	5218.4
	February	10247.0	5143.9	5102.9
	March	9825.5	6032.8	3792.6
	April	11031.0	6773.3	4258.1
	May	12211.0	7497.3	4713.3
	June	11069.0	6796.3	4272.6
	July	12256.0	7525.1	4730.8
	August	14710.0	9031.9	5678.0
	September	14163.0	8695.8	5466.7
	October	11883.0	7296.3	4586.9
	November	10124.0	6216.0	3907.8
	December	13016.0	7991.7	5024.1
1977	January	9770.7	5999.2	3771.5
	February	9351.2	5741.6	3609.5
	March	9752.2	6553.5	3198.7
	April	10132.0	6808.5	3323.2
	May	11447.0	7692.1	3754.5
	June	12948.0	8701.2	4247.0
	July	11364.0	7636.9	3727.5
	August	13150.0	8836.5	4313.0
	September	14983.0	10068.0	4914.3
	October	13019.0	8748.7	4270.2
	November	10991.0	7386.0	3605.1
	December	14503.0	9746.1	4757.0

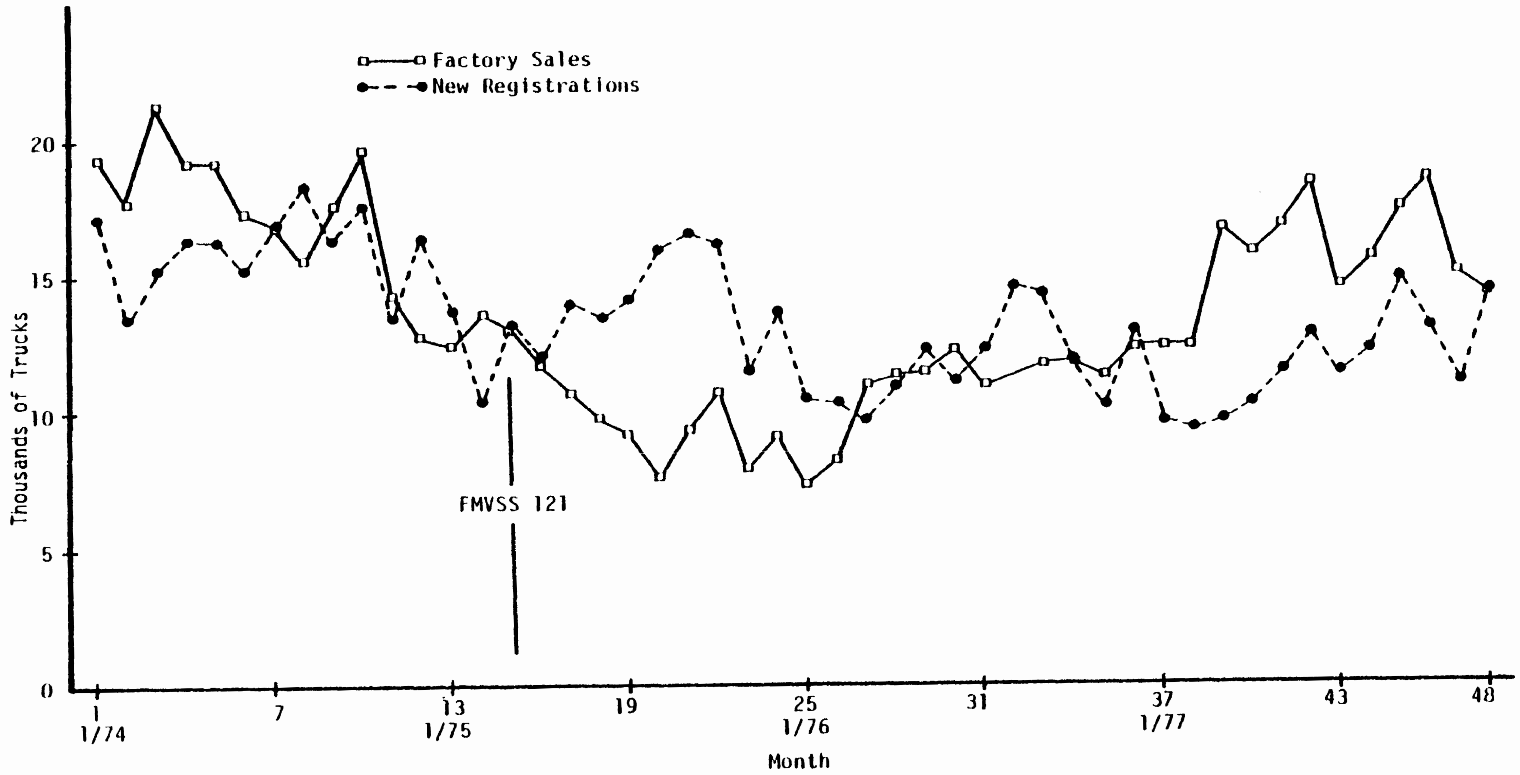

FIGURE 4.1 ADJUSTED FACTORY SALES AND NEW REGISTRATIONS BY MONTH

Factory sales show a slow recovery during 1976 which picks up during 1977. In general, the trucking industry was also described as "recovering" during this period. What is particularly puzzling, is that the registrations do not keep pace with factory sales during 1977.

Obviously, vehicles are not put into service immediately upon production. There is some time lag due to delivery, sales, and body building, even for tractors. The difficult question is: how long is the delay? For this analysis, three assumptions are tried, two, three, and four months. The general assumption is that a vehicle's model year designation will be determined by the calendar year in which it is first registered. The FARS files show a small number of new model year vehicles in accidents in November and December of the previous calendar year, so one knows that this assumption is not completely correct. In fact, the most likely situation is that the effective production and registration period for any particular model year is something different than 12 months in order to account for varying inventories. At this point, we are simply trying to cover the range in the hope that incorrect assumptions will be apparent through inconsistent results, or that the results will be insensitive to this assumption.

Generally, the manufacturers report that, for heavy trucks, the new model year production starts in October or November of the previous calendar year. Therefore, a two month lag in registration would be consistent with taking January through December registrations and production starting in November. Similarly, a three month lag would be consistent with production starting in October, and a four month lag with production starting in September. The possibilities are endless, but it is hoped that these choices reasonably span the range. Tables 4.7 through 4.9 show the resulting numbers of new vehicles in each "model year" corresponding to the three assumptions on time lag when applied to the adjusted monthly factory sales data in Table 4.5. In each case, the pre/post standard is determined by the March 1, 1975 effective date which applied to the production of the vehicle. In general, the numbers of vehicles in each model year do not vary much across these tables. Sensitivity will be discussed more fully in the last part of this section.

TABLE 4.7

Number of Vehicles by Model Year:
Two Month Lag (November-October)

Model Year	Straight Truck	Tractor	TOTAL
1974	90,455	128,035	218,490
1975	65,019	70,059	135,080
Pre	24,017	28,728	52,745
Post	41,001	41,331	82,332
1976	49,980	74,560	124,454
1977	61,062	120,950	182,010

TABLE 4.8

Number of Vehicles by Model Year:
Three Month Lag (October-September)

Model Year	Straight Truck	Tractor	TOTAL
1974	89,345	126,465	215,810
1975	67,764	76,145	143,910
Pre	32,164	40,259	72,423
Post	35,601	35,886	71,487
1976	50,793	72,706	123,500
1977	59,587	115,820	175,410

TABLE 4.9

Number of Vehicles by Model Year:
Four Month Lag (September-August)

Model Year	Straight Truck	Tractor	TOTAL
1974	88,654	125,486	214,140
1975	70,417	81,799	152,217
Pre	39,477	50,610	90,087
Post	30,941	31,189	62,130
1976	50,901	70,162	121,060
1977	58,487	111,480	169,970

The preceding discussion has covered the estimation of the number of new air-braked straight trucks and tractors introduced in each model year. Exposure projections are desired for the calendar years 1976-1978. Additional factors which need to be addressed are non-sample vehicles, vehicle use in the introductory year, and scrappage. Adjustments in vehicle mileage with age are not made since the survey periods pretty well span the time period of interest. This topic is covered in the next sub-section. For the most part, information on the total number of non-sample vehicles was not obtained as part of the sampling frame, since, in the context of the original fleet monitoring program, it was appropriate to simply request that they be deleted from the sales lists. The vehicles considered here as non-sample are basically those of the "wrong" brake type for their model year. Throughout the time the standard has been in effect, certain vehicles, like auto carriers, have been exempt from portions of the standard. Similarly, during the 1974 model year, some vehicles were fitted with prototype 121 hardware. These vehicles of anomalous brake type show up in the interviews on the FARS reported cases. The accident data, in fact, provide us with our only estimate of overall percentage of these vehicles. Three percent of the FARS-reported 1974 model year vehicles were reported to have 121 brakes. For 1976 model year vehicles, 7% were reported to not have 121 brakes, and for the 1977 model year, 5% were reported to be non-121. Of course, one might suspect that these are simply reporting errors. However, interviewers were instructed to point out to the respondent that their response to the brake type question was unusual, considering the model year of the vehicle, and request additional information. Usually, the respondent would, in fact, describe an appropriate situation like prototype hardware, or an exempt vehicle type. Recalls were also made on the majority of these cases, with few changes in the responses. It was decided that it would be best to delete these vehicles from the accident group, and to delete a similar percentage from the vehicles in service. This effectively assumes that these vehicles are neither under- nor over-involved in accidents in comparison with the rest of their model year class.

The second adjustment factor addresses the exposure during the introductory year. For the previous analysis, new model vehicles were assumed to be introduced during the calendar year. Monthly tabulations of new registrations were used to estimate a factor for the proportion of the introductory year that the "average" vehicle was in service. This factor was 0.46. However, accident rates for the introductory years for 1976 and 1977 model year vehicles were somewhat higher than for the first full year of exposure.

Conrad Cooke of the NHTSA has suggested that November through October is a more appropriate registration period to use. This suggestion is based on his analysis of a tabulation published by R.L. Polk which is found in the Automotive Industry Statistical Issue. This table is derived from registration data, and shows the number of registered vehicles by "year-model" and manufacturer as of July 1 of each year. A comparison of July 1 totals for the introductory year and for the first full year indicates that about 69% of the total are registered by July 1 of the introductory year. Assuming registrations to be constant each month, this percentage is equivalent to 8 registration months which implies a November 1 start for new model year registrations. This computation can only be made for manufacturers which produce exclusively Class 7 and 8 vehicles (Diamond Reo, Kenworth, Mack, Peterbilt, White, and Freightliner). Use of a November 1 starting date for each model year produces introductory year exposure factors of 0.55-0.60.

This suggestion certainly increases the exposure during the introductory year. In fact, it tends to produce somewhat reduced accident rates in the introductory year as compared to the first full year. As with the previous vehicle population data, further examination of this approach raises additional questions. For example, a comparison of the November through October sum of "new registrations" for these manufacturers produces totals which are 9%-15% higher than the July 1 "year-model" total. Also, one might expect that the lag between production and registration would be somewhat less for these manufacturers since they produce proportionately more tractors than the manufacturers not included. A plot of the percentage of all registrations accounted for by these manufacturers by month shows a systematic variation ranging from 46%-32%. The low point occurs in August 1975.

Certainly some new model year vehicles are registered prior to January 1 of each year. However, there does not seem to be a good way to quantify this fact. Arbitrarily, factors ranging from 0.50-0.60 have been applied to the model year totals for the introductory year.

The final adjustment to be applied is intended to account for scrappage of some vehicles each year. No figures were found which directly applied. A review of the year-to-year decreases in the tabulations of vehicles by make and "year-model" published by R.L. Polk for the subset of manufacturers listed above suggested that reasonable scrappage rates might be 1% for the second year of use, 3% for the third, and 6% for the fourth.

Table 4.10 summarizes the product of these three adjustments (non-sample, scrappage, and introductory year) by model year and calendar year. Multiplication of these factors by the numbers of vehicles shown in Tables 4.7 through 4.9 produce the adjusted numbers of air-braked vehicles in use by model year, calendar year, and vehicle type (34 cells including the split of 1975 model year into pre-standard and post-standard). These results are shown in Tables 4.11 to 4.13. These figures are used to compute vehicle miles in the next sub-section.

TABLE 4.10

Adjustments to Number of Vehicles

Model Year	Calendar Year		
	1976	1977	1978
1974	0.96	0.941	0.912
1975	1.00	0.990	0.970
1976	0.93f*	0.930	0.921
1977	---	0.950f*	0.950

*Introductory year adjustment: two month lag, f=0.50; three month lag, f=0.55; four month lag, f=0.60.

TABLE 4.11

Number of Vehicles In Use
(Two Month Lag)

Model Year	Calendar Year 1976 Straight Truck	1976 Tractor	1977 Straight Truck	1977 Tractor	1978 Straight Truck	1978 Tractor
1974	86,864	122,952	85,109	120,468	82,477	116,742
1975	65,019	70,059	64,369	69,358	63,068	67,957
Pre	24,017	28,728	23,777	28,441	23,296	27,866
Post	41,001	41,331	40,591	40,918	39,771	40,091
1976	23,240	34,670	46,481	69,341	46,032	68,670
1977	--	--	28,852	57,149	57,704	114,298

TABLE 4.12

Number of Vehicles In Use
(Three Month Lag)

Model Year	Calendar Year 1976 Straight Truck	1976 Tractor	1977 Straight Truck	1977 Tractor	1978 Straight Truck	1978 Tractor
1974	85,771	121,406	84,074	119,004	81,483	115,336
1975	67,764	76,145	67,086	75,384	65,731	73,861
Pre	32,164	40,259	31,842	39,856	31,199	39,051
Post	35,601	35,886	35,245	35,527	34,533	34,809
1976	25,981	37,189	47,237	67,617	46,780	66,962
1977	---	---	30,970	60,197	56,310	109,450

TABLE 4.13

Number of Vehicles In Use
(Four Month Lag)

Model Year	1976 Straight Truck	1976 Tractor	1977 Straight Truck	1977 Tractor	1978 Straight Truck	1978 Tractor
1974	85,108	120,467	83,423	118,082	80,852	114,443
1975	70,417	81,799	69,713	80,981	68,306	79,345
Pre	39,477	50,610	39,082	50,104	38,293	49,092
Post	30,941	31,189	30,632	30,877	30,013	30,253
1976	28,403	39,150	47,338	65,251	46,880	64,619
1977	---	---	33,162	63,209	55,270	105,349

(Calendar Year)

4.2 Vehicle Miles

Estimates of total vehicle miles are obtained by multiplying the number of vehicles in use for a particular model year and calendar year, which were presented in the previous sub-section, by the mileage estimates which were presented in Sections 2 and 3. A most important part of this process is the calculation of confidence intervals for the resulting estimates of total vehicle miles. Indeed, this consideration largely determines the estimation method used. This sub-section begins with a description of the basic calculation. Next, the overall matrix of vehicle miles per day is described and related to the matrix of vehicles in use and the resulting vehicle miles matrix. The actual estimates of total vehicle miles and their confidence intervals are contained in Appendices B through E, being too numerous to include here.

Mileage information is presented as average miles per day in Sections 2 and 3. Total vehicle miles per year are computed as shown below.

$$VM = (\text{Vehicles})(\text{MPD})(365)/10^8$$

Inclusion of the 10^8 factor in the denominator produces results having the units of one hundred million vehicle miles. For the variance computation, only the mpd is considered a random variable. All other factors, including the number of vehicles in use, are considered to be constants. This approach is taken because no variance estimates are available for the number of vehicles in use even though there is uncertainty associated with these figures. This problem is addressed in the last sub-section of this section where the sensitivity of the estimated number of vehicles in use and the resulting estimates of vehicle miles is examined in light of the three different assumptions included on the time lag between production and registration. This same sensitivity analysis is carried out for the accident rates in Sections 5 and 6.

The total vehicle miles, then, can be written as a constant (CI) times the miles per day (mpd).

$$VM = C1(\text{MPD})$$

The confidence interval on the vehicle miles, in turn, is given by the constant times the confidence interval on the estimated miles per day.

$$(CI)_{VM} = C1(CI)_{mpd},$$

where $$C1 = (\text{Vehicles})(365)/10^8$$

Numbers of straight trucks and tractors in use by model year and calendar year are developed in the previous sub-section (Table 4.12, for example). Mileage estimates are presented for model years 1974-1976 in Section 2 and model year 1977 in Section 3. Data collection for these estimates basically covered the calendar years of interest. Mileage on the 1974-1976 model year vehicles was monitored during calendar years 1976 and 1977. A comparison of 1977 calendar year mileage with 1976 calendar year mileage showed no decrease. For this reason, these mileage estimates are applied to the 1978 calendar year without change. Similarly, the survey of 1977 model year vehicles was carried out during the last four months of calendar year 1978, and the mileages are applied to calendar years 1977 and 1978.

Some additional explanation is required for the estimation of total vehicle miles for exposure categories which are a subset of all tractors (or all straight trucks). For example, to compute an accident rate for tractors on intercity trips, it is necessary to known the total intercity vehicle miles for tractors. Conceptually, this is most easily thought of as the total tractor mileage times the percentage of all tractor miles which are put on in intercity trips. Two mileage statistics are now involved, the total tractor mileage (expressed in Sections 2 and 3 as average miles per day) and the percentage of tractor mileage put on in intercity trips. It is now the variance of this product that is needed in the calculation of confidence intervals for the total vehicle miles estimate. Table 3.18 presents this kind of product. In this table the overall miles per day for tractors is broken down into 11.9 mpd in local trips and 261.8 mpd in intercity trips summing to 273.7 total mpd for 1977 model year tractors. The total vehicle mileage estimates for each exposure category are made in this manner. A miles per day figure is computed which represents both the total tractor (or straight truck) mileage times the proportion of tractor (or straight truck) mileage put on in the exposure category of interest. This "apportioned" mpd is multiplied by the number of tractors (or straight trucks) in use as described at the beginning of this sub-section. The variance on the apportioned mpd is used in similar fashion to the variance of the total vehicle miles estimate for the exposure category of interest.

At this point it is appropriate to list the exposure categories addressed. For use with the FARS accident data, there are the following 18 exposure categories.

1. Straight Truck: Total
2. Straight Truck: Local Trips
3. Straight Truck: Intercity Trips
4. Tractor: Total
5. Tractor: Local Trips
6. Tractor: Intercity Trips
7. Tractor: Intercity, Bobtail
8. Tractor: Intercity, Trailer
9. Tractor: Intercity, Pre- Trailer
10. Tractor: Intercity, Post- Trailer
11. Tractor: Intercity, Single Trailer
12. Tractor: Intercity, Double Trailer
13. Tractor: Intercity, Conventional Cab
14. Tractor: Intercity, Cabover
15. Tractor: Intercity, Small Fleets
16. Tractor: Intercity, Large Fleets
17. Tractor: Intercity, Authorized Carriers
18. Tractor: Intercity, Non-Authorized Interstate Carriers

For reference, the mpd estimates for these exposure categories are repeated in Tables 4.14 through 4.20.

Similar mpd estimates are necessary for use with the BMCS-reported accidents. In Table 4.20, the non-Authorized carrier category includes only carriers which indicated that they operated interstate. Therefore, the exposure categories presented in Table 4.20 are intended to cover all vehicles whose accidents should be reported to BMCS (the reporting threshold is any injury in the accident or $2000 property damage for the accident). The reporting of fatal accidents to FARS and BMCS is compared in Sections 5 and 6, and it is found that the non-Authorized interstate carriers seem to substantially under-report fatal accidents to BMCS. A comparison of injury accident rates for these two groups, using the BMCS accident data, produces substantially lower rates for the non-Authorized interstate carriers which is also interpreted as under-reporting. For this reason, the

TABLE 4.14

Straight Trucks:
Average Miles Per Day Apportioned by Trip Distance*

Model Year	Local Trips		Intercity Trips		TOTAL		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	36.6	±11.1	28.1	±20.2	64.8	±29.4	251
1975 Pre	43.5	±16.5	36.1	±28.1	79.7	±39.5	123
1975 Post	35.4	±6.9	32.2	±18.2	67.6	±20.0	544
1976	21.3	±11.8	11.6	±6.6	32.8	±13.5	127
1977	43.8	±5.3	32.6	±7.2	76.5	±7.9	638

*CVD >.15 for all cells except 1977 model year.

TABLE 4.15

Tractors:
Average Miles Per Day Apportioned by Trip Distance*

Model Year	Local Trips		Intercity Trips		TOTAL		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	19.6	±7.5	189.7	±46.7	209.2	±42.4	938
1975 Pre	30.4	±35.1	150.1	±47.9	180.5	±44.9	160
1975 Post	18.1	±10.7	198.3	±54.9	216.4	±52.1	521
1976	10.4	±7.0	168.2	±113.2	178.6	±107.4	126
1977	11.9	±2.0	261.8	±11.6	273.7	±11.2	1980

*CVD >.15 for all cells except 1977 model year.

TABLE 4.16

Tractors:
Average Intercity Miles Per Day Apportioned by Trailer Type*

Model Year	Bobtail		Pre-121 Trailer		Post-121 Trailer		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	0.0	--	155.5	±37.7	34.2	±9.0	938
1975 Pre	0.0	--	123.4	±38.8	26.8	±9.2	160
1975 Post	0.6	±0.3	147.7	±42.5	50.1	±12.8	521
1976	0.5	±0.5	125.5	±88.1	42.2	±24.8	126
1977	1.1	±1.0	108.7	±11.4	152.2	±14.4	1110

*CVD >.15 for all cells except 1977 model year.

TABLE 4.17

Tractors:
Average Intercity Miles Per Day
Apportioned by Number of Trailers*

Model Year	Bobtail		Single		Double		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	0.0	--	187.2	±46.6	2.5	±0.8	938
1975 Pre	0.0	--	147.7	±47.9	2.4	±0.7	160
1975 Post	0.6	±0.3	189.8	±55.8	7.9	±3.5	521
1976	0.5	±0.5	162.3	±115.0	5.4	±3.2	126
1977	1.1	±1.0	243.3	±12.0	17.5	±4.4	1403

*CVD >.15 for all cells except 1977 model year.

TABLE 4.18

Tractors:
Average Intercity Miles Per Day Apportioned by Cab Style*

Model Year	Cabovers		Conventionals		N
	MPD	C.I.	MPD	C.I.	
1974	100.6	±40.8	89.1	±36.9	938
1975 Pre	46.54	±35.2	103.6	±57.1	160
1975 Post	134.6	±65.8	63.7	±27.9	521
1976	45.1	±53.0	123.1	±129.8	126
1977	158.3	±11.4	102.3	±8.5	1959

*CVD >.15 for all cells except 1977 model year.

TABLE 4.19

Tractors:
Average Intercity Miles Per Day Apportioned by Fleet Size*

Model Year	Small Fleets (1-49)		Large Fleets (50+)		N
	MPD	C.I.	MPD	C.I.	
1974	67.5	±37.5	122.1	±41.1	938
1975 Pre	55.8	±31.9	94.3	±63.9	160
1975 Post	115.9	±55.7	82.5	±77.4	521
1976	37.0	±32.9	131.2	±133.2	126
1977	109.1	±11.0	152.7	±13.0	1956

*CVD >.15 for all cells except 1977 model year.

TABLE 4.20

Tractors:
Average Intercity Miles Per Day Apportioned by Carrier Type*

Model Year	Authorized		Non-Authorized Interstate		N
	MPD	C.I.	MPD	C.I.	
1974	121.8	±47.5	56.5	±39.4	938
1975 Pre	82.7	±70.2	34.9	±28.1	160
1975 Post	73.9	±71.8	88.0	±32.4	521
1976	100.8	±139.1	60.5	±57.8	126
1977	131.2	±10.2	100.9	±9.5	1980

*CVD >.15 for all cells except 1977 model year.

computation of accident rates using BMCS-reported accidents is restricted to the Authorized carriers. The non-Authorized interstate carriers are sometimes referred to as "private" carriers. The exposure categories covered in this analysis are listed below.

1. Authorized Tractor: Total
2. Authorized Tractor: Local Trips
3. Authorized Tractor: Intercity Trips
4. Authorized Tractor: Intercity, Bobtail
5. Authorized Tractor: Intercity, Trailer
6. Authorized Tractor: Intercity, Pre- Trailer
7. Authorized Tractor: Intercity, Post- Trailer
8. Authorized Tractor: Intercity, Single Trailer
9. Authorized Tractor: Intercity, Double Trailer
10. Non-Authorized Interstate Tractor: Intercity

Again, the miles per day estimates for these exposure categories are shown in Tables 4.21 through 4.23.

Up to this point, the discussion has been concerned with the two inputs to the vehicle miles calculation, the

TABLE 4.21

Tractors:
Average Miles Per Day for Authorized Carriers
Apportioned by Trip Distance*

Model Year	Local Trips		Intercity Trips		TOTAL		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	8.5	±4.2	121.8	±47.5	130.3	±48.4	938
1975 Pre	4.2	±2.8	82.7	±70.2	86.9	±72.0	160
1975 Post	3.2	±3.7	73.9	±71.8	77.1	±71.8	521
1976	5.6	±6.9	100.8	±139.1	106.4	±137.4	126
1977	4.7	±1.2	130.7	±10.2	135.4	±10.2	1959

*CVD >.15 for all cells except 1977 model year.

TABLE 4.22

Tractors:
Average Intercity Miles Per Day for Authorized Carriers
Apportioned by Trailer Type*

Model Year	Bobtail		Pre-121 Trailer		Post-121 Trailer		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	0.0	--	99.9	±38.4	22.0	±9.2	938
1975 Pre	0.0	--	67.5	±57.2	15.2	±13.0	160
1975 Post	0.3	±0.3	56.2	±55.0	17.4	±16.5	521
1976	0.4	±0.6	76.5	±106.8	24.0	±31.8	126
1977	0.47	±0.9	50.0	± 7.2	80.2	±9.2	1110

*CVD >.15 for all cells except 1977 model year.

TABLE 4.23

Tractors:
Average Intercity Miles Per Day for Authorized Carriers
Apportioned by Number of Trailers*

Model Year	Bobtail		Single		Double		N
	MPD	C.I.	MPD	C.I.	MPD	C.I.	
1974	0.0	--	120.2	±47.5	1.6	±0.8	938
1975 Pre	0.0	--	81.9	±69.6	0.8	±0.9	160
1975 Post	0.3	±0.3	72.5	±71.5	1.1	±0.9	521
1976	0.4	±0.6	98.4	±139.0	2.0	±1.5	126
1977	0.47	±0.9	121.0	±9.0	9.2	±3.0	1422

*CVD >.15 for all cells except 1977 model year.

number of vehicles in use and the estimated miles per day for each exposure category. All that remains is to describe the total set of vehicle mileages which were generated from these inputs. The three month time lag is felt to provide the most reasonable estimates of the number of vehicles in use available at this time (Table 4.12). The starting point is the 17 estimates of straight trucks-in-use and 17 estimates of tractors-in-use contained in Table 4.12. The first three exposure categories listed above for use with the FARS data are for straight trucks. Applying the miles per day estimates for each model year in these three exposure categories to the 17 estimates of straight trucks-in-use corresponding to the various model years and calendar years produces 51 estimates of total vehicle miles (and 51 confidence intervals). Similarly, there are 15 tractor exposure categories listed for use with the FARS data. When these are applied to the 17 tractors-in-use numbers, an additional 255 vehicle mileage estimates result (and 255 confidence intervals), for a total of 306 estimated vehicle mileages corresponding to the various vehicle types, model years, calendar years, and exposure categories. For the BMCS-reported accidents, there are 10 exposure categories, all of them involving tractors, and 7 tractors-in-use estimates. The number of tractors-in-use estimates is reduced because the 1978 BMCS accidents are not included and the pre/post distinction cannot be made in the BMCS accident file. A total of 70 estimates of total vehicle mileage are produced for use with the BMCS accident data.

All the vehicle mileage estimates and their confidence intervals are contained in the detailed printouts of accident rates presented in Appendices B through E. The final part of this section looks at the sensitivity of the vehicle mileage estimates to the assumed time lag and the mpd results.

4.3 Sensitivity

The weakest link in the overall exposure estimation described in the last three sections is clearly the estimation of the number of vehicles in use. This sub-section seeks to examine the sensitivity of the exposure estimates to the critical assumption made in estimating the vehicle populations, namely the time lag assumed between production and registration. Figures 4.2 and 4.3 show the number of straight trucks and tractors respectively in use as a function of the time lag assumed. The straight truck curves are quite flat with a maximum of 8% variation shown for the 1975 model year in going from a two month lag to a four month lag. There is a corresponding decrease in the 1976 and 1977 model years. Of course, the pre/post split in the 1975 model year is quite sensitive to the time lag assumed. Tractors are somewhat more sensitive to the assumed time lag with the 1975 model year showing a 17% change in going from from a two to a four month lag. This

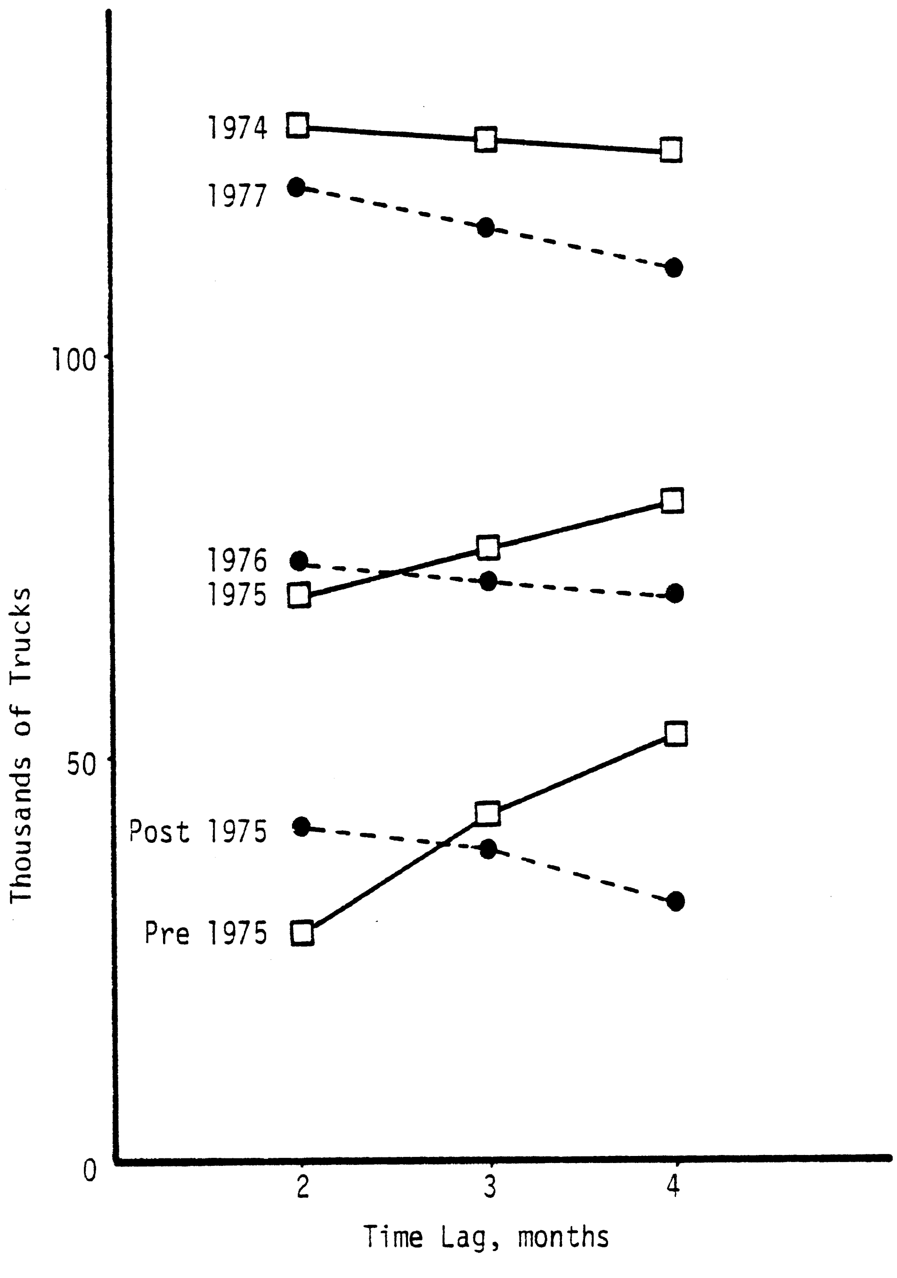

FIGURE 4.2 NUMBER OF STRAIGHT TRUCKS VERSUS TIME LAG

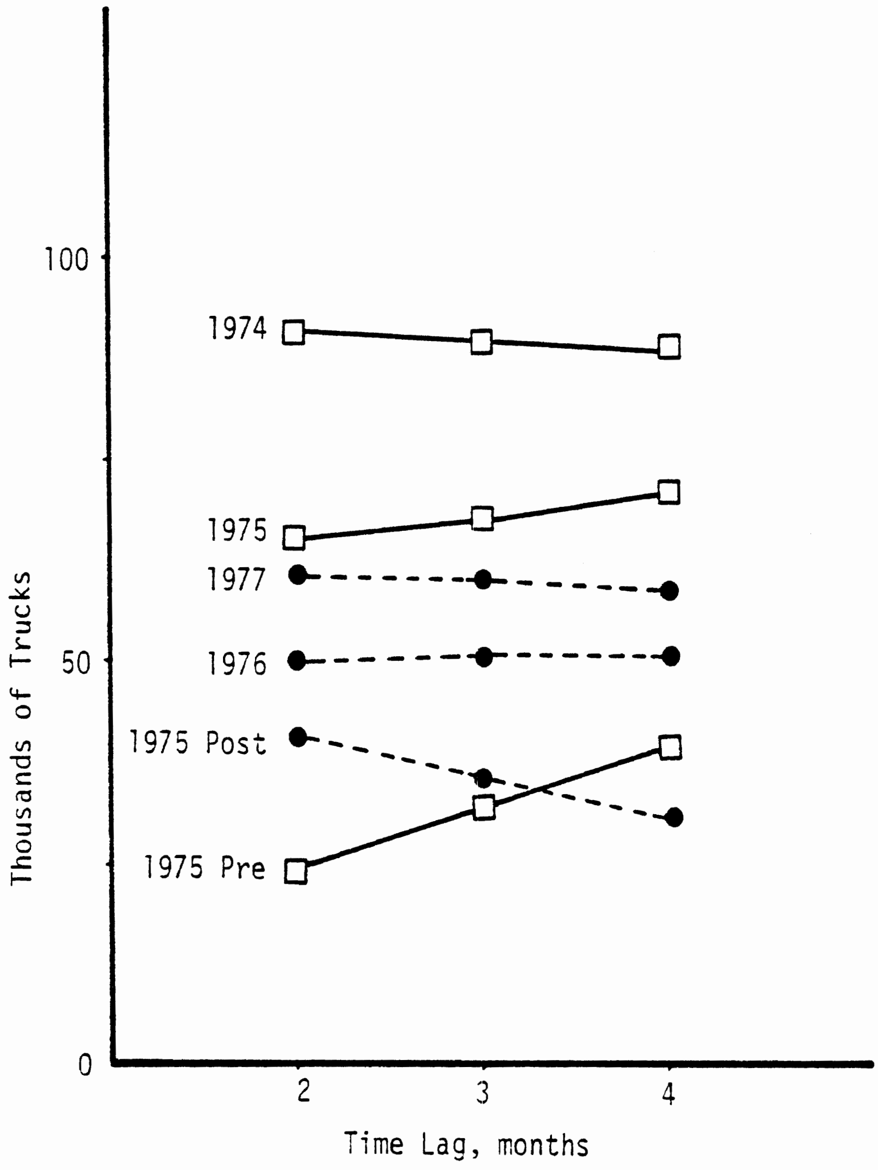

FIGURE 4.3 NUMBER OF TRACTORS VERSUS TIME LAG

result arises from the fact that the number of tractors produced was affected more severely by the introduction of the standard than was the number of straight trucks. Again, the pre/post split of the 1975 model year is sensitive to the time lag assumed.

The vehicle mileage figures are also shown for straight trucks and tractors as a function of the time lag assumed in Figures 4.4 and 4.5. The differences between these figures and the previous two showing numbers of vehicles in use is, of course, due to the differing estimates of daily mileage for each model year. Because the daily mileage estimates for the 1975 and 1977 model year straight trucks are somewhat higher than that for the 1974 model year straight trucks, the differences between these two model years diminishes in Figure 4.4, showing vehicle miles, as compared to Figure 4.2, showing number of vehicles. (The daily mileage figures for straight trucks are shown in the "total" column of Table 4.14, tractors in Table 4.15.) The model year 1976 straight trucks have a surprisingly low vehicle mileage as shown on Figure 4.4. This arises directly from the low daily mileage estimate which was pointed out in Section 2 (and is repeated in Table 4.14). It seems reasonable to assume that this result is not representative since it is so far removed from the range of the estimates for the other model years. Apparently the exceedingly small sample of 1976 straight trucks is biased toward low mileages for some reason.

The influence of the daily mileage estimate for tractors can be seen by comparing Figure 4.5 with Figure 4.3. Here the only real change is a substantial shift upward of the vehicle miles for the 1977 model year. Again, this is seen to be due to a daily mileage 30% higher than that for the 1974 model year (as shown in Table 4.15). However, this result cannot be attributed to small sample size. Indeed, this mileage estimate should be about the

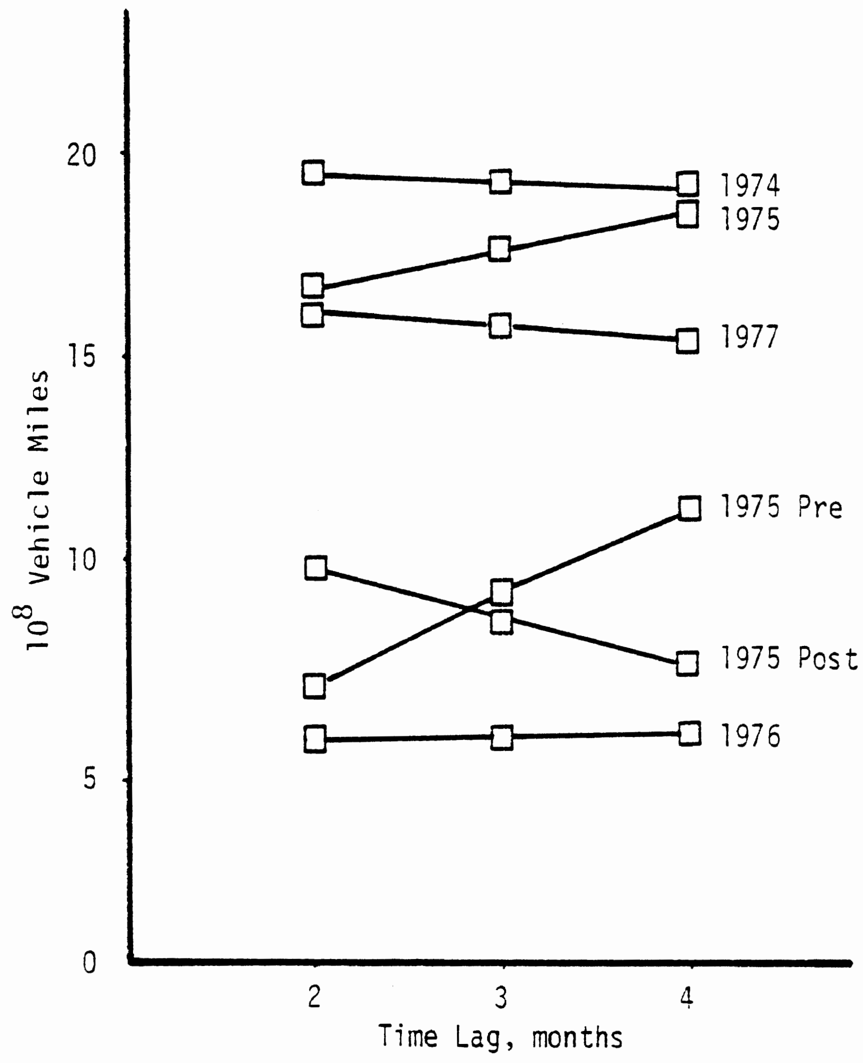

FIGURE 4.4 STRAIGHT TRUCK VEHICLE MILES VERSUS TIME LAG

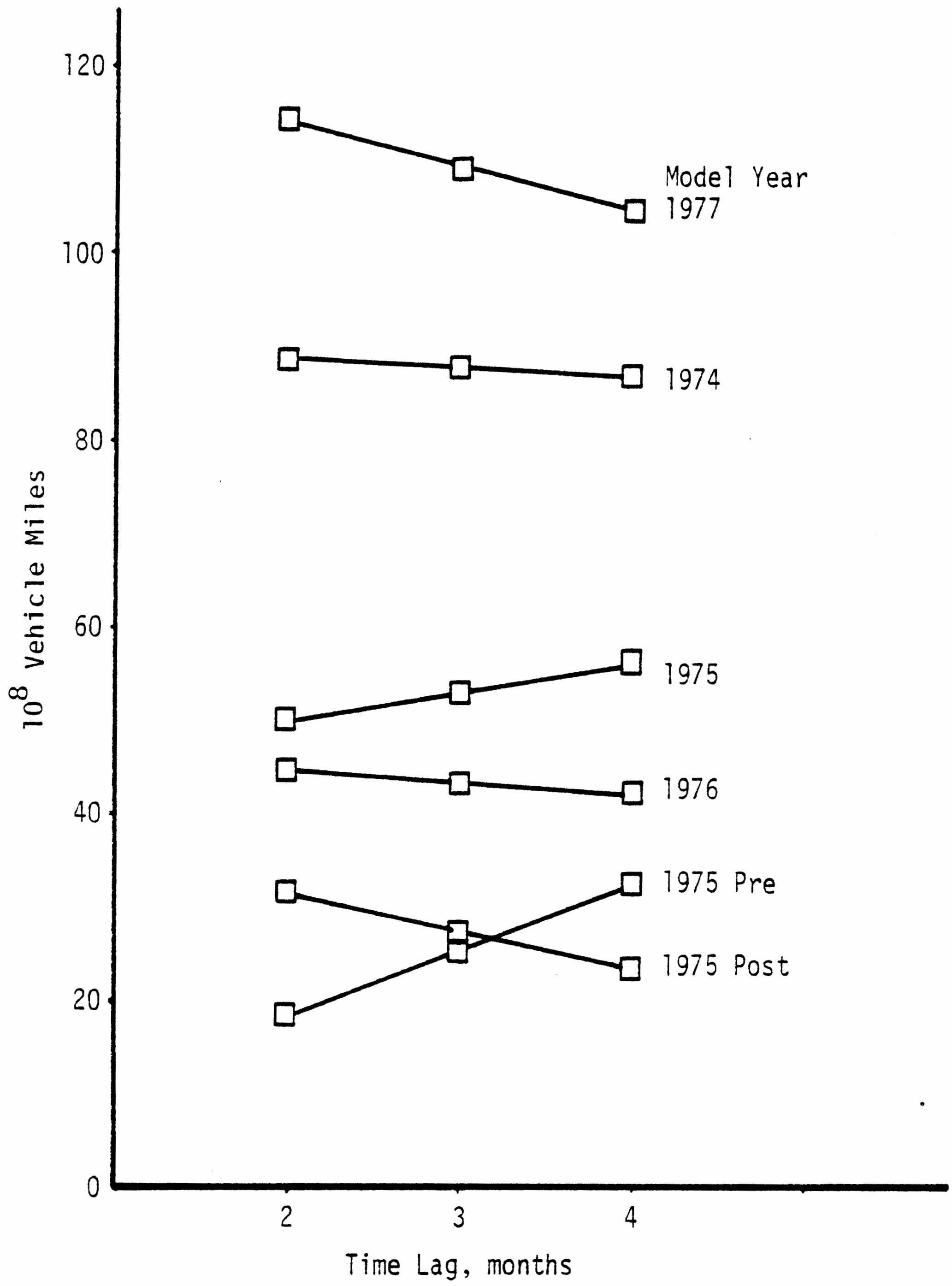

FIGURE 4.5 TRACTOR VEHICLE MILES VERSUS TIME LAG

best we have. In fact, trip survey mileages in the fleet program were biased toward low mileages for tractors when compared to odometer readings, as pointed out in Section 2, so that this figure may be an underestimate.

In order to pursue the sensitivity of the results to the exposure data, a second set of total vehicle mileages were computed after averaging the daily mileages across the model years for each exposure category. In other words, the same average daily mileage was used for each model year. The resulting vehicle miles are shown in Figures 4.6 and 4.7. Of course, the shape and relationship of these curves are exactly the same as Figures 4.2 and 4.3 since the same daily mileage is multiplying the number of vehicles for each model year. This information will be used in Sections 5 and 6 to show the sensitivity of the resulting accident rates to both the time lag assumption used in estimating the number of vehicles in service and to the variations observed in daily mileage for the various model years.

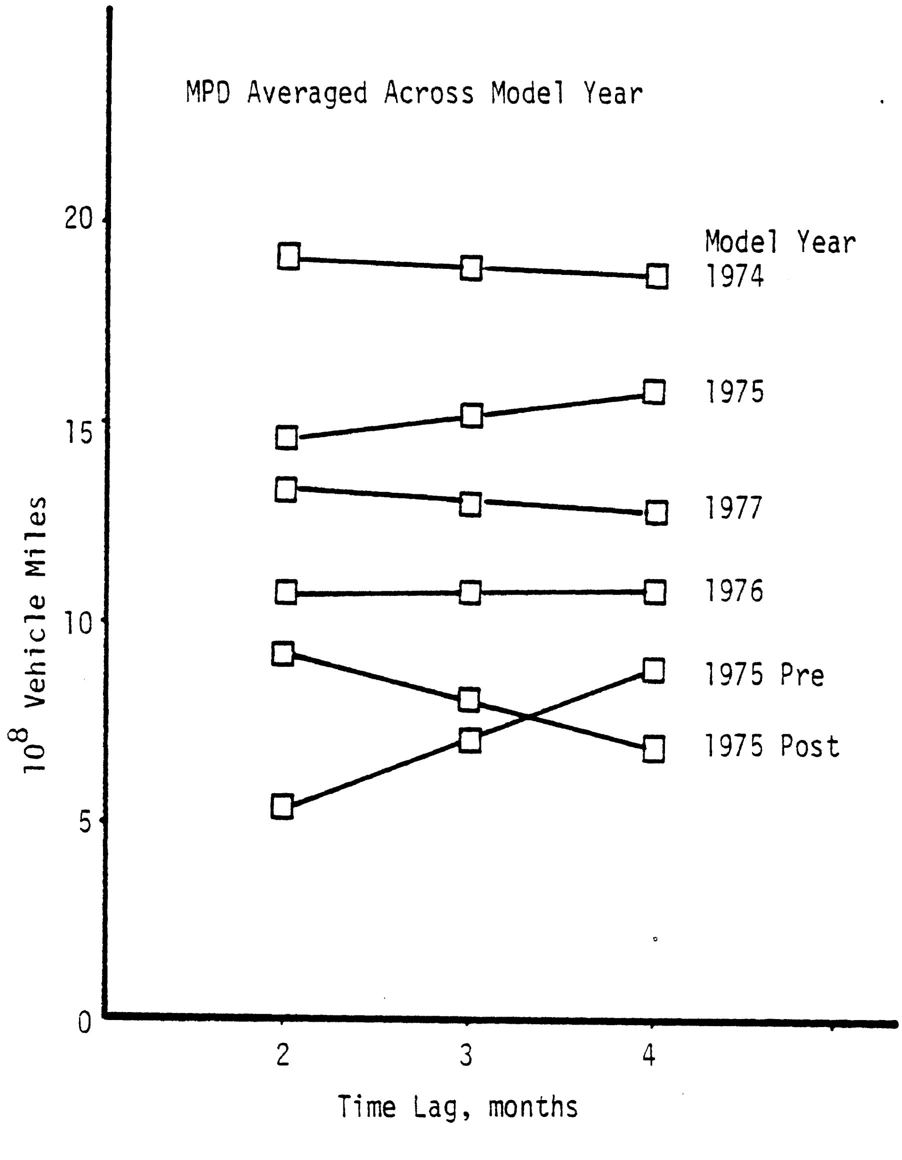

FIGURE 4.6 STRAIGHT TRUCK VEHICLE MILES (AVERAGED MPD) VERSUS TIME LAG

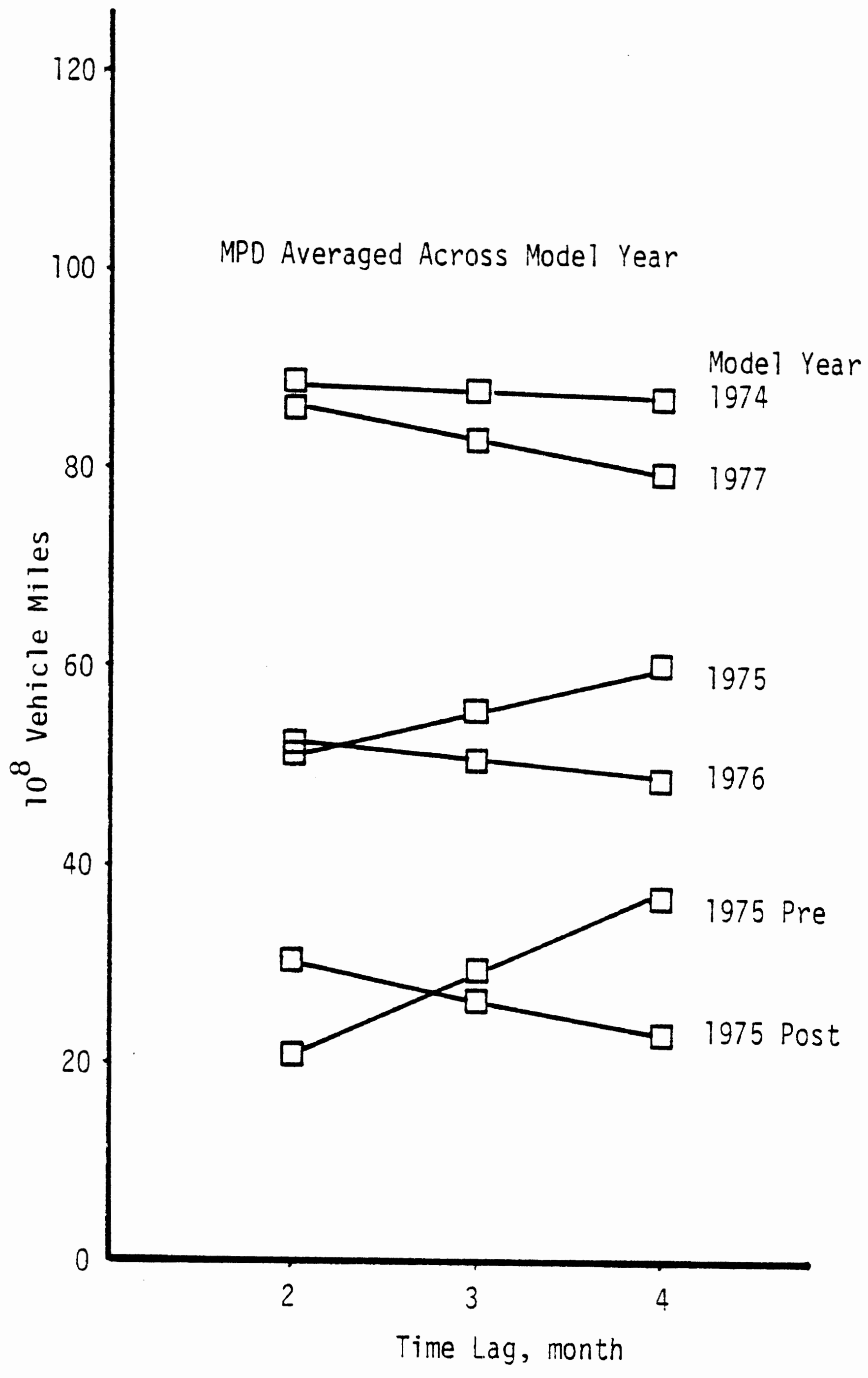

FIGURE 4.7 TRACTOR VEHICLE MILES (AVERAGED MPD) VERSUS TIME LAG

SECTION 5

FATAL ACCIDENT RATES

Uniform data on all fatal accidents are collected through the NHTSA Fatal Accident Reporting System (FARS). However, the information contained in the FARS files is not sufficient to carry out the analysis for this project. In particular, the type of brakes on tractor and trailer is not recorded, nor is the exposure category. To get this information, HSRI conducted a telephone follow-up on all 1974 model year or newer heavy trucks involved in fatal accidents during calendar years 1976-1978.

Notification on these accidents was provided to HSRI through the FARS. In order to initiate the follow-up, hard copy police reports were needed as these provide identifying information (name and address) on the owner or driver of the heavy truck. Arrangements were initially completed with all but eight states for forwarding of the police reports to HSRI. In most of the remaining states, privacy laws prevented release of the information. In some of the states, data storage systems were such that retrieval was exceedingly difficult. The cooperating states included slightly over 90% of all the heavy truck fatalities. Information on some of the missing cases was found in the Bureau of Motor Carrier Safety files. As the program wore on, a few additional states dropped out because of privacy law restrictions.

Telephone interviews were initiated for all cases received. Respondents were initially informed that we were not interested in who was at fault, nor in the cause of the accident, but only in the type of truck involved and its usage on the accident trip. When contact could not be made by phone, or when respondents asked for a written request, a mail version of the data form was sent out. If no return came within a few weeks, a second mailing was sent. Table 5.1 provides an overview of the response for the FARS follow-up effort. Initially, states were asked to identify the late-model heavy truck cases and forward them. Few did. Preliminary FARS files were used to send lists of FARS cases (by FARS case number) to each state. Response to this was quite good as can be seen in Table 5.1. Overall, police reports were received for 87% of the cases requested. For this tabulation, a completed interview was one in which the model year was verified and the brake status determined (air versus non-air). Interviews were completed on 92% of the cases received from the states and on 81% of all the cases in the preliminary listings. However, receipt of the final versions of the FARS files with 1,678 more cases for 1976-1978 produced final interview response rates that are not as good as the figures in Table 5.1 indicate.

TABLE 5.1

Number of FARS Cases Received from States and Completed Interviews

Calendar Year	Cases on Preliminary Listing	Cases Received	Percent	Completed Interviews	Percent
1976	1,345	1,258	94%	1,166	87%
1977	2,009	1,778	89%	1,560	78%
1978	2,266	1,874	83%	1,799	79%
TOTAL	5,620	4,910	87%	4,525	81%

A major problem is that the FARS file does not identify air-braked trucks. The selection of cases for follow-up was intended to be broad enough to include most trucks so equipped. Many interviews were initiated only to find the vehicle did not have air brakes. These cases are included in the "completed" category. Before accident rates can be computed, the counts of accidents obtained from the interviews must be adjusted for non-response in order to get the correct population totals. However, because the air-braked population cannot be identified in the FARS file, adjustments must be made to the FARS file totals, to produce estimates of the total accident counts for air-braked vehicles. The adjustments are based on interview data. This adjustment procedure is the topic of the first part of this section. The final response rates which are based on the adjusted totals, are about 30% lower than those shown in Table 5.1. Apparently the difference is cases which were not included in the preliminary files used to request cases from the states.

5.1 Estimating Accidents Involving Late Model Air-Braked Trucks

This sub-section discusses the various steps taken in proceeding from the original FARS data to the estimates of fatal accidents involving 1974 through 1978 model air-braked trucks. The initial problem here was that the FARS reports do not indicate whether or not a truck is equipped with air brakes. They are also somewhat deficient in distinguishing the configuration of the truck involved: tractors pulling trailers are not clearly distinguished from straight trucks pulling trailers. Computer files in which the FARS data sets were merged with the survey data collected by telephone interview were used to compute estimates of the proportion of air-braked vehicles and the distribution by vehicle configuration. A few incidental adjustments were also made to improve the estimates.

For the 1976 and 1977 FARS years an identical four-step procedure was used. The starting point, a two-way table of model year by body type, was run for each accident year using the latest FARS files. These tables include all medium and heavy trucks for model years from 1974 on. They are presented in Tables 5.2. and 5.3.

TABLE 5.2

1976 FARS

Model Year by Body Type (FARS Values):
Case Vehicles, Trucks Only

Model Year	Single Unit 53	Two Unit 57	Multiple Unit 58	Unknown 59	TOTAL
1974	140	521	25	48	734
1975	111	370	14	46	541
1976	49	192	9	24	274
1977	2	4	0	1	7
TOTAL	302	1087	48	119	1556

The first adjustment involved estimating what proportion of each FARS truck configuration (the columns in Tables 5.2 and 5.3) was air braked. For each column a constant proportion was used. This proportion was obtained separately for each accident year from the merge between the accident report file and the telephone survey file. The proportion used was the proportion of each configuration found to be air-braked on the telephone survey. The estimated total of case vehicles was reduced from 1,556 to 1,339 in the 1976 accident year, and from 2,431 to 2,115 in the 1977 accident year. The remainder were estimated to be non-air-braked.

TABLE 5.3

1977 FARS

Model Year by Body Type (FARS Values): Case Vehicles, Trucks Only

Model Year	Single Unit 53-56	Two Unit 57	Multiple Unit 58	Bobtail 59	Unknown 60	TOTAL
1974	171	526	18	9	47	771
1975	166	398	15	3	30	612
1976	108	345	12	5	38	508
1977	100	385	8	2	22	517
1978	3	18	0	0	2	23
TOTAL	548	1672	53	19	139	2431

The second step involved taking the model year totals thus calculated and dividing these among various vehicle types: bobtail tractor, straight truck, tractor with semi-trailer, and tractor with two trailers. The distributions used here were once again taken from the responses to the telephone survey and again different distributions were used for each accident year.

The telephone survey indicated that a number of trucks in each model year did not have the "proper" brake type: a few 1974 model trucks did have anti-lock and some 1976 through 1978 model trucks were not equipped with anti-lock. So in the third step a percentage of such anomalous vehicles was calculated for each model year and that percentage was deducted from every vehicle type in each model year.

In the fourth and final step a number of cases which were missing model year in the original FARS data (and so not included in Tables 5.2 and 5.3), but which were included in the telephone survey because the states sent us reports on them directly, were added to the estimates. The outcome is presented in Tables 5.4 and 5.5.

TABLE 5.4

1976 FARS

Air-Braked Trucks by Model Year and Vehicle Type
After Adjustments

Model Year	Vehicle Type				TOTAL
	Bobtail	Straight	Tr.Semi	Doubles	
1974	15.4	60.8	513.3	39.0	628.6
1975	11.6	45.2	388.7	29.3	474.8
1976	5.5	24.1	186.9	14.0	230.5
1977	0.1	0.5	4.0	0.3	4.8
TOTAL	32.6	130.6	1092.9	82.6	1338.7

The procedure for the 1978 accident year was almost identical. However, because of the late arrival of the FARS data set, no merge was possible between the FARS accident report file and the telephone survey file. So in the first three steps it was decided to use the same proportions as used for the 1977 accident year. Because of the lack of a file merge the fourth step was not possible for the 1978 accident year. The starting distribution and the final outcome for the 1978 accident year are presented in Tables 5.6 and 5.7.

These adjusted totals provide the basis for computation of the final response rates for the FARS interview activity. The overall response rates are shown in Table 5.8. It is disappointing that these figures are appreciably lower (30%)

TABLE 5.5

1977 FARS

Air-Braked Trucks by Model Year and Vehicle Type
After Adjustments

Model Year	Vehicle Type				TOTAL
	Bobtail	Straight	Tr.Semi	Doubles	
1974	13.7	70.1	563.1	29.5	676.5
1975	11.0	56.6	452.0	22.9	542.5
1976	8.7	42.6	355.6	18.0	424.9
1977	9.2	43.0	380.0	19.0	451.1
1978	0.4	1.9	16.6	0.9	19.9
TOTAL	43.0	214.2	1767.3	90.3	2114.9

TABLE 5.6

1978 FARS

Model Year by Vehicle Type (FARS Values):
Case Vehicles, Trucks Only

Model Year	Single Unit 53-56	Two Unit 57	Multiple Unit 58	Bobtail 59	Unknown 60	TOTAL
1974	190	537	15	16	43	801
1975	135	345	16	12	35	543
1976	109	338	5	11	38	501
1977	180	596	16	9	53	854
1978	128	420	9	8	47	612
TOTAL	742	2236	61	56	216	3311

TABLE 5.7

1978 FARS

Air-Braked Trucks by Model Year and Vehicle Type
After Adjustments

Model Year	Vehicle Type				TOTAL
	Bobtail	Straight	Tr.Semi	Doubles	
1974	14.2	66.4	564.9	29.4	674.9
1975	9.8	45.9	390.4	20.3	466.5
1976	8.5	40.0	339.7	17.7	405.8
1977	14.9	69.8	593.3	30.9	708.9
1978	10.8	50.4	428.9	22.3	512.4
TOTAL	58.2	272.5	2317.2	120.6	2768.5

than those in Table 5.1. The difference apparently is due to additional cases in the final versions of the FARS files that were not in the preliminary versions used to request cases from the states. NHTSA staff responsible for FARS have indicated that the heavy truck cases often are among the last to be submitted.

For the computation of accident rates, the response rate for each exposure category is indicated in Appendix B. For overall categories where figures from the "adjusted totals" tables presented in this sub-section are appropriate, a 100% response rate is indicated. For the detailed exposure categories, the response rate and number of accidents comes from the telephone interview supplementary data. The remainder of this section describes the computation of accident rates and the associated confidence intervals, and presents the results of those computations.

TABLE 5.8

Final FARS Overall Response Rates*

Calendar Year	Adjusted Totals	Completed Cases	Response Rate
1976	1,334	802	60%
1977	2,095	1,151	55%
1978	2,256	1,028	46%
TOTAL	5685	2981	52%

*1977 model year vehicles are excluded in calendar year 1976, and 1978 model year vehicles are excluded in calendar years 1977 and 1978.

5.2 Rate Computations

The starting point is the computation of accident rates (numbers of accidents per hundred million vehicle miles) for each of the 306 categories described in the previous section on exposure, corresponding to the various model years, calendar years, vehicle types, and usage categories. The rate computation is straight-forward, and is shown below:

$$RATE = (ACC) / (RR)(VM)$$

where:

ACC is the number of accidents in the exposure category (obtained from the supplementary, or interview, file);

RR is the response rate for the exposure cell, so that (ACC) / (RR) estimates the population total accident count; and

VM is the total vehicle miles associated with the exposure category.

For purposes of variance calculation, only the vehicle mileage is considered to be a random variable. The accident counts, in the numerator, are derived from a census of accidents, not a sample. It is recognized that some uncertainty is introduced due to the non-response associated with the interview activity. However, the accident data are very consistent from year to year, the number of accidents are generally quite large, and, in general, the accident data appear much better defined than the exposure data. Distributions on several variables in the FARS file were compared for responding and non-responding vehicles with little indication of bias.

Consequently, for purposes of variance calculation, the accident rate is viewed as a constant, C2, divided by a random variable, VM, as shown below:

$$\text{RATE} = (\text{C2}) / (\text{VM}),$$

where $\text{C2} = (\text{ACC}) / (\text{RR})$.

From Kendall and Stuart,[10] one can show that, if:

$$g(x) = \text{C2}/\text{VM},$$

then

$$\text{Var}[g(x)] = g^2(\theta)\ [\text{Var(VM)}/(\text{VM})^2],$$

where

$$g(\theta) = \text{C2}/\text{VM}.$$

Combining one gets:

$$\text{Var(C2/VM)} = (\text{C2})^2\ \text{Var(VM)}/(\text{VM})^4$$

or

$$(\text{CI})_{\text{Rate}} = [\text{C2}(\text{CI})_{\text{VM}}]^2/(\text{VM})^4.$$

These calculations were carried out for all 306 categories, and the results are contained in Appendix B.

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[10]Maurice G. Kendall and Alan Stuart, The Advanced Theory of Statistics, 3rd ed., Vol. 1 (New York, N.Y.: Hafner Publishing Co., 1969).

Each page in Appendix B corresponds to a particular exposure variable. Each exposure variable has two levels. The twelve columns on each page correspond to two repetitions of six variables, one repetition for each of the two levels associated with the exposure variable. The common group of six variables is, in order from left to right, shown in the following listing.

Column 1: Total vehicle miles
2: Confidence interval for total vehicle miles
3: Number of accidents
4: Response rate for the above number of accidents
5: Accident rate, column 3/(column 4 x column 1)
6: Confidence interval for the accident rate

Each page also contains 17 rows which correspond to the various model years and accident years. The first five rows show the results by model year for calendar year 1976, with rows 1-5 corresponding to the model years 1974, 1975 pre, 1975 post, 1975 total, and 1976. The next six rows show the results for calendar year 1977 for the same five model years plus the 1977 model year. The last six rows correspond to the same six model years for calendar year 1978. A discussion of these results is presented in the last two sub-sections of this section.

Results are also combined across calendar years and then across model years. These statistics are treated as a linear combination of the previous statistics. Vehicle miles are simply summed. Estimated population totals, numbers of accidents (column 3) divided by the response rate (column 4), are also summed. The accident rate for the combined rows is then obtained by division as before. The confidence interval for the vehicle miles is squared, summed across the rows, and the square root taken. Computation of the confidence interval for the combined rate is also carried out as before. Results are first combined across calendar year, and shown by model year on the next nine pages. The column associated with the response rate for the accident count has dropped out since the estimated total number of accidents must be used when combining across calendar years. The last row on each of these pages presents the results after combining across the model years as well.

These results are first discussed in the next sub-section with regard to differences in accident rates associated with the various exposure cells. Differences between pre- and post-standard vehicles are presented in Section 5.4. The final part of this section addresses jackknife accidents, and some additional analysis of the accident data aimed at revealing pre- and post-differences.

5.3 Exposure Categories Compared

The major feature of this analysis is the inclusion of several control, or exposure, variables. The assumption made is that these variables represent factors which are likely to influence the overall accident rates above and beyond the introduction of the 121 Standard. These exposure variables describe characteristics of the vehicles, their owners, and their use. Changes in the exposure of the vehicles from year-to-year would confound, or hide, the effect of the standard. Inclusion of these variables allows comparisons to be made within common categories of vehicle use, or exposure. The first step in the analysis is to look at the accident rates for the various exposure categories to see if, in fact, the rates differ. Where no difference is observed, the data can be collapsed, increasing the effective sample size and reducing variance.

This sub-section presents results on six different exposure variables which are listed below.

1. Vehicle Type
   Straight Truck vs. Tractor

2. Trip Distance
   Local vs. Intercity Trips

3. Trailer Type
   Bobtail vs. Trailer
   Single vs. Double

4. Carrier Type
   Authorized vs. Non-Authorized Interstate

5. Fleet Size
   Small (1-49) vs. Large (50+)

6. Cab Style
   Conventional vs. Cabover

The last four comparisons listed are restricted to tractors on intercity trips, since this is the only category among those listed under the first three variables which is large enough to allow further breakdowns. Rather large, and statistically significant, differences are found in all of the comparisons made with the exception of carrier type. Differences by exposure category are discussed one by one in the remainder of this sub-section.

5.3.1 Vehicle Type. Accident involvement rates by model year and vehicle type are shown in Tables 5.9 and 5.10. As is true throughout this report, the units for the rates are truck involvements per hundred million vehicle miles. This section deals with trucks involved in fatal accidents as reported to FARS. As described in the previous sub-sections of this section, three calendar years, 1976-1978, were included in the analysis. The results in this sub-section are presented for the aggregate of the three years. These tabulations seemed most appropriate since accident counts were quite consistent from year-to-year for the larger exposure categories, while for the smaller categories aggregation is desirable to produce more stable results. The breakdown by model year has been included largely to show the stability of the observed exposure difference from model year to model year. The bottom, or "All," line on each table is the aggregate across the six model year categories (1974, 1975 Pre, 1975 Post, 1975 Total, 1976, 1977).

TABLE 5.9

Fatal Accident Involvement Rates by Vehicle Type

Model Year	Straight Truck		Tractor	
	Rate	95% C.I.	Rate	95% C.I.
1974	3.314	±0.868	6.564	±0.768
1975 Pre	3.466	±0.992	13.183	±1.894
1975 Post	1.997	±0.341	3.600	±0.500
1975 Total	2.754	±0.466	8.232	±0.822
1976	7.448	±1.823	8.520	±3.048
1977	4.637	±0.353	6.178	±0.186
ALL*	3.719	±0.452	7.157	±0.539

*Difference significant at .001 level.

The first anomaly to be dealt with is the unusually high accident rate for the 1976 model year straight trucks shown in Table 5.9. This arises from an estimated average daily mileage for this model year which was less than half of that for the other model years. This result is presumed to be due to some bias in the very small number of 1976 model year vehicles in the fleet monitoring program. Consequently, this particular rate is believed to be a poor estimate. One method of dealing with such a problem is to replace the individual mpd estimates for each model year with a single average figure for all four model years, effectively removing the mpd differences observed. This would be appropriate if the observed differences were not significantly different. Such is the case for the straight trucks. In fact, this computation has been generally made for all of the results in the context of the sensitivity

TABLE 5.10

Fatal Accident Involvement Rates by Vehicle Type
(Miles Per Day Averaged)

Model Year	Straight Truck		Tractor	
	Rate	95% C.I.	Rate	95% C.I.
1974	3.386	±0.788	6.626	±1.150
1975 Pre	4.356	±1.013	11.482	±1.995
1975 Post	2.131	±0.496	3.758	±0.653
1975 Total	3.187	±0.742	7.842	±1.362
1976	3.852	±0.923	7.342	±1.314
1977	5.592	±1.659	8.159	±1.808
ALL*	3.702	±0.473	7.338	±0.698

*Difference significant at .001 level.

analysis which was discussed in Section 4.3. For this particular sub-section, Table 5.10, which presents results from the computation using an average mpd figure, is believed to provide a more accurate estimate of the differences in accident rates by model year for straight trucks and tractors, having "smoothed out" the anomalous rate for the 1976 model year straight trucks. Notice that the overall comparison given in the "All" row on each table is not appreciably changed, which, of course, will always be the case.

The obvious conclusion is that the rate of fatal accident involvement on a per mile basis is nearly <u>double</u> for tractors as compared to straight trucks. This conclusion must be tempered somewhat by the small amount of data for the straight trucks. While approximately 40% of the air-braked vehicles are found to be straight trucks, they only account for 18% of the total vehicle mileage (see the tables in Appendix B). Similarly, the total number of fatal accident involvements from the FARS file for this analysis is only 565 (10%) for the straight trucks as compared to over 5000 involvements in fatal accidents for the tractors. Identification of the air-braked straight trucks in the FARS file is more difficult than the identification of tractors. However, we feel that we may have overestimated their number, rather than underestimated it. Nonetheless, there is more uncertainty associated with the straight truck figures. These factors may influence the magnitude of the difference observed. It spite of these considerations, it seems safe to conclude that the fatal accident involvement rate is higher for tractors than for straight trucks. The next logical question is the influence of trip distance, since tractors operate primarily intercity while straight trucks operate primarily locally. This is addressed in the next sub-section.

5.3.2 Trip Distance. The influence of trip distance on accident rates is viewed separately for straight trucks and tractors in this sub-section. Again for straight trucks only, the averaged mpd figures are used. This result is presented in Table 5.11. The comparable results for tractors are shown in Table 5.12.

The differences shown in these two tables are striking. Not only are rates of fatal accident involvement higher for local trips, as might be expected, but the rates for tractors are higher in each category. Controlling for trip distance does not diminish the differences between straight trucks and tractors seen in the previous sub-section. For local trips, the rate for tractors is nearly triple that for straight trucks, while for intercity trips, the rate for tractors is double that for straight trucks. One possible mitigating factor was discussed in Section 2 and arose from

TABLE 5.11

Fatal Accident Involvement Rates by Trip Distance:
Straight Trucks Only
(Miles Per Day Averaged)

Model Year	Local		Intercity	
	Rate	95% C.I.	Rate	95% C.I.
1974	3.907	±0.720	2.746	±1.059
1975 Pre	4.905	±0.903	3.579	±1.379
1975 Post	2.836	±0.522	1.282	±0.494
1975 Total	3.810	±0.702	2.388	±0.921
1976	4.015	±0.762	3.632	±1.442
1977	4.974	±1.168	6.364	±3.128
ALL*	4.039	±0.409	3.277	±0.694

*Difference significant at .06 level.

a comparison of mpd from the trip survey with odometer readings. For tractors there seemed to be an under reporting of mileage in the trip survey. If this under reporting involved primarily local trips, then the exposure for this category may be under-estimated. Indeed, on the trip survey, respondents usually put all of the day's mileage under a single trip distance category. Local trips may only have been indicated for vehicles which put on the majority of their mileage locally on the survey date. Local mileage which was only a small part of the day's mileage may have been missed. If so, local miles may be under-estimated for tractors. Again, these considerations may be sufficient to alter the magnitude of the difference, but it seems sound to conclude that the differences are real.

TABLE 5.12

Fatal Accident Involvement Rates by Trip Distance:
Tractors Only
(Miles Per Day Averaged)

Model Year	Local		Intercity	
	Rate	95% C.I.	Rate	95% C.I.
1974	9.618	±2.125	6.244	±0.888
1975 Pre	12.136	±8.091	13.387	±2.467
1975 Post	6.382	±2.178	3.348	±0.535
1975 Total	10.201	±4.604	7.945	±0.961
1976	14.020	±5.613	8.184	±3.276
1977	15.900	±1.968	5.736	±0.187
ALL*	11.075	±2.059	6.799	±0.598

*Difference significant at .001 level.

5.3.3 Trailer Type. Two comparisons are made in this sub-section. The first involves accident rates for bobtail tractors (no trailer) as compared to tractors pulling trailers, while the second addresses the use of single versus double trailers. Local tractor mileage has been omitted for these comparisons. Results for bobtails are shown in Table 5.13. Averaged mpd figures were used because the estimates of mileage for bobtails are very small and varied considerably from year to year. In general, the trip surveys indicated that tractors operated bobtail for only 0.5% of their total mileage. However, bobtail usage was only recorded when the majority of the day's mileage was accumulated with no trailers. The computed accident involvement rate for bobtails is 13 times that for tractors pulling trailers. Even assuming a large under-reporting of bobtail mileage on intercity trips, it seems clear that they are over-involved in accidents as compared to the combination vehicles. Data are not sufficient to look at bobtail experience on local trips.

TABLE 5.13

Fatal Accident Involvement Rates by Trailer Use:
Intercity Tractors Only
(Miles Per Day Averaged)

Model Year	Bobtail		Trailer	
	Rate	95% C.I.	Rate	95% C.I.
1974	71.8	±64.8	6.1	±1.2
1975 Pre	148.5	±134.1	10.2	±2.0
1975 Post	25.3	±22.8	3.5	±0.7
1975 Total	91.7	±82.8	7.1	±1.4
1976	125.6	±116.9	7.0	±1.4
1977	90.1	±103.7	7.7	±2.0
ALL*	90.0	±44.5	6.8	±0.7

*Difference significant at .001 level.

A comparison of fatal accident involvements of tractors pulling single versus double trailers is shown in Table 5.14. Again, local mileage and accidents are excluded. The result is not as clear-cut in this table. There is an overall difference in favor of the single trailer. Estimates of double trailer mileage range from 1%-6% with the lowest for the 1974 model year and progressing in order to the 1977 model year tractor for which the 6% estimate was obtained. The rates for doubles are higher for each model year except 1977, the year for which the exposure data have the best confidence intervals. While this conclusion is not as strongly supported as some of the previous ones, the data do show that tractors pulling double trailers have a somewhat higher fatal accident rate than those pulling single trailers.

TABLE 5.14

Fatal Accident Involvement Rates by Number of Trailers: Intercity Tractors Only

Model Year	Single		Double	
	Rate	95% C.I.	Rate	95% C.I.
1974	5.9	±0.8	24.0	±4.4
1975 Pre	12.5	±2.3	45.4	±7.6
1975 Post	3.2	±0.6	4.8	±1.2
1975 Total	7.6	±1.0	15.0	±2.9
1976	7.6	±3.2	10.2	±3.6
1977	5.9	±0.2	2.8	±0.5
ALL*	6.5	±0.6	9.5	±1.1

*Difference significant at .001 level.

5.3.4 Carrier Type. In this sub-section accident rates for tractors on intercity trips are compared for Authorized Carriers and non-Authorized carriers operating interstate. The non-Authorized carriers are limited to those operating interstate in an attempt to identify those vehicles whose accidents should be reported to BMCS. This subset will be the focus of the accident data presented in the next section. The non-Authorized interstate carriers are sometimes referred to as "private" carriers, since they haul only their own goods and are not subject to Interstate Commerce Commission economic regulation. The differences in accident rates shown in Table 5.15 are generally small, and are not statistically significant at the .05 level.

TABLE 5.15

Fatal Accident Involvement Rates by Carrier Type: Intercity Tractors Operated by Interstate Carriers

Model Year	Authorized		Non-Authorized Interstate	
	Rate	95% C.I.	Rate	95% C.I.
1974	5.3	±1.2	6.0	±2.4
1975 Pre	12.7	±6.2	18.5	±8.6
1975 Post	4.5	±2.5	2.7	±0.6
1975 Total	9.0	±3.3	7.5	±1.5
1976	7.7	±6.3	7.1	±4.0
1977	6.6	±0.4	4.7	±0.3
ALL*	6.7	±1.2	6.2	±1.1

*Difference <u>not</u> significant at .05 level.

5.3.5 <u>Fleet Size</u>. Again, this comparison is limited to intercity tractor miles. Fleet size is measured in terms of the number of air-braked power units, with "small" chosen to be 1-49, and "large" being 50 or more air-braked power units. Accident rates by fleet size are shown in Table 5.16. Small fleets are found to have more than double the fatal accident involvement per mile of large fleets. This result is statistically significant. In the fleet monitoring program, a tendency was observed for small fleets to be somewhat less likely to participate in the survey. This tendency seemed to be related to the large data requirements of that program and the sometimes less-than-adequate record-keeping of small fleet operators. However, the demands of the survey of 1977 vehicles were minimal, and this problem was not observed. If small fleets have a higher non-response than large fleets, then the exposure of small fleets will be underestimated. This possible non-response bias would temper the observed difference somewhat. Overall, the results strongly indicate that small fleets have higher fatal accident rates than large fleets.

TABLE 5.16

Fatal Accident Involvement Rates by Fleet Size: Intercity Tractors Only

Model Year	Small		Large	
	Rate	95% C.I.	Rate	95% C.I.
1974	10.4	±3.3	3.9	±0.8
1975 Pre	22.6	±7.5	7.8	±3.1
1975 Post	3.4	±0.9	3.2	±1.8
1975 Total	10.2	±2.2	5.8	±1.9
1976	20.1	±10.7	4.8	±2.9
1977	7.4	±0.5	4.7	±0.3
ALL*	10.4	±1.4	4.6	±0.7

*Difference significant at .001 level.

5.3.6 Cab Style. The final exposure comparison made is for conventional cab tractors versus cabover style tractors. Again, only intercity experience is used. These results are shown in Table 5.17. The involvement rate in fatal accidents is nearly 70% higher for the cabover style tractor.

TABLE 5.17

Fatal Accident Involvement Rates by Cab Style:
Intercity Tractors Only

Model Year	Conventional		Cabover	
	Rate	95% C.I.	Rate	95% C.I.
1974	4.7	±1.1	7.6	±1.8
1975 Pre	8.3	±2.6	24.5	±10.7
1975 Post	4.3	±1.1	2.9	±0.8
1975 Total	6.9	±1.5	8.9	±2.1
1976	3.7	±2.3	20.3	±14.2
1977	5.5	±0.3	5.9	±0.3
ALL*	5.1	±0.9	8.5	±1.0

*Difference significant at .001 level.

This comparison is taken a step further in Table 5.18. Here only truck driver fatalities have been included for the computation of accident rates. This tabulation could only be carried out in the merged files which were available for only the 1976 and 1977 calendar years. The rate for truck driver fatalities is more than double for the cabover style trucks. Although based on only two years data, the result is highly significant. The effect of cab style is also pursued in a recent MVMA-sponsored report.[11]

TABLE 5.18

Fatal Accident Involvement Rates for
Drivers Only by Cabstyle:
Intercity Tractors Only
(Accident Years 1976-1977)

Model Year	Conventional		Cabover	
	Rate	95% C.I.	Rate	95% C.I.
1974	0.722	±0.211	0.818	±0.235
1975	0.643	±0.177	1.374	±0.399
1976	0.424	±0.329	4.197	±3.631
1977	0.908	±0.075	1.956	±0.141
ALL*	0.652	±0.151	1.479	±0.256

*Difference significant at .001 level.

5.4 Pre- and Post-Standard Differences

This sub-section presents the results which pertain to an evaluation of the safety impact of FMVSS 121. In the first sub-section, overall accident rates for straight trucks and tractors are presented. The next sub-section presents the results of an attempt to determine accident rates as a function of the brake type of both tractor and trailer. The remaining sub-sections look at jackknife accidents and the distribution of accidents by collision

[11]Michael Kubacki and James O'Day, The Effect of Cabstyle on the Accident Experience of Heavy Trucks, Report No. UM-HSRI-81-03 (Ann Arbor: The University of Michigan, Highway Safety Research Institute, February 1981).

type. Overall the differences observed are not clear-cut. The sensitivity of the overall rates to the exposure data is examined in the first sub-section. In general, there is little evidence of any substantial reductions in accident rates for the 121-equipped vehicles.

5.4.1 Overall Rates. Accident rates for straight trucks and tractors are examined here for differences between the pre- and post-standard vehicles. Accident rates (shown in Tables 5.9 and 5.10) are plotted versus model year for straight trucks in Figure 5.1 and tractors in Figure 5.2. The 1975 model year has been split into pre- and post-standard vehicles for this analysis. It does not appear that this split is useful. The rates for the pre- and post-standard vehicles in the 1975 model year vary wildly when compared to the rates for the other model years (see Appendix B). In particular, the 1975 pre-standard vehicles have a rate for tractors which is double that for the 1974 tractors. This outcome seems unlikely. Furthermore, the very low rates for the 1975 post-standard vehicles is not continued by the 1976 and 1977 model year vehicles. The problem lies in the estimates of the number of vehicles in service. Whereas the model year totals are not too sensitive to the assumed time lag, the pre/post split for the 1975 model year is. None of the assumed time lags yields a reasonable result for this split. For these reasons, the pre/post split of the 1975 model year will be generally ignored from here on.

Looking at Figure 5.1, we again see the anomalous rate for the 1976 model year. Also shown are the rates resulting from use of the averaged mpd figure. In general, there is an increasing trend with the 1977 model year having a rate 40%-65% higher than the 1974 model year straight trucks, depending on whether the averaged mpd or the survey data are used. These differences are statistically significant at .001 level.

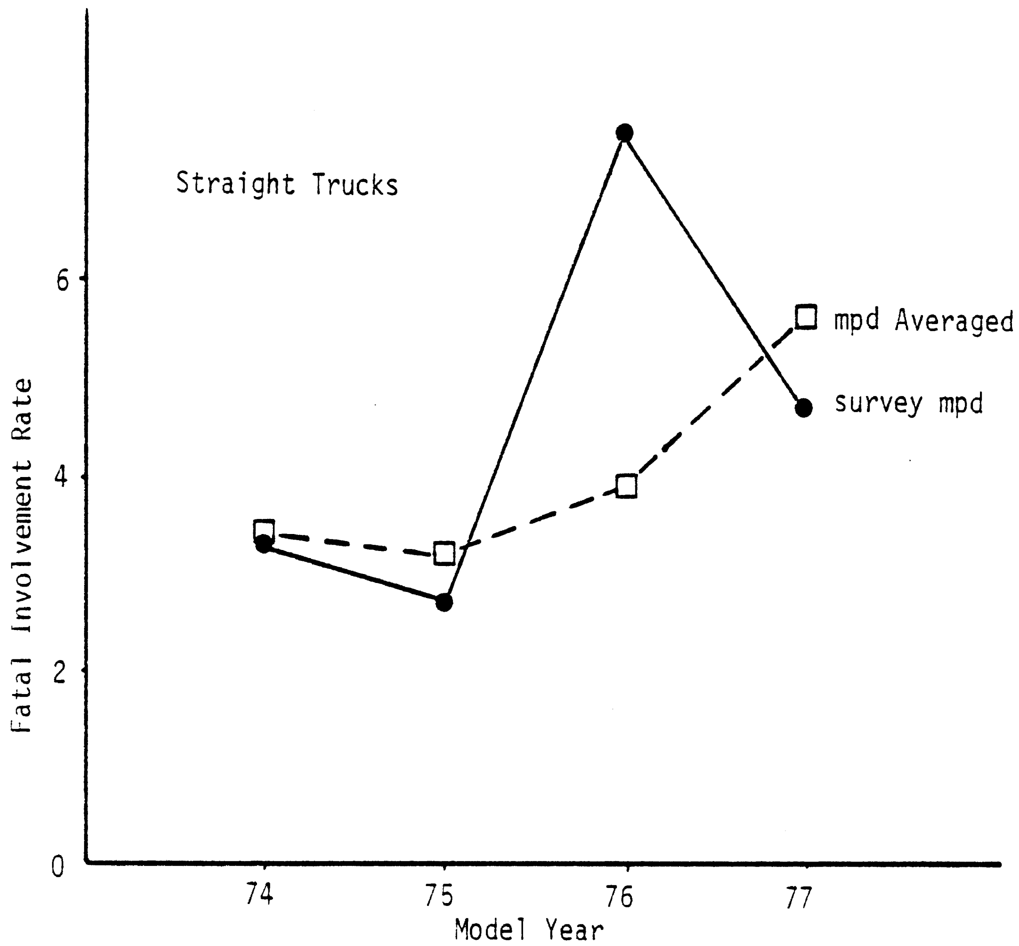

FIGURE 5.1 STRAIGHT TRUCK FATAL INVOLVEMENT RATES BY MODEL YEAR

The results are more mixed for the tractors as shown in Figure 5.2. Here the rates are generally higher for the 1975 and 1976 model years when either the survey mpd or the averaged mpd are used. However, the survey mpd produced a slightly reduced rate (-6%) for the 1977 model year when compared to the rate for the 1974 model year. Use of the averaged mpd produces a rate 23% higher for the 1977 model

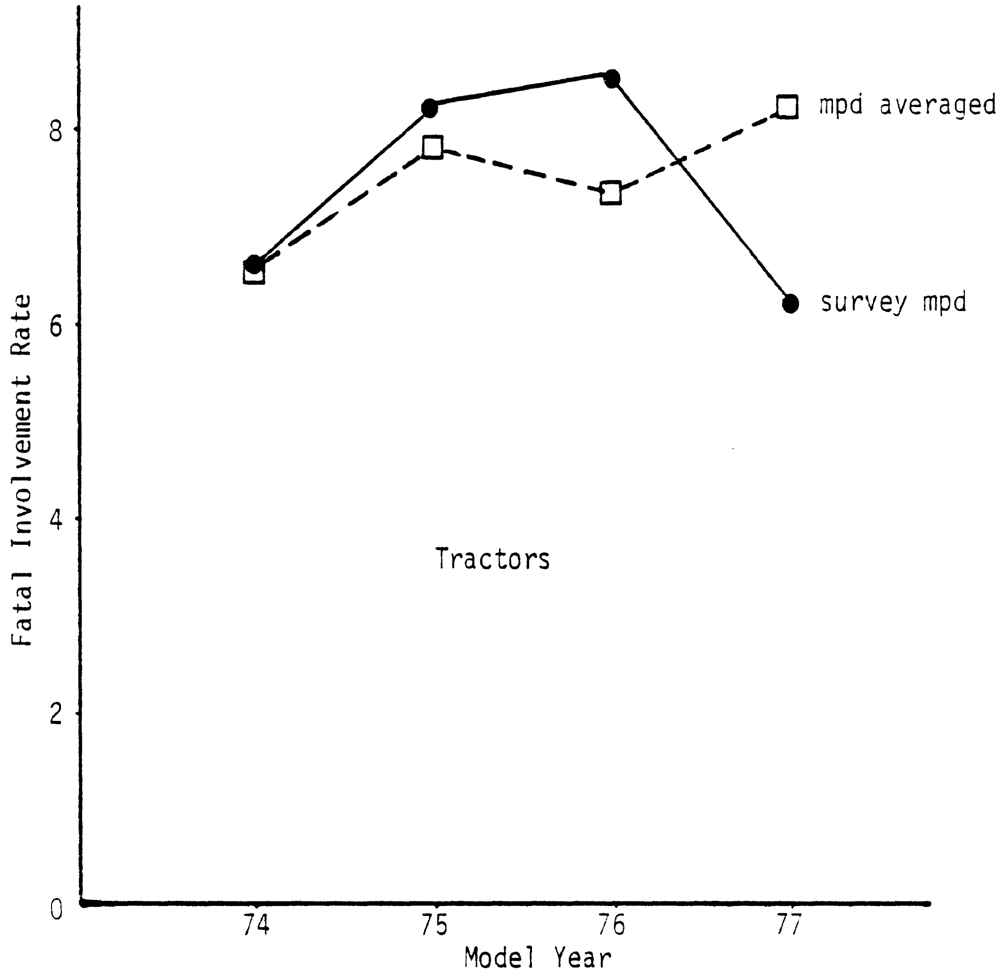

FIGURE 5.2 TRACTOR FATAL INVOLVEMENT RATES BY MODEL YEAR

year. Moreover it should be borne in mind that the MVMA-supplied data on the percentage of tractors in each production year showed a higher percentage of tractors for production year 1977 (67%) than for any of the previous three years. If this figure were slightly high, the straight truck rate would decrease and the tractor rate would increase. However, the survey of 1977 model year vehicles indicated that 77% were tractors! In general, Figure 5.2 shows dispersion in the accident rates and sensitivity to the exposure data.

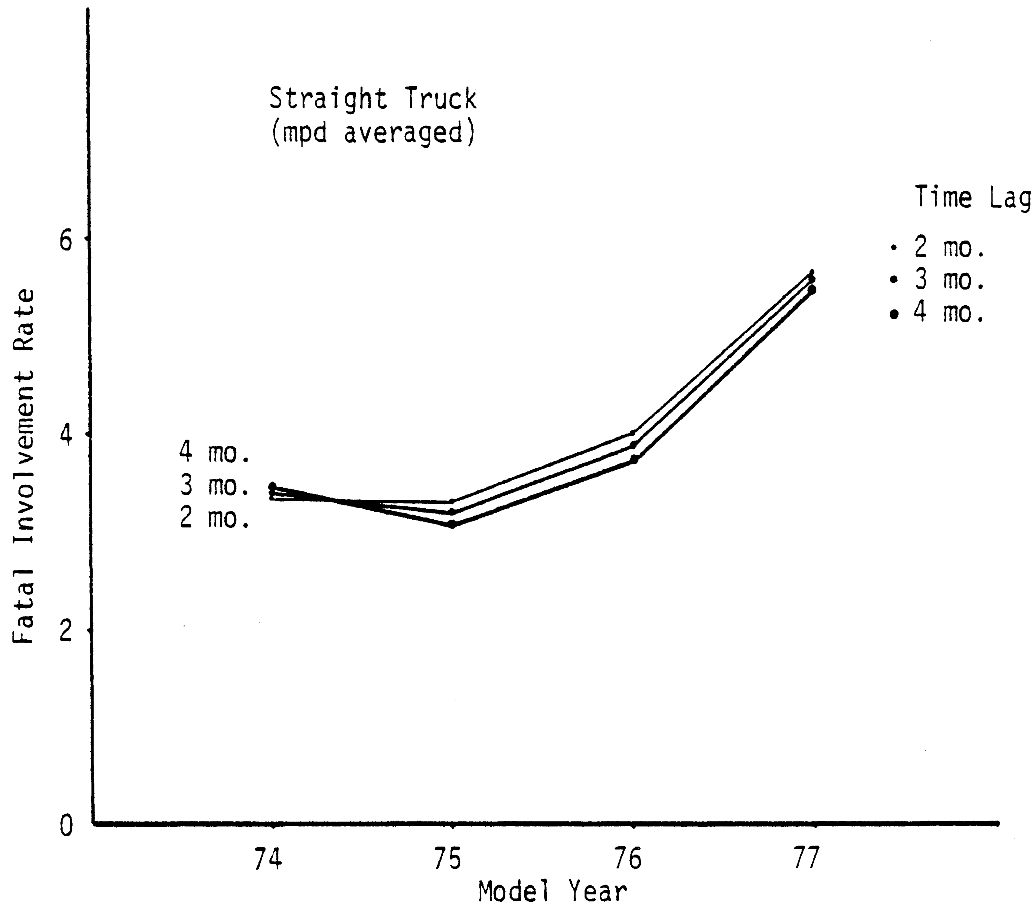

FIGURE 5.3 STRAIGHT TRUCK FATAL INVOLVEMENT RATES VERSUS TIME LAG

Figures 5.3 and 5.4 illustrate the sensitivity of the overall accident rates to the time lag assumed in estimating the number of vehicles in service. The influence of this assumption on the estimated number of vehicles and the computed vehicle miles was discussed in Section 4.3. These figures simply show the effect on the computed rate. The averaged mpd figures were used to isolate the time lag

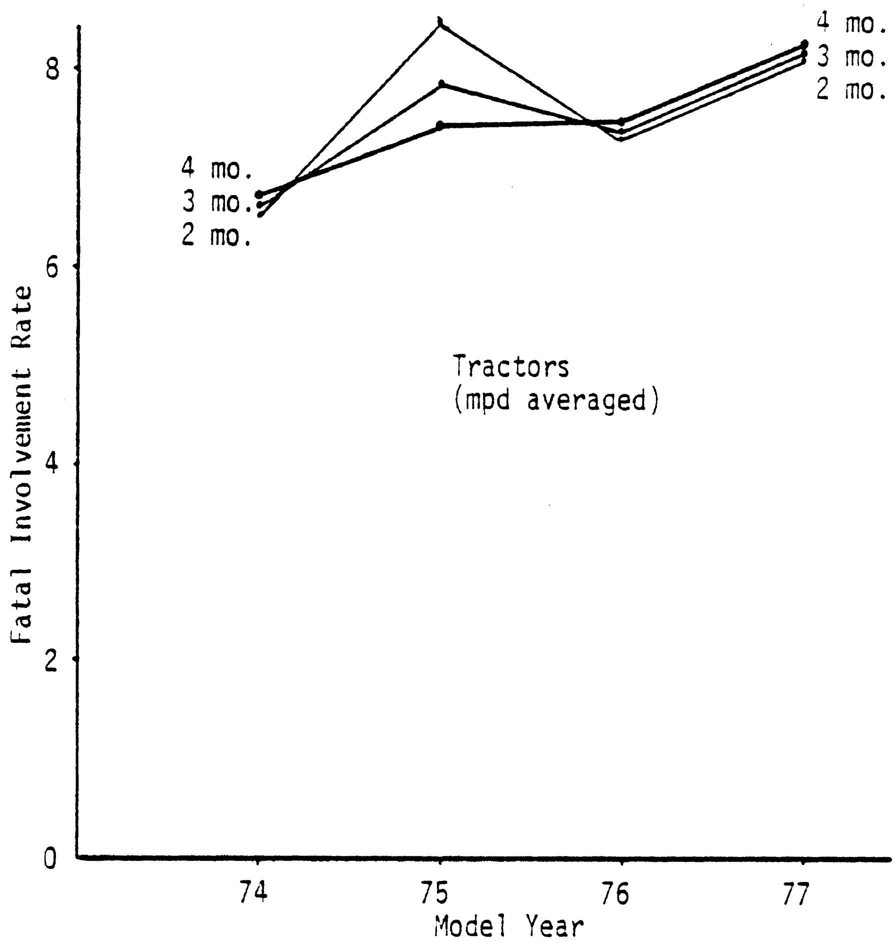

FIGURE 5.4 TRACTOR FATAL INVOLVEMENT RATES VERSUS TIME LAG

effect. Figures 5.3 and 5.4 clearly show that the overall trends by model year are not particularly sensitive to the assumption on time lag. In general, there does not seem to be any evidence of substantial reductions in the accident rates for post-standard vehicles at this point.

5.4.2 Trailer Brake Type. A specific objective of this study from the outset was to discern accident rates as a function of the brake type (pre versus post) on both tractor and trailer. In particular we wanted to isolate the experience of the combination vehicle completely equipped with brakes manufactured in conformance with FMVSS 121. It was generally recognized that the use of the 121-equipped trailers would be expected to increase by calendar year as more were introduced into the total population. The trip survey was intended to produce the necessary exposure information. This survey was carried out for the 1974 and 1975 model year vehicles (fleet monitoring program) over the 12 month period from July 1977 through June 1978. For the 1977 model year vehicles, the survey was conducted from September through December 1978. Differences in the use of the new trailers were not expected to vary much with the model year of the power unit in any given calendar year. Hence, for the Interim Report of October 1978, exposure data on the usage in 1977 of the 121 trailers for the post-standard 1975 model year power units was also applied to the 1976 power units. This computation indicated substantial over-involvement for the post-standard power units pulling post-standard trailers. Subsequent completion of the survey of 1977 model year power units produced exposure estimates for the use of the post-standard trailers which were substantially higher than those from the previous survey (58% versus 21%). Mixed results were obtained when accident rates were again computed for the various combinations of power unit model year and trailer brake type (see Appendix B).

The expanded accident data base used in this analysis offers an explanation for these mixed results. Figure 5.5 presents a plot of the percentage of accidents which involve post-standard trailers as a function of tractor model year and calendar year of accident. The relationships are striking. The number of accidents involving post-standard trailers changes more in going from one power unit model year to another in the same calendar year, than it does from one calendar year to the next for the same power unit model year. If one is willing to infer exposure from the accident experience, the implication is that the new tractors tend to

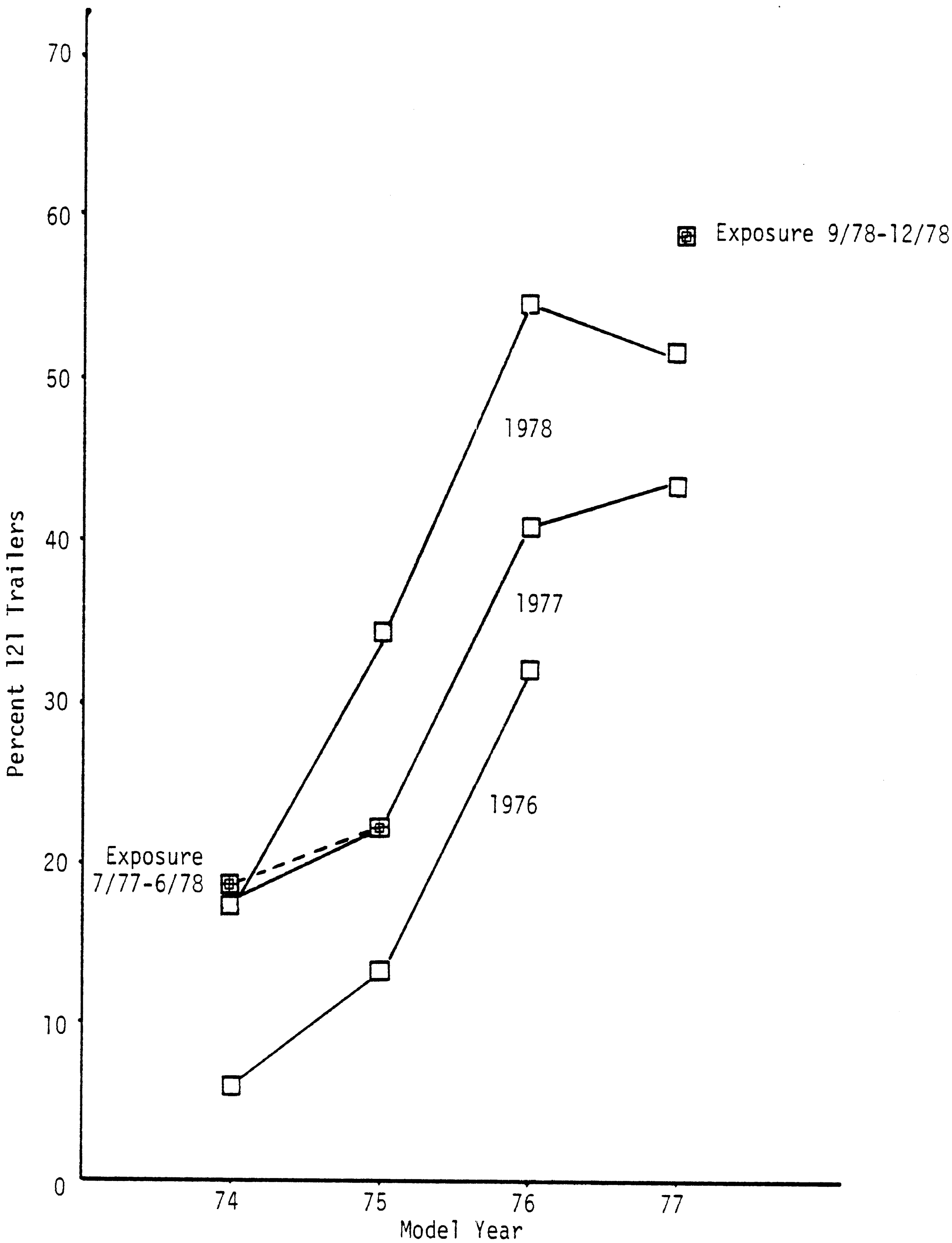

FIGURE 5.5 PROPORTION OF FATAL ACCIDENTS
INVOLVING POST-STANDARD TRAILERS

be coupled to new trailers very frequently. This heavy use of the new trailers is put into perspective somewhat when one deduces from production and registration statistics[12] that, even in 1978, the post-standard trailers were only 15% of all trailers.

Figure 5.5 implies that the trailer use data are only appropriate for the particular calendar year <u>and</u> model year for which it was collected. The exposure survey points are also indicated on Figure 5.5. Results for the appropriate model years and calendar years are repeated in Table 5.19. For the 1974 power units, the exposure percentage matches the accident percentage almost exactly for the two calendar years covered by the trip survey. For 1975 model year power units there is no evidence of over-involvement in the 1977 calendar year, but a 2:1 over-involvement is indicated in the 1978 calendar year. Averaging the two years, a 50% increase is shown for 1975 power units pulling a post-standard trailer. Looking at 1977 model year power units in calendar year 1978, the rate for the post-standard trailer is reduced by 30%. However, the plot by model year for the 1978 calendar year shown in Figure 5.5 is less smooth than the other calendar year curves. Some "visual smoothing" might suggest that the exposure point and the accident point may, in fact, lie quite close to one another. In general, there is not strong evidence to suggest that trailer brake type appreciably influences accident rates one way or the other.

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[12]<u>MVMA Motor Vehicles Facts and Figures</u> (Detroit, Mi.: Motor Vehicle Manufacturers Association, published annually).

TABLE 5.19

Fatal Accident Involvement Rates
by Tractor and Trailer Brake Type:
Intercity Tractors Only

Calendar Year	Power Unit Model Year	Trailer Brake			
		Pre-Standard		Post-Standard	
		Rate	95% C.I.	Rate	95% C.I.
1977	1974	6.1	±1.5	5.9	±1.6
1978	1974	6.2	±1.5	5.5	±1.5
1977	1975	8.2	±1.7	8.1	±1.7
1978	1975	6.0	±1.3	11.0	±2.3
1978	1977	6.2	±0.7	4.7	±0.4

5.4.3 Jackknifes. Jackknife accidents were also a focal point for this study. This particular collision type was expected to be influenced more than any other by FMVSS 121. Indeed it was hoped that a major portion of the benefits might be derived from a substantial reduction in this collision type. While it had been initially planned to study jackknifes as a function of both tractor and trailer brake type, the problems of exposure described in the previous sub-section prevent this. They also indicate that this distinction may not be important. As a result, Table 5.20 presents both the accident frequency and rates by power unit model year for jackknife accidents only. For this tabulation, only pre-impact jackknifes are included on the presumption that post-impact jackknifes are not amenable to vehicle handling countermeasures. The data shown in Table 5.20 are the aggregate of the three calendar years.

TABLE 5.20

Pre-Impact Fatal Jackknifes
(Intercity Tractors Only)

Power Unit Model Year	10^8 Vehicle Miles	C.I.	Jackknife Accidents		Rate	C.I.
			N	%		
1974	246.32	±35.018	55.3	3.7	0.225	±0.032
1975	141.94	±17.214	52.7	4.8	0.371	±0.045
1976	105.14	±41.022	41.3	5.0	0.393	±0.153
1977	161.43	±5.471	33.0	3.7	0.204	±0.007

The most striking observation is that pre-impact jackknifing occurs in only 4%-5% of the intercity tractor involvements in fatal accidents. Pre-impact jackknifes are seen to increase as a percent of all involvements for the 1975 and 1976 model years, and then decrease for the 1977 model year to the level of the 1974 model year. On a per mile basis, the rate of pre-impact jackknifes for the 1977 model year is 9% lower than the rate for the 1974 model year. As in previous comparisons, this result is sensitive to the survey mpd data, and would reverse if the averaged mpd figure were used. The difference in these two rates is not statistically significant.

Another attempt to discern differences related to the brake type of both tractor and trailer is shown in Table 5.21. This table is based solely on the accident data. Shown is the distribution of collision type by tractor model year and trailer brake type. Only intercity trips are included. The aggregate of the calendar years is shown. There are no discernible differences on this table.

TABLE 5.21

Fatal Accidents:
Collision Type Distribution by Tractor and Trailer Brake Type

COLLISION TYPE	POWER UNIT MODEL YEAR									
	1974		PRE-1975		POST-1975		1976		1977	
	Pre-Trailer (N=654)	Post-Trailer (N=96)	Pre-Trailer (N=332)	Post-Trailer (N=62)	Pre-Trailer (N=69)	Post-Trailer (N=48)	Pre-Trailer (N=233)	Post-Trailer (N=170)	Pre-Trailer (N=230)	Post-Trailer (N=210)
Single	12.7	13.5	9.3	17.7	17.4	14.6	14.6	15.3	13.9	11.9
Head On	23.7	24.0	28.3	24.2	31.9	25.0	28.8	25.9	21.7	28.6
Rear										
Other Veh into Trk	8.6	11.5	9.0	8.1	5.8	12.5	7.7	7.6	8.3	8.6
Trk into Other Veh	8.3	7.3	8.7	3.2	7.2	10.4	9.0	10.0	13.5	8.1
Angle										
Other Veh into Trk	10.4	12.5	8.1	11.3	5.8	6.3	9.9	10.0	13.9	10.0
Trk into Other Veh	17.4	19.8	17.2	19.4	13.0	16.7	11.2	14.1	16.1	12.9
Sideswipe	3.8	6.3	6.0	6.5	4.3	0.0	4.7	4.1	3.5	3.8
Other	6.9	3.1	8.4	6.5	7.2	10.4	7.7	6.5	6.1	7.6
Unknown	8.3	2.1	4.8	3.2	7.2	4.2	6.4	6.5	3.0	8.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In order to gain more insight into the role of braking in these accidents, a case-by-case review of approximately 450 cases was made by engineers with training and experience in vehicle dynamics research. Cases selected were divided equally between pre-standard combination vehicles and combination vehicles with post-standard brakes on both tractor and trailer. Out of this review came the general finding that there was evidence of braking in only about 24% of these cases. In most cases which were judged to involve braking, avoiding the accident by brake system improvement seemed to be impossible. Cases where a brake defect was indicated were also examined (about 1% of all cases). The 121 brakes did not appear as a causal factor in any greater proportion of accidents than the pre-standard brakes.

It should be pointed out that the emphasis in the overall study was on national statistics, rather than a determination of accident cause on a case-by-case basis. No accident investigations were conducted. The case-by-case review was based on police reports which provide limited information for assessment of accident causes or the role of braking.

Accident rates derived from BMCS-reported accidents are presented in the next section (Section 6).

SECTION 6

RATES FOR BMCS-REPORTED ACCIDENTS

Computerized data files for 1976 and 1977 were obtained from the Bureau of Motor Carrier Safety to provide a national data source for predominately injury-level accidents to complement the data on fatal accidents described in the previous section. All motor carriers engaged in interstate (or foreign) commerce are required to report to BMCS any accidents involving their vehicles that result in death, injury, or $2000 or more property damage. Excluded are occurrences that involve only boarding and exiting a stationary vehicle, the loading or unloading of cargo, or farm-to-market agricultural transportation. The accident information is reported to BMCS by the carriers themselves on a standardized form (50-T).

The BMCS data tapes received contained large amounts of alphanumeric information that is not compatible with most data analysis packages. HSRI performed an extensive reformatting of the data to produce numeric information for most variables. Some additional variables were created for convenience.

Many of the required analysis variables are included in the BMCS file. However, a mail follow-up was initiated for the 1976 cases to get additional information on the brake type of tractor and trailer and additional exposure variables. The response rate for this survey was only 39%. At this time, the American Trucking Association voiced concern over the HSRI study design. In a letter to the Project Director, Mr. Larry W. Strawhorn of the ATA Engineering Department states: "Frankly, we are reluctant to advise participation [of carriers] at this time." Indeed, a few carriers stated that they had been advised not to participate in the survey. Due to the poor response rate, the supplementary data were not usable. The planned follow-up on 1977 cases was dropped. Consequently, the analysis of the BMCS data is somewhat limited.

The 1975 model year is not split into pre- and post-standard power units. However, this split was not successful when estimating vehicles in service for the exposure computation either. Brake type (pre- or post-standard) for trailers was inferred from the trailer model year, taking 1975 or newer model years to be 121-equipped. (FMVSS 121 went into effect January 1, 1975 for trailers, as compared to the March 1, 1975 effective date for power units.) The small numbers of straight trucks (12%) were omitted since the air-braked vehicles could not be identified. Finally, the fleet size and cab style exposure variables were not available.

The remainder of this section presents accident rates computed using the BMCS-reported accident data for calendar years 1976 and 1977. In the first sub-section, the number of fatal accidents reported to FARS and BMCS is compared for the Authorized and non-Authorized carriers. Since many of the cases for non-Authorized carriers do not seem to be reported to BMCS, the remainder of this analysis is restricted to only the Authorized carriers. For the remaining sub-sections, the property-damage-only accidents are omitted (about 30% of the BMCS cases involve only property damage) in order to focus on injury-level accidents. Differences in the exposure categories are described in Section 6.2, while differences between pre- and post-standard are presented in Section 6.3.

6.1 Carrier Type

It is generally presumed that the non-Authorized carriers do not report accidents to BMCS as reliably as the Authorized carriers do. There are several reasons for this. The reporting requirement was only extended to the non-Authorized carriers in 1974. Because these carriers are not subject to the economic regulation of the Interstate Commerce Commission, they are less "visible" to the BMCS. In order to gauge how serious this problem may be, the number of fatal accidents reported to FARS and BMCS was compared for the Authorized and non-Authorized carriers. The comparison is restricted to accidents involving tractors on intercity trips. Only interstate non-Authorized carriers were included. Results are shown by model year of the power unit in Table 6.1. Fewer cases were found for both carrier types in the BMCS file. For the Authorized carriers, the BMCS file contains 19% fewer cases, while for the non-Authorized interstate carriers, the BMCS file contains 48% fewer cases.

Involvement rates for injury accidents are computed by carrier type using the BMCS data and shown in Table 6.2. The combined rate for the non-Authorized carriers is 61% lower than the rate for the Authorized carriers. This difference is also presumed to reflect the under-reporting of accidents to BMCS by the non-Authorized carriers. Recall from the previous section that no difference was found by carrier type in the fatal involvement rates. The remainder of the analysis of BMCS-reported accidents will be restricted to the Authorized carriers, because the severe under-reporting of the non-Authorized carriers is likely to introduce biases into this subset of the BMCS file.

TABLE 6.1

Fatal Cases Reported to FARS and BMCS by Carrier Type: Intercity Tractors Only

Model Year	Carrier Type			
	Authorized		Non-Authorized Interstate	
	FARS	BMCS	FARS	BMCS
1974	544	453	308	157
1975	384	267	285	120
1976	283	244	172	110
1977	196	176	119	69
TOTAL	1,407	1,140	884	456

TABLE 6.2

Injury Accident Involvement Rates by Carrier Type: Intercity Tractors Only, Fatals Excluded

Model Year	Carrier Type			
	Authorized		Non-Authorized Interstate	
	Rate	95% C.I.	Rate	95% C.I.
1974	40.9	±11.3	18.1	± 8.9
1975	55.5	±25.1	18.4	± 4.6
1976	48.8	±49.6	21.9	±15.4
1977	46.4	± 3.6	13.3	± 1.3
ALL	45.9	±11.1	18.0	± 4.3

6.2 Exposure Categories Compared

Differences between local and intercity trips in the accident rates of tractors are shown in the first subsection. Tractors operating without trailers (bobtail) and with double trailers are the subject of the second subsection. Both of these comparisons are limited to intercity trips and Authorized carriers. Both injury and fatal accidents are included.

6.2.1 Trip Distance. Injury accident rates for tractors operated by Authorized carriers are shown in Table 6.3 by model year and trip distance. The rate for local trips is slightly more than double that for intercity trips, as was also the case for fatal accident involvement. The difference shown on this table is also statistically significant.

TABLE 6.3

Injury Accident Involvement Rates by Trip Distance: Tractors, Authorized Carriers Only

Model Year	Trip Distance			
	Local		Intercity	
	Rate	95% C.I.	Rate	95% C.I.
1974	86.1	±30.1	44.7	±12.3
1975	200.3	±86.9	62.0	±28.0
1976	92.4	±83.9	55.2	±56.1
1977	171.4	±43.8	52.4	± 4.1
ALL*	112.6	±30.0	51.1	±12.4

*Difference significant at .001 level.

6.2.2 Trailer Type. A comparison of injury accident involvement rates for tractors operating with and without trailers on intercity trips is shown in Table 6.4. Again, the rate is much higher for the bobtail use. However, the variance in the exposure data is such that the difference in this table is not statistically significant at the .05 level. The comparison of single versus double trailers shown in Table 6.5 is statistically significant, however. As with the fatal involvement rates, the 1977 model year does not follow the general trend.

TABLE 6.4

Injury Accident Involvement Rates by Trailer Use:
Intercity Tractors, Authorized Carriers Only
(Miles Per Day Averaged)

Model Year	Bobtail		Trailer	
	Rate	95% C.I.	Rate	95% C.I.
1974	822.7	±1637.4	53.5	±32.3
1975	948.5	±1887.7	47.4	±28.6
1976	968.8	±2007.6	54.4	±34.1
1977	1095.2	±3082.6	67.2	±57.3
ALL*	913.9	±1032.3	53.5	±18.3

*Difference not statistically significant at .05 level.

In general, the findings with regard to exposure category are the same for the injury and the fatal accident involvement rates. Of course, these similarities may be partly attributed to the common exposure data base. Nonetheless, general agreement of the accident distributions is also indicated.

TABLE 6.5

Injury Accident Involvement Rates
by Number of Trailers:
Intercity Tractors, Authorized Carriers Only

Model Year	Single		Double	
	Rate	95% C.I.	Rate	95% C.I.
1974	41.7	±11.6	175.9	±62.2
1975	56.8	±25.9	330.4	±158.2
1976	52.1	±54.2	122.3	±67.8
1977	52.5	± 3.9	40.6	±13.2
ALL*	47.9	±11.9	126.3	±25.7

*Difference significant at .001 level.

Cab style is not coded in the BMCS file. However, a manual review of the make-model information, done as part of a MVMA sponsored study of truck accident experience as a function of cab style, generated the cab style information. These results are described in a report by Michael Kubacki entitled The Effect of Cab Style on the Accident Experience of Heavy Trucks. [13]

6.3 Pre- and Post-Standard Comparisons

Overall injury accident involvement rates are shown by model year in Table 6.6. In general there is a slight increasing trend. The major topic of this sub-section is to examine the sensitivity of these results to the exposure data. Accordingly, the rates are also shown in Table 6.6

[13] Michael Kubacki and James O'Day, The Effect of Cab Style on the Accident Experience of Heavy Trucks, Report No. UM-HSRI-81-03 (Ann Arbor: The University of Michigan, Highway Safety Research Institute, February 1981).

for the computation of rates using a daily mileage estimate which is the average of the survey data across model year. Differences shown here arise solely from the estimated number of vehicles in use. The difference between the 1974 and the 1977 model year rates using the survey mpd is statistically significant at the .09 level. The difference obtained using the averaged mpd for these two model years is not statistically significant. The magnitude of the increase is 19% using the survey mpd, and 24% using the averaged mpd. These results are plotted in Figure 6.1.

TABLE 6.6

Injury Accident Involvement Rates by Model Year:
Tractors, Authorized Carriers Only

Model Year	Survey MPD		Averaged MPD	
	Rate	95% C.I.	Rate	95% C.I.
1974	47.4	±12.5	59.4	±33.8
1975	68.3	±29.9	54.0	±30.7
1976	57.2	±54.4	58.4	±34.6
1977	56.6	± 4.3	73.6	±59.3

The rates obtained by model year using the three different assumptions on time lag are shown in Figure 6.2. Again, the averaged miles per day have been used in order to isolate the sensitivity to the estimated number of vehicles. Little change in the overall trend is shown. Again, these results are in general agreement with those for fatal involvement rates.

The same problems in examining accident rates as a function of the brake type of both tractor and trailer are present here as were found in the analysis of fatal

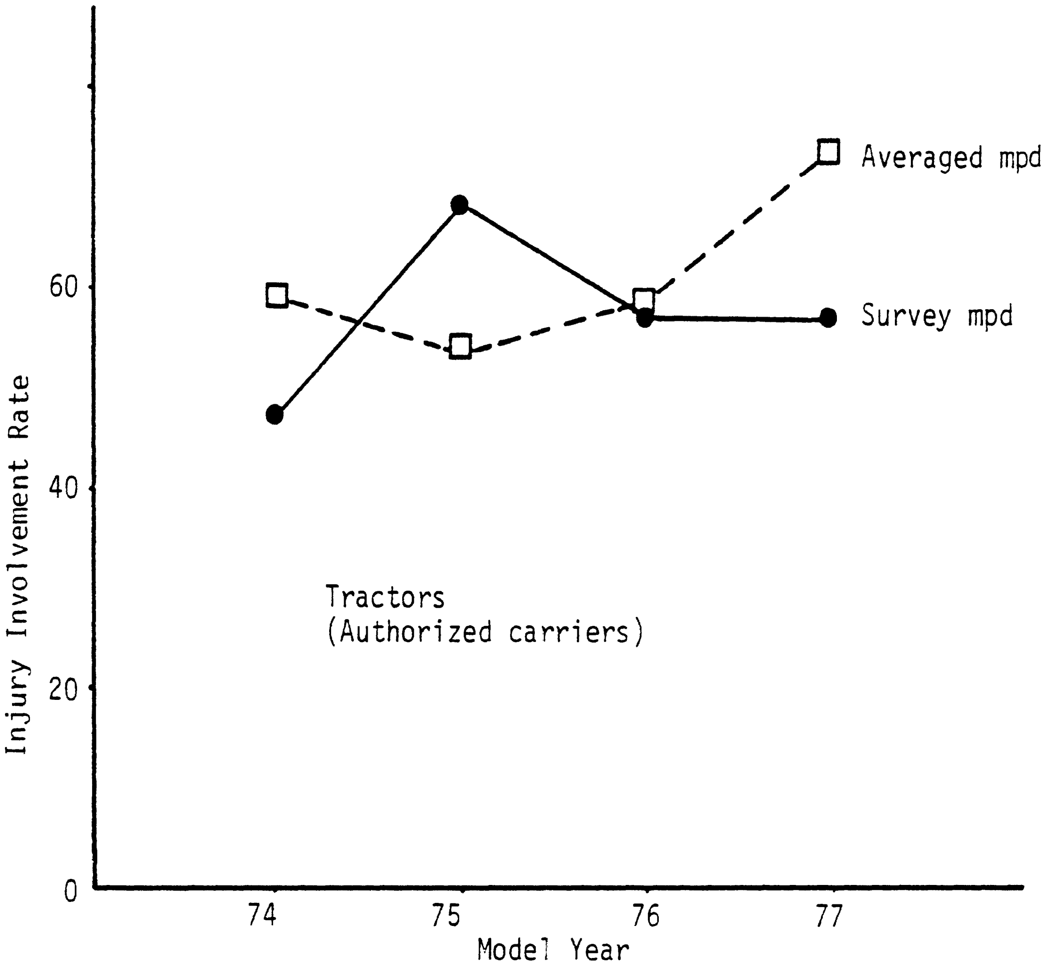

FIGURE 6.1 TRACTOR INJURY INVOLVEMENT RATES BY MODEL YEAR

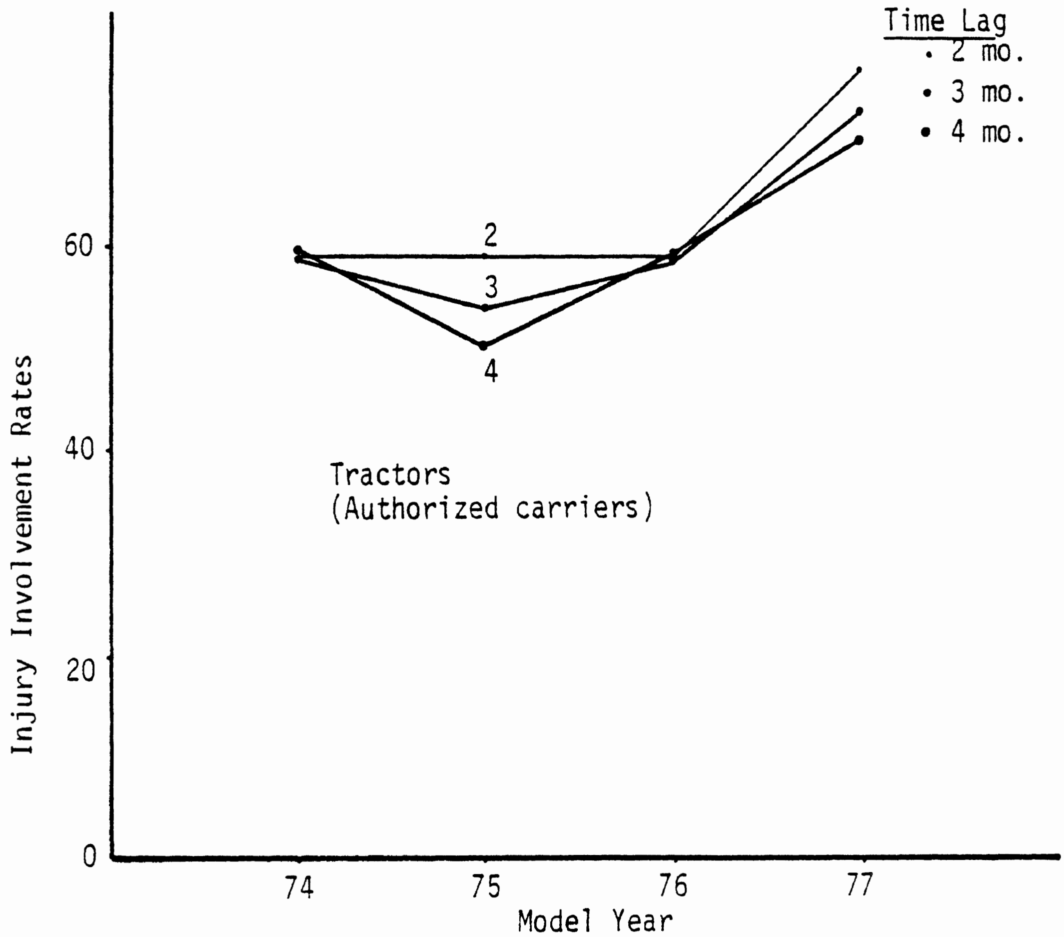

FIGURE 6.2 TRACTOR INJURY INVOLVEMENT RATES VERSUS TIME LAG

involvement rates. Figure 6.3 shows the proportion of accidents involving post-standard trailers as a function of both calendar year and power unit model year. Although the data are more limited here, the same general trends are seen. The appropriate model years and calendar years for comparison are shown in Table 6.7. As with the fatal involvement rates, there is some indication of over-involvement of the post-standard trailer when used with the 1975 power unit.

TABLE 6.7

Injury Accident Involvement Rates
by Brake Type of Tractor and Trailer:
Intercity Tractors, Authorized Carriers Only

Calendar Year	Power Unit Model Year	Trailer Brake Type: Pre-Standard		Trailer Brake Type: Post-Standard	
		Rate	95% C.I.	Rate	95% C.I.
1977	1974	43.5	±16.7	51.9	±21.7
1977	1975	55.8	±35.7	98.0	±62.6

Jackknife accident experience is also examined using the BMCS accident data. Here, property damage only accidents were also included in order to increase the sample size as much as possible. The results are presented in Table 6.8. In the BMCS file, jackknifing is only indicated for "non-collision" events. "Non-collision" events include such things as "ran off road, overturn, fire, and cargo shift or spill." Jackknife is recorded if it is the primary "non-collision" event. The table shows that, as before, the overall frequency of jackknifes, as a percent of all accidents, is very low, 4%-7%. The general trend with model year is also about the same, increasing for the 1975 and

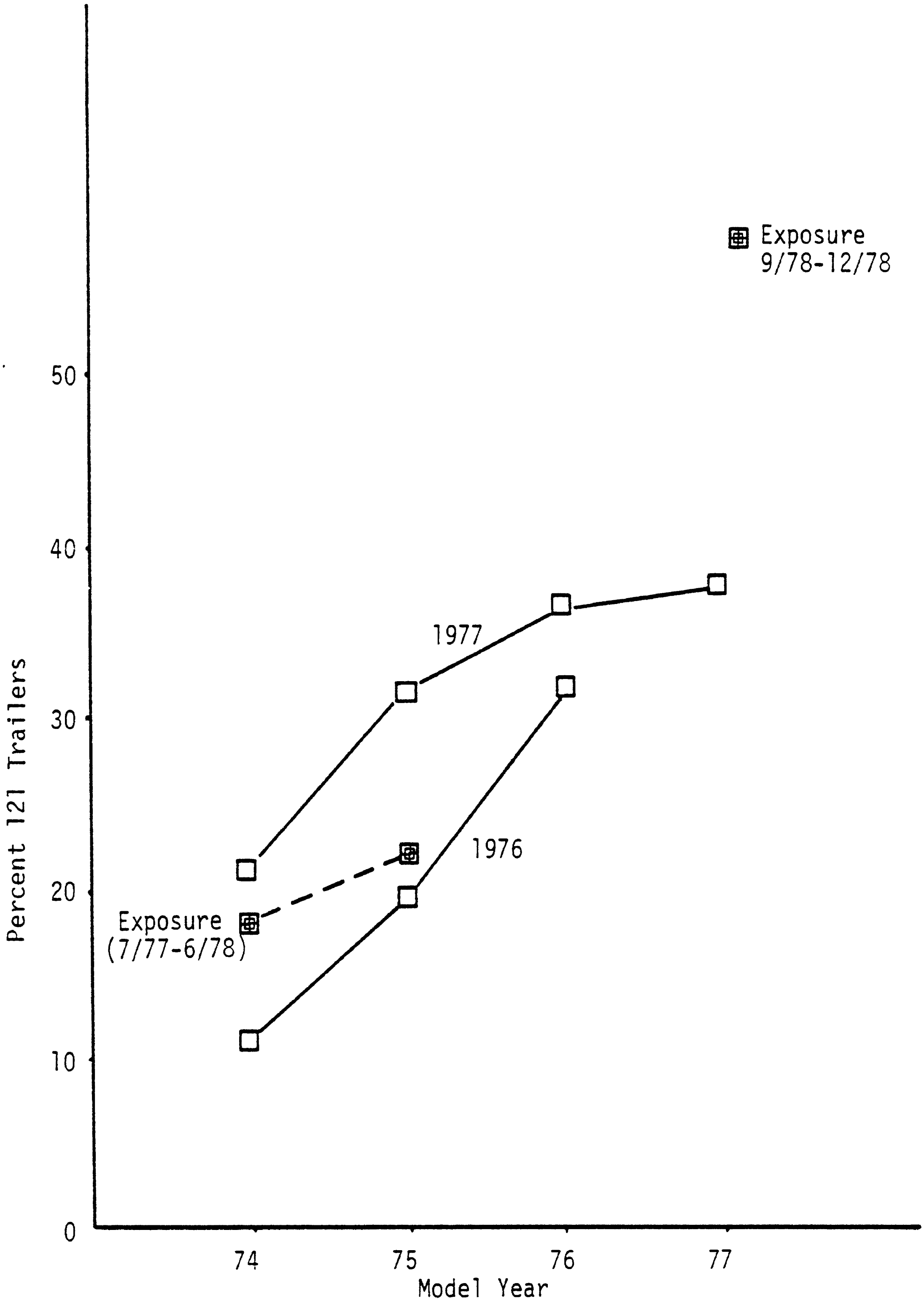

FIGURE 6.3 PROPORTION OF INJURY ACCIDENTS INVOLVING POST-STANDARD TRAILERS

1976 model years and decreasing in the 1977 model year. Jackknifing computed on a per mile basis shows a 15% reduction for the 1977 model year power unit as compared to the 1974 model year power unit. This difference is not statistically significant at the .05 level.

TABLE 6.8

Jackknifes:
Intercity Tractors, Authorized Carriers Only
(BMCS-Reported Accidents, 1976 and 1977)

Model Year	10^8 Vehicle Miles	95% C.I.	Jackknifes N	Jackknifes %	Rate	95% C.I.
1974	106.88	29.474	356	5.5	3.33	±0.92
1975	43.368	19.643	243	6.7	5.60	±2.54
1976	38.407	39.180	150	5.4	3.91	±3.98
1977	28.607	2.241	81	3.9	2.83	±0.22

In summary, the results from the FARS and BMCS accident data sets are in general agreement. Considering the different reporting requirements and mechanisms, this general agreement is reassuring. FARS cases originate with police-reported fatal accidents and are coded by analysts in each state. This information was supplemented by the HSRI telephone survey. On the other hand, BMCS accident reports are filled out and submitted by the carriers themselves. Trailer model year was used to make the pre/post distinction for trailers in this data file. Finally, the BMCS analysis was limited to the Authorized carriers.

SECTION 7

DISCUSSION

The material in this section is presented in three topical areas. The first sub-section deals with the study design. This sub-section begins with a discussion of the constraints and assumptions which shaped the design. Additional problems which arose during the course of the study are described next, followed by discussion of the strengths and weaknesses of the resulting data base. The first sub-section concludes with recommendations to expand countermeasure evaluation efforts prior to implementation of the countermeasure.

A major product of this study is the descriptive statistics on the vehicles and their owners. Little information was previously available on the population of air-braked trucks and their use. Of even more interest are the differences in accident rates found in comparing the various exposure categories. A summary of these results is presented in Section 7.2.

The last part of this section assesses the safety impact of FMVSS 121. This sub-section begins with a summary of the relevant findings from this study and a statement of the conclusions which seem warranted. These conclusions are followed by a discussion of possible explanations for the results. The impact of maintenance and reliability problems is examined. A discussion of the expected safety benefits for improved heavy truck braking systems is also included.

7.1 The Study Design

The objective of this sub-section is to relate the various strengths and weaknesses of the data base developed to the study design so that future evaluations may benefit from this experience. The discussion begins with a description of constraints and assumptions which shaped the study design.

7.1.1 Initial Constraints. Two major difficulties facing the study design were lack of knowledge of the population to be studied and lack of knowledge of the effect to be measured. The study population was, of course, air-braked vehicles. This subset is not identified in published information. The Authorized carriers are a visible subset of the tractor population, but the non-Authorized sector was relatively unknown. Information on the population of air-braked straight trucks was virtually non-existent. Although it was expected that these vehicles were used predominantly in local trips, no estimates on the size of this group were available.

Similarly, there was no good information on the type and proportion of accidents which would be affected by the improved brakes. It was assumed that braking had a rather pervasive effect, and that the safety impact of FMVSS 121 would be of substantial magnitude so as to be readily observable in the overall accident rates. This being the case, the very difficult task of identifying "brake-related" accidents was not necessary. However, the standard was expected to have its largest safety impact on loss of controllability accidents, including jackknifes.

The identification of pre- and post-standard vehicles was also a complicated task. FMVSS 121 was implemented midway through the 1975 model year. There was no ready means to identify the 121-equipped vehicles. As will be discussed in the next sub-section, this problem was compounded by the various exemptions to the standard which continued throughout its existence. Most manufacturers indicated that the Vehicle Identification Number (VIN) was not sufficient to identify pre- and post-standard vehicles. This situation effectively precluded use of existing data sources without conducting supplementary data collection.

Even more troublesome, in the end, was the fact that model year is not well defined for trucks. Again, the VIN is frequently not sufficient to determine the model year. Inability to distinguish one model year from another undermines any attempt to evaluate the heavy truck population.

To a large degree, the issues described above shaped the initial study design. The primary objective was to provide statistically defensible national estimates of the safety impact of FMVSS 121. The identification of specific brake-related accidents was not incorporated. To do so would have required detailed investigations of each accident, which would have put the cost of this evaluation on a par with the National Accident Sampling System (NASS). This distinction was judged to be not critical by NHTSA since they expected a substantial safety impact. Also, this decision was consistent with a cost/benefit analysis which examines the overall, or net, benefit.

A related issue is the determination of the operational status of the anti-lock system. Collection of this information was clearly desirable, since the system could hardly be expected to produce any benefits if it was not working. Again, the deciding factor was the difficulty and therefore the high cost of obtaining this information. While the "amber light" status could be recorded for tractors, the operational status of many trailers cannot be determined without special test equipment or actually conducting a panic brake stop. As with the determination of "brake-related" accidents, omission of information on the operational status is consistent with an evaluation of the standard, rather than the potential benefit of the concept. Indeed, the determination of the potential benefits of the concept is more properly made in limited test programs rather than national impact studies. The objective of this study, then, was an evaluation of the safety effects of the standard, and not necessarily identification of factors responsible for those effects.

The evaluation also assumed a "step change" in the vehicle population. That is, vehicles would be either pre-standard or post-standard. This distinction was expected to provide two well defined groups for comparison. The alternative which was considered was to quantify relevant performance characteristics of the vehicles in order to relate the actual vehicle characteristics to the observed accident experience. Again, the effort to acquire this information for all the various makes and models in all of the various configurations used was prohibitive.

Timing of the evaluation was also a problem. Because all air-braked vehicles were required to meet the standard as of March 1, 1975, no control group of vehicles of the same age was available. (A phased introduction would have lent itself to the establishment of control groups.) Control group information would have to come from previous model years. Only the 1974 model year was selected in order to minimize the age difference in the vehicles. The choice of a time period for the study was also difficult. Immediately after the effective date of the standard, the new vehicles would be slowly introduced into the vehicle population. Any evaluation had to wait until some minimum number of vehicles were in use. On the other hand, the longer the evaluation took, the older the control population would become. A two-year program was originally settled on as a reasonable compromise. The primary analysis feature was an attempt to identify exposure variables for control purposes so that vehicles in similar usage would be compared. As will be discussed in the following sub-sections, the first major finding was that the pre- and post-standard populations of vehicles were significantly different in their composition and use.

7.1.2 <u>Additional Problems</u>. The implementation of FMVSS 121 was not without its problems. The intent of this sub-section is only to discuss factors which influenced the evaluation. In general, the change from pre- to post-standard was not as clean as one would like. Many vehicles were built under various exemptions which continued throughout the course of the standard. The largest group exempted was the buses. Because of serious reliability problems with the early systems on over-the-road and transit type buses, these vehicles were exempted from the stopping distance (hence anti-lock) requirements beginning in January of 1976. This particular amendment to the standard should not have affected the study. It did, however. The over-the-road and transit buses were excluded from the sampling frame. Unfortunately, school buses, which are built on truck chassis, were inadvertently included. In fact, about 20% of the selected vehicles were school buses--almost three quarters of which were post-standard.

The inadvertent inclusion of school buses did more than just waste precious sample size. As will be discussed later, they were not uniformly distributed among the primary sampling units, and as a result, increased the variance of all the estimates.

The many modifications, exemptions, and amendments to the standard culminated in Notice 7 which took effect on March 1, 1976. This amendment increased the stopping distance requirement in order to allow de-powering of the front axle brakes. Manufacturers were able to meet the less stringent requirements without front axle anti-lock on many vehicles. A chronology of events in the history of FMVSS 121 has been issued by the National Transportation Safety

Board.[14] Ultimately, the Ninth Circuit Court of Appeals ruled in favor of a suit brought by Paccar seeking to invalidate major portions of the standard. The Supreme Court subsequently declined to hear the resulting NHTSA appeal in October 1978.

The reader should not get the impression that all of the problems of the evaluation were outside the influence of the project. The problems of locating the selected vehicles and securing cooperation were discussed at length in the Interim Report of October 1977.[15] Implementation problems for the fleet monitoring program arose principally from vehicles found to be located outside the selected fleets and areas. At the conclusion of this program, serious under-reporting problems remained in the areas of brake system maintenance and accidents. These problems were discussed at the end of Section 2, and resulted in heavy reliance on the FARS and BMCS accident files. The general climate for data collection was a difficult one. Everyone had strong opinions with regard to FMVSS 121. Even within the Department of Transportation, the Bureau of Motor Carrier Safety did not begin developing procedures to add the anti-lock system to their regulations requiring carriers to keep all "safety" equipment operable until March 1978. At the same time, the American Trucking Associations were informing HSRI that they were reluctant to advise carriers to participate in this evaluation program.

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[14] Safety Effectiveness Evaluation of the National Highway Traffic Safety Administration's Rulemaking Process, Volume I--Case History of Federal Motor Vehicle Safety Standard 121: Air Brake Systems, Report NHSB-SEE-79-4 (Washington, D.C.: National Transportation Safety Board, August 1979).

[15] Kenneth L. Campbell and Arthur C. Wolfe, Fleet Accident Evaluation of FMVSS 121: Interim Report, Report No. UM-H-HSRI-77-35 (Ann Arbor: The University of Michigan, Highway Safety Research Institute, October 1977).

Finally, preliminary results indicated that the pre- and post-standard vehicles were substantially different in their composition and use. The combination of the introduction of FMVSS 121 and an economic downturn for the trucking industry created substantial short-term changes in the purchase and use of heavy tucks.

7.1.3 <u>Strengths and Weaknesses in the Data</u>. The primary objective of this study was to develop national estimates of the safety impact of FMVSS 121. The impact is quantified in terms of the overall involvement rates for pre- and post-standard vehicles. To determine these overall statistics, it is not necessary to know the physical cause and effect mechanisms responsible for the observed changes. Identification of brake-related accidents or a determination of the role of braking in the causation of truck accidents is not required. Because the overall objective speaks to the impact of the standard, rather than to the potential of the improved performance characteristics called for by the standard, it is also not essential to know the operational status of the brake systems or even the actual in-use performance characteristics. All of these issues are rightfully the subject of causation research, countermeasure evaluation, and pre-testing carried out prior to the implementation of the standard. Once implemented, the appropriate primary objective is the determination of the net, or overall, safety impact of the standard itself.

7.1.3.1 Strengths. Enough cannot be said in support of the sampling procedures used in this study. The NHTSA insisted from the outset on a study design which produced defensible national statistics despite the tremendous effort and innovation such an effort required. Sampling frames and sample designs had to be developed so that probability-based selection methods could be employed. In retrospect virtually all of the strengths of this study follow directly from this requirement. The resulting descriptive statistics on the national population of late-model trucks and their use are likely to be of long-term value, aiding future heavy truck research efforts.

The use of probability-based selection methods provides a statistical basis for projection from the sample to the larger population from which the sample is drawn. This is the essential difference between anecdotal and survey data. If the elements for observation (vehicles) are not selected using probability-based methods, then the resulting information is anecdotal in nature. Results of an anecdotal nature provide no statistical basis for generalization (extrapolation) beyond the elements (vehicles) actually observed.

In addition to providing a statistical basis for extrapolation, probability-based methods also provide estimates of the precision of the extrapolation. These are presented as confidence intervals. It is perhaps even more important to know the precision of the estimates, than it is to know the estimates themselves when important decisions may depend on the information. The large confidence intervals on the preliminary results should have cautioned any users of this information. In fact, most of the topics discussed under the "Weaknesses" heading which follows could not even have been evaluated were the confidence intervals not known!

Table 7.1 summarizes the sample sizes, response rates, sampling frame totals, and frame coverage for the exposure surveys. The sampling frame is the list of vehicles from which the survey vehicles were randomly selected. The total number of vehicles in the sampling frame is given in the column labelled "Frame Total." The "Frame Coverage" is this total divided by the total population the sampling frame was intended to cover. While the response rates leave room for improvement, they are felt to be quite good considering the pioneering nature of this study. For the post-standard model year 1975 vehicles, the response rate is nearly 70%. This table also shows the minimal coverage of the 1976 model year. The fleet monitoring program was initiated early in this model year. By the time the program was expanded, the post-Notice 7 (model year 1977) vehicles were the focal point. Indeed, the sample size, response rate, and frame coverage for this last survey are very good. This is a reflection of the experience gained in the original fleet monitoring program. Again, it should be emphasized that it is the sampling procedures used which allow tabulations of this type to be made. Without the information on variance, response rates, and frame coverage, one would be hard pressed to evaluate the information collected.

TABLE 7.1

Exposure Survey Response Rates and Frame Coverage by Model Year

Model Year	Participating Sample	Response Rate	Frame Total	Frame Coverage
1974	1,191	63.1	144,813	67.1
1975 Pre	283	63.1	40,370	55.7
1975 Post	1,065	69.8	36,083	50.5
1975 Total	1,348	68.3	76,453	53.1
1976	253	69.8	6,218	5.0
1977	1,444	68.0	142,983	82.0

The second major strength is the incorporation of the control, or exposure variables. This design feature became critical when the preliminary findings revealed that the pre- and post-standard vehicles differed substantially in type and use. Comparison of the involvement rates for the various exposure categories has demonstrated that these factors strongly influence the accident experience of the vehicles. Although the number of factors included may seem minimal, the sample size simply will not accommodate further breakdowns. Comparisons of pre- and post-standard vehicles can now be made within common categories of vehicle type and use.

Turning to the accident data, the information on fatal and injury accidents obtained through the FARS and BMCS files leaves little to be desired. Both of these sources are a census of the national experience. Of course, the utility of the FARS data was greatly enhanced by the supplemental telephone survey conducted. Although the use of the BMCS data was limited to the Authorized carriers, the development of appropriate exposure data allowed this subset to be evaluated in its proper perspective. The general agreement between these two sources which resulted when they were combined with their respective exposure information certainly amplifies the overall credibility of the results. The next sub-section on the weaknesses of the data will discuss the problems associated with estimating the number of vehicles in use.

7.1.3.2 Weaknesses. The general weakness, or strength, of the mileage data is reflected by the computed variance, or the confidence interval. In general, the confidence intervals on the mileage data obtained from the fleet monitoring program are higher than one would like. For example, the confidence interval on the overall daily mileage for straight trucks in these data is on the order of 59% of the mean. For tractors the confidence interval is appreciably better at 20%-25% of the mean. However, as one proceeds to smaller subsets of the data, the confidence intervals quickly increase as a percent of the mean, reaching 100% for the very small cells like local mileage or intercity bobtail mileage for tractors. These large variances arise more from the sample design than from small sample sizes. In particular, it is the post-sample stratification for analysis that results in the large confidence intervals. The primary sampling units were geographic clusters. Post-sample stratification will not necessarily increase the variance unduly so long as the PSU's themselves are heterogeneous with respect to the post-sample stratification variables. The sample design presumed this to be the case. In fact, it was very much not the case. Straight trucks and buses, in particular, were not evenly represented in the PSU's, but were concentrated in only a few. This situation is primarily responsible for the large variances in the fleet monitoring program. Such geographic clustering should be avoided in future designs involving the trucking industry. Unfortunately, geographic clusters are the most logical way to reduce and control data collection costs when on-site visits are required. Alternatively, one would have to develop sampling frames which included the analysis strata variables to avoid this problem. For the survey of 1977 model year vehicles, the data collection demands were reduced so that on-site visits were not required. This obviated the need for a cluster design, and the confidence intervals from this survey are one of the major strengths of the data base.

The confidence intervals estimate the magnitude of the random variations present in the data. Another possible source of error is systematic error, or bias. Systematic error can only be quantified by comparison of independent data sources. In some cases such comparisons were possible (FARS data and survey mileages). For example, model year distribution in the fatal accident survey data was forced to match the distribution in the parent FARS file. Because this study breaks much new ground in the analysis of the accident experience of heavy trucks, many assumptions and approximations are without verification. Every effort has been made to trace anomalous results to possible data problems. However, the possibility remains that some of the results presented are influenced by unknown systematic errors, and consequently do not reflect the true situation. Questions of this nature can only be resolved by further research.

The problem with the 1976 model-year vehicles, on the other hand, is simply one of inadequate sample size. This is shown by the 5% frame coverage for this model year in Table 7.1. As was mentioned earlier, the fleet monitoring program was initiated very early in the 1976 model year; hence the low frame coverage. When the subsequent sample of 1977 vehicles was initiated the pre-Notice 7 vehicles were no longer of interest. Results derived from the small number of 1976 model year vehicles in the fleet monitoring program seem reasonable for the most part. The exception is the straight truck mileage, which is so low compared to the other model years that some bias must be present.

Mileage distributions by trip distance and trailer type were derived from the trip surveys. The primary difficulty here is in the estimation of the mileage distribution for pre-and post-standard trailers. These surveys covered the calendar years of interest reasonably well. However, all model years were not covered in each calendar year on the presumption that the post-standard 1975 power units would represent the 1976 power units fairly well with regard to the use of pre- and post-standard trailers. In fact, the original fleet questionnaires asked whether any special attempt would be made to couple post-standard equipment, and the response was a fairly unanimous "no." However, the proportions from the accident data discussed in Sections 5 and 6 indicate a strong tendency for new model year equipment to be coupled together, if the proportions in the accident data are interpreted as exposure information. This being the case, the exposure data on trailer brake type are applicable to only the specific calendar years and model years surveyed. The resulting data are of limited use.

This brings the discussion to what is probably the major difficulty of the exposure estimation, the number of vehicles in service. This topic is discussed extensively in Section 4. The required information must come from registration files, and is not currently available in suitable detail. Consequently, a number of assumptions and adjustments must be made in working from factory sales or "new registrations." Some analysis of the sensitivity of the results to these assumptions is presented, but even this may not adequately quantify the uncertainty of this information. However, potentially better information has become available since the completion of this study. R.L. Polk has prepared more detailed heavy truck registration data which include both the model year from the state registration files and the weight class of the vehicle. Even better should be the data collected in the 1977 Truck Inventory and Use Survey conducted by the Census Bureau. Trucks with air brakes are identified in this survey together with the registration model year. A secondary effect of the difficulty in estimating the number of vehicles in use was the apparent inability to divide the 1975 model year into pre- and post-standard groups. This is discussed in Section 5.

With respect to accident data, the major failure was our inability to obtain fleet-reported accidents. This was intended to be the main source of property damage level accidents. Although the major benefits were expected to come from the injury and fatal accident experience, the jackknife accidents, in particular, were thought to be primarily property-damage-only accidents. However, the BMCS file does include accidents which result in $2,000 or more property damage. A second failure in the collection of accident data was the supplementary mail survey for the

BMCS-reported cases involving Authorized carriers. This is the only survey conducted where refusals were the primary reason for non-response. In the other efforts, the non-response was usually a result of not being able to locate the current owner of the vehicle. Failure to obtain the support of the American Trucking Associations is felt to be partly responsible for the failure of the supplementary survey of BMCS-reported cases.

A last problem in the collection of accident data is the lower-than-expected response rate in the telephone survey to collect supplemental information on FARS cases. In order to acquire hard-copy police reports, it was generally necessary to send states a list of the FARS case numbers requested. These lists naturally came from preliminary FARS files. Apparently many heavy truck cases were received too late to be in the preliminary files. Unfortunately, we did not become aware of this problem soon enough to react to it.

7.1.4 Recommendations. The experience gained in this analysis of the safety impact of FMVSS 121 suggests several modifications which might benefit future countermeasure evaluation programs. In general, we recommend that future evaluation programs for accident causation countermeasures be expanded to include limited pilot, or demonstration, programs and planning of the national impact evaluation prior to implementation of the countermeasure. The remainder of this section develops these recommendations in more detail.

This discussion is confined to the evaluation of accident causation countermeasures. Identification of accident causes and development of countermeasures is not included. Many countermeasures, especially those in the vehicle area, involve the development of new hardware (components) and associated engineering performance tests as was the case with FMVSS 121. This discussion presumes that such development has been completed.

Before proceeding, the authors wish to underscore the need for rigorous, independent evaluation of the national impact of Federal Motor Vehicle Safety Standards. FMVSS 121 was expected to produce substantial safety benefits in return for a substantial economic investment. This study concludes that such benefits were not realized. This fact alone demonstrates the continuing need to evaluate Federal Motor Vehicle Safety Standards. Although many difficult problems hampered this program to evaluate FMVSS 121, the reader should not be tempted to conclude that national impact evaluations in the highway safety area are not feasible. The knowledge gained in this program and, in particular, the recommendations presented in this section should greatly aid the planning of future countermeasure evaluation programs.

Although this study concludes that FMVSS 121 did not produce substantial safety benefits, very little information is available to answer the obvious question as to why this result occurred. (Nonetheless, further discussion of this question is presented in Section 7.3.3.) One would like to know whether the hardware did not meet expectations in actual use or whether the original concept was in error. It has already been argued in Section 7.1 that such information was not essential to a national impact evaluation. The authors suggest that an important phase of the evaluation is a determination that the proposed countermeasure can, in fact, influence the accident experience of equipped vehicles. Such a determination is the logical complement to the engineering performance tests and should be carried out prior to implementation. While this task may be very difficult and time consuming due to the numerous and complex factors contributing to any collision, FMVSS 121 has illustrated the tremendous economic consequences if this determination is omitted. This phase will be referred to as a pilot, or demonstration, program.

One approach is to design a carefully controlled field trial. The objective here is not to determine the national impact, but rather, to demonstrate that in a specific, controlled real-world trial, the countermeasure does alter the accident experience of the vehicles. One would probably choose an operating environment where the countermeasure was expected to be most effective. A control group would also be established. Such a pilot program might be conducted cooperatively in a few large trucking companies over a two- or three-year period. All contributing factors, such as drivers, routes, cargo, maintenance, etc., would be carefully monitored and controlled. The objective would be to demonstrate that the proposed countermeasure could, in fact, alter the accident experience of the vehicles in the specific environment of the pilot program. A gradual, or phased, introduction might serve this purpose, although the "experiment" would lack control and be far more difficult to analyze.

Such a pilot program could also provide needed information on the type and proportion of all accidents influenced by the countermeasure. Assuming some benefit is demonstrated in the pilot program, such information would provide a basis to estimate the potential benefit in other operating environments. Such information would also materially aid the decision to implement the countermeasure on a national scope and the development of a national impact evaluation plan. Our experience also suggests that the design problems of a national impact evaluation would be reduced if the plan were developed prior to implementation.

Development of an effective national impact evaluation plan is enhanced by knowledge of the real-world operating environment, knowledge of the expected changes, and some influence over the way in which the countermeasure is implemented. Prior to this evaluation of FMVSS 121, very little was known about the number, type, and use of air-braked vehicles, particularly the straight trucks. As more information of this type is obtained, more effective evaluation programs can be developed. Similarly, more specific information on the expected changes in the accident experience would help focus the evaluation plan more accurately. Pilot, or demonstration, programs conducted prior to implementation would provide some of this type of information.

With more detailed knowledge of the composition and use of the vehicle population for which the countermeasure is intended, one would be better able to estimate an expected national impact, based on the experience gained in the demonstration program. Such an analysis would precede implementation and would not replace or remove the need for an actual national impact evaluation to be conducted after implementation. The pilot program would produce data demonstrating the effectiveness of the countermeasure in a specific controlled environment. The environment selected for the pilot program would most likely be one in which the countermeasure would be most effective. Once a benefit has been demonstrated in the pilot program, knowledge of the proportion of <u>all</u> vehicles which are used in a similar environment would materially aid the decision on national implementation.

Major problems in the design of a national impact evaluation are the identification of vehicles affected by the countermeasure and the establishment of suitable control groups. These problems are usually central considerations in constructing a sampling frame. Development of a plan for the national impact evaluation <u>prior</u> to implementation would provide more options in dealing with these problems. Convenient ways of "tagging" vehicles with the countermeasure might be employed. Some influence over the implementation schedule for the countermeasure could enhance the definition of more suitable control groups.

Considerations such as these may even make phased introductions more attractive.

In summary, we wish to underscore the need for rigorous, independent evaluation of the safety impact of Federal Motor Vehicle Safety Standards. Careful monitoring is important to ensure that limited resources are applied to achieve maximum benefits. In our view, the experience gained in this evaluation of FMVSS 121 suggests that future evaluation programs would be enhanced if they were initiated well before implementation of the countermeasure. During this period, limited pilot programs could be conducted to demonstrate that the proposed countermeasure can, in fact, influence the accident experience of equipped vehicles in a specific controlled environment. In addition to these pilot tests, a plan for the national impact evaluation should also be developed prior to implementation of the countermeasure. While these additions will be costly and time-consuming, they would appear to be necessary safeguards in the pursuit of improved highway safety. The authors hope that these recommendations will reduce the problems associated with implementation and evaluation of future countermeasures.

7.2 The Exposure Categories

The general information on heavy trucks, their use, and their accident experience developed in this study is likely to be of greater long-term value than the comparative statistics on the pre- and post-standard vehicles. Knowledge of the heavy truck population will aid future research and countermeasure development in this area. This sub-section summarizes the findings of this study with regard to the composition, use, and accident experience of heavy trucks.

First a discussion of the differences in the use and accident experience of straight trucks and tractors is presented. While straight trucks comprise about 40% of all air-braked vehicles, they account for only about 18% of the total vehicle miles and only about 10% of the fatal accident involvements for air-braked vehicles. Without knowing something of the causes of heavy truck accidents, and the role of braking in particular, the many differences between straight trucks and tractors described below would not lead one to expect the same countermeasures to be effective for both types of vehicles. The second sub-section focuses on the differences in the accident experience of the tractors in the various exposure categories. Most of the exposure variables used produce substantial differences in the observed accident rates.

7.2.1 Straight Trucks Versus Tractors. In estimating the exposure of heavy trucks, the single most important factor is the vehicle type, straight truck or tractor. In general, straight trucks are operated in local trips by small, non-Authorized carriers. Frequently they are operated by units of the state, county, or city government. Straight trucks are predominantly of the conventional cab style. Tractors, on the other hand, are operated primarily by large Authorized and large private carriers on intercity trips. The cabover style vehicles are 40% of all tractors. These comparisons are summarized in Table 7.2. The figures shown are an average of the 1974 and 1977 model years.

The other component of exposure is the average daily mileage estimates. In general, average daily mileage differs substantially by vehicle type and trip distance. This result is summarized below in Table 7.3. The total mileage for straight trucks or tractors shown on the table is the sum of the local and intercity miles. The figures in this table underscore the differences in the exposure of the straight trucks and tractors. A review of the results of Sections 2 and 3 indicates that the average daily mileage does not vary appreciably with the other exposure variables such as fleet size, and carrier type. Cabover-style tractors do seem to put on somewhat more mileage than conventional cab tractors, even when the comparison is restricted to intercity use.

TABLE 7.2

Summary of Differences in the Use of Straight Trucks and Tractors

Vehicle Type and Use	Percent of Vehicles	
	Straight Truck	Tractor
Conventional Cab	90%	59%
Local Trips	57%	5%
Operated by Small, Non-Authorized Carriers	68%	30%

TABLE 7.3

Average Daily Mileage for Straight Trucks and Tractors Apportioned by Trip Distance

Trip Distance	Straight Truck		Tractor	
	Mean	95% C.I.	Mean	95% C.I.
Local	36.1	±11.1	18.1	±17.1
Intercity	28.1	±18.0	193.6	±63.9
TOTAL	64.3	±24.8	211.7	±60.3

Table 7.4 summarizes the fatal accident involvement rates (involvements per hundred million vehicle miles) for straight trucks and tractors. Rates for local and intercity

use are shown separately. These results are an average of results obtained for the four model years. All the differences shown in this table are statistically significant at the .06 level or less. Tractors are found to have substantially higher rates than straight trucks in both local and intercity usage.

TABLE 7.4

Summary of Fatal Involvement Rates
by Vehicle Type and Trip Distance*

Trip Distance	Straight Truck		Tractor	
	Rate	95% C.I.	Rate	95% C.I.
Local	4.0	±0.4	11.1	±2.1
Intercity	3.3	±0.7	6.8	±0.6
ALL	3.7	±0.5	7.2	±0.5

*All differences significant at .06 level or less.

These results are presented to emphasize the differences in the use and accident experience of straight trucks and tractors. These differences make vehicle type the most important control variable in the comparison of pre- and post-standard vehicles. As the next table shows, the composition of the pre- and post-standard model years varied appreciably by vehicle type.

The proportion of air-braked vehicles which were tractors as compared to straight trucks varied considerably over the model years studied. Figures based on factory sales and supplied by the MVMA are repeated in Table 7.5. This information is presented in Section 4. The percentage of air-braked vehicles which are tractors ranges from a low of 50% in 1975 to a high of 67% in 1977. As will be discussed next, these variations are a reflection of unusual trends in the purchase of heavy trucks resulting from the introduction of the standard and the economic conditions in the trucking industry in 1975.

TABLE 7.5

MVMA-Supplied Data on the Percentage of Tractors in Air-Braked Factory Sales by Year

Calendar Year	Percent Tractors
1974	58.6
1975	50.2
1976	61.4
1977	67.2

7.2.2 Exposure Differences for Tractors. The straight truck data are too small to allow further disaggregation. However, for the tractors there is sufficient data to examine the effect on accident experience of several exposure variables. The comparisons made highlight substantial differences in the accident experience of tractors related to the various exposure categories. The exposure variables include trip distance, trailer type (bobtail, single, double), carrier type, fleet size, and cab style. All comparisons except the first are limited to intercity use. Involvement rates are summarized by exposure category for tractors in Table 7.6. Both the fatal involvement rate and the injury involvement rate are shown when available.

All the differences shown in this table are statistically significant at the .05 level or less except

TABLE 7.6

Summary of Involvement Rates
for Tractors by Exposure Category

Exposure Variable and Levels	Fatal (Cal. Yrs. 76-78)		Injury (Cal. Yrs. 76-77)	
	Rate	95% C.I.	Rate	95% C.I.
Trip Distance				
Local	11.1	±2.1	112.6	±30.0
Intercity	6.8	±0.6	51.1	±12.4
Difference	4.3	±2.2	61.5	±32.5
Intercity Use Only				
Trailer Type				
Bobtail	90.0	±44.5	913.5	±1032.3
Trailer	6.8	± 0.7	53.5	± 18.3
Difference	83.2	±44.5	*860.0	±1032.7
Single	6.5	±0.6	47.9	±11.9
Double	9.5	±1.1	126.3	±25.7
Difference	-3.0	±1.3	-78.4	±28.3
Carrier Type				
Authorized	6.7	±1.2	45.9	±11.1
Non-Auth Interstate	6.2	±1.1	18.0	± 4.3
Difference	*0.5	±1.6	27.9	±11.9
Fleet Size				
Small	10.4	±1.4		
Large	4.6	±0.7		
Difference	5.8	±1.6		

*Differences significant at .05 level except when marked with asterisk.

those marked with an asterisk. The fatal involvement rates by trip distance for tractors were shown in a previous table. Here, the comparable results are shown for the injury accident involvement rate. In general, the consistency shown in the fatal and injury involvement rates is reassuring. Of course, the same data base provides the exposure information for both computations. Nonetheless, it is still necessary to subset the exposure data to Authorized carriers for estimation of the injury rates. One would not expect the results to be so consistent if this subset were incorrectly estimated.

With regard to trailer type, the bobtail and double trailer configurations are found to have higher involvement rates than the single trailer. The confidence intervals are generally large for these two subsets because they represent very small proportions of the overall tractor vehicle miles. In fact, the discussion of the bobtail result presented in Section 5 suggests that the bobtail mileage may be underestimated. Even assuming the bobtail use to be 2 or 3 times that estimated, it would still appear that this configuration is overrepresented in both fatal and injury accidents. The increase in the involvement rate for doubles is not nearly so large. In fact, the results for the 1977 model year tractors did not show doubles to be overinvolved. However, the overall result shown here is statistically significant.

No significant difference by carrier type is shown in the fatal involvement rate. On the surface, it would appear that the non-Authorized interstate carriers have an appreciably lower injury accident involvement rate. However, the comparison of fatal accidents reported to FARS and BMCS presented in Section 6 indicates a serious under-reporting of accidents to BMCS on the part of the non-Authorized interstate carriers. The injury accident involvement rate shown in this table is felt to be simply another reflection of this under-reporting problem.

Partitioning of the data on fleet size produced one of the more substantial differences in exposure categories. Fleet size was measured in terms of the number of air-braked power units, with small fleets being those with less than 50 air-braked power units and large being those with 50 or more. Small fleets are found to have more than double the fatal involvement rate of large fleets.

A final comparison by cab style of the tractor is shown in Table 7.7. The cabover-style tractors have a fatal involvement rate 67% higher than that for conventional-cab tractors. This comparison is also limited to intercity use. Even more striking is the result when only accidents which resulted in death to the truck driver are used. Now the cabover-style tractor has a fatality rate slightly more than double that of the conventional cab tractor. These results are also highly significant.

TABLE 7.7

Fatal Involvement Rates by Cab Style:
Intercity Tractors Only

Cab Style	Fatal		Driver Fatal	
	Rate	95% C.I.	Rate	95% C.I.
Conventional	5.1	±0.9	0.65	±0.15
Cabover	8.5	±1.0	1.48	±0.26
Difference*	-3.4	±1.3	-0.83	±0.30

*Differences significant at .001 level.

The previous sub-section discussed differences in the exposure and accident experience of straight trucks and tractors. At the end of that sub-section it was pointed out that those differences were important to the comparison of pre- and post-standard vehicles because the percentage of tractors (and straight trucks) varied appreciably over the study period. Similarly, the differences in the accident rates associated with the various exposure categories for tractors also bears on the pre/post comparison. Differences were also observed in the purchase of tractors before and after the standard. In general, there was a decrease in purchases by large Authorized carriers in 1975. There was a corresponding increase in the percentage of vehicles purchased by small non-Authorized carriers. This trend is also likely to be primarily responsible for the decrease in the proportion of tractors in 1975, since the large Authorized carriers purchase mostly tractors. These differences in fleet size and carrier type are summarized below in Table 7.8.

TABLE 7.8

Percentage of Tractors in Large Fleets and Authorized Fleets by Model Year

Model Year	Large Fleets		Authorized Fleets	
	Percent	95% C.I.	Percent	95% C.I.
1974	58.4	±11.3	56.8	±13.9
1975 Pre	45.4	±25.9	40.6	±31.1
1975 Post	38.1	±22.9	28.8	±17.5
1976	56.7	±35.5	43.6	±37.7
1977	57.2	± 2.9	49.1	± 2.9

This discussion has focused on exposure differences and their effect on the accident experience of heavy trucks. As such, it is necessary background for comparison of pre- and post-standard vehicles which is finally addressed in the last part of this section.

7.3 Safety Impact of FMVSS 121

This sub-section begins with a summary of the accident experience of the pre- and post-standard vehicles. The remainder of this section is a discussion of possible explanations for the results. Maintenance and reliability problems are examined and there is a discussion of the expected safety benefits of the standard.

7.3.1 Summary Results. The accident experience of pre- and post-standard vehicles is summarized in this sub-section. Results are presented in four areas: straight trucks, tractors, trailer brake type, and jackknifes. Tractors and straight trucks are separated in light of the previous discussion of the differences in the use and accident experience of these two distinct vehicle types. Overall rates are presented here, rather than looking at local and intercity trips separately. This is appropriate because the exposure distributions by trip distance (see Section 4) do not change appreciably from model year to model year.

Tabulations in this sub-section are presented by model year. All 1974 and the majority of the 1975 model year are pre-standard. Efforts to split the 1975 model year were not successful. Model year 1977 vehicles are post-Notice 7.

7.3.1.1 Straight Trucks. Table 7.9 summarizes the fatal involvement rates (involvements in fatal accidents per hundred million vehicle miles) for straight trucks by model year. The data shown are an aggregate of the calendar years 1976-1978. Sufficient information was not available in the BMCS file to estimate injury involvement rates for straight trucks. Exposure data were particularly weak for the 1976 model year straight trucks. For this reason an average of daily mileage across model years was used in place of actual survey data for the 1976 model year. The 1974 model year is taken as a baseline in the computation of the percent change in the involvement rate for each successive model year. The percent change in the involvement rates is somewhat mixed, but generally increasing. These results were found to be sensitive to the exposure data. However, there is no evidence of substantial reductions in the involvement rates of straight trucks.

TABLE 7.9

Summary of Fatal Involvement Rates for Straight Trucks by Model Year

Model Year	Rate	95% C.I.	Percent Change*
1974	3.3	±0.9	0
1975	2.8	±0.5	-15
1976**	3.9	±0.9	+18
1977	4.6	±0.4	+39

*Base model year is 1974.

**Survey data replaced with an average of the daily mileages across model year.

7.3.1.2 Tractors. A summary of involvement rates for tractors is shown in Table 7.10. Here, results for both fatal and injury involvements are available. The fatal involvement rates are an aggregate of data from calendar years 1976-1978, while the injury accident involvement rates are derived from an aggregate of data from calendar years 1976-1977. Again, the percent change is computed using the 1974 model year as a baseline. As with the straight trucks, the percent change in the involvement rates is somewhat mixed, but generally increasing for the newer model years. These results were also found to be somewhat sensitive to the exposure data. Worth noting is the result for model year 1977 tractors which indicates a slight reduction. Yet the 1977 model year showed the sharpest <u>increase</u> for the straight trucks. The MVMA-supplied data on the percentage of tractors in each production year showed a higher percentage of tractors for production year 1977 (67%) than for any of the previous three years. If this figure were slightly high, the straight truck rate would decrease and the tractor rate would increase. However, the survey of 1977 model year vehicles indicated that 77% were tractors! This kind of problem emphasizes the importance of the estimates of the total numbers of vehicles in use. In conclusion, there is no evidence of substantial reductions in the involvement rates of tractors for the new model year vehicles.

TABLE 7.10

Summary of Involvement Rates
for Tractors by Model Year

Model Year	Fatal Involvements			Injury Involvements		
	Rate	95% C.I.	Percent Change*	Rate	95% C.I.	Percent Change*
1974	6.6	±0.7	0	47.4	±12.5	0
1975	8.2	±0.8	+24	68.3	±29.9	+44
1976	8.5	±3.0	+29	57.2	±54.4	+21
1977	6.2	±0.2	-6	56.6	±4.3	+19

*Base model year is 1974.

7.3.1.3 Trailer Brake Type. A serious problem was encountered in our efforts to estimate involvement rates for the various combinations of brake type (pre/post) on tractor and trailer. Surveys of trailer use were conducted during most of the time period under study. However, not all model years were surveyed in each calendar year. Subsequent analysis of the accident data suggests that the use of new trailers is strongly related to the tractor model year. Apparently fleets which buy new power units also buy new trailers, so the new equipment is very likely to be coupled together. A complete discussion of this problem is presented in section 5. The survey data are quite limited when restricted to the calendar year and model years surveyed. These results are presented in Table 7.11 and they are very mixed. A strong over-involvement is shown for the 1975 power units with post-standard trailers. In each case in this table, the percent change shown is a comparison of the involvement rate for tractors pulling post-standard trailers as compared to the involvement rate of the same model year tractor pulling pre-standard trailers. A reduction (24%) is shown for the 1977 model year tractor (post-Notice 7) pulling post-standard trailers in calendar year 1978. In general, there is no strong evidence here to indicate that the involvement rates are influenced by trailer brake type. This conclusion is primarily a reflection of the limited exposure data describing the brake type on both tractor and trailer.

7.3.1.4 Jackknifes. Jackknife accidents were of particular interest, since it was felt that this type of accident might show the most dramatic improvements for the post-standard vehicles. For a complete analysis, brake type of both tractor and trailer is needed. As previously discussed, the attempt to determine exposure by trailer brake type was not particularly successful. Consequently, the tabulations in this sub-section are presented by model year of tractor only. Summary results are presented in Table 7.12. For the fatal involvements, only pre-impact jackknifes were included on the presumption that post-impact jackknifing is not amenable to vehicle handling countermeasures. The second computation of jackknife involvements used the BMCS file. For this tabulation, property damage accidents were included. In the BMCS file, jackknifing is only indicated for "non-collision" events.

TABLE 7.11

Summary of Percent Change in Involvement Rates for Post-Standard Trailers by Model Year and Calendar Year: Intercity Tractors Only

Calendar Year	Tractor Model Year	Percent Change*	
		Fatal	Injury
1977	1974	- 3%	+19%
1978	1974	-11%	--
1977	1975	- 1%	+83%
1978	1975	+83%	--
1978	1977	-24%	--

*Baseline is the rate for the same calendar year and model year with a pre-standard trailer.

"Non-collision" events include such things as ran off road, overturn, fire, and cargo shift or spill. Jackknife is recorded if it is the primary "non-collision" event. Two types of statistic are shown in the table. First, the jackknifes are shown as a percent of all accidents for the model year in question under the column "percent." No exposure data are involved in this computation. Next, the "rate" for jackknifes is computed as the number of jackknife accidents per hundred million vehicle miles. The confidence interval of the rate is also computed.

Looking at Table 7.12, the trends in the fatal involvements and the BMCS-reported involvements are strikingly consistent. Perhaps, the most important result is that jackknifing as a pre-impact or primary non-collision event occurs in only 4%-7% of the fatal and BMCS-reported accidents! Jackknifes increase as a percent of all accidents and as a rate for the 1975 and 1976 model years,

TABLE 7.12

Summary of Jackknife Accidents:
Intercity Tractors Only

Power Unit Model Year	Fatal Involvements 1976-1978			BMCS-Reported Involvements 1976-1977		
	Percent	Rate	95% C.I.	Percent	Rate	95% C.I.
1974	3.7	0.225	±0.032	5.5	3.33	±0.92
1975	4.8	0.371	±0.045	6.7	5.6	±2.54
1976	5.0	0.393	±0.153	5.4	3.91	±3.98
1977	3.7	0.204	±0.007	3.9	2.83	±0.22

dropping for the 1977 model year. The percentage of BMCS-reported jackknifes shows a 29% reduction from 5.5% for the 1974 model year to 3.9% for the 1977 model year. The rate of BMCS-reported jackknifes decreases 15% for the 1977 model year power unit. For the most part, the difference in jackknife involvement rates is not statistically significant.

7.3.2 Conclusion. Many approximations and assumptions were necessary to carry out this analysis with the available data. These qualifications must be taken into account when interpreting the results. The authors conclude that this study provides no evidence of a substantial safety benefit for post-standard vehicles. On the other hand, as a consequence of the large confidence intervals and fluctuations in the estimated involvement rates, we do not believe the results support a conclusion that the involvement rates of post-standard vehicles have increased over those of pre-standard vehicles. In summary, the overall results do not support either the hypothesis that involvement rates are lower, or that they are higher.

Efforts to discern differences in involvement rates related to the use of pre- and post-standard trailers were largely unsuccessful due primarily to a lack of satisfactory exposure data. In general, there is not strong evidence that the use of pre- or post-standard trailers influences the involvement rate of the combination unit one way or the other.

Jackknife accidents were found to increase for the 1975 and 1976 model years and decrease modestly (15%-29%) for the 1977 model year power unit. These reductions are not statistically significant. Most important is the finding that the jackknife accidents are only 4%-7% of the fatal and BMCS-reported involvements. A 29% reduction represents a change of only 1.6% in all accidents!

7.3.3 Discussion. The objective of this sub-section is to consider possible explanations for the observed absence of any substantial safety benefits from FMVSS 121. First, a discussion of maintenance and reliability problems is explored. These problems resulted in inoperable anti-lock systems on large proportions of the 121-equipped tractors and trailers. Knowledge of truck maintenance practices suggests that less sophisticated countermeasures might not have required the drastic upgrading of truck maintenance capabilities. As an example of maintenance problems, difficulties with brake adjustment are cited. These problems do not seem sufficient to completely explain the lack of safety benefit. The second sub-section of this discussion considers the estimation of the expected benefits. Available information suggests that NHTSA over-estimated the role of braking as a causal factor in heavy truck accidents. It does not appear to be realistic to expect brake-related countermeasures to produce substantial reductions in the overall accident experience of air-braked trucks.

7.3.3.1 Maintenance Problems. The brake systems developed to comply with FMVSS 121 have many more components and are more complex than pre-standard brake systems. The most sophisticated component is the computerized anti-lock control. Serious maintenance and reliability problems were encountered when these systems were put into use. Maintenance and reliability problems offer a likely explanation for the missing safety benefits of the standard, since inoperable systems would not improve the braking performance of the vehicle. These problems were so severe for intercity and transit buses that NHTSA amended the standard by suspending the stopping distance requirement (hence anti-lock) for buses until January 1978. Despite reporting and consistency problems, the maintenance data collected in the fleet monitoring program indicate that the mileage <u>between</u> brake system maintenance entries decreased 31% for post-standard tractors and 60% for post-standard straight trucks. In other words, the post-standard systems apparently required more frequent maintenance. Maintenance and reliability were frequently mentioned at a public meeting on FMVSS 121 held by NHTSA in Washington, D.C. in October 1975. Subsequent to this meeting, the Truck and Bus Safety Subcommittees of the National Highway Safety Advisory Committee and the National Motor Vehicle Safety Advisory Council initiated a series of public meetings on FMVSS 121. In a letter from the Chairman of this subcommittee to the Secretary of Transportation dated May 3, 1977, the following conclusions are stated:

> "<u>Second</u>, it is concluded that driver training programs have not been adequate to properly instruct drivers in large and small fleets, as well as those operating independent and agriculture trucks."

> "<u>Third</u>, it is concluded that a shortage of qualified mechanics for all motor vehicle equipment is developing, since fewer and fewer are being trained."

> "<u>Fourth</u>, although suppliers are offering adequate and effective programs for journeyman mechanics, the

programs are being only partially used. A representative of the International Association of Machinists stated that there are approximately 300,000 journeyman mechanics involved with FMVSS 121, and that only about 25,000 have been trained on 121 equipment to date."

Results from the fleet monitoring program indicated that 18 months after the standard went into effect, only 20% of the fleets with 121-equipped vehicles were equipped to diagnose problems with the 121 brake system, and that only 15% reported that their mechanics had received special training in servicing the 121 brake system. The primary sources of such special training were supplier and manufacturer training courses.

There is also evidence that the anti-lock was inoperable on substantial numbers of vehicles. In a joint NHTSA-BMCS effort, a total of 500 combination vehicles in which at least one unit was 121-equipped were inspected. One hundred units were chosen at random from the traffic stream at state weighing stations in five locations across the country. The results from this survey were stated as follows:

> "The overall operational rate for the 407 antilock-equipped power units in the sample was 64 percent definitely operative, 6 percent definitely inoperative, and the other 30 percent unknown. Of the 249 anti-lock equipped trailers, 35 percent were definitely operative, 45 percent definitely inoperative, and 20 percent unknown."
>
> "The "unknown" category resulted from vehicles for which there was no failure indicator light or where the light would not go on for the bulb check, and the trailer function tester could not be used, but still there was no visible evidence of a problem with the system."[16]

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[16] Technical Assessment of FMVSS 121--Air Brake Systems (Washington, D.C.: National Highway Traffic Safety Administration, February 1978).

The same reference cites similar results from a survey conducted by the California Highway Patrol.[17] This study also includes some important findings on the incidence of improper brake adjustment.

> "Table I clearly reveals a surprisingly high percentage of 121-equipped intermixed combinations in need of brake adjustment. Twenty-two percent or more than one out of every five of intermixed 121-equipped vehicle combinations, were found so dangerously out of adjustment that they are unfit, by California standards, for highway operation, while only 9 percent of the pre-121 combinations were found to be within this category."

> "Table I also reflects another significant figure--17 percent of all the totally 121-equipped vehicle combinations also fall within the 40 percent or more of the brakes out of adjustment danger zone."

The overall incidence of improper brake adjustment (including the combination vehicles with less than 40% of their brakes improperly adjusted so that they were not in the danger zone) was 48% for pre-standard combinations, 60% for intermixed combinations, and 51% for combinations fully equipped with 121.

It would seem that brake adjustment was a serious maintenance problem before FMVSS 121. If pre-standard brake systems were not properly maintained, then one might expect increased problems when a more complex system requiring more maintenance was introduced. In fact, the introduction of FMVSS 121 aggravated an existing problem, especially on the combination vehicles with a mixture of pre- and post-standard units. Brakes made in conformance with FMVSS 121 exert a higher brake torque for a given line pressure. On a mixed vehicle, the unit with 121 brakes will always do more than its share of the braking. This accelerates the wear of the 121 brakes since their use is increased. The

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[17] Study of 121-Equipped Vehicles (Calif.: California Highway Patrol, October 1977).

accelerated wear is likely to increase the incidence of improperly adjusted brakes.

This discussion of maintenance and reliability problems was initiated as a possible explanation for the failure of FMVSS 121 to produce the expected safety benefits. In fact, the available evidence indicates significant maintenance problems and appreciable proportions of vehicles in service with inoperable anti-lock systems, especially on trailers. There is another important aspect of the problem revealed here. Improper brake adjustment is found to have been a prevailing maintenance problem before FMVSS 121 was introduced. Many of the difficulties associated with the design of this evaluation study reflected a lack of knowledge of the population for study. Here also, the knowledge available now of pre-existing maintenance problems and practices in the trucking industry would suggest that the introduction of a more complex brake system would aggravate such problems as improper brake adjustment. The next sub-section reviews present information on the accident experience of heavy trucks in relation to the estimation of the expected safety benefits for improved braking.

7.3.3.2 Estimating Potential Benefits. In October 1975, NHTSA placed in the public docket a "working draft" economic analysis.[18] This document presents estimated annual costs associated with FMVSS 121 ranging from a low estimate of $396 million to a high estimate of $889 million. Total safety benefits were estimated at $790 million. These safety benefits were the result of an estimated 31% reduction in fatalities, 41% reduction in personal injuries, and 21% reduction in property damage. These estimates were derived from a review of 305 in-depth

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[18] Economic Impact of FMVSS 121, Air Brake Systems: A "Quick-Look" Evaluation (Washington, D.C.: National Highway Traffic Safety Administration, April 1975).

field investigations performed by the staff of the Bureau of Motor Carrier Safety during calendar year 1972.

FMVSS 121 is an accident avoidance countermeasure. It seeks to prevent, or lessen the severity of, collisions. The development of such countermeasures presumes knowledge of the causes of accidents. It is also necessary to know the proportion of all accidents influenced by the particular causes identified. Having this information, one then estimates the effectiveness of the countermeasure and multiplies by the proportion of accidents to estimate the expected reduction. For example, if 50% of all accidents are caused by brake failures, and if some countermeasure will eliminate 30% of the brake failures, then one would expect to eliminate 15% (0.30 times 50%) of all accidents.

NHTSA has stated that two major classes of accidents appear to be relevant:

1. Accidents involving skidding or other loss of control, including jackknifing of tractor-trailer combinations;

2. Accidents where stopping distance is a factor, such as those in which a truck rear-ends another vehicle.[1']

This reference also cites percentages for some of these classes of accidents obtained from a current NHTSA study.

> "Brake-caused swerving, weaving, and leaving the traveled lane were reported for 8 percent of the involved commercial vehicles. Wheel lockups were reported by the investigating officer to be factors contributing to the accident in about 2 percent of the accidents. While jackknifing of combination trucks occurred in close to 8 percent of the accidents, roughly 4 percent jackknifed prior to the collision."

The percentage of accidents where stopping distance is a factor was not estimated.

[1']<u>Technical Assessment of FMVSS 121--Air Brake Systems</u> (Washington, D.C.: National Highway Traffic Safety Administration, February 1978).

The frequency of pre-impact jackknifing found in this study (4%-7%) agrees well with these estimates. The maximum reduction observed for post-standard vehicles was 29% of the jackknifes for a total benefit of 1.6%. Our review of 450 police reports on fatal accident involvements (see Section 5) indicated that braking was involved in only 24% of the cases, with virtually none amenable to stopping distance countermeasures.

NHTSA has included "loss of control" as an accident type which is expected to be favorably influenced by the requirements of FMVSS 121. It is not clear that this assumption is justified. Compromises between braking and stability are among the issues discussed in a recent submission by the HSRI Physical Factors Division in response to NHTSA's Advanced Notice of Proposed Rule Making for a new Air Brake Standard No. 130. The relevant sub-section of the response begins with the statement:

> "A braking performance standard, which specifies a deceleration level or stopping distance requiring high braking efficiencies to be attained on a specified surface, must recognize that vehicle braking performance up to the limits of tire traction is not free for the asking but is bought with reductions in vehicle stability."

The section ends:

> "We conclude that the warnings of the manufacturers, with regard to directional stability being overly compromised if heavy trucks are designed to achieve high deceleration levels, are real and well founded."
>
> "Further, it is <u>not</u> clear that such increases (in maximum deceleration) will improve the traffic safety record. We would suggest that, to the degree that normal braking and downhill-descent performance are compromised by designing to achieve shorter wheels-unlocked stopping distances (for obstacle-avoidance braking), the traffic safety record may also be compromised. HSRI suggests that NHTSA may have adopted certain premises which are unfounded and, if this proves to be the case, the question of whether the 60 mph stopping distance requirement should be reinstated should be held in abeyance until it becomes clear that

the stopping-distance performance of heavy trucks should be biased in favor of a limit-performance requirement."[20]

The foregoing discussion suggests that it was not realistic to expect substantial reductions in the overall accident rate as a result of implementation of FMVSS 121. The problems run much deeper than simply maintenance and reliability. The available information suggests that only a small proportion of all accidents are amenable to stopping-distance related countermeasures, and then possibly at the expense of other collision types. Before further brake-related countermeasures can be justified, comprehensive information is needed on the relationship of various braking performance measures and the causes of heavy truck accidents.

7.3.4 Recommendations. The cost of nearly four years of FMVSS 121 is well over $1 billion even when NHTSA's lower estimate is used.[21] Everyone would like to bring about improvements in highway safety as quickly as possible, especially where heavy trucks are concerned. The mixture of cars and heavy trucks on the same roads is perhaps our most serious highway safety problem. When vehicles of such disparate size collide, the consequences are most grim for the occupants of the smaller vehicle. The trucking industry has prospered on the interstate highway system. Yet, the cost in human lives of moving goods by truck is far greater than the cost using any other transportation mode.[22]

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[20]Response to Advanced Notice of Proposed Rulemaking, Air Brake Systems, Report No. UM-HSRI-79-32 (Ann Arbor: The University of Michigan, Highway Safety Research Institute, 1979).

[21]Economic Impact of FMVSS No. 121, Air Brake Systems: A "Quick-Look" Evaluation (Washington, D.C.: National Highway Traffic Safety Administration, April 1975).

[22]See James O'Day in response to Item IIID--Impacts on Highway and Motor Carrier Safety, of the Department of Transportation "Notice 79-10: Truck Size and Weight Study,"

However, limited economic resources should be carefully allocated to maximize the benefits realized. In an understatement, the Council on Wage and Price Stability concludes:

> "The overall public interest will not be well served if the proposed safety standards are unduly expensive or are written to preclude gains in safety by less expensive means."[23]

The problems of accident causation are so complex that it is extremely difficult to assure that any change will have its intended effect. Consequently, it seems imperative to pursue countermeasure development in a cautious and deliberate manner.

Federal Register 44:10 (June 5, 1979), pp. 32344-32346, prepared for the Motor Vehicle Manufacturers Association.

[23]George C. Eads, Statement to the National Highway Traffic Safety Administration Public Meeting on Air Brake Systems--Standard No. 121 (Washington, D.C.: Council on Wage and Price Stability, 30 October 1975).

APPENDICES

APPENDIX A

MVMA LETTER TO HARRY CLOSE

WASHINGTON DC
1909 K STREET N W SUITE 300

NEW YORK
366 MADISON AVENUE

MOTOR VEHICLE MANUFACTURERS ASSOCIATION
of the United States, Inc.
300 NEW CENTER BUILDING • DETROIT, MICHIGAN 48202 • AREA 313-872 4311

February 14, 1979

Mr. Harry Close
U.S. Department of Transportation
Room 5221, 2100 Second St., S. W.
Washington, D. C. 20590

Dear Mr. Close:

As per your November 29, 1978 request to Mr. Griskivich, please find enclosed the airbraked truck/tractor industry data for G.V.W. groups 6, 7 and 8 for the years 1974 through 1978.

It was pointed out to me by most suppliers of these data that no actual figures could be made available on truck versus tractors. As you realize, in many instances modifications could have been made by the dealers which would change the truck/tractor classification. Therefore, the summary reflects estimates based upon installation rates of production options such as tractor hook-up air hoses, or electrical connections, or fifth wheels, or brake components, etc. Even then, as some companies pointed out, this rate does not represent total tractor usage, because of aftermarket and fleet installation of such components on the companies' chassis truck cabs.

The data were supplied by Chrysler Corporation, Ford Motor Company, Freightliner Corporation, General Motors Corporation, International Harvester Company, Mack Trucks, Inc., PACCAR, Inc. and White Motor Corporation. Please note that the data aggregates for most companies are U.S. domestic factory sales plus Canadian factory sales exports to the U.S. One company, however, could only supply the requested data on a retail sales basis. It also should be mentioned that for 1978, two companies reported 9 months data and one company reported 10 months data. On the basis of the information available to me, the reported data were extended to a 1978 calendar year period.

TWX NO. 710-822-9245 AUTOMAKERS WSH.

I should also like to add that I was in no position to perform audit procedures on the data submitted to us. Therefore, MVMA assumes no responsibility other than the responsibility for the compilation of the data.

I hope, Mr. Close, that this information will be helpful to you.

Sincerely,

Jacques J. Evers, Manager
Statistics Department

JJE/jo

cc: Messrs. Bridenstine, Jr.
Griskivich
Boron
Good
Rossow

AIR BRAKED TRUCK/TRACTOR SUMMARY

G.V.W. in Lbs.	TRUCKS 19,501-26,000	TRUCKS 26,001-33,000	TRUCKS 33,001 & Over	TRUCKS Total	TRACTORS 19,501-26,000	TRACTORS 26,001-33,000	TRACTORS 33,001 & Over	TRACTORS Total	TOTAL 19,501-26,000	TOTAL 26,001-33,000	TOTAL 33,001 & Over	TOTAL Total
1974	25,726	14,689	46,656	87,071	8,182	12,182	102,779	123,143	33,908	26,871	149,435	210,214
1975	19,829	12,857	29,711	62,397	6,581	7,600	48,729	62,910	26,410	20,457	78,440	125,307
1976	13,240	10,863	26,556	50,659	3,967	5,995	70,453	80,415	17,207	16,858	97,009	131,074
1977	14,475	13,057	34,188	61,720	5,408	10,398	110,413	126,219	19,883	23,455	144,601	187,939
1978	14,436	15,686	39,898	70,020	5,299	9,557	114,970	129,826	19,735	25,243	154,868	199,846

Above data subject to stipulations outlined in the February 14, 1979 letter to Mr. Close.

APPENDIX B

FATAL RATES: SURVEY MILES PER DAY

This appendix presents fatal accident involvement rates computed using FARS accident data and survey mileage data by calendar year and power unit model year. These data are presented in a series of 9 tables as listed below.

Subset	Variable	Levels
1. None	Vehicle Type	Straight Truck, Tractor
2. Straight Truck	Trip Distance	Local, Intercity
3. Tractor	Trip Distance	Local, Intercity
4. Intercity Tractor	Trailer Type	Bobtail, Trailer
5. Intercity Tractor (with Trailer)	Trailer Type	Single, Double
6. Intercity Tractor (with Trailer)	Trailer Type	Pre-Standard, Post-Standard
7. Intercity Tractor	Cab Style	Conventional, Cabover
8. Intercity Tractor	Fleet Size	Small, Large
9. Intercity Tractor	Carrier Type	Authorized, Non-Auth. Interstate

Each page also contains 17 rows which correspond to the various model years and accident years. The first five rows show the results by model year for calendar year 1976, with rows 1-5 corresponding to the model years 1974, 1975 Pre, 1975 Post, 1975 Total, and 1976. The next six rows show the results for calendar year 1977 for the same five model years plus the 1977 model year. The last six rows correspond to the same six model years for calendar year 1978. The calendar year and power unit model year corresponding to each row are listed in columns 1 and 2 of the table, respectively.

The remaining twelve columns on each page correspond to two repetitions of six variables, one repetition for each of the two levels associated with the exposure variable. The common group of six variables is, in order from left to right, shown in the following listing.

Column 1: Total vehicle miles
2: Confidence interval for total vehicle miles
3: Number of accidents
4: Response rate for the above number of accidents
5: Accident rate, column 3/(column 4 x column 1)
6: Confidence interval for the accident rate

Data are also combined across calendar years and then across model years. This information is presented in the second set of 9 tables in this appendix. The column format is the same as for the first 9 tables, except that the response rate for the accident counts is omitted since the estimated totals must be used in combining the data. The first 6 rows of each table present results for each of the 6 model year divisions shown above after combining across calendar year. The final row presents the data after combining across calendar year and model year.

Survey Data

Fatal Involvement Rates
Vehicle Type by Calendar Year and Model Year

CAL YR	MOD YR	Straight Truck: Veh. Miles	Straight Truck: V.M. C.I.	Straight Truck: No. Acc.	Straight Truck: Response Rate	Straight Truck: Acc. Rate	Straight Truck: Acc. Rate C.I.	Tractor: Veh. Miles	Tractor: V.M. C.I.	Tractor: No. Acc.	Tractor: Response Rate	Tractor: Acc. Rate	Tractor: Acc. Rate C.I.
76	74	20.287	9.2041	61.000	1.0000	3.0069	1.3642	92.703	18.789	568.00	1.0000	6.1271	1.2418
	75 Pre	9.3567	4.6372	29.000	1.0000	3.0994	1.5361	26.524	6.5978	333.00	1.0000	12.555	3.1231
	75 Post	8.7972	2.5989	16.000	1.0000	1.8188	.53730	28.345	6.8243	97.000	1.0000	3.4221	.82390
	75 Total	18.154	5.3158	45.000	1.0000	2.4788	.72585	54.869	9.4922	430.00	1.0000	7.8369	1.3558
	76	3.1104	1.2802	24.000	1.0000	7.7159	3.1758	24.243	14.578	206.00	1.0000	8.4973	5.1098
77	74	19.885	9.0220	70.000	1.0000	3.5202	1.5971	90.869	18.417	606.00	1.0000	6.6689	1.3516
	75 Pre	9.2630	4.5908	37.000	1.0000	3.9944	1.9797	26.258	6.5318	376.00	1.0000	14.319	3.5620
	75 Post	8.7092	2.5729	20.000	1.0000	2.2964	.67841	28.061	6.7560	110.00	1.0000	3.9200	.94377
	75 Total	17.972	5.2626	57.000	1.0000	3.1716	.92870	54.319	9.3972	486.00	1.0000	8.9471	1.5478
	76	5.6552	2.3276	43.000	1.0000	7.6036	3.1295	44.079	26.507	382.00	1.0000	8.6663	5.2114
	77	8.6476	.89302	43.000	1.0000	4.9725	.51350	60.137	2.4609	408.00	1.0000	6.7845	.27763
78	74	19.272	8.7439	66.000	1.0000	3.4246	1.5538	88.068	17.849	609.00	1.0000	6.9151	1.4015
	75 Pre	9.0759	4.4981	30.000	1.0000	3.3054	1.6382	25.728	6.3999	326.00	1.0000	12.671	3.1520
	75 Post	8.5333	2.5209	16.000	1.0000	1.8750	.55392	27.494	6.6195	95.000	1.0000	3.4553	.83188
	75 Total	17.609	5.1564	46.000	1.0000	2.6123	.76493	53.222	9.2074	421.00	1.0000	7.9103	1.3685
	76	5.6005	2.3051	40.000	1.0000	7.1422	2.9396	43.652	26.250	366.00	1.0000	8.3845	5.0420
	77	15.723	1.6237	70.000	1.0000	4.4520	.45975	109.34	4.4743	639.00	1.0000	5.8441	.23914

Survey Data

Fatal Involvement Rates for Straight Trucks
Trip Distance by Calendar Year and Model Year

		TRIP DISTANCE - STRAIGHT TRUCKS											
		LOCAL						INTERCITY					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	11.458	3.4750	30.000	.77000	3.4003	1.0312	8.7971	6.3239	17.000	.77000	2.5097	1.8041
	75 Pre	5.1068	1.9371	12.000	.65300	3.5985	1.3649	4.2381	3.2989	7.0000	.65300	2.5294	1.9689
	75 Post	4.6000	.89661	9.0000	.68300	2.8646	.55835	4.1842	2.3650	2.0000	.68300	.69984	.39556
	75 Total	9.7068	2.1345	21.000	.67000	3.2290	.71005	8.4223	4.0590	9.0000	.67000	1.5949	.76866
	76	2.0199	1.1190	2.0000	.20700	4.7833	2.6499	1.1000	.62588	3.0000	.20700	13.175	7.4960
77	74	11.231	3.4063	24.000	.54200	3.9425	1.1957	8.6230	6.1988	14.000	.54200	2.9955	2.1533
	75 Pre	5.0557	1.9177	17.000	.76700	4.3840	1.6629	4.1957	3.2659	11.000	.76700	3.4182	2.6607
	75 Post	4.5540	.88765	10.000	.84600	2.5956	.50592	4.1423	2.3413	7.0000	.84600	1.9975	1.1290
	75 Total	9.6097	2.1132	27.000	.78900	3.5610	.78306	8.3380	4.0184	18.000	.78900	2.7361	1.3186
	76	3.6724	2.0345	12.000	.56300	5.8039	3.2153	2.0000	1.1379	12.000	.56300	10.657	6.0635
	77	4.9512	.59911	9.0000	.41900	4.3383	.52495	3.6851	.81389	9.0000	.41900	5.8288	1.2873
78	74	10.885	3.3013	30.000	.67800	4.0649	1.2328	8.3573	6.0077	15.000	.67800	2.6473	1.9030
	75 Pre	4.9536	1.8790	19.000	.94600	4.0545	1.5379	4.1109	3.1999	9.0000	.94600	2.3143	1.8014
	75 Post	4.4620	.86971	11.000	.79700	3.0932	.60291	4.0587	2.2940	2.0000	.79700	.61828	.34947
	75 Total	9.4156	2.0705	30.000	.89100	3.5760	.78635	8.1696	3.9373	11.000	.89100	1.5112	.72830
	76	3.6369	2.0148	15.000	.47500	8.6829	4.8102	1.9807	1.1269	4.0000	.47500	4.2516	2.4190
	77	9.0023	1.0893	12.000	.34400	3.8750	.46889	6.7003	1.4798	12.000	.34400	5.2063	1.1499

Survey Data

Fatal Involvement Rates for Tractors
Trip Distance by Calendar Year and Model Year

		TRIP DISTANCE - TRACTORS											
		LOCAL						INTERCITY					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	8.6854	3.3235	35.000	.58800	6.8533	2.6224	84.062	20.694	299.00	.58800	6.0491	1.4892
	75 Pre	4.4671	5.1578	21.000	.56800	8.2764	9.5560	22.056	7.0387	168.00	.56800	13.410	4.2794
	75 Post	2.3708	1.4015	2.0000	.45300	1.8622	1.1009	25.974	7.1910	42.000	.45300	3.5695	.98823
	75 Total	6.8379	5.3448	23.000	.54200	6.2059	4.8508	48.031	10.062	210.00	.54200	8.0668	1.6900
	76	1.4117	.95018	14.000	.63900	15.520	10.446	22.831	15.366	118.00	.63900	8.0881	5.4434
77	74	8.5135	3.2577	52.000	.53400	11.438	4.3768	82.399	20.285	272.00	.53400	6.1817	1.5218
	75 Pre	4.4224	5.1062	29.000	.46800	14.012	16.178	21.836	6.9682	147.00	.46800	14.385	4.5905
	75 Post	2.3471	1.3875	10.000	.52800	8.0693	4.7703	25.714	7.1191	48.000	.52800	3.5354	.97877
	75 Total	6.7695	5.2913	39.000	.48200	11.953	9.3426	47.550	9.9618	195.00	.48200	8.5082	1.7825
	76	2.5667	1.7276	16.000	.54400	11.459	7.7127	41.512	27.938	192.00	.54400	8.5021	5.7220
	77	2.6147	.43944	34.000	.59300	21.929	3.6855	57.522	2.5487	208.00	.59300	6.0978	.27018
78	74	8.2511	3.1573	37.000	.42100	10.651	4.0758	79.859	19.660	219.00	.42100	6.5138	1.6036
	75 Pre	4.3331	5.0030	24.000	.39000	14.202	16.398	21.395	6.8275	103.00	.39000	12.344	3.9393
	75 Post	2.2997	1.3595	9.0000	.42000	9.3182	5.5085	25.195	6.9752	31.000	.42000	2.9296	.81106
	75 Total	6.6328	5.1844	33.000	.39700	12.532	9.7957	46.589	9.7605	134.00	.39700	7.2448	1.5178
	76	2.5419	1.7109	17.000	.42400	15.774	10.617	41.110	27.667	138.00	.42400	7.9171	5.3283
	77	4.7540	.79898	28.000	.46800	12.585	2.1151	104.59	4.6341	271.00	.46800	5.5366	.24532

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Trailer Use by Calendar Year and Model Year

		Trailer Use											
		BOBTAIL						TRAILER					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	0.	-0.	2.0000	.58000	-0.	-0.	84.062	20.694	292.00	.58000	5.9890	1.4744
	75 Pre	0.	.39295 -1	4.0000	.56800	-0.	-0.	22.056	7.0387	160.00	.56800	12.771	4.0756
	75 Post	.78590 -1	.39295 -1	0.	.44300	0.	0.	25.896	7.2041	41.000	.44300	3.5740	.99429
	75 Total	.78590 -1	.39295 -1	4.0000	.53000	96.032	48.016	47.952	10.072	201.00	.53000	7.9088	1.6612
	76	.67870 -1	.67870 -1	8.0000	.63000	187.10	187.10	22.764	14.931	108.00	.63000	7.5308	4.9397
77	74	0.	-0.	3.0000	.52300	-0.	-0.	82.399	20.285	262.00	.52300	6.0796	1.4967
	75 Pre	0.	.38902 -1	6.0000	.46300	-0.	-0.	21.836	6.9682	139.00	.46300	13.749	4.3875
	75 Post	.77804 -1	.38902 -1	2.0000	.52000	49.434	24.717	25.636	7.1320	45.000	.52000	3.3756	.93909
	75 Total	.77804 -1	.38902 -1	8.0000	.47500	216.47	108.23	47.472	9.9711	184.00	.47500	8.1599	1.7139
	76	.12340	.12340	4.0000	.51800	62.577	62.577	41.389	27.148	178.00	.51800	8.3025	5.4459
	77	.24169	.21972	2.0000	.56800	14.569	13.244	57.281	2.6366	196.00	.56800	6.0242	.27729
78	74	0.	-0.	11.000	.40100	-0.	-0.	79.859	19.660	196.00	.40100	6.1205	1.5067
	75 Pre	0.	.38116 -1	2.0000	.37200	-0.	-0.	21.395	6.8275	95.000	.37200	11.936	3.8092
	75 Post	.76232 -1	.38116 -1	0.	.42000	0.	0.	25.118	6.9879	31.000	.42000	2.9385	.81748
	75 Total	.76232 -1	.38116 -1	2.0000	.38200	68.680	34.340	46.513	9.7696	126.00	.38200	7.0914	1.4895
	76	.12221	.12221	4.0000	.38000	86.136	86.136	40.988	26.885	118.00	.38000	7.5761	4.9694
	77	.43944	.39949	8.0000	.43500	41.850	38.046	104.15	4.7939	242.00	.43500	5.3417	.24588

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Number of Trailers by Calendar Year and Model Year

		Number of Trailers											
		SINGLE						DOUBLE					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	82.954	20.650	273.00	.58800	5.5969	1.3932	1.1078	.35451	24.000	.58800	36.844	11.790
	75 Pre	21.704	7.0387	156.00	.56800	12.654	4.1039	.35267	.10286	8.0000	.56800	39.937	11.648
	75 Post	24.861	7.3089	37.000	.45300	3.2854	.96589	1.0348	.45844	5.0000	.45300	10.667	4.7257
	75 Total	46.565	10.147	193.00	.53000	7.8203	1.7042	1.3874	.46984	13.000	.53000	17.679	5.9867
	76	22.031	15.610	105.00	.63900	7.4587	5.2850	.73300	.43437	5.0000	.63900	10.675	6.3259
77	74	81.313	20.241	253.00	.53400	5.8267	1.4504	1.0859	.34749	16.000	.53400	27.592	8.8295
	75 Pre	21.487	6.9682	135.00	.46800	13.425	4.3539	.34914	.10183	6.0000	.46800	36.720	10.710
	75 Post	24.612	7.2358	44.000	.52800	3.3859	.99543	1.0244	.45386	2.0000	.52800	3.6976	1.6382
	75 Total	46.099	10.046	179.00	.48100	8.0727	1.7592	1.3736	.46514	8.0000	.48100	12.109	4.1005
	76	40.056	28.382	177.00	.54400	8.1228	5.7555	1.3327	.78977	11.000	.54400	15.172	8.9910
	77	53.458	2.6366	202.00	.59300	6.3722	.31429	3.8451	.96676	4.0000	.59300	1.7543	.44108
78	74	78.807	19.618	205.00	.42100	6.1789	1.5381	1.0524	.33678	3.0000	.42100	6.7708	2.1667
	75 Pre	21.053	6.8275	93.000	.39000	11.327	3.6734	.34209	.99775 -1	8.0000	.39000	59.964	17.489
	75 Post	24.115	7.0895	31.000	.42000	3.0608	.89985	1.0037	.44468	0.	.42000	0.	0.
	75 Total	45.167	9.8426	124.00	.39400	6.9679	1.5184	1.3458	.45574	8.0000	.39400	15.087	5.1091
	76	39.668	28.107	131.00	.46800	7.0564	4.9999	1.3198	.78212	3.0000	.46800	4.8569	2.8782
	77	97.197	4.7939	252.00	.45700	5.6733	.27982	6.9911	1.7578	11.000	.45700	3.4429	.86565

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Trailer Brake Type by Calendar Year and Model Year

		Trailer Brake Type											
		PRE-STANDARD						POST-STANDARD					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	68.907	16.706	274.00	.58000	6.8558	1.6621	15.155	3.9882	18.000	.58000	2.0478	.53889
	75 Pre	18.133	5.7015	145.00	.56800	14.078	4.4265	3.9381	1.3519	15.000	.56800	6.7058	2.3020
	75 Post	19.346	5.5668	29.000	.44300	3.3837	.97365	6.5623	1.6766	12.000	.44300	4.1278	1.0546
	75 Total	37.479	7.9685	174.00	.53000	8.7595	1.8624	10.500	2.1537	27.000	.53000	4.8516	.99510
	76	17.035	11.959	74.000	.63000	6.8951	4.8403	5.7282	3.3663	34.000	.63000	9.4215	5.5368
77	74	67.544	16.376	216.00	.52300	6.1146	1.4824	14.855	3.9093	46.000	.52300	5.9207	1.5581
	75 Pre	17.952	5.6444	116.00	.46300	13.956	4.3883	3.8987	1.3384	23.000	.46300	12.742	4.3740
	75 Post	19.153	5.5111	28.000	.52000	2.8114	.80897	6.4966	1.6598	17.000	.52000	5.0322	1.2857
	75 Total	37.104	7.8887	144.00	.47500	8.1704	1.7371	10.395	2.1322	40.000	.47500	8.1008	1.6615
	76	30.974	21.743	106.00	.51800	6.6067	4.6378	10.415	6.1207	72.000	.51800	13.346	7.8430
	77	23.883	2.5048	112.00	.56800	8.2561	.86586	33.397	3.1640	84.000	.56800	4.4281	.41951
78	74	65.462	15.871	164.00	.40100	6.2476	1.5147	14.397	3.7888	32.000	.40100	5.5427	1.4586
	75 Pre	17.589	5.5304	71.000	.37200	10.851	3.4119	3.8200	1.3113	24.000	.37200	16.889	5.7978
	75 Post	18.766	5.3997	12.000	.42000	1.5225	.43810	6.3653	1.6263	19.000	.42000	7.1069	1.8157
	75 Total	36.355	7.7293	83.000	.38200	5.9766	1.2707	10.185	2.0891	43.000	.38200	11.052	2.2668
	76	30.674	21.533	54.000	.38000	4.6328	3.2522	10.314	6.0614	64.000	.38000	16.329	9.5963
	77	43.425	4.5542	118.00	.43500	6.2468	.65513	60.723	5.7527	124.00	.43500	4.6944	.44473

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Cab Style by Calendar Year and Model Year

		CAB STYLE											
		CONVENTIONAL						CAB-OVER-ENGINE					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	39.483	16.352	98.000	.58000	4.2794	1.7723	44.579	18.080	196.00	.58000	7.5805	3.0744
	75 Pre	15.224	8.3906	66.000	.56300	7.7005	4.2442	6.8330	5.1725	100.00	.56300	25.995	19.678
	75 Post	8.3437	3.6545	15.000	.44300	4.0582	1.7774	17.630	8.6187	26.000	.44300	3.3289	1.6274
	75 Total	23.567	9.1519	81.000	.53500	6.4243	2.4947	24.463	10.052	126.00	.53500	9.6272	3.9557
	76	16.710	17.619	41.000	.63000	3.8947	4.1067	6.1219	7.1942	75.000	.63000	19.446	22.853
77	74	38.702	16.028	110.00	.53400	5.3225	2.2043	43.697	17.722	162.00	.53400	6.9426	2.8157
	75 Pre	15.071	8.3066	68.000	.46000	9.8085	5.4061	6.7646	5.1207	76.000	.46000	24.424	18.489
	75 Post	8.2602	3.6179	21.000	.52800	4.8150	2.1089	17.454	8.5325	27.000	.52800	2.9298	1.4322
	75 Total	23.331	9.0603	89.000	.47500	8.0308	3.1186	24.219	9.9512	103.00	.47500	8.9535	3.6789
	76	30.381	32.035	62.000	.53600	3.8073	4.0145	11.131	13.081	127.00	.53600	21.287	25.016
	77	22.477	1.8676	65.000	.58800	4.9180	.40864	34.782	2.5048	141.00	.58800	6.8943	.49650
78	74	37.509	15.534	71.000	.41600	4.5502	1.8844	42.350	17.176	145.00	.41600	8.2304	3.3380
	75 Pre	14.767	8.1388	42.000	.38400	7.4068	4.0823	6.6279	5.0173	59.000	.38400	23.182	17.548
	75 Post	8.0933	3.5448	14.000	.42000	4.1187	1.8039	17.101	8.3601	17.000	.42000	2.3668	1.1570
	75 Total	22.860	8.8773	56.000	.39200	6.2492	2.4268	23.729	9.7501	76.000	.39200	8.1704	3.3571
	76	30.087	31.725	45.000	.41800	3.5781	3.7729	11.023	12.954	91.000	.41800	19.750	23.210
	77	40.868	3.3957	109.00	.46300	5.7605	.47864	63.240	4.5542	159.00	.46300	5.4303	.39107

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Fleet Size by Calendar Year and Model Year

		FLEET SIZE											
		SMALL (1-49)						LARGE (50+)					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	29.911	16.617	173.00	.58300	9.9207	5.5115	54.106	18.213	123.00	.58300	3.8993	1.3125
	75 Pre	8.1996	4.6876	106.00	.56500	22.881	13.080	13.857	9.3898	61.000	.56500	7.7914	5.2796
	75 Post	15.181	7.2958	19.000	.43300	2.8904	1.3891	10.806	10.138	21.000	.43300	4.4881	4.2106
	75 Total	23.381	8.6719	125.00	.53500	9.9931	3.7065	24.663	13.818	82.000	.53500	6.2146	3.4820
	76	5.0224	4.4658	67.000	.62000	21.517	19.132	17.809	18.081	47.000	.62000	4.2566	4.3215
77	74	29.320	16.289	148.00	.51800	9.7448	5.4138	53.036	17.852	114.00	.51800	4.1496	1.3968
	75 Pre	8.1175	4.6406	100.00	.46000	26.781	15.310	13.718	9.2958	44.000	.46000	6.9726	4.7248
	75 Post	15.029	7.2228	30.000	.51000	3.9140	1.8810	10.698	10.037	16.000	.51000	2.9325	2.7513
	75 Total	23.147	8.5851	130.00	.47100	11.924	4.4228	24.416	13.680	60.000	.47100	5.2174	2.9232
	76	9.1317	8.1198	120.00	.53400	24.609	21.882	32.380	32.874	68.000	.53400	3.9326	3.9926
	77	23.971	2.4169	107.00	.57800	7.7226	.77863	33.551	2.8563	95.000	.57800	4.8988	.41706
78	74	28.416	15.787	136.00	.41400	11.561	6.4225	51.401	17.302	79.000	.41400	3.7124	1.2496
	75 Pre	7.9535	4.5469	55.000	.38100	18.150	10.376	13.441	9.1081	45.000	.38100	8.7872	5.9544
	75 Post	14.725	7.0768	21.000	.42000	3.3955	1.6318	10.482	9.8339	10.000	.42000	2.2715	2.1311
	75 Total	22.679	8.4117	76.000	.39200	8.5488	3.1708	23.923	13.404	55.000	.39200	5.8649	3.2860
	76	9.0432	8.0411	56.000	.41600	14.886	13.236	32.067	32.556	79.000	.41600	5.9221	6.0124
	77	43.585	4.3944	141.00	.45200	7.1573	.72163	61.003	5.1934	126.00	.45200	4.5697	.38904

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Carrier Type by Calendar Year and Model Year

		CARRIER TYPE											
		AUTHORIZED						NON-AUTHORIZED					
CAL YR	MOD YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	53.973	21.049	161.00	.58700	5.0817	1.9818	25.037	17.459	95.000	.58700	6.4640	4.5077
	75 Pre	12.152	10.316	81.000	.56500	11.797	10.014	5.1284	4.1292	60.000	.55600	21.042	16.942
	75 Post	9.6797	9.4046	24.000	.45300	5.4733	5.3178	11.527	4.2439	14.000	.45300	2.6812	.98717
	75 Total	21.832	13.959	105.00	.53500	8.9896	5.7478	16.655	5.9212	74.000	.53800	8.2586	2.9361
	76	13.683	18.881	63.000	.63900	7.2056	9.9435	8.2123	7.8458	38.000	.63900	7.2414	6.9182
77	74	52.906	20.632	144.00	.53400	5.0971	1.9878	24.542	17.114	78.000	.53400	5.9518	4.1505
	75 Pre	12.031	10.212	67.000	.46300	12.028	10.210	5.0771	4.0878	51.000	.46000	21.837	17.583
	75 Post	9.5829	9.3106	22.000	.52800	4.3480	4.2245	11.411	4.2014	19.000	.52800	3.1534	1.1610
	75 Total	21.614	13.819	89.000	.47500	8.6690	5.5429	16.488	5.8619	70.000	.47500	8.9377	3.1775
	76	24.878	34.330	100.00	.54100	7.4301	10.253	14.932	14.265	60.000	.53100	7.5675	7.2298
	77	28.827	2.2411	116.00	.59300	6.7858	.52756	22.170	2.0873	70.000	.58800	5.3698	.50559
78	74	51.275	19.996	124.00	.42100	5.7443	2.2402	23.785	16.586	56.000	.42100	5.5924	3.8998
	75 Pre	11.788	10.006	65.000	.38700	14.249	12.095	4.9745	4.0053	24.000	.38400	12.564	10.116
	75 Post	9.3892	9.1224	14.000	.42000	3.5502	3.4493	11.181	4.1165	10.000	.42000	2.1295	.78405
	75 Total	21.177	13.540	79.000	.39300	9.4923	6.0693	16.155	5.7435	34.000	.39200	5.3689	1.9087
	76	24.637	33.998	84.000	.41800	8.1568	11.256	14.787	14.127	40.000	.41600	6.5026	6.2124
	77	52.413	4.0748	159.00	.46600	6.5098	.50610	40.309	3.7952	80.000	.46300	4.2866	.40359

Survey Data

Fatal Involvement Rates
Vehicle Type by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	VEHICLE TYPE									
	STRAIGHT TRUCK					TRACTOR				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	59.444	15.575	197.00	3.3140	.86829	271.64	31.793	1783.0	6.5638	.76824
1975 Pre	27.696	7.9254	96.000	3.4663	.99191	78.510	11.276	1035.0	13.183	1.8935
1975 Post	26.040	4.4417	52.000	1.9970	.34063	83.901	11.663	302.00	3.5995	.50038
1975 Total	53.735	9.0852	148.00	2.7542	.46567	162.41	16.223	1337.0	8.2322	.82231
1976	14.366	3.5171	107.00	7.4481	1.8234	111.97	40.052	954.00	8.5198	3.0475
1977	24.371	1.8531	113.00	4.6367	.35256	169.48	5.1064	1047.0	6.1778	.18614
TOTAL	151.92	18.464	565.00	3.7192	.45202	715.50	53.891	5121.0	7.1572	.53907

Survey Data

Fatal Involvement Rates for Straight Trucks
Trip Distance by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	TRIP DISTANCE - STRAIGHT TRUCKS: LOCAL					INTERCITY				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	33.575	5.8802	127.49	3.7972	.66502	25.777	10.701	70.032	2.7168	1.1278
1975 Pre	15.116	3.3106	60.626	4.0106	.87838	12.545	5.6381	34.575	2.7562	1.2387
1975 Post	13.616	1.5324	38.799	2.8495	.32070	12.385	4.0420	13.712	1.1071	.36131
1975 Total	28.732	3.6481	99.234	3.4538	.43852	24.930	6.9373	48.592	1.9492	.54239
1976	9.3292	3.0742	62.555	6.7053	2.2096	5.0807	1.7195	44.228	8.7051	2.9461
1977	13.953	1.2432	56.363	4.0394	.35989	10.385	1.6889	56.363	5.4272	.88256
TOTAL	85.590	7.6734	345.64	4.0384	.36205	66.173	12.979	219.22	3.3127	.64973

Survey Data

Fatal Involvement Rates for Tractors
Trip Distance by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	TRIP DISTANCE - TRACTORS									
	LOCAL					INTERCITY				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	25.450	5.6238	244.79	9.6184	2.1254	246.32	35.018	1538.1	6.2441	.88768
1975 Pre	13.223	8.8151	160.48	12.136	8.0909	65.287	12.030	873.98	13.387	2.4666
1975 Post	7.0176	2.3953	44.783	6.3816	2.1782	76.883	12.290	257.43	3.3484	.53525
1975 Total	20.240	9.1347	206.47	10.201	4.6039	142.17	17.198	1129.5	7.9451	.96108
1976	6.5203	2.6105	91.415	14.020	5.6131	105.45	42.215	863.08	8.1844	3.2764
1977	7.3686	.91186	117.16	15.900	1.9677	162.11	5.2888	929.82	5.7357	.18713
TOTAL	59.579	11.078	659.84	11.075	2.0592	656.05	57.724	4460.5	6.7990	.59822

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Trailer Use by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	Trailer Use									
	BOBTAIL					TRAILER				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	0.	-0.	36.616	-0.	-0.	246.32	35.018	1493.2	6.0620	.86178
1975 Pre	0.	.67159 -1	25.378	-0.	-0.	65.287	12.030	837.28	12.825	2.3631
1975 Post	.23263	.67159 -1	3.8462	16.534	4.7732	76.650	12.312	252.90	3.2994	.52998
1975 Total	.23263	.67159 -1	29.625	127.35	36.766	141.94	17.214	1096.5	7.7249	.93685
1976	.31348	.18646	30.947	98.721	58.721	105.14	41.022	825.58	7.8522	3.0637
1977	.68113	.45593	21.912	32.170	21.533	161.43	5.4711	901.39	5.5839	.18925
TOTAL	1.2272	.49714	119.10	97.047	39.313	654.83	56.879	4316.6	6.5920	.57259

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Number of Trailers by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	Number of Trailers									
	SINGLE					DOUBLE				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	243.07	34.943	1425.0	5.8624	.84274	3.2462	.59987	77.905	23.999	4.4348
1975 Pre	64.243	12.030	801.57	12.477	2.3364	1.0439	.17580	47.418	45.424	7.6497
1975 Post	73.587	12.492	238.82	3.2454	.55091	3.0629	.78352	14.825	4.8403	1.2382
1975 Total	137.83	17.342	1051.0	7.6254	.95945	4.1068	.80300	61.465	14.967	2.9264
1976	101.75	42.886	769.60	7.5633	3.1877	3.3855	1.1934	34.456	10.177	3.5874
1977	150.65	5.4711	892.06	5.9213	.21504	10.836	2.0061	30.815	2.8437	.52646
TOTAL	633.31	58.232	4137.7	6.5334	.60073	21.575	2.5403	204.64	9.4852	1.1168

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Trailer Brake Type by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	Trailer Brake Type									
	PRE-STANDARD					POST-STANDARD				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	201.91	28.269	1294.4	6.4107	.89753	44.408	6.7486	198.79	4.4764	.68028
1975 Pre	53.674	9.7443	696.68	12.980	2.3565	11.657	2.3105	140.60	12.062	2.3908
1975 Post	57.265	9.5142	147.88	2.5824	.42905	19.424	2.8654	105.02	5.4066	.79757
1975 Total	110.94	13.619	848.74	7.6505	.93918	31.081	3.6809	247.72	7.9701	.94390
1976	78.683	32.855	464.20	5.8996	2.4635	26.457	9.2486	361.39	13.659	4.7747
1977	67.308	5.1976	468.45	6.9597	.53743	94.120	6.5654	432.94	4.5999	.32087
TOTAL	458.84	45.728	3075.8	6.7033	.66805	196.07	13.702	1240.8	6.3287	.44226

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Cab Style by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	CAB STYLE									
	CONVENTIONAL					CAB-OVER-ENGINE				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	115.69	27.669	545.63	4.7162	1.1279	130.63	30.593	989.86	7.5778	1.7748
1975 Pre	45.061	14.340	374.43	8.3093	2.6443	20.225	8.8402	496.48	24.547	10.729
1975 Post	24.697	6.2458	106.97	4.3311	1.0953	52.186	14.730	150.30	2.8802	.81296
1975 Total	69.759	15.641	481.63	6.9042	1.5481	72.411	17.179	646.23	8.9245	2.1173
1976	77.178	48.406	288.41	3.7369	2.3438	28.276	19.765	573.69	20.289	14.183
1977	63.345	3.8754	345.97	5.4616	.33413	98.021	5.1976	583.21	5.9498	.31549
TOTAL	325.98	58.038	1661.6	5.0974	.90756	329.33	40.605	2793.0	8.4807	1.0456

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Fleet Size by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	FLEET SIZE									
	SMALL (1-49)					LARGE (50+)				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	87.647	28.119	910.96	10.393	3.3345	158.54	30.818	621.88	3.9224	.76246
1975 Pre	24.271	8.0114	549.36	22.635	7.4715	41.016	16.048	321.73	7.8439	3.0690
1975 Post	44.936	12.469	152.70	3.3983	.94298	31.986	17.327	103.68	3.2414	1.7559
1975 Total	69.206	14.821	703.53	10.166	2.1771	73.002	23.617	420.97	5.7665	1.8655
1976	23.197	12.269	467.40	20.149	10.657	82.256	49.674	393.05	4.7784	2.8856
1977	67.556	5.0152	497.07	7.3579	.54623	94.554	5.9271	443.12	4.6865	.29377
TOTAL	247.61	34.439	2579.0	10.416	1.4487	408.36	63.326	1879.0	4.6014	.71356

Survey Data

Fatal Involvement Rates for Intercity Tractors Only
Carrier Type by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	CARRIER TYPE									
	AUTHORIZED					NON-AUTHORIZED				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	158.15	35.617	838.48	5.3016	1.1940	73.364	29.544	440.92	6.0101	2.4203
1975 Pre	35.971	17.630	456.03	12.678	6.2137	15.180	7.0571	281.28	18.530	8.6145
1975 Post	28.652	16.073	127.98	4.4667	2.5058	34.119	7.2531	90.699	2.6584	.56513
1975 Total	64.623	23.857	584.65	9.0471	3.3400	49.298	10.120	371.65	7.5388	1.5475
1976	63.197	51.874	484.39	7.6648	6.2915	37.931	21.555	268.62	7.0818	4.0244
1977	81.241	4.6505	536.82	6.6077	.37825	62.478	4.3313	291.83	4.6710	.32381
TOTAL	367.21	67.456	2444.3	6.6564	1.2228	223.07	38.192	1373.0	6.1551	1.0538

APPENDIX C

FATAL RATES: AVERAGED MILES PER DAY

This appendix presents data in the same format as Appendix B. The only difference is in the way the survey data on mileage is treated. For Appendix B, separate estimates were computed for each model year and exposure category. For the computations presented in this appendix, the survey data were averaged across model year in each exposure category, thus removing the survey differences by model year. This computation was carried out to isolate the influence of the estimated number of vehicles in service. This influence can be evaluated by comparing the results in Appendices B and C.

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates
Vehicle Type by Calendar Year and Model Year

		VEHICLE TYPE											
		STRAIGHT TRUCK						TRACTOR					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	19.857	8.0015	61.000	1.0000	3.0719	1.2378	91.839	27.633	568.00	1.0000	6.1847	1.8609
	75 Pre	7.4464	3.0005	29.000	1.0000	3.8945	1.5693	30.454	9.1633	333.00	1.0000	10.934	3.2900
	75 Post	8.2421	3.3212	16.000	1.0000	1.9412	.78223	27.146	8.1679	97.000	1.0000	3.5732	1.0751
	75 Total	15.688	6.3216	45.000	1.0000	2.8684	1.1558	57.601	17.331	430.00	1.0000	7.4652	2.2462
	76	6.0150	2.4237	24.000	1.0000	3.9900	1.6078	28.132	8.4645	206.00	1.0000	7.3226	2.2033
77	74	19.464	7.8432	70.000	1.0000	3.5963	1.4491	90.022	27.086	606.00	1.0000	6.7317	2.0255
	75 Pre	7.3719	2.9705	37.000	1.0000	5.0191	2.0224	30.150	9.0715	376.00	1.0000	12.471	3.7524
	75 Post	8.1597	3.2880	20.000	1.0000	2.4511	.98766	26.875	8.0862	110.00	1.0000	4.0930	1.2315
	75 Total	15.531	6.2584	57.000	1.0000	3.6700	1.4788	57.025	17.158	486.00	1.0000	8.5226	2.5643
	76	10.936	4.4067	43.000	1.0000	3.9320	1.5844	51.150	15.390	382.00	1.0000	7.4683	2.2471
	77	7.1700	2.8892	43.000	1.0000	5.9972	2.4166	45.537	13.701	408.00	1.0000	8.9598	2.6959
78	74	18.864	7.6015	66.000	1.0000	3.4986	1.4098	87.247	26.251	609.00	1.0000	6.9802	2.1002
	75 Pre	7.2230	2.9105	30.000	1.0000	4.1534	1.6736	29.541	8.8883	326.00	1.0000	11.036	3.3205
	75 Post	7.9949	3.2215	16.000	1.0000	2.0013	.80642	26.332	7.9228	95.000	1.0000	3.6078	1.0855
	75 Total	15.218	6.1320	46.000	1.0000	3.0228	1.2180	55.873	16.811	421.00	1.0000	7.5349	2.2671
	76	10.830	4.3641	40.000	1.0000	3.6934	1.4882	50.654	15.241	366.00	1.0000	7.2255	2.1740
	77	13.037	5.2531	70.000	1.0000	5.3695	2.1637	82.795	24.912	639.00	1.0000	7.7179	2.3222

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Straight Trucks
Trip Distance by Calendar Year and Model Year

		TRIP DISTANCE - STRAIGHT TRUCKS											
		LOCAL						INTERCITY					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	11.136	3.5529	30.000	.77000	3.4986	1.1162	8.7032	5.8095	17.000	.77000	2.5368	1.6933
	75 Pre	4.1760	1.3323	12.000	.65300	4.4005	1.4039	3.2637	2.1786	7.0000	.65300	3.2846	2.1925
	75 Post	4.6223	1.4747	9.0000	.68300	2.8508	.90952	3.6124	2.4114	2.0000	.68300	.81061	.54109
	75 Total	8.7982	2.8070	21.000	.67000	3.5625	1.1366	6.8760	4.5898	9.0000	.67000	1.9536	1.3040
	76	3.3733	1.0762	2.0000	.20700	2.8642	.91381	2.6363	1.7598	3.0000	.20700	5.4974	3.6696
77	74	10.916	3.4826	24.000	.54200	4.0565	1.2942	8.5310	5.6946	14.000	.54200	3.0278	2.0211
	75 Pre	4.1342	1.3190	17.000	.76700	5.3612	1.7104	3.2310	2.1567	11.000	.76700	4.4387	2.9629
	75 Post	4.5761	1.4599	10.000	.84600	2.5831	.82411	3.5763	2.3872	7.0000	.84600	2.3136	1.5444
	75 Total	8.7102	2.7789	27.000	.78900	3.9288	1.2534	6.8072	4.5439	18.000	.78900	3.3514	2.2371
	76	6.1330	1.9567	12.000	.56300	3.4753	1.1088	4.7931	3.1995	12.000	.56300	4.4469	2.9683
	77	4.0210	1.2829	9.0000	.41900	5.3419	1.7043	3.1425	2.0977	9.0000	.41900	6.8352	4.5626
78	74	10.579	3.3753	30.000	.67800	4.1824	1.3344	8.2681	5.5191	15.000	.67800	2.6758	1.7862
	75 Pre	4.0507	1.2924	19.000	.94600	4.9582	1.5819	3.1658	2.1132	9.0000	.94600	3.0052	2.0060
	75 Post	4.4836	1.4305	11.000	.79700	3.0783	.98209	3.5041	2.3390	2.0000	.79700	.71614	.47804
	75 Total	8.5342	2.7228	30.000	.89100	3.9453	1.2587	6.6697	4.4521	11.000	.89100	1.8510	1.2356
	76	6.0737	1.9378	15.000	.47500	5.1993	1.6588	4.7468	3.1685	4.0000	.47500	1.7741	1.1842
	77	7.3110	2.3325	12.000	.34400	4.7714	1.5223	5.7138	3.8140	12.000	.34400	6.1052	4.0753

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Tractors
Trip Distance by Calendar Year and Model Year

		TRIP DISTANCE - TRACTORS											
		LOCAL						INTERCITY					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	8.2074	7.8230	35.000	.58800	7.2524	6.9127	83.641	29.294	299.00	.58800	6.0796	2.1293
	75 Pre	2.7216	2.5942	21.000	.56800	13.584	12.948	27.736	9.7139	168.00	.56800	10.664	3.7348
	75 Post	2.4260	2.3124	2.0000	.45300	1.8199	1.7346	24.723	8.6588	42.000	.45300	3.7501	1.3134
	75 Total	5.1476	4.9065	23.000	.54200	8.2437	7.8575	52.459	18.373	210.00	.54200	7.3858	2.5867
	76	2.5141	2.3963	14.000	.63900	8.7146	8.3064	25.621	8.9732	118.00	.63900	7.2075	2.5243
77	74	8.0451	7.6682	52.000	.53400	12.104	11.537	81.986	28.714	272.00	.53400	6.2128	2.1759
	75 Pre	2.6944	2.5682	29.000	.46800	22.998	21.921	27.458	9.6167	147.00	.46800	11.439	4.0064
	75 Post	2.4017	2.2892	10.000	.52800	7.8857	7.5163	24.476	8.5722	48.000	.52800	3.7142	1.3008
	75 Total	5.0962	4.8575	39.000	.48200	15.877	15.133	51.935	18.189	195.00	.48200	7.7898	2.7282
	76	4.5711	4.3570	16.000	.54400	6.4342	6.1329	46.584	16.315	192.00	.54400	7.5765	2.6535
	77	4.0695	3.8789	34.000	.59300	14.089	13.429	41.472	14.525	208.00	.59300	8.4577	2.9621
78	74	7.7971	7.4319	37.000	.42100	11.272	10.744	79.459	27.829	219.00	.42100	6.5466	2.2928
	75 Pre	2.6400	2.5163	24.000	.39000	23.310	22.218	26.904	9.4225	103.00	.39000	9.8166	3.4381
	75 Post	2.3532	2.2430	9.0000	.42000	9.1061	8.6796	23.981	8.3989	31.000	.42000	3.0778	1.0779
	75 Total	4.9932	4.7594	33.000	.39700	16.647	15.867	50.886	17.822	134.00	.39700	6.6331	2.3231
	76	4.5268	4.3148	17.000	.42400	8.8570	8.4422	46.133	16.157	138.00	.42400	7.0551	2.4709
	77	7.3992	7.0526	28.000	.46800	8.0859	7.7072	75.404	26.409	271.00	.46800	7.6794	2.6896

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Trailer Use by Calendar Year and Model Year

		Trailer Use											
		BOBTAIL						TRAILER					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	.17409	.27226	2.0000	.58000	19.808	30.978	83.467	28.789	292.00	.58000	6.0317	2.0804
	75 Pre	.57729 -1	.90285 -1	4.0000	.56800	121.99	190.79	27.678	9.5465	160.00	.56800	10.177	3.5103
	75 Post	.51458 -1	.80478 -1	0.	.44300	0.	0.	24.672	8.5096	41.000	.44300	3.7513	1.2939
	75 Total	.10919	.17076	4.0000	.53000	69.122	108.10	52.350	18.056	201.00	.53000	7.2444	2.4987
	76	.53326 -1	.83400 -1	8.0000	.63000	238.13	372.42	25.568	8.8185	108.00	.63000	6.7049	2.3126
77	74	.17064	.26688	3.0000	.52300	33.615	52.572	81.816	28.219	262.00	.52300	6.1230	2.1119
	75 Pre	.57151 -1	.89381 -1	6.0000	.46300	226.75	354.63	27.401	9.4510	139.00	.46300	10.956	3.7790
	75 Post	.50943 -1	.79673 -1	2.0000	.52000	75.499	118.08	24.425	8.4244	45.000	.52000	3.5430	1.2220
	75 Total	.10810	.16906	8.0000	.47500	155.81	243.68	51.827	17.876	184.00	.47500	7.4743	2.5780
	76	.96958 -1	.15164	4.0000	.51800	79.643	124.56	46.487	16.034	178.00	.51800	7.3920	2.5496
	77	.86318 -1	.13500	2.0000	.56800	40.792	63.797	41.386	14.274	196.00	.56800	8.3379	2.8758
78	74	.16538	.25865	11.000	.40100	165.87	259.41	79.294	27.349	196.00	.40100	6.1641	2.1261
	75 Pre	.55996 -1	.87576 -1	2.0000	.37200	96.012	150.16	26.848	9.2601	95.000	.37200	9.5120	3.2808
	75 Post	.49914 -1	.78063 -1	0.	.42000	0.	0.	23.931	8.2542	31.000	.42000	3.0842	1.0638
	75 Total	.10591	.16564	2.0000	.38200	49.434	77.312	50.780	17.514	126.00	.38200	6.4956	2.2404
	76	.96019 -1	.15017	4.0000	.38000	109.63	171.45	46.037	15.879	118.00	.38000	6.7452	2.3265
	77	.15694	.24545	8.0000	.43500	117.18	183.27	75.247	25.954	242.00	.43500	7.3932	2.5500

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Number of Trailers by Calendar Year and Model Year

		Number of Trailers											
		SINGLE						DOUBLE					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	80.637	29.656	273.00	.58800	5.7577	2.1175	2.8360	1.2398	24.000	.58800	14.392	6.2913
	75 Pre	26.740	9.8340	156.00	.56800	10.271	3.7774	.94045	.41111	8.0000	.56800	14.976	6.5468
	75 Post	23.835	8.7658	37.000	.45300	3.4267	1.2602	.83830	.36645	5.0000	.45300	13.167	5.7557
	75 Total	50.575	18.600	193.00	.53000	7.2002	2.6480	1.7787	.77756	13.000	.53000	13.790	6.0280
	76	24.701	9.0841	105.00	.63900	6.6524	2.4465	.86874	.37976	5.0000	.63900	9.0070	3.9373
77	74	79.042	29.069	253.00	.53400	5.9941	2.2044	2.7799	1.2152	16.000	.53400	10.778	4.7116
	75 Pre	26.472	9.7356	135.00	.46800	10.897	4.0075	.93104	.40699	6.0000	.46800	13.770	6.0195
	75 Post	23.597	8.6782	44.000	.52800	3.5315	1.2988	.82991	.36279	2.0000	.52800	4.5642	1.9952
	75 Total	50.070	18.414	179.00	.48100	7.4325	2.7334	1.7610	.76979	8.0000	.48100	9.4448	4.1287
	76	44.911	16.517	177.00	.54400	7.2447	2.6644	1.5795	.69048	11.000	.54400	12.802	5.5961
	77	39.983	14.704	202.00	.59300	8.5197	3.1333	1.4062	.61471	4.0000	.59300	4.7969	2.0969
78	74	76.606	28.173	205.00	.42100	6.3564	2.3377	2.6942	1.1778	3.0000	.42100	2.6449	1.1562
	75 Pre	25.938	9.5390	93.000	.39000	9.1937	3.3811	.91223	.39877	8.0000	.39000	22.486	9.8297
	75 Post	23.120	8.5028	31.000	.42000	3.1925	1.1741	.81314	.35546	0.	.42000	0.	0.
	75 Total	49.058	18.042	124.00	.39400	6.4153	2.3593	1.7254	.75424	8.0000	.39400	11.768	5.1443
	76	44.476	16.357	131.00	.46800	6.2936	2.3146	1.5642	.68379	3.0000	.46800	4.0980	1.7914
	77	72.696	26.735	252.00	.45700	7.5853	2.7896	2.5568	1.1177	11.000	.45700	9.4143	4.1154

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Trailer Brake Type by Calendar Year and Model Year

		Trailer Brake Type											
		PRE-STANDARD						POST-STANDARD					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	59.307	23.009	274.00	.58000	7.9656	3.0903	24.179	6.7499	18.000	.58000	1.2835	.35831
	75 Pre	19.667	7.6298	145.00	.56900	12.981	5.0359	8.0180	2.2383	15.000	.56800	3.2937	.91946
	75 Post	17.530	6.8011	29.000	.44300	3.7343	1.4487	7.1470	1.9952	12.000	.44300	3.7901	1.0580
	75 Total	37.197	14.431	174.00	.53000	8.8261	3.4242	15.165	4.2335	27.000	.53000	3.3593	.93778
	76	18.167	7.0480	74.000	.63000	6.4656	2.5084	7.4065	2.0676	34.000	.63000	7.2866	2.0341
77	74	58.133	22.553	216.00	.52300	7.1044	2.7562	23.701	6.6163	46.000	.52300	3.7110	1.0360
	75 Pre	19.470	7.5534	116.00	.46300	12.868	4.9923	7.9377	2.2159	23.000	.46300	6.2582	1.7471
	75 Post	17.355	6.7330	28.000	.52000	3.1026	1.2037	7.0755	1.9752	17.000	.52000	4.6205	1.2899
	75 Total	36.825	14.287	144.00	.47500	8.2324	3.1938	15.013	4.1912	40.000	.47500	5.6090	1.5658
	76	33.031	12.815	106.00	.51800	6.1952	2.4035	13.467	3.7593	72.000	.51800	10.322	2.8814
	77	29.406	11.408	112.00	.56800	6.7055	2.6015	11.989	3.3468	84.000	.56800	12.335	3.4436
78	74	56.342	21.858	164.00	.40100	7.2589	2.8162	22.970	6.4124	32.000	.40100	3.4741	.96983
	75 Pre	19.076	7.4009	71.000	.37200	10.005	3.8815	7.7774	2.1711	24.000	.37200	8.2954	2.3157
	75 Post	17.004	6.5969	12.000	.42000	1.6803	.65187	6.9325	1.9353	19.000	.42000	6.5255	1.8217
	75 Total	36.081	13.998	83.000	.38200	6.0219	2.3363	14.710	4.1065	43.000	.38200	7.6522	2.1362
	76	32.711	12.691	54.000	.38000	4.3443	1.6854	13.336	3.7229	64.000	.38000	12.629	3.5255
	77	53.466	20.743	118.00	.43500	5.0736	1.9683	21.798	6.0852	124.00	.43500	13.077	3.6506

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Cab Style by Calendar Year and Model Year

		CAB STYLE											
		CONVENTIONAL						CAB-OVER-ENGINE					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	42.512	30.630	98.000	.58000	3.9745	2.8637	41.053	20.645	196.00	.58000	8.2316	4.1395
	75 Pre	14.097	10.157	66.000	.56300	8.3157	5.9915	13.613	6.8460	100.00	.56300	13.047	6.5613
	75 Post	12.566	9.0539	15.000	.44300	2.6946	1.9414	12.135	6.1023	26.000	.44300	4.8366	2.4322
	75 Total	26.663	19.211	81.000	.53500	5.6783	4.0912	25.748	12.948	126.00	.53500	9.1468	4.5998
	76	13.022	9.3826	41.000	.63000	4.9975	3.6007	12.575	6.3239	75.000	.63000	9.4668	4.7607
77	74	41.671	30.024	110.00	.53400	4.9433	3.5617	40.241	20.236	162.00	.53400	7.5389	3.7912
	75 Pre	13.956	10.055	68.000	.46000	10.592	7.6317	13.477	6.7774	76.000	.46000	12.259	6.1649
	75 Post	12.440	8.9633	21.000	.52800	3.1971	2.3035	12.013	6.0413	27.000	.52800	4.2566	2.1406
	75 Total	26.397	19.019	89.000	.47500	7.0981	5.1142	25.491	12.819	103.00	.47500	8.5067	4.2779
	76	23.677	17.059	62.000	.53600	4.8854	3.5199	22.864	11.498	127.00	.53600	10.363	5.2113
	77	21.079	15.187	65.000	.58800	5.2443	3.7785	20.355	10.236	141.00	.58800	11.780	5.9242
78	74	40.387	29.099	71.000	.41600	4.2260	3.0448	39.000	19.613	145.00	.41600	8.9373	4.4944
	75 Pre	13.674	9.8524	42.000	.38400	7.9986	5.7630	13.205	6.6406	59.000	.38400	11.635	5.8513
	75 Post	12.189	8.7821	14.000	.42000	2.7347	1.9704	11.771	5.9192	17.000	.42000	3.4388	1.7293
	75 Total	25.864	18.635	56.000	.39200	5.5235	3.9797	24.976	12.560	76.000	.39200	7.7626	3.9037
	76	23.448	16.894	45.000	.41800	4.5913	3.3080	22.643	11.387	91.000	.41800	9.6146	4.8350
	77	38.326	27.614	109.00	.46300	6.1427	4.4258	37.010	18.612	159.00	.46300	9.2789	4.6662

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Fleet Size by Calendar Year and Model Year

		FLEET SIZE											
		SMALL(1-49)						LARGE(50+)					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	33.134	16.777	173.00	.58300	8.9559	4.5349	50.508	35.303	123.00	.58300	4.1772	2.9197
	75 Pre	10.987	5.5635	106.00	.56500	17.075	8.6461	16.749	11.707	61.000	.56500	6.4462	4.5056
	75 Post	9.7939	4.9592	19.000	.43300	4.4804	2.2686	14.929	10.435	21.000	.43300	3.2486	2.2706
	75 Total	20.781	10.523	125.00	.53500	11.243	5.6930	31.678	22.142	82.000	.53500	4.8384	3.3819
	76	10.149	5.1392	67.000	.62000	10.647	5.3913	15.471	10.814	47.000	.62000	4.8998	3.4247
77	74	32.478	16.445	148.00	.51800	8.7971	4.4545	49.508	34.604	114.00	.51800	4.4453	3.1071
	75 Pre	10.877	5.5078	100.00	.46000	19.986	10.120	16.581	11.589	44.000	.46000	5.7688	4.0322
	75 Post	9.6959	4.9096	30.000	.51000	6.0669	3.0720	14.780	10.331	16.000	.51000	2.1226	1.4836
	75 Total	20.573	10.417	130.00	.47100	13.416	6.7931	31.361	21.920	60.000	.47100	4.0620	2.8391
	76	18.454	9.3442	120.00	.53400	12.177	6.1661	28.130	19.662	68.000	.53400	4.5268	3.1641
	77	16.429	8.3188	107.00	.57800	11.268	5.7057	25.043	17.504	95.000	.57800	6.5630	4.5873
78	74	31.477	15.939	136.00	.41400	10.436	5.2845	47.982	33.538	79.000	.41400	3.9769	2.7797
	75 Pre	10.658	5.3965	55.000	.38100	13.545	6.8586	16.246	11.355	45.000	.38100	7.2701	5.0815
	75 Post	9.4999	4.8103	21.000	.42000	5.2632	2.6650	14.481	10.122	10.000	.42000	1.6442	1.1492
	75 Total	20.158	10.207	76.000	.39200	9.6180	4.8701	30.728	21.477	55.000	.39200	4.5661	3.1915
	76	18.275	9.2536	56.000	.41600	7.3661	3.7299	27.858	19.471	79.000	.41600	6.8169	4.7648
	77	29.871	15.125	141.00	.45200	10.443	5.2880	45.534	31.826	126.00	.45200	6.1221	4.2791

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Carrier Type by Calendar Year and Model Year

		CARRIER TYPE											
		AUTHORIZED						NON-AUTHORIZED					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	44.313	36.556	161.00	.58700	6.1895	5.1059	29.168	16.906	95.000	.58700	5.5486	3.2162
	75 Pre	14.695	12.122	81.000	.56500	9.7562	8.0483	9.6722	5.6063	60.000	.55600	11.157	6.4670
	75 Post	13.098	10.805	24.000	.45300	4.0448	3.3367	8.6215	4.9973	14.000	.45300	3.5846	2.0778
	75 Total	27.793	22.927	105.00	.53500	7.0616	5.8254	18.294	10.604	74.000	.53800	7.5188	4.3581
	76	13.574	11.198	63.000	.63900	7.2633	5.9917	8.9346	5.1788	38.000	.63900	6.6559	3.8580
77	74	43.436	35.832	144.00	.53400	6.2082	5.1214	28.590	16.572	78.000	.53400	5.1089	2.9613
	75 Pre	14.547	12.001	67.000	.46300	9.9473	8.2059	9.5753	5.5502	51.000	.46000	11.579	6.7114
	75 Post	12.967	10.697	22.000	.52800	3.2132	2.6507	8.5353	4.9473	19.000	.52800	4.2160	2.4437
	75 Total	27.515	22.698	89.000	.47500	6.8096	5.6175	18.111	10.498	70.000	.47500	8.1370	4.7165
	76	24.680	20.360	100.00	.54100	7.4895	6.1784	16.245	9.4160	60.000	.53100	6.9557	4.0317
	77	21.972	18.125	116.00	.59300	8.9030	7.3444	14.462	8.3828	70.000	.58800	8.2316	4.7713
78	74	42.098	34.728	124.00	.42100	6.9965	5.7717	27.709	16.061	56.000	.42100	4.8004	2.7825
	75 Pre	14.254	11.758	65.000	.38700	11.784	9.7207	9.3819	5.4381	24.000	.38400	6.6617	3.8614
	75 Post	12.705	10.481	14.000	.42000	2.6236	2.1643	8.3628	4.8473	10.000	.42000	2.8471	1.6503
	75 Total	26.959	22.240	79.000	.39300	7.4564	6.1510	17.745	10.286	34.000	.39200	4.8878	2.8331
	76	24.441	20.162	84.000	.41800	8.2221	6.7827	16.088	9.3248	40.000	.41600	5.9769	3.4644
	77	39.949	32.956	159.00	.46600	8.5409	7.0457	26.295	15.241	80.000	.46300	6.5710	3.8088

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates
Vehicle Type by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	VEHICLE TYPE									
	STRAIGHT TRUCK					TRACTOR				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	58.186	13.540	197.00	3.3857	.78784	269.11	46.759	1783.0	6.6256	1.1512
1975 Pre	22.041	5.1282	96.000	4.3555	1.0134	90.145	15.661	1035.0	11.482	1.9947
1975 Post	24.397	5.6762	52.000	2.1314	.49590	80.353	13.960	302.00	3.7584	.65295
1975 Total	46.437	10.804	148.00	3.1871	.74152	170.50	29.621	1337.0	7.8417	1.3623
1976	27.781	6.6587	107.00	3.8515	.92315	129.94	23.255	954.00	7.3421	1.3140
1977	20.207	5.9952	113.00	5.5922	1.6592	128.33	28.431	1047.0	8.1586	1.8075
TOTAL	152.61	19.502	565.00	3.7022	.47311	697.88	66.429	5121.0	7.3380	.69849

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Straight Trucks
Trip Distance by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	TRIP DISTANCE - STRAIGHT TRUCKS									
	LOCAL					INTERCITY				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	32.631	6.0120	127.49	3.9070	.71981	25.502	9.8305	70.032	2.7461	1.0586
1975 Pre	12.361	2.2771	60.626	4.9046	.90349	9.6605	3.7233	34.575	3.5790	1.3794
1975 Post	13.682	2.5204	38.799	2.8358	.52239	10.693	4.1212	13.712	1.2823	.49424
1975 Total	26.043	4.7974	99.234	3.8104	.70193	20.353	7.8445	48.592	2.3875	.92018
1976	15.580	2.9566	62.555	4.0151	.76195	12.176	4.8346	44.228	3.6323	1.4422
1977	11.332	2.6620	56.363	4.9738	1.1684	8.8563	4.3528	56.363	6.3642	3.1280
TOTAL	85.586	8.6595	345.64	4.0385	.40861	66.888	14.160	219.22	3.2774	.69379

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Tractors
Trip Distance by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	TRIP DISTANCE - TRACTORS									
	LOCAL					INTERCITY				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	24.050	13.238	244.79	10.178	5.6025	245.09	49.569	1538.1	6.2756	1.2692
1975 Pre	8.0560	4.4336	160.48	19.920	10.963	82.098	16.602	873.98	10.646	2.1528
1975 Post	7.1809	3.9521	44.783	6.2364	3.4322	73.180	14.799	257.43	3.5178	.71137
1975 Total	15.237	8.3858	206.47	13.551	7.4576	155.28	31.401	1129.5	7.2743	1.4710
1976	11.612	6.5836	91.415	7.8724	4.4634	118.34	24.653	863.08	7.2934	1.5194
1977	11.469	8.0489	117.16	10.216	7.1698	116.88	30.140	929.82	7.9556	2.0516
TOTAL	62.367	18.806	659.84	10.580	3.1903	635.58	70.422	4460.5	7.0180	.77759

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Trailer Use by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	Trailer Use									
	BOBTAIL					TRAILER				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	.51011	.46071	36.616	71.780	64.828	244.58	48.714	1493.2	6.1052	1.2160
1975 Pre	.17088	.15430	25.378	148.51	134.11	81.927	16.316	837.28	10.220	2.0353
1975 Post	.15231	.13754	3.8462	25.251	22.803	73.028	14.544	252.90	3.4630	.68967
1975 Total	.32319	.29185	29.625	91.663	82.774	154.96	30.860	1096.5	7.0759	1.4092
1976	.24630	.22913	30.947	125.64	116.88	118.09	24.228	825.58	6.9911	1.4343
1977	.24326	.28013	21.912	90.076	103.73	116.63	29.620	901.39	7.7285	1.9627
TOTAL	1.3229	.65452	119.10	90.031	44.545	634.26	69.208	4316.6	6.8058	.74262

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Number of Trailers by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	Number of Trailers									
	SINGLE					DOUBLE				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	236.28	50.182	1425.0	6.0309	1.2808	8.3102	2.0978	77.905	9.3746	2.3665
1975 Pre	79.150	16.807	801.57	10.127	2.1505	2.7837	.70262	47.418	17.034	4.2994
1975 Post	70.552	14.982	238.82	3.3850	.71880	2.4813	.62630	14.825	5.9747	1.5080
1975 Total	149.70	31.789	1051.0	7.0207	1.4908	5.2651	1.3289	61.465	11.674	2.9466
1976	114.09	24.957	769.60	6.7457	1.4757	4.0125	1.0433	34.456	8.5871	2.2328
1977	112.68	30.512	892.06	7.9169	2.1438	3.9630	1.2756	30.815	7.7759	2.5028
TOTAL	612.75	71.292	4137.7	6.7526	.79565	21.551	2.9804	204.64	9.4957	1.3132

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Trailer Brake Type by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	Trailer Brake Type									
	PRE-STANDARD					POST-STANDARD				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	173.78	38.934	1294.4	7.4484	1.6687	70.850	11.422	198.79	2.8058	.45231
1975 Pre	58.213	13.040	696.68	11.968	2.6809	23.733	3.8254	140.60	5.9243	.95491
1975 Post	51.889	11.624	147.88	2.8499	.63840	21.155	3.4099	105.02	4.9642	.80016
1975 Total	110.10	24.664	848.74	7.7086	1.7268	44.889	7.2354	247.72	5.5185	.88951
1976	83.909	19.363	464.20	5.5322	1.2766	34.209	5.6805	361.39	10.564	1.7542
1977	82.873	23.673	468.45	5.6526	1.6147	33.787	6.9448	432.94	12.814	2.6339
TOTAL	450.67	55.313	3075.8	6.8250	.83766	183.73	16.227	1240.8	6.7534	.59643

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Cab Style by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	CAB STYLE									
	CONVENTIONAL					CAB-OVER-ENGINE				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	124.57	51.830	545.63	4.3801	1.8225	120.29	34.934	989.86	8.2287	2.3896
1975 Pre	41.728	17.359	374.43	8.9732	3.7330	40.296	11.700	496.48	12.321	3.5776
1975 Post	37.195	15.474	106.97	2.8758	1.1964	35.919	10.429	150.30	4.1846	1.2150
1975 Total	78.924	32.834	481.63	6.1024	2.5387	76.215	22.130	646.23	8.4791	2.4620
1976	60.147	25.777	288.41	4.7950	2.0550	58.083	17.374	573.69	9.8771	2.9545
1977	59.405	31.515	345.97	5.8239	3.0896	57.366	21.241	583.21	10.167	3.7644
TOTAL	323.05	73.635	1661.6	5.1436	1.1724	311.96	49.630	2793.0	8.9531	1.4244

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Fleet Size by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	FLEET SIZE									
	SMALL (1-49)					LARGE (50+)				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	97.089	28.390	910.96	9.3827	2.7436	148.00	59.737	621.88	4.2019	1.6960
1975 Pre	32.522	9.5085	549.36	16.892	4.9386	49.576	20.008	321.73	6.4896	2.6191
1975 Post	28.990	8.4756	152.70	5.2675	1.5401	44.191	17.834	103.68	2.3462	.94688
1975 Total	61.512	17.984	703.53	11.437	3.3439	93.767	37.842	420.97	4.4895	1.8118
1976	46.878	14.119	467.40	9.9705	3.0030	71.459	29.710	393.05	5.5004	2.2868
1977	46.299	17.262	497.07	10.736	4.0027	70.577	36.322	443.12	6.2786	3.2312
TOTAL	251.78	40.333	2579.0	10.243	1.6408	383.80	84.868	1879.0	4.8958	1.0826

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates for Intercity Tractors Only
Carrier Type by Model Year
(Aggregate of Calendar Years 1976-1978)

Model Year	CARRIER TYPE									
	AUTHORIZED					NON-AUTHORIZED				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	129.85	61.857	838.48	6.4574	3.0762	85.467	28.608	440.92	5.1590	1.7268
1975 Pre	43.496	20.718	456.03	10.485	4.9939	28.629	9.5816	281.28	9.8250	3.2882
1975 Post	38.771	18.467	127.98	3.3009	1.5723	25.520	8.5408	90.699	3.5541	1.1895
1975 Total	82.267	39.185	584.65	7.1067	3.3850	54.150	18.123	371.65	6.8634	2.2970
1976	62.695	30.764	484.39	7.7261	3.7911	41.267	14.228	268.62	6.5092	2.2442
1977	61.921	37.611	536.82	8.6694	5.2658	40.757	17.395	291.83	7.1603	3.0559
TOTAL	336.73	87.880	2444.3	7.2590	1.8944	221.64	40.643	1373.0	6.1948	1.1360

APPENDIX D

INJURY RATES: SURVEY MILES PER DAY

This appendix presents injury accident involvement rates computed using BMCS accident data and survey mileage data by calendar year and power unit model year. These data are presented in a series of 7 tables as listed below.

Subset	Variable	Levels
1. Tractor, Auth. Carrier	----	Tractor Only
2. Tractor, Auth. Carrier	Trip Distance	Local, Intercity
3. Intercity Tractor, Auth. Carrier	Trailer Type	Bobtail, Trailer
4. Intercity Tractor, Auth. Carrier (with Trailer)	Trailer Type	Single, Double
5. Intercity Tractor, Auth. Carrier (with Trailer)	Trailer Type	Pre-Standard, Post-Standard
6. Intercity Tractor (Fatals Excluded)	Carrier Type	Authorized, Non-Auth. Interstate
7. Intercity Tractor (BMCS Fatals)	Carrier Type	Authorized, Non-Auth. Interstate

Each page also contains 11 rows which correspond to the various model years and accident years. BMCS accident data were not available for the 1978 calendar year. The first five rows show the results by model year for calendar year 1976, with rows 1-5 corresponding to the model years 1974, 1975 Pre, 1975 Post, 1975 Total, and 1976. The next six rows show the results for calendar year 1977 for the same five model years plus the 1977 model year. The rows corresponding to the pre/post split of the 1975 model year power units do not contain accident counts because this distinction could not be made in the BMCS file. The calendar year and power unit model year corresponding to each row are listed in columns 1 and 2 of the table, respectively.

The remaining twelve columns on each page correspond to two repetitions of six variables, one repetition for each of the two levels associated with the exposure variable. The common group of six variables is, in order from left to right, shown in the following listing.

Column 1: Total vehicle miles
2: Confidence interval for total vehicle miles
3: Number of accidents
4: Response rate for the above number of accidents
5: Accident rate, column 3/(column 4 x column 1)
6: Confidence interval for the accident rate

Data are also combined across calendar years and then across model years. This information is presented in the second set of 7 tables in this appendix. The column format is the same as for the first 7 tables, except that the response rate for the accident counts is omitted since the estimated totals must be used in combining the data. The first 6 rows of each table present results for each of the 6 model year divisions shown above after combining across calendar year. The final row presents the data after combining across calendar year and model year.

Survey Data

Injury Involvement Rates for Tractors, Authorized Carriers Only
Overall Rates by Calendar Year and Model Year

Cal. Year	Model Year	Overall Rates for Tractors					
		Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	57.740	21.448	2744.0	1.0000	47.523	17.653
	75 Pre	12.770	10.590	-0.	-0.	-0.	-0.
	75 Post	10.099	9.4046	-0.	-0.	-0.	-0.
	75 Total	22.868	14.156	1542.0	1.0000	67.429	41.739
	76	14.443	18.651	720.00	1.0000	49.852	64.377
77	74	56.598	21.023	2680.0	1.0000	47.352	17.589
	75 Pre	12.642	10.474	-0.	-0.	-0.	-0.
	75 Post	9.9978	9.3106	-0.	-0.	-0.	-0.
	75 Total	22.640	14.014	1564.0	1.0000	69.083	42.763
	76	26.260	33.911	1607.0	1.0000	61.196	79.026
	77	29.750	2.2411	1683.0	1.0000	56.572	4.2617

Survey Data

Injury Involvement Rates for Tractors, Authorized Carriers Only
Trip Distance by Calendar Year and Model Year

		TRIP DISTANCE - TRACTORS											
		LOCAL						INTERCITY					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	3.7666	1.8612	314.00	1.0000	83.364	41.192	53.973	21.049	2430.0	1.0000	45.022	17.558
	75 Pre	.61717	.41145	-0.	-0.	-0.	-0.	12.152	10.316	-0.	-0.	-0.	-0.
	75 Post	.41915	.48464	-0.	-0.	-0.	-0.	9.6797	9.4046	-0.	-0.	-0.	-0.
	75 Total	1.0363	.63574	199.00	1.0000	192.03	117.80	21.832	13.959	1343.0	1.0000	61.515	39.332
	76	.76014	.93660	55.000	1.0000	72.355	89.151	13.683	18.881	665.00	1.0000	48.602	67.069
77	74	3.6921	1.8243	328.00	1.0000	88.838	43.897	52.906	20.632	2352.0	1.0000	44.457	17.337
	75 Pre	.61099	.40733	-0.	-0.	-0.	-0.	12.031	10.212	-0.	-0.	-0.	-0.
	75 Post	.41496	.47979	-0.	-0.	-0.	-0.	9.5829	9.3106	-0.	-0.	-0.	-0.
	75 Total	1.0259	.62938	214.00	1.0000	208.59	127.96	21.614	13.819	1350.0	1.0000	62.461	39.937
	76	1.3821	1.7029	143.00	1.0000	103.47	127.49	24.878	34.330	1464.0	1.0000	58.848	81.208
	77	1.0327	.26366	177.00	1.0000	171.40	43.761	28.717	2.2411	1506.0	1.0000	52.442	4.0927

Survey Data

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Use by Calendar Year and Model Year

		Trailer Use											
		BOBTAIL						TRAILER					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	0.	-0.	60.000	1.0000	-0.	-0.	53.973	21.049	2370.0	1.0000	43.910	17.124
	75 Pre	0.	-0.	-0.	-0.	-0.	-0.	12.152	10.316	-0.	-0.	-0.	-0.
	75 Post	.39295 -1	.39295 -1	-0.	-0.	-0.	-0.	9.6404	9.4046	-0.	-0.	-0.	-0.
	75 Total	.39295 -1	.39295 -1	54.000	1.0000	1374.2	1374.2	21.793	13.959	1289.0	1.0000	59.148	37.887
	76	.54296 -1	.81444 -1	21.000	1.0000	386.77	580.15	13.628	18.881	643.00	1.0000	47.181	65.368
77	74	0.	-0.	90.000	1.0000	-0.	-0.	52.906	20.632	2262.0	1.0000	42.755	16.674
	75 Pre	0.	-0.	-0.	-0.	-0.	-0.	12.031	10.212	-0.	-0.	-0.	-0.
	75 Post	.38902 -1	.38902 -1	-0.	-0.	-0.	-0.	9.5440	9.3106	-0.	-0.	-0.	-0.
	75 Total	.38902 -1	.38902 -1	55.000	1.0000	1413.8	1413.8	21.575	13.819	1295.0	1.0000	60.024	38.448
	76	.98721 -1	.14808	56.000	1.0000	567.26	850.88	24.779	34.330	1408.0	1.0000	56.822	78.725
	77	.10327	.19775	50.000	1.0000	484.18	927.15	28.607	2.2411	1456.0	1.0000	50.896	3.9872

Survey Data

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Number of Trailers by Calendar Year and Model Year

		Number of Trailers											
		SINGLE						DOUBLE					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	53.264	21.049	2233.0	1.0000	41.923	16.567	.70901	.35451	141.00	1.0000	198.87	99.434
	75 Pre	12.035	10.227	-0.	-0.	-0.	-0.	.11756	.13225	-0.	-0.	-0.	-0.
	75 Post	9.4963	9.3653	-0.	-0.	-0.	-0.	.14408	.11789	-0.	-0.	-0.	-0.
	75 Total	21.531	13.868	1216.0	1.0000	56.476	36.375	.26164	.17716	86.000	1.0000	328.70	222.57
	76	13.357	18.868	622.00	1.0000	46.568	65.782	.27148	.20361	23.000	1.0000	84.721	63.541
77	74	52.211	20.632	2161.0	1.0000	41.390	16.356	.69498	.34749	106.00	1.0000	152.52	76.261
	75 Pre	11.914	10.125	-0.	-0.	-0.	-0.	.11638	.13093	-0.	-0.	-0.	-0.
	75 Post	9.4013	9.2717	-0.	-0.	-0.	-0.	.14264	.11671	-0.	-0.	-0.	-0.
	75 Total	21.316	13.729	1218.0	1.0000	57.141	36.803	.25902	.17539	86.000	1.0000	332.02	224.82
	76	24.285	34.305	1339.0	1.0000	55.136	77.885	.49360	.37020	71.000	1.0000	143.84	107.88
	77	26.586	1.9775	1395.0	1.0000	52.471	3.9028	2.0214	.65916	82.000	1.0000	40.566	13.228

Survey Data

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Brake Type by Calendar Year and Model Year

		Trailer Brake Type											
		PRE-STANDARD						POST-STANDARD					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	44.269	17.016	1514.0	.69300	49.351	18.970	9.7489	4.0768	188.00	.69300	27.827	11.637
	75 Pre	9.9188	8.4053	-0.	-0.	-0.	-0.	2.2336	1.9103	-0.	-0.	-0.	-0.
	75 Post	7.3613	7.2041	-0.	-0.	-0.	-0.	2.2791	2.1612	-0.	-0.	-0.	-0.
	75 Total	17.280	11.070	752.00	.67800	64.186	41.120	4.5127	2.8845	183.00	.67800	59.812	39.231
	76	10.384	14.497	314.00	.67900	44.534	62.173	3.2578	4.3165	144.00	.67900	65.099	86.256
77	74	43.393	16.680	1284.0	.68000	43.515	16.726	9.5560	3.9962	337.00	.68000	51.861	21.687
	75 Pre	9.8195	8.3211	-0.	-0.	-0.	-0.	2.2112	1.8912	-0.	-0.	-0.	-0.
	75 Post	7.2877	7.1320	-0.	-0.	-0.	-0.	2.2563	2.1396	-0.	-0.	-0.	-0.
	75 Total	17.107	10.959	619.00	.64900	55.753	35.717	4.4675	2.8556	284.00	.64900	97.950	62.609
	76	18.880	26.358	631.00	.66400	50.333	70.269	5.9232	7.9493	355.00	.66400	90.261	119.60
	77	10.986	1.5820	637.00	.66100	87.720	12.632	17.621	2.0214	384.00	.66100	32.969	3.7819

Survey Data

Injury Involvement Rates for Intercity Tractors (Fatals Excluded)
Carrier Type by Calendar Year and Model Year

		CARRIER TYPE											
		AUTHORIZED						NON-AUTHORIZED					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	53.973	21.049	2213.0	1.0000	41.002	15.990	25.037	17.459	481.00	1.0000	19.212	13.397
	75 Pre	12.152	10.316	-0.	-0.	-0.	-0.	5.1284	4.1292	-0.	-0.	-0.	-0.
	75 Post	9.6797	9.4046	-0.	-0.	-0.	-0.	11.527	4.2439	-0.	-0.	-0.	-0.
	75 Total	21.832	13.959	1184.0	1.0000	54.232	34.675	16.655	5.9212	313.00	1.0000	18.793	6.6814
	76	13,683	18.881	584.00	1.0000	42.682	58.899	8.2123	7.8458	172.00	1.0000	20.944	20.010
77	74	52.906	20.632	2153.0	1.0000	40.695	15.870	24.542	17.114	414.00	1.0000	16.869	11.764
	75 Pre	12.031	10.212	-0.	-0.	-0.	-0.	5.0771	4.0878	-0.	-0.	-0.	-0.
	75 Post	9.5829	9.3106	-0.	-0.	-0.	-0.	11.411	4.2014	-0.	-0.	-0.	-0.
	75 Total	21.614	13.819	1226.0	1.0000	56.724	36.268	16.488	5.8619	297.00	1.0000	18.013	6.4039
	76	24.878	34.330	1298.0	1.0000	52.175	72.000	14.932	14.265	334.00	1.0000	22.369	21.371
	77	28.827	2.2411	1338.0	1.0000	46.415	3.6085	22.170	2.0873	295.00	1.0000	13.306	1.2528

Survey Data

Fatal Involvement Rates (BMCS-Reported Accidents) for Intercity Tractors
Carrier Type by Calendar Year and Model Year

		CARRIER TYPE											
		AUTHORIZED						NON-AUTHORIZED					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	53.973	21.049	221.00	1.0000	4.0946	1.5968	25.037	17.459	87.000	1.0000	3.4749	2.4232
	75 Pre	12.152	10.316	-0.	-0.	-0.	-0.	5.1284	4.1292	-0.	-0.	-0.	-0.
	75 Post	9.6797	9.4046	-0.	-0.	-0.	-0.	11.527	4.2439	-0.	-0.	-0.	-0.
	75 Total	21.832	13.959	139.00	1.0000	6.3668	4.0708	16.655	5.9212	71.000	1.0000	4.2630	1.5156
	76	13.683	18.881	75.000	1.0000	5.4814	7.5641	8.2123	7.8458	36.000	1.0000	4.3837	4.1881
77	74	52.906	20.632	232.00	1.0000	4.3852	1.7101	24.542	17.114	70.000	1.0000	2.8523	1.9890
	75 Pre	12.031	10.212	-0.	-0.	-0.	-0.	5.0771	4.0878	-0.	-0.	-0.	-0.
	75 Post	9.5829	9.3106	-0.	-0.	-0.	-0.	11.411	4.2014	-0.	-0.	-0.	-0.
	75 Total	21.614	13.819	128.00	1.0000	5.9222	3.7866	16.488	5.9619	49.000	1.0000	2.9718	1.0565
	76	24.878	34.330	169.00	1.0000	6.7932	9.3744	14.932	14.265	74.000	1.0000	4.9560	4.7348
	77	28.827	2.2411	176.00	1.0000	6.1054	.47465	22.170	2.0873	69.000	1.0000	3.1124	.29304

Survey Data

Injury Involvement Rates for Tractors, Authorized Carriers Only
Overall Rates by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Overall Rates for Tractors				
	Veh. Miles	**V.M. C.I.**	**No. Acc.**	**Acc. Rate**	**Acc. Rate C.I.**
1974	114.34	30.033	5424.0	47.438	12.461
1975 Pre	25.411	14.888	-0.	-0.	-0.
1975 Post	20.097	13.234	-0.	-0.	-0.
1975 Total	45.508	19.919	3106.0	68.252	29.875
1976	40.702	38.701	2327.0	57.171	54.360
1977	29.750	2.2411	1683.0	56.572	4.2617
TOTAL	230.30	52.930	12540.	54.451	12.515

Survey Data

Injury Involvement Rates for Tractors, Authorized Carriers Only
Trip Distance by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	TRIP DISTANCE - TRACTORS									
	LOCAL					INTERCITY				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	7.4587	2.6062	642.00	86.074	30.075	106.88	29.474	4782.0	44.742	12.339
1975 Pre	1.2282	.57897	-0.	-0.	-0.	24.183	14.516	-0.	-0.	-0.
1975 Post	.83410	.68197	-0.	-0.	-0.	19.263	13.234	-0.	-0.	-0.
1975 Total	2.0623	.89458	413.00	200.27	86.872	43.446	19.643	2693.0	61.985	28.025
1976	2.1422	1.9435	198.00	92.427	93.853	38.560	39.180	2129.0	55.212	56.100
1977	1.0327	.26366	177.00	171.40	43.761	28.717	2.2411	1506.0	52.442	4.2927
TOTAL	12.696	3.3822	1430.0	112.63	30.006	217.60	52.865	11110.	51.056	12.404

Survey Data

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Use by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Trailer Use									
	BOBTAIL					TRAILER				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	0.	-0.	150.00	-0.	-0.	106.88	29.474	4632.0	43.339	11.952
1975 Pre	0.	-0.	-0.	-0.	-0.	24.183	14.516	-0.	-0.	-0.
1975 Post	.78197 -1	.55294 -1	-0.	-0.	-0.	19.184	13.234	-0.	-0.	-0.
1975 Total	.78197 -1	.55294 -1	109.00	1393.9	985.66	43.368	19.643	2584.0	59.584	26.989
1976	.15302	.16900	77.000	503.21	555.78	38.407	39.180	2051.0	53.401	54.476
1977	.10327	.19775	50.000	484.18	927.15	28.697	2.2411	1456.0	50.896	3.9872
TOTAL	.33448	.26594	386.00	1154.0	917.53	217.26	52.865	10723.	49.355	12.009

Survey Data

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Number of Trailers by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Number of Trailers									
	SINGLE					DOUBLE				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	105.48	29.474	4394.0	41.659	11.641	1.4040	.49641	247.00	175.93	62.203
1975 Pre	23.949	14.392	-0.	-0.	-0.	.23394	.18610	-0.	-0.	-0.
1975 Post	18.898	13.179	-0.	-0.	-0.	.28672	.16588	-0.	-0.	-0.
1975 Total	42.847	19.514	2434.0	56.807	25.872	.52066	.24930	172.00	330.35	153.18
1976	37.642	39.152	1961.0	52.096	54.185	.76508	.42250	94.000	122.86	67.848
1977	26.586	1.9775	1395.0	52.471	3.9028	2.0214	.65916	82.000	40.566	13.228
TOTAL	212.55	52.785	10184.	47.913	11.899	4.7112	.95998	595.00	126.30	25.735

Survey Data

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Brake Type by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Trailer Brake Type: PRE-STANDARD Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	POST-STANDARD Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	87.662	23.828	4072.9	46.462	12.629	19.305	5.7087	766.87	39.724	11.747
1975 Pre	19.738	11.828	-0.	-0.	-0.	4.4448	2.6881	-0.	-0.	-0.
1975 Post	14.649	10.137	-0.	-0.	-0.	4.5354	3.0412	-0.	-0.	-0.
1975 Total	34.387	15.577	2062.9	59.991	27.176	8.9802	4.0589	707.51	78.785	35.609
1976	29.264	30.082	1412.7	48.275	49.624	9.1810	8.9570	746.72	81.333	79.348
1977	10.986	1.5820	963.69	87.720	12.632	17.621	2.0214	580.94	32.968	3.7818
TOTAL	162.30	41.447	8512.3	52.448	13.394	55.088	11.549	2802.0	50.865	10.664

Survey Data

Injury Involvement Rates for Intercity Tractors (Fatals Excluded)
Carrier Type by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	CARRIER TYPE									
	AUTHORIZED					NON-AUTHORIZED				
	Veh. Miles	**V.M. C.I.**	**No. Acc.**	**Acc. Rate**	**Acc. Rate C.I.**	**Veh. Miles**	**V.M. C.I.**	**No. Acc.**	**Acc. Rate**	**Acc. Rate C.I.**
1974	106.88	29.474	4366.0	40.850	11.265	49.579	24.448	895.00	18.052	9.9019
1975 Pre	24.183	14.516	-0.	-0.	-0.	10.205	5.8104	-0.	-0.	-0.
1975 Post	19.263	13.234	-0.	-0.	-0.	22.938	5.9718	-0.	-0.	-0.
1975 Total	43.446	19.643	2410.0	55.472	25.080	33.143	9.3320	610.00	18.405	4.6269
1976	38.560	39.180	1882.0	48.807	49.591	23.144	16.280	506.00	21.863	15.380
1977	28.827	2.2411	1338.0	46.415	3.6085	22.170	2.0873	295.00	13.306	1.2528
TOTAL	217.71	52.865	9996.0	45.914	11.149	128.04	30.603	2306.0	18.011	4.3049

Survey Data

Fatal Involvement Rates (BMCS-Reported Accidents) for Intercity Tractors
Carrier Type by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	CARRIER TYPE									
	AUTHORIZED					NON-AUTHORIZED				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	106.88	29.474	453.00	4.2384	1.1688	49.579	24.448	157.00	3.1667	1.5616
1975 Pre	24.183	14.516	-0.	-0.	-0.	10.205	5.8104	-0.	-0.	-0.
1975 Post	19.263	13.234	-0.	-0.	-0.	22.938	5.9718	-0.	-0.	-0.
1975 Total	43.446	19.643	267.00	6.1456	2.7786	33.143	8.3320	120.00	3.6206	.91021
1976	38.560	39.180	244.00	6.3278	6.4295	23.144	16.280	110.00	4.7529	3.3434
1977	28.827	2.2411	176.00	6.1054	.47465	22.170	2.0873	69.000	3.1124	.29304
TOTAL	217.71	52.865	1140.0	5.2363	1.2715	128.04	30.603	456.00	3.5615	.85128

APPENDIX E

INJURY RATES: AVERAGED MILES PER DAY

This appendix presents data in the same format as Appendix D. The only difference is in the way the survey data on mileage is treated. For Appendix D, separate estimates where computed for each model year and exposure category. For the computations presented in this appendix, the survey data were averaged across model year in each exposure category, thus removing the survey differences by model year. This computation was carried out to isolate the influence of the estimated number of vehicles in service. This influence can be evaluated by comparing the results in Appendices D and E.

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Tractors, Authorized Carriers Only
Overall Rates by Calendar Year and Model Year

Cal. Year	Model Year	Overall Rates for Tractors					
		Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	46.125	37.141	2744.0	1.0000	59.490	47.903
	75 Pre	15.295	12.316	-0.	-0.	-0.	-0.
	75 Post	13.634	10.978	-0.	-0.	-0.	-0.
	75 Total	28.929	23.295	1542.0	1.0000	53.302	42.921
	76	14.129	11.377	720.00	1.0000	50.959	41.034
77	74	45.213	36.406	2680.0	1.0000	59.276	47.730
	75 Pre	15.142	12.193	-0.	-0.	-0.	-0.
	75 Post	13.498	10.869	-0.	-0.	-0.	-0.
	75 Total	28.640	23.062	1564.0	1.0000	54.609	43.972
	76	25.689	20.686	1607.0	1.0000	62.555	50.371
	77	22.870	18.416	1683.0	1.0000	73.599	59.256

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Tractors, Authorized Carriers Only
Trip Distance by Calendar Year and Model Year

		TRIP DISTANCE - TRACTORS											
		LOCAL						INTERCITY					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	2.3486	1.9540	314.00	1.0000	133.70	111.24	43.777	37.216	2430.0	1.0000	55.599	47.191
	75 Pre	.77881	.64797	-0.	-0.	-0.	-0.	14.517	12.341	-0.	-0.	-0.	-0.
	75 Post	.69421	.57758	-0.	-0.	-0.	-0.	12.940	11.001	-0.	-0.	-0.	-0.
	75 Total	1.4730	1.2256	199.00	1.0000	135.10	112.40	27.456	23.342	1343.0	1.0000	48.914	41.584
	76	.71942	.59856	55.000	1.0000	76.450	63.606	13.410	11.400	665.00	1.0000	49.591	42.160
77	74	2.3021	1.9154	328.00	1.0000	142.48	118.54	42.910	36.480	2352.0	1.0000	54.812	46.598
	75 Pre	.77101	.64148	-0.	-0.	-0.	-0.	14.371	12.218	-0.	-0.	-0.	-0.
	75 Post	.68727	.57181	-0.	-0.	-0.	-0.	12.810	10.891	-0.	-0.	-0.	-0.
	75 Total	1.4583	1.2133	214.00	1.0000	146.75	122.09	27.182	23.108	1350.0	1.0000	49.665	42.223
	76	1.3081	1.0883	143.00	1.0000	109.32	90.956	24.381	20.728	1464.0	1.0000	60.046	51.048
	77	1.1645	.96887	177.00	1.0000	152.00	126.46	21.706	18.453	1506.0	1.0000	69.382	58.985

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Use by Calendar Year and Model Year

		Trailer Use											
		BOBTAIL						TRAILER					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	.92073 -1	.25915	60.000	1.0000	651.66	1834.1	43.683	37.216	2370.0	1.0000	54.255	46.223
	75 Pre	.30532 -1	.85935 -1	-0.	-0.	-0.	-0.	14.486	12.341	-0.	-0.	-0.	-0.
	75 Post	.27216 -1	.76600 -1	-0.	-0.	-0.	-0.	12.912	11.001	-0.	-0.	-0.	-0.
	75 Total	.57740 -1	.16254	54.000	1.0000	935.11	2631.9	27.398	23.342	1289.0	1.0000	47.048	40.083
	76	.28204 -1	.79382 -1	21.000	1.0000	744.58	2095.7	13.381	11.400	643.00	1.0000	48.053	40.940
77	74	.90251 -1	.25402	90.000	1.0000	997.22	2806.7	42.819	36.480	2262.0	1.0000	52.827	45.007
	75 Pre	.30226 -1	.85075 -1	-0.	-0.	-0.	-0.	14.341	12.218	-0.	-0.	-0.	-0.
	75 Post	.26943 -1	.75834 -1	-0.	-0.	-0.	-0.	12.783	10.891	-0.	-0.	-0.	-0.
	75 Total	.57170 -1	.16091	55.000	1.0000	962.04	2707.7	27.124	23.108	1295.0	1.0000	47.744	40.676
	76	.51280 -1	.14433	56.000	1.0000	1092.0	3073.6	24.329	20.729	1408.0	1.0000	57.873	49.306
	77	.45653 -1	.12849	50.000	1.0000	1095.2	3082.6	21.659	18.453	1456.0	1.0000	67.222	57.271

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Number of Trailers by Calendar Year and Model Year

		Number of Trailers											
		SINGLE						DOUBLE					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	42.688	37.119	2233.0	1.0000	52.309	45.484	.99458	.62703	141.00	1.0000	141.77	89.377
	75 Pre	14.156	12.309	-0.	-0.	-0.	-0.	.32981	.20793	-0.	-0.	-0.	-0.
	75 Post	12.618	10.972	-0.	-0.	-0.	-0.	.29399	.18534	-0.	-0.	-0.	-0.
	75 Total	26.774	23.281	1216.0	1.0000	45.417	39.492	.62380	.39327	96.000	1.0000	137.87	86.917
	76	13.076	11.370	622.00	1.0000	47.567	41.361	.30466	.13207	23.000	1.0000	75.494	47.595
77	74	41.844	36.384	2161.0	1.0000	51.644	44.906	.97491	.61463	106.00	1.0000	108.73	68.547
	75 Pre	14.014	12.186	-0.	-0.	-0.	-0.	.32651	.20595	-0.	-0.	-0.	-0.
	75 Post	12.492	10.862	-0.	-0.	-0.	-0.	.29105	.18349	-0.	-0.	-0.	-0.
	75 Total	26.506	23.048	1218.0	1.0000	45.951	39.956	.61756	.38934	86.000	1.0000	139.26	87.794
	76	23.775	20.673	1339.0	1.0000	56.319	48.971	.55393	.34922	71.000	1.0000	128.17	80.807
	77	21.166	18.405	1395.0	1.0000	65.907	57.308	.49315	.31090	82.000	1.0000	166.28	104.83

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Brake Type by Calendar Year and Model Year

		Trailer Brake Type											
		PRE-STANDARD						POST-STANDARD					
CAL YR	MDI YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	32.014	28.948	1514.0	.69300	68.243	61.707	11.689	8.3019	188.00	.69300	23.209	16.484
	75 Pre	10.616	9.5993	-0.	-0.	-0.	-0.	3.8761	2.7530	-0.	-0.	-0.	-0.
	75 Post	9.4629	8.5566	-0.	-0.	-0.	-0.	3.4551	2.4539	-0.	-0.	-0.	-0.
	75 Total	20.079	18.156	752.00	.67800	55.239	49.949	7.3312	5.2069	183.00	.67800	36.817	26.149
	76	9.8065	8.8673	314.00	.67900	47.157	42.641	3.5805	2.5430	144.00	.67900	59.231	42.068
77	74	31.380	28.375	1284.0	.68000	60.172	54.410	11.458	8.1377	337.00	.68000	43.254	30.721
	75 Pre	10.510	9.5032	-0.	-0.	-0.	-0.	3.8373	2.7254	-0.	-0.	-0.	-0.
	75 Post	9.3682	8.4710	-0.	-0.	-0.	-0.	3.4205	2.4294	-0.	-0.	-0.	-0.
	75 Total	19.878	17.974	619.00	.64900	47.981	43.386	7.2579	5.1549	284.00	.64900	60.293	42.822
	76	17.830	16.123	631.00	.66400	53.298	48.193	6.5101	4.6238	355.00	.66400	82.125	58.329
	77	15.873	14.353	637.00	.66100	60.711	54.897	5.7957	4.1164	384.00	.66100	100.24	71.192

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors (Fatals Excluded)
Carrier Type by Calendar Year and Model Year

		CARRIER TYPE											
		AUTHORIZED						NON-AUTHORIZED					
CAL YR	MDL YR	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	43.801	37.216	2213.0	1.0000	50.524	42.928	28.592	17.198	481.00	1.0000	16.823	10.119
	75 Pre	14.525	12.341	-0.	-0.	-0.	-0.	9.4812	5.7028	-0.	-0.	-0.	-0.
	75 Post	12.947	11.001	-0.	-0.	-0.	-0.	8.4514	5.0834	-0.	-0.	-0.	-0.
	75 Total	27.472	23.342	1184.0	1.0000	43.099	36.620	17.933	10.786	313.00	1.0000	17.454	10.498
	76	13.417	11.400	584.00	1.0000	43.526	36.983	8.7592	5.2680	172.00	1.0000	19.639	11.812
77	74	42.935	36.480	2153.0	1.0000	50.146	42.607	28.026	16.857	414.00	1.0000	14.772	8.8851
	75 Pre	14.379	12.218	-0.	-0.	-0.	-0.	9.3863	5.6457	-0.	-0.	-0.	-0.
	75 Post	12.818	10.891	-0.	-0.	-0.	-0.	8.3668	5.0325	-0.	-0.	-0.	-0.
	75 Total	27.197	23.108	1226.0	1.0000	45.078	38.301	17.753	10.678	297.00	1.0000	16.729	10.062
	76	24.395	20.729	1298.0	1.0000	53.208	45.209	15.924	9.5782	334.00	1.0000	20.978	12.616
	77	21.718	18.453	1338.0	1.0000	61.608	52.346	14.177	8.5271	295.00	1.0000	20.809	12.516

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates (BMCS-Reported Accidents) for Intercity Tractors
Carrier Type by Calendar Year and Model Year

CAL YR	MDL YR	CARRIER TYPE: AUTHORIZED Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.	NON-AUTHORIZED Veh. Miles	V.M. C.I.	No. Acc.	Response Rate	Acc. Rate	Acc. Rate C.I.
76	74	43.801	37.216	221.00	1.0000	5.0455	4.2870	28.592	17.198	87.000	1.0000	3.0428	1.8302
	75 Pre	14.525	12.341	-0.	-0.	-0.	-0.	9.4812	5.7028	-0.	-0.	-0.	-0.
	75 Post	12.947	11.001	-0.	-0.	-0.	-0.	8.4514	5.0834	-0.	-0.	-0.	-0.
	75 Total	27.472	23.342	139.00	1.0000	5.0597	4.2991	17.933	10.786	71.000	1.0000	3.9593	2.3814
	76	13.417	11.400	75.000	1.0000	5.5899	4.7495	8.7582	5.2680	36.000	1.0000	4.1104	2.4724
77	74	42.935	36.480	232.00	1.0000	5.4036	4.5912	28.026	16.857	70.000	1.0000	2.4977	1.5023
	75 Pre	14.379	12.218	-0.	-0.	-0.	-0.	9.3863	5.6457	-0.	-0.	-0.	-0.
	75 Post	12.818	10.891	-0.	-0.	-0.	-0.	8.3668	5.0325	-0.	-0.	-0.	-0.
	75 Total	27.197	23.108	128.00	1.0000	4.7064	3.9988	17.753	10.678	49.000	1.0000	2.7600	1.6601
	76	24.395	20.728	169.00	1.0000	6.9276	5.8862	15.924	9.5782	74.000	1.0000	4.6470	2.7951
	77	21.718	18.453	176.00	1.0000	8.1039	6.8856	14.177	8.5271	69.000	1.0000	4.8671	2.9275

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Tractors, Authorized Carriers Only
Overall Rates by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Overall Rates for Tractors				
	Veh. Miles	**V.M. C.I.**	**No. Acc.**	**Acc. Rate**	**Acc. Rate C.I.**
1974	91.338	52.009	5424.0	59.384	33.814
1975 Pre	30.438	17.331	-0.	-0.	-0.
1975 Post	27.132	15.448	-0.	-0.	-0.
1975 Total	57.570	32.780	3106.0	53.952	30.720
1976	39.818	23.608	2327.0	58.440	34.649
1977	22.870	18.416	1683.0	73.599	59.256
TOTAL	230.30	52.930	12540.	54.451	12.515

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Tractors, Authorized Carriers Only
Trip Distance by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	TRIP DISTANCE - TRACTORS									
	LOCAL					INTERCITY				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	4.6507	2.7362	642.00	138.04	81.216	86.687	52.114	4782.0	55.164	33.163
1975 Pre	1.5498	.91179	-0.	-0.	-0.	28.888	17.366	-0.	-0.	-0.
1975 Post	1.3815	.81275	-0.	-0.	-0.	25.750	15.480	-0.	-0.	-0.
1975 Total	2.9313	1.7246	413.00	140.89	82.889	54.638	32.846	2693.0	49.288	29.629
1976	2.0275	1.2420	198.00	97.659	59.826	37.791	23.656	2129.0	56.336	35.265
1977	1.1645	.96887	177.00	152.00	126.46	21.706	18.453	1506.0	69.382	58.985
TOTAL	12.696	3.3822	1430.0	112.63	30.006	217.60	52.865	11110.	51.056	12.404

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Use by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Trailer Use									
	BOBTAIL					TRAILER				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	.18232	.36288	150.00	822.71	1637.4	86.502	52.114	4632.0	53.548	32.261
1975 Pre	.60758 -1	.12092	-0.	-0.	-0.	28.826	17.366	-0.	-0.	-0.
1975 Post	.54159 -1	.10779	-0.	-0.	-0.	25.695	15.490	-0.	-0.	-0.
1975 Total	.11492	.22871	109.00	948.50	1887.7	54.521	32.846	2594.0	47.394	28.552
1976	.79484 -1	.16472	77.000	968.75	2007.6	37.710	23.656	2051.0	54.389	34.119
1977	.45653 -1	.12949	50.000	1095.2	3082.6	21.659	18.453	1456.0	67.222	57.271
TOTAL	.33448	.26594	386.00	1154.0	917.53	217.26	52.865	10723.	49.355	12.009

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Number of Trailers by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Number of Trailers									
	SINGLE					DOUBLE				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	84.532	51.977	4394.0	51.980	31.962	1.9695	.87803	247.00	125.41	55.911
1975 Pre	28.170	17.320	-0.	-0.	-0.	.65632	.29259	-0.	-0.	-0.
1975 Post	25.110	15.439	-0.	-0.	-0.	.58503	.26081	-0.	-0.	-0.
1975 Total	53.280	32.760	2434.0	45.683	28.089	1.2414	.55340	172.00	138.56	61.769
1976	36.852	23.594	1961.0	53.214	34.069	.85859	.39856	94.000	109.48	50.821
1977	21.166	18.405	1395.0	65.907	57.308	.49315	.31090	82.000	166.28	104.93
TOTAL	212.55	52.785	10184.	47.913	11.899	4.7112	.95998	595.00	126.30	25.735

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors, Authorized Carriers Only
Trailer Brake Type by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	Trailer Brake Type									
	PRE-STANDARD					POST-STANDARD				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	63.394	40.536	4072.9	64.248	41.081	23.146	11.625	766.87	33.131	16.640
1975 Pre	21.126	13.508	-0.	-0.	-0.	7.7134	3.8739	-0.	-0.	-0.
1975 Post	18.831	12.041	-0.	-0.	-0.	6.8756	3.4531	-0.	-0.	-0.
1975 Total	39.957	25.548	2062.9	51.628	33.011	14.589	7.3270	707.51	48.496	24.356
1976	27.637	18.400	1412.7	51.119	34.034	10.091	5.2770	746.72	74.001	38.699
1977	15.873	14.353	963.69	60.711	54.897	5.7957	4.1164	580.94	100.24	71.192
TOTAL	162.30	41.447	8512.3	52.448	13.394	55.088	11.549	2802.0	50.865	10.664

Survey Data on Daily Miles Averaged Across Model Year

Injury Involvement Rates for Intercity Tractors (Fatals Excluded)
Carrier Type by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	CARRIER TYPE									
	AUTHORIZED					NON-AUTHORIZED				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	86.736	52.114	4366.0	50.337	30.244	56.618	24.082	895.00	15.808	6.7236
1975 Pre	28.904	17.366	-0.	-0.	-0.	18.868	8.0248	-0.	-0.	-0.
1975 Post	25.765	15.480	-0.	-0.	-0.	16.818	7.1531	-0.	-0.	-0.
1975 Total	54.669	32.846	2410.0	44.084	26.486	35.686	15.178	610.00	17.094	7.2702
1976	37.812	23.656	1882.0	49.772	31.138	24.682	10.931	506.00	20.500	9.0792
1977	21.718	18.453	1338.0	61.609	52.346	14.177	8.5271	295.00	20.809	12.516
TOTAL	217.71	52.865	9996.0	45.914	11.149	128.04	30.603	2306.0	18.011	4.3049

Survey Data on Daily Miles Averaged Across Model Year

Fatal Involvement Rates (BMCS-Reported Accidents) for Intercity Tractors
Carrier Type by Model Year
(Aggregate of Calendar Years 1976-1977)

Model Year	CARRIER TYPE									
	AUTHORIZED					NON-AUTHORIZED				
	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.	Veh. Miles	V.M. C.I.	No. Acc.	Acc. Rate	Acc. Rate C.I.
1974	86.736	52.114	453.00	5.2228	3.1380	56.618	24.082	157.00	2.7730	1.1794
1975 Pre	28.904	17.366	-0.	-0.	-0.	18.868	8.0248	-0.	-0.	-0.
1975 Post	25.765	15.480	-0.	-0.	-0.	16.818	7.1531	-0.	-0.	-0.
1975 Total	54.669	32.846	267.00	4.8839	2.9343	35.686	15.178	120.00	3.3627	1.4302
1976	37.812	23.656	244.00	6.4530	4.0370	24.682	10.931	110.00	4.4566	1.9737
1977	21.718	18.453	176.00	8.1039	6.8956	14.177	8.5271	69.000	4.8671	2.9275
TOTAL	217.71	52.865	1140.0	5.2363	1.2715	128.04	30.603	456.00	3.5615	.35128

APPENDIX F

SAMPLING ERRORS

Sampling errors were computed using the PSALMS command in the OSIRIS IV[24] programs. As described in Section 2, a multi-stage, stratified, clustered, controlled probability design was employed for the Fleet Monitoring Program vehicle sample. The three sampling stages were: the selection of Primary Sampling Units (PSU's), counties or groups of counties; selection of fleets within the selected PSU's; and selection of vehicles within the selected fleets. Stratification variables were introduced for PSU geographic size, geographic regions, PSU urbanicity, fleet size, and fleets with both pre- and post-standard vehicles. Even numbers of PSU's were selected in each region and paired for calculation of sampling errors. Variables in the data file associate each vehicle with one of 36 PSU's and one of 18 pairs. Also included for each vehicle is the strata number and the inverse of the selection probability, or sample weight.

PSALMS computes estimates and sampling errors for ratio means and totals for stratified clustered sample designs. The paired selection model was used in this case. Further documentation for PSALMS will be available in the future.[25] PSALMS formulae have previously been documented by Kish.[26] In addition, various programs for computing sampling errors were recently evaluated by Francis and Sedransky.[27] This evaluation provides independent confirmation of the accuracy of the PSALMS algorithm.

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[24]OSIRIS IV User's Manual, 6th ed. (Ann Arbor: The University of Michigan, Institute for Social Research, 1980), pp. 125-132.

[25]"PSALMS Sampling Error Monograph," The University of Michigan, Institute for Social Research, Ann Arbor (to be released).

[26]Leslie Kish, "Multipurpose Programs for Sampling Errors," Proceeding of the International Institute (Washington, D.C., August, 1971).

[27]Ivor Francis and J. Sedransky, "Comparing Software for Processing and Analyzing Survey Data," Bulletin of the International Statistical Institute, 48, 1979.