Report No. UM-HSRI-81-03

THE EFFECT OF CAB STYLE
ON THE ACCIDENT EXPERIENCE OF HEAVY TRUCKS

by

Michael Kubacki
and
James O'Day

February 1981

Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48109

The research reported herein was conducted under the general funds contributed by the Motor Vehicle Manufacturers Association. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the MVMA.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UM-HSRI-81-03		

4. Title and Subtitle	5. Report Date
The Effect of Cab Style on the Accident Experience of Heavy Trucks	February 1981
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Michael Kubacki and James O'Day	UM-HSRI-81-03
9. Performing Organization Name and Address	10. Work Unit No.
Highway Safety Research Institute The University of Michigan Ann Arbor, Michigan 48109	11. Contract or Grant No. #1.48
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Motor Vehicle Manufacturers Association 320 New Center Building Detroit, Michigan 48202	Final
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Trucks and tractors of two cab styles--Conventional (with the engine forward of the driver compartment) and Cabover (with the engine below the driver compartment) are compared with respect to operational characteristics and occupant injury experience. Accident data from city, state, and federal sources are analyzed; the latter are compared with national exposure information to determine accident, injury, and fatality rates (per mile traveled).

There are major differences in usage, including trip length, cargo type, cargo weight, etc. between the two different cab styles. In this study an attempt was made to measure the injury rates after controlling for such usage variations.

It is concluded that injury and fatality rates derived from the Bureau of Motor Carrier Safety statistics are not different for the two cab styles, but that fatality rates derived from a combination of the Fatal Accident Reporting System and the Truck Inventory and Use Survey show the occupants of Cabovers to be at a somewhat greater risk.

17. Key Words	18. Distribution Statement
Trucks, Accidents, Fatal accident rates, Truck Cab Style	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	70	

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Section 1: BACKGROUND

1.1 The Rise of Cabovers

On June 29, 1956, President Eisenhower signed the Federal-aid Highway Act, and construction of the interstate highway system began soon after. The importance of these highways in the history of transportation and communications in America has been enormous, and in the early and mid-sixties truck size and weight became a major concern of state legislatures. This concern was augmented by the federal government, which limited federal aid for the interstate system to those states that observed federal guidelines on vehicle size and weight[1]. Between 1964 and 1967, every state except Arizona and Florida passed legislation on the limits of truck dimensions[2]. Most of their attention focused on length, and length laws today are not very much different from what they were at the close of 1967.

Length laws for articulated vehicles generally specify the total length that the combination may attain. Only fourteen states have any requirement at all on the maximum length of trailers, and four of these regulate only full trailers (not semis)[3]. The result has been to encourage designs which trade tractor length for trailer length and thus can carry more cargo. This is the cabover, a boxlike tractor in which the driver compartment is directly over the engine. The economics of

---

[1]This was the Federal-Aid Highway Act of 1956. It did contain a grandfather clause permitting the states to retain truck size and weight laws that had been in effect before July 1, 1956.

[2]Winfrey, R. et al., Economics of the Maximum Limits of Motor Vehicle Dimensions and Weights, Report No. FHWA-RD-73-67, U.S. DOT, September 1968, (pp. 3-3 to 3-10).

[3]The source for this and other information on current length laws is a table found in Fleet Owner, November 1978, vol. 73, no. 11, (pp. 22-4).

the trucking industry, especially with the long hauls facilitated by the interstate system, require a maximization of cargo space. The Truck Trailer Manufacturers Association of Washington D.C. reports that in 1956, 93.3% of all trailers built were under 36 feet in length, and that by 1976, a majority were over 42 feet, six inches.

A cabover tractor also offers the capability of pulling two 27-foot trailers within an overall limit of 65 feet, and it is this capability that has led to the popularity of cabovers in those states permitting doubles. Some states that allow 65-foot doubles restrict them to designated highways, but there are seventeen states that do not permit them at all; all of these are east of the Mississippi River. The cabover is found everywhere, but the proportion of them is especially large in California, the Dakotas, Nebraska, Kansas, and North Carolina.

Figure 1 shows the distribution of a random sample of two thousand air-braked (hence large) trucks sold in 1977, by cab style. This map was derived from addresses on the sales lists of the eight major truck manufacturers. Note that trucks may be sold in one state and used in another. Also, in terms of the total number of trucks sold, neither New England nor the area west of the Rockies are major truck markets. Most trucks are sold to addresses in the South and Midwest.

A different representation of the distribution of trucks by cab style may be found in Figure 2. This map shows which cab style predominates in accidents in each state. The information comes from the 1976 BMCS accident file and reflects use rather than registration, so that interpretation of the effect of a truck being sold in one state and used in another is eased. The "Even" category in this map shows states

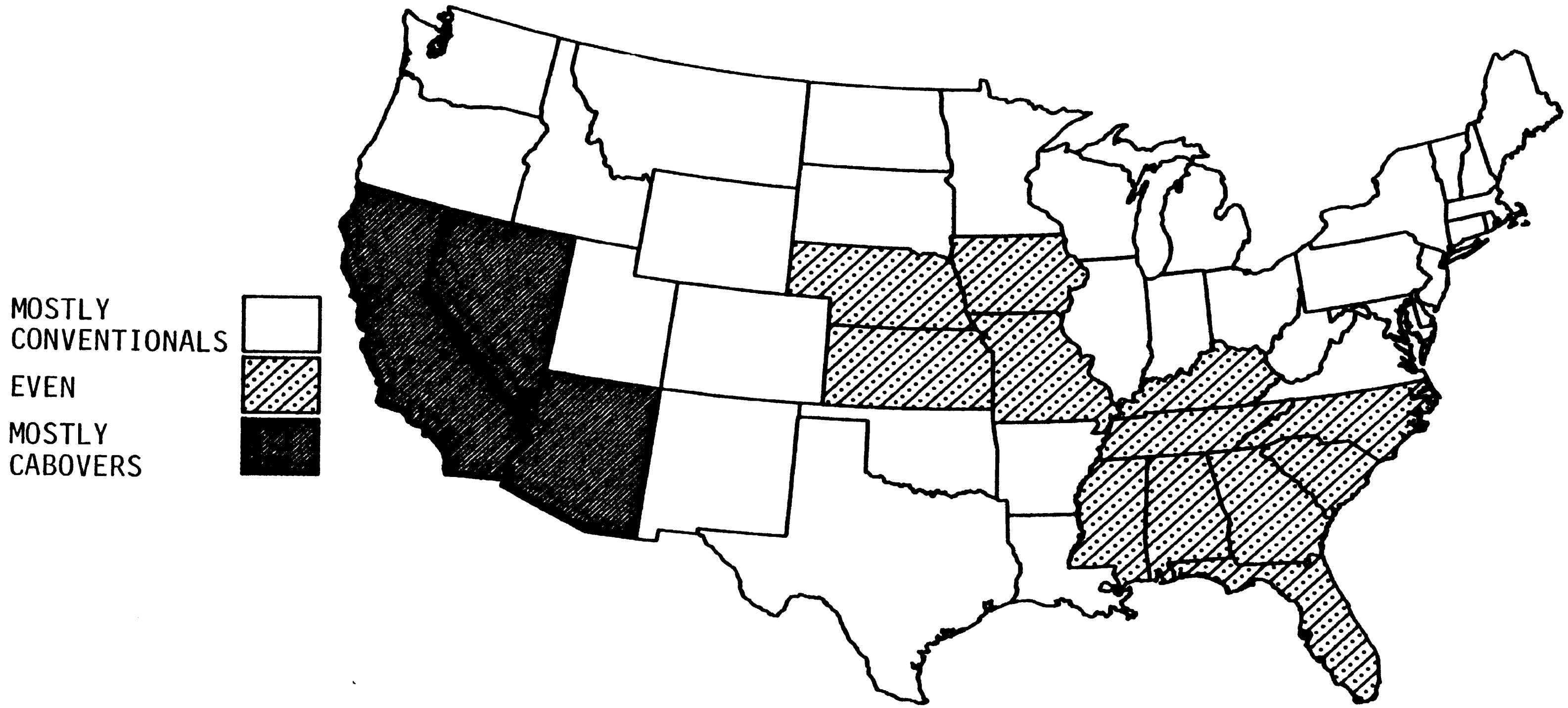

FIGURE 1
Distribution of Cab Style by State - Air-braked Trucks
Delivered by Eight U.S. Manufacturers in 1977

in which each cab style registers between 45% and 55% of the BMCS-reported accidents.

The graphic representation in Figure 3 is based on data from the 1977 Truck Inventory and Use Survey (TIU). The proportion of cabover to conventional tractors is shown for each state by the intensity of the shading, with the darkest states having a higher proportion of their <u>registered</u> tractors as cabovers.

Another aspect of length laws warrants mention, and this is their variability from state to state. The maximum width and height, for example, are almost universally 96 inches and 13 feet, six inches, respectively. There is, however, a considerable lack of uniformity in length laws. To give just one example, double trailers permitted in Ohio must be separated at the Pennsylvania border and pulled separately for fifty miles to the New York Thruway at Ripley, New York, where they may again be joined. The yearly cost of this in fuel alone has been estimated in millions of dollars.

For purposes of this study tractors have been arbitrarily divided into just two categories: cabovers and conventionals. While there exists a variety of conventional profiles ranging from a short-nosed to a very long-nosed tractor, these have all been considered together here.

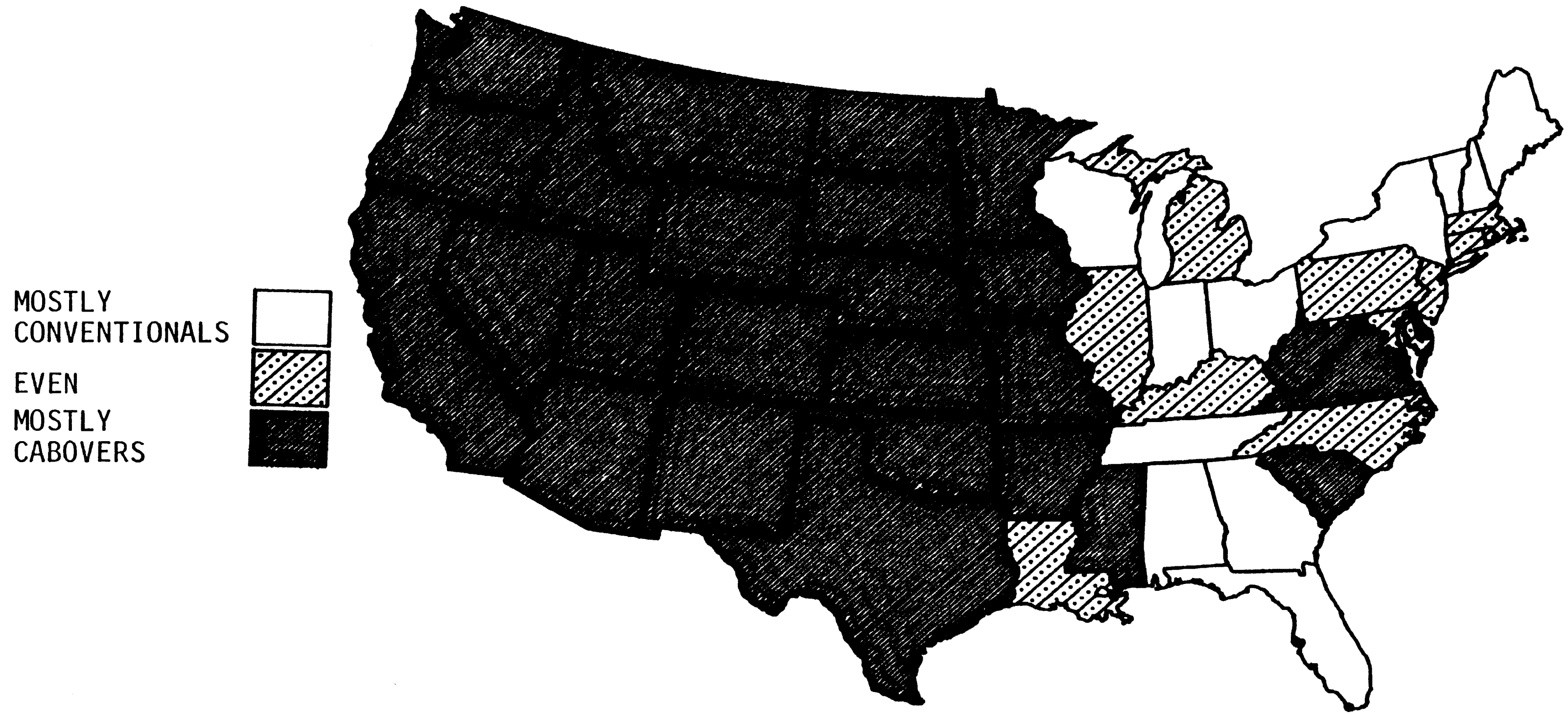

FIGURE 2
Distribution of Cab Style by State - Trucks Involved in BMCS-reported Crashes - 1976

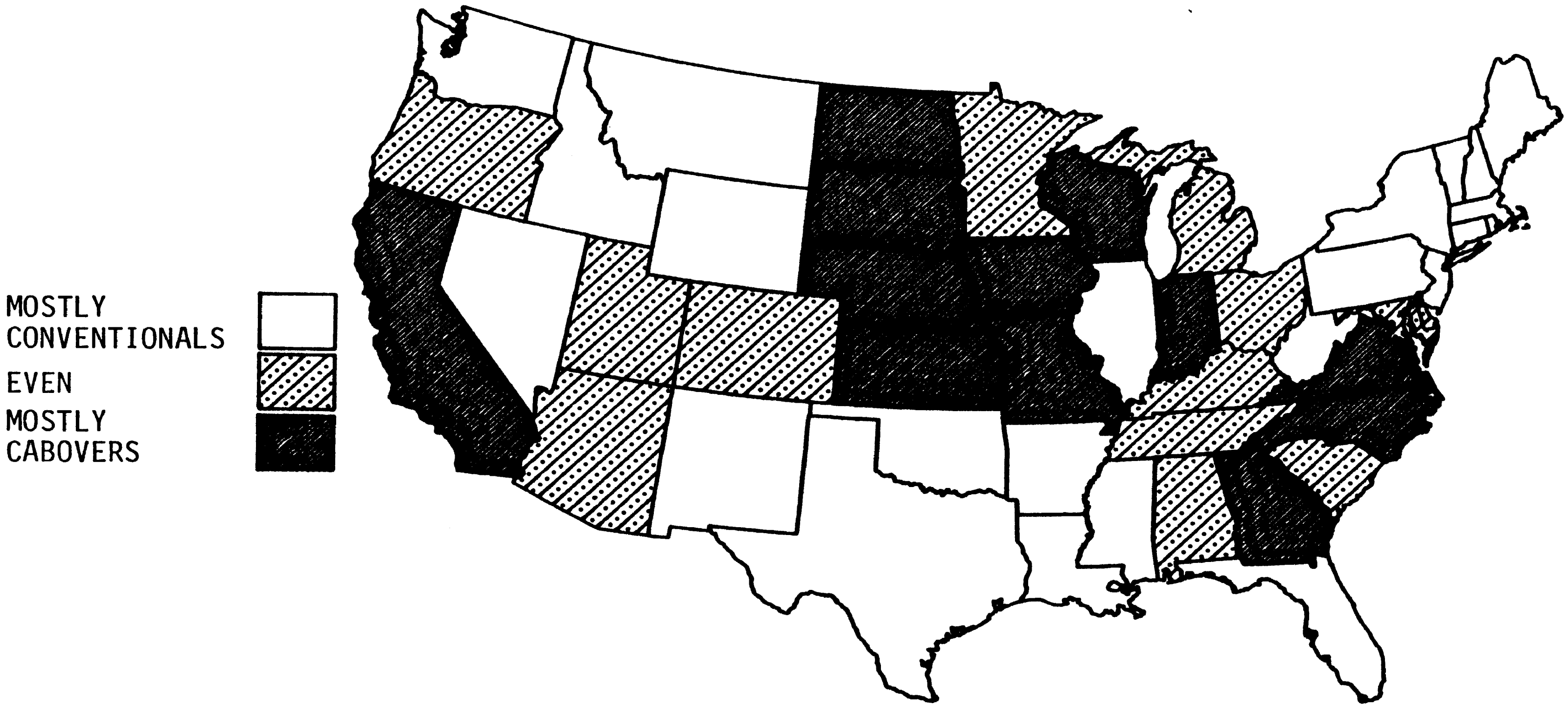

FIGURE 3
Distribution of Cab Style by State - 1977 Registrations in the Truck Inventory and Use (TIU) Survey

1.2 Concerns Over Cab Style

The cabover design, in addition to allowing a longer trailer to be used, has other potentially useful characteristics. The shorter wheelbase produces a vehicle which can manuever in tighter spaces. This characteristic is valuable for some urban delivery applications such as retail foods. Often the access to loading docks in urban areas is limited. Extended cargo space, or course, permits the same amount of freight to be carried in a smaller number of trips when weight is not the limiting factor.

With the rise of cabovers, however, has come a variety of concerns. Truckers have complained that the driver compartments of some cabovers are poorly designed and have the seat-back too close to the steering wheel. This could conceivably lead to fatigue and eventually to a lack of alertness for the driving task. Fatigue can also be caused by noise, vibration, and high air temperatures in the driver compartment. Miller and Anderson[4] point out that if foot pedals and other controls are not easily accessible, the performance of even an alert driver can be affected when split-second responses are necessary. Survival space is another important concept relating to the minimum size compartment that should still exist after the deformation caused by an impact. A small compartment will not allow much deformation without harming the occupant.

---

[4]Miller J. and Anderson, C., "Human Factors Considerations Regarding the Advanced Notice of Proposed Rulemaking 'Minimum Cab Space Dimensions'", Submission to BMCS Docket No. MC79: Notice No. V77-10, Federal Register 43 (31), (pp. 6274-5).

1.3 Other Studies

In 1976, Fee and Schwendeman[5] produced a document for in-house review at the Federal Highway Administration, summarizing what was known about cab style in terms of handling characteristics, sight distance, fumes and noise, space restriction, and bridge fatigue. In addition, the authors used available accident data to compute accident rates for cabovers and conventionals.

The two principal conclusions of this study were:

1) "...there are some indications that in the COE design the commercial vehicle operator is more likely to be killed than the passenger car operator. The reverse appears to be true for the CBE design, where the positioning of the engine poses a serious threat to the passenger car occupant." (p.4)

2) "Because of the relatively low exposure and high percentage of accident involvement, the accident rates for COE's is almost 4 times that for CBE's. Although the actual differences in rates might be somewhat smaller, it is doubtful that the rates are equal." (p.4)

The study was intended as an overview of the problem and, as such, was cursory and limited in scope. One of the main reasons it was undertaken was to block out areas for further research, and any conclusions should be regarded as quite tenuous.

There are problems in the analysis, most of which the authors frankly acknowledge. Exposure information was derived from the 1972 Census of Transportation[6] while accident data came from a sample of about five hundred 1975 BMCS-reported accidents. The data bases did not fit at all well for computing accident rates. Using 1972 exposure with

---

[5]Fee, J. and Schwendeman, M., "Preliminary Analysis of the Cab-Over-Engine vs. The Cab-Behind-Engine Designs", Federal Highway Administration, unpublished, February 10, 1976.

[6]U.S. Bureau of the Census, Census of Transportation, 1972 Truck Inventory and Use Survey.

1975 accidents fails to account for new cabovers put into service during that three-year period. In addition, the BMCS data concerns itself with the interstate operations of authorized carriers[7], and as a result contains a much greater proportion of cabovers than does the U.S. truck population as a whole. Both of these problems would lead to an overrepresentation of cabovers in the 1975 BMCS data as compared to the 1972 Census of Transportation data, and hence, to an overestimation of cabover accident rates.

Another problem concerns the accident data itself. Since the basic BMCS accident report form[8] does not ask about cab style, Fee and Schwendeman analyzed only accidents for which a supplementary form had been filled out. This form, which included a question about cab style, was sent only to those who answer "yes" to the BMCS question, "Were mechanical defects or failures apparent on your vehicle at time of accident?" It is difficult to determine exactly how this subset would differ from the universe of truck accidents, but one should not assume that it doesn't.

A more recent study[9] examined some 3000 California Highway Patrol accident reports from the Los Angeles and Sacramento areas. Though there was no measure of the exposure of cabovers and conventionals, an

---

[7]Although the BMCS receives some accident reports from private carriers, these constitute only about 20% of the total BMCS accident file. By contrast, private carriers in the Truck Inventory and Use Survey (TIU) account for about 50% of the vehicle miles traveled.

[8]A copy of the MCS-50-T form may be found in Appendix B.

[9]Philipson, L., Rashti, P., and Fleisher, G., Statistical Analysis of Commercial Vehicle Accident Factors, Traffic Safety Center, University of Southern California, February 1978.

appraisal was made of the relative injury severity (given that an accident has occurred) of the two cab styles. The authors conclude:

1) "The ratio of the frequency of major (i.e. - up to fatal) injury accidents to the frequency of no-injury accidents appears to be significantly larger for the cabover configuration than for the cab-behind configuration: (22) / 1247 = .018, compared to (13) / 1366 = .010." (p. 3-24)

This report concludes that, given a crash, a cabover is more dangerous to its driver than is a conventional. The differences in their sample of only thirty-five severe accidents may be large, but they are not statistically significant.

1.4 Purposes of the Study

The present study is an examination of the issues relating to cab style and an attempt to describe statistically the relationship of cab style to the accident and injury experience of heavy trucks.

The statistics that follow were derived from available accident data files compiled by Washington State, Denver County, the Bureau of Motor Carrier Safety, and the NHTSA's Fatal Accident Reporting System; and from exposure information taken from the 1977 Truck Inventory and Use Survey. In none of the accident files is the cab style of trucks explicitly identified.

The Washington (state) and Denver (county) files have been used for two reasons. They represent total sets of police-reported crashes within the respective jurisdictions, thus covering a range of crash severities, and both of them had sufficient reporting of Vehicle Identification Numbers (VIN) to permit unique identification of truck cab style in a substantial proportion of the truck crash involvements. While neither of these data sets could be considered representative of the nation, they do provide a first look at both rural and urban minor-to-severe truck crashes with cab style identified.

In analyzing the Bureau of Motor Carrier Safety data, on the other hand, it was necessary to insert cab style designation into the data manually, based on alphanumeric make and model information in the computerized file. Cab styles in the Fatal Accident Reporting System data were obtained in interviews with truck owners and drivers in connection with another study at HSRI, and have become a part of the computer record for several years of FARS data stored at HSRI.

The FARS data are of particular interest and value because they constitute a census of the nation's fatal crashes (although it has not been possible to identify cab style in every case). Using the FARS data in conjunction with exposure information from the TIU provides an estimate of involvement rate by cab style.

The BMCS data are of value because of the relatively rich detail relating to accident, vehicle, and driver factors. These help to explain differences in the use or exposure of trucks by cab style. On the other hand, the BMCS data are of limited value in injury comparisons because the majority of cases in that file involve injury. The test of whether an occupant of one style cab or another was more often injured in a set of accidents limited to "Injury or $2000 damage" is not easily interpreted.

Section 2: RESULTS

2.1 State Accident Files

Several available state accident files contain VIN's for crash-involved vehicles, and in the case of trucks, these VIN's frequently carry information on cab style. (See Appendix A for a listing of truck VIN's and their meanings.) No directly comparable exposure information[10] is available for these states, so accident rates cannot be computed. However, it is possible to get comparative information on the severity of accidents involving cabovers and conventionals by looking at the ratio of fatal or serious accidents to all accidents.

The required VIN translation was performed for Denver County (1970-1976) and Washington State (1975-1977), and the results are presented in Tables 1-3.

TABLE 1
Truck Driver Injury by Cab Style (Denver 1970-76)

	Conventional	Cabover
Fatal or Serious Injury	21 (0.48%)	11 (0.76%)
Minor Injury or Pain	85 (1.96%)	19 (1.3%)
No Injury	4228 (97.6%)	1436 (98.0%)
Total	4334 (100%)	1466 (100%)

$X^2 = 4.124$ d.f. = 2 sig. level 0.1272

[10] TIU exposure information is available by state, but reports have been made only with regard to vehicles registered in that state. Because of interstate movement it is judged to be an inadequate representation of truck travel in tne individual states for purposes of this study.

The Denver data displayed in Table 1 have been grouped into three injury categories: Fatal or Serious (the police-reported "K" or "A"), Minor (police-reported "B" or "C"), and "no injury." For this primarily urban data several observations can be made. Conventional tractors constitute nearly 75% of the total number of combination vehicles in (these urban) reported accidents. Serious injuries to truck drivers in urban accidents are relatively rare. If this data set could be considered a sample of a larger population, the frequencies shown in the table do not indicate a significant difference in the injury rate (i.e., driver injuries per reported crash) for drivers of the two different cab styles.

Table 2 presents a similar arrangement of data for the driver of the vehicle struck by (or striking) a cabover or conventional truck in a Denver multi-vehicle accident. It is clear that the average injury severity to the occupant of the "other" vehicle is greater than that of the truck occupant, but again there is no statistically significant difference between the injury distributions associated with the two cab styles. The difference in total frequencies reported in Tables 1 and 2 are mainly accounted for by the single-vehicle truck accidents included in Table 1.

Table 3 is comparable to Table 1, but contains data from three years of Washington (state) accidents. This statewide data contains a mix of urban and rural crashes, and shows much more equal numbers of conventional and cabover trucks in accidents. The slightly higher injury rate for drivers of cabovers is significant at the .07 level, and suggests that a further inquiry would be in order. A possible interacting factor is the kind of trip engaged in by each of the two

TABLE 2
Other Driver Injury by Cab Style (Denver 1970-76)

	Conventional	Cabover
Fatal or Serious Injury	72 (1.86%)	29 (2.28%)
Minor Injury or Pain	252 (6.53%)	90 (7.08%)
No Injury	3538 (91.61%)	1150 (90.48%)
Total	3862 (100%)	1271 (100%)

$X^2 = 1.423$ d.f. = 2   sig. level 0.4910

TABLE 3
Truck Driver Injury by Cab Style (Washington 1975-77)

	Conventional	Cabover
Fatal or Disabling Injury	47 (1.73%)	51 (2.25%)
Minor or Possible Injury	279 (10.25%)	269 (11.88%)
No Injury	2395 (88.02%)	1945 (85.87%)
Total	2721 (100%)	2265 (100%)

$X^2 = 5.345$ d.f. = 2   sig. level 0.0691

truck types--cabovers being more likely to operate on high speed roads. Whether the increased injury rate is attributable to the vehicle characteristic or to the operating environment will be considered in the analysis of the BMCS data.

While the Denver and Washington data cannot be considered representative of a national population, the small differences observed here suggest that one should not expect to find large differences in occupant injury distributions between the two types of cabs compared. These two files contain a total of nearly 11,000 combination vehicle accidents, all serious enough to have been reported by a police agency. The implication of this finding is that it may be necessary to look at a very large number of crashes to find a statistically significant difference in injuries to the truck drivers. The apparent differences in injury rate are small, but in addition the probability of injury to the truck occupants is much smaller than for passenger car occupants. Further, with low injury rates and small differences it will be important to account for variations in the environment or operations which may affect driver injury and may interact with cab style. These matters were considered in the analysis of the BMCS data.

2.2 Bureau of Motor Carrier Safety Data

The Bureau of Motor Carrier Safety (BMCS) collects and compiles accident information submitted by owners of vehicles engaged in interstate commerce. Regulations require that a "Motor Carrier Accident Report" be completed for each accident which results in an injury to a human being or $2,000 worth of property damage. Approximately 26,000 such reports are submitted to the BMCS each year.

The accident information is supplied by literally thousands of different people each year, with some variation in understanding of the entries on the form. This data collection effort is not rigidly enforced, and it is reasonable to assume that some qualifying accidents are not reported; the extent of this is not well known. Authorized carriers, especially the larger ones, are probably good reporters. Small fleets, private carriers and exempt carriers, may be not so good. Record keeping of all kinds in the trucking industry runs the gamut from excellent to almost non-existent, and accident record keeping is no exception.

In past years the information provided on the MCS-50-T form has been computerized with minimal editing, and this leads to some difficulty in analyzing the data. The BMCS does not routinely record VIN's, so, as an alternative, cab style was deciphered from "Make" and "Model No." categories. Since the responses are not edited or standardized, an International Transtar II may be reported an an "Int CO-7 Trans II" or an "Inter 4070B." The "Model No." is especially confusing, since the responses include model names, model numbers, and occasional VIN's. Translating these responses into cab styles was done manually. Approximately 58.4% of the accident vehicles were identified as to cab style in this manner.

In this study, BMCS data for the 1976 and 1977 accident years were used. The subset used for analysis contains 15,760 accidents for the two year period, with 4004 conventionals (25.4%), 5204 cabovers (33.0%), and 6552 unknown cab styles (41.6%). The data have been analyzed first to ascertain differences between cabover and conventional styles in operation (as reflected by their accident experience), and then with respect to injuries and fatalities by cab style. Tables 4 through 17 show a number of accident characteristics from the BMCS file by the cabover/conventional mix.

Conventional cabs dominate the lower weight classes of trucks, the type normally used in metropolitan areas and for short hauls. Among larger over-the-road vehicles there is a predominance of cabovers. The subset analyzed here is restricted to vehicles operated by authorized carriers, thus minimizing the differences between cabovers and conventionals that may be related to vehicle weight.

2.2.1 Environmental Differences

Tables 4 and 5, for example, show that cabovers tend to be found (or at least to have accidents) more frequently on divided highways with four or more lanes. The differences shown are not large, but they show rather clearly that cabover tractors are used more for long hauls than are conventionals. These differences are statistically significant at a very high level.

Identification of environmental factors (weather, light, time of day, etc.), which are associated with with one style of cab more than the other are shown in Tables 6 through 10. Except for the "light

TABLE 4
Highway Type by Cab Style (1976-77 BMCS Data)*

	Conventional	Cabover	Total
Divided	2200 (41.4%)	3118 (58.6%)	5318 (100%)
Undivided	1721 (46.5%)	1979 (53.5%)	3700 (100%)
Total	3921 (43.5%)	5097 (56.5%)	9018 (100%)

X^2 = 23.29 d.f. = 1 sig. level 0.0000**

* Except where noted the tables in this section show row percentages, allowing a direct comparison of the cab type distribution within the variable considered. For example, in this table cabovers represent 58.6% of the trucks (in accidents) on Divided Highways and only 53.5% of those on Undivided Highways.

** The significance level indicates the probability that the distributions for the two cab types were drawn from the same population. The notation 0.0000 indicates a probability of less than 1 in 10,000.

TABLE 5
Number of Lanes by Cab Style (1976-77 BMCS Data)

Number of Lanes	Conventional	Cabover	Total
One	144 (47.7%)	158 (52.3%)	302 (100%)
Two	1455 (46.1%)	1698 (53.9%)	3153 (100%)
Three	155 (53.3%)	136 (46.7%)	291 (100%)
Four or more	2179 (41.1%)	3118 (58.9%)	5297 (100%)
Total	3933 (43.5%)	5110 (56.5%)	9043 (100%)

X^2 = 34.464 d.f. = 3 sig. level 0.0000 condition" comparison (Table 7) cabovers and conventionals are observed to operate under markedly different environmental conditions. Cabovers predominate on icy roads (Table 6), in snow and sleet (Table 8), from 8:00 p.m. to midnight (Table 9), and on Sundays (Table 10).

TABLE 6
Road Surface by Cab Style (1976-77 BMCS Data)

Road Surfaces	Conventional	Cabover	Total
Dry	2571 (43.4%)	3354 (56.6%)	5925 (100%)
Wet	828 (46.6%)	947 (53.4%)	1775 (100%)
Snow	188 (46.3%)	218 (53.7%)	406 (100%)
Ice	286 (35.0%)	532 (65.0%)	1224 (100%)
Other	16 (33.3%)	32 (66.7%)	48 (100%)
Total	3889 (43.3%)	5083 (56.7%)	8972 (100%)

$X^2 = 34.7$ d.f. = 4 Sig. level = 0.0000

2.2.2 Injury and Fatality Differences

Aggregate data for injury severity for both truck drivers and the "other" vehicle drivers are found in Tables 11-14. Looking first at fatalities (in Tables 11 and 12), a higher proportion of deaths is associated with the cabovers, both for the truckers and the other vehicle drivers. These fatalities are not sufficiently numerous, even with two years of BMCS data, to render these figures statistically significant at the 5% level. The results suggest that a fatal truck accident, especially one that kills a driver encased in a massive truck,

TABLE 7
Light Condition by Cab Style (1976-77 BMCS Data)

Light	Conventional	Cabover	Total
Day	2053 (44.7%)	2544 (55.3%)	4597 (100%)
Artificial Light	108 (39.7%)	164 (60.3%)	272 (100%)
Dawn	190 (40.8%)	276 (59.2%)	466 (100%)
Dusk	141 (40.2%)	209 (59.8%)	350 (100%)
Dark	1492 (43.0%)	1976 (57.0%)	3468 (100%)
Total	3984 (43.5%)	5169 (56.5%)	9153 (100%)

$X^2 = 7.309$ d.f. = 4 Sig. level = 0.1204

TABLE 8
Weather Condition by Cab Style (1976-77 BMCS Data)

Weather	Conventional	Cabover	Total
Rain	698 (48.1%)	754 (51.9%)	1452 (100%)
Clear	2397 (42.8%)	3210 (57.2%)	5607 (100%)
Snow	398 (41.9%)	551 (58.1%)	949 (100%)
Fog/Smog	107 (49.3%)	110 (50.7%)	217 (100%)
Cloudy	279 (42.1%)	383 (57.9%)	662 (100%)
Sleet	20 (30.3%)	46 (69.7%)	66 (100%)
Total	3899 (43.5%)	5054 (56.5%)	8953 (100%)

$X^2 = 22.707$ d.f. = 5 Sig. level = .0004

TABLE 9
Hour of Day by Cab Style (1976-77 BMCS Data)

Time of Day	Conventional	Cabover	Total
Midnight - 4:00AM	654 (43.5%)	850 (56.5%)	1504 (100%)
4:00AM - 8:00AM	719 (43.7%)	928 (56.3%)	1647 (100%)
8:00AM - Noon	750 (43.8%)	961 (56.2%)	1711 (100%)
Noon - 4:00PM	759 (45.1%)	924 (54.9%)	1683 (100%)
4:00PM - 8:00PM	623 (44.2%)	786 (55.8%)	1409 (100%)
8:00PM - Midnight	499 (39.7%)	757 (60.3%)	1256 (100%)
Total	4004 (43.5%)	5206 (56.5%)	9210 (100%)

X^2 d.f = 5 Sig. level = .0924

TABLE 10
Day of Week by Cab Style (1976-77 BMCS Data)

	Conventional	Cabover	Total
Monday	574 (43.8%)	738 (56.2%)	1312 (100%)
Tuesday	634 (43.7%)	817 (56.3%)	1451 (100%)
Wednesday	661 (44.5%)	823 (55.5%)	1484 (100%)
Thursday	651 (42.9%)	867 (57.1%)	1518 (100%)
Friday	680 (45.1%)	828 (54.9%)	1508 (100%)
Saturday	505 (44.8%)	622 (55.2%)	1127 (100%)
Sunday	299 (36.9%)	511 (63.1%)	810 (100%)
Total	4004 (43.5%)	5206 (56.5%)	9210 (100%)

X^2 d.f. = 6 Sig level = .0046

involves such catastrophic forces as to render differences due to cab style difficult to evaluate.

Tables 13 and 14 show that conventionals are more often associated with <u>injury</u> to "other" vehicle occupants than are cabovers, and conversely that cabover drivers are more likely to be injured than those in conventionals. For the injury comparisons the differences are statistically significant.

TABLE 11
Truck Driver Fatalities by Cab Style (1976-77 BMCS Data)

	Killed	Not Killed	Total
Conventional	59 (1.5%)	3946 (98.5%)	4005 (100%)
Cabover	104 (2.0%)	5101 (98.0%)	5205 (100%)

X^2 = 3.292 d.f. = 1 Sig. level = 0.0696

TABLE 12
Other Vehicle Fatalities by Cab Style (1976-77 BMCS Data)

	Killed	Not Killed	Total
Conventional	215 (5.4%)	3790 (94.6%)	4005 (100%)
Cabover	325 (6.2%)	4881 (93.8%)	5206 (100%)

X^2 = 2.980 d.f. = 1 Sig. level = 0.0843

TABLE 13
Truck Driver Injury by Cab Style (1976-77 BMCS Data)

	Injured	Not Injured	Total
Conventional	1108 (27.6%)	2896 (72.4%)	4004 (100%)
Cabover	1655 (31.8%)	3547 (68.2%)	5202 (100%)

X^2 = 18.286   d.f. = 1   Sig. level = 0.0000

TABLE 14
Other Vehicle Injury by Cab Style (1976-77 BMCS Data)

	Injured	Not Injured	Total
Conventional	1946 (48.6%)	2059 (51.4%)	4005 (100%)
Cabover	2180 (41.9%)	3026 (58.1%)	5206 (100%)

X^2 = 40.998   d.f. = 1   Sig. level = 0.0000

2.2.3 Vehicle/load Differences

It has been noted in section 2.1 that several environmental factors associate strongly with one or the other cab styles under discussion. For example, cabover designs predominate in these data on divided and four-lane (presumably higher speed) highways, and this may account for part or all of the injury differences observed. In this section differences in cargo by cab type are discussed.

Within the standard limits of width and height for tractor-trailer units, a trucking firm wishing to carry the maximum legal amount of cargo will find itself limited by either weight or length. Dense cargoes will reach the maximum allowable weight before vehicle length becomes a problem. With less dense cargoes, this situation is reversed.

In regulating the length of vehicles, states have chosen to set limits on the overall length of the combination rather than the length of the trailer. Since the early and mid 1960's, when the bulk of these laws were passed, the effect has been to encourage the use of cabovers, especially for haulers of low density cargoes. Tractor length is thus traded for trailer length, resulting in trailers three to ten feet longer and an increased payload.

The effects of this are seen in Tables 15 and 16. Table 15 shows the breakdown of BMCS cargo categories by cab style. The differences here are clear. Bulk cargoes and motor vehicles are carried far more often by conventionals than by cabovers. Other categories, such as household goods, heavy machinery, lumber, and food, are just as clearly cabover territory. Hazardous cargo, as seen in Table 16, is carried far more frequently by conventionals than by cabovers, probably because the majority of hazardous cargoes are liquids in bulk.

This variation in tractor use for the two cab styles prompted a further examination of accident experience by the differing cargo types. The density of cargo, after all, affects not only the length of the unit, but also its axle weights and center of gravity. In Tables 17 and 18 accidents divide the data into two cargo groups. The first of these includes bulk cargoes and motor vehicles; the second contains all other categories.

TABLE 15
Cargo Type by Cab Style (1976-77 BMCS Data)*

Cargo Type	Conventional	Cabover	Total
General Freight	1595 (43.6%)	2066 (56.4%)	3661 (100%)
Household Goods	43 (19.1%)	182 (80.9%)	225 (100%)
Metal: Coils,etc.	147 (38.9%)	231 (61.1%)	378 (100%)
Heavy Machinery	55 (31.1%)	122 (68.9%)	177 (100%)
Motor Vehicles	142 (88.8%)	18 (11.2%)	160 (100%)
Gases in Bulk	27 (69.2%)	12 (30.8%)	39 (100%)
Solids in Bulk	138 (76.2%)	43 (23.8%)	181 (100%)
Liquids in Bulk	279 (64.4%)	154 (35.6%)	433 (100%)
Logs Lumber	31 (28.7%)	77 (71.3%)	108 (100%)
Food (Refer)	231 (29.7%)	547 (70.3%)	778 (100%)
Farm Products	57 (39.6%)	87 (60.4%)	144 (100%)
Other	525 (38.4%)	841 (61.6%)	1366 (100%)
Empty	711 (46.8%)	809 (53.2%)	1520 (100%)
Total	3981 (43.4%)	5189 (56.6%)	9170 (100%)

* The distributions of cargo type by truck style may also be reviewed in the Truck Inventory and Use (TIU) survey. There are substantial differences in the two, probably because the TIU covers the truck population more completely. See the HSRI TIU Factbook to be published in July, 1981.

If the cargoes were responsible for differences in the injury distributions between the cab styles, those distributions within a particular cargo group should be similar for both cab styles. Conventionals with bulk cargoes, for example, would have the same injury distribution as cabovers with bulk cargoes. This, however, is not the

TABLE 16
Hazardous Cargo by Cab Style (1976-77 BMCS Data)

Cargo	Conventional	Cabover	Total
Hazardous	305 (60.2%)	202 (39.8%)	507 (100%)
Not Hazardous	3697 (42.5%)	5003 (57.5%)	8700 (100%)
Total	4002 (43.5%)	5205 (56.5%)	9207 (100%)

$X^2 = 60.111$ d.f. = 1 Sig. level = 0.0000

TABLE 17
Injuries and Deaths by Cab Style for Bulk Cargoes
and Motor Vehicles (1976 BMCS Data)
(Column percentages shown)

	Conventional	Cabover	Total
Truck Driver Deaths and Injuries			
Killed or Injured	67 (30.2%)	33 (41.8%)	100 (33.2%)
Uninjured	155 (69.8%)	46 (58.2%)	201 (66.8%)
$X^2 = 3.026$ d.f. = 1 Sig. level = 0.0819			
Other Vehicle Deaths and Injuries			
Killed or Injured	120 (54.1%)	28 (35.4%)	148 (49.2%)
Uninjured	102 (45.9%)	51 (64.6%)	153 (50.8%)
X^2 d.f. = 1 Sig. level = 0.0067			
Totals			
Total Truck Involvement	222 (100%)	79 (100%)	301

TABLE 18
Deaths and Injuries by Cab Style for Cargoes
of Low Density (1976 BMCS Data)
Column percentages shown)

	Conventional	Cabover	Total
Truck Driver Deaths and Injuries			
Killed or Injured	397 (30.5%)	670 (35.3%)	1067 (33.4%)
Uninjured	903 (69.5%)	1226 (64.7%)	2129 (66.6%)
X^2 = 7.772 d.f. = 1 Sig. level = 0.0053			
Other Vehicle Deaths and Injuries			
Killed or Injured	699 (53.8%)	925 (48.8%)	1624 (50.8%)
Uninjured	601 (46.2%)	971 (51.2%)	1572 (49.2%)
X^2 = 7.462 d.f. = 1 Sig. level = 0.0056			
Totals			
Total Truck Involvement	1300 (100%)	1896 (100%)	3196

case. Cabovers are more often associated with injury to truck drivers, with injury or death in 42 percent of their crashes, than are conventionals with 30 percent. Conventionals, on the other hand, show a greater risk to occupants of the other vehicle, where the corresponding percentages are 54 and 35, the conventionals being the larger of the two. Chi-square analysis of these two tables indicates that the results are statistically significant. Thus, though the cargoes carried by cabovers and conventionals differ markedly, there is no indication that these differences are responsible for the observed variation in injury.

2.2.4 Geographic Differences

Table 19 describes the distribution of cab styles by DOT region. The conventional is more frequently an Eastern vehicle, while the cabover is more common in the West. This may well be the result of a more tolerant attitude toward double trailer units in Western legislatures. The length limit for these combinations is generally 65 feet, and a common configuration is a cabover tractor pulling two 27-foot trailers. In Eastern states, these are often prohibited or restricted.

The distribution of cab styles in the 1976 BMCS data was shown by state in Figure 2. As was the case for cargo types, this suggests that region of the country may affect accidents and injury severity. It is possible that the greater proportion of injuries in cabovers might result from the higher proportion of cabovers operating over longer trip distances in more rural areas at higher speeds (in a region where there are more cabovers present).

This is not supported by the data, however. Tables 20 and 21 show deaths and injuries in Eastern and Western regions, respectively, broken down by cab style. Cabovers continue to account for a higher percentage of truck driver injuries than do conventionals, regardless of the section of the country. Conventionals continue to associate with injury to drivers of other vehicles. These results are statistically significant, based on chi-square analysis for each of the four conditions shown in the tables, except for the other vehicle deaths and injuries in Western regions.

TABLE 19
Region of Accident by Cab Style (1976-77 BMCS Data)

BMCS Region	Conventional	Cabover	Total
Northeast	387 (55.3%)	313 (44.7%)	700 (100%)
Mid Atlantic	574 (45.9%)	677 (54.1%)	1251 (100%)
Southeast	638 (48.4%)	680 (51.6%)	1318 (100%)
North Central	1262 (48.7%)	1328 (51.3%)	2640 (100%)
Gulf	452 (40.2%)	672 (59.8%)	2590 (100%)
Midlands	310 (34.6%)	585 (65.4%)	895 (100%)
Rockies	111 (27.1%)	309 (72.9%)	420 (100%)
Pacific	105 (21.2%)	390 (78.8%)	495 (100%)
Northwest	111 (37.0%)	189 (63.0%)	300 (100%)
Total Truck Involvement	3950 (43.4%)	5143 (56.6%)	9093 (100%)

Northeast = Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont.
Mid Atlantic = Delaware, DC, Maryland, Pennsylvania, Virginia, West Virginia.
Southeast = Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee.
North Central = Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin.
Gulf = Arkansas, Louisiana, New Mexico, Oklahoma, Texas.
Midlands = Iowa, Kansas, Missouri, Nebraska.
Rockies = Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming.
Pacific = Arizona, California, Nevada.
Northwest = Idaho, Oregon, Washington.

2.2.5 Accident Type Differences

The Bureau of Motor Carrier Safety files report accident type in several ways. One code is assigned for the "type of non-collision event" associated with an accident, and the differences between the two cab styles for this variable are significant.

Table 20 shows the number of vehicles by cab style for the more frequent categories of this variable. Row percentages are shown in the table. It can be seen that cabovers are overrepresented in both the Ran-off-road and Overturn categories, and this may partially explain the increased injury associated with this cab style. It does not explain why the cabovers are more likely to be involved in these kinds of accidents, but it has already been observed that cabovers are somewhat more likely to be involved in long distance operations, operating on higher speed roads, etc.

TABLE 20

Accident Types by Cab Style
(1976-1977 BMCS Data)

Accident Type	Conventional	Cabover	Total
Ran-off-road . .	436 (39.3%)	673 (60.7%)	1109
Jackknife	240 (43.4%)	313 (56.6%)	553
Overturn	283 (36.1%)	501 (63.9%)	784
Other single Vehicle Collision	104 (47.4%)	113 (52.6%)	217
Two vehicle Collision	2931 (45.0%)	3588 (55.0%)	6519
Total Truck Involvement	3994 (43.5%)	5188 (56.5%)	9180

TABLE 21
Injuries and Deaths by Cab Style in Eastern Regions
(1976 BMCS Data) (Column percentages shown)

	Conventional	Cabover	Total
Truck Driver Deaths and Injuries			
Killed or Injured	331 (30.3%)	391 (34.5%)	722 (32.4%)
Uninjured	763 (69.7%)	742 (65.5%)	1505 (67.6%)
X^2 = 4.405 d.f.= 1 sig. level 0.0358			
Other Vehicle Deaths and Injuries			
Killed or Injured	618 (56.5%)	578 (51.0%)	1196 (53.7%)
Uninjured	476 (43.5%)	555 (49.0%)	1031 (46.3%)
X^2 = 6.492 d.f. = 1 sig. level 0.0108			
Totals			
Total Truck Involvement	1094 (100%)	1133 (100%)	2227

2.2.6 BMCS Summary

Operating solely within the accident data, the statistic of interest is the relative frequency of injury or death to the truck occupant, given a BMCS-reported crash. Since these data consist mainly of accidents which involve injury to someone (either in the truck or in the other vehicle in a crash), it can be inferred that either the cabover is less protective of its occupants or the conventional is more damaging to the vehicles it hits. Both of these explanations could be true. Conventionals operate more often in urban traffic, and have more two-vehicle crashes; cabovers have more single-vehicle crashes and

TABLE 22
Injuries and Deaths by Cab Style in Western Regions (1976 BMCS Data)

	Conventional	Cabover	Total
Truck Driver Deaths and Injuries			
Killed or Injured	121 (30.3%)	305 (37.2%)	426 (34.9%)
Uninjured	278 (69.7%)	515 (62.8%)	793 (65.1%)
X^2 = 5.273 d.f. = 1 sig. level 0.0217			
Other Vehicle Deaths and Injuries			
Killed or Injured	189 (47.4%)	365 (44.5%)	554 (45.4%)
Uninjured	210 (52.6%)	455 (55.5%)	665 (54.6%)
X^2 = 0.772 d.f. = 1 sig. level 0.3797			
Totals			
Totals			
Total Truck Involvement	399 (100%)	820 (100%)	1219

operate more in rural areas. Within single-vehicle crashes, cabovers experience more rollovers and more run-off-road accidents. Without a separate exposure measure it does not seem possible to determine which effect is the stronger.

Accepting the values in Table 13 as the most complete, however, the cabover design is associated with a 15% higher probability of driver injury than is the conventional. While the explanation of the difference is not simple, there is sufficient data for the finding to be significant in a statistical sense.

2.3 Fatal Accident Reporting System Data

The Fatal Accident Reporting System (FARS) is a nationwide data collection program for fatal traffic accidents. It is administered by the U.S. Department of Transportation and derives its strength from the cooperation of state agencies, in most cases the the state police. Each state has a FARS analyst with access to police accident reports. Details may vary from state to state, but usually this person is a state civil service employee but is supported by federal funding.

Fatal accidents in the state are routed to the FARS analyst, who codes a nationally consistent set of information from the available police report and other records. At length these data reach the central FARS computer file at the U.S. DOT and become available for use in compiling nationwide fatal accident statistics.

Efforts on another project at HSRI which used the FARS data have proved invaluable to the current study. Since 1976, HSRI has been engaged in a study of anti-lock systems on the air brakes of heavy trucks. Part of this effort has been directed toward determining the fatal accident experience of these vehicles, using the FARS file. With the help of the central FARS office and FARS analysts in most of the states, a copy of the basic police report was obtained for each fatal accident involving a late-model heavy truck in calendar years 1976-1978. Owners and/or drivers of these trucks were then contacted by telephone and asked to provide supplementary information on the truck involved. Brake status was the main concern of this interview, but information on exposure (length of trip, carrier type, etc.), and cab style was also obtained.

The subset of FARS-reported accidents addressed in this study is 1976 and 1977 calendar year fatal accidents involving air-braked trucks and tractors with model years from 1974 through 1977. The file of telephone interviews contains 972 conventionals (45.9%), 1103 cabovers (52.1%), and 43 unknowns (2.0%). Tables 25-27 further describe the subset.

Since the data are restricted to air-braked trucks, the majority of vehicles shown in Table 22 are tractors. These are more often cabovers than conventionals, with a strong bias toward cabovers when the tractor is pulling two trailers. More than four out of five of the straight trucks represented are conventionals.

TABLE 23
Vehicle Configuration by Cab Style (1976-77 FARS Data)
Trucks Involved in Fatal Accidents

	Conventional	Cabover	Total
Straight Truck	200 (83.0%)	41 (17.0%)	241 (100%)
Straight Truck/ Full Trailer	16 (84.2%)	3 (15.8%)	19 (100%)
Bobtail Tractor	22 (44.0%)	28 (56.0%)	50 (100%)
Tractor/Semi	712 (42.8%)	953 (57.2%)	1665 (100%)
Doubles	19 (19.8%)	77 (80.2%)	96 (100%)
Total Truck Involvement	969 (46.8%)	1102 (53.2%)	2071 (100%)

Table 23 shows the truck's intended area of operation on the day of its accident. As in the BMCS data, the cabover is the cab design of choice for long hauls. Table 24 indicates that the cabover is also more often associated with an authorized (for hire) carrier than a private carrier.

TABLE 24
Trip Length by Cab Style (1976-77 FARS Data)
(1974-1977 Air-Braked Trucks Involved in Fatal Crashes)

	Conventional	Cabover	Total
Local	288 (76.4%)	89 (23.6%)	377 (100%)
Less than 200 miles	381 (64.2%)	212 (35.8%)	593 (100%)
More than 200 miles	285 (26.9%)	774 (73.1%)	1058 (100%)
Total Truck Involvement	954 (47.0%)	1075 (53.0%)	2029 (100%)

TABLE 25
Carrier Type by Cab Style (1976-77 FARS Data)
(1974-1977 Air-Braked Trucks Involved in Fatal Crashes)

	Conventional	Cabover	Total
Private	518 (54.2%)	438 (45.8%)	956 (100%)
For Hire	442 (44.2%)	559 (55.8%)	1001 (100%)
Total Truck Involvement	960 (49.1%)	997 (50.9%)	1957 (1005)

Injury severity for the truck driver is shown in Tables 26-28. Since this data comes from the FARS file, all of these accidents involve at least one death, and those that were not fatal for the truck driver were fatal for someone else. What these tables show is that, given a fatal accident, a truck driver is more likely to be killed in a cabover than he is in a conventional. In all three tables, the percentage of fatalities among drivers of cabovers is higher than the percentage of cabovers in the entire file.

TABLE 26
Injury Severity of Truck Drivers
by Cab Style (1976-77 FARS Data)

	Conventional	Cabover	Total
No Injury	526 (50.5%)	515 (49.5%)	1041 (100%)
Possible	94 (47.5%)	104 (52.5%)	198 (100%)
Minor	96 (45.7%)	114 (54.3%)	210 (100%)
Major	50 (34.2%)	96 (65.8%)	146 (100%)
Fatal	151 (40.5%)	222 (59.5%)	373 (100%)
Total Truck Involvement	917 (46.6%)	1051 (53.4%)	1968 (100%)

The reported accident configuration is coded on eight levels, as shown in Table 29. (The "Other" category includes pedestrian accidents.) Single vehicle truck accidents shown here involve a fatality to a truck occupant, and a portion of the overrepresentation of cabovers in occupant fatalities results from their predominance in single-vehicle crashes.

2.3.1 Fatal Accident Reporting System Summary

Analysis of driver injury and fatality statistics wholly within the FARS data presents the same limitations as were described in connection with the BMCS analysis. It is clear that drivers of cabovers are

TABLE 27
Injury Severity of Drivers of Straight Trucks
by Cab Style (1976-77 FARS Data)

	Conventional	Cabover	Total
No Injury	115 (85.8%)	19 (14.2%)	134 (100%)
Possible	16 (80.0%)	4 (20.0%)	20 (100%)
Minor	20 (95.2%)	1 (4.8%)	21 (100%)
Major	11 (84.6%)	2 (15.4%)	13 (100%)
Fatal	23 (79.3%)	6 (20.7%)	29 (100%)
Total Truck Involvement	185 (85.3%)	32 (14.7%)	217 (100%)

TABLE 28
Injury Severity of Drivers of Tractors
by Cab Style (1976-77 FARS Data)

	Conventional	Cabover	Total
No Injury	401 (45.2%)	487 (54.8%)	888 (100%)
Possible	78 (44.3%)	98 (55.7%)	176 (100%)
Minor	76 (41.3%)	108 (58.7%)	184 (100%)
Major	37 (28.9%)	91 (71.1%)	128 (100%)
Fatal	124 (36.6%)	215 (63.4%)	339 (100%)
Total Truck Involvement	716 (41.7%)	999 (58.3%)	1715 (100%)

fatally injured more often than their conventional counterparts, given an involvement in a fatal accident. From table 25, taking all large

TABLE 29
Accident Configuration by Cab Style (1976-77 FARS Data)

	Conventional	Cabover	Total
Single	88 (38.1%)	143 (61.9%)	231 (100%)
Head-on	238 (47.3%)	265 (52.7%)	503 (100%)
Rear (other veh. into truck)	92 (48.4%)	98 (51.6%)	190 (100%)
Rear (truck into other veh.)	66 (38.2%)	107 (61.8%)	173 (100%)
Angle (other veh. into truck)	112 (51.9%)	104 (48.1%)	216 (100%)
Angle (truck into other veh.)	201 (56.5%)	155 (43.5%)	356 (100%)
Sideswipe	37 (44.6%)	46 (55.4%)	83 (100%)
Other	83 (47.2%)	93 (52.8%)	176 (100%)
Total Truck Involvement	917 (47.6%)	1011 (52.4%)	1928 (100%)

trucks together, the cabover occupant is at about a 28% greater risk; the corresponding figure for tractors alone (from Table 28) is 24%.

Table 30 shows the total numbers of persons killed by their location for both single- and multi-vehicle accidents involving cabovers and conventionals. In the fatal accident set, of course, there are relatively few non-truck occupants killed outside of the truck in single-vehicle accidents. A more informative comparison is the relative likelihood of an in-truck fatality in the multi-vehicle accident group.

In table 30 the number of truck occupants killed per fatal crash is greater for cabovers than for conventionals--154 in 142 single vehicle

TABLE 30

Total Fatalities In and Out of the Truck by Accident Type
(1976-1977 FARS Data)

Accident Type	Conventional			Cabover		
	Killed in Truck	Killed not in Truck	Number of Trucks	Killed in Truck	Killed not in Truck	Number of Trucks
One Vehicle Accident	154	1	142	84	10	86
Multi-Vehicle Accident	123	967	890	79	876	817
All Accidents	277	968	1032	153	886	903

involvements. This may result at least in part from the higher occupancy rate for cabovers--observed in the FARS file to be 1.26 occupants per involved cabover vs. 1.10 for conventionals.

2.4 Truck Inventory and Use Survey

In 1978 the Bureau of the Census of the Department of Commerce undertook a national survey to determine the physical and operational characteristics of the country's truck population. The data collected were sampled from the 1977 registrations, and details of the survey methodology can be found in the Bureau's report.[11] These data were analyzed to estimate exposure (in terms of the number of registered vehicle and their mileage) for subsets comparable to those observed in the FARS data. The estimated number of registered vehicles and their total annual mileage are shown in Table 31 for air-braked trucks of model year 1974-1977.

Table 31

Registration and Mileage Estimates from the
Truck Inventory and Use Survey
1974-1977 Air-Braked Trucks

	Conventional	Cabover
Registered Vehicles	264,497	156,074
Total Miles Traveled	11.263×10^{9}	11.913×10^{9}

The TIU survey variables are fairly directly related to the information reported in the BMCS MCS-50-T form. With some reservations, subsets of both the TIU and BMCS may be identified which are directly comparable, and this offers the possibility of making accident rate computations with the BMCS data.

[11] 1977 Census of Transportation, Truck Inventory and Use Survey, TC77-T-52, Government Printing Office, Washington, D.C. 20402.

Such computations are shown and discussed in the next section (2.5) of this report.

2.5 Computation of Accident and Fatality Rates

The comparison of injuries or fatalities associated with the two cab styles under consideration is not straightforward when using the accident data sets alone. As noted above, the BMCS accident records consist primarily of crashes involving injury to someone. The observation that one cab style exhibits a higher driver injury rate than another (the "rate" being computed by dividing the number of injured drivers by BMCS-reported crashes for that group) could be explained by either (1) a greater propensity for injury associated with that cab style or (2) a lower propensity for that cab style to cause injury to a struck vehicle. It is not difficult to believe that both of these explanations are true. The same kind of argument holds for analysis completely within the fatal accident population (FARS).

For single-vehicle crashes in either the BMCS or FARS records such internal comparisons are not very helpful, since in essentially every crash some truck occupant was killed or injured. What is needed is some independent measure of exposure to risk. With some limitations to be discussed, the Truck Inventory and Use Survey provides this.

In the BMCS data used for this study, cab style was identified by a manual review of the "truck type" entries in the file. It is known that the BMCS data are relatively incomplete for certain classes of trucks (or carriers)--the accident file containing only about 20% "private" vehicles as compared with their being about 50% of the registration population. BMCS may be expected to be relatively more complete for

Authorized Carriers, and it is this subset which was chosen for comparison with the exposure set.

While the FARS data sets constitute a nearly complete set of truck fatal accidents, cab style has been identified well only for 1974 and later air-braked vehicles. This subset includes both straight trucks and combination vehicles, but is more complete for the latter. Thus for the comparisons with exposure records, a subgroup consisting of combination vehicles of 1974-77 model year in non-local service was considered.

Sufficient detail was present, then, in these three data sets--the FARS, the BMCS, and the TIU, to develop relatively large subgroups which were compared by cab style. The BMCS analysis is presented first.

For the BMCS data discussed in section 2.2, cab style was identified by manually inserting appropriate codes on the basis of the make and model designations recorded. For the accident files covering calendar years 1976 and 1977, 58.4% of the trucks were assigned a cabstyle designation. Assuming that the group with missing data on cab style is distributed in the same manner as in the known group, the number of involvements reported has been increased by the factor 1/0.584. Since this is a two-year accident file, the entries are further divided by 2 to estimate a one-year statistic. This provides an estimate of involvements (at a level which would be reported to BMCS) of combination vehicles in other-than-local service by authorized carriers over a one-year period, and is shown as the first line in Table 32.

The second line presents an estimate of the number of injured drivers for a one-year period, and the third line the number of fatally injured drivers. Lines 4 and 5 present the estimated number of

TABLE 32

Accident, Injury, Fatality, and Exposure Counts
BMCS and TIU for Authorized Carriers, Non-Local, Combination Vehicles

Item	Conventional	Cabover
Involvements	3325	4305
Driver Injuries	924	1385
Driver Fatalities	48	85
Registered Vehicles . . .	82,348	122,910
Vehicle Miles Traveled .	58.3x10^8	101.2x10^8
Involvements per 10^8 Mile	57.1	42.6
Injuries per 10^8 Mile . .	15.9	13.7
Fatalities per 10^8 Mile .	0.82	0.84

registered vehicles and vehicle miles traveled for the comparable populations taken from the TIU survey. The last three entries constitute the computed rates--involvements, driver injuries, and driver deaths, each per 100 million miles traveled.

Some further limitations of the comparison must be noted. The BMCS nominally requires reports from all authorized carriers in interstate service, and the subset chosen was intended to include those. In a study comparing BMCS and FARS fatal accident counts[12] it was learned that (for all large truck accidents) BMCS reports about half as many as FARS. A portion of the missing data may be explained by accidents

[12]Green, J. A., Gimotty, P. A., and Compton, C. P. FARS/BMCS Accident File Merge and Analysis, Final Report. HSRI, September 1979. 39 pages. Report Number UM-HSRI-79-54. Sponsored by National Highway Traffic Safety Administration, Contract No. NHTSA-9-6441.

involving non-interstate carriers (who do not ordinarily report to BMCS, but do appear in the FARS census), and a part of it may be explained by authorized carriers who somehow have failed to report. If these are equally divided, the fatality rates shown might be increased by a factor of about 1.5, but the justification for a particular multiplier is so weak that it seems more appropriate to leave the numbers in the table and offer this comment.

Using the method and the data shown, then, the fatality rate (per mile traveled by authorized combination vehicles in other-than-local service) is nearly the same for the two cab types. The estimated injury rate for drivers of cabovers is about 14% lower than for drivers of conventionals in this data set.

FARS and TIU

A similar comparison may be made between the FARS record and the TIU subset. In this case the data are limited to 1974-77 model year vehicles (those for which cab style was determined in the interviews), for combination vehicles in other-than-local service, but including both private and authorized carriers. Again the accident data were available for a two-year period, and the numbers shown in Table 33 have been computed for a one-year period. The number of registered vehicles (and their miles) have been reduced from the 1977 (TIU) estimate by 17.7% to account for the 1976 and 1977 vehicles being introduced over the comparison period.

In the FARS presentation cabovers exhibit both a higher fatal accident involvement rate and a higher fatality rate--the combination indicating approximately a 30% higher driver fatality rate (given an accident).

TABLE 33

Accident, Injury, Fatality, and Exposure Counts
FARS and TIU for 1974-77 Combination Vehicles, Non-Local, All Carriers

Item	Conventional	Cabover
Fatal Involvements . . .	503	845
Driver Fatalities	64	140
Registered Vehicles . . .	80,138	96,344
Vehicle Miles Traveled .	5.86×10^8	8.96×10^8
Involvements per 10^8 Mile	85.8	94.3
Fatalities per 10^8 Mile .	1.09	1.56

Discussion

The differences between the BMCS/TIU and FARS/TIU results are obvious. The reasons for such differences are not. The relatively large proportion of missing data on cab style identification in both the BMCS recodes and the FARS interviews suggests that there may be bias in either or both of these. While the injury and fatality rates in the BMCS were relatively invariant across many accident characteristics studied, there may be other characteristics which cannot be observed in the present data. For example, accident involvement rate is a strong function of road class--interstates having (for large trucks) perhaps one-third the fatal accident rate of two-lane rural roads. It seems possible that miles traveled on these two classes of roads might be different for the two cab styles, but data are not available in the exposure set to determine this. There may be significant differences in the driver characteristics for authorized vs. private carriers, or in the time of day for travel by carrier type, etc. At any rate, the FARS/TIU analysis indicates that the cabover designs are both more likely to be involved in fatal accidents (per mile traveled), and more likely to involve a fatal injury to their drivers, given a crash.

Section 3: SUMMARY AND CONCLUSIONS

The purpose of this study was to gain an understanding of any differences in accident, injury, or fatality rates associated with the style of cab employed in commercial vehicles. Cab styles may be defined in various ways, and the detailed classification as offered in the Truck Inventory and Use Survey lists: (1) Cab Forward of Engine, (2) Cab Over Engine, (3) Short Hood Conventional, (4) Medium Hood Conventional, (5) Long Hood Conventional, and (6) a final "other" category. While there may be significant accident and injury differences among all of these, the available accident data could not provide the detail necessary to make such comparisons. In this report comparisons are made between the Cabover Engine Group, and the Conventional (short, medium, and long together). Indeed, there are varieties of Cabover (of different lengths, with and without sleeper compartment), but they have all been grouped together in the comparisons made in this report.

Two somewhat different methods of analysis were used in this study. The first involved operating completely within an accident data set, and making comparisons between the two cab classes such as injuries per accident, fatalities per fatal involvement, etc. What resulted might be thought of as a rate, but the interpretation of the statistic is not always straightforward. The second method involved computing a rate with accidents, injuries, or fatalities (from an accident data set) in the numerator, and registered vehicle counts or miles traveled (from a separate exposure data set) in the denominator. This produced a more understandable statistic, but its applicability is limited to the subsets of the accident and exposure files that can be considered common.

There are many points of uncertainty in the data presented in the report. Except for the TIU survey, the differentiation of Cabovers and Conventionals had to be arrived at indirectly--by interpretation of a Vehicle Identification Number, or by interpretation of descriptive make and model information. In all of the accident files a moderate proportion of the trucks could not be decoded for cab style, and there is always a possibility of bias in the missing data. The analyses proceeded by generally assuming that such bias is small and may be neglected. Where possible these uncertainties have been noted in the text.

Comparisons Made Within the Accident Data

Injuries and fatalities per reported accident have been computed for a set of urban accidents (Denver), an entire state (Washington), and for the BMCS and FARS data sets.

In the urban data, about 75 percent of the trucks in accidents were of conventional cab style, but the numbers of injuries per crash were not significantly different, either for the truck driver or for the occupants of vehicles in collision with trucks.

In the statewide data, the numbers of Cabovers and Conventionals were approximately equal. Fatality and injury "rates" (i.e., per reported accident) were slightly higher for Cabovers, but with the data available not significant at the 5 percent level.

In the BMCS data, the probability of a fatality per reported crash was slightly higher for cabovers, but not significantly so in a chi-square test. The probability of injury, however, was about 15% greater in a cabover than in a conventional (given a BMCS-reported crash). The probability of injury to the driver of the vehicle struck by (or striking) the truck was about 16 percent greater in a crash with a Conventional. The differences in injury rates were statistically significant.

Using the BMCS data as a source of exposure information, it is clear that trucks having the two different cab styles operate under markedly different environments, and have different kinds of accidents. However, analyses of the BMCS data led to the conclusion that the differences in injury rates for the two cab styles are relatively constant across such other dimensions as region of the country, type of cargo, etc.

Within the FARS data, the cabover exhibits a 28 percent higher probability of a driver fatality, given a fatal accident. It can be seen in the FARS data that Cabovers have a higher proportion of single-vehicle accidents and more rollovers, and that these may partially explain the difference. The comparisons within FARS were limited to vehicles in over-the-road (i.e., not local) service in order to consider the two types in as similar an environment as possible. When considering all occupants in the truck (passengers as well as drivers), the cabover has an even higher fatality rate; but this may be explained by the higher occupancy rate for the cabovers.

FARS data, too, were used to estimate exposure of the two cab classes. Within the subset analyzed, Cabovers had more long trips (greater than 200 miles), were involved in more single-vehicle accidents, and were more likely to be a common (as opposed to private) carrier. At least the first two of these could explain a portion of their higher fatality rate.

Comparisons Made Including Accident and Exposure Data

Using the Truck Inventory and Use Survey to estimate truck registrations and miles traveled, the BMCS accident data show little difference between the two cab styles with regard to injuries or fatalities per mile traveled. The subset analyzed in these data includes Authorized Carriers in non-local service (in order to make the accident and exposure data most comparable).

FARS data in conjunction with the TIU data indicate, however, a driver fatality rate about 43 percent higher for the cabover designs (per mile traveled) and fatal accident involvement rate about 10 percent higher. Both the FARS and the TIU data indicate that the cabover exposure is different, involving more long range operation, and probably more operation on higher-speed roads. The detail available in the TIU does not permit a separate analysis by road class, however, and it has not been possible to ascribe a certain percentage of the difference in fatality rates to that factor. It seems likely, however, that taking such environmental factors into account would make the observed difference smaller.

Driver fatality rates shown in Section 2.5 were computed using the TIU mileage estimates. These are, respectively, 1.56 and 1.09 fatalities per 10^8 miles traveled for cabovers and for conventionals. There is some question about the absolute estimates of miles traveled from the TIU data, stemming mainly from a comparison of total combination vehicle miles in TIU for 1977 of about 40 x 10^9 miles vs. an FHWA estimate of 61 x 10^9 miles. If the FHWA estimate were used, the fatality rates would drop to 1.02 and 0.71. Compared with the passenger car fatality rate more than 2 per 10^8 miles, both cab styles might be viewed as relatively safe, even using the higher of the two computations.

Conclusion

From the BMCS/TIU comparison, then, considering only authorized carriers, the two cabstyles exhibit very similar injury and fatality rates. From the FARS/TIU comparison, considering all long-range operations (private as well as authorized), the fatality rate is higher for the cabover style.

There is certainly room for argument about these findings. Bias in the missing data, faults in matching the exposure and accident sets, unknown variations in driver characteristics, unknown effects of differences in travel by road class--all of these probably have some effect. Young drivers, for example, may be expected to have a lower probability of fatality of serious injury (given a crash) than older drivers, but a greater chance of involvement in a serious accident.

This analysis, of course, has been restricted to a statistical presentation of accident and fatality involvements, and has not considered the actual mechanisms of injury. In a review of in-depth truck accident investigations occupant ejection was identified as a principal cause of fatal injury, and a panel judgment suggests that the majority of these (ejection) fatalities might have been prevented by proper wearing of restraints.[13] In these in-depth investigations ejections were twice as frequent for cabover occupants as compared with occupants of conventional cab designs. These in-depth data are too sparse to permit a complete multivariate analysis, but it is likely that

[13]Wolf, B. G. et al, Occupant Survivability in Large Truck Crashes, HSRI, University of Michigan (to be published).

other factors (such as the tendency for conventionals to operate more often in urban areas) also interact with this.

APPENDICES

APPENDIX A
VIN's for Cabovers and Conventionals[13]

CHEVROLET and GMC
(Second Character)
Conventional = C, H, J, M
Cabover = D, F, L, T, U, W

DIAMOND REO
(First Three Characters)
Conventional = DRB, DRE
Cabover = DRH

DODGE
(First Character)
Conventional = D, H, J, N, R, W
Cabover = L, U

FORD
(First Character)
Conventional = F, L, N, R, S, U, V, W, X, Y
Cabover = C, Q, Z

FREIGHTLINER
(Second Character)
Conventional = B
Cabover = A

INTERNATIONAL
(First Three Characters)
Conventional = D05, D06, D12, D13, D20, D21, D30, D31, D32, DA1, DF1, DR1, DX1, DA2, DF2, DG2, B-any-any
Cabover = D10, D11, D23, D35, E-any-any

KENWORTH
(First Character)
Conventional = 1, W
Cabover = 2, K

MACK
(First Character)
Conventional = D, R, U
Cabover = F, M, W

PETERBILT
These VIN's carry no descriptive data.

WHITE
(First Character)
Conventional = A, B, C, F, G, H, 4, 5, 6
Cabover = E, I, M, 2, 3

---

[13]The source for most of these codes was the Commercial Vehicle Identification Manual, 2nd ed., published by the National Automobile Theft Bureau, Jericho NY, 1978. Some supplementary information was obtained from other published sources and the truck manufacturers themselves.

APPENDIX B

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF MOTOR CARRIER SAFETY

MOTOR CARRIER ACCIDENT REPORT

Original and two copies of MCS 50-T shall be filed with the Director, Regional Motor Carrier Safety Office, FHWA, as required by 394.9. Copy shall be retained in carrier's file. Circle or (X) appropriate boxes below.

1. Name of carrier (*Corporate business name*)
(7-21)

2. Principal Address (*Street and no., City, State, ZIP Code.*)
(22-50)

3. Type of carrier (51-66) [A] Private, Employer ID No. (IRS)______ [B] ICC authorized, MC ______ [C] Other (*Specify*) ______ Employer ID No. (IRS)______

4. Type of trip (67) [A] Over-the-road [B] Local pick-up and delivery operation

5. Place accident occurred (*Nearest Town or City, State*)
(68-78)

5A. Type of district (79) [A] Residential [B] Rural [C] Primarily business

6. Street or highway (*Route or Name*)
(7-16)

6A. Location if off highway
(17-26)

7. Day of week (27) [A] M [B] T [C] W [D] TH [E] F [F] S [G] S

8. Date accident occurred (28-33) ..../........./.........

9. Time accident occurred (*Military time to nearest hour*) (34-35)

10. ACCIDENT TYPE (*Primary Event*)

10A. Collision (*Check appropriate box*)
(36) [A] Not applicable [B] Collision with moving object [C] Collision with fixed or parked object

10B. Collision (*Check other object involved*)
(37-45)
[A] Not applicable
[B] Commercial truck
[C] Fixed object
[D] Automobile
[E] Pedestrian
[F] Bus
[G] Train
[H] Bicyclist
[I] Animal
[J] Motorcycle
[K] Other (*Specify*)______

10C. Collision with another vehicle—Accident Classification (*Check appropriate box*) zzz [ ] not applicable

(46-48)	VEHICLES 1	2	3	ACTION	(46-48)	VEHICLES 1	2	3	ACTION
A				Slowing—Stopping	L				Intersection
B				Stopped	M				Passing
C				Parked	N				Changing Lanes
D				Rear-end	O				Sideswipe—Opposite Direction
E				Backing	P				Head-On—Crossed Into Opposing Lane
F				Making Right Turn	Q				Skidding
G				Making Left Turn	R				Vehicle Out-Of-Control
H				Making U-Turn	S				Roll-Away
I				Proceeding Straight	T				Controlled Railroad Crossing
J				Merging	U				Uncontrolled Railroad Crossing
K				Entering Traffic From Shoulder, Median, Parking Strip or Private Drive	V				Other (*Specify*)______

10D. Non-collision (*Check primary event*)
(49-57)
[A] Not applicable
[B] Ran off road
[C] Jackknife
[D] Overturn
[E] Separation of units
[F] Fire
[G] Loss or spillage of cargo
[H] Cargo shift
[I] Other (*Specify*) ______

10E. If not primary event, did accident result in
(58) [A] Not applicable [B] Spillage of hazardous cargo [C] Fire [D] Spillage of non-hazardous cargo [E] Explosion

11. DRIVER INFORMATION

11A. Name of your driver
(59-72)

11B. Age
(73-74)

11C. Social Security No.
(7-15)............../......../..............

11D. How long employed as your driver (*To nearest year*)
(16-17)

11E. Hours actually driving since last period of 8 consecutive hours off duty
(18)
[A] 1 hr. [B] 2 hrs. [C] 3 hrs. [D] 4 hrs. [E] 5 hrs. [F] 6 hrs. [G] 7 hrs. [H] 8 hrs. [I] 9 hrs. [J] 10 hrs. [K] 11-12 hrs. [L] Not applicable

11F. Estimated hours of driving for entire trip or portion of trip, since last period of 8 consecutive hours off duty
(19)
[A] 1 hr. [B] 2 hrs. [C] 3 hrs. [D] 4 hrs. [E] 5 hrs. [F] 6 hrs. [G] 7 hrs. [H] 8 hrs. [I] 9 hrs. [J] 10 hrs. [K] 11-12 hrs. [L] Not applicable

11G. Condition of driver
(20-28)
[A] Apparently normal
[B] Sick
[C] Had been drinking
[D] Dozed at wheel
[E] Medical waiver
[F] Other (*Specify*) ______

11H. Date of last medical certificate (29-34) ....../....../......

Form MCS 50-T (Property-Carrying) (Rev. 8-72) Previous editions of this form are obsolete

(over)

BIBLIOGRAPHY

Bibliography

Bishop, Y. M. M., Feinberg, S. E., and Holland, P.W. Discrete Multivariate Analysis: Theory and Practice, MIT Press, Cambridge, 1975.

Durham, L., Trucking in 1995, The Laird Durham Company, San Francisco, June 1975.

Fay, G.E. and Kaye, M.C., Truck Noise III-D - The Economics of Quieting the Freightliner Cab-over-engine Diesel Truck, Report No. DOT-TST-75-22, October 1974.

Fee, J. and Schwendeman, M., "Preliminary Analysis of the Cab-Over-Engine vs. The Cab-Behind-Engine Designs", Federal Highway Administration, unpublished, February 10, 1976.

Flower, W., Analytical and Subjective Ride Quality Comparison of Front and Rear Cab Isolation Systems on a COE Tractor, SAE Technical Paper Series No. 780411, February 1978.

Hemmings, K.R., "Commercial Vehicle Cabs: Design for Packaging, Access and Visibility", Proceedings of the Institution of Mechanical Engineers, Vol. 188, 1974.

Hutton, T.D., How Loud are Diesel Truck Cabs?, SAE Technical Paper Series No. 720698, August 1972.

Irwine, C., Driver Falls While Mounting or Dismounting Cab Over Engine Tractor Trailer Cabs, unpublished, March 10, 1967.

Miller J. and Anderson, C., "Human Factors Considerations Regarding the Advanced Notice of Proposed Rulemaking 'Minimum Cab Space Dimensions'", Submission to BMCS Docket No. MC79: Notice No. V77-10, Federal Register 43 (31), (pp. 6274-5).

National Automobile Theft Bureau, Commercial Vehicle Identification Manual, 2nd ed., Jericho NY, 1978.

Philipson, L., Rashti, P., and Fleisher, G., Statistical Analysis of Commercial Vehicle Accident Factors, Traffic Safety Center, University of Southern California, February 1978.

Ryder Program in Transportation (University of Miami) and Escher Technology Associates, Alternative Fuels and Intercity Trucking, June 1978.

Truck Index Inc., 1976 Diesel Truck Index, Anaheim CA, 1976.

Truck Index Inc., 1977 Gasoline Truck Index, Anaheim CA, 1977.

U.S. Bureau of the Census, Census of Transportation, 1972 Truck Inventory and Use Survey.

U.S. DOT (Federal Highway Administration), Slips and Falls - Truck Related Personal Injury Accidents, July 1977.

U.S. Government, Interagency Study of Post-1980 Goals for Commercial Motor Vehicles, November 1976.

Winfrey, R. et al., Economics of the Maximum Limits of Motor Vehicle Dimensions and Weights, Report No. FHWA-RD-73-67, U.S. DOT, September 1968.