DOT HS-803 419

STATISTICAL ANALYSES OF COMMERCIAL VEHICLE ACCIDENT FACTORS
Volume II: Summary Report

Gerald A. Fleischer
Lloyd L. Philipson

Traffic Safety Center
Institute Of Safety and Systems Management
University of Southern California
Los Angeles, California 90007

Contract No. DOT HS-7-01565
Contract Amt. $94,536

FEBRUARY 1978
FINAL REPORT

Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590

37202130

DOT HS-803 419

STATISTICAL ANALYSES OF COMMERCIAL VEHICLE ACCIDENT FACTORS
Volume II: Summary Report

Gerald A. Fleischer
Lloyd L. Philipson

Traffic Safety Center
Institute Of Safety and Systems Management
University of Southern California
Los Angeles, California 90007

Contract No. DOT HS-7-01565
Contract Amt. $94,536

FEBRUARY 1978
FINAL REPORT

This document is available to the U.S. public through the
National Technical Information Service,
Springfield, Virginia 22161

Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS-803-419		

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code / 8. Performing Organization Report No.
Statistical Analyses of Commercial Vehicle Accident Factors, Volume II - Summary Report	5. March 1978 6. 8. 78-2
7. Author's: G.A. Fleischer and L.L. Philipson	
9. Performing Organization Name and Address: Traffic Safety Center Institute of Safety and Systems Management University of Southern California Los Angeles, California 90007	10. Work Unit No. (TRAIS) 11. Contract or Grant No.: DOT-HS-7-01565
12. Sponsoring Agency Name and Address: U.S. Department of Transportation National Highway Traffic Safety Administration 400 Seventh Street, SW, Washington D.C.20590	13. Type of Report and Period Covered: Final Report February 1977- February 1978 14. Sponsoring Agency Code

15. Supplementary Notes

Volume I, the Technical Report, is an expanded and detailed version of this document. The abstract below is applicable to both Volumes I and II.

16. Abstract

Procedures for conducting statistical analyses of commercial vehicle accidents have been established and initially applied. A file of some 3,000 California Highway Patrol accident reports from two areas of California during a period of about one year in 1975-76 provides the data base for the application.

Computer implementation and evaluation of the quality of the data file were first accomplished. Then an exhaustive univariate analysis of the data was conducted to describe the file in detail. Selected sets of dependent and independent variables were then subjected to linear regression analysis. The resulting linear models of the interactions of the variables were found to be unsatisfactory. More complex models of the interactions were then constructed with contingency table analysis methods, and acceptable log-linear models to explain these interactions were successfully established.

Vehicle exposure was introduced into one of these analyses to assess its impact on the set of significant interactions; it was indeed found to be important. The estimation of exposure was carried out by two independent methods: a "direct" procedure based on a series of linear extrapolations of basic State of California commercial vehicle traffic data, and an "induced" estimation procedure essentially employing only data in the accident reports.

While necessarily limited in scope, certain initial accident causation and countermeasure implications were established from these analyses. These related to multi-unit jackknife and brakes-related accidents and accident severity. Finally, the effect of considering economic costs of accidents instead of only the frequency of their occurrence was briefly investigated.

17. Key Words	18. Distribution Statement
commercial vehicles, highway accidents, statistical analysis, exposure analysis	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
unclassified	unclassified	56	

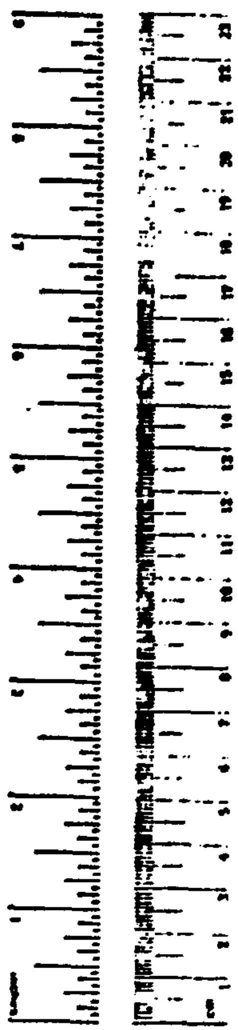
Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

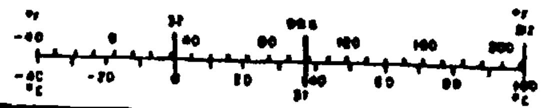
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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

[illegible]



Approximate Conversions from Metric Measures

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



PREFACE

This report summarizes a 12-month study funded by the National Highway Traffic Safety Administration (NHTSA) and conducted by the Traffic Safety Center, University of Southern California.

The study was directed to accident statistics related to certain commercial vehicle accidents in California, with the objectives of establishing and evaluating appropriate data base development procedures and associated statistical analysis techniques. Other objectives included the derivation of inferences about accident causation and the potential of possible countermeasures. Special aspects of the study are the estimation and introduction into the causation analysis of (a) the exposure of commercial vehicles to accidents and (b) surrogate measures of the economic costs of accidents.

An expanded version of this Summary Report is available in the document, "Statistical Analyses of Commercial Vehicle Accident Factors, Volume I, Technical Report. available from The National Technical Information Service (NTIS), Springfield, Virginia 22151. Readers interested in additional detail concerning research design, statistical methods, univariate and multivariate results and the like should consult the Technical Report (Volume I).

This current document, the Summary Report (Volume II), is intended for distribution to truck manufacturers, law enforcement officials and other interested parties in the highway safety professional community. The authors have attempted, therefore, to encapsulate the technical content of the study while bearing in mind the needs and interests of the intended readers.

LIST OF ABBREVIATIONS

AADT	Annual Average Daily Traffic
AADTT/A	Annual Average Daily Traffic of Trucks by Number of Axles
CALTRANS	California Department of Transportation
CHP	California Highway Patrol
CVARS	Commercial Vehicle Accident Report Supplement
D.F.	Degrees of Freedom
DMV	Department of Motor Vehicles
JKAA	Jackknife After Accident
JKBA	Jackknife Before Accident
MDI	Minimum Discrimination Information
NHTSA	National Highway Transportation Safety Administration
PDO	Property Damage Only
SAS	Statistical Analysis System
SOW	Statement of Work
SPSS	Statistical Package for Social Sciences
TCT	Truck Characteristics Table
TSO	Time Sharing Option
TVC	Truck Weight Study Volume Counts
TWD	Truck Weight Study Data
TWS	Truck Weight Studies
USC	University of Southern California
VMT	Vehicle Miles Traveled

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

STATISTICAL ANALYSIS
OF
COMMERCIAL VEHICLE ACCIDENT FACTORS

Volume II: Summary Report

1. INTRODUCTION

Project Overview

As indicated in the Preface, this report presents the results of a 12-month study of commercial vehicle accidents in California, with the objectives of establishing and evaluating appropriate data base development procedures and statistical analysis techniques, and of deriving inferences about accident causation and the potential of possible countermeasures.

An earlier study for NHTSA performed by USC (Contract No. DOT-HS-4-00964) involved a more limited effort toward similar objectives. It resulted in a partial accident data base, exposure estimates (in terms of vehicle miles travelled [VMT] by each category of commercial vehicle of interest during a specified time period), initial efforts at certain statistical analyses of accident frequency and exposure data, and some inferences about accident causation.

The present study has extended and deepened the previous study in a number of ways. The accident data base of the previous study consisted of some 925 California Traffic Collision Reports (Form 555), together with an additional form developed by USC, the Commercial Vehicle Accident Report Supplement (CVARS), completed by officers of two divisions of the California Highway Patrol (CHP) during the period May 15-August 15, 1975. Exposure data consisted of counts of certain relatively specific truck characteristics and of less detailed supplementary truck traffic volumes, observed at several weighing stations during this time period by the California Department of Transportation (CALTRANS). The present study employs similar data, now derived from some 2,097 additional reports, for a total of 3,022 for a time period of approximately one year, May 15, 1975-May 1, 1976. Moreover, the present study includes an in-depth appraisal of the quality of these data, and points out numerous important problems with their development. These begin with the field reports and extend through the verification, coding, and keypunching of those reports. Evaluating and overcoming these problems as well as possible have been major tasks in the present study.

There are several other methodological and conceptual differences between the earlier study and the current effort. Principal among these is the current attempt to provide some measures of confidence at various stages of the data analysis as well as in the final results. Such measures are explicitly exhibited by statements of statistical significance associated with certain regression and contingency table analyses. Only limited success has been achieved in this regard, however, primarily because of the unmeasurable uncertainties in the original data derived from the CHP reports and CALTRANS estimates. Nevertheless, some quantitative as well as qualitative confidence statements are made where possible and where they appear to be meaningful. More important, the attempt to investigate the errors in the data and the sources of inaccuracy in the analysis in more depth than usual has led to a clearer recognition of the critical reasons for these errors. A better structuring of desirable data acquisition, processing, and analysis procedures has thereby resulted, and recommendations to aid its attainment have been derived.

Work Plan

The planning and initiation of the project had two unique features. The first was the reappraisal of the previous study's documentation and data files, and the delineation of their quantity and quality. The second was the establishment of a working relationship with the CHP. Arrangements were made to have an experienced CHP officer review and verify the field accident reports, acquired or otherwise not yet analyzed since the termination of the previous project, for the period August 15, 1975-May 1, 1976.

Accident data processing involved three groups of California commercial vehicle accident report cases.

a) Group 1 consists of the 925 cases reported on, coded, keypunched, filed, and analyzed in the previous study. These cases cover the time period May 15-August 15, 1975.

b) Group 2 consists of 934 cases for the time period August 16-November 15, 1975, whose reports were acquired and coded during the previous study, but were not keypunched or included in the analysis.

c) Group 3 consists of the 1,163 most recent reports, covering the period November 16, 1975-May 1, 1976, and acquired since the end of the earlier project. These have been coded during the present project.

The group 1 and 2 reports had been reviewed and verified by a CHP officer during the earlier study. The remaining coding, keypunching, and computer filing needed for these cases was therefore carried out. After waiting as long as was thought desirable for the CHP review of the Group 3 reports, these too were coded, keypunched, and inserted into the computer file. Subsequent CHP review, however, uncovered numerous discrepancies in the field reports, and, late in the project, the entire Group 3 file were re-keypunched and reentered into the record.

In parallel with the accident data processing efforts, an exposure data acquisition, processing, and analysis procedure was carried out. A thorough investigation was made of the quality of the basic sources of the data in CALTRANS' Truck Weight Studies (TWS)[1] and Annual Average Daily Traffic (AADT) estimates for

[1] Previously also referred to as Truck Characteristics Studies.

commercial vehicles. A careful structuring of a clearcut process for estimating Vehicle Miles Travelled (VMT) as a usable measure of exposure was worked out.

Qualitative assessments of the quality of the accident and exposure data were made at appropriate points throughout the project and, in particular, following the univariate analyses noted below. One specific quantitative analysis was also made to assess the distributions of coding and keypunching errors. A controlled experiment was conducted, involving duplication of random samples of Groups 1, 2, and 3 reports, and then the final records of both versions were compared. Simple confidence statements on the frequency of error for various report data elements were then derived.

The statistical analyses of the accident data then began with the establishment of a set of univariate frequency tables. These provide descriptions of all of the over 300 variables of interest in the accident reports, indicating the number of times in the reports each variable takes on each one of its possible values or "levels," including the "unknown" level when a value in a report is missing or is not one of the possible ones, so that an error is indicated. The "unknowns" thus indicate frequencies of error in reporting, coding, or keypunching.

A straightforward extension of the univariate analysis is that of multivariate cross-tabulation. This has also been done in the present study for a number of cases of interest, in response to specific questions from NHTSA, and also in the development of the requisite inputs for the contingency table and exposure analyses noted below.

The univariate tables provide information on variables of greatest interest as possible causative factors in accidents. (The cross-tabulations provide similar information of selected combinations of variables.) If a particular level of a variable appears with relatively high frequency in the accident reports, it may be such a factor. Whether the implied relationship between the variable and the occurrence of accidents is statistically significant, and how its significance may depend on its interrelationships with other variables, are the main objectives of the remaining statistical analyses. These analyses form the heart of the present study.

First, stepwise linear regressions are applied to sets of variables of interest to further reduce these sets to only the apparently most significant variables. Then contingency table analyses are applied to the reduced sets. These establish potentially significant interrelationships of the independent variables with a dependent accident occurrence or accident consequence variable, with minimal arbitrariness in assumptions about these interrelationships.

The contingency table analyses of accident frequencies are also extended in two important directions. First, estimated VMT is introduced so that changes in the significance of the interrelationships of accident frequency and some set of variables, when exposure is considered, can be investigated. (This is akin to the change in the difference in the significance of a variable in accident causation that can arise if, instead of accident frequency, accident rate [e.g., frequency per mile of exposure] is treated.) For a variable whose interactions with frequency of occurrence appear to be statistically significant when exposure is neglected in the analysis but not when it is included, it can be determined that the apparent significance is merely an artifact of exposure; i.e., the interactions occur often, whether or not an accident takes place, as common characteristics of the transportation system under investigation.

A second extension of the contingency table analysis involves the introduction of economic costs of accidents to determine if apparently significant interrelationships change as a function of accident cost. A surrogate procedure has been adopted for present purposes: only accidents with major severities or fatalities are considered when conducting the statistical analysis. Such accidents are generally most costly in any terms. As with the introduction of exposure, the significant interrelationships among variables, in such high-cost accidents only, can differ from those in all accidents. A countermeasure that might mitigate the frequency or rate of occurrence of an important high-cost accident variable might be especially cost-beneficial.

The final analytical task is the review of the basic and supplementary CHP reports, and the development of a set of recommendations for improvements in their applicability to future studies.

2. THE TRUCK ACCIDENT DATA FILE

The commercial vehicle accident reports analyzed in the earlier and present studies derive from the period May 15, 1975 - May 1, 1976, and from two geographically separated areas of the state of California: Zone II, now the Valley Division, of the CHP in the Sacramento area; and Zone V, now the Southern Division,[2] in the Los Angeles area. (See Figure 1.)

Characteristics of the Study Areas

The southern study area covers a major portion of the County of Los Angeles and small contiguous sections of Ventura County and Kern County. The northern area includes a cluster of 14 counties surrounding the Sacramento-Lake Tahoe region of the state. Within these study areas, the CHP provided accident reports on all truck-related traffic collisions occurring on all interstate, U.S., and state roads, and certain adjacent county roads.

Table 1 indicates the total highway miles and their distribution by state, county, city, and other categories, for Zone II. As noted, Zone II has a total of 22,202 miles of highways of all types. Of these, state highways (interstates, U.S., and state combined) involve 2,068 miles, or about 9.3% of the total for the 14 counties in Zone II. Of these 2,068 miles of state highways, 1,882 miles (8.5% of the total miles) are designated as "outside" cities, and only 186 miles (0.8%) as "inside" cities. Table 2 similarly describes the distribution of highways by type within Zone V.

Accident Reports

The CHP standard Traffic Collision Report form (Form 555) and USC's CVARS (the "Green Sheet") were the instruments for accident data acquisition in both the previous and present studies.[3] The forms were completed by a CHP officer for each accident in the geographical study areas during the period of interest that involved a commercial vehicle of 10,000 lbs. gross weight or greater. They were verified for internal consistency by a different CHP officer, and then sent to USC's project staff for processing. Copies of the two forms are provided in Appendices A and B.

---

[2] Some small variations in the area covered were made in the reorganization of Zone V into the Southern Division in January 1976. These have been accounted for in the accident reports data base and exposure estimates in this study.

[3] An additional two-sided page is also completed with Form 555 when the magnitude of supplementary accident diagramming and other information requires it.

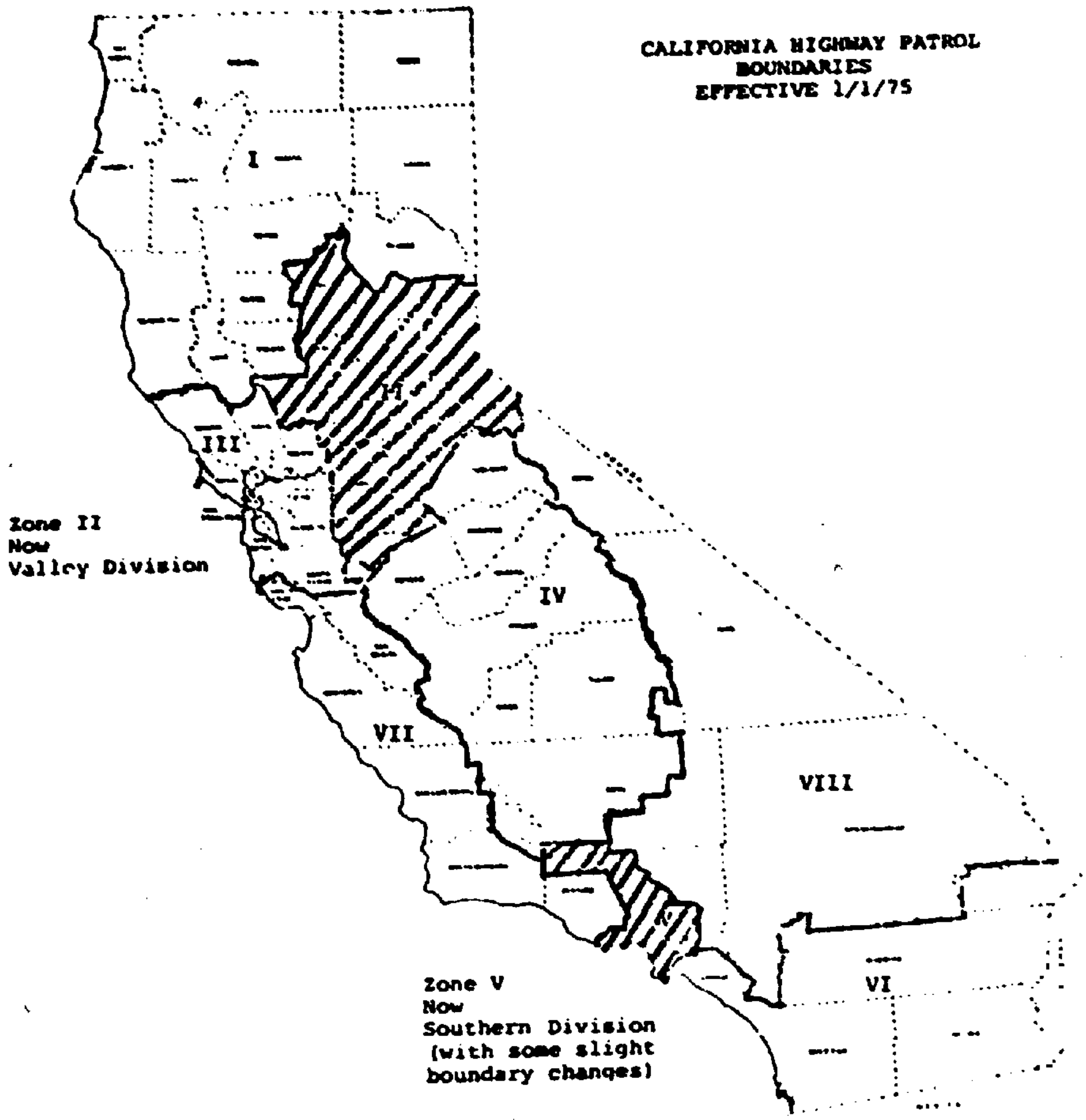


FIGURE 1 TRUCK/BUS ACCIDENT STUDY AREAS FOR CHP DATA ACQUISITION

TABLE 1 ZONE II HIGHWAY MILEAGE BY HIGHWAY TYPE (1973)

County	Total Highway Miles	Total	Outside Cities	Inside Cities	County Roads	City Streets	State Roads Other Than State Highway	National Roads Not Overlapping State or Local Systems
Alpine	288	82	82	-	133	-	2	71
Amador	684	127	120	7	398	49	-	110
Butte	2,205	181	165	16	1,452	166	4	402
Calaveras	1,256	148	144	4	700	15	9	384
El Dorado	2,288	173	160	13	1,020	158	13	924
Nevada	1,203	133	128	5	627	40	1	402
Placer	1,894	158	137	21	977	165	36	558
Sacramento	3,170	209	155	54	1,960	991	10	-
San Joaquin	2,622	245	221	24	1,766	609	2	-
Sierra	1,276	98	97	1	304	5	-	779
Stanislaus	2,268	179	157	22	1,644	441	3	1
Sutter	983	84	81	3	837	62	-	-
Yolo	1,270	187	178	9	908	159	-	16
Yuba	795	64	57	7	72	54	-	105
Total	22,202	2,068	1,882	186	13,388	2,904	80	3,752
% of Total	-	9.3	8.5	0.8	60.3	13.1	0.4	16.9

TABLE 2 ZONE V HIGHWAY MILEAGE BY HIGHWAY TYPE (1973)

County	Total Highway Miles	Total	Outside Cities	Inside Cities	County Roads	City Streets	State Roads Other Than State Highway	National Roads Not Overlapping State or Local Systems
Los Angeles	20,211	902	395	507	4,131	14,183	7	988
Ventura (Total)	2,107	265	185	80	624	935	8	275
Kern (Total)	5,807	862	823	39	3,355	1,147	-	443
Total	28,115	2,029	1,403	626	8,110	16,265	15	1,706
Estimate Miles in Zone V Study Area*								
Los Angeles	18,000	700						
Ventura	150							
Kern	150							
Total	18,300	700						

*Includes all of Los Angeles and parts of Ventura and Kern Counties.

The CVARS provides for the analysis of 45 additional accident variables besides those in Form 555, as follows:

a) A set of vehicle/equipment type characteristics
b) A number of load or cargo descriptors
c) Equipment status
d) Vehicle weights
e) Braking performance
f) Causal factors

A total of 3,022 accident reports with completed CVAR supplements were obtained, coded, edited, keypunched, and filed for analysis.

Insuring consistency and quality of the data sets used for analysis has been of concern to the project staff. All reports and supplements were audited for obvious errors, omissions, etc. When required, forms and supplements with gross errors were returned to the CHP for revision. Normally, follow-up telephone calls to the reporting officer were initiated by the CHP for immediate correction of omissions, errors, or illogical inclusions. A CHP officer also carried out an intensive final verification of the accident reports. Removal of all detectable recording errors from the accident reports prepared them for the data processing procedures next described.

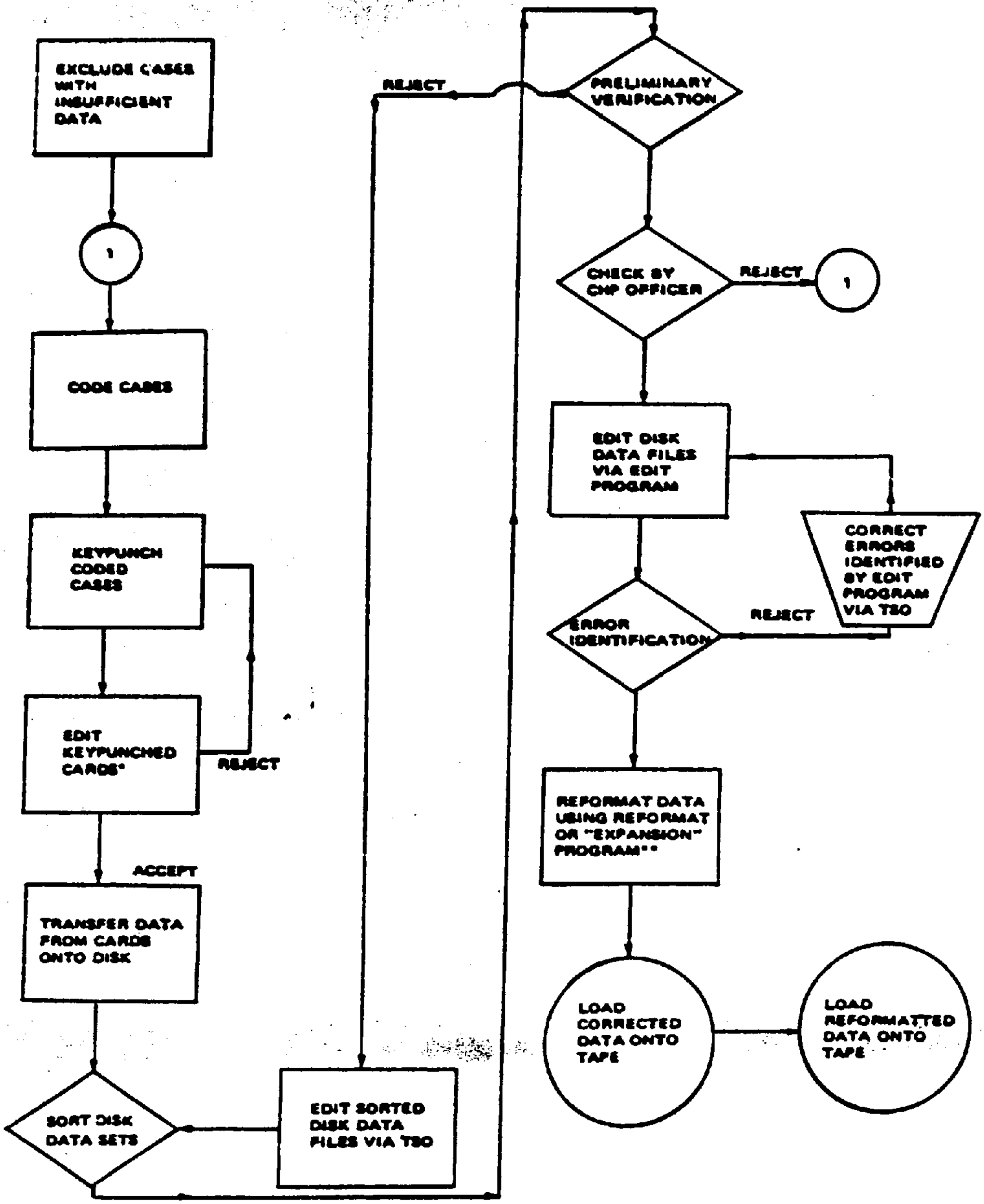
Data Processing

Figure 2 is a flowchart of the overall process of establishing the computer file of accident reports. The two functions of principal interest are data editing and reformatting of the data files to facilitate the statistical analyses. These functions are described at length in the Project Technical Report (Volume 1) but are are not detailed here in this summary document. It should be noted, however, that editing and data quality checks were run on the data to find and correct obvious effects of keypunch errors or bent, unsorted, or misplaced cards, etc., at various stages throughout the process.

The verified accident report data were first transferred to a Summary Form developed by the USC staff specifically for processing and analyzing truck accident data. (The Summary Form provides for more efficient, uniform, and error-free keypunching, and also facilitates subsequent computer processing.)

The accident data Summary Form consists of five pages, each of which consists of many entries. Each entry is coded numerically and then keypunched, with some probability of error. A testing procedure was developed for predicting these probabilities. (See Figure 3) The total relative frequency of error was low for most of the 11? separate variables tested. In twenty of these variables, however, the error rate was 9% or greater. (See Table 3)

Errors were due to either faulty coding or keypunching. With respect to the former, a large number of errors arose because



*KEYPUNCHED CARDS ARE AUTOMATICALLY VERIFIED BY KEYPUNCH MACHINE; I.E., CARDS ARE REPUNCHED AND THE TWO COPIES ARE COMPARED WHEN THE MACHINE IS SET TO VERIFICATION MODE

**REFORMAT OR "EXPANSION" PROGRAM IS A FORTRAN PROGRAM WHICH REFORMATS THE DATA SO THAT ALL RECORDS HAVE THE SAME LENGTH AS REQUIRED BY MOST STANDARD STATISTICAL PACKAGES

FIGURE 2 DATA PROCESSING FLOWCHART

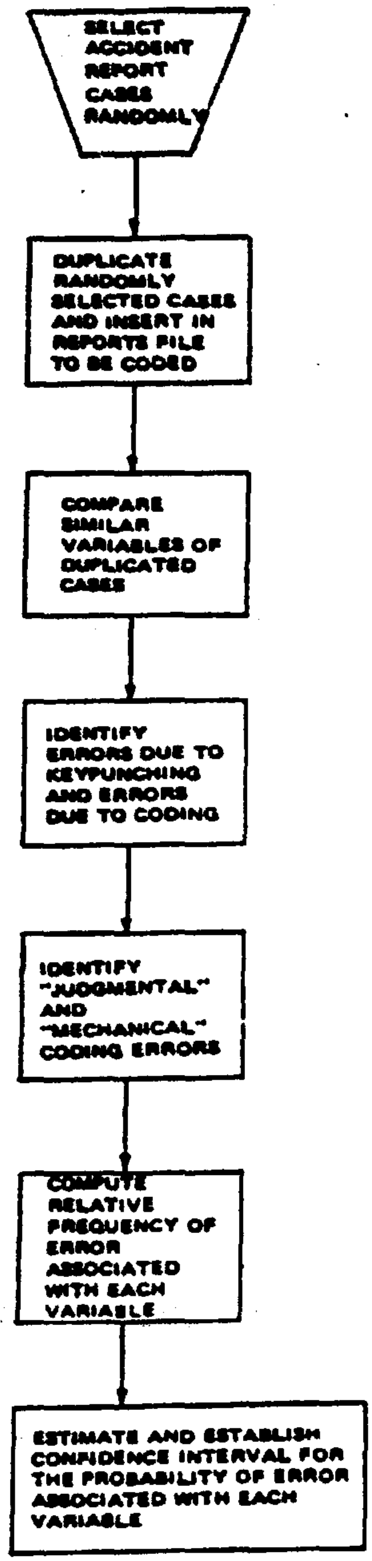


FIGURE 3. FLOW CHART OF DATA QUALITY ANALYSIS

TABLE 3 VARIABLES WITH 9% OR MORE RELATIVE FREQUENCY OF ERROR

Variable	Total Relative Frequency of Error
Road type	0.21
Accident event	0.40
Event coded by CHP[a]	0.11
Total number of events	0.14
Vehicle make	0.23
Vehicle registration	0.17
Configuration code	0.12
Speed prior to involvement	0.14
Tractor number of axles	0.09
Semi-trailer number of axles	0.11
Semi-trailer body type	0.09
Truck brakes	0.11
Tractor brakes	0.10
Semi-trailer brakes	0.11
Braking performance	0.09
Vehicle weight	0.18
Driver age	0.28
Vehicle violation code	0.11
Associated factors[b]	0.17
Driver experience	0.15

[a]This is the main accident event number associated with the event profile, according to the reporting CHP officer.

[b]Vision obscurement, inattention, and so on.

NOTE: Errors associated with accident events, events coded by the CHP officer, total number of events, vehicle registration, and speed prior to involvement are "judgmental" errors. Information pertinent to such variables is obtained from the narrative of From 555. Moreover, the narratives are not prepared uniformly, and as a result the codes resulting from the narratives are not uniform either.

the narrative portions of the CHP accident reports (Form 555) are not prepared uniformly, and thus the codes resulting from the narratives are not uniform either. These "judgemental errors" apply especially to the following variables: (1) accident events, (2) events coded by the CHP officer, (3) total number of events, (4) vehicle registration and (5) speed prior to involvement. Other sources of errors were the clerical procedures used by keypunchers when reading the coded forms, misreading of 555 or CVARS forms and arithmetic mistakes.

Implications of the foregoing results of the quality test to improvements in the reporting forms and data processing procedures are discussed among the recommendations for such improvements in the concluding section of this report.

3. EXPOSURE ESTIMATION

Two approaches are presented for the estimation of exposure for the various commercial vehicle categories (defined by type, number of axles, and weight). The first approach is a "direct" process, making use of existing vehicle population assessment data, and employing numerous linear extrapolations to arrive at the final estimates. The second approach is that of "induced" estimation, essentially making use of only accident data. Here, exposure is defined as the number of vehicle miles traveled (VMT), in millions of miles, during the study period and in the two CHP zones of the study area.

Direct Estimates

As noted earlier, two sets of data established by CALTRANS have been employed in the direct exposure estimation process: Annual Average Daily Traffic (AADT) observations of commercial vehicle counts, categorized only by number of axles of the vehicle, and obtained at many locations on the state's roads; and Truck Weight Studies (TWS) observations of commercial vehicle counts and, for certain periods, weights. The TWS data, categorized by vehicle type and number of axles, and, when available, weight, are obtained at a number of weighing stations in the state.

A series of linear extrapolations has been performed to arrive at VMT estimates for 46 categories of commercial vehicles defined by type (single-unit bus or truck, tractor/semi-trailer, truck plus full-trailer, tractor/semi-trailer/full-trailer, number of axles ranging from two to seven or more), and weight (10,000-25,000 lbs., 25,000-60,000 lbs., over 60,000 lbs.). These extrapolations generally extend small, more specific samples (e.g., eight hours of observations involving all three vehicle characteristics, above) to larger samples of less specific observations (e.g., 24 hours of observations of types and axle counts only), by disaggregating the larger sample into finer categories in the same proportions as these categories exist in the smaller sample.

The process is quite involved. In many instances, it may be assessed as reasonable but not rigorously justified. Furthermore, the basic AADT and TWS data are themselves not well justified in all important respects. Nevertheless, the procedure is believed to be the best possible with existing data, and its exposition provides a clear-cut framework for improvements developed from more comprehensive and higher quality data.[4]

[4] Potentially applicable additional data sources are described in Appendix D of The Technical Report, Volume I, Part 1.

The results are shown in Table 4. The values appear to be fairly reasonable in relation to one another, but their absolute accuracy is questionable. In particular, the very small values probably suffer from large percentage errors in view of the approximations that were inherent in the process of their development.

Induced Estimates

The induced estimation process is entirely different. It is based on a theoretical approach initiated by Thorpe [1] and extended by Haight [2]. It assumes that the proportions of the various categories of vehicles to be found on the roads at any time are the same as the proportions of their involvements in accidents that are collisions (a) with a single non-commercial vehicle, and (b) for which the commercial vehicle is not responsible. Thus only accident reports data are required for estimates of these proportions. Categorized VMT estimates then derive from multiplying the categories' derived proportions by some overall VMT estimate has been obtained as the direct exposure estimate's total. More generally, it would derive from vehicle registration data, gasoline consumption data, or other means. Whatever its problems, the single overall estimate is clearly easier to establish than the many values for the various vehicle categories.

The procedure for developing induced exposure estimates is relatively straightforward, requiring only a cross-tabulation of accident involvement frequencies by vehicle category (type, number of axles, weight), counting only those accidents in which only one other vehicle, a non-commercial vehicle, is involved, and the particular category commercial vehicle is judged non-responsible by the reporting CHP officer.

The results are given in Table 5. It is noted that they often differ considerably from, and are generally "smoother" than, the direct estimates in Table 4, even though the total VMT over all categories is the same in both tables. It has not been possible as yet to determine which set of estimates is to be preferred. From what has been said, it is clear that neither can be accepted however, and their complementary natures give promise of future utility as mutual tests and, perhaps, calibrators of one another.

TABLE 4 DIRECT EXPOSURE ESTIMATES (VMT) BY COMMERCIAL VEHICLE CATEGORY (MILLIONS OF MILES)

Weight, lb.	Truck Type															
	Single Unit				Tractor + Semi-Trailer				Truck + One Full Trailer				Tractor + Semi-Trailer + Full Trailer			
	No. of Axles				No. of Axles				No. of Axles				No. of Axles			
	Bus	2	3	4+	3	4	5	6+	3	4	5	6+	4	5	6	7+
10,000–25,000	0	798.4	113.1	0	55	7	94	0.3	14.9	9.7	6.7	0	0	15.9	0	0
25,001–60,000	16.8	16.5	405	0	89.5	50.2	155.5	0.4	0.5	14.7	19.4	1.0	0.1	303.2	3.3	0.1
60,001 +	0	0	0	0	0	0.3	143.6	0	0.2	0.1	52.7	1.7	0	118.4	4.9	0.2

Total VMT = 2,429

TABLE 5 INDUCED EXPOSURE ESTIMATES (VMT, MILLIONS OF MILES)

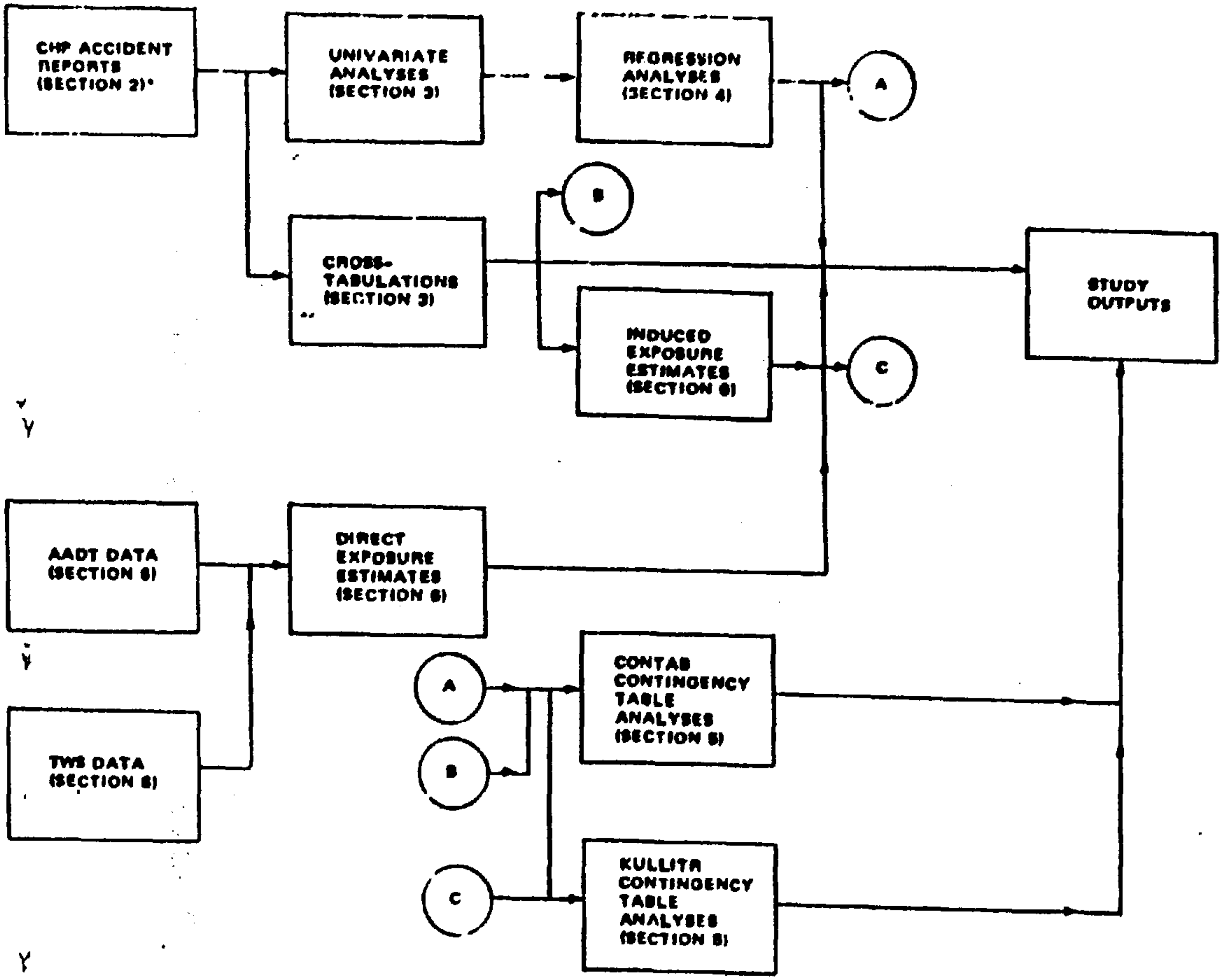
Weight, lb.	Truck Type															
	Single Unit				Tractor + Semi-Trailer				Truck + One Full Trailer				Tractor + Semi-Trailer + Full Trailer			
	No. of Axles				No. of Axles				No. of Axles				No. of Axles			
	Bus	2	3	4+	3	4	5	6+	3	4	5	6+	4	5	6	7+
10,000-26,000	0	409.5	115.5	0	60	56	115.6	0	7.0	14.0	49	0	0	60	0	0
26,001–60,000	16.8*	42.0	60	0	52.6	66.6	343	3.6	0	10.6	45.3	3.6	0	248.4	56	10.6
60,001 +	0	7	7	0	0	10.6	248.6	0	0	3.6	91.0	3.6	0	213.4	0	0

Total VMT = 2,429

*Direct Exposure Estimate for Buses is employed as substitute for not determined Induced Exposure Estimate.

4. STATISTICAL ANALYSIS: AN OVERVIEW

Figure 4 outlines the statistical analysis process that has been carried out. The principal methodological and numerical results that have been obtained in the indicated steps of this process are summarized in the Sections 5 through 8. More detailed discussions may be found in The Technical Report (Volume I).



*REPORT SECTION IN WHICH TOPIC INDICATED IS DISCUSSED.

FIGURE 4 STATISTICAL ANALYSIS PROCESS SUMMARY

5. UNIVARIATE ANALYSES AND CROSS-TABULATIONS

Univariate Analyses: Introduction

Univariate frequency tables, histograms, and associated statistics (mean, median, standard deviation) for the variables in the accident reports have been produced and are presented in detail in Appendix A of the Final Report (Volume I, Part 2). There are over 300 of these variables describing the circumstances surrounding the accident (e.g., time and place of occurrence, physical features of roadway, etc.), vehicle characteristics (e.g., number of axles, location of brakes and controls, etc.), descriptions of involved persons (e.g., age, state of driver's license, injury severity, etc.), and the like.

The results, discussed in the following section, describe the accident data base through simple summaries of the many variables. Certain elementary indications about accident factors fall out easily from these descriptions. Also, comparison of the values of certain summary ratios developed from the univariate results with the same ratios developed in a previous independent study [3] is a means of establishing some confidence in the validity of the present data base. Additionally, the exhibited univariate frequencies make possible for some variables a more efficient categorization of their levels (e.g., vehicle weight has been reduced to only three levels, with approximately equal sample populations in each). Finally, the univariate results provide some initial indication of interesting dependent variables, and of potentially significant independent variables, by showing whether the variables have significant amounts of variation.

Selected Results From Univariate Analyses

Certain of the implications of the univariate analysis results are of immediate interest and worthy of particular note here. These are summarized briefly in four categories of results: accident factors, involved commercial vehicle factors, non-commerical vehicle factors, and human factors. Human factors are discussed with respect to commercial and non-commercial vehicle occupants.

Accident factors are summarized as follows:

a) Commercial vehicle accident frequencies in the study area tend to peak in the late summer and early fall, and in the early afternoon, apparently as a consequence of increased truck operations at these times. The latter result is somewhat surprising; previous studies--as well as intuition--would lead one to expect more accidents during rush hours, especially in a study area including the Los Angeles fre[illegible]s.

b) The number of vehicles involved in an accident has a sharply maximum frequency at two: 68.4% of the accidents involved two vehicles; 20.3% were single-vehicle accidents.

c) In 2,920 accidents,[5] 66 fatalities occurred. This rate (2.26 fatalities per 100 accidents) compares closely with the findings of a previous study, 2.39, for Texas in 1969 [3].

d) In 2,923 accidents, 967 injuries were reported. This rate (33.1 injuries per 100 accidents) is comparable with the Texas study rate of 27.0 injuries per 100 accidents.

e) 86% of the accidents occurred on freeways or conventional two-way highways. Only small percentages occurred at intersections, ramps, etc.

f) The most frequently occurring single collision factor (in 26% of all accidents) is "Other Speed," i.e., an unsafe speed other than exceeding the maximum allowable speed. (The Texas study reports a value of 22%.) "Unsafe lane change" is the second most prevalent factor at 16.5%. Vehicle equipment or cargo problems are noted at primary collision factors in 14.4% of the accidents (11.3% in the Texas study).

g) Weather and road conditions were normal in roughly 90% of the accidents. However, it is important to note that the study period occurred during unusually dry conditions in California. Much more rain, and snow at higher altitudes, is normally expected. Thus a bias undoubtedly exists in these data.

h) Among the principal accident events were "sideswipe collision" and "rear-end collision," occurring with frequencies of 32.6% and 28.4% respectively.

<u>Commerical vehicle factors</u> are summarized as follows:

a) Some 3,124 commercial vehicles were involved in the 2,923 accidents analyzed; 77 of these vehicles were transporting hazardous materials.

b) Of the 3,124 commercial vehicles, approximately 24.1% were two-axle trucks, buses, or tractors; 25.5% were three-axle tractor/two-axle semi-trailer combinations (25.8% in the Texas study): 17.3% were two-axle tractor/one-axle semi-trailer/ two-axle fulltrailer combinations.

c) Speeds of commercial vehicles prior to the accidents showed a peak frequency of occurrence at 50-55 mph, a mean of 33.9 mph, and a median of 39.6 mph.

d) In 53.4% of the 3,124 commercial vehicle involvements reported, the vehicle was proceeding straight prior to the accident. "Changing lanes" occurred in 9.6% of the cases; "slowing or stopping" in 6.7%.

e) 105 of the 3,124 vehicles (3.4%) jackknifed prior to the collision, 121 (3.9%) after. Other such events occurred as follows:

---

[5] Slight variations occur in the total number of usable reports for different variables, because of the presence of "unknowns," etc.

	Before Collision	After Collision
Separation of units	1.6%	1.9%
Cargo spill	2.5%	8.0%
Cargo shift	2.7%	4.0%

f) An automobile rear-ended and underrode a commercial vehicle 193 times (6.2%). A commercial vehicle struck with its front end and overrode a car 239 times (7.7%). This result is also roughly consistent with that of the Texas study, in which a truck striking a car occurred about as often as a car striking a truck.

g) 1,031 (33%) of the 3,124 commercial vehicles involved in the accidents were on other than level roads when the accidents occurred. Of these, 15.8% were proceeding downhill, 12.6% uphill.

h) While not necessarily primary accident causes, the inadequacy of certain functions was noted in some of the 3,124 commercial vehicles:

Braking in lane	27.0%
Steering (only)	24.3%
Braking and steering	15.8%
No brake-caused loss of control	32.7%
Wheel lock-up:	
Motor unit	9.0%
Towed unit	6.2%
Brake fade	0.7%
Runaway on grade	1.0%
Brake-caused:	
Skid	3.3%
Leaving of lane	3.3%

i) In only about 200 cases (6%) were equipment violations cited by the reporting officer.

j) Total vehicle weight distribution was, briefly, 32% up to 20,000 lbs., 90.7% up to 75,000 lbs.

k) The driver was found to be at fault in 45.7% of the 3,124 cases; vehicle equipment was at fault in 10.8% of the cases (11.3% in the Texas study).

l) Among driver failure causes, the following distribution is established (expressed as percentages of total commercial vehicle driver involved in reported accidents):

Fatigue	2.2%
Excessive driving time	0.3%
Drugs or alcohol	1.0%

m) Vehicle dimensions were identified as significant factors in relatively small percentages of accidents (expressed here as percentages of total commercial vehicles involved):

Height	0.8% Width
Width	0.7%
Length	3.1%
Weight	0.6%

n) Damage to the commercial vehicle was found by the reporting officer to be at most minor in 66.1% of the cases. The damage was considered to be total in 2.8% of the cases.

o) The univariate tables present frequencies of occurrence of numerous descriptive vehicle factors that need not be repeated here. One such factor, however, is worthy of note because of its present interest in accident severity studies: 262 (25.4%) of 1,031 trucks involved had cabover configurations; 1,139 (61.3%) of 1,856 tractors were non-cabovers (cab-behind).

p) It is also of interest that 65.4% of the trucks, 64.3% of the semi-trailers, 59.7% of the full trailers, 59.1% of the buses, and 65.1% of the school buses were laden when they were involved in accidents.

Non-commercial vehicle factors are summarized as follows:

a) 80.9% of non-commercial vehicles involved in accidents with commercial vehicles were passenger automobiles; 10.1% were pickup and panel trucks. (Vehicles with gross vehicle weight less than 10,000 lbs. were considered to be "non-commercial" for purposes of this study.)

b) The mean speed of non-commercial vehicles prior to the accident was 40.8 mph; the median speed was 44.8 mph.

c) In 44.2% of the non-commercial vehicle cases, the vehicle was proceeding straight; it was stopped in 14.6% of the cases; changing lanes in 9.2% of the cases; slowing or stopping in 7.9% of the cases.

d) Damage to non-commercial vehicles was no more than minor in 33.5% of cases; it was total in 7.9%.

Commercial vehicle drivers and passenger factors are summarized as follows:

a) 96.1% of commercial drivers, in cases in which sex was reported, were male. The drivers' mean age was 36.5; median 34.6. Mean years of experience was 9.2; median 5.9.

b) Alcohol, drugs, or physical impairment were reported in only a few cases.

c) No commercial vehicle driver injury occurred in 91.7% of the cases; fatal injuries occurred in 13 of 3,014 cases (0.4%).

d) Of only 54 commercial vehicle passengers who suffered injury in the total set of accidents, five had major injuries. There were no fatalities for this class of occupants.

e) In the judgment of the reporting officer, human operational shortcomings contributed to accidents with the following frequencies:

Vision obscurement	3.0%
Inattention	34.7%
Stop-and-go traffic	7.9%
Entering/leaving ramp	3.6%
Preceding collision	1.4%
Unfamiliarity with road	1.8%

Non-commercial vehicle drivers and passenger factors are summarized as follows:

a) 70.8% of the 2,314 drivers involved were male. The mean age was 36.8; the median 22.0.

b) Alcohol, drugs, or physical impairment were involved in about 7% of the cases, with alcohol predominant.

c) The severity of injury to non-commercial vehicle drivers was no worse than minor in 96.6% of the cases; 32 fatalities (1.4%) occurred.

d) Again, the single most common California Vehicle Code violation (26.0%) was unsafe speed.

e) As with the commercial vehicle drivers, human operational inadequacies, particularly inattention (32.3%), were found by the reporting officer to have contributed to a significant fraction of the accidents.

f) 222 non-commercial vehicle passengers suffered injuries in the accidents reported; of these 86.9% were at most minor; 10, or 4.5%, were fatal.

Some Cross-Tabulations

A selected set of cross-tabulations has been developed to exhibit the joint frequencies of certain combinations of variables. The most striking implications of these cross-tabulations are as follows:

a) The ratio of overturn accidents to non-overturns in the reported commercial vehicle accidents on conventional two-way roads (0.096), and also at intersections and ramps (0.103), is about twice as large as it is elsewhere on freeways and expressways (0.048). Overturn accidents thus appear to be significantly less likely on the latter roadways.

b) No significant difference appears to exist between the ratios of the numbers of single to multiple-vehicle accidents, for the cases of one or more commercial vehicle occupants, respectively. It has been conjectured that the likelihood of single-vehicle accidents could differ when several occupants are present, but the approximate equality of the two ratios tends to militate against this.

c) The relative likelihood, given that an accident occurs, of major injuries to occupants of cabover commercial vehicles (0.018) appears to be significantly greater than for non-cabover vehicle occupants (0.010). Interestingly, however, the chance of <u>minor</u> injuries may be slightly greater for the latter (0.087 vs. 0.093).

d) As had been expected, accidents involving an automobile underriding a commercial vehicle do tend significantly to result in more high-severity injuries to the automobile occupants, compared to other kinds of accidents.

Cross-tabulations have also been produced for inputs to the contingency table and induced exposure analyses.

6. REGRESSION ANALYSES

Methodology

The simplest explanatory models for the relationships among statistical variables are linear regression models. Several analyses of the accident data have been carried out in attempts to establish such models. In addition to the basic utility these models would have in accident causation assessment, the process of their development also provides indications of the relative significance of individual independent variables. These indications enable preselection of the variables that appear to be most necessary to include in other model analyses, in particular, the contingency table analyses discussed in the following section.

Linear regression models are often applicable for explaining the variation of one or more numerical dependent variables as functions of the variations of a number of numerical independent variables. If, for a given data set, the explanation is "good", i.e., a high percentage of the total observed variation in the dependent variables data is explained by their modelled variation, then the model is accepted as a satisfactory means for understanding how the dependent variables correlate to all the independent variables acting simultaneously. The model can then also be used for predicting future values of the dependent variables, given observed or predicted future values of the independent variables.

Regression models, while often effective, nevertheless have several significant limitations. First and foremost, they are linear models; they assume that the dependent variables can be satisfactorily expressed as simple linear functions of the independent variables. Second, regression analysis requires that all variables be expressible numerically. Thus inherently qualitative, categorical variables must be scaled, with some unavoidable arbitrariness, e.g., the variable "Road Condition", wet or dry, must be restated, assigning some numerical values to "wet" and "dry" respectively (0 and 1, -10 and +10, or . . .). However, procedures exist for mitigating this difficulty, and they have been used in this study. Third, among the more subtle difficulties with regression methods is the theoretical requirement that the combinations of values of the variables be approximately normally distributed. This is necessary in the assessment of goodness of fit. Even with large sets of variables this requirement may or may not be satisfactorily met.

A stepwise regression procedure, available in a standard statistical analysis package, was employed in establishing best-fit linear regression models to several sets of variables. As will be seen, the results indicate poor to very poor fits in the five analyses carried out. The implication is that the true relationships among the variables studied are unlikely to be even roughly linear.

This adds to the motivation for seeking other model structures, particularly the log-linear models considered in the contingency table analyses described subsequently. The regressions nevertheless helped to establish candidate significant variables for these latter analyses.

Some Results

The five dependent variables studied are shown below, together with their most significant independent variables.

a) Jackknife-Before-Accident
   - Road Surface (Dry or Not)
   - Lockup, Motor Vehicle (Yes or No)
   - Drive Axles, Number (One or Two)
b) Jackknife-After-Accident
   - Lockup, Motor Vehicle (Yes or No)
   - Commercial Vehicle Speed (Range of Values)
   - Combination (Several Types of Vehicle)
   - Load Status (Laden or Not)
   - Road Alignment (Uphill or Not)
c) Underride Accident
   - Commercial Vehicle Moving (Stopped or Not)
   - Commercial Vehicle Speed (Range of Values)
   - Road Type (Freeway or Not)
   - Daylight (Yes or No)
   - Time of Day (Three Periods)
d) Overide Accident
   - Commercial Vehicle Moving (Slowing/Stopping or Not)
   - Commercial Vehicle Proceeding Straight (Yes or No)
   - Hydraulic Brakes (Yes or No)
   - Type of Roadway (Freeway or Not)
e) Brakes-Related Accident
   - Roadway Alignment (Downhill or Not)

Again we note that the relatively low percentage of explained variation that the models derived in all five studies are poor fits to the data and are of little value in themselves. Except to the extent that they provide bases for some of the contingency table analyses described in the following section, they, and the linear regression process, are consequently not considered further in the present study.

7. CONTINGENCY TABLE ANALYSES

A Note on Methodology

The preponderance of the variables in the commercial vehicle accident reports analyzed in the present study (and in most other such reports as well) are qualitative, or categorical, in nature. Contingency table analysis methods have been developed for studying the interrelationships among such variables; they obviate some of the difficulties with the regression analysis approach, which was demonstrated to be unsatisfactory for the present study. The contingency table analysis process has been applied to several specific investigations of variable interrelationships, with the objective of exposing possible accident occurrence or accident severity "causations" among them.

The CONTAB program has been employed to this purpose for the accident variables. Also discussed below is the application of another program, KULLITR, for use when it is desired to incorporate exposure in the causation analysis. A number of CONTAB studies have been performed, and have led to the following results.

Jackknife-Before-Accident (JKBA) Study

A highly satisfactory model has been obtained for explaining or predicting the occurrence of this type of accident cause by incorporating all of the individual two-way interactions between JKBA and Road Surface (RS), JKBA and Lockup (LU), and JKBA and Number of Drive Axles (DA). But no higher-order interactions with JKBA (e.g., JKBA, RS, and LU jointly) need to be considered. Thus, in particular, sample information on such interactions need not be obtained. As also shown by the JKBA regression analysis, Road Surface (RS) is the most important independent variable: the JKBA/RS interaction explains the greatest variance of the three first-order interactions.

The model's predicted, or "smoothed," values of the joint frequencies of all the possible combinations of the levels of the variables JKBA, RS, LU, and DA can be employed to predict the odds of the occurrence of JKBA, compared to its non-occurrence, for various possible conditions. The dominant results are that the odds of occurrence of JKBA are about 10 times greater on a wet road than on a dry one, whatever the condition of LU and DA.

	Road Surface	
	Dry	Wet
Lockup, one drive axle	0.22	2.0
Lockup, two drive axles	0.06	0.56
No lockup, one drive axle	0.03	0.29
No lockup, two drive axles	0.009	0.08

A secondary note is that, as would be expected, the presence of two drive axles significantly decreases the odds of JKBA. It is less to be expected that this decrease is given by the same proportion for either road surface when lockup occurs: on a dry road, by a factor of 0.22/0.06 = 3.7, and on a wet road, by a factor of 2.0/0.56 = 3.6. When lockup does not occur, the corresponding factors are 0.03/0.009 = 3.3, and 0.29/0.08 = 3.6, still about the same as before. The interesting conclusion, therefore, is that two drive axles reduce the odds of occurrence of JKBA by about a factor of 3.5 under all conditions.

With the data provided, further investigations can be made along these lines.

It is finally worth noting generally that a complete odds analysis enables the identification of the combinations of those levels of the independent variables that produce the lowest odds of a deleterious level of the dependent variable. To the extent that the independent variables' levels are controllable, countermeasures to the deleterious level's occurrence could then be defined by these combinations. For example, in the present case of JKBA, if two drive axles could be required for certain vehicles that would not otherwise employ them, the odds of the occurrence of JKBA would be decreased. Results of this character could often be expected to be found.

CONTAB Analysis of Injury Severity

An earlier CONTAB study was conducted by James Hedlund of NHTSA of the factors in the occurrence of a fatality, employing a nationwide data base [4]. An analogous study has been performed with the present data base, with closely related variables:

a) Dependent variable: A high-severity (more than minor) injury occurs to a car occupant, or not

b) Independent variables:
- Road Type (conventional two-way, or freeway/expressway)
- Truck Type (semi-trailer or full-trailer [and thus generally a double-bottom])
- Weight (10,000-25,000 lbs., 25,000-60,000 lbs., or more than 60,000 lbs.)

The analysis of interactions leads to primary results consistent with Hedlund's, taking into account the differences in the two studies imposed by the differences in the data bases. It is found that Road Type is much the most important individual variable.

A highly satisfactory model includes the two second-order ("three-way") interactions among Severity, Road Type, and Weight, and among Severity, Truck Type, and Weight. (The third such interaction, among Severity, Road Type, and Truck Type, is not required.)

Using the model's predicted joint frequencies, an odds analysis can now be conducted for the occurrence of a high-severity injury to a car occupant compared to the occurrence of only low-severity (at most) injuries. Consistent with the previously noted conclusion that Road Type is the most important individual factor in severity causation, it is found, for example, that the odds of occurrence of a high-severity injury are 2.5 times as great on conventional roads than on freeways or expressways for lightly laden (up to 25,000 lbs.) semi-trailers, and about 1.5 times as great for heavily laden (more than 60,000 lbs.) full-trailer combinations.

Vehicle Type	Conventional Two-Way Roads	Freeways and Expressways
Lightweight Semi-trailers (<25,000 lbs)	0.15	0.06
Heavyweight Full Trailers (>60,000 lbs)	0.20	0.14

Thus, while not as significant as Road Type, extreme variations, at least, in Vehicle Type and Weight combinations can also be important factors in the severity of accidents.

As also noted by Hedlund (for fatalities only), it is clear that road type is the dominant factor in the odds of severe injuries, with conventional roads more involved (evidently significantly) with such injuries than freeways. The dominance appears to be significantly more pronounced, however, for the lighter vehicles (a factor of 0.15/0.06 = 2.5) than for heavier vehicles (0.20/0.14 = 1.4).

CONTAB Analysis of Brakes-Related Accidents

A class of commercial vehicle accidents of great significance is that of brakes-related accidents. A contingency table analysis has been performed of the interaction between the dependent variable, Brakes-related Accident Occurrence or Not, and the independent variables, Vehicle Category (Type, Number of Axles, Weight) and Road Direction (Downhill or Not). The latter variable was established in the brakes-related accidents regression analysis as the most significant single variable. The vehicle category characteristics have also been considered here as particularly relevant to the new brake system needs evaluation of NHTSA. They are also appropriate in the case of high-cost brakes-related accident causation, considered in the following section. Therefore, the analysis treated:

a) Dependent variable: A brakes-related accident occurs, or not
b) Independent variables:
   - Road Direction (downhill or not)
   - Vehicle Configuration (16 combinations of type and number of axles)
   - Vehicle Weight (three levels)

Some representative odds analyses have been performed using the predicted joint frequencies of the accepted model. It is found, for example, that the odds that a single unit, two-axle truck will have a brakes-related accident on a downhill road are twice as large as the corresponding odds on a non-downhill road (0.16 vs. 0.087). The analogous result for a five-axle tractor/semi-trailer is that the downhill, brakes-related accident odds are 4.6 times those for a non-downhill road (0.14 vs. 0.03).

CONTAB Analysis of "High-Cost" Brakes-Related Accidents

The variables that appear to be significant in the explanation of the frequency of a given type of accident may change if instead of only the frequency, the total economic cost of accidents is considered. Time has not permitted the development of a satisfactory procedure for introducing costs directly in the present study.[6] Consequently, a surrogate procedure has been established and briefly tested. It assumes high-cost accidents are largely those in which relatively high-severity injuries have occurred. Given this assumption, it is then only necessary to first delete from the data base all accidents not in the severity range of interest, and conduct the analysis of interactions just as before, but with only the high-severity portion of the accident cases.

[6] The simplest procedure, based on regressions, has not been carried out because of the poor fits of the regressions discussed above. A contingency table procedure is not immediately available.

This surrogate procedure has been carried out in a CONTAB analysis of brakes-related accidents with vehicle category and road direction (Downhill or not) again the independent variables. "High-cost" accidents considered are those with the severity levels Fatal, Major Injury, or Minor Visible Injury only. (The low-severity levels--Complaint of Pain and No Injury--are excluded.) The analysis proceeds exactly as in the previous section.

The results on important interactions are the same: the model incorporating only the three-way interaction, Brakes-related accident/Direction/Configuration, is satisfactory. (It explains 55% of the initial variation.) Again, weight is not important.

The following results reflect the odds of a brakes-related accident recurring compared to not occurring:

Vehicle Type	Downhill	Non-Downhill
Light, single unit, 2-axle	0.14	0.08
Heavy, 5 axle, tractor/semi-trailer	0.03	0.06

The odds ratios for the single-unit vehicle accidents do not appear to differ very significantly from those derived from the full data base (0.14 and 0.08, compared to 0.16 and 0.087 for downhill and non-downhill roads, respectively). The implication is that for this type of vehicle, the variables and interactions that are important in high-cost, brakes-related accidents are those that are also important, and have essentially the same effects, in all brakes-related accidents.

For the tractor/semi-trailer vehicles, however, while the same significant variables and interactions apply to high-severity, as well as to all, brakes-related accidents, their effects appear to vary in the high-cost accidents from their effects in all accidents. The odds of a high-cost, brakes-related accident on a downhill road are only a fifth (0.03 ÷ 0.14) of the corresponding odds for unrestricted brakes-related accidents. For non-downhill roads, on the other hand, the high-cost odds are twice as great (0.06 ÷ 0.03) as for unrestricted brakes-related accidents. It may be conjectured that these results indicate a relatively greater effort on downhill roads by the drivers of these larger vehicles to avoid conditions that can lead to more severe accidents. Of course, it may merely be the sparseness of the data that is causing the observed results. A deeper investigation must await a future study.

KULLITR Contingency Table Analyses

In order to treat the interaction of commercial vehicle exposure, in terms of VMT in the two CHP zones during the study period (May 15, 1975-May 1, 1976), the KULLITR contingency table analysis program has been employed. Two sets of estimates of VMT have been developed: direct and induced estimates. The procedures and results of these estimates were discussed previously. The effects of their incorporation in the KULLITR interaction analyses are described here.

The dependent variable considered is that of commercial vehicle accident occurrence as a function of the independent variables vehicle configuration (type and number of axles), weight and exposure--with the latter in turn also a function of vehicle configuration and weight. It is found that vehicle configuration and weight together are more important than exposure in the explanation of accident occurrence. However, exposure is also important, and its inclusion adds significantly to the explanation. This conclusion holds for both direct and induced estimates, but is somewhat stronger for the latter.

The joint frequences predicted by the model resulting from the inclusion of both the vehicle characteristics and exposure do not fit the observed accident frequency data very well. Nevertheless, as the best available, they have been employed, together with the two sets of exposure estimates, to establish two corresponding sets of estimates of accident involvement rates for the vehicle categories considered.

Tables 6 and 7 illustrate the accident involvement rates of the various truck categories, expressed in accidents per million miles travelled, using direct and induced exposure measures respectively. While in many cases the relative values of the rates for different vehicle categories appear to be reasonable, the absolute accuracy of their individual values cannot now be ascertained. Moreover, the direct and induced estimates generally differ greatly. Perhaps the highest confidence results are the relatively high involvement rates in both sets of estimates that are exhibited by tractor/semi-trailer combinations. These rates range from about 1.5 to 9.7 involvements per million miles with the direct estimates, and from about 0.66 to 6.9 with the indirect estimates. Single-unit vehicles, truck/full-trailer combinations, and tractor/semi-trailer/full-trailer combinations tend to have relatively lower involvement rates. The values, and the trends in them, appear generally to be more consistent with the induced than with the direct exposure estimates, but as has been discussed previously, this does not necessarily mean that the former are more "correct".

TABLE 6 ACCIDENT INVOLVEMENT RATES OF THE VARIOUS TRUCK CATEGORIES, ACCIDENTS PER MILLIONS OF MILES TRAVELLED, USING DIRECT EXPOSURE ESTIMATES

Weight, lb.	Truck Type															
	Single Unit				Tractor + Semi-Trailer				Truck + One Full Trailer				Tractor + Semi-Trailer + Full Trailer			
	No. of Axles				No. of Axles				No. of Axles				No. of Axles			
	Bus	2	3	4+	3	4	5	6+	3	4	5	6+	4	5	6	7+
10,000–25,000	ND	0.44	0.71	ND	3.0	8.3	1.5	9.7	ND	0.88	6.7	ND	ND	5.4	ND	ND
25,001–60,000	0.26	3.2	0.60	ND	2.8	1.7	1.8	7.6	ND	0.61	3.2	2.5	ND	0.83	7.2	45.6**
60,001 +	ND	ND	ND	ND	ND	277*	2.1	ND	ND	94.2*	1.4	1.6	0	1.4	5.4	25.0*

Not Determined: Zero exposure estimate.

*Anomalous value, due to very small exposure estimate.

TABLE 7 . ACCIDENT INVOLVEMENT RATES OF THE VARIOUS TRUCK CATEGORIES, ACCIDENTS PER MILLIONS OF MILES TRAVELLED, USING INDUCED EXPOSURE ESTIMATES

Weight, lb.	Truck Type															
	Single Unit				Tractor + Semi-Trailer				Truck + One Full Trailer				Tractor + Semi-Trailer + Full Trailer			
	No. of Axles				No. of Axles				No. of Axles				No. of Axles			
	Bus	2	3	4+	3	4	5	6+	3	4	5	6+	4	5	6	7+
10,000–26,000	ND	0.87	1.3	ND	3.1	1.2	0.66	ND	ND	0.48	0.87	ND	ND	0.94	ND	ND
26,001–60,000	0.26*	1.3	2.4	ND	4.6	1.4	1.2	1.1	ND	0.83	1.2	0.89	ND	0.95	0.62	0.46
60,001 +	ND	6.8	16.6	ND	ND	6.9	1.0	ND	ND	2.6	0.90	0.76	ND	0.99	ND	ND

Not Determined: Zero exposure estimate.
*Uses direct exposure estimate, in lieu of undetermined indirect estimate.

8. CRITIQUE OF ACCIDENT REPORTING AND CODING PROCEDURES

The Technical Report (Volume I) for the project discusses at some length the standard California Highway Patrol's Traffic Collision Report (Form 555) as well as the supplementary data forms and coding procedures. The highlights of that discussion are presented here in this summary report.

Evaluation of Traffic Collision Reports

The primary criticisms that can be directed to most highway traffic collision reports, including that employed by the CHP (Form 555), concern:

a) their overall paucity of specific data for detailed analysis;

b) their inclusion of rather extensive narrative or opinion data, leaving much room for error, and making coding and subsequent analysis difficult; and

c) the failure to collect general accident system data as measures of exposure for correlation with the general driving population's exposure attributes.

From the standpoint of accident research, whether of a routine statistical nature or for purposes of causation analysis, accident reconstruction, or forecasting purposes, the sets of selected variables generally contained in traffic accident reports are too meager to provide a good basis for management of highway safety programs. While the data compiled on the selected set of some 30 to 50 variables in typical accident reports are useful, they are not sufficient to make detailed decisions on new legislation affecting vehicle safety sandards, highway design standards, or driver education of licensing procedures.

The CVARS was introduced to supplement Form 555 in order to alleviate this difficulty, particularly for commercial vehicle accidents. However, as depicted in Figure 5, a logical procedure to follow in designing an accident record system and/or research program, as in any experimental design process, would be to commence with an hypothesis to be tested, then to proceed to a definition of required data to be employed with these tools to yield proof or disproof of the established hypothesis, and on to a definition of the necessary data collection process itself. Thus, the specifications for required data content (i.e., required variables and resultant data) are determined by the form of analysis and original hypothesis. This procedure was not followed in the development of the CVARS form and also does not appear to have been the basis for the original design of Form 555. Undoubtedly, most traffic accident record systems have developed "like Topsy," without consistent guidelines for their specific data acquisition

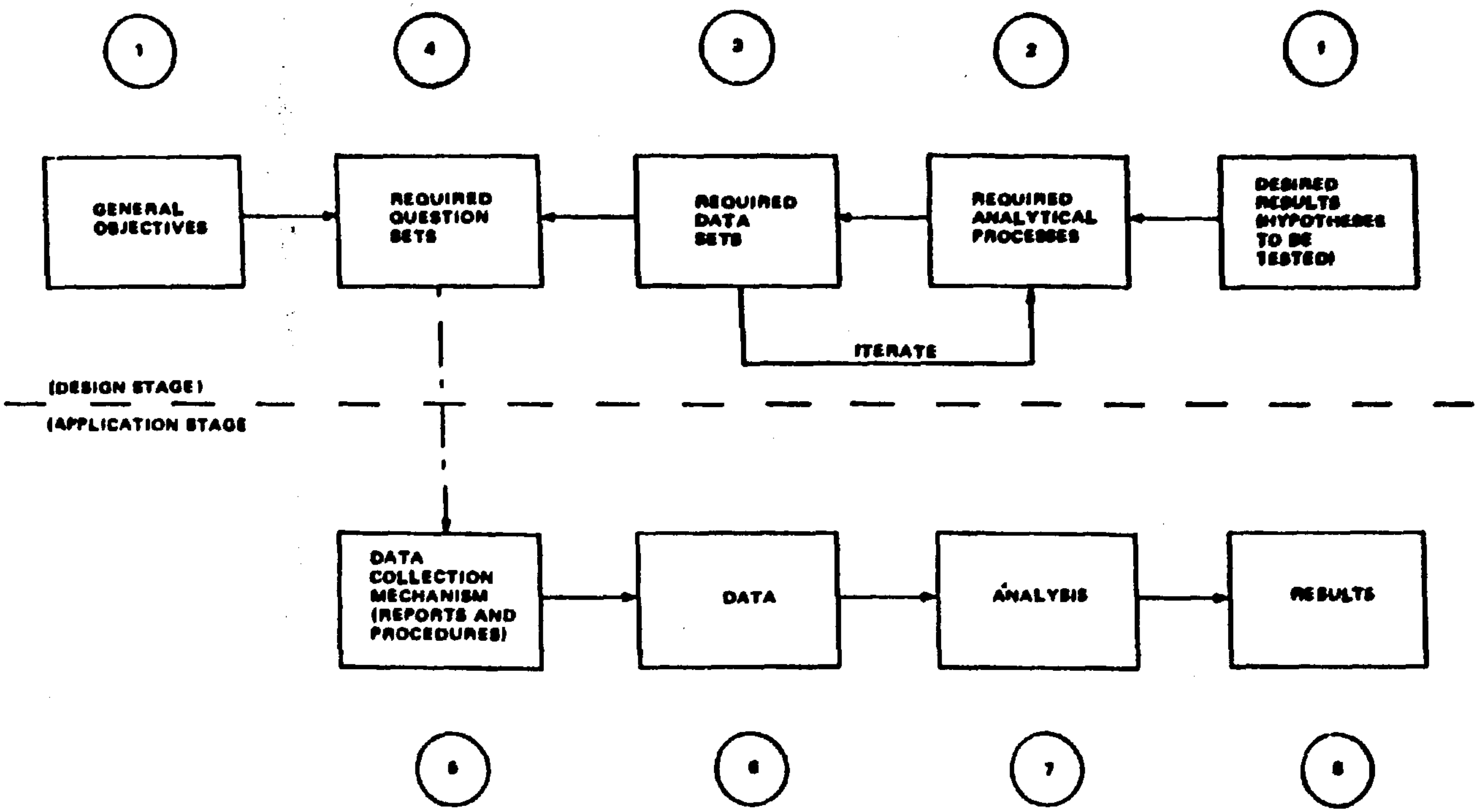


FIGURE 5 METHODOLOGY FOR DESIGN AND IMPLEMENTATION OF AN EFFECTIVE ACCIDENT DATA COLLECTION AND ANALYSIS SYSTEM

so as to produce specific analytical results. Generally, the variables to be measured have been assembled from non-specific requests for information from a number of participating agencies, and reflect compromises with time availability or work load limitations of traffic officers.

The Traffic Collision Report (Form 555) consists of four pages:

Page 1: Accident Number and Location Data, Party Names and Addresses, Vehicle Descriptions, Extent of Injury, etc.
Page 2: Collision Narrative and 13 separate categories of accident factors ranging from Primary Collision Factor to Sobriety, etc.
Page 3: Sketch and Narative Continuation Data
Page 4: Supplemental Data

and identifies data for 44 specific accident variables. The first two pages represent the "primary" report; pages 3 and 4 are supplements. (See Appendix A.) Multiple copies are used by the traffic officers, if necessary, to set forth data on multiple vehicles or involved passengers or pedestrians. In the Technical Report, Volume I, a total of fifteen specific criticisms are made of the Form 555. Most of these criticisms relate to data elements required on the form but of no subsequent practical use, and information which could be useful but which is not currently recorded. The interested reader is directed to Section 7.1.1 of that document for additional discussion.

The Commercial Vehicle Accident Report Summary (CVARS)

The development by the earlier USC project staff of the CVARS or "Green Sheet" (See Appendix B) involved nine months of activity in the early stages of the previous project, consisting of a three-way integration of inputs from the NHTSA, the CHP, and the project staff. A seven-page set of instructions was also developed for purposes of training and for establishing understanding and consistency in the application of the form.

The genesis of the CVARS was USC's submission to NHTSA in the fall of 1974 of a preliminary draft of a plan for development of this accident report supplement. It commenced with an attempt by USC to set forth a series of hypotheses to be tested, relating to the objective of substantiating the validity of NHTSA's new FMVS-121 Air Brake Standards, involving new anti-skid subsystems. When it became evident that too few new FMVS-121 brake systems would be operating on the highway over the course of the USC contract period, NHTSA modified its requirements for the variables and coding content of the CVARS report supplement. The next step was the submission in December 1974 by the project staff of a set of some 75 variables and 260 specific codes concerning truck accidents. Following some five months of integration effort by USC with NHTSA and the CHP, the final "Green Sheet" was established. The final configuration included 48 variables and 172 specific codes. Approval by both the CHP and NHTSA was established in April 1975. In the approved and final configuration, the CVARS included few specific questions bearing on the FMVS-121 Standard, but reflected rather general aspects of large truck/trailer performance and accident causation or contributing factors.

Through use we detected a number of defects in the design of this form. Again, these are detailed in the Technical Report (Volume I) and the interested reader is directed to Section 7.1.2 of that document.

Recommendations

The following general recommendations for reporting forms improvements are made as means for enhancing truck accident analysis capabilities. (Some detail-level changes in the forms, derived from CHP and project staff experience and from the data quality analysis that has been conducted, are recommended in the Technical Report, Volume I, Section 7.2.2.)

Accident Location. It is important that a reasonably precise accident reference location be cited for all highway accidents by noting the nearest milepost for a key event in the accident, such as the point of first impact. Additionally, X, Y, Z coordinates of pre-crash or post-crash events relative to the cited milepost reference could be noted on a Form 555 or associated CVARS report. Since many state highway logs give precise geometrics of state highways to an accuracy of ± one to five feet, accident location to this level of precision is feasible.

Truck-Car History. It is recommended that an expanded set of exposure-oriented data be collected on the trucks and cars involved in the reported accidents. Such additional vehicle historical data should perhaps include, but not be limited to:

a) Miles driven during the past 24 hours, week, month, and year
b) Current odometer reading
c) Total estimated mileage on vehicle if odometer is not functional
d) Miles planned for this trip
e) Miles completed on this trip prior to accident
f) Nature of general vehicle maintenance performed during past 12 months, such as:

i) Front end alignment
ii) Brake overhaul
iii) Tire/wheel servicing
iv) Suspension system servicing
v) Other

Driver Record or History. Considerable additional driver record of or history information should be collected on all involved drivers in order to assemble consistent exposure data. Such additional data should include:

a) How many days/weeks/months/years as commercial vehicle driver?
b) How many months/years since obtaining first driver's license?
c) How many months/years driving the truck type involved in the accident?
d) How many miles driven today (or last eight hours)?
e) How many traffic citations have been received in

i) Last month
ii) Last year
iii) Last five years
iv) Total driving history

Proposed Codes for Recording Narrative and Collision Diagram Data.

It is recommended that a set of codes be defined for convenient use of Form 555 narrative and collision diagram data. A procedure for extracting and encoding the collision data is described in Appendix E of the Technical Report, Volume I.

Proposed PDO Data. It is recommended that increased attention be given by traffic officers to estimating the PDO costs for all reported traffic involvements. Generally, current practice of traffic police departments is to ignore this type of data. It is believed that traffic officers can readily be trained to assess such costs with reasonable accuracy.

Proposed Injury Severity Data. It is recommended that increased use of injury severity data collected by emergency medical groups, e.g., paramedics, be merged with the existing Form 555. An addendum on injury severity could be appended to the form.

Proposed Training Program for Improved Sketching of Form 555 Collision Diagrams. A special program is recommended for training traffic investigators in improved procedures for drawing collision diagrams.

Ambiguities. Experience with the application and use of Form 555 and CVARS has emphasized that areas of ambiguity exist that lead to reporting inconsistencies and coding errors. Based on this experience, a new effort should be made to clean up the forms, specify important data elements more exactly, and eliminate all those proven to have little value or that are unduly difficult to develop.

9. PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

The principal findings, conclusions and recommendations stemming from this research effort have been summarized in the preceding sections. However, to provide a capstone to this report, certain of these are highlighted for emphasis.

Conclusions

The present study's commercial vehicle accident reports data base is capable of supporting an almost endless set of statistical analyses. An initial very small sampling of such analyses has been carried out. The required procedures and computer programs have been installed or developed, and, while they are capable of further improvement, complete analysis methods have been demonstrated and certain initial implications for accident causation and mitigation have been derived.

The introduction of exposure has been found to be important in explaining accident occurrence, albeit not as important as vehicle category (configuration and weight). Two independent exposure estimation procedures have provided the exposure values employed in obtaining this result. More important, they have illuminated the general capabilities and shortcomings of the processes and data involved. The results establish a foundation for the further evolution of exposure estimation techniques.

In sum, the development of a comprehensive commercial vehicle accident statistical analysis capability has been carried out. Strengths and weaknesses have been exhibited and exemplified with a range of cases of initial interest. Certain useful implications for accident causation have been established, and, while still very limited, some means for enhancing the possible understanding of countermeasures have been set forth.

Recommendations

Many areas of potential extension and improvement of the present study are now evident. Following are specific recommendations for the most important areas to be considered in future efforts:

a) A thorough review and "clean-up" of the present data base should be carried out. The need has been specifically demonstrated by the data quality analysis in the present study and by the sometimes large numbers of unknowns in the frequency tables.

b) Redesign of the CVARS and Summary coding forms and processing procedures is still to be accomplished. This should be done, and a new period of commercial vehicle accidents reporting should be instituted to aid in the establishment of an improved data base. The lessons learned in the present study would provide the basis for this redesign.

c) The univariate tables should be reviewed jointly with the CHP and NHTSA, and variables of little importance deleted. Other important variables that may have been neglected should be added to the redesigned forms.

d) An improved expanded file should be established to facilitate univariate and joint frequency data retrieval with less cumbersome, potentially error-prone procedures than are now sometimes necessary.

e) It is possible to develop many additional cross-tabulated or joint frequency tables of importance, even with the present data base and retrieval procedures. They provide immediately useful perceptions of variable interactions, albeit without measures of statistical significance. More of these should be established for their inherent value, and as guidance to more rigorous statistical analyses of interactions among variables of interest.

f) A powerful contingency table analysis capability is now available for use. A larger data base is required to enable its application at the detailed levels needed to be treated in studies of accident factors that can be affected by meaningful countermeasures (e.g., specific vehicle equipment and driver characteristics). The building of this larger data base has already been recommended. These further analyses should be conducted concomitantly.

g) An improved direct exposure estimation procedure is vitally needed. The procedure developed in the present study is believed to make the best possible use of the AADT and TWS data that were readily available. An enhancement incorporating other available special data, and also new data from new data development procedures, some of which are already receiving attention elsewhere (e.g., special traffic sampling at selected locations), should be established. The present procedure has deliberately been built on a framework that can help to structure the integration of these new procedures and data into the estimation process.

h) An enhanced contingency table analysis process incorporating exposure is desirable to allow more detailed investigations of the impact of exposure on important accident variable interactions and, thus, causation.

i) Similarly, a contingency table analysis process should be developed for incorporating economic costs of accidents more directly than was possible in the present study.

SELECTED REFERENCES

1. Thorpe, J. D. "Calculating Relative Involvement Rates in Accidents without Determining Exposure." Australian Road Research 2 (1964): 25-36. Reported in Traffic Research Review 11 (1967): 308.

2. Haight, F. A. "Induced Exposure." Accident Analysis and Prevention 5, No. 2 (June 1973).

3. Scott, R. E., et al. Statistical Analysis of Truck Accident Involvements. Report prepared for National Highway Traffic Safety Administration, University of Michigan, Ann Arbor, December 1971.

4. Hedlund, J. The Severity of Large Truck Accidents. Technical note DOT HS-802322. National Highway Traffic Safety Administration, April 1977.

TRAFFIC COLLISION REPORT **DEPARTMENT OF CALIFORNIA HIGHWAY PATROL**

LOCATION

PARTY 1 — STREET ADDRESS — CITY — STATE — PHONE — OWNER'S NAME — SAME AS DRIVER — OWNER'S ADDRESS — SAME AS DRIVER — VEHICLE DAMAGE — VIOLATION CHARGED

PARTY 2 — STREET ADDRESS — CITY — STATE — PHONE — OWNER'S NAME — SAME AS DRIVER — OWNER'S ADDRESS — SAME AS DRIVER — VEHICLE DAMAGE — VIOLATION CHARGED

PROPERTY — DESCRIPTION OF DAMAGE — OWNER'S NAME — ADDRESS

INJURED/WITNESS — EXTENT OF INJURY — NAME — PHONE — ADDRESS — TAKEN TO (INJURED ONLY)

SKETCH — INDICATE NORTH — MISCELLANEOUS

VEHICLE TYPE			
PARTY 1		PARTY 2	

ROAD TYPE
A CONVENTIONAL, ONE WAY
B CONVENTIONAL, TWO WAY
C EXPRESSWAY
D FREEWAY
E OTHER (EXPLAIN IN NARRATIVE)

CHP 555

APPENDIX A. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, (FORM 555) PAGE 1

No.

PAGE ____

COLLISION NARRATIVE

PRIMARY COLLISION FACTOR

- A VC SECTION VIOLATION ____
- B OTHER IMPROPER DRIVING*
- C OTHER THAN DRIVER*
- D UNKNOWN*

WEATHER

- A CLEAR
- B CLOUDY
- C RAINING
- D SNOWING
- E FOG
- F OTHER ____

LIGHTING

- A DAYLIGHT
- B DUSK - DAWN
- C DARK - STREET LIGHTS
- D DARK - NO STREET LIGHTS
- E DARK - STREET LIGHTS NOT FUNCTIONING

ROADWAY SURFACE

- A DRY
- B WET
- C SNOWY - ICY
- D SLIPPERY (MUDDY, OILY, ETC.)

ROADWAY CONDITIONS
(MARK ONE TO THREE ITEMS)

- A HOLES, DEEP RUTS
- B LOOSE MATERIAL ON ROADWAY
- C OBSTRUCTION ON ROADWAY
- D CONSTRUCTION-REPAIR ZONE
- E REDUCED ROADWAY WIDTH
- F FLOODED
- G OTHER ____
- H NO UNUSUAL CONDITIONS

RIGHT OF WAY CONTROL

- A CONTROLS FUNCTIONING
- B CONTROLS NOT FUNCTIONING
- C CONTROLS OBSCURED
- D NO CONTROLS PRESENT

TYPE OF COLLISION

- A HEAD-ON
- B SIDESWIPE
- C REAR END
- D BROADSIDE
- E HIT OBJECT
- F OVERTURNED
- G AUTO-PEDESTRIAN
- H OTHER ____

MOTOR VEHICLE INVOLVED WITH

- A NON-COLLISION
- B PEDESTRIAN
- C OTHER MOTOR VEHICLE
- D MOTOR VEHICLE ON OTHER ROADWAY
- E PARKED MOTOR VEHICLE
- F TRAIN
- G BICYCLE
- H ANIMAL ____
- I FIXED OBJECT ____
- J OTHER OBJECT ____
- K OTHER ____

PEDESTRIAN'S ACTION

- A NO PEDESTRIAN INVOLVED
- B CROSSING IN CROSSWALK AT INTERSECTION
- C CROSSING IN CROSSWALK - NOT AT INTERSECTION
- D CROSSING - NOT IN CROSSWALK
- E IN ROAD - INCLUDES SHOULDER
- F NOT IN ROAD
- G APPROACHING/LEAVING SCHOOL BUS

TYPE OF VEHICLE (1 2 3 4)

- A PASSENGER CAR (INCLUDES STATION WAGON)
- B PASSENGER CAR W/TRAILER
- C MOTORCYCLE/SCOOTER
- D PICKUP OR PANEL TRUCK
- E PICKUP OR PANEL TRUCK W/TRAILER
- F TRUCK OR TRUCK TRACTOR
- G TRUCK OR TRUCK TRACTOR W/TRAILER(S)
- H SCHOOL BUS
- I OTHER BUS
- J EMERGENCY VEHICLE
- K HIGHWAY CONSTRUCTION EQUIPMENT
- L BICYCLE
- M OTHER ____

OTHER ASSOCIATED FACTOR (1 2 3 4)
(MARK ONE TO THREE ITEMS)

- A VC SECTION VIOLATION ____
- B VC SECTION VIOLATION ____
- C VC SECTION VIOLATION ____
- D VC SECTION VIOLATION ____
- E VISION OBSCUREMENTS ____
- F INATTENTION
- G STOP & GO TRAFFIC
- H ENTERING/LEAVING RAMP
- I PREVIOUS COLLISION
- J UNFAMILIAR WITH ROAD
- K DEFECTIVE VEHICLE EQUIPMENT ____
- L UNINVOLVED VEHICLE
- M OTHER*
- N NONE APPARENT

MOVEMENT PRECEDING COLLISION (1 2 3 4)

- A STOPPED
- B PROCEEDING STRAIGHT
- C RAN OFF ROAD
- D MAKING RIGHT TURN
- E MAKING LEFT TURN
- F MAKING U TURN
- G BACKING
- H SLOWING - STOPPING
- I PASSING OTHER VEHICLE
- J CHANGING LANES
- K PARKING MANEUVER
- L ENTERING TRAFFIC FROM SHOULDER, MEDIAN, PARKING STRIP OR PRIVATE DRIVE
- M OTHER UNSAFE TURNING
- N CROSSED INTO OPPOSING LANE
- O PARKED
- P MERGING
- Q TRAVELING WRONG WAY
- R OTHER ____

SOBRIETY - DRUG - PHYSICAL (1 2 3 4)
(MARK ONE TO THREE ITEMS)

- A HAD NOT BEEN DRINKING
- B HBD - UNDER INFLUENCE
- C HBD - NOT UNDER INFLUENCE
- D HBD - IMPAIRMENT UNKNOWN
- E UNDER DRUG INFLUENCE
- F OTHER PHYSICAL IMPAIRMENT*
- G IMPAIRMENT NOT KNOWN
- H NOT APPLICABLE

INVESTIGATED BY	I.D. NUMBER	INVESTIGATED BY	I.D. NUMBER	REVIEWED BY

*EXPLAIN IN NARRATIVE

APPENDIX A. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, (FORM 555) PAGE 2

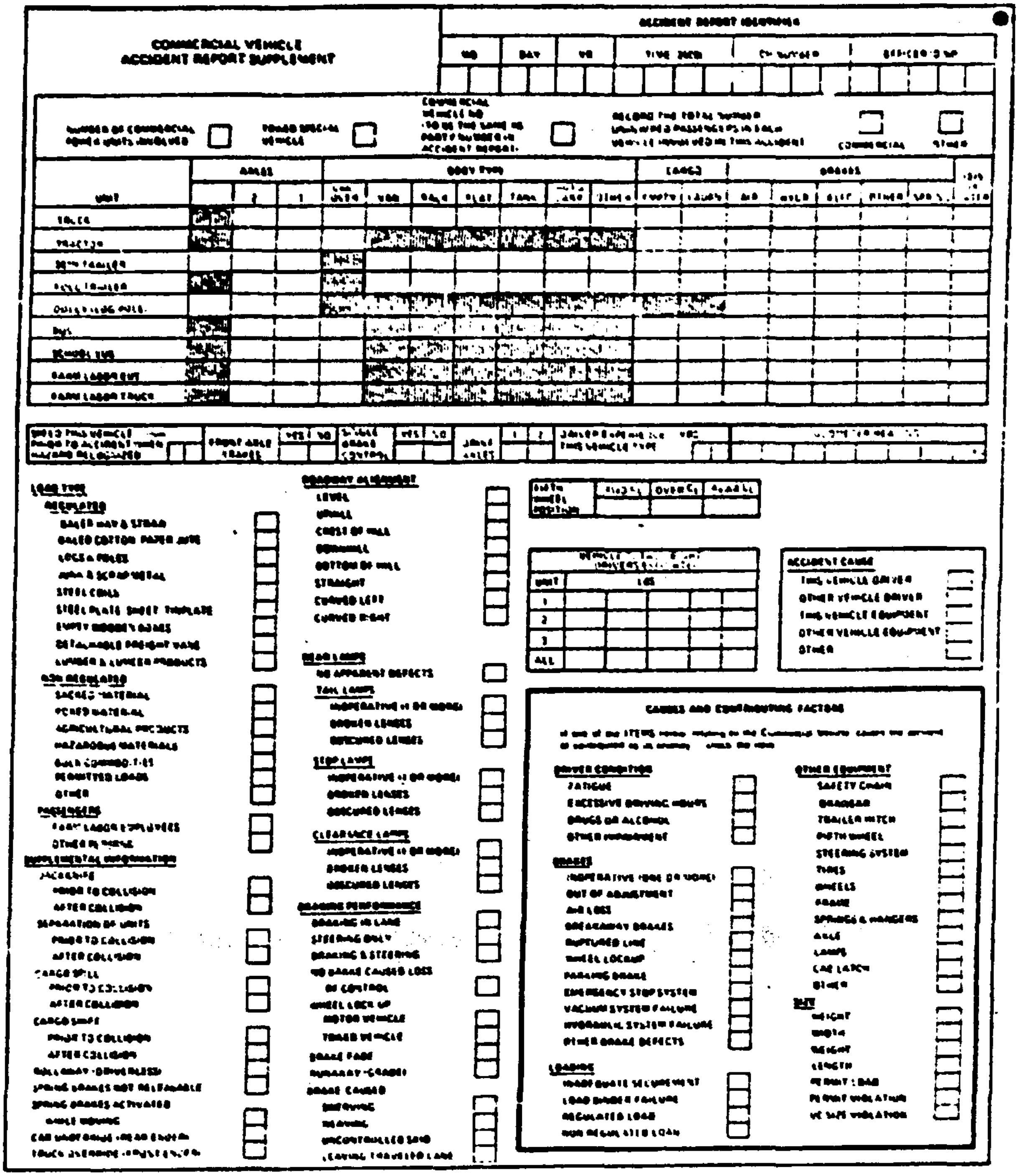
SKETCH - NARRATIVE CONTINUATION

NARRATIVE CONTINUATION (Use reverse side as necessary)

APPENDIX A. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, SKETCH NARRATIVE CONTINUATION, PAGE 3

SUPPLEMENTAL		
TRAFFIC COLLISION REPORT		
PREPARED BY	I.D. NUMBER PREPARED	REVIEWED - APPROVED BY	I.D. NUMBER	DATE

APPENDIX A. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, SUPPLEMENTAL, PAGE 4



APPENDIX B. CALIFORNIA HIGHWAY PATROL COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT ("GREEN SHEET")