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STATISTICAL ANALYSES OF COMMERCIAL VEHICLE ACCIDENT FACTORS
Volume I, Part I

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Appendix A, which includes the univariate analyses, may be found in Part II of Volume I.

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.

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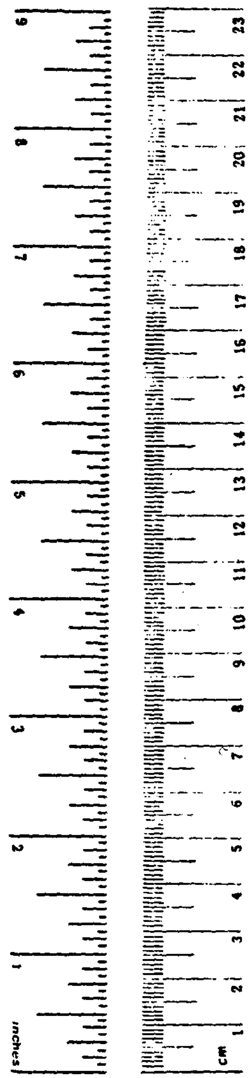
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

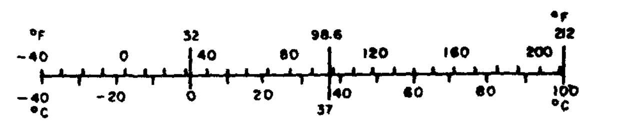
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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

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



Approximate Conversions from Metric Measures

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



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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

STATISTICAL ANALYSES OF COMMERICAL VEHICLE ACCIDENT FACTORS

1. INTRODUCTION AND SUMMARY

This report is submitted in fulfillment of the requirements of Contract No. DOT-HS-7-01565, awarded to the University of Southern California (USC) by the National Highway Transportation Safety Administration (NHTSA) of the U. S. Department of Transportation. It presents the results of a 12-month study of commercial vehicle accident statistics, 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. 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) surrogates for accident economic costs.

1.1. Background

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 accident miles travelled [VMT] by each category of commercial vehicle of interest during a specified time period), first cuts at certain statistical analyses of accident frequency and exposure data, and some inferences on 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 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 (located near Sacramento and Los Angeles) of the California Highway Patrol (CHP) during the period 15 May–15 August 1975. Exposure data consisted of counts of certain relatively specific truck characteristics and of less detailed supplementary truck traffic volumes, observed 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, 15 May 1975–1 May 1976.[1] 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.

The earlier study derived a set of univariate frequency tables for the variables included in the accident reports. The present study repeats these tables with the larger data base now available. As in the previous study, the variables that appear to be most important in the accident reports, as measured by the frequencies of occurrence of their more consequential levels, are then assessed in a set of stepwise regression analyses. These are meant to establish significant models for various relationships of accident frequency and vehicle, driver, and environmental characteristics.

While these models were end products in the previous study, in the present study they serve only as intermediate steps in the refinement of the selection of important accident variables. Variables selected in this way are now further analyzed with contingency

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[1] Completion of the CVARS was terminated by the CHP on 1 May instead of 15 May because of an administrative oversight. The numerical results of the present study take this into account.

table methods to establish their significant interactions with accident occurrences. These interactions define log-linear models with fewer allowed variables in practice than linear regression models, but decreased arbitrariness in assumptions, and thus greater confidence in the results.

The contingency table analysis also enables the convenient introduction of an exposure variable into the causation analysis. In the earlier study, it was possible to employ exposure only in developing independent accident factor involvement rates. The power of the contingency table procedures makes possible the joint consideration of several factors together with exposure, with the all-important dependencies thereby allowed to become evidenced.

A final dimension of the present study, already touched on, is the 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 the significance statements in the outputs of the regression and contingency table analyses. However, only limited success has been achieved in this regard in other aspects of the study. This is due primarily to 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.

1.2. Approach

Figure 1-1 is a flow diagram of the present study's activities and their interrelationships. It calls out the tasks delineated in

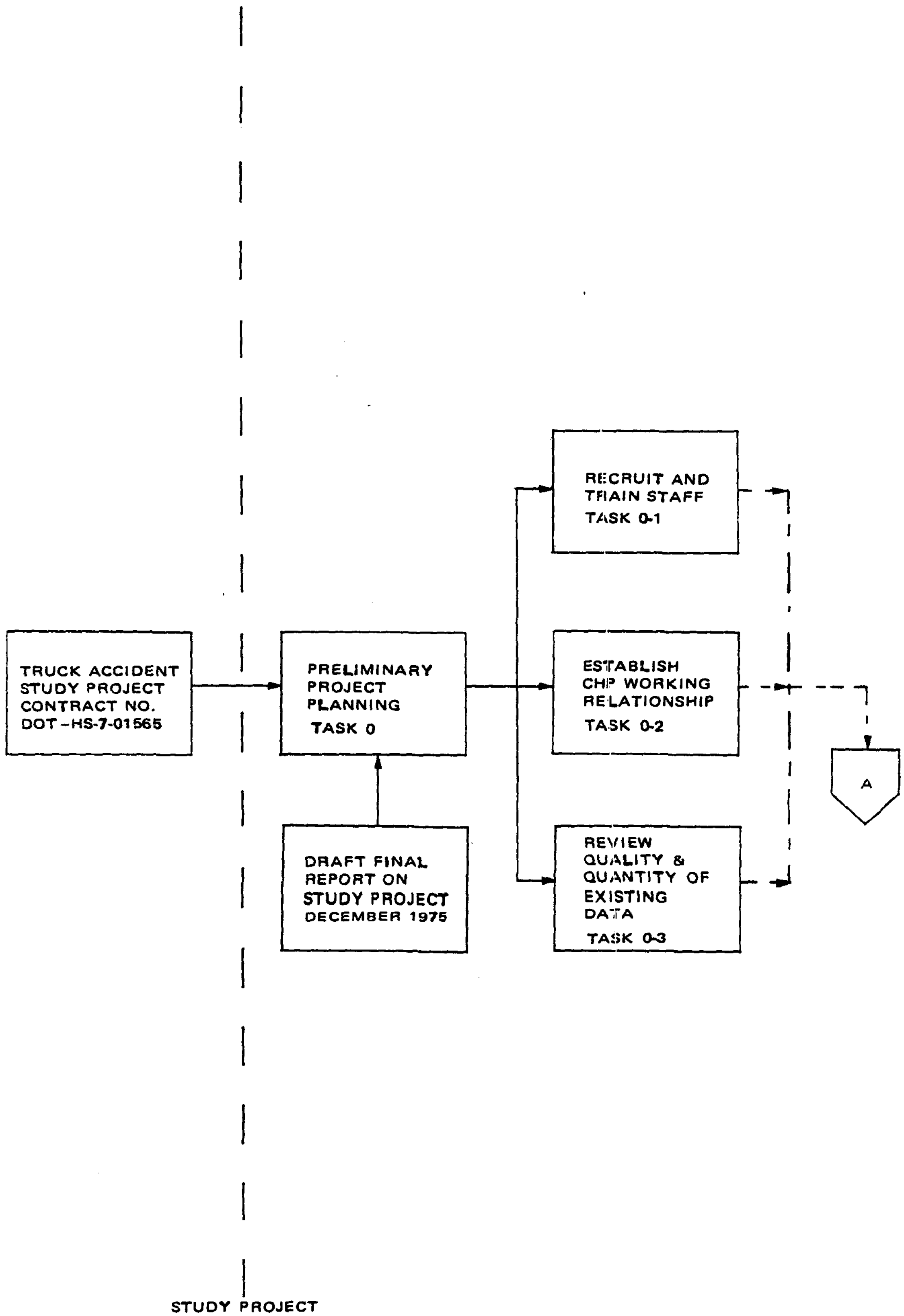


FIGURE 1-1. OVERALL PROJECT ACTIVITY FLOW (SHEET 1 OF 9)

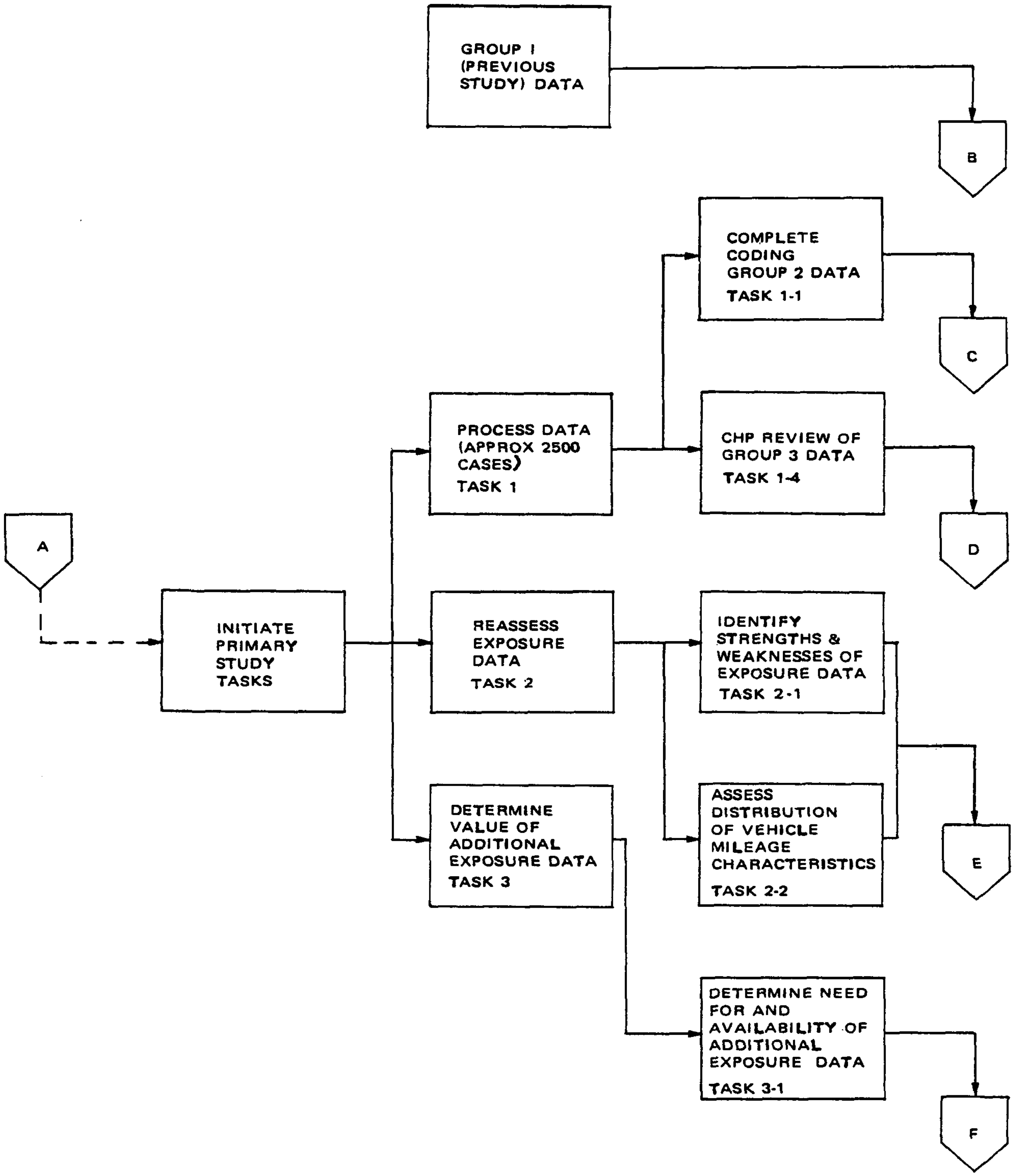


FIGURE 1-1. (SHEET 2 OF 9)

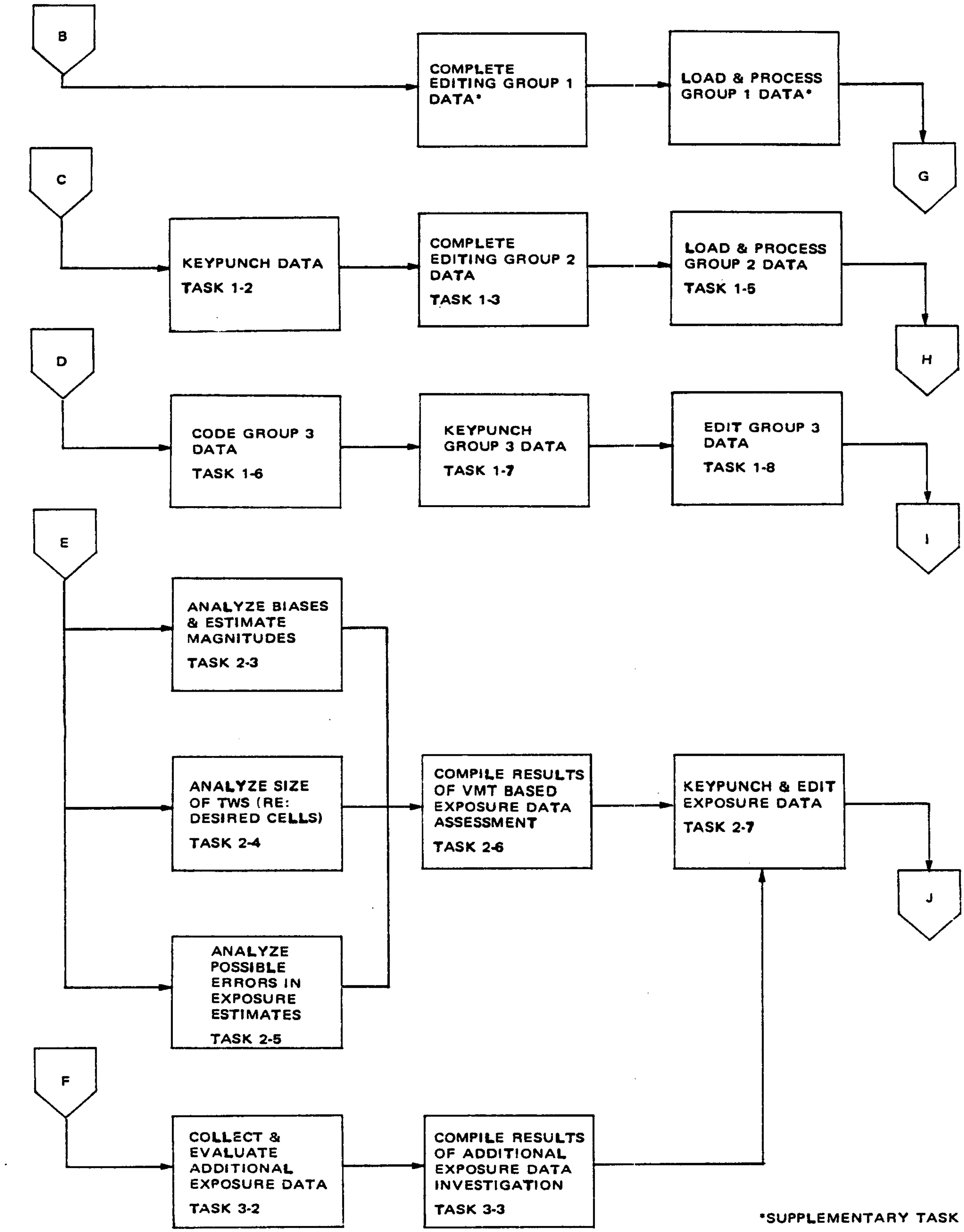


FIGURE 1-1. (SHEET 3 OF 9)

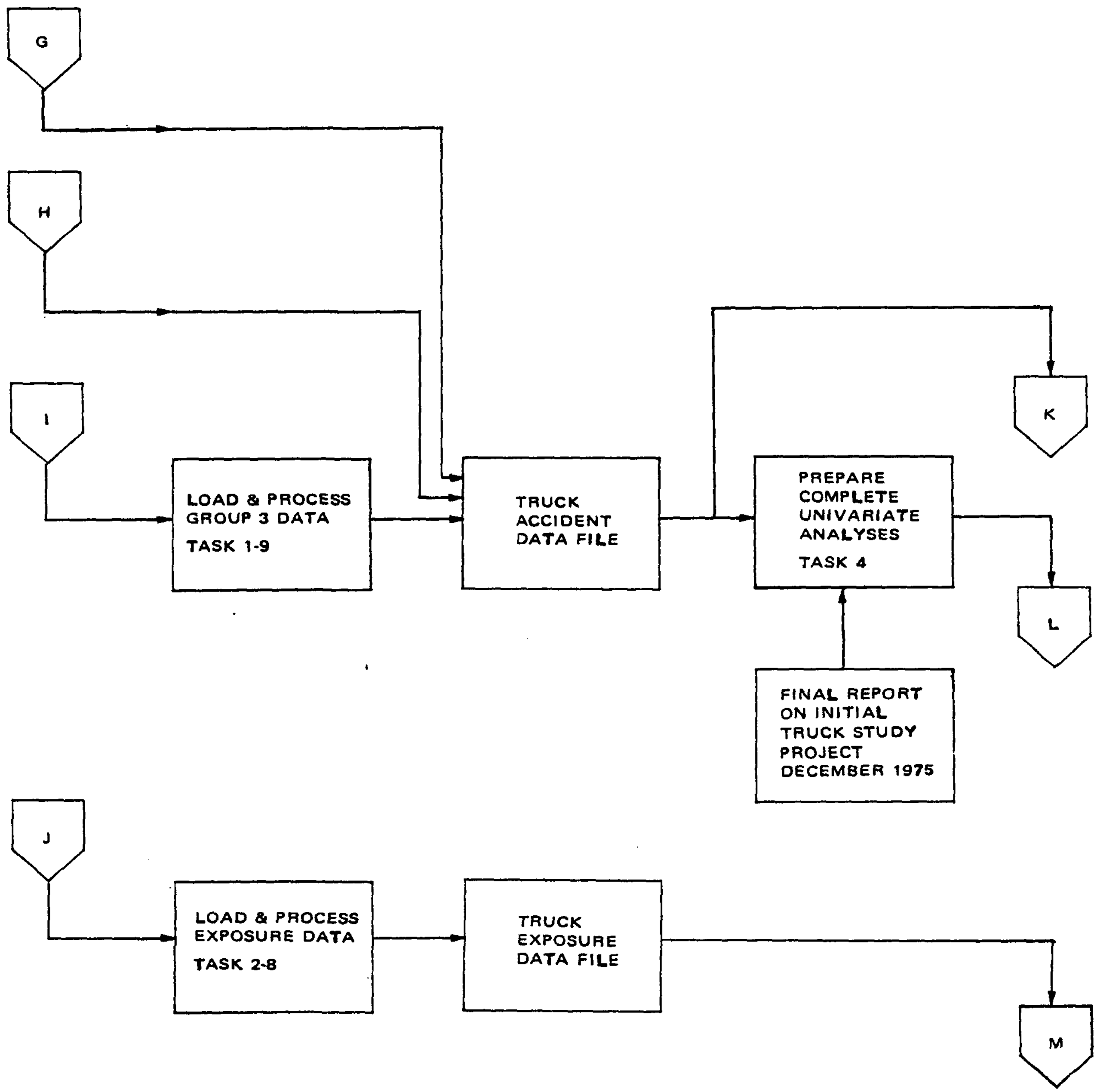


FIGURE 1-1. (SHEET 4 OF 9)

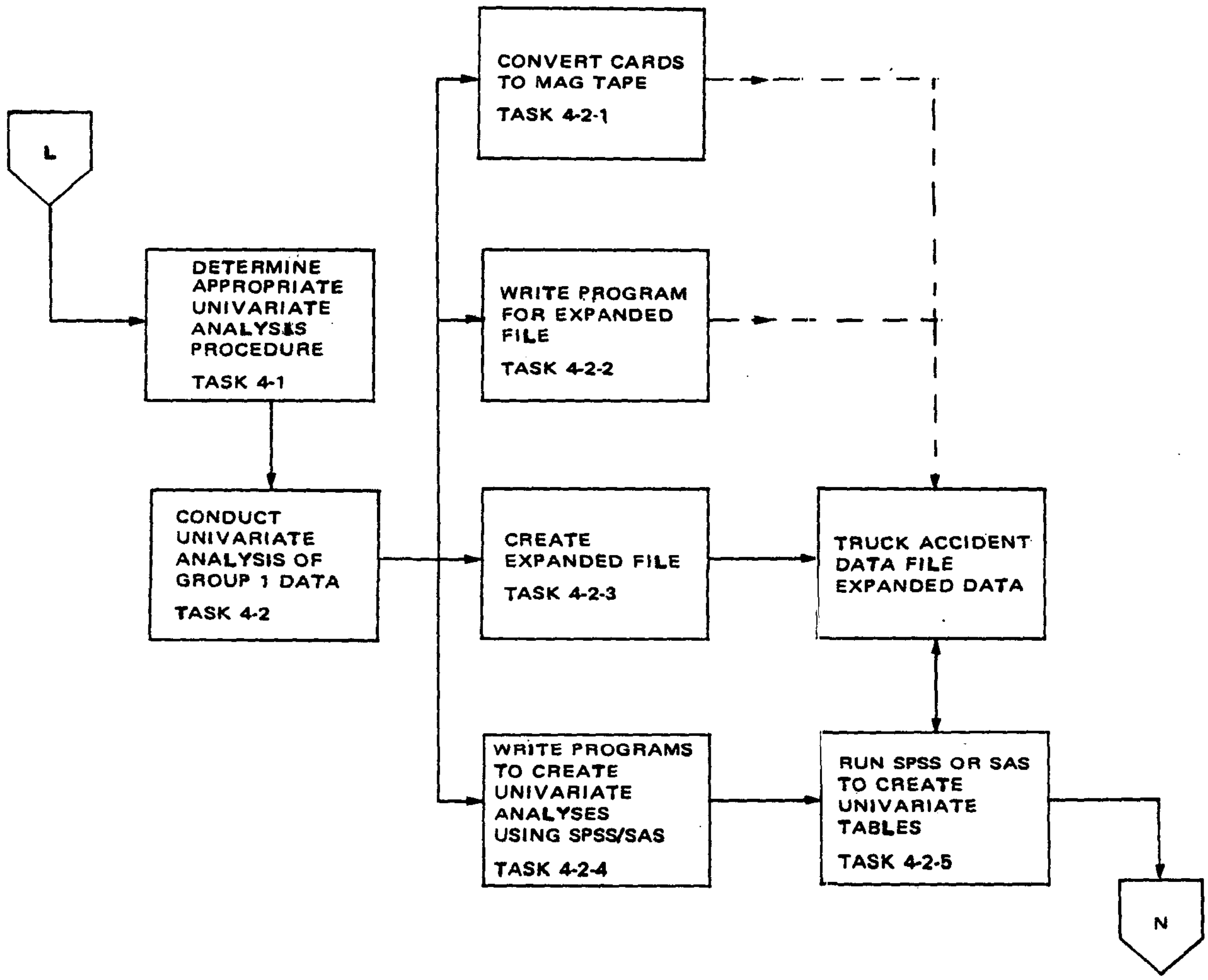


FIGURE 1-1. (SHEET 5 OF 9)

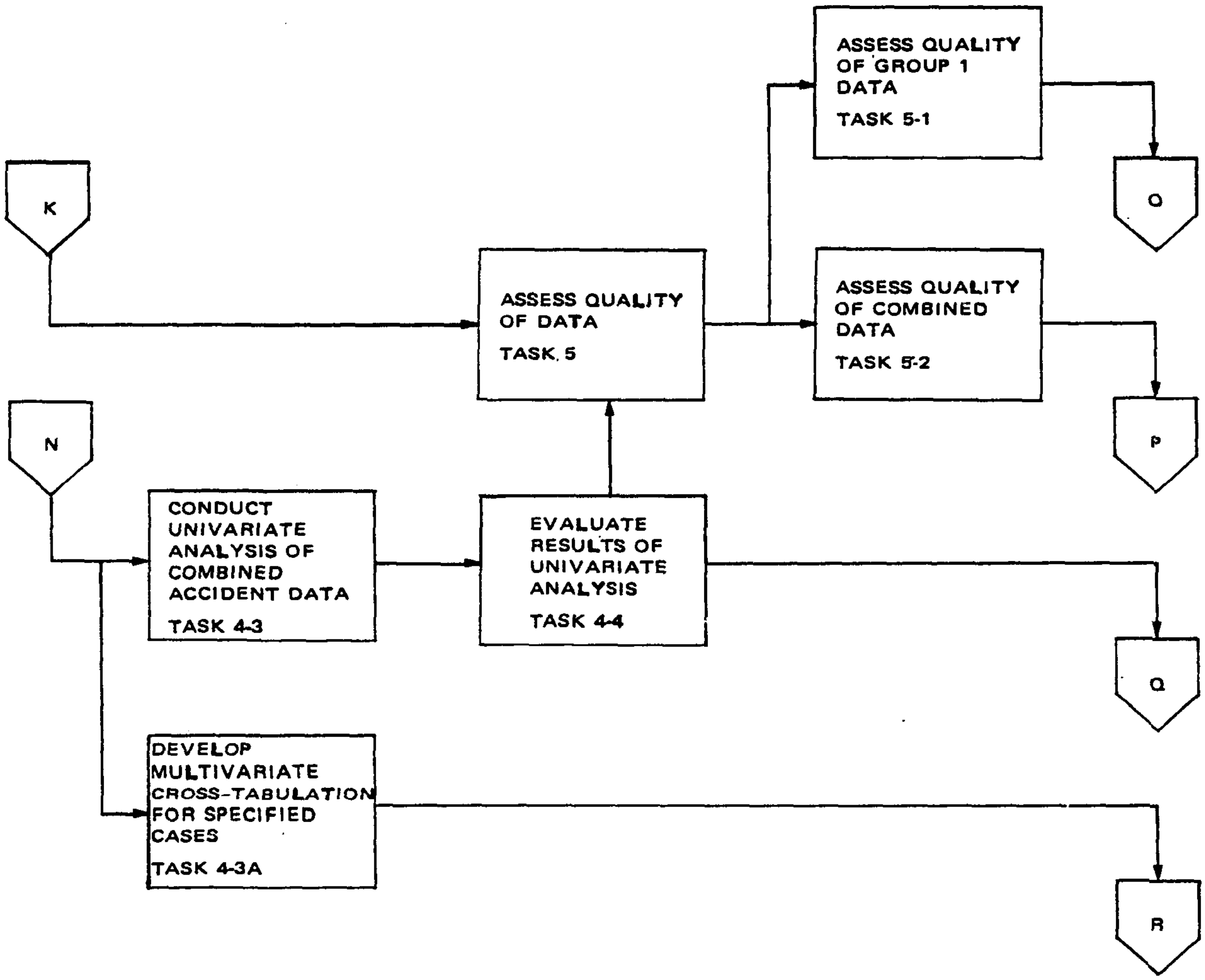
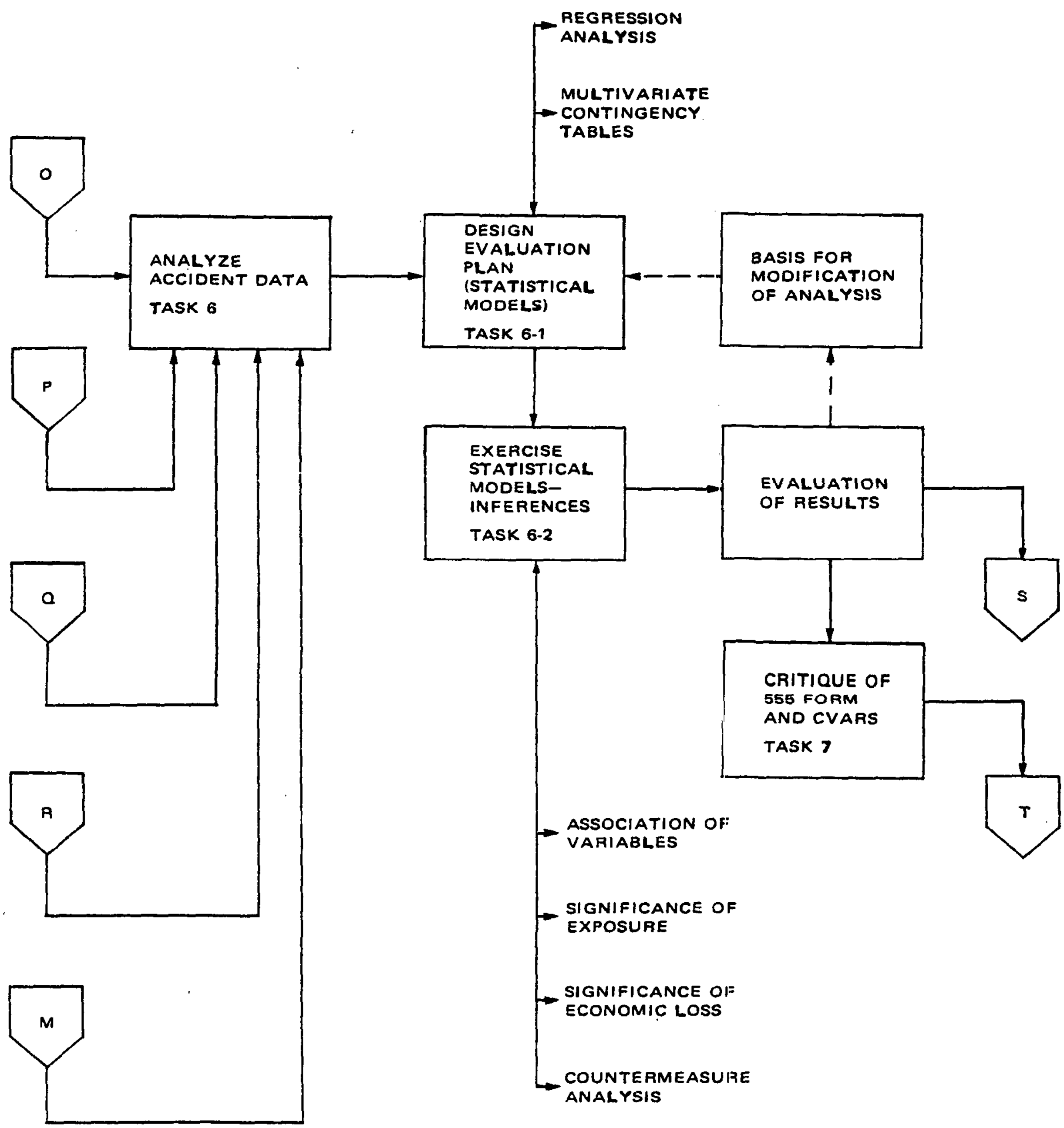


FIGURE 1-1. (SHEET 6 OF 9)



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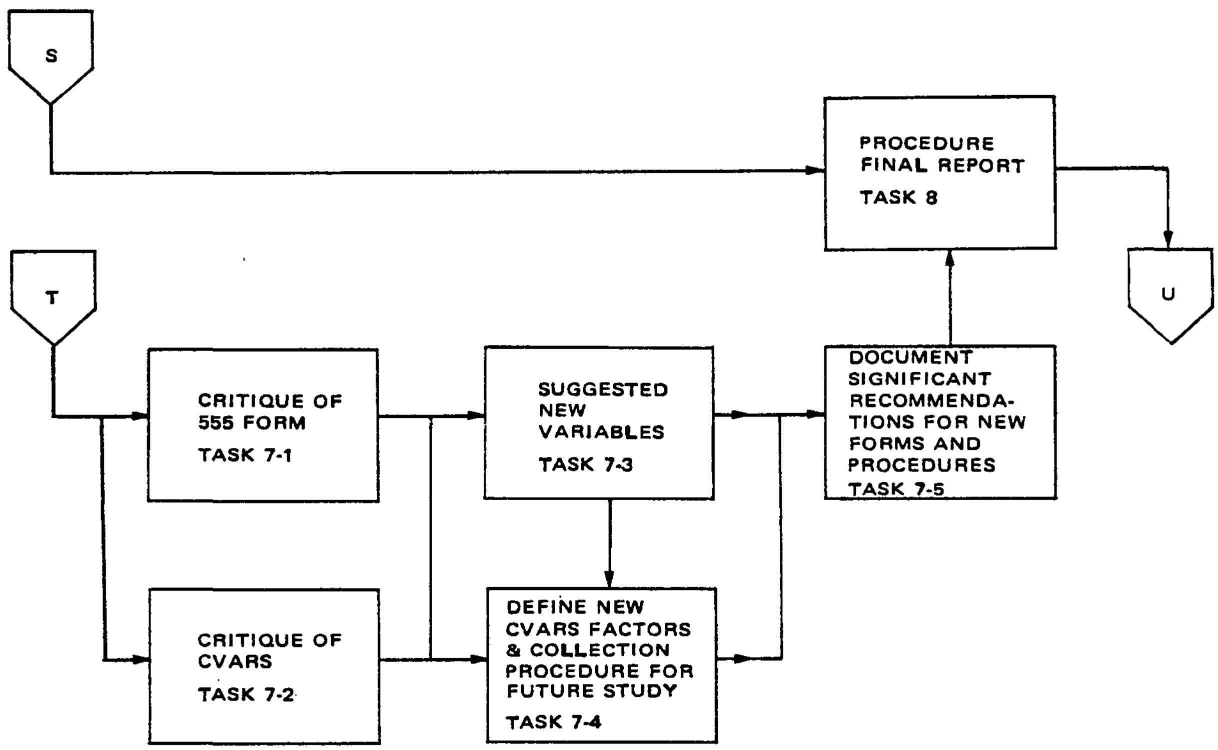

FIGURE 1-1. (SHEET 8 OF 9)

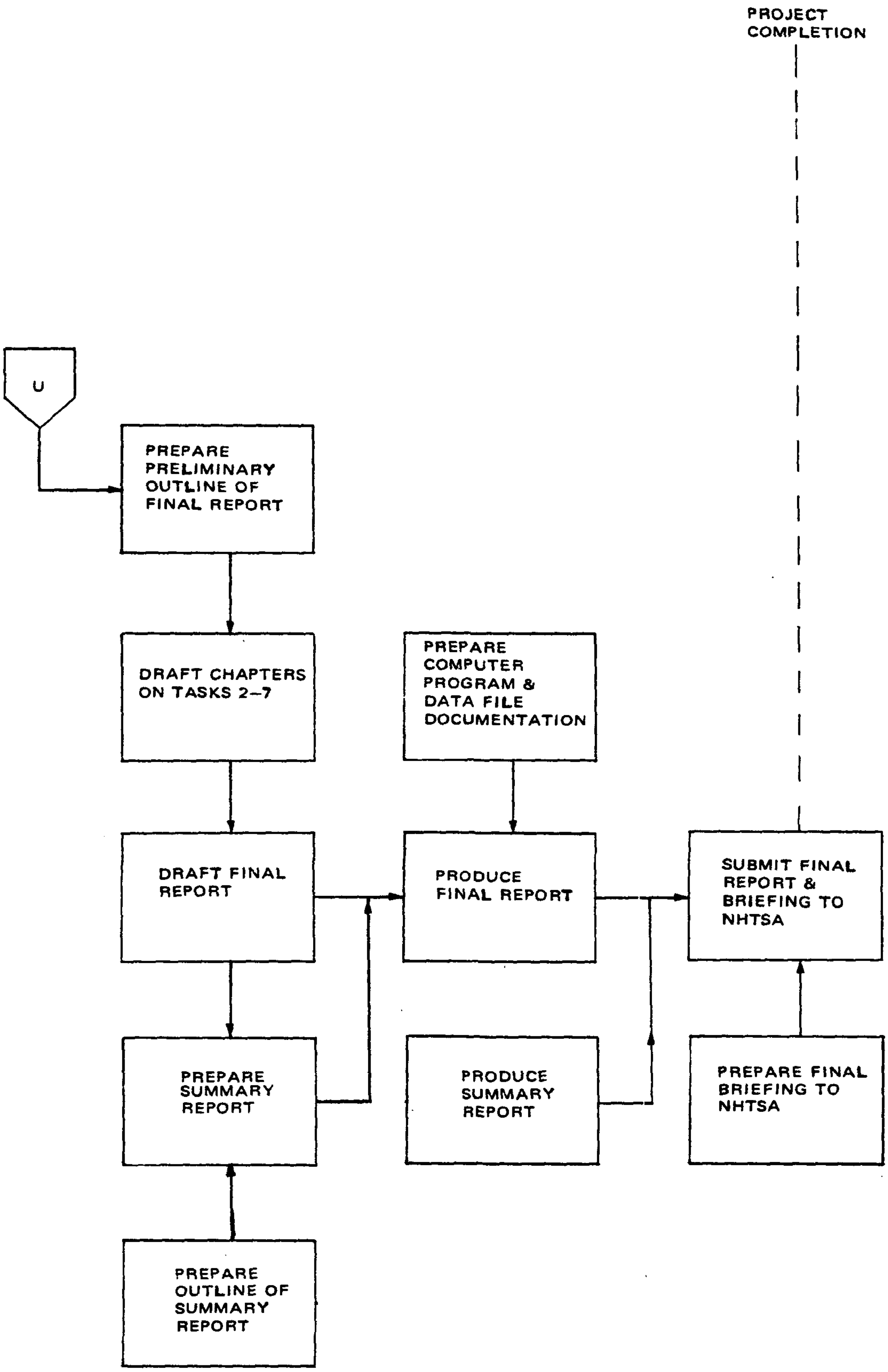

FIGURE 1-1. (SHEET 9 OF 9)

the contract Statement of Work (SOW) and breaks them further into the subtasks that have been conducted to meet the SOW's detailed requirements. A summary of the highlights of the more significant of these tasks and subtasks is presented next.

The planning and initiation of the project (Task 0) 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. Unfortunately, some difficulty was experienced in the acquisition of all requisite information, because of the turnover of certain key personnel since the completion of that study a year earlier. Most particularly, the accident data tape employed in the previous study was no longer available and had to be reconstructed from the hard-copy coded accident reports and, in some cases, the original reports themselves. This added considerable time to the reacquisition of these data.

The second unique feature of the project initiation 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 15 August 1975–1 May 1976. This review and verification was to be accomplished early in the study. However, priority CHP requirements delayed the selected officer's accomplishment of the effort for some three months. This created major difficulties in other project work, as will be further explained later.

Accident data processing (Task 1) involved three groups of accident report cases.

a) Group 1 consists of the 925 cases reported on, coded, keypunched, filed, and analyzed in the previous study. (As has been noted, however, their computer tape was no longer available, so that some keypunching and filing had to be done again.) These cases cover the time period 15 May-15 August 1975.

b) Group 2 consists of 934 cases for the time period 16 August–15 November 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 16 November 1975–1 May 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. It was hoped that this would save time if, as was expected, the CHP's review found only a few reporting errors that would necessitate changes to the file. Instead, as will be discussed later, massive discrepancies in the field reports were discovered, and, late in the project, the entire Group 3 file had to be re-keypunched and reentered into the record. The magnitude of the corrections made by the CHP officer, and the possibility that must be recognized of his introducing errors as well, also raise the question of whether an independent second verification would have been desirable.

In parallel with the accident data processing efforts, an exposure data acquisition, processing, and analysis procedure (Tasks 2 and 3) 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 commercial vehicles. A careful structuring of a clearcut process for estimating VMT as a usable measure of exposure was worked out.

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

This enables comprehensive identification of the strengths and weaknesses of the two sets of basic data and of the steps by which they are integrated and extrapolated. Areas for possible improvement can then be delineated. The entire effort is discussed in detail later in this report. It may be noted now, however, that while the procedures followed by CALTRANS in developing their data may be adequate for the purposes of CALTRANS' normal activities, they were found to be weak in many vital respects for the purposes of this study. Nevertheless, since they remain the only usable data available, the CALTRANS data have been employed in the present exposure estimates. A considerable effort has been made to explicate their weaknesses and, wherever possible, to make evident means for mitigating them.

Qualitative assessments of the quality of the accident and exposure data (Task 5) 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 comparisons of the final records of both versions. 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 (Task 4). These provide descriptions of all the 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. These apply to the objectives of Task 5, discussed above.

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 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 on 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 (Task 6). 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, VMT, as estimated in Tasks 2 and 3, 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 in the first case but not in the second, 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 involved 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. It is simply to consider only accidents with major severities or fatalities 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.

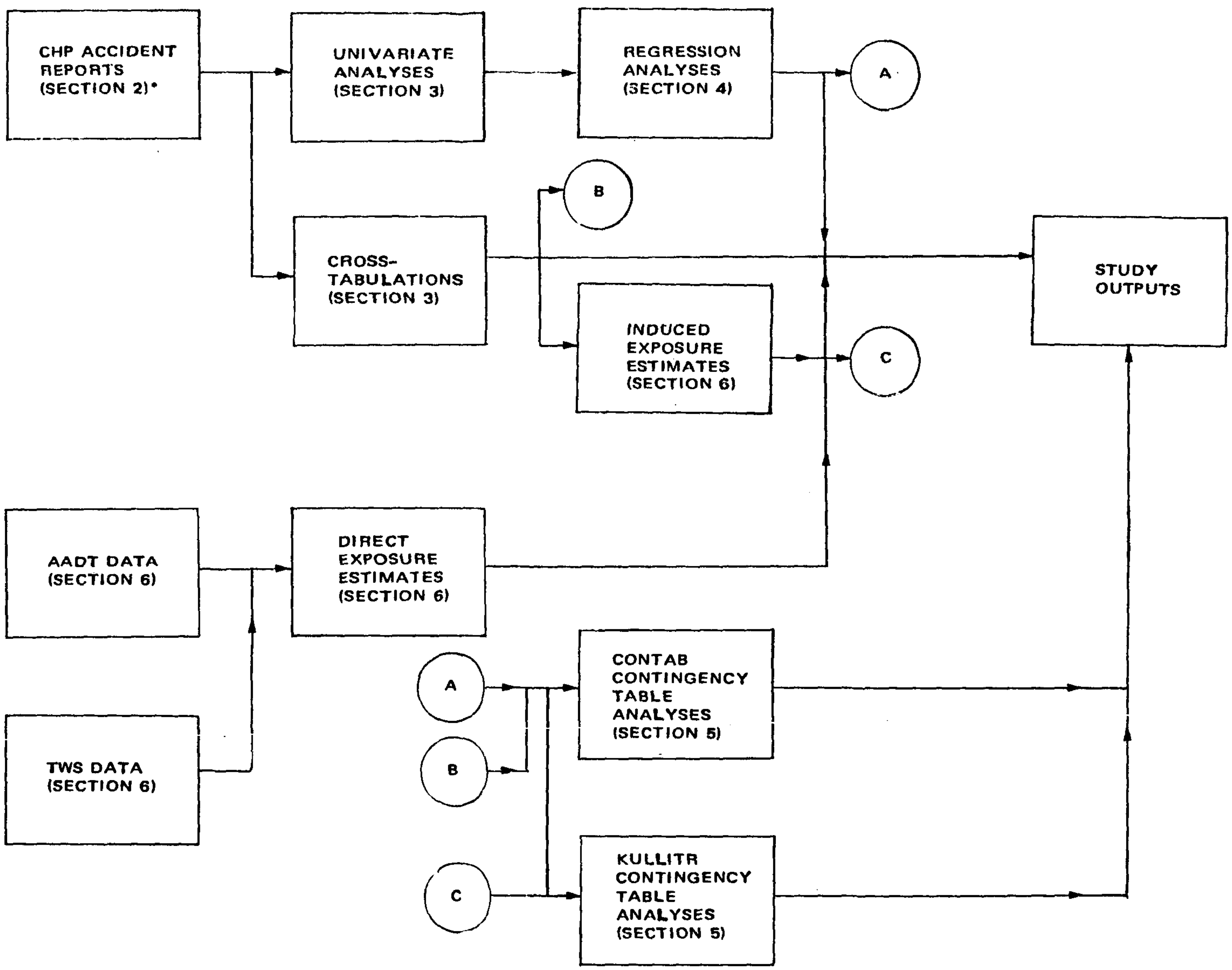
The final analytical task (Task 7) is the review of the basic and supplementary CHP reports. It is evident from what has already been said that a high frequency of error appears to be possible with these reports. A set of recommendations is established for their improvement.

1.3. Principal Results

Figure 1-2 outlines the statistical analysis process that has been carried out. The main methodological and numerical results that have been obtained in the indicated steps of this process are next summarized. Complete discussions are to be found in the report sections indicated in the figure.

1.3.1. Accident Data Development: CHP Accident Reports and Processing of Data

The reporting, coding, and keypunching of the two CHP accident



*REPORT SECTION IN WHICH TOPIC INDICATED IS DISCUSSED.

FIGURE 1-2. STATISTICAL ANALYSIS PROCESS SUMMARY report forms (the Collision Report [Form 555] and the CVARS), as with other similar forms, have been susceptible to, and have exhibited, many errors. The present study has attempted both to minimize them through verification efforts and to assess their impacts. In the latter area, a data quality test has been carried out that evaluates coding and keypunching errors.

The verification effort has exposed a need to overcome subjective errors resulting from interpretation difficulties in the original completion of the reports. The coding and keypunching error test has also indicated points of difficulty in interpretation as well as sources of more mechanical errors. Among the recommendations for further investigations given in Section 1.5 below are efforts aimed at minimizing these difficulties.

The formatting of fixed-length data files to facilitate their analysis with standard statistical packages has been straightforward. However, accident reports involving unusually large numbers of vehicles or individuals had to be deleted to allow this. Only a small number of reports have been affected in the present study, but in the future, if the file grows, and the number of unusual cases increases, it may become desirable to develop more flexible procedures so that all reports can be treated.

1.3.2. Univariate Analyses

Univariate frequency tables, histograms, and descriptive statistics are provided in Appendix A for the many variables represented in the accident reports. A detailed discussion of their implications is given in Section 3 below. Reasonable consistency with the results of a previous study [1] has been observed. Certain points of particular significance may be summarized as follows:

a) 68.4% of the reported commercial vehicle accidents involved two vehicles; 20.3% only the commercial vehicle.

b) 25.5% of the involved vehicles were three-axle tractor/ two-axle semi-trailer combinations; 24.1% were two-axle trucks, buses or tractors; 17.3% were two-axle tractor/one-axle semi-trailer/two-axle full-trailer combinations.

c) 3.4% of the involved vehicles jackknifed before the accident; 3.9% after.

d) 6.2% of the accidents involved an automobile underriding the commercial vehicle.

e) 15.8% of the accidents occurred when the commercial vehicle was proceeding downhill.

f) The commercial vehicle driver was deemed to be at fault in 45.7% of the accidents; equipment was at fault in 10.8% of the accidents.

g) In over 60% of the accidents, the commercial vehicles involved were laden.

h) No commercial vehicle occupant injury occurred in over 90% of the reported accidents; only about 0.4% involved fatalities among these occupants.

i) About 87% of the involved non-commercial vehicle occupants suffered no worse than minor injuries; 4.5% suffered fatalities.

1.3.3. 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, and also at intersections and ramps, is about twice as large as it is elsewhere on freeways and expressways. 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 be greater 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 appears to be significantly greater than for non-cabover vehicle occupants. Interestingly, however, the chance of minor injuries appears to be greater for the latter.

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.

1.3.4. Regression Analyses

Five regression analyses have been conducted, resulting in linear models for certain dependent variables in terms of sets of the most significant related independent variables. However, in all cases the models have turned out to provide poor fits to the data, implying that linearity is not a satisfactory assumption for the relationships among the variables. The regression models have therefore not been further employed in accident causation analysis.

However, the regression process has been helpful in selecting the most significant independent variables for certain of the contingency table analyses that followed.

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) Override 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)

1.3.5. CONTAB Contingency Table Analyses

The failure of linear regression models reinforces the desirability of investigating the utility of more general log-linear models. These potentially take into account all higher-order, as well as first-order interactions between the dependent variable and individual independent variables. All categorical variables are treated directly as such. Comprehensive causation analyses are thereby facilitated.

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.

1.3.5.1. Jackknife-Before-Accident (JKBA)

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, RS is the most important independent variable: of the three first-order interactions, the JKBA'RS interaction explains the greatest variation.

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. An important secondary result is that the presence of two drive-axles is predicted to decrease the JKBA odds by a factor of approximately 3.5, whatever the RS and LU characteristics.

1.3.5.2. Accident Severity

An earlier CONTAB study was conducted by James Hedlund of NHTSA of the factors in the occurrence of a fatality, employing a nation-wide data base [2]. 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. 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.

1.3.5.3. Brakes-Related Accidents

This CONTAB study has investigated the interactions among variables related to the causation of brakes-related accidents. The corresponding regression analysis has indicated that the variable Road Direction: Downhill or not, is the most important single factor in this type of accident. The association of commercial vehicle characteristics is also of interest.

The analysis therefore 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)

It is found that the most important individual variable in explaining the data is again Road Direction. A satisfactory model, explaining 64% of the initial variation, subsumes the single three-way interaction, Brakes-related accident/Direction/Configuration. Vehicle weight is not important.

Some representative odds analyses have been performed using the predicted joint frequencies of this 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 (and independent of weight). The analogous result for a five-axle tractor/semi-trailer is that the downhill, brakes-related accident odds are 4.6 times times those for a non-downhill road.

1.3.5.4. "High-Cost" Brakes-Related Accidents

It is desired to investigate how the set of important interactions and model predictions might change if the costs of accidents, rather than just their frequency, were considered as the measure of the dependent variable. Time has permitted only an exemplary analysis of one surrogate case. High-severity brakes-related accidents are studied in a CONTAB analysis under the assumption that they adequately represent high-cost accidents of this kind.

The analysis proceeds exactly as with the complete set of brakes-related accidents described in Section 1.3.5.3 above, except that now only the higher-severity accident reports are considered (minor visible injury, major injury, and fatality; the reports involving no injuries or only "complaint of pain" are deleted).

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 odds that were discussed in Section 1.3.5.3 are also essentially the same for the two-axle single-unit truck. However, the odds for the five-axle tractor/semi-trailer appear to differ significantly. For a downhill road, the odds of a high-severity, brakes-related accident are only a fifth as great as those for any-severity accidents. For a non-downhill road, however, the corresponding odds are twice as great. No adequate explanation can be given for this difference at present, and it may merely be a spurious result of sparse data in the present restrictive circumstances. However, it may also be conjectured that it results from relatively greater care by drivers of large tractor/semi-trailer trucks on downhill roads to avoid conditions that can lead to the more severe kinds of accidents.

1.3.6. 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 (15 May 1975–1 May 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 are summarized in Section 1.3.7 below. 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. 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 this does not necessarily mean that the former are more correct. The following discussions of the two estimation procedures will help to clarify this.

1.3.7. Exposure Estimates

Two procedures have been developed and applied in developing estimates of commercial vehicle category (type, number of axles, weight) exposure (VMT, in millions of miles, during the study period and in the two CHP zones of the study area). These procedures are direct and induced exposure estimations.

1.3.7.1. Direct Estimates

As noted earlier, two sets of data established by CALTRANS have been employed in the direct exposure estimation process: 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 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.[1]

The results are shown in Table 1-1. The values appear to be fairly reasonable in relation to one another, but their absolute accuracy is problematical. 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.

1.3.7.2. Induced Estimates

The induced estimation process is entirely different. It is based on a theoretical approach initiated by Thorpe [3] and extended by Haight [4]. 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 applying to all categories. In the present study this overall 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 justification of the induced exposure assumption noted

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[1]Potentially applicable additional data sources are described in Appendix D.

TABLE 1-1. 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

above is provided in Section 6. The resulting procedure is 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 1-2. It is noted that they often differ considerably from, and are generally "smoother" than, the direct estimates in Table 1-1, 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 as it stands. The two methods are worthy of further development, however, and their complementary natures give promise of future utility as mutual tests and, perhaps, calibrators of one another.

1.4. 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

TABLE 1-2. 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+
10,000–25,000	0	409.5	115.5	0	60	56	115.5	0	7.0	14.0	49	0	0	60	0	0
25,001–60,000	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.

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.

1.5. 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, while 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 logics 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 logics. 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.

2. ACCIDENT DATA BASE DEVELOPMENT

The commercial vehicle accident reports analyzed in the earlier and present studies derive from the period 15 May 1975–1 May 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,[1] in the Los Angeles area.

Pertinent descriptive characteristics of these two areas are first presented. Next, the contents and format of the accident reports are described. The procedures by which the information in the reports has been verified, reduced, coded, edited, keypunched, and entered into computer records are then presented. A special data quality test and evaluation is also described.

2.1. 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. Figure 2-1 shows these two areas (cross-hatched). The selection of these specific study areas arose from the requirement for participation in the study by the CHP, and its capacity to initiate early use in 1975 of a CVARS. 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.

Overall demographic characteristics of the study areas are

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[1]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.

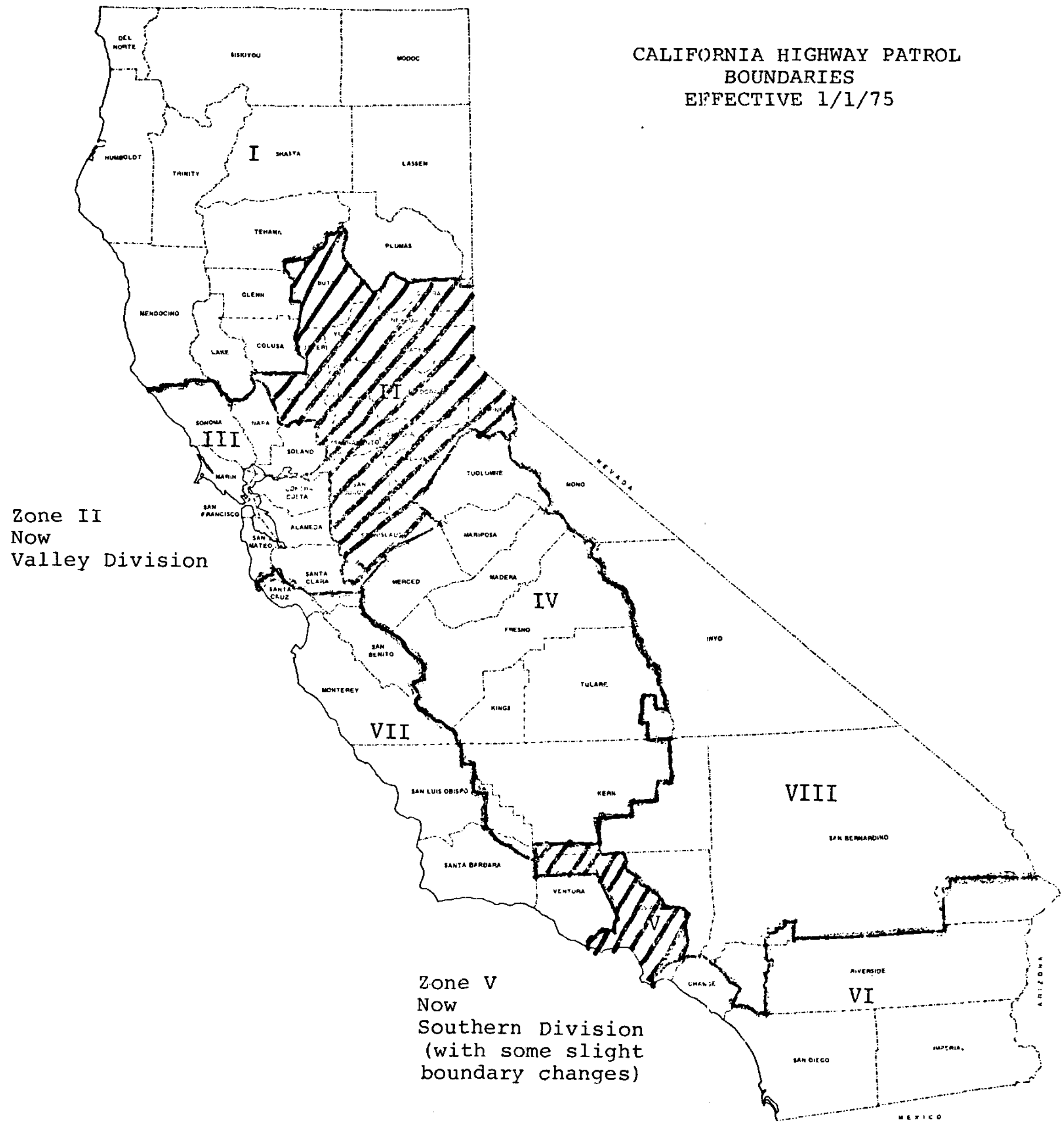

FIGURE 2-1. TRUCK/BUS ACCIDENT STUDY AREAS FOR CHP DATA ACQUISITION

shown in Table 2-1, together with statewide comparisons. As shown, the total study area involves a region of California containing a population of 8,482,690 persons, or about 40.19% of the total state population, while the land area represents only 11.5% of the state's total area. The average population density for the study area is about 466.7 persons per square mile, or 3.6 times that of the overall state average.

Table 2-2 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 2-3 similarly describes the distribution of highways by type within Zone V.

Finally, Table 2-4 gives the approximate numbers of in-state autos, trucks, trailers, and motorcycles registered within the separate counties covered by the two study areas. It is seen that the combined number of registered motor vehicles in the study area in 1974 was about 5,693,539, or 35.7% of the state total of 15,933,822 vehicles. The study areas contained 817,297 registered trucks, or about 33.3% of the statewide total of 2,454,856. Of course, the number of registrations does not reflect the transient vehicles operating within California under reciprocal agreements with other states. Discussions with the Pro-Rate License Division of the California Department of Motor Vehicles (DMV) have indicated that there were about 237,570 trucks and trailers operating in interstate commerce under a Pro-Rate License in 1974. The Division estimated that about 50% of the licenses could be considered "power units," or tractors. Thus, the number of Pro-Rate License tractors is about 118,785. The total number of commercial vehicles in Cali-

TABLE 2-1. DEMOGRAPHIC CHARACTERISTICS OF STUDY AREAS

Area	Population	Land Area Square Miles	Average Population Density*
Zone II	1,682,690	15,224	110.5
Zone V	6,800,000	2,950	2,305.0
Total (Study Area)	8,482,690	18,174	466.7
State	20,741,000	158,693	130.7
Percent Study Area of State	40%	11.5%	--

*Persons per square mile.

TABLE 2-2. 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 2-3. 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.

TABLE 2-4. REGISTERED VEHICLES WITHIN THE STUDY AREA (1974)

Area	Autos	Trucks	Trailers	Motorcycles	Total Vehicles	Percent Trucks of Total Vehicles	Percent Trucks of Autos
Zone II	866,255	279,297	205,874	62,113	1,413,539	19.8	32.2
Zone V	3,290,000	538,000	283,000	172,000	4,280,000	12.6	16.4
Total Study Areas	4,156,255	817,297	488,874	234,113	5,693,539	14.4	19.7
Total State	11,061,869	2,454,856	1,751,824	665,273	15,933,822	15.4	22.2
Study Area Percent of State	37.6	33.3	27.9	35.2	35.7	--	--

fornia in 1974, then, should be about 2,600,000, or the sum of 2,454,856, as listed in Table 2-4, plus about 118,785 Pro-Rate License trucks. Zones II and V would have about 850,000 of these operating at any time in 1974.

2.2. Accident Reports

The CHP standard Traffic Collision Report form (Form 555) and USC's CVARS (the "Green Sheet") have been the vehicles for accident data acquisition in the previous and present studies. 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 Figures 2-2 and 2-3.[1] (The instructions for completing and coding the forms are exhibited in Appendix B.)

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

The Supplement's data elements were defined and arrived at through iterative group discussions with representatives of the CHP, USC's staff, the Los Angeles Police Department, Fire Rescue teams, and others.

A total of 3,022 accident reports with completed CVAR supplements have been obtained, coded, edited, keypunched, and filed for

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

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

SPECIAL CONDITIONS	NO. INJ.	H & R FELONY ☐	CITY	JUDICIAL DISTRICT	No.
	NO. KILLED	H & R MISD ☐	COUNTY	REPORTING DISTRICT	BEAT

LOCATION

COLLISION OCCURRED ON	MO. DAY YR.	TIME(2400)	CII NO.	OFFICER I.D.
☐ AT INTERSECTION WITH ☐ OR: ______ FEET/MILES ______ OF			INJURY, FATAL OR TOW AWAY ☐ YES ☐ NO	STATE HWY ☐ YES ☐ NO

PARTY 1 — DRIVER ☐ / PEDESTRIAN ☐ / PARKED VEH. ☐ / BI-CYCLIST ☐ / OTHER ☐

NAME (FIRST, MIDDLE, LAST)				STREET ADDRESS
DRIVER'S LICENSE NO.	STATE	BIRTHDATE MO. DAY YR.	SEX / RACE	CITY / STATE / PHONE
VEHICLE YR.	MAKE	LICENSE NO.	STATE	OWNER'S NAME ☐ SAME AS DRIVER
DIRECTION OF TRAVEL	ON/ACROSS (STREET OR HIGHWAY)			OWNER'S ADDRESS ☐ SAME AS DRIVER
SPEED LIMIT	DISPOSITION OF VEHICLE	☐ BY DRIVER	ON ORDERS OF	VEHICLE DAMAGE: EXTENT ☐ MINOR ☐ MOD. ☐ MAJOR ☐ TOTAL; LOCATION / VIOLATION CHARGED 1 ______ 2 ______

PARTY 2 — DRIVER ☐ / PEDESTRIAN ☐ / PARKED VEH. ☐ / BI-CYCLIST ☐ / OTHER ☐

NAME (FIRST, MIDDLE, LAST)				STREET ADDRESS
DRIVER'S LICENSE NO.	STATE	BIRTHDATE MO. DAY YR.	SEX / RACE	CITY / STATE / PHONE
VEHICLE YR.	MAKE	LICENSE NO.	STATE	OWNER'S NAME ☐ SAME AS DRIVER
DIRECTION OF TRAVEL	ON/ACROSS (STREET OR HIGHWAY)			OWNER'S ADDRESS ☐ SAME AS DRIVER
SPEED LIMIT	DISPOSITION OF VEHICLE	☐ BY DRIVER	ON ORDERS OF	VEHICLE DAMAGE: EXTENT ☐ MINOR ☐ MOD. ☐ MAJOR ☐ TOTAL; LOCATION / VIOLATION CHARGED 1 ______ 2 ______

PROPERTY

DESCRIPTION OF DAMAGE		
OWNER'S NAME	ADDRESS	NOTIFIED ☐ YES ☐ NO

INJURED/WITNESS

WITNESS ONLY	AGE	SEX	EXTENT OF INJURY: FATAL INJURY	SEVERE WOUND DISTORTED MEMBER	OTHER VISIBLE INJURIES	COMPLAINT OF PAIN	INJURED WAS (*check one*): DRIVER	PASS.	PED.	BI-CYCLIST	OTHER	IN VEH. NUMBER
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
NAME								PHONE				
ADDRESS							TAKEN TO (INJURED ONLY)					
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
NAME								PHONE				
ADDRESS							TAKEN TO (INJURED ONLY)					
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
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 (Rev 11-71)

FIGURE 2-2a. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, 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

1	2	3	4	TYPE OF VEHICLE
				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 ______

1	2	3	4	OTHER ASSOCIATED FACTOR (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

1	2	3	4	MOVEMENT PRECEDING COLLISION
				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 ______

1	2	3	4	SOBRIETY - DRUG - PHYSICAL (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

?

FIGURE 2-2b. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, PAGE 2

COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT

ACCIDENT REPORT IDENTIFIER

MO	DAY	YR	TIME (2400)	CII NUMBER	OFFICER ID NO

NUMBER OF COMMERCIAL POWER UNITS INVOLVED ☐ TOWED SPECIAL VEHICLE ☐ COMMERCIAL VEHICLE NO. (TO BE THE SAME AS PARTY NUMBER IN ACCIDENT REPORT) ☐ RECORD THE TOTAL NUMBER UNINJURED PASSENGERS IN EACH VEHICLE INVOLVED IN THIS ACCIDENT ☐ COMMERCIAL ☐ OTHER

UNIT	AXLES			BODY TYPE							CARGO		BRAKES					1975 OR LATER
		2	3	CAB OVER	VAN	RACK	FLAT	TANK	AUTO CARR	OTHER	EMPTY	LADEN	AIR	HYDR	ELEC	OTHER	SPRING	
TRUCK																		
TRACTOR																		
SEMI TRAILER																		
FULL TRAILER																		
DOLLY (LOG.POLE)																		
BUS																		
SCHOOL BUS																		
FARM LABOR BUS																		
FARM LABOR TRUCK																		

SPEED THIS VEHICLE mph PRIOR TO ACCIDENT WHEN HAZARD RECOGNIZED	FRONT AXLE BRAKES	YES	NO	SINGLE BRAKE CONTROL	YES	NO	DRIVE AXLES	1	2	DRIVER EXPERIENCE YRS THIS VEHICLE TYPE	ODOMETER READING MILES

LOAD TYPE

REGULATED
- BALED HAY & STRAW ☐
- BALED COTTON, PAPER/JUTE ☐
- LOGS & POLES ☐
- JUNK & SCRAP METAL ☐
- STEEL COILS ☐
- STEEL PLATE, SHEET, TINPLATE ☐
- EMPTY WOODEN BOXES ☐
- DETACHABLE FREIGHT VANS ☐
- LUMBER & LUMBER PRODUCTS ☐

NON-REGULATED
- SACKED MATERIAL ☐
- BOXED MATERIAL ☐
- AGRICULTURAL PRODUCTS ☐
- HAZARDOUS MATERIALS ☐
- BULK COMMODITIES ☐
- PERMITTED LOADS ☐
- OTHER ☐

PASSENGERS
- FARM LABOR EMPLOYEES ☐
- OTHER PERSONS ☐

SUPPLEMENTAL INFORMATION
- JACKKNIFE
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- SEPARATION OF UNITS
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- CARGO SPILL
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- CARGO SHIFT
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- ROLLAWAY (DRIVERLESS) ☐
- SPRING BRAKES NOT RELEASABLE ☐
- SPRING BRAKES ACTIVATED WHILE MOVING ☐
- CAR UNDERRIDE (REAR ENDER) ☐
- TRUCK OVERRIDE (FRONT ENDER) ☐

ROADWAY ALIGNMENT
- LEVEL ☐
- UPHILL ☐
- CREST OF HILL ☐
- DOWNHILL ☐
- BOTTOM OF HILL ☐
- STRAIGHT ☐
- CURVED LEFT ☐
- CURVED RIGHT ☐

REAR LAMPS
- NO APPARENT DEFECTS ☐
- TAIL LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐
- STOP LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐
- CLEARANCE LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐

BRAKING PERFORMANCE
- BRAKING IN LANE ☐
- STEERING ONLY ☐
- BRAKING & STEERING ☐
- NO BRAKE CAUSED LOSS OF CONTROL ☐
- WHEEL LOCK UP
  - MOTOR VEHICLE ☐
  - TOWED VEHICLE ☐
- BRAKE FADE ☐
- RUNAWAY (GRADE) ☐
- BRAKE CAUSED
  - SWERVING ☐
  - WEAVING ☐
  - UNCONTROLLED SKID ☐
  - LEAVING TRAVELED LANE ☐

FIFTH WHEEL POSITION	FWD CL	OVER CL	REAR CL

VEHICLE TOTAL WEIGHT (DRIVERS ESTIMATE)					
UNIT	LBS				
1					
2					
3					
ALL					

ACCIDENT CAUSE
- THIS VEHICLE DRIVER ☐
- OTHER VEHICLE DRIVER ☐
- THIS VEHICLE EQUIPMENT ☐
- OTHER VEHICLE EQUIPMENT ☐
- OTHER ☐

CAUSES AND CONTRIBUTING FACTORS

If one of the ITEMS below, relating to the Commercial Vehicle, caused the accident or contributed to its severity check the item.

DRIVER CONDITION
- FATIGUE ☐
- EXCESSIVE DRIVING HOURS ☐
- DRUGS OR ALCOHOL ☐
- OTHER IMPAIRMENT ☐

BRAKES
- INOPERATIVE (ONE OR MORE) ☐
- OUT OF ADJUSTMENT ☐
- AIR LOSS ☐
- BREAKAWAY BRAKES ☐
- RUPTURED LINE ☐
- WHEEL LOCKUP ☐
- PARKING BRAKE ☐
- EMERGENCY STOP SYSTEM ☐
- VACUUM SYSTEM FAILURE ☐
- HYDRAULIC SYSTEM FAILURE ☐
- OTHER BRAKE DEFECTS ☐

LOADING
- INADEQUATE SECUREMENT ☐
- LOAD BINDER FAILURE ☐
- REGULATED LOAD ☐
- NON-REGULATED LOAD ☐

OTHER EQUIPMENT
- SAFETY CHAIN ☐
- DRAWBAR ☐
- TRAILER HITCH ☐
- FIFTH WHEEL ☐
- STEERING SYSTEM ☐
- TIRES ☐
- WHEELS ☐
- FRAME ☐
- SPRINGS & HANGERS ☐
- AXLE ☐
- LAMPS ☐
- CAB LATCH ☐
- OTHER ☐

SIZE
- HEIGHT ☐
- WIDTH ☐
- WEIGHT ☐
- LENGTH ☐
- PERMIT LOAD ☐
- PERMIT VIOLATION ☐
- VC SIZE VIOLATION ☐

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FIGURE 2-3. CALIFORNIA HIGHWAY PATROL COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT analysis. Coded information from all sources was then summarized and categorized into four groups:

a) Accident data
b) Vehicle data
c) Party data
d) Human factors data

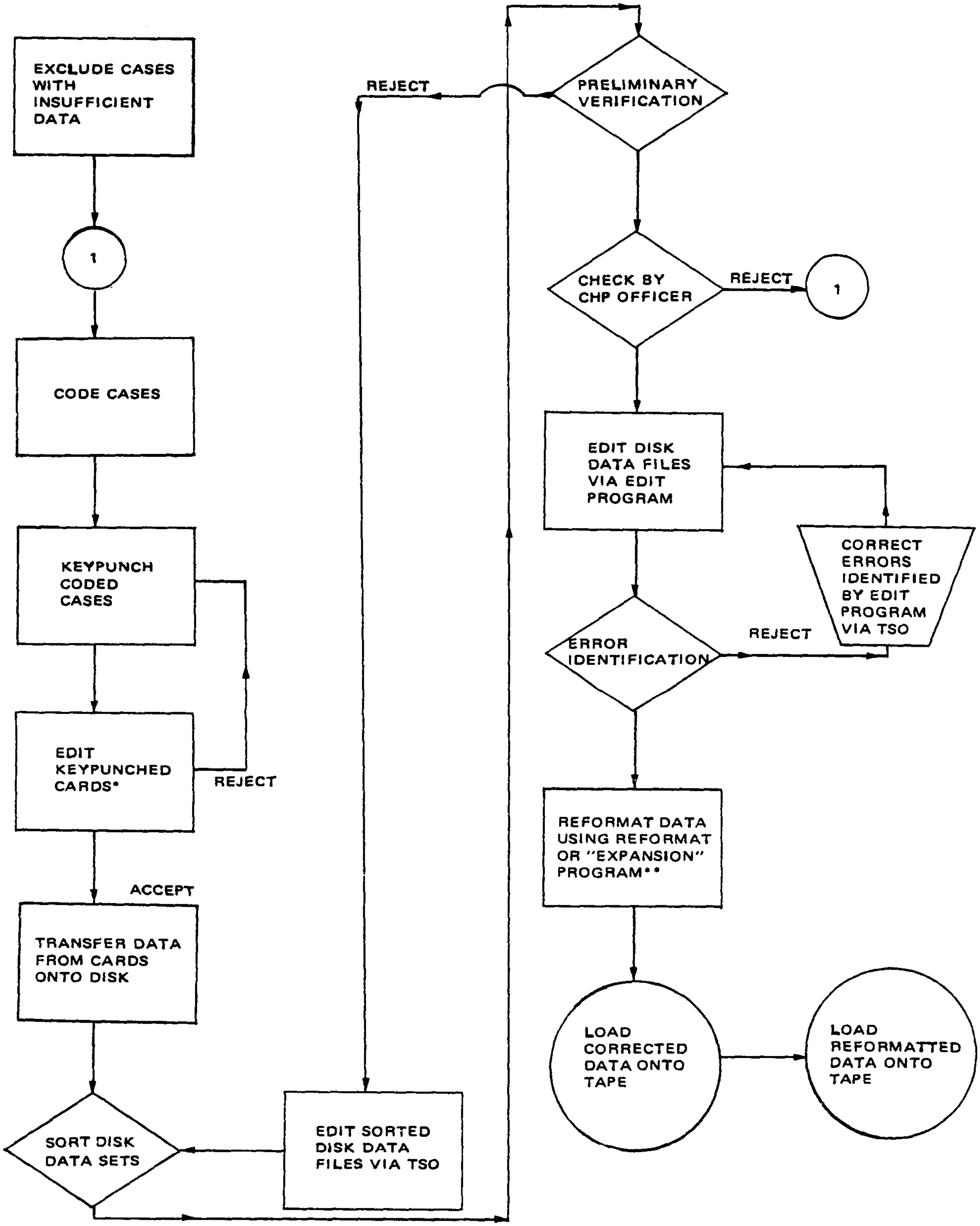
Insuring consistency and quality of the data sets used for analysis has been of concern to the project staff. All reports and supplements were audited for obvious errors, omissions, etc. When required, forms and supplements with gross errors were returned to the CHP for revision. Normally, follow-up 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.

2.3. Data Processing

Figure 2-4 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 next. Additional details on the data processing procedures are provided in Appendix C.

2.3.1. Data Editing

The verified accident report data were first transferred to a Summary Form (see Appendix B) 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.



*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 2-4. DATA PROCESSING FLOWCHART

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. Specifically, editing was completed in four steps. Keypunched cards were first verified by using the keypunch machine in the verification mode, with repunching of existing keypunched cards, and comparing the two copies. Obvious keypunch errors were thus corrected at the time of keypunching.

Second, to ensure accurate sorting of the data cards, the edited cards were entered onto disk data files. These files were then sorted by means of an efficient IBM sort routine. Subsequent to this sorting, further editing was done manually by the project staff. In this way, addditional errors were identified, as misplaced cards were easily observed.

Third, the entire set of coded CVARS's and Summaries was reviewed by an officer of the CHP for consistency of the data. In addition, he revised some of the information given on the CVARS when he considered it incorrect. For example, frequent corrections were made in the commercial vehicle's weight and number of axles. Moreover, where weight was not given by the reporting CHP officer, the reviewing officer often estimated the missing weight from other information given in the CVARS, based on his experience. However, this could not be done for all missing weights. It is also to be noted that minor discrepancies in the views of different CHP officers were observed as a result of this editing. A number of the cases had already been reviewed by another CHP officer during the course of the previous truck accident study. In the new review, further corrections were sometimes made.

Finally, the disk data files were run through a Fortran program (see Appendix C) developed by the project staff. This program checked for completeness and additional aspects of the consistency of the data. The most common errors identified by this program were the following:

a) Incomplete set of Summary Form data items

b) Missing commercial vehicle configuration code

c) Incorrect formats

d) Incorrect Summary information (e.g., total number of vehicles involved, total number of people involved, etc.)

This was the most difficult and time-consuming part of the editing process. It was often necessary to refer to the original Form 555, CVARS, and/or coded Summary Forms to identify the correct code. The incorrect codes were then replaced by the correct ones via a Time Sharing Option (TSO) edit procedure, which was also time-consuming. Nonetheless, it was possible in this way to edit the data file directly, without further keypunching.

2.3.2. Reformatted Data Files

As described before, the accident data fall into four categories:

a) General accident data

b) Vehicle/party data

c) Human factors data

d) Commercial vehicle data

Of these four categories, the first three are maintained in one file, while the last one (commercial vehicle data) is in another. The reason for this two-file arrangement is that the coding of information in the two files is done separately. The first is done by the project staff from portions of the accident reports, while the other is directly accomplished by the reporting CHP officers.

The complete data base for the truck accident study is then obtained by merging the two files. To facilitate the applications, described in subsequent sections, of the Statistical Analysis System (SAS) and the Statistical Package for the Social Sciences (SPSS) to the analysis of the data, it is first necessary to arrange the data base in a fixed-record length format. In any accident, multiple vehicles and/or people may be involved. The number of records pertaining to these vehicles and individuals can vary, and may in rare cases be fairly large. For the sake of efficiency, it was decided to reject the few large cases. The following constraints on the accidents to be analyzed were established (for further details, see Appendix C):

a) A maximum of four vehicle/party (commercial and non-commercial) involvements

b) A maximum of four persons (including driver[s]) involved

c) A maximum of two commercial vehicles involved

These constraints pertain only to the portions of the reports in the file coded by the project staff (cards 1, 2, 4, 7; the other file consists of cards 4, 5, 6, derived from the data coded by the reporting CHP officer). Of the 3,022 cases, 92 were rejected by these constraints.

The flow-diagram in Figure 2-5 shows how the final data-base is then arrived at, through an "expansion" procedure. File A, containing the general Accident, Human Factor, and Vehicle/Party data, is first screened for possible keypunch and coding errors. Then accident report cases that do not meet the constraints are deleted. At the same time their case numbers are recorded. The File B (Commercial Vehicle data) cases with the same case numbers are then also deleted. The remaining files are finally processed by the Reformatting or Expansion Program (see Appendix C) to generate the Reformatted File. The Expansion Program does the following:

a) Matches the cases from the two files

b) Inserts blanks whenever necessary (e.g., when fewer than four vehicle/party involvements occur)

c) Arranges the record format in the following order:

1 2	3_1 3_2 3_3 3_4	7_1 7_2 7_3 7_4	4_1 5_1 6_1 4_2 5_2 6_2
General Accident Data	Vehicle/Party Data	Human Factor Data	Commercial Vehicle Data

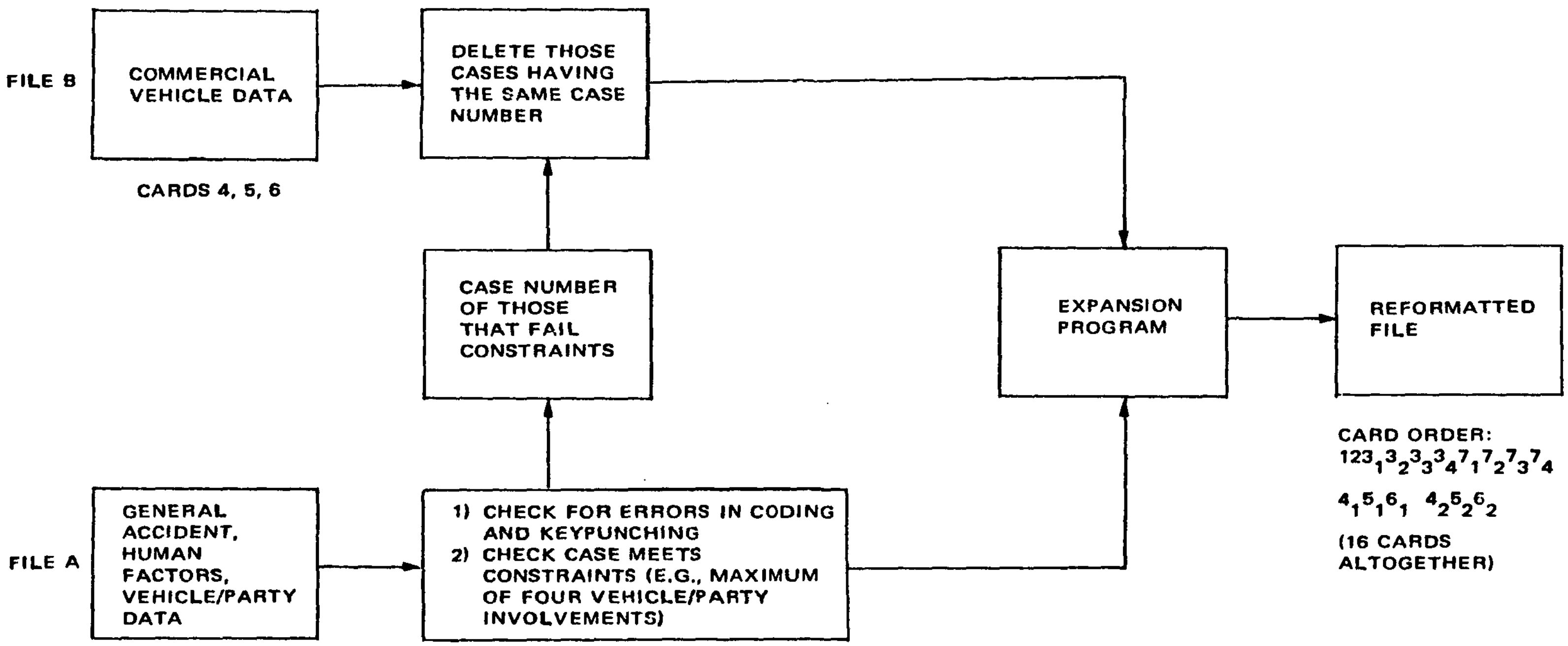


FIGURE 2-5. FLOW DIAGRAM OF GENERATION OF REFORMATTED FILE

2.4. Data Quality Analysis

The accident data Summary Form consists of five pages. Each page consists of many entries. Each entry is coded numerically and then keypunched, with some probability of error. It is desired to estimate these probabilities by a testing procedure. The flowchart in Figure 2-6 illustrates this procedure.

For the purpose of establishing confidence intervals for the estimated probabilities of error, the coding error process for each variable is considered to be a random Bernoulli process, with each entry coded either correctly or incorrectly. That is, the assumption is made that the events, coding of data entries correctly or incorrectly, are independent for different cases and for different variables. Although one may argue that coding errors of successive entries are not necessarily independent (e.g., in cases of extreme coder fatigue), this consideration is ignored for the present for the sake of simplicity.

Let p be the probability of error associated with any given variable, to be estimated for each variable. To obtain an estimate of p, a simple experiment was employed. A number of randomly selected accident report cases was duplicated and added in random order to the total file of reports. Then they were coded and keypunched without the coders and keypunchers being aware of their identity to other cases. Finally, the coded and keypunched values of the variables for the identical cases were printed out together by means of a Fortran program developed for the purpose. Manual comparisons were then made.

Errors observed as differences in the comparisons were first categorized in two parts: errors due to coding and errors due to keypunching. Further, errors due to coding were divided into "judgmental" and "mechanical" errors. Frequency counts of these categorized errors were obtained by comparing the values of the variables exhibiting errors with the original accident forms. This

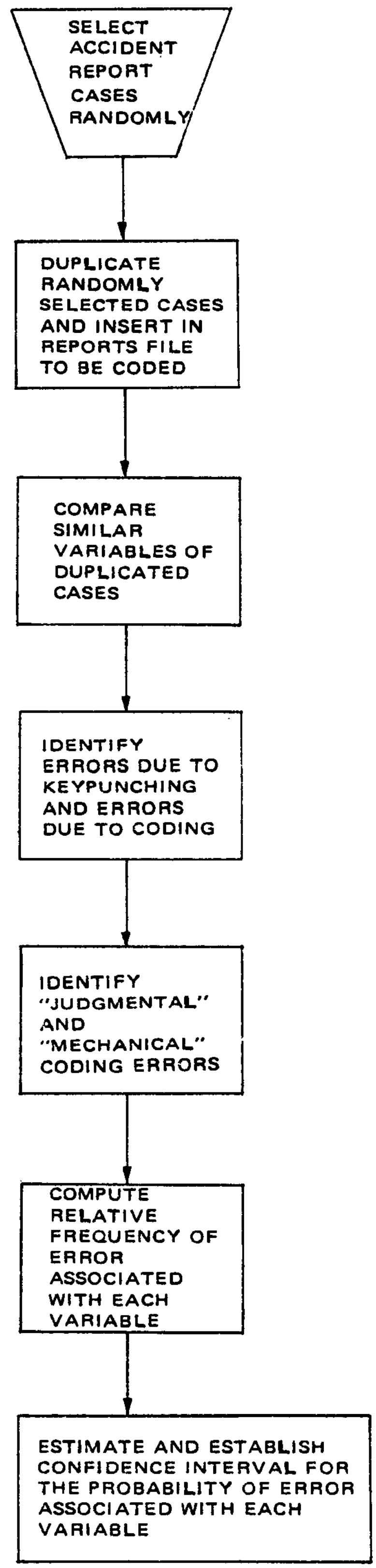


FIGURE 2-6. FLOW CHART OF DATA QUALITY ANALYSIS

was the most time-consuming part of the process. It was necessary to refer to the original Form 555 and/or CVARS to determine whether the error was due to coding or keypunching. Moreover, if the error was due to coding, "judgmental" and "mechanical" errors were categorized by considering the coding procedure. If the value of the code was already explicitly reported on Form 555 or CVARS, then the coding error was identified as "mechanical." However, if the value of the code had to be inferred by the coder from the accident report, e.g., by interpreting the narrative of Form 555, etc., then the error was identified as "judgmental."

Tables 2-5 to 2-11 present the frequency, relative frequency or probability, and the 90% confidence upper bound on the probability of error, associated with each variable tested. The tables are arranged by card number. The upper confidence bounds for the failure probabilities are established from binomial tables [6], and, for the sake of simplicity, tabulated sample sizes that approximate the actual sizes are used.

Note that the total relative frequency of error is low for most of the variables. The variables listed in Table 2-12, however, have a 9% or more total relative frequency of error associated with them.

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 Form 555. Moreover, the narratives are not prepared uniformly, and as a result the codes resulting from the narratives are not uniform either.

Many of the errors associated with the variables on cards 4, 5, and 6 are due to keypunching. All of the variables on cards 4, 5, and 6 are directly keypunched from CVARS forms. These forms are coded by the CHP officers. Most of the codes on CVARS forms are presented with a "cross" or "check" mark. Then templates are placed over the forms to identify the columns for keypunching. Many of

TABLE 2-5. QUALITY TEST RESULTS: CARD NUMBER 1

Variable	Sample Size	Number of Errors			Relative Frequency				90% Combined Evidence
		Coder		Keypuncher	Coder		Keypuncher	Total	
		Judgmental	Mechanical		Judgmental	Mechanical			Upper Bound*
1. Month	72							0	0.03
2. Day	72		2			0.03		0.03	0.07
3. Year	72		1			0.01		0.01	0.05
4. Time	72							0	0.03
5. Jurisdiction	72							0	0.03
6. District	72		1			0.01		0.01	0.05
7. County	72		2			0.03		0.03	0.07
8. Number of Principle Parties	72		1			0.01		0.01	0.05
9. Number of Fatalities	72							0	0.03
10. Number Injured	72							0	0.03
11. Road Type	72	5	10		0.07	0.14		0.21	0.26
12. Collision Factor	72	1			0.01			0.01	0.05
13. Responsible Party	72		1			0.01		0.01	0.05
14. Weather	72							0	0.03
15. Lighting	72		1			0.01		0.01	0.05
16. Road Surface	72		1			0.01		0.01	0.05
17. Roadway Condition	72							0	0.03
18. Right of Way Control	72		2			0.03		0.03	0.05

*Upper bounds on failure probabilities are obtained using binomial distribution. Confidence level is 90%. Sample size of 75 assumed for the sake of simplicity.

TABLE 2-6. QUALITY TEST RESULTS: CARD NUMBER 2

Variable	Sample Size	Number of Errors			Relative Frequency				90% Combined Evidence
		Coder		Keypuncher	Coder		Keypuncher	Total	
		Judgmental	Mechanical		Judgmental	Mechanical			Upper Bound*
1. Accident Event	111	43			0.40			0.40	0.52
2. Event Coded by CHP	72	8			0.11			0.11	0.13
3. Total Number of Events	72	10			0.14			0.14	0.15

*Sample size of 100 used for simplicity.

TABLE 2-7. QUALITY TEST RESULTS: CARD NUMBER 3

Variable	Sample Size	Number of Errors			Relative Frequency				90% Combined Evidence
		Coder		Keypuncher	Coder		Keypuncher	Total	
		Judgmental	Mechanical		Judgmental	Mechanical			Upper Bound*
1. Party Description	142	1	9	1	0.01	0.06	0.01	0.08	0.16
2. Vehicle Year	142	2	8		0.01	0.06		0.07	0.15
3. Vehicle Make	142	10	20	2	0.10	0.14	0.01	0.25	0.38
4. Vehicle Registration	142	22	2		0.15	0.01		0.16	0.31
5. Configuration Code	142	1	15	1	0.01	0.11	0.01	0.13	0.23
6. Posted Speed Limit	142		3			0.02		0.02	0.07
7. Speed Prior to Involvement	142	20			0.14			0.14	0.26
8. Vehicle Movement	142		4			0.03		0.03	0.08
9. Vehicle Violation Code	142		4	1		0.03	0.01	0.04	0.09
10. Vehicle Damage	142		2			0.01		0.01	0.05
11. Direction of Travel	142		3			0.02		0.02	0.07
12. Pedestrian Action	142								

*Upper bounds for this table are based on sample size of 100, used for the sake of simplicity.

TABLE 2-8. QUALITY TEST RESULTS: CARD NUMBER 4

Variable	Sample Size	Number of Errors: Coder: Judgmental	Number of Errors: Coder: Mechanical	Number of Errors: Keypuncher	Relative Frequency: Coder: Judgmental	Relative Frequency: Coder: Mechanical	Relative Frequency: Keypuncher	Relative Frequency: Total	90% Combined Evidence Upper Bound*
1. Number of Commercial Power Units	74			1			0.01	0.01	0.05
2. Towed Special Vehicle	74		1	2		0.01	0.03	0.04	0.09
3. Commercial Vehicle Number	74			3			0.04	0.04	0.09
4. Number of Uninjured Passengers In Commercial Vehicle	74		1	3		0.01	0.04	0.05	0.10
5. Number of Uninjured Passengers in Other Vehicle	74		1	3		0.01	0.04	0.05	0.10
6. Truck Number of Axles	74		2	2		0.03	0.03	0.06	0.10
7. Tractor Number of Axles	74		4	3		0.05	0.04	0.09	0.15
8. Semi-Trailer Number of Axles	74		5	3		0.07	0.04	0.11	0.17
9. Full Trailer Number of Axles	74		3	2		0.04	0.03	0.07	0.12
10. Dolly Number of Axles	74			1			0.01	0.01	0.05
11. Bus Number of Axles	74			2			0.03	0.03	0.07
12. School Bus Number of Axles	74			1			0.01	0.01	0.05
13. Farm Bus Number of Axles	74			1			0.01	0.01	0.05
14. Farm Tractor Numqer of Axles	74			1			0.01	0.01	0.05
15. Cabover	74			1			0.01	0.01	0.05
16. Truck Body Type	74		2	1		0.03	0.01	0.04	0.09
17. Semi-Trailer Body Type	74		5	2		0.07	0.03	0.10	0.15
18. Truck Cargo	74			1			0.01	0.01	0.05
19. Tractor Cargo	74			2			0.03	0.03	0.07
20. Semi-Trailer Cargo	74		1	2		0.01	0.03	0.04	0.09
21. Full Trailer Cargo	74			2			0.03	0.03	0.07
22. Bus Cargo	74			2			0.03	0.03	0.07
23. School Bus Cargo	74							0	0.03
24. Farm Truck Cargo	74							0	0.03
25. Truck Brakes	74		4	4		0.05	0.05	0.10	0.17
26. Tractor Brakes	74		3	4		0.05	0.05	0.10	0.17
27. Semi-Trailer Brakes			2	6		0.03	0.08	0.11	0.17
28. Full Trailer Brakes	74		2	3		0.03	0.04	0.07	0.12
29. Dolly Brakes	74							0	0.03
30. Bus Brakes	74			2			0.03	0.03	0.07
31. School Bus Brakes	74							0	0.03
32. Farm Bus Brakes	74							0	0.03
33. Farm Truck Brakes	74							0	0.03
34. Truck 1975 or Later	74		1			0.01		0.01	0.03
35. Tractor 1975 or Later	74			2			0.03	0.03	0.07
36. Semi-Trailer 1975 or Later	74							0	0.03
37. Full Trailer 1975 or Later	74		1			0.01		0.01	0.05
38. Dolly 1975 or Later	74							0	0.03
39. Bus 1975 or Later	74							0	0.03
40. School Bus 1975 or Later	74							0	0.03
41. Farm Bus 1975 or Later	74							0	0.03
42. Farm Truck 1975 or Later	74							0	0.03

*Sample size of 75 used for the sake of simplicity.

TABLE 2-9. QUALITY TEST RESULTS: CARD NUMBER 5

Variable	Sample Size	Number of Errors			Relative Frequency				90% Combined Evidence
		Coder		Keypuncher	Coder		Keypuncher	Total	
		Judgmental	Mechanical		Judgmental	Mechanical			Upper Bound*
1. Front Axle Brakes	74	1			0.01			0.01	0.05
2. Single Brake Control	74	3		1	0.04		0.01	0.05	0.10
3. Drive Axles	74	1			0.01			0.01	0.05
4. Load Type	74							0	0.03
5. Non-Regulated	74			2			0.03	0.03	0.07
6. Passengers	74			2			0.03	0.03	0.07
7. Jackknife	74							0	0.03
8. Separation of Unit	74							0	0.03
9. Cargo Spill	74							0	0.03
10. Cargo Shift	74							0	0.03
11. Spring Brake Activated	74			2			0.03	0.03	0.07
12. Roadway Alignment	74	1		1	0.01		0.01	0.02	0.07
13. Rear Lamps	74	1		2	0.01		0.03	0.04	0.09
14. Tail Lamps	74							0	0.03
15. Stop Lamps	74	1			0.01			0.01	0.05
16. Clearance Lamps	74			1			0.01	0.01	0.05
17. Braking Performance	74	3		4	0.04		0.05	0.09	0.15

*Sample size of 75 used for the sake of simplicity.

TABLE 2-10. QUALITY TEST RESULTS: CARD NUMBER 6

Variable	Sample Size	Number of Errors			Relative Frequency				90% Combined Evidence
		Coder		Keypuncher	Coder		Keypuncher	Total	
		Judgmental	Mechanical		Judgmental	Mechanical			Upper Bound*
1. Odometer Reading	74		2	3		0.03	0.04	0.07	0.12
2. Fifth Wheel Position	74		1	1		0.01	0.01	0.02	0.07
3. Vehicle Weight	74		10	3		0.14	0.04	0.18	0.25
4. Accident Cause	74			2			0.03	0.03	0.07
5. *Driver Condition*	74			1			0.01	0.01	0.05
6. Brakes	74			1			0.01	0.01	0.05
7. Loading	74			1			0.01	0.01	0.05
8. Other Equipment	74			1			0.01	0.01	0.05
9. Size	74			1			0.01	0.01	0.05

*Sample size of 75 used for simplicity.

TABLE 2-11. QUALITY TEST RESULTS: CARD NUMBER 7

Variable	Sample Size	Number of Errors			Relative Frequency				90% Combined Evidence
		Coder		Keypuncher	Coder		Keypuncher	Total	
		Judgmental	Mechanical		Judgmental	Mechanical			Upper Bound*
1. Sex	149		4	1		0.03	0.01	0.04	0.09
2. Age	149		40	2		0.27	0.01	0.28	0.50
3. Drug	149		10	1		0.07	0.01	0.08	0.16
4. Physical Impairment	149		2	1		0.01	0.01	0.02	0.07
5. Injury Severity	149		9	1		0.06	0.01	0.07	0.15
6. Occupant Role	149		8	1		0.05	0.01	0.06	0.14
7. State of Driver License	149		9	1		0.06	0.01	0.07	0.15
8. Ownership	149		4	1		0.03	0.01	0.04	0.09
9. Vehicle Violation Code	149		14	2		0.09	0.01	0.10	0.22
10. Associated Factors	149		24	1		0.16	0.01	0.17	0.31
11. Driver Experience	149		20	2		0.13	0.01	0.14	0.28

*Sample size of 100 used for simplicity.

TABLE 2-12. 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 keypunching errors result from misplacement of templates on the CVARS forms or illegible marks. The latter problem is exacerbated by the coders having to use Xerox copies of the reporting forms, the originals being retained by the CHP.

The remaining errors are mostly mechanical. Such mechanical errors are primarily due to arithmetic mistakes or misreading of 555 or CVARS forms. However, most arithmetic errors are not very critical since they are generally small.

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 Section 7 below.

3. UNIVARIATE ANALYSIS AND CROSS-TABULATIONS

A standard SAS package has been employed to produce a full set of univariate frequency tables, histograms, and statistics for the variables in the accident reports. The outputs are presented in Appendix A. The results, discussed in Section 3.3 below, describe the accident data base through simple summaries of the many variables. As the discussion in Section 3.3 points out, 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 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.

The univariate programs and procedures used in the present study are described in Appendix C. In Sections 3.1 and 3.2, the variables in the accident data base are listed, and the univariate results and their most evident and important implications are summarized. General conclusions that follow from these results are given in Section 3.3.

Simple multivariate analyses, employing cross-tabulations among several variables, are also made possible by the present data base. Several of these have been carried out, and their procedures and results are described in Section 3.4.

3.1. List of Accident Variables

Table 3-1 lists all univariate frequency tables and histograms that have been established. Together with certain basic statistics (mean, median, standard deviation) that are relevant for some of the tables, they describe essentially all of the data present in the accident reports. The complete set of tables, histograms, and statistics is provided in Appendix A.

3.2. Results

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-commercial vehicle factors, and human factors. Human factors are subdivided with respect to commercial and non-commercial vehicle occupants.

3.2.1. Accident Factors

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 freeways.

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,[1] 66 fatalities occurred. This rate

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

TABLE 3-1. LIST OF ALL UNIVARIATE FREQUENCY TABLES/ HISTOGRAMS (SHEET 1 OF 8)

1. 'ACCIDENT FACTORS'

VARIABLE	VARIABLE CODE
MONTH	C1001
DAY OF MONTH	C1002
YEAR	C1003
TIME	C1004
REPORTING JURISDICTION	C1005
REPORTING DISTRICT	C1006
COUNTY	C1007
NO. OF PRINCIPAL PARTIES	C1008
NO. OF FATALITIES	C1009
NO. OF INJURIES	C1010
ROAD TYPE	C1011
PRIMARY COLLISION FACTOR-PCF	C1012
PARTY RESPONSIBLE FOR PCF	C1013
WEATHER	C1014
LIGHTING	C1015
ROAD SURFACE	C1016
HOLES AND RUTS	C1017
LOOSE MATERIALS IN ROADWAY	C1018
OBSTRUCTION IN ROADWAY	C1019
CONSTRUCTION ZONE	C1020
REDUCED ROADWAY WIDTH	C1021
FLOODED	C1022
OTHERS	C1023
NO UNUSUAL CONDITIONS	C1024
RIGHT OF WAY CONDITIONS	C1025
EVENT CODED BY CHP	C2031
TOTAL NO. OF EVENTS IN ACCIDENT	C2032

TABLE 3-1. (SHEET 2 OF 8)

2. 'COMMERCIAL VEHICLE FACTORS'

A. 'COMMERCIAL VEHICLE DATA'

NO. OF COMMERCIAL POWER UNITS INVOLVED	C4101
TOWED SPECIAL VEHICLE	C4102
COMMERICIAL VEHICLE PARTY NO.	C4103
TOTAL NO. UNINJURED PASSENGERS IN COMM. UNIT	C4104
TOTAL NO. INJURED PASSENGER IN OTHER UNIT	C4105
FRONT AXLE BRAKE-YES	C5101
FRONT AXLE BRAKE-NO	C5102
SINGLE BRAKE CONTROL-YES	C5103
SINGLE BRAKE CONTROL-NO	C5104
DRIVE AXLE-ONE	C5105
DRIVE AXLE-TWO	C5106
LOAD TYPE-BAILED HAY & STRAW	C5107
LOAD TYPE-BAILED COTTON PAPER JUTE	C5108
LOAD TYPE-LOGS & POLES	C5109
LOAD TYPE-JUNK & SCRAP METAL	C5110
LOAD TYPE-STEEL COILS	C5111
LOAD TYPE-STEEL PLATE SHEET	C5112
LOAD TYPE-EMPTY WOODEN BOXES	C5113
LOAD TYPE-DETACHABLE FREIGHT VANS	C5114
LOAD TYPE-LUMBER PRODUCTS	C5115
LOAD TYPE-SACKED MATERIAL	C5116
LOAD TYPE-BOXED MATERIAL	C5117
LOAD TYPE-AGRICULTURAL PRODUCTS	C5118
LOAD TYPE-HAZARDOUS MATERIALS	C5119
LOAD TYPE-BULK COMMODITIES	C5120
LOAD TYPE-PERMITTED LOADS	C5121
LOAD TYPE-OTHERS	C5122
PASSENGER-FARM LABOR EMPLOYEE	C5123
PASSENGERS-OTHERS	C5124
JACKKNIFE-PRIOR TO COLLISION	C5125
JACKKNIFE-AFTER COLLISION	C5126
SEPARATION OF UNIT BEFORE COLLISION	C5127
SEPARATION OF UNIT AFTER COLLISION	C5128
CARGO SPILL BEFORE COLLISION	C5129
CARGO SPILL AFTER COLLISION	C5130
CARGO SHIFT BEFORE COLLISION	C5131
CARGO SHIFT AFTER COLLISION	C5132
ROLLAWAY-DRIVERLESS	C5133
SPRING BRAKES NOT RELEASABLE	C5134
SPRING BRAKES ACTIVATED WHILE MOVING	C5135
CAR UNDERRIDE-REAR ENDER	C5136
TRUCK OVERRIDE-FRONT ENDER	C5137
ROADWAY ALIGNMENT-LEVE	C5138
ROADWAY ALIGNMENT-UPHILL	C5139
ROADWAY ALIGNMENT-CREST OF HILL	C5140
ROADWAY ALIGNMENT-DOWNHILL	C5141
ROADWAY ALIGNMENT-BOTTOM OF HILL	C5142
ROADWAY ALIGNMENT-STRAIGHT	C5143
ROADWAY ALIGNMENT-CURVED LEFT	C5144
ROADWAY ALIGNMENT-CURVED RIGHT	C5145
REAR LAMPS-NO APPARENT DEFECTS	C5146
TAIL LAMPS-INOPERATIVE	C5147
TAIL LAMPS-BROKEN LENSES	C5148
TAIL LAMPS-OBSCURED LENSES	C5149
STOP LAMPS-INOPERATIVE	C5150

TABLE 3-1. (Sheet 3 OF 8)

STOP LAMPS-BROKEN LENSES	C5151
STOP LAMPS-OBSCURED LENSES	C5152
CLEARANCE LAMPS-INOPERATIVE	C5153
CLEARANCE LAMPS-BROKEN LENSES	C5154
CLEARANCE LAMPS-OBSCURED LENSES	C5155
BRAKING IN LANE	C5156
STEERING ONLY	C5157
BRAKING AND STEERING	C5158
NO-BRAKE CAUSED LOSS OF CONTROL	C5159
WHEEL LOCK UP-MOTOR VEHICLE	C5160
WHEEL LOCK-UP TOWED VEHICLE	C5161
BRAKE FADE	C5162
RUNAWAY-GRADE	C5163
BRAKE-CAUSED SWAVING	C5164
BRAKE-CAUSED WEAVING	C5165
BRAKE-CAUSED UNCONTROLLED SKID	C5166
BRAKE-CAUSED LEAVING TRAVELED LANE	C5167
ODOMETER READING	C6101
FIFTH WHEEL POSITION-FWD CL	C6102
FIFTH WHEEL POSITION-OVER CL	C6103
FIFTH WHEEL POSITION-REAR CL	C6104
VEHICLE TOTAL WEIGHT-UNIT 1	C6105
VEHICLE TOTAL WEIGHT-UNIT 2	C6106
VEHICLE TOTAL WEIGHT-UNIT 3	C6107
VEHICLE TOTAL WEIGHT-ALL	C6108
ACCIDENT CAUSE-THIS VEHICLE DRIVER	C6109
ACCIDENT CAUSE-OTHER VEHICLE DRIVER	C6110
ACCIDENT CAUSE-THIS VEHICLE EQUIPMENT	C6111
ACCIDENT CAUSE-OTHER VEHICLE EQUIPMENT	C6112
ACCIDENT CAUSE-OTHERS	C6113
DRIVER CONDITION-FATIGUE	C6114
DRIVER CONDITION-EXCESSIVE DRIVING HOURS	C6115
DRIVER CONDITION-DRUGS OR ALCHOL	C6116
DRIVER CONDITION-OTHER IMPAIRMENTS	C6117
BRAKES INOPERATIVE	C6118
BRAKES-OUT OF ADJUSTMENTS	C6119
BRAKES-AIR LOSS	C6120
BRAKES-BREAKAWAY BRAKES	C6122
BRAKES-RUPTURED LINE	C6122
BRAKES-WHEEL LOCKUP	C6123
BRAKES-PARKING BRAKES	C6124
BRAKES-EMERGENCY STOP SYSTEM	C6125
BRAKES-VACCUM SYSTEM FAILURE	C6126
BRAKES-HYDRAULIC SYSTEM FAILURE	C6127
BRAKES-OTHER BRAKE DEFECTS	C6128
LOADING-INADEQUATE SECUREMENT	C6129
LOADING-LOAD BINDER FAILURE	C6130
LOADING-REGULATED LOAD	C6131
LOADING-NON REGULATED LOAD	C6132
SAFETY CHAIN	C6133
DRAWBAR	C6134
TRAILER HITCH	C6135
FIFTH WHEEL	C6136
STEERING SYSTEM	C6137
TIRES	C6138
WHEELS	C6139
FRAMES	C6140
SPRING AND HANGOVERS	C6141
AXLE	C6142

TABLE 3-1. (SHEET 4 OF 8)

LAMPS	C6143
CAB LATCH	C6144
OTHER EQUIPMENTS	C6145
HEIGHT	C6146
WIDTH	C6147
WEIGHT	C6148
LENGTH	C6149
PERMIT LOAD	C6150
PERMIT VIOLATION	C6151
VC SIZE VIOLATION	C6152

B. <u>'COMMERCIAL VEHICLE (PARTY) DATA'</u>

PRINCIPAL PARTY NO.	C3101
PARTY DESCRIPTION-POWER UNIT	C3102
PARTY DESCRIPTION-POWER UNIT 2	C3103
PARTY DESCRIPTION-UNIT 3	C3104
PARTY DESCRIPTION-UNIT 4	C3105
VEHICLE YEAR-POWER UNIT	C3106
VEHICLE YEAR-UNIT 2	C3107
VEHICLE YEAR-UNIT 3	C3108
VEHICLE YEAR-UNIT 4	C3109
VEHICLE MAKE-POWER UNIT	C3110
VEHICLE MAKE-UNIT 2	C3111
VEHICLE MAKE-UNIT 3	C3112
VEHICLE MAKE-UNIT 4	C3113
VEHICLE REGISTRATION-POWER UNIT	C3114
VEHICLE REGISTRATION-UNIT 2	C3115
VEHICLE REGISTRATION-UNIT 3	C3116
VEHICLE REGISTRATION-UNIT 4	C3117
COMMERCIAL VEHICLE CONFIGURATION CODE	C3118
POSTED SPEED LIMIT	C3119
SPEED PRIOR TO INVOLVEMENT	C3120
VEHICLE MAOVEMENT PRECEDING INVOLVEMENT	C3121
VC-CODE EQUIPMENT VIOLATIONS -1	C3122
VC-CODE EQUIPMENT VIOLATIONS -2	C3123
VC-CODE EQUIPMENT VIOLATIONS -3	C3124
VEHICLE DAMAGES	C3125
DIRECTION OF TRAVEL	C3126

C. <u>'COMMERCIAL VEHICLE - TRUCK ONLY DATA'</u>

TRUCK-NO OF AXLES	C4106
TRUCK-CABOVER	C4107
TRUCK-BODY TYPE	C4121
TRUCK-EMPTY OR LADEN	C4122
TRUCK-BRAKE TYPPE	C4132
TRUCK-SPRING BRAKES	C4133
TRUCK-1975 OR LATER	C4134

TABLE 3-1. (SHEET 5 OF 8)

D. 'COMMERCIAL VEHICLE - TRACTOR ONLY DATA'

TRACTOR-NO. OF AXLES	C4108
TRACTOR-CABOVER	C4109
TRACTOR-EMPTY OR LADEN	C4123
TRACTOR-BRAKE TYPE	C4135
TRACTOR-SPRING BRAKES	C4136
TRACTOR -1975 OR LATER	C4137

E. 'COMMERCIAL VEHICLE - SEMI.-TRAILER DATA'

SEMI-TRAILER NO. OF AXLES	C4110
SEMI-TRAILER BODY TYPE	C4124
SEMI-TRAILER EMPTY OR LADEN	C4125
SEMI-TRAILER BRAKE TYPE	C4138
SEMI-TRAILER SPRING BRAKES	C4139
SEMI-TRAILER 1975 OR LATER	C4140

F. 'COMMERCIAL VEHICLE - FULL TRAILER DATA'

FULL-TRAILER NO. OF AXLES	C4111
FULL-TRAILER BODY TYPE	C4126
FULL-TRAILER EMPTY OR LADEN	C4127
FULL-TRAILER BRAKE TYPE	C4141
FULL-TRAILER SPRING BRAKES	C4142
FULL-TRAILER 1975 OR LATER	C4143

G. 'COMMERCIAL VEHICLE-DOLLY DATA'

DOLLY-NO OF AXLES	C4112
DOLLY-BRAKE TYPE	C4144
DOLLY-SPRING BRAKES	C4145
DOLLY-1975 OR LATER	C4146

H. 'COMMERCIAL VEHICLE - BUS DATA'

BUS-NO. OF AXLES	C4113
BUS-CABOVER	C4114
BUS-EMPTY OR LADEN	C4128
BUS-BRAKE TYPE	C4147
BUS-SPRING BRAKES	C4148
BUS-1975 OR LATER	C4149

TABLE 3-1. (SHEET 6 OF 8)

I. 'COMMERCIAL VEHICLE - SCHOOL BUS DATA'

SCHOOL BUS-NO. OF AXLES	C4115
SCHOOL BUS-CAROVER	C4116
SCHOOL BUS-EMPTY OR LADEN	C4129
SCHOOL BUS-BRAKE TYPE	C4150
SCHOOL BUS SPRING BRAKES	C4151
SCHOOL BUS-1975 OR LATER	C4152

3. 'NON-COMMERCIAL VEHICLE FACTORS'

PRINCIPAL PARTY NO.	C3101
PARTY DESCRIPTION-POWER UNIT	C3102
PARTY DESCRIPTION-UNIT 2	C3103
PARTY DESCRIPTION-UNIT 3	C3104
PARTY DESCRIPTION-UNIT 4	C3105
VEHICLE YEAR-POWER UNIT	C3106
VEHICLE YEAR-UNIT 2	C3107
VEHICLE YEAR-UNIT 3	C3108
VEHICLE YEAR-UNIT 4	C3109
VEHICLE MAKE-POWER UNIT	C3110
VEHICLE MAKE-UNIT 2	C3111
VEHICLE MAKE-UNIT 3	C3112
VEHICLE MAKE-UNIT 4	C3113
VEHICLE REGISTRATION-POWER UNIT	C3114
VEHICLE REGISTRATION-POWER UNIT	C3115
VEHICLE REGISTRATION-UNIT 2	C3116
VEHICLE REGISTRATION-UNIT 3	C3117
VEHICLE REGISTRATION-UNIT 4	C3118
POSTED SPEED LIMIT	C3119
SPEED PRIOR TO INVOLVEMENT	C3120
VEHICLE MOVEMENT PRECEDING INVOLVEMENT	C3121
VC-CODE EQUIPMENT VIOLATIONS - 1	C3122
VC-CODE EQUIPMENT VIOLATIONS - 2	C3123
VC-CODE EQUIPMENT VIOLATIONS - 3	C3124
VEHICLE DAMAGES	C3125
DIRECTION OF TRAVEL	C3126
PEDESTRIAN ACTION	C3127

TABLE 3-1. (SHEET 7 OF 8)

4. 'HUMAN FACTORS'

A. 'COMMERCIAL VEHICLE DRIVER AND PASSENGERS FACTORS'

1) COMMERCIAL VEHICLE DRIVERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107
VEHICLE OCCUPANY ROLE	C7108
STATE OF DR LICENSE	C7109
DOES DR OWN VEHICLE	C7110
VEHICLE CODE VIOLATION AGAINST PERSON-1	C7111
VEHICLE CODE VIOLATION AGAINST PERSON-2	C7112
VEHICLE CODE VIOLATION AGAINST PERSON-3	C7113
VISION OBSCUREMENT	C7114
INATTENTION	C7115
STOP AND GO TRAFFIC	C7116
ENTERING-LEAVING RAMP	C7117
PREVIOUS COLLISION	C7118
UNFAMILIAR WITH ROAD	C7119
OTHER	C7120
NON APPARENT	C7121
DRIVER EXPERIENCE-YEARS	C7122

2) 'COMMERCIAL VEHICLE PASSENGERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON-ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107

TABLE 3-1. (SHEET 8 OF 8)

B. 'NON-COMMERCIAL VEHICLE DRIVER AND PASSENGERS FACTORS'

1) 'NON-COMMERCIAL VEHICLE DRIVERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON-ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107
VEHICLE OCCUPANY ROLE	C7108
STATE OF DR LICENSE	C7109
DOES DR OWN VEHICLE	C7110
VEHICLE CODE VIOLATION AGAINST PERSON-1	C7111
VEHICLE CODE VIOLATION AGAINST PERSON-2	C7112
VEHICLE CODE VIOLATION AGAINST PERSON-3	C7113
VISION OBSCUREMENT	C7114
INATTENTION	C7115
STOP AND GO TRAFFIC	C7116
ENTERING-LEAVING RAMP	C7117
PREVIOUS COLLISION	C7118
UNFAMILIAR WITH ROAD	C7119
OTHER	C7120
NON APPARENT	C7121

2) 'NON-COMMERCIAL VEHICLE PASSENGERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON-ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107

(2.26 fatalities per 100 accidents) compares closely with the findings of a previous study, 2.39, in Texas in 1969 [1]

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.

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 gives a value for other states of 22%. Unsafe lane change is the second most prevalent factor at 16.5%. Vehicle equipment or cargo problems are noted as 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) Accident events were coded as sideswipe collision 32.6%, and as rear-end collision 28.4% of the time by CHP officers.

3.2.2. Commercial Vehicle Factors

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 full-trailer 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:

	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%

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:

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

m) Gross vehicle characteristics were found to be accident factors in some cases:

Height	0.8%
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 in Appendix A 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.

3.2.3. Non-Commercial Vehicle Factors

a) 80.9% of non-commercial vehicles involved in accidents with commercial vehicles were passenger automobiles; 10.1% were pickup and panel trucks.

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%.

3.2.4. Commercial Vehicle Drivers and Passengers Factors

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 driver injury occurred in 91.7% of the cases; fatal injuries occurred in 13 of 3,014 cases (0.4%).

d) The single most frequently reported vehicle code violation (39.7% of all cases) was unsafe speed.

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%

f) Of only 54 commercial vehicle passengers who suffered injury in the total set of accidents, five had major injuries.

3.2.5. Non-Commercial Vehicle Drivers and Passengers Factors

a) 70.8% of the 2,314 drivers involved were male. The mean age was 36.8; the median 33.0.

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.

3.3. Conclusions

The present univariate analyses of commercial vehicle accidents treat a much larger set of variables than any used previously. This has been made possible by the use of a special commercial accident report form that was completed by CHP officers at the scene over a period of almost a year. A subset of the variables has been treated elsewhere, however, and in particular in the 1969 study by Scott referred to above. A satisfactory correspondence of the results for these variables between that study and the present one has been exhibited, particularly if differences in place and time are considered. It is therefore concluded that the present data base and its description in the univariate outputs are reasonably validated, and confidence may generally be felt in its application to further statistical studies.

Of course, the data for some individual variables may still prove to be untrustworthy, particularly where a high degree of subjectivity in reporting or coding is present. This point has been appraised earlier in this report in the data quality analysis. Despite the overall assessment of the present data base's validity, therefore, appropriate caution is still required in using the data for such variables.

3.4. Some Cross-Tabulations

A simple extension of the univariate to a multivariate analysis procedure is that of cross-tabulation of frequencies for several selected variables. Such cross-tabulations can answer basic questions about the interactions of the variables, albeit in an unsummarized manner, requiring additional interpretation, and with no quantitative delineation of the significance of any apparent interaction.

A number of such cross-tabulations have been carried out in the present study in response to certain questions from NHTSA, and also in order to generate the requisite input for the contingency table analyses of Section 5 and the induced exposure estimates of Section 6. The latter are covered in the discussions of Sections 5 and 6; those developed for NHTSA are discussed here.

A description of the procedures employed in generating the cross-tabulations is given in Appendix C.

3.4.1. General

NHTSA submitted a number of questions on the possible interaction of commercial vehicle accident variables with a high degree of interest. The responses to those questions that could be answered with cross-tabulations from the present data base are next presented. They treat:

a) Type of Accident Cause vs. Road Type

b) Single- or Multiple-Vehicle Accident vs. Number of Commercial Vehicle Occupants

c) Injury Severity Level for Commercial Vehicle Occupants vs. Cabover or Cab-Behind Configuration

d) Passenger Car Injury Severity Level vs. Underride/Non-Underride Accident

3.4.2. Type of Accident Cause vs. Road Type

Table 3-2 presents the results of this cross-tabulation. Here the accident causes, as judged by the reporting officer, are limited to those involving the behavior of the commercial vehicle. Note that since causes only are considered, there may be fewer instances of any particular behavior—e.g., jackknife—in this table than in a tabulation taking into account all occurrences of that behavior, whether or not it is judged the cause of the accident. Note also that a relatively large number of unknown cases exists, perhaps indicating some difficulty in reporting by the officer at the scene.

TABLE 3-2. CROSS-TABULATION OF FREQUENCIES OF TYPE OF ACCIDENT OCCURRENCE VERSUS ROAD TYPE (SHEET 1 OF 3)

	Frequency Percent Row PCT Col PCT	Missing Value .	Conventional One-way 1	Conventional Two-way 2	Express-way 3	Freeway 4	On-ramp 5	Off-ramp 6	Intersection 7	Other 8	Total
Unknown	0	2	6	373	10	572	26	21	55	23	1086
		.	0.21	12.80	0.34	19.63	0.89	0.72	1.89	0.79	37.27
		.	0.55	34.35	0.92	52.67	2.39	1.93	5.06	2.12	
		.	31.58	37.00	33.33	38.16	34.67	26.25	41.35	32.86	
Head-on	1	0	0	0	8	0	3	0	3	0	14
		.	0.00	0.27	0.00	0.10	0.00	0.00	0.10	0.00	0.48
		.	0.00	57.14	0.00	21.43	0.00	0.00	21.43	0.00	
		.	0.00	0.79	0.00	0.20	0.00	0.00	2.26	0.00	
Rear-End	2	1	2	129	6	307	2	16	8	5	475
		.	0.07	4.43	0.21	10.54	0.07	0.55	0.27	0.17	16.30
		.	0.42	27.16	1.26	64.63	0.42	3.37	1.68	1.05	
		.	10.53	12.80	20.00	20.48	2.67	20.00	6.02	7.14	
Sideswipe	3	0	3	167	6	304	14	15	29	12	550
		.	0.10	5.73	0.21	10.43	0.48	0.51	1.00	0.41	18.87
		.	0.55	30.36	1.09	55.27	2.55	2.73	5.27	2.18	
		.	15.79	16.57	20.00	20.28	18.67	18.75	21.80	17.14	
Angle	4	0	0	2	0	2	2	0	2	1	9
		.	0.00	0.07	0.00	0.07	0.07	0.00	0.07	0.03	0.31
		.	0.00	22.22	0.00	22.22	22.22	0.00	22.22	11.11	
		.	0.00	0.20	0.00	0.13	2.67	0.00	1.50	1.43	
Broadside	5	0	1	72	1	19	0	4	19	1	117
		.	0.03	2.47	0.03	0.65	0.00	0.14	0.65	0.03	4.02
		.	0.85	61.54	0.85	16.24	0.00	3.42	16.24	0.85	
		.	5.26	7.14	3.33	1.27	0.00	5.00	14.29	1.43	
Other Collision	6	2	3	116	2	131	12	11	8	14	297
		.	0.10	3.98	0.07	4.50	0.41	0.38	0.27	0.48	10.19
		.	1.01	39.06	0.67	44.11	4.04	3.70	2.69	4.71	
		.	15.79	11.51	6.67	8.74	16.00	13.75	6.02	20.00	
	Total	.	19	1008	30	1499	75	80	133	70	2914
		.	0.65	34.59	1.03	51.44	2.57	2.75	4.56	2.40	100.00

TABLE 3-2. (SHEET 2 OF 3)

	Frequency Percent Row PCT Col PCT	Missing Value .	Conventional One-way 1	Conventional Two-way 2	Express-way 3	Freeway 4	On-ramp 5	Off-ramp 6	Intersection 7	Other 8	Total
Thrown debris	15	0 . . .	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	3 0.10 100.00 0.20	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	3 0.10
Catalytic vehicle	16	0 . . .	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	2 0.07 100.00 0.13	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	2 0.07
Other (non-collisions)	17	0 . . .	0 0.00 0.00 0.00	4 0.14 30.77 0.40	0 0.00 0.00 0.00	9 0.31 69.23 0.50	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	13 0.45
Animal in roadway	50	0 . . .	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 0.03 100.00 0.07	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 0.03
Object off way	53	0 . . .	0 0.00 0.00 0.00	1 0.03 50.00 0.10	0 0.00 0.00 0.00	1 0.03 50.00 0.07	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	2 0.07
	Total	. .	19 0.65	1008 34.59	30 1.03	1499 51.44	75 2.57	80 2.75	133 4.56	70 2.40	2914 100.00

TABLE 3-2. (SHEET 3 OF 3)

	Frequency Percent Row PCT Col PCT	Missing Value .	Conventional One-way 1	Conventional Two-way 2	Express-way 3	Freeway 4	On-ramp 5	Off-ramp 6	Intersection 7	Other 8	Total
Ran off road	7	0	0	21	1	10	1	1	1	4	39
		.	0.00	0.72	0.03	0.34	0.03	0.03	0.03	0.14	1.34
		.	0.00	53.85	2.56	25.64	2.56	2.56	2.56	10.26	
		.	0.00	2.08	3.33	0.67	1.33	1.25	0.75	5.71	
Over turn	8	1	4	88	3	67	13	7	7	9	198
		.	0.14	3.02	0.10	2.30	0.45	0.24	0.24	0.31	6.79
		.	2.02	44.44	1.52	33.84	6.57	3.54	3.54	4.55	
		.	21.05	8.73	10.00	4.47	17.33	8.75	5.26	12.86	
Jackknife	9	1	0	7	0	16	1	1	0	0	25
		.	0.00	0.24	0.00	0.55	0.03	0.03	0.00	0.00	0.86
		.	0.00	28.00	0.00	64.00	4.00	4.00	0.00	0.00	
		.	0.00	0.69	0.00	1.07	1.33	1.25	0.00	0.00	
Separation of unit	10	0	0	7	0	10	0	1	0	0	18
		.	0.00	0.24	0.00	0.34	0.00	0.03	0.00	0.00	0.62
		.	0.00	38.89	0.00	55.56	0.00	5.56	0.00	0.00	
		.	0.00	0.69	0.00	0.67	0.00	1.25	0.00	0.00	
Separation of cargo	11	1	0	10	1	17	4	2	1	1	36
		.	0.00	0.34	0.03	0.58	0.14	0.07	0.03	0.03	1.24
		.	0.00	27.78	2.78	47.22	11.11	5.56	2.78	2.78	
		.	0.00	0.99	3.33	1.13	5.33	2.50	0.75	1.43	
Cargo shift	12	0	0	1	0	3	0	0	0	0	4
		.	0.00	0.03	0.00	0.10	0.00	0.00	0.00	0.00	0.14
		.	0.00	25.00	0.00	75.00	0.00	0.00	0.00	0.00	
		.	0.00	0.10	0.00	0.20	0.00	0.00	0.00	0.00	
Fire	13	0	0	2	0	22	0	1	0	0	25
		.	0.00	0.07	0.00	0.75	0.00	0.03	0.00	0.00	0.86
		.	0.00	8.00	0.00	88.00	0.00	4.00	0.00	0.00	
		.	0.00	0.20	0.00	1.47	0.00	1.25	0.00	0.00	
	Total	.	19	1008	30	1499	75	80	133	70	2914
		.	0.65	34.59	1.03	51.44	2.57	2.75	4.56	2.40	100.00

Of particular interest to NHTSA are the relative frequencies of occurrence of an overturn accident vs. all others, on different road types. For example, for conventional two-way roads, the ratio of overturns to non-overturns is 88 ÷ (1008 - 88) = .096. For expressways and freeways, this ratio is (3 + 67) ÷ (30 + 1499 - 3 - 67) = .048, exactly one-half the two-way road ratio. At ramps and intersections, the ratio is (13 + 7 + 7) ÷ (75 + 80 + 133 - 13 - 7 - 7) = .103, roughly the same as the two-way road ratio. The apparent, reasonable implication is that overturns are much less likely to be involved if an accident takes place on a freeway or expressway (other than at ramps). Other analyses of this nature may easily be made by the reader from Table 3-2.

3.4.3. Single- or Multiple-Vehicle Accident vs. Number of Commercial Vehicle Occupants

Table 3-3 presents an approximation of this cross-tabulation, as enabled by the present data base. Of interest to NHTSA is the comparison between the two ratios of the frequency of single- to multiple-vehicle accidents when the commercial vehicle has either one or several occupants. These ratios are not easily obtainable directly from the present data base, but certain reasonable approximations to them are.

The number of uninjured commercial vehicle occupants is regularly provided in the accident reports. Since the rate of injury of commercial vehicle occupants is very low, this number approximates the number of occupants. The cases of zero uninjured occupants, meaning at least one was in fact injured, have been distributed, as a second approximation, over the cases of one or more occupants in proportion to their frequencies. Unknown cases are neglected, as usual.

In this way Table 3-4 is generated. The desired ratios are now:

TABLE 3-3. CROSS-TABULATION OF FREQUENCIES OF ACCIDENTS WITH GIVEN NUMBERS OF UNINJURED COMMERCIAL VEHICLE OCCUPANTS AND NUMBERS OF INVOLVED VEHICLES

	Frequency Percent Row PCT Col PCT	Number of uninjured commercial vehicle occupants*											
		.	0**	1	2	3	4	5	6	7	8	9	Total
	.	0 . . .	1 . . .	2 . . .	0 . . .	0 . . .	0 . . .	0 . . .	0 . . .	0 . . .	0 . . .	0 . . .	. .
Number of vehicles in accident	1	40 . . .	100 3.65 18.05 34.48	399 14.56 72.02 18.79	44 1.61 7.94 18.49	8 0.29 1.44 22.22	2 0.07 0.36 15.38	0 0.00 0.00 0.00	1 0.04 0.18 20.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	554 20.21
	2 or more	138 . . .	190 6.93 8.69 65.52	1724 62.90 78.83 81.21	194 7.08 8.87 81.51	28 1.02 1.28 77.78	11 0.40 0.50 84.62	8 0.29 0.37 100.00	4 0.15 0.18 80.00	5 0.18 0.23 100.00	7 0.26 0.32 100.00	16 0.58 0.73 100.00	2187 79.79
	Total	. .	290 10.58	2123 77.45	238 8.68	36 1.31	13 0.47	8 0.29	5 0.18	5 0.18	7 0.26	16 0.58	2741 100.00

*Approximating number of occupants

**Therefore distribute cases of 0 uninjured occupants over other cases according to their frequencies

TABLE 3-4. APPROXIMATE CROSS-TABULATION OF FREQUENCIES OF ACCIDENTS WITH ONE OR SEVERAL COMMERCIAL VEHICLE OCCUPANTS AND ONE OR SEVERAL INVOLVED VEHICLES

Number of Involved Vehicles	Number of Occupants		
	1	More than 1	Total
1	487	67	554
More than 1	1,888	299	2,187
Total	2,375	366	2,741

one occupant	:	487/1888 = .26
several occupants	:	67/299 = .22

It does not appear that a very significant difference exists between these two ratios with the present data base, keeping in mind the necessary approximations that have been made.

3.4.4. Injury Severity Level for Commercial Vehicle Occupants vs. Cabover or Cab-Behind Configuration

Table 3-5 shows the results of this cross-tabulation. While the significance of the absolute frequencies cannot be determined without knowledge of the relative exposures of the two configurations, an interesting relative appraisal can be made. 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: (14 + 8) ÷ 1247 = .018, compared to (8 + 5) ÷ 1366 = .010. For less severe injuries, the relationship is reversed, but appears to be much less significant: (46 + 63) ÷ 1247 = .087 for cabover, compared to (53 + 75) ÷ 1365 = .093 for cab-behind.

If the present data base accurately represents the true population of commercial vehicle accidents, then the implication is that while there is little difference in the relative likelihood of minor injuries between the two configurations, cabover is significantly more likely to be associated with a major injury or fatality.

3.4.5. Passenger Car Injury Severity Level vs. Underride/Non-Underride Accident

This cross-tabulation is given in Table 3-6. Note first that the apparently large number of missing cases is merely an artifact of the fixed file structure of the data base, and has no significance.

TABLE 3-5. INJURY SEVERITY LEVEL FOR COMMERCIAL VEHICLE OCCUPANTS VERSUS CABOVER OR CAR-BEHIND CONFIGURATION

	Frequency Percent Row PCT Col PCT	Missing	Not Injured	Complaint of Pain	Minor Visible Injuries	Severe/ Major Injury	Fatal	Total
Not Cabover (Cab-Behind)	0	48	1366	53	75	8	5	1507
		.	47.35	1.84	2.60	0.28	0.17	52.24
		.	90.64	3.52	4.98	0.53	0.33	
		.	52.28	53.54	54.35	36.36	38.46	
Cab-over	1	30	1247	46	63	14	8	1378
		.	43.22	1.59	2.18	0.49	0.28	47.76
		.	90.49	3.34	4.57	1.02	0.58	
		.	47.72	46.46	45.65	63.64	61.54	
	Total	.	2613	99	138	22	13	2885
		.	90.57	3.43	4.78	0.76	0.45	100.00

TABLE 3-6. CROSS-TABULATION OF PASSENGER CAR INJURY SEVERITY LEVEL VERSUS UNDERRIDE/NON-UNDERRIDE ACCIDENT

	Frequency Percent Row PCT Col PCT	Missing	Not Injured	Complaint of Pain	Minor Visible Injuries	Severe/ Major Injury	Fatal	Total
No Underride	0	5561*	1972	289	249	55	43	2608
		.	69.34	10.16	8.76	1.93	1.51	91.70
		.	75.61	11.08	9.55	2.11	1.65	
		.	94.22	92.04	78.80	74.32	91.49	
Underride	1	320*	121	25	67	19	4	236
		.	4.25	0.88	2.36	0.67	0.14	8.30
		.	51.27	10.59	28.39	8.05	1.69	
		.	5.78	7.96	21.20	25.68	8.51	
	Total	.	2093	314	316	74	47	2844
		.	73.59	11.04	11.11	2.60	1.65	100.00

*Meaningless, due to fixed file structure with spaces for up to 10 passengers per accident.

The implication is striking that an underride accident is associated with a greater likelihood of car passenger injury, and especially a higher-severity level injury, than are other kinds of accidents. Thus, for example, the ratio of the frequency of major (i.e., up to fatal) injuries to that of no injury for underride is (19 + 4) ÷ 121 = .190, compared to (55 + 43) ÷ 1972 = .050 for other accidents. The ratios for all injury levels compared to the no-injury consequence is (236 - 121) ÷ 121 = .950, compared to (2608 - 1972) ÷ 1972 = .323.

Assuming the validity of the present data base, it is evident that underride accidents are in fact strongly associated with injuries to the striking car's passengers.

4. REGRESSION ANALYSES

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. (Details on the procedures are given in Appendix C.) 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 are probably most necessary to include in other model analyses; in particular, the contingency table analyses discussed in Section 5.

4.1. General Considerations

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. Considering henceforth only one dependent variable, y, and n independent variables, x_i, this means it is assumed that, approximately,

$$y = a_o + \sum_{i=1}^{n} a_i x_i \qquad (4\text{-}1)$$

for some regression coefficients, a_i. These are determined by finding the best least squares fit of the observed y data to the linear combinations of x data described by the right side of (4-1). Clearly, it is possible that no linear model will fit well.

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. Each "level" (numerical value or category) of a variable (e.g., "wet") is treated as a separate independent variable, with the values 1 or 0 only, depending on whether in each given case in the data base the original variable takes on that level ("wet") or not ("not wet"). (Similarly, "dry" and "not dry" correspond to 1 and 0, separately.)

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.

As described in Appendix C, 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 in Section 5. The regressions nevertheless helped to establish candidate significant variables for these latter analyses.

4.2. Regression Analysis Studies

The five studies conducted involved the following sets of dependent and independent variables, quantified or categorized in the 3,022 cases in the accident data base:

- Table 4-1. Variables Treated in Regressions of Jackknife Occurrences (Before and After Accident)
- Table 4-2. Variables Treated in Regressions of Hits-to-the-Rear (Including Underride and Override) Accidents
- Table 4-3. Variables Treated in Regression of Brakes-Related Involvements

The variables and levels given in Table 4-1 are input to each of the Jackknife regressions (before and after accident) following. The Table 4-2 variables and levels are input to the Underride and Override regressions. The variables and levels in Table 4-3 are input to the final Brakes-Related regression.

4.3. Results

The outputs of the five regression analysis studies that have been conducted are summarized below in terms of the dependent and most significant independent variables; the latter's significance and regression model coefficients; and the percentage of variation explained by the model that includes these variables.

The indicated significant variables provide bases for some of the contingency table analyses in Section 5. Except for this useful output, it is seen from the low percentages of explained variation that the models derived in all five studies are poor fits to the data and therefore are of little value. They, and the linear regression process, are consequently not considered further in the

TABLE 4-1. VARIABLES TREATED IN REGRESSIONS OF JACKKNIFE OCCURRENCES (BEFORE AND AFTER ACCIDENT)

	Variable Name and Levels	Internal Label
Dependent Variable	Jackknife, Before Crash (No=0, Yes=1)	C5R25
	Jackknife After Crash (No=0, Yes =1)	C5R26
Independent Variable		
1	Road Surface (Not Dry=0, Dry =1)	C1R16
2	Road Alignment (Level=1, No=0)	C5R38
3	Road Alignment (Uphill-1, No=0)	C5R39
4	Road Alignment (Downhill=1, No=0)	C5R41
5	Road Alignment (Straight=1, No=0)	C5R43
6	Road Alignment (Curved Left=1, No=0)	C5R44
7	Road Alignment (Curved Right=1, No=0)	C5R45
8	Road Type (Two Way=1, No=0)	C1A11
9	Road Type (Freeway=1, No=0)	C1B11
10	Road Type (On Ramp=1, No=0)	C1C11
11	Road Type (Off Ramp=1, No=0)	C1D11
12	Road Type (Intersection=1, No=0)	C1E11
13	Weather (Clear=1, No=0)	C1R14
14	Daytime (Value, 0-2400 hrs)	C1004
15	Experience (Value, years)	C7R22
16	Combination (Loaded=1, No=0)	C4R22
17	Commercial Vehicle Weight (Value, lbs)	C6R08
18	Brake Type (Air=1, No=0)	C4A32
19	Brake Type (Hydraulic=1, No=0)	C4B32
20	Single Brake Control (Yes=1, No-0)	C5R03
21	Vehicle Movement Preceding Involvement (Straight=1, No=0)	C3A21
22	Vehicle Movement Preceding Involvement (Right turn=1, No=0)	C3B21
23	Vehicle Movement Preceding Involvement (Left turn=1, No=0)	C3C21
24	Vehicle Movement Preceding Involvement, Evasive Action (Yes=1, No=0)	C3D21
25	Number of Drive Axles (One=1, Two=2)	C5R05
26	Braking in Maneuvering (Yes=1, No=0)	C5R58
27	Brakes on Towed Vehicle (Yes=1, No=0)	C4R10
28	Truck or Tractor (Tractor=1, Truck=0)	C4R08
29	Brake Equipment (Failure=1, No=0)	C1R12
30	Fifth Wheel Equipment (Failure=1, No=0)	C6R36
31	Steering System (Failure=1, No=0)	C6R37
32	Tire Failure (Yes=1, No=0)	C6R38
33	Lock up, Motor Vehicle (Yes=1, No=0)	C5R60
34	Fifth Wheel Position, Forward of Center Line (Yes=1, No=0)	C6R02
35	Fifth Wheel Position, Over Center Line (Yes=1, No=0)	C6R03
36	Fifth Wheel Position, Rear of Center Line (Yes=1, No=0)	C6R04
37	Commercial Vehicle Speed (Value, mph)	C3R20

TABLE 4-2. VARIABLES TREATED IN REGRESSIONS OF HITS-TO-THE-REAR (INCLUDING UNDERRIDE AND OVERRIDE) ACCIDENTS

	Variable Name and Levels	Internal Label
Dependent Variable	Underride (No=0, Yes=1)	C5R36
	Override (No=0, Yes=1)	C5R37
Independent Variable		
1	Day Time (Value, 0-2400 hrs)	C1004
2	Weight (Value, lbs)	C6R08
3	Commercial Vehicle Speed (Value, mph)	C3R20
4	Experience (Value, years)	C7R22
5	Road Surface* (Dry=0, Not Dry=1)	C1R16
6	Freeway (Yes=1, No=0)	C1A11
7	Two-Way (Yes=1, No=0)	C1B11
8	On-Ramp (Yes=1, No=0)	C1C11
9	Off-Ramp (Yes=1, No=0)	C1D11
10	Intersection (Yes=1, No=0)	C1E11
11	Roadway Alignment Level (Yes=1, No=0)	C5R38
12	Roadway Alignment, Uphill (Yes=1, No=0)	C5R39
13	Roadway Alignment, Downhill (Yes=1, No=0)	C5R40
14	Daylight (Yes=1, No=0)	C1A15
15	Dusk/Dawn (Yes=1, No=0)	C1B15
16	Dark, No Street Light (Yes=1, No=0)	C1C15
17	Weather (Yes=1, No=0)	C1R14
18	Air Brake (Yes=1, No=0)	C4A32
19	Hydraulic Brake (Yes=1, No=0)	C3B32
20	Unusual Roadway Condition, Construction (Yes=1, No=0)	C1R20
21	Body Type, Cabover (Yes=1, No=0)	C4R07
22	Tail Light Condition (Damaged=1, No=0)	C5R47
23	Stop Light Condition (Damaged=1, No=0)	C5R50
24	Clearance Lights Condition (Damaged=1, No=0)	C5R53
25	Commercial Vehicle Movement Prior to Involvement (Stopped=1, No=0)	C3A21
26	Commercial Vehicle Movement Prior to Involvement (Proceeding Straight=1, No=0)	C3B21
27	Commercial Vehicle Movement Prior to Involvement (Right Turn=1, No=0)	C3C21
28	Commercial Vehicle Movement Prior to Involvement (Left Turn=1, No=0)	C3D21
29	Commercial Vehicle Movement Prior to Involvement (Slowing--Stopping=1, No=0)	C3E21
30	Commercial Vehicle Movement Prior to Involvement (Changing Lane=1, No=0)	C3F21

*The coding of the levels of Road Surface in the regressions of Hits-to-the-Rear accidents is reversed from that used in the regressions of Jackknife accidents.

TABLE 4-3. VARIABLE TREATED IN REGRESSION OF BRAKE-RELATED INVOLVEMENTS

	Variable Name and Levels	Internal Label
Dependent Variable	Occurrence of Brakes-Related Accident (Yes=1, No=0)	C6R18
Independent Variable		
1	Speed (Value, mph)	C3I20
2	Roadway Alignment (Level=1, No=0)	C5R38
3	Roadway Alignment (Uphill=1, No=0)	C5R39
4	Roadway Alignment (Downhill=1, No=0)	C5R41
5	Experience (Value, years)	C7R22
6	Weight (Value, pounds)	C6108
7	Commercial Vehicle Load Status (Empty=0, No=1)	C4R22
8	Brake Type, Air (Yes=1, No=0)	C4A32
9	Brake Type, Hydraulic (Yes=1, No=0)	C4B32
10	Single Brake Control (Yes=1, No=0)	C5R03
11	Front Axle Brakes (Yes=1, No=0)	C5R01
12	Commercial Vehicle Movement, Proceeding Straight (Yes=1, No=0)	C3A20
13	Commercial Vehicle Movement, Making Turn	C3B20
14	Commercial Vehicle Movement, Changing Lane	C3C20
15	Commercial Vehicle Movement, Passing (Yes=1, No=0)	C3D20
16	Commercial Vehicle Movement, Merging (Yes=1, No=0)	C3E20
17	Commercial Vehicle Movement, Slowing–Stopping (Yes=1, No=0)	C3F20
18	Road Surface* (Not Dry=0, Dry=1)	
19	Road Alignment, Straight (Yes=1, No=0)	C5R43
20	Road Alignment, Curved Left (Yes=1, No=0)	C5R44
21	Road Alignment, Curved Right (Yes=1, No=0)	C5R45
22	Spring Brake (Yes=1, No=0)	C4R33
23	Cab Type (Conventional=0, Cabover=1)	C4R07

*The coding of the levels of Road Surface in the regression of Brakes-Related accidents is reversed from that used in the regressions of the Jackknife accidents.

present study.

4.3.1. Regression of the Frequency of JKBA on Potentially Relevant Variables

The set of independent variables considered in the stepwise regression was listed in Table 4-1. The results, including identification of the most significant variables, are shown in Table 4-4.

The F-test of significance indicates a very low probability of error in rejecting the hypothesis of a good fit by the regression. The R SQUARE fraction of explained variation of only .17 also indicates a poor fit of the linear model to the data.

The F values for the independent variables, and more explicitly the values of the probabilities of exceeding the F values, indicate the significance of the variables in explaining the dependent variable. While, in view of the poor fit of the model, these significance indicators cannot be given a great deal of absolute importance, they nevertheless provide some guidance to the likely relative importance of the independent variables. In this way, a subset of the variables most likely to be significant is selected for further analysis by the contingency table methods described in Section 5 below. The variables of highest significance so selected are: Road Surface (wet or dry), Lock Up (of brakes of motor unit, yes or no), Drive Axles (number, one or two), and Commercial Vehicle Weight (three levels: 10,000-25,000 lbs., 25,000-60,000 lbs., greater than 60,000 lbs.). Commercial Vehicle Speed is the next most significant variable, but is neglected for the present. It is to be noted that all these variables do appear reasonable in their apparent importance in JKBA.

The B values, which are the coefficients of the linear regression model, and the error values, are of little consequence in the present case because of the poor fit of the model.

TABLE 4-4. RESULTS OF REGRESSION OF JACKKNIFE BEFORE ACCIDENT ON SELECTED INDEPENDENT VARIABLES

R Square = 0.16867466 Intercept = 3.12659921

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	960.32490008	96.03249001	23.60	0.0001
Error	1163	4733.03114762	4.06967425		
Total	1173	5693.35604770			

		B Value	Std Error	Type II SS	F	Prob>F
Road Surface (Not Dry=0,Dry=1)	C1R16	-2.09793218	0.21978571	370.80335001	91.11	0.0001
Rd. Align., Curved Left (Yes,No)	C5R44	0.41756723	0.18885783	19.89493275	4.89	0.0272
Comb., Load=1,No=0	C4R22	-0.32695233	0.15581091	17.91978502	4.40	0.0361
Com. Veh. Weight	C6R08	-0.00000943	0.00000337	31.85131918	7.83	0.0052
Dr. Axles (1 or 2)	C5R05	-0.39665451	0.11958180	44.77692765	11.00	0.0009
Braking Manuevering	C5R58	0.39787333	0.16330212	24.15826086	5.94	0.0150
Brake Equip. (Fail=1,No=0)	C1R12	0.53545184	0.31176042	12.00489911	2.95	0.0862
Steering System (Faul=1,No=0)	C6R37	2.14272222	1.01302894	18.20738974	4.47	0.0346
Lock Up, Motor Veh. (Yes,No)	C5R60	1.23944088	0.22054517	128.53345282	31.58	0.0001
Com. Veh. Speed	C3R20	0.00840498	0.00314448	29.07607409	7.14	0.0076

NOTE: All variables in the model are significant at the 0.1000 level.

4.3.2. Regression of the Frequency of JKAA

Based again on the variables in Table 4-1, Table 4-5 shows that this linear regression model is an extremely poor fit to the data, with less than 7% explained variation.

The most significant independent variables, as indicated by the PROB>F values, nevertheless, are Lock Up and Commercial Vehicle Speed (both highly significant); Combination; Loaded or Not; and Road Alignment, Uphill or Not. Except perhaps for the last, the association of these variables with JKAA is immediately felt to be reasonable.

4.3.3. Regression of the Frequency of Underride Accidents

Table 4-6 again indicates a poor fit of the linear regression model to the data, based on the variables in Table 4-2 above. The most significant independent variables appear to be: Commercial Vehicle Moving (Stopped or Not), Commercial Vehicle Speed, Road Type (Freeway or Not), Daylight (or Not), and Time of Day (three levels: 0000-1000, 1000-1500, 1500-2400). These variables do indeed have an appropriate intuitive significance.

4.3.4. Regression of the Frequency of Override Accidents

This regression also treated the variables listed in Table 4-2. Table 4-7 again shows a poor model fit, but intuitively reasonable significant independent variables. These are: Commercial Vehicle Moving (Slowing-Stopping or Not), Commercial Vehicle Proceeding (Straight or Not), Hydraulic Brakes (Yes or No), and Type of Road (Freeway or Not). Unless it results from a consistent misunderstanding in reporting, significance of the first variable is of particular interest. It may to some extent imply that override accidents tend to occur when the overtaking commercial vehicle

TABLE 4-5. RESULTS OF REGRESSION OF JACKKNIFE AFTER ACCIDENT ON SELECTED INDEPENDENT VARIABLES

R Square = 0.06824030 **Intercept** = 0.64425091

		DF	Sum of Squares	Mean Square	F	Prob>F
Regression		10	376.24005226	37.62400523	8.52	0.0001
Error		1163	5137.21821009	4.41721256		
Total		1173	5513.45826235			

		B Value	Std Error	Type II SS	F	Prob>F
Rd. Surf. (Not Dry=0,Dry=1)	C1R16	-0.44311947	0.22796073	16.69052014	3.78	0.0522
Rd. Align, Uphill	C5R39	0.42759389	0.18004145	24.91530920	5.64	0.0177
Rd. Align, Turned Right	C5R45	-0.21976705	0.19269598	12.16383240	2.75	0.0973
Rd. Type, Fwy	C1B11	-0.26187942	0.14023400	15.40438514	3.49	0.0621
Comb., Loaded=1,No=0	C4R22	-0.32548101	0.13308681	26.41980224	5.98	0.0146
Veh. Mov. Proc. Inv., Evasive	C3D21	1.72362782	0.75273605	23.16060279	5.24	0.0222
Braking Manuevering	C5R58	0.30635396	0.17060293	14.24368474	3.22	0.0728
Steering System, Fail=1,No=0	C6R37	1.99577236	1.05493633	15.80948810	3.58	0.0588
Lock Up, Motor Veh. (Yes=1,No=0)	C5R60	1.04924949	0.23043712	91.58006642	20.73	0.0001
Com. Veh., Speed	C3R20	0.01334056	0.00365781	58.75637427	13.30	0.0003

NOTE: All variables in the model are significant at the 0.1000 level.

TABLE 4-6. RESULTS OF REGRESSION OF UNDERRIDE OCCURRENCE ON SELECTED INDEPENDENT VARIABLES

R Square = 0.06950382 Intercept = 0.15166682

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	8.29188887	0.82918889	15.57	0.0001
Error	2084	111.00930444	0.5326742		
Total	2094	119.30119332			

		B Value	Std Error	Type II SS	F	Prob>F
Daytime	C1004	-0.00003510	0.0000926	0.76596322	14.38	0.0002
Weight	C6R08	0.00000053	0.0000023	0.29062394	5.46	0.0196
Com. Veh. Speed	C3R20	-0.00168508	0.00032151	1.46321128	27.47	0.0001
Road Surface (Not Dry=0,Dry=1)	C1R16	-0.04702030	0.01764056	0.37844931	7.10	0.0077
Road Type (Fwy)	C1A11	0.05438855	0.01167684	1.15564972	21.70	0.0001
Daylight	C1A15	-0.05207013	0.01258708	0.91156731	17.11	0.0001
Tail Light Cond. (Damage=1,No=0)	C5R47	0.10486774	0.04190356	0.33361352	6.26	0.0124
Com. Veh. Mov. (Stopped)	C3A21	0.15697355	0.02589024	1.95813508	36.76	0.0001
Com. Veh. Mov. (Rt. Turn)	C3C21	-0.03886223	0.02209029	0.16485961	3.09	0.0787
Com. Veh. Mov. (Chang. Lane)	C3F21	-0.03867523	0.01744866	0.26169979	4.91	0.0268

NOTE: All variables in the model are significant at the 0.1000 level.

TABLE 4-7. RESULTS OF REGRESSION OF OVERRIDE OCCURRENCE ON SELECTED INDEPENDENT VARIABLES

R Square = 0.03353678 Intercept = -0.00530513

		DF	Sum of Squares	Mean Square	F	Prob>F
Regression		5	5.26669921	1.05333984	14.50	0.0001
Error		2089	151.77578289	0.07265475		
Total		2094	157.04248210			

		B Value	Std Error	Type II SS	F	Prob>F
Type of Road (Fwy)	C1A11	0.03451816	0.01208936	0.59231516	8.15	0.0043
Daylight	C1A15	0.02899712	0.01443275	0.29327540	4.04	0.0447
Hydraulic Brakes	C4B32	0.05344131	0.01802475	0.63867438	8.79	0.0031
Com. Veh. Mov. (Proceeding Straight)	C3B21	0.05480830	0.01251279	1.39395431	19.19	0.0001
Com. Veh. Mov. (Slowing-Stopping)	C3E21	0.15187730	0.02501286	2.67869349	36.87	0.0001

NOTE: All variables in the model are significant at the 0.1000 level.

is already slowing but cannot stop fast enough, as in suddenly slowing heavy traffic.

4.3.5. Regression of the Frequency of Brakes-Related Accidents

This regression model, based on the variables in Table 4-3, is seen in Table 4-8 to be also a poor fit to the data, although the selected independent variables, the direction of their effects, as indicated by the signs of the regression coefficients ("B values"), and their relative significances all appear reasonable. The occurrence of brakes-related accidents depends most significantly on whether the roadway is downhill. The apparent dependence on whether the vehicle has a single brake control for braking all units is spurious, however. It has been discovered that all vehicles in California are required to have such a control. The apparent variation is no doubt due to many instances where the CHP officer does not bother to indicate "Yes," and then the coder or computer treats the resulting blank as "No."

TABLE 4-8. RESULTS OF THE REGRESSION OF BRAKES-RELATED ACCIDENT OCCURRENCE ON SELECTED INDEPENDENT VARIABLES

R Square = 0.03819514   Intercept = 0.06663591

		DF	Sum of Squares	Mean Square	F	Prob>F
Regression		4	0.86255352	0.21563838	12.54	0.0001
Error		1263	21.72025405	0.01719735		
Total		1267	22.58280757			

		B Value	Std Error	Type II SS	F	Prob>F
Roadway Align. (Downhill or Not)	C5R41	0.04840636	0.00977662	0.42158863	24.51	0.0001
Experience of Driver (Years)	C7R22	-0.00081308	0.00037654	0.08018735	4.66	0.0310
Com. Veh. Load Status (Empty=1, Laden=0)	C4R22	0.01524155	0.00787911	0.06435250	3.74	0.0533
Single Brake Control (Yes=1,No=0)	C5R03	-0.06182783	0.01525276	0.28257448	16.43	0.0001

NOTE: No other variables met the 0.5000 significance level for entry into the model.

5. CONTINGENCY TABLE ANALYSES

As a review of the univariate tables in Section 3 will make evident, 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 in Section 4 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. This process is discussed in this section.

The discussion begins with some key points on the methodology of modern contingency table analysis based on the minimum discrimination information approach. A more complete mathematical delineation of this approach is provided in Appendix F. The method is then applied to the investigation of the interaction of the most significant variables (identified in a regression analysis described in Section 4) in the occurrence of JKBA. The computer program CONTAB has been employed in this investigation. A detailed discussion of this particular application is provided in order to illuminate the important features of the method. The results of some other CONTAB studies are then presented more briefly. These treat:

a) Accident severity vs. road type, commercial vehicle configuration, and weight. (This study is analogous to, and its results are compared with, those of the study reported on by James Hedlund of NHTSA in Reference 3.)

b) Brakes-related accident occurrence vs. commercial vehicle configuration and weight, and direction of road (downhill or not).

c) High-cost brakes-related accident occurrence vs. the same variables. (This study considers high severity as a surrogate for high cost.)

Finally, another contingency table analysis program, KULLITR, is applied to an extended form of analysis in which the exposure to accident (in terms of VMT) of the various categories of commercial vehicles (defined by type, number of axles, weight) is included as a constraint. Two different sets of exposure estimates are employed; their derivation is discussed in Section 6. The objective in these analyses is to ascertain whether the incorporation of exposure affects the set of significant interactions among the variables relating to the occurrence of some kind of accident. If it does, the interactions (say, of truck type and accident occurrence) established as significant, neglecting exposure, may merely be artifacts of exposure in commercial vehicle operations, rather than being of real importance in accident causation.

The KULLITR case studies are those of accident involvement vs. commercial vehicle type, number of axles, weight, and exposure, using the direct and induced exposure estimates derived in Section 6.

5.1. The Minimum Discrimination Information (MDI) Approach to the Analysis of Categorical Data

In recent years analysis of categorical data, or data classified in the form of contingency tables, has received considerable attention. One of the primary reasons for taking recourse to this form of data analysis is the minimal number of assumptions required.

Typically, quantitative data, consisting of actual measurements, $X_{ijk...}$, say, are analyzed by the following standard techniques:

a) Regression (simple or multiple)

b) Analysis of variance

c) Discriminant analysis

d) Principal components and factor analysis

These methods require some or all of the following assumptions for estimation and tests of significance:

a) Random sampling

b) A structure on the <u>means</u> of $X_{ijk...}$

c) Constancy of variance of $X_{ijk...}$

d) Normality of distributions of $X_{ijk...}$

Without assumption (d), the validity of associated F-tests and other tests of significance is open to doubt. In some cases, "distribution-free procedures" based on rank scores are available. But for these, too, some assumptions, such as continuity of distribution functions, are required. Moreover, when the techniques enumerated (a) to (d) above are to be applied to qualitative data, the qualitative variables must be assigned some quantitative "scores"; in many analyses, more or less arbitrarily.

Analytical procedures for categorical data do away with all the assumptions above except (a). Rather than considering individual $X_{ijk...}$ and making assumptions (b), (c), and (d), one treats directly the observed frequency distributions of $X_{ijk...}$ In this approach, note that X can be quantitative[1] as well as qualitative. Since the analysis requires minimal assumptions, the conclusions are valid for a wider class of problems. This enhanced validity is obtained at the cost of the requirement that the sample be larger.

Appendix F presents the mathematical framework of the MDI

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[1]The categorization of the range of a quantitative variable may now be somewhat arbitrary, however. But this arbitrariness usually should not be of any significance.

methodology. The following section summarizes the features of importance in its application.

5.2. Methodology

The aim of contingency table analysis is to study the interrelationships among different variables. The data are assumed to derive from a collection of one or more multinomial distributions. To each cell of the distribution is associated the probability that a data point selected at random is classified in that cell. The analysis examines various structural log-linear models, from the most simplistic to the most complex, and tries to strike a balance between structural simplicity and goodness of fit. As a result, that model is chosen that contains as few parameters as possible, and at the same time incorporates within itself all the important interactions as exhibited by the data. In the accident causation analysis application of present interest, a model that fits the data well and requires a certain set of parameters demonstrates the significance to causation of a dependent accident variable (e.g., accident severity), of the dominant independent variables (e.g., truck type, road type) and their interactions subsumed in the required parameters. If only a few such parameters are needed in the model, a useful understanding of causation and a valuable predictive capability are established. If many, approaching all possible, parameters are needed, the model establishes that causation apparently derives from all the considered variables and their interactions, and no simpler understanding is possible. In support of decision making on the utility of any assessed model, the contingency table analysis process provides both a statistic to test the overall goodness-of-fit, and measures of the relative importance of the variables and their interactions.

In a log-linear model, of the class assessed by the analysis, the logarithms of multinomial probabilities are expressed as linear functions of the parameters: for the sake of illustration, consider a four-way cross-tabulated frequencies table (hijk) of dimensions 2x2x2x2. In such a four-way table, the data evidently can be summarized with least complexity by just the total of the counts (equivalent to assuming a uniform distribution, with every cell having an equal probability). The next most simple set of summary measures is that of the four independent one-way marginals, then the six two-way marginals, the four three-way marginals, and finally, there is no reduction achieved if the model requires all the individual cell entries (the "four-way" marginals) for its specification.

With this in mind, a reasonable way to construct log-linear models is to begin with a scaling constant (corresponding to the total of all cell-frequencies), then include parameters corresponding to all one-way marginals, then those corresponding to all two-way marginals, and so on.[1]

For a 2x2x2x2 table with 16 cells, a schematic representation of the complete ("saturated") model, which involves 16 parameters, and thus is most complex, is given in Table 5-1, where the four factors involved are denoted by A, B, C, and D, and their levels by h, i, j, and k.

The method of analysis proceeds to select the model that contains as few parameters (L and the τ's) as possible and, at the same time, provides a good fit to the data. If the model includes

---

[1]Two facts should also be borne in mind; first, to preserve linear independence, parameters should be included only for those marginal totals that are not implied by the previous ones, and second, a fixed higher-order marginal total implies fixed lower-order marginal totals for all subscripts appearing in the higher-order marginal. Consequently, if the parameters of, say, a particular three-factor interaction are to be included, then the parameters corresponding to all the first- and second-order interactions appearing in the three-factor interaction must also be included. This remark is illustrated in the example below.

TABLE 5-1. DESIGN MATRIX FOR 2X2X2X2 CONTINGENCY TABLE ILLUSTRATION

Cell Index h i j k	Parameters or Column Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	L	τ_1^A	τ_1^B	τ_1^C	τ_1^D	τ_{11}^{AB}	τ_{11}^{AC}	τ_{11}^{AD}	τ_{11}^{BC}	τ_{11}^{BD}	τ_{11}^{CD}	τ_{111}^{ABC}	τ_{111}^{ABD}	τ_{111}^{ACD}	τ_{111}^{BCD}	τ_{1111}^{ABCD}
1 1 1 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1 1 1 2	1	1	1	1	0	1	1	0	1	0	0	1	0	0	0	0
1 1 2 1	1	1	1	0	1	1	0	1	0	1	0	0	1	0	0	0
1 1 2 2	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
1 2 1 1	1	1	0	1	1	0	1	1	0	0	1	0	0	1	0	0
1 2 1 2	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0
1 2 2 1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
1 2 2 2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 1 1 1	1	0	1	1	1	0	0	0	1	1	1	0	0	0	1	0
2 1 1 2	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0
2 1 2 1	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
2 1 2 2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2 2 1 1	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0
2 1 1 2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2 2 2 1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2 2 2 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

just column 1, we have

$$\ell n\ p(hijk) = L \text{ for each of } h,i,j,k = 1,2$$

Hence, the model assumes that <u>no</u> parameters are necessary, apart from the scaling constant, to describe the data (i.e., a uniform distribution applies). Columns 2 through 5 correspond to parameters of the one-way marginals. Observe that the model incorporating one-factor interactions ("main effects") can be written as

$$\begin{aligned} \ln p(hijk) = L &+ T_1^A(hijk)\ \tau_1^A \\ &+ T_1^B(hijk)\ \tau_1^B \\ &+ T_1^C(hijk)\ \tau_1^C \\ &+ T_1^D(hijk)\ \tau_1^D \end{aligned}$$

The T_1-functions are the columns of zeroes and ones associated with parameters 2-5, and, in fact, yield the desired one-way marginal totals. See, for example, that

$$\begin{aligned} \sum_{hijk} p(hijk) T_1^B(hijk) &= \sum_{hjk} p(h1jk) \\ &= p(.1..) \text{ ("dot notation")} \end{aligned}$$

corresponding to the B-marginal at its first level. Since L fixes the total, inclusion of the B-marginal at its first level ($j = 1$) fixes its marginal at the second level ($j = 2$);[1] so that in order to preserve linear independence τ_2^B is not included. The remaining columns are written similarly and the interaction parameters to which they correspond are given on top. For example, if one wants to include in the model the three-factor interaction parameter τ_{111}^{ABD}, the parameters τ_1^A, τ_1^B, and τ_1^D, the one-factor interaction parameters, and τ_{11}^{AB}, τ_{11}^{AD}, and τ_{11}^{BD}, the two-factor interaction

---

[1]That is, since $p(.1..) + p(.2..) = 1$, only one term on the left can be assigned an independent value.

parameters, must also be included.

The application of this method is illustrated by the example next described, an analysis of the interaction of the occurrence of JKBA and several independent variables.

5.3. Application to the Analysis of JKBA

The preceding discussion is illustrated with an example treating data on JKBA as associated with the number of drive axles (DA), the occurrence of wheel lock-up (LU), and the condition of the road surface (RS). The different levels of each of these variables and respective indices used are given below.

TABLE 5-2.—JKBA ANALYSIS VARIABLES

Characteristic	Variable	Variable name in analysis description	Associated index	Levels	
				1	2
Jackknife-Before-Accident	JKBA	A	h	No	Yes
Drive Axles	DA	B	i	1	2
Lock-Up	LU	C	j	No	Yes
Road Surface	RS	D	k	Not Dry	Dry

5.3.1. Input

There are 16 cells for this 2x2x2x2 contingency table with observed (cross-tabulated) cell frequencies x_{hijk} as given in Table 5-3.[1] The underlying cell probabilities are denoted by p(hijk), and are subject to the constraint Σ_{hijk} p(hijk) = 1.

[1]The cross-tabulated or joint frequencies are established by the procedure described, and also employed to obtain cross-tabulations with their own interest, in Section 3 above.

Dot-notation is again used to indicate sums: thus, p(1 ijk) + p(2 ijk) = p(. ijk), is the sum over h, or the A-marginal, for each set of i,j,k values,etc.

TABLE 5-3.—CONTINGENCY TABLE FOR JKBA (2x2x2x2)

			RS(k) 1	RS(k) 2
JKBA(h) 1	DA(i) 1	LU(j) 1	73	940
		2	6	58
	2	LU 1	60	714
		2	7	60
2	DA 1	LU 1	22	28
		2	4	19
	2	LU 1	8	6
		2	3	2

Example of a one-way marginal:

x(1...) = 73 + 940 + 6 + 58 + 60 + 714 + 7 + 60 = 1918

Example of a two-way marginal:

x(11..) = 73 + 940 + 6 + 58 = 1077

Example of a three-way marginal:

x(111.) = 73 + 940 = 1013

Example of a four-way marginal:

x(1122) = 58

5.3.2. Computer Analyses

An object of this analysis is to be able to estimate ("predict") the probability of JKBA, i.e., p(hijk) for h = 2, given any particular combination of levels of i,j,k. For example, for i = 2, j = 1, k = 1 (two drive axles, no lock-up, dry road), what are the estimates of p(h211), the probabilities of occurrence (h = 2) or non-occurrence (h = 1) of JKBA? In the usual terminology of multiple regression, A is regarded as the dependent variable and B, C, and D are independent variables.

The simplest prediction model assumes that A is independent of B, C, D; there is no predictive capacity in the levels of B, C, D as far as A is concerned. This is formulated in symbols in terms of an hypothesis, H_a, as

$$H_a : p(hijk) = p(h...)\ p(.ijk)$$

The computer output in Table 5-4[1] shows this hypothesis as Hypothesis 1,

JKBA
DA*LU*RS

corresponding to the two sets of marginals that are fitted to the data (the one-way A-marginal and the four three-way BCD marginals). Under H_a,

$$p^*(hijk) = \frac{x(h...)\ x(.ijk)}{N}$$

where N is the total frequency (3,745) and p* denotes the MDI estimate of p(hijk). The x's denote the observed frequencies. Note that H_a includes all the interactions among B, C, D, but exclusive of A. It is not necessary to assume a priori that any of these possible interactions are absent, as that will impose unnecessary structure on the model. Further, the fitting procedure will adjust accordingly if there are in fact no interactions present among B, C, D. The interest is only in the associations of the dependent variable with the various possible individual and joint occurrences of the independent variables. There is no

[1]The output in Table 5-4 on Outliers, CI, smooth and zero, is not of present interest and can be ignored.

TABLE 5-4. SUMMARY OF RESULTS OF JACKKNIFE-BEFORE-ACCIDENT CONTINGENCY TABLE ANALYSIS (SHEET 1 OF 2)

```
CONTAB SUMMARY        JKBA CONTINGENCY TABLE.  FACTORS:  JKBA * DRIVE AXLE * LOCKUP * RD SURF
SAMPLE SIZE                            2010.000000

HYPOTHESIS    NONZERO EFFECTS                                              SMOOTH      ZERO     I.S.      D.F.   PROB
   I*   CI*

  1           MARGINALS  EFFECTS  RESIDUALS
              JKBA
              DRIVE AXLE * LOCKUP * RD SURF
                OUTLIERS
                       2    1    1    1     36.188110
                       2    1    1    2      7.046116
                       2    1    2    1     10.264101
                       2    1    2    2     33.188324
                       2    2    1    2     33.834106
                                                                          0.0000    0.000001  142.727    7    0.0000
 0.00  0.00

  2           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1
              JKBA * RD SURF
              DRIVE AXLE * LOCKUP * RD SURF
                OUTLIERS
                       2    1    2    2     46.716827
                       2    2    1    2     16.058746
                                                                          0.0000    0.000001   73.449    6    0.0000
 0.49  0.40

  3           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1
              JKBA * DRIVE AXLE
              DRIVE AXLE * LOCKUP * RD SURF
                OUTLIERS
                       2    1    1    1     25.134277
                       2    1    1    2     23.447388
                       2    1    2    1      8.001560
                       2    1    2    2     23.467606
                       2    2    1    1     13.784729
                       2    2    1    2      8.161221
                       2    2    2    1     10.096851
                                                                          0.0000    0.000001  121.777    6    0.0000
 0.15  0.00
```

TABLE 5-4. (SHEET 2 OF 2)

```
CONTAB SUMMARY         JKBA CONTINGENCY TABLE.  FACTORS:  JKBA * DRIVE AXLE * LOCKUP * RD SURF
SAMPLE SIZE                        2010.000000

HYPOTHESIS    NONZERO EFFECTS                                                    SMOOTH       ZERO    I.S.      D.F.   PROB
   I*   CI*

  4           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1

              JKBA * LOCKUP
              DRIVE AXLE * LOCKUP * RD SURF

                 OUTLIERS
                        2    1    1    1      46.422333
                        2    2    1    1       8.310833
                        2    2    1    2      20.891678
                        2    2    2    2      11.083714

 0.30  0.18                                                                      0.0000   0.000001   99.957    6   0.0000

  5           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1

              JKBA * RD SURF
              JKBA * DRIVE AXLE
              DRIVE AXLE * LOCKUP * RD SURF

                 OUTLIERS
                        2    1    2    2      35.610199

 0.64  0.50                                                                      0.0000   0.000001   51.412    5   0.0000


  6           JKBA * RD SURF
              JKBA * LOCKUP
              JKBA * DRIVE AXLE
              DRIVE AXLE * LOCKUP * RD SURF

 0.95                                                                            0.0000   0.000001    7.800    4   0.0992
```

interest in the characterization of these joint occurrences in themselves.

Referring to the design matrix in Section 5.2., H_a uses columns 1 (L), 2 (τ_1^A), the three-factor interaction BCD (column 15), and therefore all lower-order interactions, columns 9, 10, 11, and 3, 4, 5, involving only i, j, k, and B, C, D. Other τ-parameters are set equal to zero. The latter number equals the degrees of freedom (D.F.). In the present case, for H_a, D.F. = 16 - 9 = 7.

Now, refer to Table 5-4 for the evaluation of the model H_a (Hypothesis 1). The MDI statistic (I.S.) is 142.72, which is highly significant (the probability of a greater value [PROB] being zero to four decimal places). The test of significance uses the χ^2 approximation to the MDI statistic. This shows that H_a is strongly rejected; its model is a very poor fit to the data, and thus one or more of the variables B, C, D are needed for the prediction of p(hijk).

If the value of the MDI statistic had been non-significant (with PROB>.05, say), the analysis would conclude that A is independent of B, C, D; i.e., B, C, D have no predictive capacity as far as A is concerned. The quantity 142.72 (the value of the MDI statistic) can be looked upon as "unexplained variation" (by analogy with the analysis of variance) when the hypothesis of independence, H_a, is assumed. In a sequence of increasingly complex hypotheses to follow, the attempt is made to reduce this variation by including more and more interaction parameters in the model. The sequence is halted with as simple a model as possible, when a non-significant MDI statistic occurs, and a satisfactorily high percentage of variation in the data is explained.

In the output summarized in Table 5-4, the sequence derives from adding interaction parameters to the existing ones in the following order:

H_d (Hypothesis 2) includes τ_{11}^{AD} (col. 8 of the design matrix)

H_c (Hypothesis 3) includes $\tau_{11}{}^{AC}$ (col. 7 of the design matrix)

H_b (Hypothesis 4) includes $\tau_{11}{}^{AB}$ (col. 6 of the design matrix)

In the output for H_d (Hypothesis 2), the inclusion of $\tau_{11}{}^{AD}$ is reflected in the marginals fitted as

JKBA* RS	(A*D)
DA* LU*RS	(B*C*D)

The MDI statistic is 73.45 with 6 D.F., still highly significant (PROB of a value > I.S., given H_d, is still essentially zero), showing that the model provided by H_d is not adequate and more interactions should be included to improve the model. The difference 142.72 - 73.45 = 69.27 with 7 - 6 = 1 D.F. measures the <u>effect</u> of inclusion of the interaction parameter $\tau_{11}{}^{AD}$. A χ^2 table shows this is highly significant, indicating that the association of A with D should be incorporated in the model. (But the rejection of H_d shows that the model has to include some other appropriate interactions as well.) The quantity 69.27/142.73 = 0.49 is the fraction of the variation in the "base" hypothesis (H_a) explained by including the interaction between A and D. (This is shown on the left-hand side in the CONTAB summary in Table 5-4.)

A similar analysis can now be made for the interaction parameter $\tau_{11}{}^{AC}$, incorporated in the model under H_c (Hypothesis 3). The MDI statistic is 121.78 with 6 D.F., so the model is still poor. The difference from H_a is 20.95, however, so the interaction AC should be included in the model. (The difference is highly significant: χ^2 = 20.95, D.F. = 7 - 6 = 1.) The fraction of variation explained by the interaction AC alone is 20.95/142.72 = 0.15.

Under H_b, the MDI statistic is 99.97, the difference is 42.76, and the explained variation is 0.30. So the conclusion is very similar to that for H_c: the model is still poor but the AB interaction is significant.

At this point, the effect of the single most important predictor can be assessed. All the interactions of JKBA with a single independent variable, A*D, A*C, and A*B are important enough to be included in the model. The single most important is the interaction with D (RS), the next is that with C (LU), and the last is that with B (DA).

The next step in the sequence of models to be tried is the inclusion of all three of the pairwise interactions of A with B, C, and D simultaneously. (Simpler possibilities, each including one of the three possible sets of two of these, could have been tried first, if desired.) This hypothesis can be indexed as H_e (Hypothesis 5 in the output). The computer output for this model shows that the interactions included are:

JKBA*RS

JKBA*LU

JKBA*DA

DA*LU*RS

implying that over and above the parameters included in the base hypothesis (which fitted marginals JKBA and DA*LU*RS), interaction parameters $\tau_{11}{}^{AD}$ (corresponding to JKBA*RS), $\tau_{11}{}^{AC}$ (corresponding to JKBA*LU), and $\tau_{11}{}^{AB}$ (corresponding to JKBA*SA) are included.

The MDI statistic for this model is 7.8 with 4 D.F., which is not significant at 5% but is significant at the 10% level. More important, it accounts for $\frac{142.73 - 7.8}{142.73} = 0.95$ of the unexplained variation in H_a. So H_e can be regarded as an acceptable model. In this model all three-factor interactions can be taken as negligible. Thus prediction of the JKBA probability requires the cross-tabulations of data in the form JKBA*RS, JKBA*LU, and JKBA*DA only; but no three-way cross-tabulations involving JKBA.

The implication, then, is that JKBA causation depends, and its prediction therefore requires information, only on the interaction of JKBA with all three of the independent variables individually (on RS more than the others, then LU). However, no information is required on their joint occurrence with JKBA. Thus a simple situation exists for the further study of the probability of occurrence of JKBA. Sample data need only be obtained on the joint occurrences of JKBA with the DA, LU, and RS levels separately, and the probability (or frequency) of JKBA can then be predicted simply by the model in which parameters τ_{111}^{ABC}, τ_{111}^{ABD}, τ_{111}^{ACD}, and τ_{1111}^{ABCD} (in the design matrix, Table 5-1), are set equal to zero.

A final note is in order on the sequence of hypothesis tests that have been made. It is evident that there is no fully <u>objective</u> criterion available for deciding where to stop the sequence and accept a model, if successive models exist that are all statistically non-rejectable and explain increasing fractions of the initial variation. (Note that the final possible model, which fits every input contingency table cell exactly, necessarily explains 100% of this variation. But it is clearly virtually certain to be spurious in its prediction of the "noise," as well as meaningful components of the observed data. Moreover, it is certainly neither simple nor useful.) A subjective decision must be made; the simplest possible model must be accepted that is both non-rejectable at a reasonable level of significance, and a reasonable explainer of the variation. Judgment, based on experience with both the general behavior of accident parameters and with contingency table analysis, is an unavoidable requirement.

5.3.3. The Log-Linear Model

The corresponding log-linear model includes the first 11 τ's and L and the first 10 τ's in the design matrix (Table 5-1) in Section 5.2. To estimate ln p(hijk) from a future set of data, only data sufficient to compute estimates of these 11 L and τ's should be required. For the present data set, it is of interest to see the L and τ values actually determined, and then to compare the table of joint frequencies, x*(hijk), predicted by the log-linear model they establish, with the original Table 5-3 of observed x(hijk). CONTAB does not produce all of these results, but KULLITR does. The $\tau(1)$ to $\tau(11)$ values (with $\tau(1)$ representing L), and x* values are shown in Table 5-6. Note that $2I(\bar{x}:x^*) = 7.79668$ is the same as the final IS = 7.80 produced by the CONTAB run, as previously discussed. (The output $2I[x^*:x]$ can be ignored.)

Comparing x* (or XSTAR) of Table 5-6 with x of Table 5-3 shows quite good agreement, e.g.:

TABLE 5-5.—COMPARISON OF x* WITH x, TABLE 5-6 AND 5-3

Cell	x* (Table 5-6)	x (Table 5-3)
1 1 1 1	73	73
1 2 2 2	58	60
2 1 1 1	21.6	22
2 2 2 2	3.7	2

5.3.4. Use of Model to Predict JKBA Odds

The x* values given in Table 5-6 for the accepted model can be used to develop the predicted odds of the occurrence of JKBA compared to its non-occurrence, under various conditions given by different combinations of the levels of the independent variables. The possible cases follow (refer to Table 5-3 for the definitions of the levels of the variables):

a) Dry road surface, one drive axle, no lockup:

$$\frac{x^*(2,1,1,2)}{x^*(1,1,1,2)} = \frac{30.7}{937.3} = 0.03$$

b) Wet road, one drive axle, no lockup:

TABLE 5-6. KULLITR OUTPUT OF τ-VALUES AND RESULTING PREDICTED JOINT FREQUENCY TABLE FOR JKBA ANALYSIS

```
ESTIMATE OF X AT COUNT= 14
   1   1   1   1       XSTAR( 1)=   73.445663
   1   1   1   2       XSTAR( 2)=  937.293457
   1   1   2   1       XSTAR( 3)=    3.330279
   1   1   2   2       XSTAR( 4)=   62.930725
   1   2   1   1       XSTAR( 5)=   62.823318
   1   2   1   2       XSTAR( 6)=  713.437500
   1   2   2   1       XSTAR( 7)=    6.400710
   1   2   2   2       XSTAR( 8)=   58.338379
   2   1   1   1       XSTAR( 9)=   21.554337
   2   1   1   2       XSTAR(10)=   30.706497
   2   1   2   1       XSTAR(11)=    6.669728
   2   1   2   2       XSTAR(12)=   14.069423
   2   2   1   1       XSTAR(13)=    5.176656
   2   2   1   2       XSTAR(14)=    6.562517
   2   2   2   1       XSTAR(15)=    3.599280
   2   2   2   2       XSTAR(16)=    3.662082
```

```
Z IS OBSERVED TABLE AND X IS INITIAL DIST.

2I(XSTAR:X)= 5454.324219

2I(Z:XSTAR)=      7.796698

TAU( 1)= 2.768229
TAU( 2)= 1.345972
TAU( 3)= 0.583343
TAU( 4)=-0.017297

TAU( 5)=-1.270198
TAU( 6)= 1.920491
TAU( 7)=-2.192554
TAU( 8)= 0.197128
TAU( 9)=-0.729127
TAU(10)=-0.219917
TAU(11)= 0.612444
```

$$\frac{x^*(2,1,1,1)}{x^*(1,1,1,1)} = \frac{21.55}{73.45} = 0.29$$

c) Dry road, one drive axle, lockup:

$$\frac{x^*(2,1,2,2)}{x^*(1,1,2,2)} = \frac{14.07}{62.93} = 0.22$$

d) Wet road, one drive axle, lockup:

$$\frac{x^*(2,1,2,1)}{x^*(1,1,2,1)} = \frac{6.67}{3.33} = 2.0$$

e) Dry road, two drive axles, no lockup:

$$\frac{x^*(2,2,1,2)}{x^*(1,2,1,2)} = \frac{6.56}{713.4} = 0.009$$

f) Wet road, two drive axles, no lockup:

$$\frac{x^*(2,2,1,1)}{x^*(1,2,1,1)} = \frac{5.18}{62.8} = 0.08$$

g) Dry road, two drive axles, lockup:

$$\frac{x^*(2,2,2,2)}{x^*(1,2,2,2)} = \frac{3.66}{58.3} = 0.06$$

h) Wet road, two drive axles, lockup:

$$\frac{x^*(2,2,2,1)}{x^*(1,2,2,1)} = \frac{3.60}{6.40} = 0.56$$

Clearly, a wet road surface is the primary factor in the odds of occurrence of JKBA. About a factor of 10 increase from the dry road odds appears in all four pairs of cases comparing these two conditions for various combinations of the levels of number of drive axles and occurrence of lockup.

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 discrimination of the combinations of the 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.

5.4. CONTAB Analysis of Injury Severity

A contingency table analysis has also been conducted that is as similar as possible to one previously reported on by James Hedlund of NHTSA [2]. Hedlund was able to make use of a larger data base (derived from the nationwide Bureau of Motor Carrier Safety accident reports data) that also included certain factors not involved in the present study. Hedlund's variables were:

a) Year, District, Roadway (two levels: two lanes, or at least four lanes)

b) Truck Type (four levels: three-, four-, or five-axle semi-trailers, or double-bottoms)

c) Weight (seven levels: 10,000 lb. intervals)

d) Fatality (two levels: of some involved car occupant, or not)

Certain of these variables also appear, at least approximately, in the present data base. The smaller present sample size, however, necessitates some further aggregation of their levels. Thus, the present analysis treats:

a) Road Type (two levels: conventional two-way, or freeway or expressway)

b) Truck Type (two levels: semi-trailer, or full trailer [generally a double-bottom])

c) Weight (three levels: 10,000-25,000 lbs., 25,000-60,000 lbs., greater than 60,000 lbs.)

d) High-Severity Injury (two levels: for some car occupant, yes or no)

Here "High-Severity Injury" refers to the highest injury levels— major or fatality. This combination was necessitated by the relatively small number of fatalities occurring in the present data base.

The input Contingency Table for this analysis is shown in Table 5-7. (The observed values are the x-values of interest. The LOG RATIO data may be ignored.) The summary results for the hypotheses tested are given in Table 5-8.

It is seen first that Injury Severity does depend upon the independent variables (Hypothesis 1 is quite strongly rejected, at about a 3% level of significance). It is next observed that Road Type is the most important individual explanatory variable (Hypothesis 2); it alone explains 0.40 of the initial variation under the first hypothesis. Moreover, this simple model is not rejected at a 23.5% significance level. If all three two-way interactions of Severity with Road Type, Truck Type, and Weight are incorporated (Hypothesis 9), the explained variation is raised to 0.58, and the model is not rejected at an 18% level of significance.

It is to be noted in passing that, as discussed earlier, and unlike the apparent inference in Hedlund's report, the strong

TABLE 5-7. INPUT CONTINGENCY TABLE FOR CONTAB ANALYSIS OF "HEDLUND STUDY"

Injury Severity	Road Type	Truck Type	Weight		
			1	2	3
1	1	1	68	99	73
		2	20	86	87
	2	1	138	264	151
		2	68	166	158
2	1	1	12	15	14
		2	6	16	17
	2	1	7	34	22
		2	11	13	23

TABLE 5-8. SUMMARY OF RESULTS OF CONTAB ANALYSIS OF "HEDLUND STUDY" (SHEET 1 OF 4)

CONTAB SUMMARY SEVER INJ CONTINGENCY TABLE. FACTORS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT

SAMPLE SIZE 1568.000000

HYPOTHESIS	I*	CI*	NONZERO EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
1	0.00	0.00	MARGINALS EFFECTS RESIDUALS INJ SEVERITY ROAD TYPE * TRUCK TYPE * WEIGHT OUTLIERS 2 2 1 1 8.325960	0.0000	0.000001	21.158	11	0.0318
2	0.40	0.33	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	12.800	10	0.2351
3	0.03	-0.07	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * TRUCK TYPE ROAD TYPE * TRUCK TYPE * WEIGHT OUTLIERS 2 2 1 1 7.417522	0.0000	0.000001	20.622	10	0.0239
4	0.12	-0.07	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	18.558	9	0.0292
5			MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE INJ SEVERITY * TRUCK TYPE ROAD TYPE * TRUCK TYPE * WEIGHT					

TABLE 5-8. (SHEET 2 OF 4)

CONTAB SUMMARY SEVER INJ CONTINGENCY TABLE. FACTORS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT

SAMPLE SIZE 1568.000000

HYPOTHESIS	I*	CI*	NONZERC EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
	0.41	0.28		0.0000	0.000001	12.398	9	0.1918
6	0.50	0.32	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE INJ SEVERITY * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	10.509	8	0.2311
7	0.13	-0.19	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * TRUCK TYPE INJ SEVERITY * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	18.307	8	0.0190
8	0.51	0.23	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE INJ SEVERITY * TRUCK TYPE INJ SEVERITY * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	10.337	7	0.1703
9	0.42	0.20	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE * TRUCK TYPE ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	12.262	8	0.1399
10	0.58	0.24	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	8.820	6	0.1840

TABLE 5-8. (SHEET 3 OF 4)

CONTAB SUMMARY SEVER INJ CONTINGENCY TABLE. FACTORS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT

SAMPLE SIZE 1568.000000

HYPOTHESIS I*	CI*	NONZERO EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
11		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * TRUCK TYPE * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	13.956	6	0.0301
0.34	-0.21						
12		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * WEIGHT INJ SEVERITY * ROAD TYPE * TRUCK TYPE ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	10.212	6	0.1160
0.52	0.12						
13		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE INJ SEVERITY * TRUCK TYPE * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	5.014	5	0.4142
0.76	0.48						
14		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * TRUCK TYPE INJ SEVERITY * ROAD TYPE * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	8.580	5	0.1270
0.59	0.11						
15		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE * WEIGHT INJ SEVERITY * TRUCK TYPE * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	2.583	3	0.4604
0.88	0.55						
16		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 INJ SEVERITY * ROAD TYPE * WEIGHT INJ SEVERITY * ROAD TYPE * TRUCK TYPE					

TABLE 5-8. (SHEET 4 OF 4)

CONTAB SUMMARY SEVER INJ CONTINGENCY TABLE. FACTORS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT

SAMPLE SIZE 1568.000000

HYPOTHESIS I* CI*	NONZERC EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
	ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	8.227	4	0.0836
0.61 -0.07						
17	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	INJ SEVERITY * TRUCK TYPE * WEIGHT INJ SEVERITY * ROAD TYPE * TRUCK TYPE ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	4.838	4	0.3044
0.77 0.37						
18	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	INJ SEVERITY * ROAD TYPE * TRUCK TYPE INJ SEVERITY * ROAD TYPE * WEIGHT INJ SEVERITY * TRUCK TYPE * WEIGHT ROAD TYPE * TRUCK TYPE * WEIGHT	0.0000	0.000001	2.306	2	0.3156
0.89 0.40						

statistical acceptance (or more properly, non-rejection) of a model does not in itself assure its value. The fraction of explained variation is at least as important a consideration. The two hypotheses noted are both statistically very acceptable, but their models do not provide good predictions of the possibilities of the injury severity levels.

Comparing the output in Table 5-8 with Hedlund's results, it appears that both studies agree that Road Type is the most important single factor in interacting with Injury Severity (or just Fatality, in Hedlund's case), other than District, not presently treated. Hedlund's model 4 incorporates this interaction and attains statistical acceptance at a 6.3% level of significance. Hedlund does not state it explicitly, but this model can be seen to explain 0.62[1] of the initial variation. In the present study, the Injury Severity/Road Type interaction alone (Hypothesis 2) is seen to explain 0.40 of the initial variation, and provides an acceptable model statistically at a 23.5% level of significance, as was previously noted. However, a much better explanation of the variation, 88%, is provided by Hypothesis 15, also statistically acceptable (at a 46% level of significance), which includes the two three-way interactions Severity/Road Type/Weight and Severity/Truck Type/Weight.

The conclusion is reached that this last model is a satisfactory one for predicting injury severity level. The third three-way interaction Severity/Road Type/Truck Type is not required; Hypothesis 18 shows this adds only 1% to the explained variation.

The final predicted, or "smoothed," x* values deriving from this model are shown in Table 5-9 (rows 2 and 7). The original observed x-values and the differences (residuals) between x* and x are also given. (The Outlier and Log Ratio values can be ignored.)

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[1]Employing Hedlund's IS values: (633.8 - 243.5) ÷ 633.8 = 0.62.

TABLE 5-9. PREDICTED VALUES FROM FINAL MODEL IN "HEDLUND STUDY"(SHEET 1 OF 2)

CONTAB PROGRAM SEVER INJ CONTINGENCY TABLE. FACTORS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT

RESIDUALS: INJ SEVERITY * RCAD TYPE * TRUCK TYPE * WEIGHT. FIRST 2 LEVELS: 1 1

			1	2	3
1	OBSERVED	1	68.000000	99.000000	73.000000
1	PREDICTED	2	69.443756	96.972549	73.583740
1	RESIDUAL	3	-1.443756	2.027451	-0.583740
1	OUTLIER	4	0.030951	0.044928	0.003191
1	LOG RATIO	5	1.130726	1.464637	1.188633
2	OBSERVED	6	20.000000	86.000000	87.000000
2	PREDICTED	7	18.557770	88.027878	86.416382
2	RESIDUAL	8	1.442230	-2.027878	0.583618
2	OUTLIER	9	0.110664	0.047672	0.004201
2	LOG RATIO	10	-0.188902	1.367863	1.349386

RESIDUALS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT. FIRST 2 LEVELS: 1 2

			1	2	3
1	OBSERVED	1	138.000000	264.000000	151.000000
1	PREDICTED	2	136.555847	266.027588	150.416245
1	RESIDUAL	3	1.444153	-2.027588	0.583755
1	OUTLIER	4	0.016636	0.016222	0.002338
1	LOG RATIO	5	1.806542	2.473809	1.903615
2	OBSERVED	6	68.000000	166.000000	158.000000
2	PREDICTED	7	69.443024	163.972092	158.583588
2	RESIDUAL	8	-1.443024	2.027908	-0.583588
2	OUTLIER	9	0.029533	0.027887	0.001900
2	LOG RATIO	10	1.130715	1.989905	1.956491

RESIDUALS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT. FIRST 2 LEVELS: 2 1

			1	2	3
1	OBSERVED	1	12.000000	15.000000	14.000000
1	PREDICTED	2	10.556196	17.027481	13.416255
1	RESIDUAL	3	1.443804	-2.027481	0.583745
1	OUTLIER	4	0.190760	0.252092	0.025206
1	LOG RATIO	5	-0.753078	-0.274962	-0.513324
2	OBSERVED	6	6.000000	16.000000	17.000000
2	PREDICTED	7	7.442226	13.972106	17.583649
2	RESIDUAL	8	-1.442226	2.027894	-0.583649
2	OUTLIER	9	0.300659	0.283695	0.017641
2	LOG RATIO	10	-1.102620	-0.472728	-0.242821

TABLE 5-9. (SHEET 2 OF 2)

RESIDUALS: INJ SEVERITY * ROAD TYPE * TRUCK TYPE * WEIGHT. FIRST 2 LEVELS: 2 2

			1	2	3
1	OBSERVED	1	7.000000	34.000000	22.000000
1	PREDICTED	2	8.444154	31.972458	22.583710
1	RESIDUAL	3	-1.444154	2.027542	-0.583710
1	OUTLIER	4	0.263790	0.128899	0.015285
1	LOG RATIO	5	-0.976317	0.355084	0.007438
2	OBSERVED	6	11.000000	13.000000	23.000000
2	PREDICTED	7	9.556934	15.027972	22.416306
2	RESIDUAL	8	1.443066	-2.027972	0.583694
2	OUTLIER	9	0.209230	0.288643	0.015622
2	LOG RATIO	10	-0.852524	-0.399878	-0.000002

A good fit of x* to x clearly exists.

Finally, it is of interest to develop certain odds predicted by the present study's results. Four representative cases for the odds of a high-severity injury compared to a low-severity one are as follows (refer to Table 5-7 for the definition of the variables and levels indices):

a) Conventional two-way roads, lightweight (less than 25,000 lbs.) semi-trailers:

$$\frac{x^*(2,1,1,1)}{x^*(1,1,1,1)} = \frac{10.6}{69.4} = 0.15$$

b) Freeways and expressways, lightweight semi-trailers:

$$\frac{x^*(2,2,1,1)}{x^*(1,2,1,1)} = \frac{8.4}{136.6} = 0.06$$

c) Conventional roads, heavyweight (greater than 60,000 lbs.) full-trailers:

$$\frac{x^*(2,1,2,3)}{x^*(1,1,2,3)} = \frac{17.6}{86.4} = 0.20$$

d) Freeways, heavyweight full-trailers:

$$\frac{x^*(2,2,2,3)}{x^*(1,2,2,3)} = \frac{22.4}{158.6} = 0.14$$

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).

5.5. 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 Section 5.6 below.

Table 5-10 shows the input contingency table for this analysis. Table 5-11 is the summary of the CONTAB tests of successive hypotheses or models. It is seen that of the hypotheses tested, Hypothesis 10, based on the single three-way interaction: Brakes-related/ Downhill/Configuration (Type and Axles), provides the greatest explanation of the initial variance, 64%. It is noteworthy that *not only* Hypothesis 10, but the interactions subsumed under all hypotheses, are statistically highly acceptable. In particular, a statistically acceptable (or rather non-rejectable) model, at about a 21% level of significance, is that one given by the initial hypothesis. The data permit the acceptance of the hypothesis that the occurrence of brakes-related accidents is entirely unassociated with the independent variables. However, it is not necessary to accept this simplest possible, but not very useful, model; among the others tested, that of Hypothesis 10 is even more acceptable, explains much of the variation not explained by the Hypothesis 1 model, and is still reasonably simple.

More complex hypotheses than Hypothesis 10 could also have been tested, but comparison of Hypotheses 6 and 8 gives good reason to believe that the inclusion of Weight in more complex models would add little to the explanation of variance. Only 2% is added to the explanation by the two two-way interactions, Brakes-related/ Downhill and Brakes-related/Configuration, if the third such

TABLE 5-10. INPUT CONTINGENCY TABLE FOR CONTAB ANALYSIS OF BRAKES-RELATED ACCIDENTS

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+
Not Brakes-related — Not Downhill																
10,000–25,000	0	346	83	0	38	57	93	3	4	14	31	1	0	45	7	0
25,001–60,000	12	48	60	0	37	54	262	6	2	5	48	5	1	165	28	7
60,000 +	0	9	3	1	3	14	202	0	0	5	76	1	0	152	18	3
Not Brakes-related — Downhill																
10,000–25,000	0	59	21	0	13	8	10	0	0	5	5	0	0	15	1	0
25,001–60,000	0	8	12	0	7	6	43	1	0	0	6	0	0	27	2	1
60,000 +	0	1	0	1	1	2	39	2	0	1	19	0	0	26	1	0
Brakes-related — Not Downhill																
10,000–25,000	0	30	13	0	4	4	2	0	1	1	2	0	0	7	0	0
25,001–60,000	0	5	6	0	1	1	8	0	0	0	2	0	0	5	3	1
60,000 +	0	0	0	0	0	0	6	1	0	1	3	0	0	6	1	0
Brakes-related — Downhill																
10,000–25,000	0	10	2	0	2	2	2	0	1	0	1	0	0	1	0	0
25,001–60,000	0	1	2	0	1	2	5	0	0	1	1	0	0	4	1	0
60,000 +	0	0	0	0	0	0	6	0	0	0	4	0	0	7	0	0

TABLE 5-11. SUMMARY OF RESULTS OF CONTAB ANALYSIS OF BRAKES-RELATED ACCIDENTS (SHEET 1 OF 3)

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CONTAB SUMMARY         BRAKE RELATED CONTINGENCY TABLE.  FACTORS:  BRK RELATED * DOWN HILL * WEIGHT * CONFIG
SAMPLE SIZE                          2462.000000

HYPOTHESIS     NONZERO EFFECTS                                          SMOOTH     ZERO      I.S.      D.F.   PROB
   I*    CI*

   1           MARGINALS  EFFECTS  RESIDUALS
               BRK RELATED
               DOWN HILL * WEIGHT * CONFIG
                  OUTLIERS
                        2     1     2     7       7.793228
                                                                       0.0000   0.000001   105.926    95   0.2083
  0.00   0.00
   2           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1
               BRK RELATED * DOWN HILL
               DOWN HILL * WEIGHT * CONFIG
                  OUTLIERS
                        2     1     1     3       7.937994
                                                                       0.0000   0.000001    74.623    94   0.9298
  0.30   0.29
   3           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1
               BRK RELATED * WEIGHT
               DOWN HILL * WEIGHT * CONFIG
                  OUTLIERS
                        2     1     1     7       7.311966
                        2     2     3    14       8.186245
                                                                       0.0000   0.000001    95.682    93   0.4037
  0.10   0.08
   4           MARGINALS  EFFECTS  RESIDUALS  NESTED ON HYPOTHESIS   1
               BRK RELATED * CONFIG
               DOWN HILL * WEIGHT * CONFIG
                                                                       0.0000   0.000001    82.794    80   0.3932
  0.22   0.07
```

TABLE 5-11. (SHEET 2 OF 3)

CONTAB SUMMARY — BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

SAMPLE SIZE 2462.000000

HYPOTHESIS I*	CI*	NONZERO EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
5		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * DOWN HILL BRK RELATED * WEIGHT DOWN HILL * WEIGHT * CONFIG					
0.39	0.37		0.0000	0.000001	64.680	92	0.9863
6		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * DOWN HILL BRK RELATED * CONFIG DOWN HILL * WEIGHT * CONFIG					
0.51	0.41		0.0000	0.000001	51.928	79	0.9920
7		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * WEIGHT BRK RELATED * CONFIG DOWN HILL * WEIGHT * CONFIG					
0.24	0.08		0.0000	0.000001	80.279	78	0.4075
8		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * DOWN HILL BRK RELATED * WEIGHT BRK RELATED * CONFIG DOWN HILL * WEIGHT * CONFIG					
0.53	0.42		0.0000	0.000001	49.831	77	0.9930
9		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * DOWN HILL * WEIGHT DOWN HILL * WEIGHT * CONFIG					
0.45	0.42		0.0000	0.000001	57.997	90	0.9965
10		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * DOWN HILL * CONFIG					

TABLE 5-11. (SHEET 3 OF 3)

CONTAB SUMMARY BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

SAMPLE SIZE 2462.000000

HYPOTHESIS I*	CI*	NONZERO EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
		DOWN HILL * WEIGHT * CONFIG					
0.64	0.46		0.0000	0.000001	38.531	64	0.9951
11		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
		BRK RELATED * WEIGHT * CONFIG DOWN HILL * WEIGHT * CONFIG					
0.42	-0.16		0.0000	0.000001	61.946	48	0.0850

interaction, Brakes-related/Weight, is also incorporated.

It is thus considered that a satisfactory model for explaining brakes-related accidents is that given by the inclusion of the single three-way interaction of brakes-related accident occurrence with the occurrence of a downhill road (the most important factor, as is seen by its effect on the explanation of variation wherever it appears in Table 5-11), and of the various commercial vehicle configurations. It is next of interest to appraise the odds of the occurrence of such an accident for the several configurations, and for the alternate road directions.

Table 5-12 is the computer printout of the accepted model's x* (PREDICTED) values; the initial x (OBSERVED) values, the same as in the input contingency table, are also given, together with the x*, x differences (RESIDUALS). The OUTLIER and LOG RATIO values can be ignored. (Note the unfortunate, but still readable overprinting of columns 7 and 14 in the left margin.) Comparison with the input table makes clear that the variables are tabulated as follows:

a) Each of the four subtables corresponds to a pair of levels of Brakes-related Accident Occurrence (Yes or No), and Downhill (Yes or No).

b) The columns correspond to Configuration (16 levels).

c) The rows correspond to Weight (three levels).

Many odds ratios can be quantified and appraised from the predicted values in Table 5-12. However, because of the fairly small available sample size, various predicted (as well as observed) values in the output table are essentially zero. The corresponding sets of levels of the variables cannot therefore be treated meaningfully.

Some selected odds comparisons that are both feasible and of interest follow:

a) Odds of a brakes-related accident (compared to not), for

TABLE 5-12. PREDICTED VALUES FROM FINAL MODEL (HYPOTHESIS 10) IN BRAKES-RELATED ACCIDENTS ANALYSIS (SHEET 1 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 1 1

		1	2	3	4	5	6	7
1 OBSERVED	1	0.000001	346.000000	83.000000	0.000001	38.000000	57.000000	93.000000
1 PREDICTED	2	0.000002	345.954102	84.945435	0.000002	39.469864	58.653854	92.347290
1 RESIDUAL	3	-0.000001	0.045898	-1.945435	-0.000001	-1.469864	-1.653854	0.652710
1 OUTLIER	4	-0.000001	-0.000093	0.045679	-0.000001	0.055300	0.045584	0.004784
1 LOG RATIO	5	12.716904	31.685562	30.281265	12.716901	29.514801	29.910919	30.364822
2 OBSERVED	6	12.000000	48.000000	60.000000	0.000001	37.000000	54.000000	262.000000
2 PREDICTED	7	11.999997	48.764832	58.399963	0.000002	35.710846	52.884598	262.460449
2 RESIDUAL	8	0.000003	-0.764832	1.600037	-0.000001	1.289154	1.115402	-0.460449
2 OUTLIER	9	0.000000	0.010789	0.044510	-0.000001	0.046705	0.024010	-0.001250
2 LOG RATIO	10	28.324173	29.726273	29.906570	12.716901	29.414719	29.807373	31.409363
3 OBSERVED	11	0.000001	9.000000	3.000000	1.000000	3.000000	14.000000	202.000000
3 PREDICTED	12	0.000002	8.280823	2.654546	0.999998	2.819278	13.461541	202.191879
3 RESIDUAL	13	-0.000001	0.719177	0.345454	0.000002	0.180722	0.538459	-0.191879
3 OUTLIER	14	-0.000001	0.061035	0.043061	0.000004	0.011339	0.021495	0.000040
3 LOG RATIO	15	12.716904	27.953201	26.815536	25.839264	26.875748	28.439102	31.148483

		8	9	10	11	12	13	14
1 OBSERVED	1	3.000000	4.000000	14.000000	31.000000	1.000000	0.000001	45.000000
1 PREDICTED	2	2.700000	4.285713	13.846148	31.574066	1.000000	0.000002	49.536835
1 RESIDUAL	3	0.300000	-0.285713	0.153852	-0.574066	0.000000	-0.000001	-4.536835
1 OUTLIER	4	0.032369	0.015306	0.001515	0.007512	0.000000	-0.000001	0.433041

TABLE 5-12. (SHEET 2 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

1	LOG RATIO	5	26.832520	27.294556	28.467270	29.291595	25.839264	12.716901	29.741974
2	OBSERVED	6	6.000000	2.000000	5.000000	48.000000	5.000000	1.000000	165.000000
2	PREDICTED	7	5.399999	1.714286	4.615385	47.839508	4.999997	0.999998	161.947250
2	RESIDUAL	8	0.600001	0.285714	0.384615	0.160492	0.000003	0.000002	3.052750
2	OUTLIER	9	0.064664	0.045307	0.031216	0.000577	0.000000	0.000004	0.060839
2	LOG RATIO	10	27.525665	26.378265	27.368652	29.707108	27.448700	25.839264	30.926529
3	OBSERVED	11	0.000001	0.000001	5.000000	76.000000	1.000000	0.000001	152.000000
3	PREDICTED	12	0.900001	0.000002	5.538461	75.586411	1.000000	0.000002	150.515762
3	RESIDUAL	13	-0.900000	-0.000001	-0.538461	0.413589	0.000000	-0.000001	1.484238
3	OUTLIER	14	1.798170	-0.000001	0.050270	0.002156	0.000000	-0.000001	0.015507
3	LOG RATIO	15	25.733902	12.562753	27.550980	30.164536	25.839264	12.716901	30.853333

			15	16
1	OBSERVED	1	7.000000	0.000001
1	PREDICTED	2	6.508774	0.000002
1	RESIDUAL	3	0.491226	-0.000001
1	OUTLIER	4	0.036066	-0.000001
1	LOG RATIO	5	27.712418	12.621593
2	OBSERVED	6	28.000000	7.000000
2	PREDICTED	7	28.824539	7.272724
2	RESIDUAL	8	-0.824539	-0.272724
2	OUTLIER	9	0.022539	0.008053
2	LOG RATIO	10	29.200485	27.823395
3	OBSERVED	11	18.000000	3.000000
3	PREDICTED	12	17.666656	2.727273
3	RESIDUAL	13	0.333344	0.272727
3	OUTLIER	14	0.006287	0.026302
3	LOG RATIO	15	28.710938	26.842560

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 1 2

			1	2	3	4	5	6	7
1	OBSERVED	1	0.000001	59.000000	21.000000	0.000001	13.000000	8.000000	10.000000
1	PREDICTED	2	0.000001	59.392395	20.513489	0.000002	13.125000	7.999997	

TABLE 5-12. (SHEET 3 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

10.514286

1 RESIDUAL	3	0.000000	-0.392395	0.486511	-0.000001	-0.125000	0.000003	-0.514286
1 OUTLIER	4	0.000000	0.001492	0.011858	-0.000001	-0.001245	0.000000	0.025795
1 LOG RATIO	5	12.023757	29.923431	28.860352	12.716901	28.413788	27.918701	28.192001
2 OBSERVED	6	0.000001	8.000000	12.000000	0.000001	7.000000	6.000000	43.000000
2 PREDICTED	7	0.000001	7.746837	12.486485	0.000002	7.000000	6.399995	42.057144
2 RESIDUAL	8	0.000000	0.253163	-0.486485	-0.000001	0.000000	-0.399995	0.942856
2 OUTLIER	9	0.000000	0.008099	0.018123	-0.000001	0.000000	0.021838	0.021523
2 LOG RATIO	10	12.023757	27.886551	28.363907	12.716901	27.785172	27.695557	29.578293
3 OBSERVED	11	0.000001	1.000000	0.000001	1.000000	1.000000	2.000000	39.000000
3 PREDICTED	12	0.000001	0.860761	0.000002	0.999998	0.875001	1.600000	39.428574
3 RESIDUAL	13	0.000000	0.139239	-0.000001	0.000002	0.124999	0.400000	-0.428574
3 OUTLIER	14	0.000000	0.021458	-0.000001	0.000004	0.016806	0.092800	0.002431
3 LOG RATIO	15	12.023757	25.689316	12.602493	25.839264	25.705734	26.309265	29.513748

		8	9	10	11	12	13	14
1 OBSERVED	1	0.000001	0.000001	5.000000	5.000000	0.000001	0.000001	15.000000
1 PREDICTED	2	0.000002	0.000003	4.285713	5.000000	0.000001	0.000001	13.599998
1 RESIDUAL	3	-0.000001	-0.000002	0.714287	0.000000	0.000000	0.000000	1.400002
1 OUTLIER	4	-0.000001	-0.000002	0.113420	0.000000	0.000000	0.000000	0.140266
1 LOG RATIO	5	12.716903	13.122365	27.294556	27.448700	12.023757	12.023757	28.449326
2 OBSERVED	6	1.000000	0.000001	0.000001	6.000000	0.000001	0.000001	27.000000
2 PREDICTED	7	1.000000	0.000000	0.857143	5.833333	0.000001	0.000001	26.349991
2 RESIDUAL	8	0.000000	0.000001	-0.857142	0.166667	0.000000	0.000000	0.650009
2 OUTLIER	9	0.000000	0.000024	1.713674	0.004854	0.000000	0.000000	0.016162
2 LOG RATIO	10	25.839264	-0.000000	25.685104	27.602844	12.023757	12.023757	

TABLE 5-12. (SHEET 4 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

29.110733

3	OBSERVED	11	2.000000	0.000001	1.000000	19.000000	0.000001	0.000001	26.000000
3	PREDICTED	12	1.999999	0.000000	0.857143	19.166656	0.000001	0.000001	28.049988
3	RESIDUAL	13	0.000001	0.000001	0.142857	-0.166656	0.000000	0.000000	-2.049988
3	OUTLIER	14	0.000000	0.000024	0.022544	-0.001038	0.000000	0.000000	0.154591
3	LOG RATIO	15	26.532410	-0.000000	25.685104	28.792435	12.023757	12.023757	29.173248

			15	16
1	OBSERVED	1	1.000000	0.000001
1	PREDICTED	2	0.800000	0.000002
1	RESIDUAL	3	0.200000	-0.000001
1	OUTLIER	4	0.046107	-0.000001
1	LOG RATIO	5	25.616119	12.716901
2	OBSERVED	6	2.000000	1.000000
2	PREDICTED	7	2.399998	0.999998
2	RESIDUAL	8	-0.399998	0.000002
2	OUTLIER	9	0.068306	0.000004
2	LOG RATIO	10	26.714737	25.839264
3	OBSERVED	11	1.000000	0.000001
3	PREDICTED	12	0.800000	0.000002
3	RESIDUAL	13	0.200000	-0.000001
3	OUTLIER	14	0.046107	-0.000001
3	LOG RATIO	15	25.616119	12.716901

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 2 1

			1	2	3	4	5	6	7
1	OBSERVED	1	0.000001	30.000000	13.000000	0.000001	4.000000	4.000000	2.000000
1	PREDICTED	2	0.000000	30.045654	11.054546	0.000000	2.530120	2.346155	2.652704
1	RESIDUAL	3	0.000001	-0.045654	1.945454	0.000001	1.469880	1.653845	-0.652704
1	OUTLIER	4	0.000029	-0.003105	0.325432	0.000024	0.725559	0.961502	0.174495
1	LOG RATIO	5	-2.484903	29.241974	28.242096	-0.000000	26.767532	26.692047	26.814835
2	OBSERVED	6	0.000001	5.000000	6.000000	0.000001	1.000000	1.000000	8.000000
2	PREDICTED	7	0.000003	4.235159	7.599998	0.000000	2.289157	2.115385	7.539263

TABLE 5-12. (SHEET 5 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

2 RESIDUAL	8	-0.000002	0.764841	-1.599998	0.000001	-1.289157	-1.115385	0.460737
2 OUTLIER	9	-0.000002	0.131004	0.361776	0.000024	0.919955	0.730663	0.027484
2 LOG RATIO	10	13.122368	27.282684	27.867416	-0.000000	26.667450	26.588501	27.859390
3 OBSERVED	11	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	6.000000
3 PREDICTED	12	0.000000	0.719178	0.345455	0.000003	0.180723	0.538462	5.808025
3 RESIDUAL	13	0.000001	-0.719177	-0.345454	-0.000002	-0.180722	-0.538461	0.191975
3 OUTLIER	14	0.000029	1.436706	0.690222	-0.000002	0.361546	1.075215	0.006369
3 LOG RATIO	15	-2.484903	25.509613	24.776367	13.122365	24.128479	25.220230	27.598495

		8	9	10	11	12	13	14
1 OBSERVED	1	0.000001	1.000000	1.000000	2.000000	0.000001	0.000001	7.000000
1 PREDICTED	2	0.300001	0.714287	1.153846	1.425925	0.000000	0.000000	2.463158
1 RESIDUAL	3	-0.300000	0.285713	-0.153846	0.574075	0.000001	0.000001	4.536842
1 OUTLIER	4	0.596317	0.101414	0.018898	0.205370	0.000002	0.000024	5.557529
1 LOG RATIO	5	24.635284	25.502792	25.982361	26.194077	11.176459	-0.000000	26.740707
2 OBSERVED	6	0.000001	0.000001	0.000001	2.000000	0.000001	0.000001	5.000000
2 PREDICTED	7	0.600001	0.285715	0.384616	2.160494	0.000002	0.000003	8.052626
2 RESIDUAL	8	-0.600000	-0.285714	-0.384615	-0.160494	-0.000001	-0.000002	-3.052626
2 OUTLIER	9	1.197280	0.568145	0.765345	0.010292	-0.000002	-0.000002	1.341608
2 LOG RATIO	10	25.328445	24.586502	24.883759	26.609604	12.785896	13.122365	27.925262
3 OBSERVED	11	1.000000	0.000001	1.000000	3.000000	0.000001	0.000001	6.000000
3 PREDICTED	12	0.100000	0.000000	0.461539	3.413580	0.000000	0.000000	7.484209
3 RESIDUAL	13	0.900000	0.000001	0.538461	-0.413580	0.000001	0.000001	-1.484209
3 OUTLIER	14	2.805573	0.000003	0.469578	0.050505	0.000002	0.000024	0.316612
3 LOG RATIO	15	23.536682	10.770995	25.066071	27.067017	11.176459	-0.000000	27.852051

TABLE 5-12. (SHEET 6 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

			15	16
1	OBSERVED	1	0.000001	0.000001
1	PREDICTED	2	0.491228	0.000000
1	RESIDUAL	3	-0.491227	0.000001
1	OUTLIER	4	0.981317	0.000003
1	LOG RATIO	5	25.128418	10.319010
2	OBSERVED	6	3.000000	1.000000
2	PREDICTED	7	2.175438	0.727274
2	RESIDUAL	8	0.824562	0.272726
2	OUTLIER	9	0.279420	0.091491
2	LOG RATIO	10	26.616486	25.520813
3	OBSERVED	11	1.000000	0.000001
3	PREDICTED	12	1.333333	0.272728
3	RESIDUAL	13	-0.333333	-0.272727
3	OUTLIER	14	0.091137	0.544668
3	LOG RATIO	15	26.126938	24.539978

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 2 2

			1	2	3	4	5	6	7
1	OBSERVED	1	0.000001	10.000000	2.000000	0.000001	2.000000	2.000000	2.000000
1	PREDICTED	2	0.000001	9.607595	2.486485	0.000000	1.875000	1.999999	1.485714
1	RESIDUAL	3	0.000000	0.392405	-0.486485	0.000001	0.125000	0.000001	0.514286
1	OUTLIER	4	0.000000	0.015728	0.100272	0.000024	0.008001	0.000000	0.160745
1	LOG RATIO	5	12.023757	28.101822	26.750137	-0.000000	26.467865	26.532410	26.235153
2	OBSERVED	6	0.000001	1.000000	2.000000	0.000001	1.000000	2.000000	5.000000
2	PREDICTED	7	0.000001	1.253164	1.513514	0.000000	1.000000	1.599998	5.942857
2	RESIDUAL	8	0.000000	-0.253164	0.486486	0.000001	0.000000	0.400002	-0.942857
2	OUTLIER	9	0.000000	0.050887	0.142030	0.000024	0.000000	0.092806	0.150032
2	LOG RATIO	10	12.023757	26.064926	26.253693	-0.000000	25.839264	26.309265	27.621445
3	OBSERVED	11	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	6.000000
3	PREDICTED	12	0.000001	0.139241	0.000000	0.000003	0.125000	0.400000	5.571428
3	RESIDUAL	13	0.000000	-0.139240	0.000001	-0.000002	-0.124999	-0.399999	

TABLE 5-12. (SHEET 7 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

0.428572

3	OUTLIER	14	0.000000	0.277026	0.000003	-0.000002	0.248852	0.798211	0.032252
3	LOG RATIO	15	12.023757	23.867706	10.492280	13.122365	23.759827	24.922974	27.556915

			8	9	10	11	12	13	14
1	OBSERVED	1	0.000001	1.000000	0.000001	1.000000	0.000001	0.000001	1.000000
1	PREDICTED	2	0.000000	0.999998	0.714287	1.000000	0.000001	0.000001	2.400001
1	RESIDUAL	3	0.000001	0.000002	-0.714286	0.000000	0.000000	0.000000	-1.400001
1	OUTLIER	4	0.000026	0.000004	1.427317	0.000000	0.000000	0.000000	1.045881
1	LOG RATIO	5	-1.098610	25.839264	25.502792	25.839264	12.023757	12.023757	26.714737
2	OBSERVED	6	0.000001	0.000001	1.000000	1.000000	0.000001	0.000001	4.000000
2	PREDICTED	7	0.000001	0.000002	0.142857	1.166666	0.000001	0.000001	4.650002
2	RESIDUAL	8	0.000000	-0.000001	0.857143	-0.166666	0.000000	0.000000	-0.650002
2	OUTLIER	9	0.000000	-0.000001	2.178211	0.024961	0.000000	0.000000	0.093892
2	LOG RATIO	10	12.023756	12.716901	23.893356	25.993408	12.023757	12.023757	27.376129
3	OBSERVED	11	0.000001	0.000001	0.000001	4.000000	0.000001	0.000001	7.000000
3	PREDICTED	12	0.000002	0.000002	0.142857	3.833332	0.000001	0.000001	4.950001
3	RESIDUAL	13	-0.000001	-0.000001	-0.142856	0.166668	0.000000	0.000000	2.049999
3	OUTLIER	14	-0.000001	-0.000001	0.281722	0.007304	0.000000	0.000000	0.753252
3	LOG RATIO	15	12.716902	12.716901	23.893356	27.182999	12.023757	12.023757	27.438644

			15	16
1	OBSERVED	1	0.000001	0.000001
1	PREDICTED	2	0.200001	0.000000
1	RESIDUAL	3	-0.200000	0.000001
1	OUTLIER	4	0.399110	0.000024
1	LOG RATIO	5	24.229828	-0.000000
2	OBSERVED	6	1.000000	0.000001
2	PREDICTED	7	0.600001	0.000003
2	RESIDUAL	8	0.399999	-0.000002
2	OUTLIER	9	0.221846	-0.000002
2	LOG RATIO	10	25.328430	13.122365
3	OBSERVED	11	0.000001	0.000001
3	PREDICTED	12	0.200001	0.000000
3	RESIDUAL	13	-0.200000	0.000001
3	OUTLIER	14	0.399110	0.000024
3	LOG RATIO	15	24.229828	-0.000000

a downhill road, and a light, single unit, two-axle vehicle:

$$\frac{x^*(2,2,2,1)}{x^*(1,2,2,1)} = \frac{9.61}{59.4} = 0.16$$

b) The comparable odds for a non-downhill road:

$$\frac{x^*(2,1,2,1)}{x^*(1,1,2,1)} = \frac{30.0}{346} = 0.087$$

c) The comparable odds again for a downhill road, but for a heavy two-axle vehicle:

$$\frac{x^*(2,2,2,3)}{x^*(1,2,2,3)} = \frac{0.139}{0.861} = 0.16$$

d) The comparable odds for a non-downhill road:

$$\frac{x^*(2,1,2,3)}{x^*(1,1,2,3)} = \frac{0.72}{8.28} = 0.087$$

It is thus seen that for single-unit, two-axle vehicles (e.g., simple trucks) the odds of a brakes-related accident are about twice as great on a downhill as on a non-downhill road. Furthermore, this conclusion is seen to be independent of the weight of the vehicle. (This must hold since the interaction with weight is excluded in the model being employed.)

The largest vehicle configuration for which a reasonable brakes-related accidents sample size exists is the five-axle tractor/semi-trailer. The first two of the above odds evaluations follow for that configuration:

$$\frac{x^*(2,2,7,1)}{x^*(1,2,7,1)} = \frac{1.49}{10.5} = 0.14$$

$$\frac{x^*(2,1,7,1)}{x^*(1,1,7,1)} = \frac{2.65}{92.3} = 0.03$$

For this multi-unit vehicle the odds of a brakes-related accident are seen to be about 4.6 times as great on a downhill as on a non-downhill road. This compares with the factor of only about two for the single-unit vehicle. This result is again essentially independent of weight.

5.6. 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.[1] 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.

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 Section 5.5 above.

The input contingency table is shown as Table 5-13. Note the relatively small joint frequencies, as compared to Table 5-10, whose frequencies are derived from the full data base. It is to be noted that the very large number of zero frequencies, resulting from the

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[1]The simplest procedure, based on regressions, has not been carried out because of the poor fits of the regressions discussed in Section 4. A contingency table procedure is not immediately available.

TABLE 5-13. INPUT CONTINGENCY TABLE FOR CONTAB ANALYSIS OF BRAKES-RELATED ACCIDENTS WITH SEVERE INJURIES (FATAL, MAJOR INJURY, MINOR VISIBLE INJURY)

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+
Not Brakes-related — Not Downhill																
10,000–25,000	0	19	7	0	1	4	6	0	1	1	0	0	0	0	0	0
25,001–60,000	0	3	2	0	1	0	20	0	0	0	3	0	0	3	0	0
60,000 +	0	2	2	1	0	3	28	0	0	0	4	0	0	6	0	0
Not Brakes-related — Downhill																
10,000–25,000	0	6	4	0	1	0	1	0	0	0	0	0	0	3	0	0
25,001–60,000	0	1	0	0	1	1	5	0	0	0	1	0	0	3	0	0
60,000 +	0	0	0	0	0	0	5	1	0	0	4	0	0	0	0	0
Brakes-related — Not Downhill																
10,000–25,000	0	2	0	0	0	0	1	0	0	0	1	0	0	1	0	0
25,001–60,000	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
60,000 +	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Brakes-related — Downhill																
10,000–25,000	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
25,001–60,000	0	0	0	0	0	0	2	0	0	1	1	0	0	0	0	0
60,000 +	0	0	0	0	0	0	3	0	0	0	1	0	0	1	0	0

inherently sparse data applicable to the present highly restrictive case, will cause many zero marginals, and inflate the D.F. in the contingency table analysis.[1] This must cause masking of some interactions, as well as other effects in the models. The CONTAB program is limited in its ability to effectively analyze such sparse data, and in future studies will need to be replaced, perhaps by KULLITR, which is more powerful in this area. CONTAB is nevertheless applicable for present purposes, providing care is exercised in the interpretation of its outputs.

Table 5-14 is the CONTAB summary of the tests of the same 11 hypotheses as in the full data-base case, and does exhibit the behavior just noted. Again all models appear to be highly (in fact, entirely) acceptable statistically. The model of Hypothesis 10 again provides the most satisfactory explanation (55% now, however, instead of 64%) of the initial variation, consistent with reasonable simplicity. Thus, again, only the single three-way interaction of Brakes-related Accident Occurrence/Downhill/Configuration needs to be considered; Weight is not an important factor in the explanation of the variation. Thus, despite the restricted set of accidents being treated, no difference in the significant variables and interactions arises.

Similar investigations for other types of "high-cost" accidents can readily be conducted but must be left for consideration in future studies.

The brakes-related odds analysis carried out in Section 5.5

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[1]For the present analysis, it can be shown that there are 57 zero marginals involved. The true D.F. under Hypothesis 1, for example, is therefore only 95 - 57 = 38. If adjustments had been made initially for the zero marginals, it is probable that the IS value would have been larger, and thus, in conjunction with the smaller D.F.'s, could have led to rejection of the first hypothesis.

TABLE 5-14. SUMMARY OF RESULTS OF CONTAB ANALYSIS OF BRAKES-RELATED, HIGH SEVERITY ACCIDENTS (SHEET 1 OF 2)

CONTAB SUMMARY — BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

SAMPLE SIZE 174.000000

HYPOTHESIS I*	CI*	NONZERO EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
1		MARGINALS EFFECTS RESIDUALS BRK RELATED DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	48.193	95	1.0000
0.00	0.00						
2		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 BRK RELATED * DOWN HILL DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	38.064	94	1.0000
0.21	0.20						
3		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 BRK RELATED * WEIGHT DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	47.984	93	1.0000
0.00	-0.02						
4		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 BRK RELATED * CONFIG DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	35.672	80	1.0000
0.26	0.12						
5		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 BRK RELATED * DOWN HILL BRK RELATED * WEIGHT DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	37.727	92	1.0000
0.22	0.19						
6		MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1 BRK RELATED * DOWN HILL BRK RELATED * CONFIG					

TABLE 5-14. (SHEET 2 OF 2)

CONTAB SUMMARY BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

SAMPLE SIZE 174.000000

HYPOTHESIS I* CI*	NONZERO EFFECTS	SMOOTH	ZERO	I.S.	D.F.	PROB
	DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	27.653	79	1.0000
0.43 0.31						
7	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	BRK RELATED * WEIGHT BRK RELATED * CONFIG DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	33.972	78	1.0000
0.30 0.14						
8	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	BRK RELATED * DOWN HILL BRK RELATED * WEIGHT BRK RELATED * CONFIG DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	25.412	77	1.0000
0.47 0.35						
9	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	BRK RELATED * DOWN HILL * WEIGHT DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	34.110	90	1.0000
0.29 0.25						
10	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	BRK RELATED * DOWN HILL * CONFIG DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	21.537	64	1.0000
0.55 0.34						
11	MARGINALS EFFECTS RESIDUALS NESTED ON HYPOTHESIS 1					
	BRK RELATED * WEIGHT * CONFIG DOWN HILL * WEIGHT * CONFIG	0.0000	0.000001	25.410	48	0.9969
0.47 -0.04						

TABLE 5-15. PREDICTED VALUES FROM FINAL MODEL (HYPOTHESIS 10) IN HIGH-COST, BRAKES-RELATED ACCIDENTS ANALYSIS (SHEET 1 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 1 1

		1	2	3	4	5	6	7
1 OBSERVED	1	0.000001	19.000000	7.000000	0.000001	1.000000	4.000000	6.000000
1 PREDICTED	2	0.000001	19.384598	6.999997	0.000002	0.999999	3.999999	6.631577
1 RESIDUAL	3	0.000000	-0.384598	0.000003	-0.000001	0.000001	0.000001	0.631577
1 OUTLIER	4	0.000000	0.008554	0.000000	-0.000001	0.000000	0.000000	0.064254
1 LOG RATIO	5	-0.000000	16.779984	15.761422	0.693144	13.815512	15.201806	15.707355
2 OBSERVED	6	0.000001	3.000000	2.000000	0.000001	1.000000	0.000001	20.000000
2 PREDICTED	7	0.000001	2.769231	2.000000	0.000002	0.999999	0.000002	19.894730
2 RESIDUAL	8	0.000000	0.230769	0.000000	-0.000001	0.000001	-0.000001	0.105270
2 OUTLIER	9	0.000000	0.019044	0.000000	-0.000001	0.000000	-0.000001	0.000606
2 LOG RATIO	10	-0.000000	14.834082	14.508659	0.693144	13.815512	0.693146	16.805954
3 OBSERVED	11	0.000001	2.000000	2.000000	1.000000	0.000001	3.000000	28.000000
3 PREDICTED	12	0.000001	1.846154	2.000000	0.999998	0.000002	2.999998	27.473679
3 RESIDUAL	13	0.000000	0.153846	0.000000	0.000002	-0.000001	0.000002	0.526321
3 OUTLIER	14	0.000000	0.012616	0.000000	0.000004	-0.000001	0.000000	0.011859
3 LOG RATIO	15	-0.000000	14.428617	14.508659	13.815510	0.693145	14.914124	17.128738

		8	9	10	11	12	13	14
1 OBSERVED	1	0.000001	1.000000	1.000000	0.000001	0.000001	0.000001	0.000001
1 PREDICTED	2	0.000001	0.999998	0.999998	0.777778	0.000001	0.000001	0.900001
1 RESIDUAL	3	0.000000	0.000002	0.000002	-0.777777	0.000000	0.000000	0.900000
1 OUTLIER	4	0.000000	0.000004	0.000004	1.558959	0.000000	0.000000	1.804358

TABLE 5-15. (SHEET 2 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

1	LOG RATIO	5	-0.000000	13.815510	13.815510	13.564198	-0.000000	-0.000000	13.710152
2	OBSERVED	6	0.000001	0.000001	0.000001	3.000000	0.000001	0.000001	3.000000
2	PREDICTED	7	0.000001	0.000002	0.000002	2.333334	0.000001	0.000001	2.700000
2	RESIDUAL	8	0.000000	-0.000001	-0.000001	0.666666	0.000000	0.000000	0.300000
2	OUTLIER	9	0.000000	-0.000001	-0.000001	0.177145	0.000000	0.000000	0.032710
2	LOG RATIO	10	-0.000000	0.693144	0.693144	14.662810	-0.000000	-0.000000	14.808764
3	OBSERVED	11	0.000001	0.000001	0.000001	4.000000	0.000001	0.000001	6.000000
3	PREDICTED	12	0.000001	0.000002	0.000002	3.888888	0.000001	0.000001	5.399999
3	RESIDUAL	13	0.000000	-0.000001	-0.000001	0.111112	0.000000	0.000000	0.600001
3	OUTLIER	14	0.000000	-0.000001	-0.000001	0.003222	0.000000	0.000000	0.066468
3	LOG RATIO	15	-0.000000	0.693144	0.693144	15.173635	-0.000000	-0.000000	15.501910

			15	16
1	OBSERVED	1	0.000001	0.000001
1	PREDICTED	2	0.000001	0.000001
1	RESIDUAL	3	0.000000	0.000000
1	OUTLIER	4	0.000000	0.000000
1	LOG RATIO	5	-0.000000	-0.000000
2	OBSERVED	6	0.000001	0.000001
2	PREDICTED	7	0.000001	0.000001
2	RESIDUAL	8	0.000000	0.000000
2	OUTLIER	9	0.000000	0.000000
2	LOG RATIO	10	-0.000000	-0.000000
3	OBSERVED	11	0.000001	0.000001
3	PREDICTED	12	0.000001	0.000001
3	RESIDUAL	13	0.000000	0.000000
3	OUTLIER	14	0.000000	0.000000
3	LOG RATIO	15	-0.000000	-0.000000

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 1 2

			1	2	3	4	5	6	7
1	OBSERVED	1	0.000001	6.000000	4.000000	0.000001	1.000000	0.000001	1.000000
1	PREDICTED	2	0.000001	6.124997	3.999997	0.000001	1.333332	0.000002	

TABLE 5-15. (SHEET 3 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

								0.687500
1 RESIDUAL	3	0.000000	-0.124997	0.000003	0.000000	-0.333332	-0.000001	0.312500
1 OUTLIER	4	0.000000	0.002420	0.000000	0.000000	0.091856	-0.000001	0.124929
1 LOG RATIO	5	-0.000000	15.627891	15.201805	-0.000000	14.103192	0.693144	13.440819
2 OBSERVED	6	0.000001	1.000000	0.000001	0.000001	1.000000	1.000000	5.000000
2 PREDICTED	7	0.000001	0.875000	0.000002	0.000001	0.666667	0.999998	4.812499
2 RESIDUAL	8	0.000000	0.125000	-0.000001	0.000000	0.333333	0.000002	0.187501
2 OUTLIER	9	0.000000	0.017140	-0.000001	0.000000	0.144901	0.000004	0.007397
2 LOG RATIO	10	-0.000000	13.681981	0.693146	-0.000000	13.410048	13.815510	15.386728
3 OBSERVED	11	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	5.000000
3 PREDICTED	12	0.000001	0.000002	0.000002	0.000001	0.000001	0.000002	5.499999
3 RESIDUAL	13	0.000000	-0.000001	-0.000001	0.000000	-0.000000	-0.000001	0.499999
3 OUTLIER	14	0.000000	-0.000001	-0.000001	0.000000	-0.000001	-0.000001	0.048221
3 LOG RATIO	15	-0.000000	0.559615	0.693146	-0.000000	0.287680	0.693144	15.520260

		8	9	10	11	12	13	14
1 OBSERVED	1	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	3.000000
1 PREDICTED	2	0.000002	0.000003	0.000000	0.000001	0.000001	0.000001	2.571428
1 RESIDUAL	3	-0.000001	-0.000002	0.000001	-0.000000	0.000000	0.000000	0.428572
1 OUTLIER	4	-0.000001	-0.000002	-0.000017	-0.000001	0.000000	0.000000	0.068852
1 LOG RATIO	5	0.693144	1.098608	-12.023757	0.356674	-0.000000	-0.000000	14.759974
2 OBSERVED	6	0.000001	0.000001	0.000001	1.000000	0.000001	0.000001	3.000000
2 PREDICTED	7	0.000002	0.000000	0.000003	1.428571	0.000001	0.000001	2.571428
2 RESIDUAL	8	-0.000001	0.000001	-0.000002	-0.428571	0.000000	0.000000	0.428572
2 OUTLIER	9	-0.000001	-0.000017	-0.000002	0.144831	0.000000	0.000000	0.068852
2 LOG RATIO	10	0.693144	-12.023757	1.098608	14.172186	-0.000000	-0.000000	

TABLE 5-15. (SHEET 4 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

14.759974

3	OBSERVED	11	1.000000	0.000001	0.000001	4.000000	0.000001	0.000001	0.000001
3	PREDICTED	12	0.999998	0.000000	0.000000	3.571426	0.000001	0.000001	0.857143
3	RESIDUAL	13	0.000002	0.000001	0.000001	0.428574	0.000000	0.000000	-0.857142
3	OUTLIER	14	0.000004	-0.000017	-0.000017	0.050547	0.000000	0.000000	1.718174
3	LOG RATIO	15	13.815510	-12.023757	-12.023757	15.088477	-0.000000	-0.000000	13.661362

			15	16
1	OBSERVED	1	0.000001	0.000001
1	PREDICTED	2	0.000001	0.000001
1	RESIDUAL	3	0.000000	0.000000
1	OUTLIER	4	0.000000	0.000000
1	LOG RATIO	5	-0.000000	-0.000000
2	OBSERVED	6	0.000001	0.000001
2	PREDICTED	7	0.000001	0.000001
2	RESIDUAL	8	0.000000	0.000000
2	OUTLIER	9	0.000000	0.000000
2	LOG RATIO	10	-0.000000	-0.000000
3	OBSERVED	11	0.000001	0.000001
3	PREDICTED	12	0.000001	0.000001
3	RESIDUAL	13	0.000000	0.000000
3	OUTLIER	14	0.000000	0.000000
3	LOG RATIO	15	-0.000000	-0.000000

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 2 1

			1	2	3	4	5	6	7
1	OBSERVED	1	0.000001	2.000000	0.000001	0.000001	0.000001	0.000001	1.000000
1	PREDICTED	2	0.000001	1.615385	0.000002	0.000000	0.000001	0.000002	0.368421
1	RESIDUAL	3	0.000000	0.384615	-0.000001	0.000001	-0.000000	-0.000001	0.631579
1	OUTLIER	4	0.000000	0.085910	-0.000001	-0.000017	-0.000001	-0.000001	0.736191
1	LOG RATIO	5	-0.000000	14.295085	0.646626	-12.023757	0.405463	0.538995	12.816983
2	OBSERVED	6	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	1.000000
2	PREDICTED	7	0.000001	0.230769	0.000001	0.000000	0.000001	0.000000	1.105263

TABLE 5-15. (SHEET 5 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

2	RESIDUAL	8	0.000000	-0.230768	0.000000	0.000001	-0.000000	0.000001	-0.105263
2	OUTLIER	9	0.000000	0.461644	-0.000040	-0.000017	-0.000001	-0.000014	0.010291
2	LOG RATIO	10	-0.000000	12.349175	-0.606136	-12.023757	0.405463	-13.969664	13.915595
3	OBSERVED	11	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	1.000000
3	PREDICTED	12	0.000001	0.153846	0.000001	0.000003	0.000000	0.000001	1.526316
3	RESIDUAL	13	0.000000	-0.153845	0.000000	-0.000002	0.000001	-0.000000	-0.526316
3	OUTLIER	14	0.000000	0.307492	-0.000040	-0.000002	-0.000016	-0.000001	0.208258
3	LOG RATIO	15	-0.000000	11.943710	-0.606136	1.098608	-12.716902	0.251313	14.238368

			8	9	10	11	12	13	14
1	OBSERVED	1	0.000001	0.000001	0.000001	1.000000	0.000001	0.000001	1.000000
1	PREDICTED	2	0.000001	0.000003	0.000003	0.222222	0.000001	0.000001	0.100000
1	RESIDUAL	3	0.000000	-0.000002	-0.000002	0.777778	0.000000	0.000000	0.900000
1	OUTLIER	4	0.000000	-0.000002	-0.000002	1.456080	0.000000	0.000000	2.809822
1	LOG RATIO	5	-0.000000	1.098608	1.098608	12.311436	-0.000000	-0.000000	11.512929
2	OBSERVED	6	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
2	PREDICTED	7	0.000001	0.000000	0.000000	0.666667	0.000001	0.000001	0.300001
2	RESIDUAL	8	0.000000	0.000001	0.000001	-0.666666	0.000000	0.000000	-0.300000
2	OUTLIER	9	0.000000	-0.000017	-0.000017	1.335541	0.000000	0.000000	0.600157
2	LOG RATIO	10	-0.000000	-12.023757	-12.023757	13.410048	-0.000000	-0.000000	12.611541
3	OBSERVED	11	0.000001	0.000001	0.000001	1.000000	0.000001	0.000001	0.000001
3	PREDICTED	12	0.000001	0.000000	0.000000	1.111111	0.000001	0.000001	0.600001
3	RESIDUAL	13	0.000000	0.000001	0.000001	-0.111111	0.000000	0.000000	0.600000
3	OUTLIER	14	0.000000	-0.000017	-0.000017	0.011279	0.000000	0.000000	1.201950
3	LOG RATIO	15	-0.000000	-12.023757	-12.023757	13.920872	-0.000000	-0.000000	13.304688

TABLE 5-15. (SHEET 6 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

			15	16
1	OBSERVED	1	0.000001	0.000001
1	PREDICTED	2	0.000001	0.000001
1	RESIDUAL	3	0.000000	0.000000
1	OUTLIER	4	0.000000	0.000000
1	LOG RATIO	5	-0.000000	-0.000000
2	OBSERVED	6	0.000001	0.000001
2	PREDICTED	7	0.000001	0.000001
2	RESIDUAL	8	0.000000	0.000000
2	OUTLIER	9	0.000000	0.000000
2	LOG RATIO	10	-0.000000	-0.000000
3	OBSERVED	11	0.000001	0.000001
3	PREDICTED	12	0.000001	0.000001
3	RESIDUAL	13	0.000000	0.000000
3	OUTLIER	14	0.000000	0.000000
3	LOG RATIO	15	-0.000000	-0.000000

RESIDUALS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG. FIRST 2 LEVELS: 2 2

			1	2	3	4	5	6	7
1	OBSERVED	1	0.000001	1.000000	0.000001	0.000001	1.000000	0.000001	0.000001
1	PREDICTED	2	0.000001	0.875001	0.000003	0.000001	0.666667	0.000000	0.312500
1	RESIDUAL	3	0.000000	0.124999	-0.000002	0.000000	0.333333	0.000001	-0.312499
1	OUTLIER	4	0.000000	0.017161	-0.000002	0.000000	0.144900	-0.000017	0.625335
1	LOG RATIO	5	-0.000000	13.681982	1.098611	-0.000000	13.410048	-12.023757	12.652362
2	OBSERVED	6	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	2.000000
2	PREDICTED	7	0.000001	0.125000	0.000000	0.000001	0.333334	0.000003	2.187500
2	RESIDUAL	8	0.000000	-0.124999	0.000001	0.000000	-0.333333	-0.000002	-0.187500
2	OUTLIER	9	0.000000	0.249791	-0.000015	0.000000	0.667074	-0.000002	0.016652
2	LOG RATIO	10	-0.000000	11.736073	-13.410048	-0.000000	12.716901	1.098608	14.598271
3	OBSERVED	11	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	3.000000
3	PREDICTED	12	0.000001	0.000000	0.000000	0.000001	0.000001	0.000000	2.500000
3	RESIDUAL	13	0.000000	0.000001	0.000001	0.000000	0.000000	0.000001	

TABLE 5-15. (SHEET 7 OF 7)

CONTAB PROGRAM BRAKE RELATED CONTINGENCY TABLE. FACTORS: BRK RELATED * DOWN HILL * WEIGHT * CONFIG

0.500000

3	OUTLIER	14	0.000000	-0.000039	-0.000015	0.000000	-0.000041	-0.000017	0.095371
3	LOG RATIO	15	-0.000000	-1.386292	-13.410048	-0.000000	-0.405465	-12.023757	14.731803

			8	9	10	11	12	13	14
1	OBSERVED	1	0.000001	1.000000	0.000001	0.000001	0.000001	0.000001	0.000001
1	PREDICTED	2	0.000000	0.999998	0.000002	0.000001	0.000001	0.000001	0.428572
1	RESIDUAL	3	0.000001	0.000002	-0.000001	0.000000	0.000000	0.000000	0.428571
1	OUTLIER	4	-0.000017	0.000004	-0.000001	-0.000040	0.000000	0.000000	0.857818
1	LOG RATIO	5	-12.023757	13.815510	0.693144	-0.559615	-0.000000	-0.000000	12.968216
2	OBSERVED	6	0.000001	0.000001	1.000000	1.000000	0.000001	0.000001	0.000001
2	PREDICTED	7	0.000000	0.000002	0.999998	0.571429	0.000001	0.000001	0.428572
2	RESIDUAL	8	0.000001	-0.000001	0.000002	0.428571	0.000000	0.000000	-0.428571
2	OUTLIER	9	-0.000017	-0.000001	0.000004	0.263155	0.000000	0.000000	0.857818
2	LOG RATIO	10	-12.023757	0.693144	13.815510	13.255897	-0.000000	-0.000000	12.968216
3	OBSERVED	11	0.000001	0.000001	0.000001	1.000000	0.000001	0.000001	1.000000
3	PREDICTED	12	0.000003	0.000002	0.000002	1.428571	0.000001	0.000001	0.142857
3	RESIDUAL	13	-0.000002	-0.000001	-0.000001	-0.428571	0.000000	0.000000	0.857143
3	OUTLIER	14	-0.000002	-0.000001	-0.000001	0.144831	0.000000	0.000000	2.181768
3	LOG RATIO	15	1.098608	0.693144	0.693144	14.172166	-0.000000	-0.000000	11.869604

			15	16
1	OBSERVED	1	0.000001	0.000001
1	PREDICTED	2	0.000001	0.000001
1	RESIDUAL	3	0.000000	0.000000
1	OUTLIER	4	0.000000	0.000000
1	LOG RATIO	5	-0.000000	-0.000000
2	OBSERVED	6	0.000001	0.000001
2	PREDICTED	7	0.000001	0.000001
2	RESIDUAL	8	0.000000	0.000000
2	OUTLIER	9	0.000000	0.000000
2	LOG RATIO	10	-0.000000	-0.000000
3	OBSERVED	11	0.000001	0.000001
3	PREDICTED	12	0.000001	0.000001
3	RESIDUAL	13	0.000000	0.000000
3	OUTLIER	14	0.000000	0.000000
3	LOG RATIO	15	-0.000000	-0.000000

for the full data base is repeated here[1] using the predicted x* values from the best model (Hypothesis 10) for the high-severity accidents. Table 5-15 gives these values, as well as the observed x values, and the usual other values of no present interest. The odds of concern are:

TABLE 5-16.—ODDS OF BRAKES-RELATED ACCIDENT (COMPARED TO NOT)

Vehicle Type	Downhill Odds	Non-Downhill Odds
Light, single unit, 2-axle	$\frac{x^*(2,2,2,1)}{x^*(1,2,2,1)} = \frac{0.88}{6.12} = 0.14$	$\frac{x^*(2,1,2,1)}{x^*(1,1,2,1)} = \frac{1.62}{19.4} = 0.08$
Heavy, 5-axle tractor/semi-trailer	$\frac{x^*(2,2,7,3)}{x^*(1,2,7,3)} = \frac{0.14}{5.50} = 0.03$	$\frac{x^*(2,1,7,3)}{x^*(1,1,7,3)} = \frac{1.53}{27.5} = 0.06$

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

[1]Except that variations with weight are immediately neglected now, since it is understood that the model obviates them.

[2]Table 5-13 shows this weight has the largest joint sample frequency for this vehicle configuration. Since weight is irrelevant, this frequency is used here in preference to the frequency for light weight.

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, previously noted and discussed, that is causing the observed results. A deeper investigation must await a future study.

5.7. KULLITR Contingency Table Analyses Incorporating Exposure

The KULLITR program allows the incorporation of a "constraint matrix" that the joint variables represented by the cells of the Contingency Table must also satisfy. (See Appendix F for a discussion of the comparable capabilities of KULLITR and CONTAB.) This capability is applied to the introduction of exposure (VMT during the 350 days of the study's accident data collection, and in the two areas of California where the data were acquired) for each commercial vehicle category of interest.

As described in Section 6, the categories considered involve 16 vehicle configurations (four types, each with four values of the number of axles possessed by the vehicle), and three classes of weight. Two sets of exposure estimates were developed: direct and induced, which are defined and discussed in Section 6. Only their results will be needed here.

The studies conducted were of accident involvement vs. commercial vehicle category and exposure, for the two exposure estimates. The interest here is whether the inclusion of exposure in the analysis affects any of the significant interactions of vehicle characteristics with accident involvement that are found to exist when exposure is excluded. If it does, these interactions may merely be artifacts of exposure, derived more from their frequent appearance on the roads than from their relationship with accident causation. The fact that they cease to be significant when exposure is explicitly included would argue for this.

A complete analysis along this line has not been possible within the scope of the present study, but a simplified analysis with the main features of interest has been conducted.

The discussion begins with a still more simplified illustration of the analysis process. Then specific KULLITR studies are examined.

5.7.1. Treatment of Vehicle Exposure in the Analysis of Commercial Vehicle Accidents

Suppose that a number, N, of commercial vehicles involved in accidents are classified according to Weight and Configuration, Weight having I levels and Configuration having J levels. To fix ideas, let N = 400, I = 2 and J = 3. Let i = 1 denote "less than 50,000 lbs." and i = 2 be "over 50,000 lbs." The resulting contingency table has 2 x 3 = 6 cells. Let a typical cell be denoted by (ij), i = 1,2; j = 1,2,3. For each cell there is available a number V(ij), being the estimated value of VMT by a vehicle of the (ij) category. The fictitious table appears below.

TABLE 5-17.—FICTITIOUS CONTINGENCY TABLE

Weight (i)		Configuration j = 1	j = 2	j = 3	Total no. of vehicles
i = 1	No. of vehicles[a]	40	90	20	150
	V(ij)	(15)	(35)	(22)	
i = 2	No. of vehicles[a]	60	110	80	250
	V(ij)	(26)	(12)	(15)	
Total no. of vehicles[a]		100	200	100	400

[a]Involved in accidents.

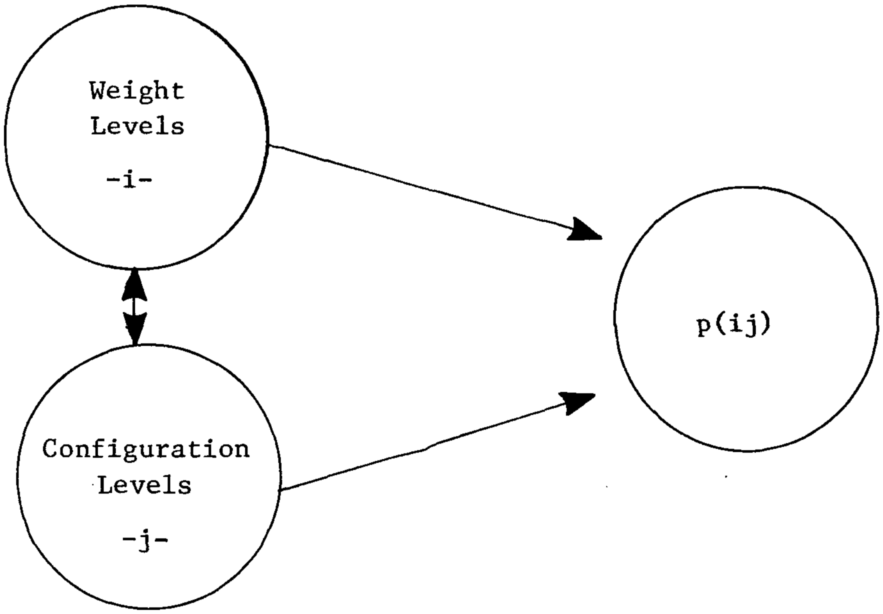
5.7.1.1. Problem

Let p(ij) be the population proportion of vehicles of the (ij) category involved in accidents. Then the problems to be investigated are as follows:

Study the relationship(s) of p(ij) to the Weight and Configuration characteristics, both with and without consideration of the numbers V(ij). In particular,

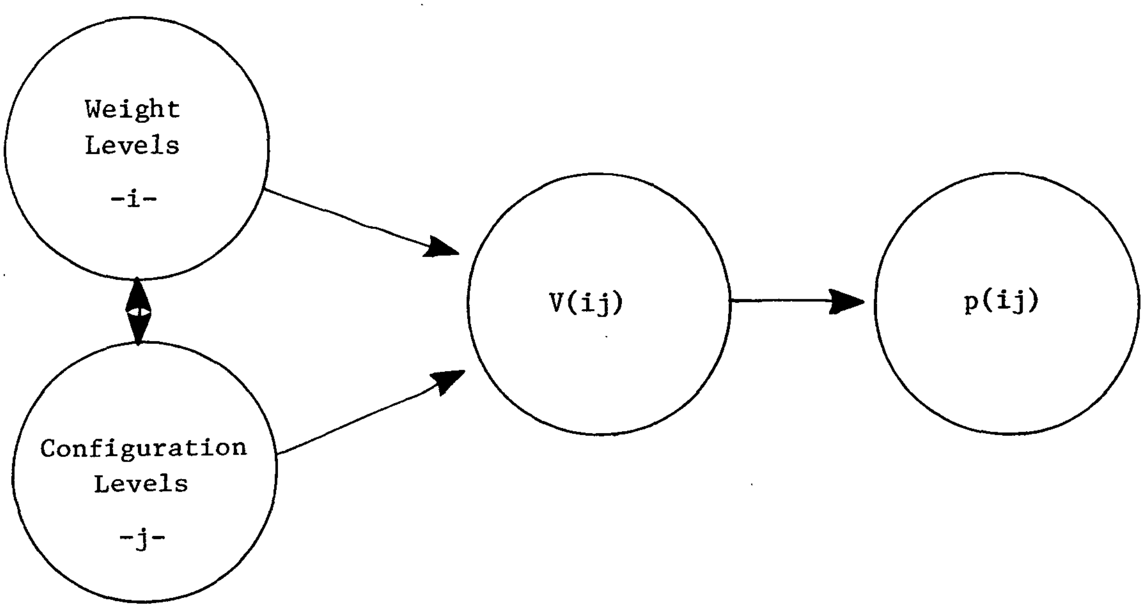
a) Ignore the V(ij)'s and examine whether there is any interaction (e.g.,"vehicles over 50,000 lbs. weight and of configuration 3 are more likely to be involved in accidents") between Weight and Configuration.

Pictorially, the situation can be represented as follows (see diagram, next page):



If there is no interaction, the double-headed arrow on the left is absent.

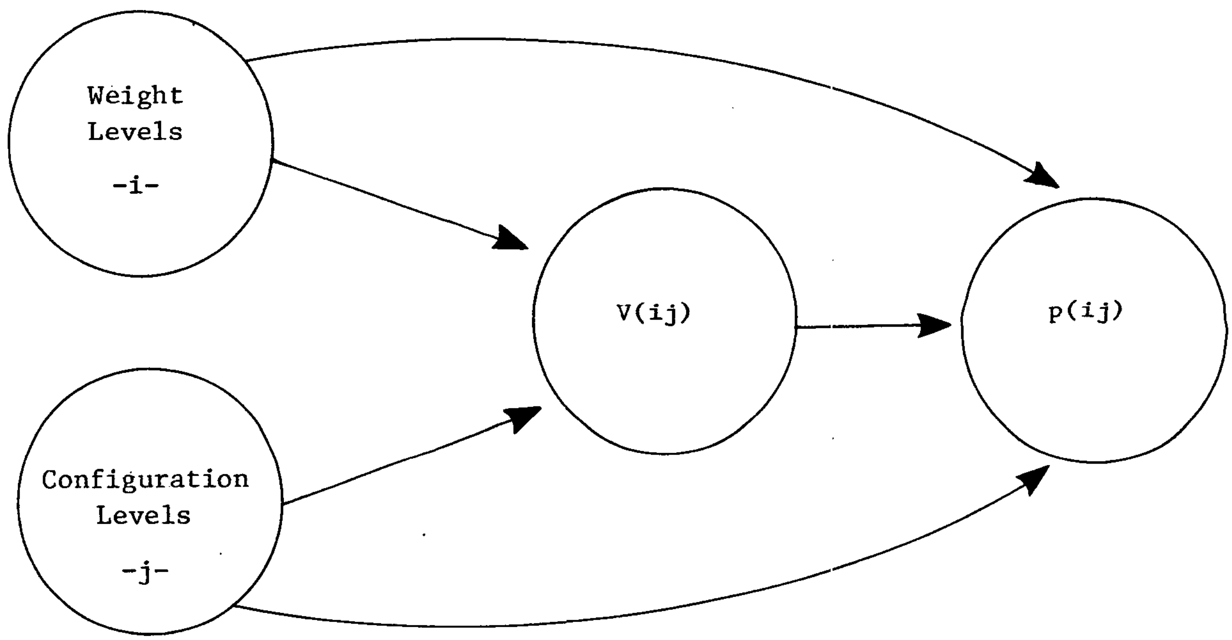
b) Consider the V(ij)'s and adjust the proportions, p(ij), by expressing the ℓn p(ij)'s as linear functions of the V(ij)'s. The model assumes that since the V(ij)'s are functions of i and j, once the p(ij) are so adjusted, it is not necessary to consider the dependence of p(ij) on Weight and Configuration separately. The picture corresponding to this model is:



The model (b) assumes that the V(ij)'s include in themselves all the information about accident involvement contained in the (ij)-level combinations. A knowledge of exposure is sufficient for the prediction of the p(ij). Other characteristics of the vehicle categories are not significant in accident involvement.

c) Take into account the relationships between p(ij) and V(ij) and also those between Weight characteristics and Configuration characteristics. It is assumed in this model that, having adjusted for the V(ij)'s, it is not necessary to consider the interaction between i-levels and j-levels, however.

This is seen pictorially as:



d) If the i,j interactions also must be considered, all possible interactions are necessary for consideration, and nothing of importance can be said about the relative roles of vehicle characteristics and exposure in the occurrence of commercial vehicle accidents.

5.7.1.2. Method

The present method of attack is to use the log-linear model given by

$$\ell n\ p(ij) = L + \tau_i^{A} T_i^{A}(ij) + \tau_j^{B} T_j^{B}(ij)$$

$$+ \tau_{ij}^{AB} T_{ij}^{AB}(ij) + \beta\ V(ij) \quad , \ i = 1,2, \quad j = 1,2,3.$$

Here, L, τ's with subscripts, and β are parameters, and the T(ij) with subscripts are indicator functions of various one-way and two-way marginals (recall the "design matrix" in Section 5.2). The model is valid as long as it contains up to, but not more than IJ = 6 linearly independent parameters.

The problems formulated above can be analyzed by hypothesizing that various parameters are equal to zero.

H_a: $\tau_{ij}^{AB} = 0$ for all i and j, and with $\beta = 0$ (exposure interaction excluded)

H_b: $\tau_i^{A} = \tau_j^{B} = \tau_{ij}^{AB} = 0$ for all i and j

H_c: $\tau_{ij}^{AB} = 0$ for all i and j.

A comparison of the MDI statistics under the three hypotheses will provide at least partial answers to the problems posed earlier.

5.7.1.3. Extension

In the foregoing illustration, and in all of the KULLITR studies conducted in the present project, the cells of the contingency table correspond to the combinations of vehicle configuration and weight. The exposure constraints correspond similarly. However, the procedure can be extended to cases where the contingency table also includes other variables for which it may not be possible to estimate exposure, e.g., driver experience. The constraint matrix, still with the same cell indices as the contingency table, would simply reflect a constant exposure value for all cells in the driver experience variable's row corresponding to a given commercial vehicle category for which that exposure value applies. The KULLITR procedure for incorporating exposure is thus quite generally applicable.

5.7.2. KULLITR Analysis of Accident Involvement vs. Commercial Vehicle Configuration, Weight, and Exposure

The procedure outlined in the foregoing illustration is now carried out for the actual data base, and for two sets of exposure estimates: direct and induced (see Section 6).

5.7.2.1. Inputs

Tables 5-18, 5-19, and 5-20 describe the input data for the KULLITR tests of the three hypotheses H_a, H_b, and H_c, defined above. Table 5-18 gives the contingency table of accident involvement frequency data for the 48 commercial vehicle categories considered. (However, all buses are incorporated in the single middle-weight category, arbitrarily employed. No actual weight information is available for buses, as is noted in the exposure discussion of Section 6.) Since columns 4, 9, and 13 contain essentially only zeros, they can be deleted in the KULLITR input, leaving a total of 39 cells of interest.

Table 5-19 provides the direct, and Table 5-20 the induced, exposure estimates in terms of millions of VMT in the two study areas during the accident data acquisition period, 15 May 1975–1 May 1976.

5.7.2.2. Computations and Results

For the test of H_a, in which the interaction of exposure and

TABLE 5-18. ACCIDENT INVOLVEMENT FREQUENCY VERSUS COMMERCIAL VEHICLE CATEGORY (TYPE, NUMBER OF AXLES, WEIGHT)

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	385	131	0	125	90	104	3	0	16	34	1	0	66	9	0
25,001–60,000	12	68	144	0	282	100	342	6	0	6	53	4	1	220	35	8
60,001 +	0	3	133	0	221	38	288	2	0	3	94	2	0	218	24	5

*Excluded columns in KULLITR Input

TABLE 5-19. 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

*Exclude in KULLITR Input.

Total VMT = 2,429

TABLE 5-20. 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+
10,000–25,000	0	409.5	115.5	0	60	56	115.5	0	7.0	14.0	49	0	0	60	0	0
25,001–60,000	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

*Exclude in KULLITR Input

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

accident frequency is deleted, only Table 5-18 is input.

After 14 iterations, the process produces the results in Table 5-21. The X STAR values are the values of cell frequency predicted by the log-linear model established. (It is the same as CONTAB could have produced also, since exposure is not involved in the test of H_a.) These predictions may be compared with the input frequencies in Table 5-18. The fit is evidently not close.

The relevant Information Statistic is given as 2I(Z:X STAR) = 982.5. Its approximation to a χ^2 value with 39 - 15 = 24 D.F.,[1] as shown in Appendix F, implies H_a must be rejected. The 14 TAU-values in Table 5-12 (L, plus 13 τ-coefficients) define the log-linear model corresponding to H_a, as described in Section 5.5.1. The output 2I (XSTAR:X) can be ignored.

<u>For the test of H_b with direct exposure estimates</u> included, Table 5-19 is now also input. The results of the analysis after 38 iterations are shown in Table 5-22. The value of the 2I (Z: XSTAR) statistics is now 3299, much larger than with H_a, so H_b is again strongly rejected (39 - 2 = 37 D.F. apply). The interaction of truck characteristics alone with accident occurrence is more important than that of exposure alone.

The value of the single log-linear model parameter for H_b, β, is given by TAU (1) = .002682. The fit of the predicted XSTAR values to the input contingency Table 5-18 is seen in fact to be poor.

<u>For the test of H_c</u>, the output of Table 5-23, developed after 19 iterations, applies. Again the fit is not good, and the hypothesis is rejected (IS = 374; 39 - 16 = 23 D.F.). However, it is

---

[1]The number of D.F. is equal to the number of columns minus the number of rows of the KULLITR design matrix. The number of columns equals the number of cells in the contingency table; the number of rows equals the number of constraints imposed by the fitted marginals under the hypothesis of interest.

TABLE 5-21. OUTPUT OF KULLITR TEST OF H_a

```
ESTIMATE OF X AT COUNT= 14
  1  1       XSTAR( 1)=    3.534376
  1  2       XSTAR( 2)=  134.306366
  1  3       XSTAR( 3)=  120.168915
  1  4       XSTAR( 4)=  184.965805
  1  5       XSTAR( 5)=   67.153152
  1  6       XSTAR( 6)=  215.597046
  1  7       XSTAR( 7)=    3.239845
  1  8       XSTAR( 8)=    7.363288
  1  9       XSTAR( 9)=   53.310196
  1 10       XSTAR(10)=    2.061721
  1 11       XSTAR(11)=  148.443863
  1 12       XSTAR(12)=   20.028122
  1 13       XSTAR(13)=    3.826725
  2  1       XSTAR(14)=    4.685620
  2  2       XSTAR(15)=  178.053665
  2  3       XSTAR(16)=  159.311096
  2  4       XSTAR(17)=  245.214035
  2  5       XSTAR(18)=   89.026779
  2  6       XSTAR(19)=  285.822754
  2  7       XSTAR(20)=    4.295153
  2  8       XSTAR(21)=    9.761705
  2  9       XSTAR(22)=   70.674728
  2 10       XSTAR(23)=    2.733278
  2 11       XSTAR(24)=  196.795944
  2 12       XSTAR(25)=   26.551849
  2 13       XSTAR(26)=    5.073191
  3  1       XSTAR(27)=    3.779997
  3  2       XSTAR(28)=  143.639954
  3  3       XSTAR(29)=  128.520035
  3  4       XSTAR(30)=  197.819946
  3  5       XSTAR(31)=   71.819946
  3  6       XSTAR(32)=  230.579910
  3  7       XSTAR(33)=    3.464997
  3  8       XSTAR(34)=    7.874998
  3  9       XSTAR(35)=   57.014969
  3 10       XSTAR(36)=    2.205000
  3 11       XSTAR(37)=  158.759933
  3 12       XSTAR(38)=   21.419983
  3 13       XSTAR(39)=    4.092663

Z IS OBSERVED TABLE AND X IS INITIAL DIST.

2I(XSTAR:X)= 3667.566406

2I(Z:XSTAR)=  982.523926

TAU( 1)=-0.067186
TAU( 2)= 0.214774
TAU( 3)=-0.079472
TAU( 4)= 3.558114
TAU( 5)= 3.446889
TAU( 6)= 3.878161
TAU( 7)= 2.864966
TAU( 8)= 4.031402
TAU( 9)=-0.166483
TAU(10)= 0.654497
TAU(11)= 2.634118
TAU(12)=-0.618468
TAU(13)= 3.658197
TAU(14)= 1.655128
```

TABLE 5-22. OUTPUT OF KULLITR TEST OF H_b USING DIRECT EXPOSURE ESTIMATES

ESTIMATE OF X AT COUNT= 38

1	1	XSTAR(1)=	62.318115
1	2	XSTAR(2)=	530.355469
1	3	XSTAR(3)=	84.401443
1	4	XSTAR(4)=	72.223160
1	5	XSTAR(5)=	63.499069
1	6	XSTAR(6)=	63.909149
1	7	XSTAR(7)=	62.368225
1	8	XSTAR(8)=	63.960541
1	9	XSTAR(9)=	63.448029
1	10	XSTAR(10)=	62.318115
1	11	XSTAR(11)=	65.033051
1	12	XSTAR(12)=	62.318115
1	13	XSTAR(13)=	62.318115
2	1	XSTAR(14)=	65.190216
2	2	XSTAR(15)=	65.137772
2	3	XSTAR(16)=	184.648819
2	4	XSTAR(17)=	79.224777
2	5	XSTAR(18)=	71.299347
2	6	XSTAR(19)=	94.566238
2	7	XSTAR(20)=	62.384949
2	8	XSTAR(21)=	64.824066
2	9	XSTAR(22)=	65.646332
2	10	XSTAR(23)=	62.485458
2	11	XSTAR(24)=	140.531158
2	12	XSTAR(25)=	62.872086
2	13	XSTAR(26)=	62.334808
3	1	XSTAR(27)=	62.318115
3	2	XSTAR(28)=	62.318115
3	3	XSTAR(29)=	62.318115
3	4	XSTAR(30)=	62.318115
3	5	XSTAR(31)=	62.368225
3	6	XSTAR(32)=	91.595749
3	7	XSTAR(33)=	62.318115
3	8	XSTAR(34)=	62.334808
3	9	XSTAR(35)=	71.779022
3	10	XSTAR(36)=	62.602844
3	11	XSTAR(37)=	85.609726
3	12	XSTAR(38)=	63.142471
3	13	XSTAR(39)=	62.351517

Z IS OBSERVED TABLE AND X IS INITIAL DIST.

2I(XSTAR:X)= 1350.892578

2I(Z:XSTAR)= 3299.157227

TAU(1)= 0.002682

seen that the addition of exposure in H_c to the non-exposure model of H_a explains a substantial part of the initial variation:

$$\frac{2\ I(Z : XSTAR)\ of\ H_a - 2\ I(Z : XSTAR)\ of\ H_c}{2\ I(Z : XSTAR)\ of\ H_a} = \frac{982 - 374}{982} = 0.62$$

That is, the inclusion of exposure explains 62% of the variation present when it is not considered.

The fit of the XSTAR values to those in Table 5-18 may again be seen to be in fact unsatisfactory (although much better than the fits of H_a or H_b).

The 15 TAU values are those of L, the 13 τ's, and β.

The tests of H_b and H_c using the induced exposure estimates lead to the results in Tables 5-24 and 5-25, respectively.

Again, both hypotheses are rejected, although again the inclusion of exposure makes H_c preferable to H_a or H_b.

It is to be noted that the inclusion of the induced exposure estimates explains a greater part of the initial (H_a) variation than did the direct estimates above. The final information statistic in Table 5-25 is 235, compared to 374 in Table 5-23. Thus,

$$\frac{982 - 235}{982} = 0.76$$

or 76% of the initial variation is now explained, compared to the 62% explained with the direct estimates. This result is very likely due to the development in the first place of the induced estimates from, and thus likely correlation with, the accident frequencies. It cannot, therefore, be considered to imply that the induced estimates are necessarily better.

5.7.2.3. Conclusions

The results of the KULLITR analysis verify that exposure is an important factor in accident occurrence. Commercial vehicle

TABLE 5-23. OUTPUT OF KULLITR TEST OF H_c USING DIRECT EXPOSURE ESTIMATES

```
ESTIMATE OF X AT COUNT= 19
  1  1      XSTAR( 1)=   3.110767
  1  2      XSTAR( 2)= 348.234619
  1  3      XSTAR( 3)=  80.468430
  1  4      XSTAR( 4)= 168.783401
  1  5      XSTAR( 5)=  57.910782
  1  6      XSTAR( 6)= 142.848862
  1  7      XSTAR( 7)=   2.900154
  1  8      XSTAR( 8)=   6.624429
  1  9      XSTAR( 9)=  44.787857
  1 10      XSTAR(10)=   1.839975
  1 11      XSTAR(11)=  85.294144
  1 12      XSTAR(12)=  17.772614
  1 13      XSTAR(13)=   3.423760
  2  1      XSTAR(14)=   4.345107
  2  2      XSTAR(15)=  52.653793
  2  3      XSTAR(16)= 241.733261
  2  4      XSTAR(17)= 247.662704
  2  5      XSTAR(18)=  87.057922
  2  6      XSTAR(19)= 285.972900
  2  7      XSTAR(20)=   3.866915
  2  8      XSTAR(21)=   8.953976
  2  9      XSTAR(22)=  61.849579
  2 10      XSTAR(23)=   2.459484
  2 11      XSTAR(24)= 252.969727
  2 12      XSTAR(25)=  23.909119
  2 13      XSTAR(26)=   4.565068
  3  1      XSTAR(27)=   4.544124
  3  2      XSTAR(28)=  55.111435
  3  3      XSTAR(29)=  85.798080
  3  4      XSTAR(30)= 211.553680
  3  5      XSTAR(31)=  83.031326
  3  6      XSTAR(32)= 303.178223
  3  7      XSTAR(33)=   4.232927
  3  8      XSTAR(34)=   9.421598
  3  9      XSTAR(35)=  74.362457
  3 10      XSTAR(36)=   2.700535
  3 11      XSTAR(37)= 165.736191
  3 12      XSTAR(38)=  26.318268
  3 13      XSTAR(39)=   5.004116

Z IS OBSERVED TABLE AND X IS INITIAL DIST.

2I(XSTAR:X)= 4276.179688

2I(Z:XSTAR)=  373.911133

TAU( 1)=-0.378965
TAU( 2)=-0.091550
TAU( 3)=-0.095870
TAU( 4)= 2.399652
TAU( 5)= 2.842292
TAU( 6)= 3.744774
TAU( 7)= 2.808678
TAU( 8)= 3.704881
TAU( 9)=-0.166811
TAU(10)= 0.633022
TAU(11)= 2.552547
TAU(12)=-0.620987
TAU(13)= 3.171105
TAU(14)= 1.646918
TAU(15)= 0.002784
```

TABLE 5-24. OUPUT OF KULLITR TEST OF H_b USING INDUCED EXPOSURE ESTIMATES

ESTIMATE OF X AT COUNT= 34

1	1	XSTAR(1)=	44.158432
1	2	XSTAR(2)=	533.956543
1	3	XSTAR(3)=	89.193207
1	4	XSTAR(4)=	63.623932
1	5	XSTAR(5)=	62.093567
1	6	XSTAR(6)=	89.193207
1	7	XSTAR(7)=	44.158432
1	8	XSTAR(8)=	48.086349
1	9	XSTAR(9)=	59.503494
1	10	XSTAR(10)=	44.158432
1	11	XSTAR(11)=	63.623932
1	12	XSTAR(12)=	44.158432
1	13	XSTAR(13)=	44.158432
2	1	XSTAR(14)=	44.428009
2	2	XSTAR(15)=	57.021454
2	3	XSTAR(16)=	63.623932
2	4	XSTAR(17)=	60.821762
2	5	XSTAR(18)=	66.231903
2	6	XSTAR(19)=	356.218506
2	7	XSTAR(20)=	45.136688
2	8	XSTAR(21)=	47.101395
2	9	XSTAR(22)=	58.178391
2	10	XSTAR(23)=	45.136688
2	11	XSTAR(24)=	200.283997
2	12	XSTAR(25)=	62.093567
2	13	XSTAR(26)=	47.101395
3	1	XSTAR(27)=	44.158432
3	2	XSTAR(28)=	46.080551
3	3	XSTAR(29)=	46.080551
3	4	XSTAR(30)=	44.158432
3	5	XSTAR(31)=	47.101395
3	6	XSTAR(32)=	200.528061
3	7	XSTAR(33)=	44.158432
3	8	XSTAR(34)=	45.136688
3	9	XSTAR(35)=	76.836426
3	10	XSTAR(36)=	45.136688
3	11	XSTAR(37)=	161.854828
3	12	XSTAR(38)=	44.158432
3	13	XSTAR(39)=	44.158432

Z IS OBSERVED TABLE AND X IS INITIAL DIST.

2I(XSTAR:X)= 2371.011719

2I(Z:XSTAR)= 2279.046875

TAU(1)= 0.006087

TABLE 5-25. OUTPUT OF KULLITR TEST OF H_c USING INDUCED EXPOSURE ESTIMATES

```
ESTIMATE OF X AT COUNT= 21
  1   1        XSTAR( 1)=    3.111633
  1   2        XSTAR( 2)=  355.220459
  1   3        XSTAR( 3)=  148.355560
  1   4        XSTAR( 4)=  188.183609
  1   5        XSTAR( 5)=   63.690994
  1   6        XSTAR( 6)=   76.251770
  1   7        XSTAR( 7)=    2.836659
  1   8        XSTAR( 8)=    6.701302
  1   9        XSTAR( 9)=   42.610428
  1  10        XSTAR(10)=    1.790059
  1  11        XSTAR(11)=   56.443390
  1  12        XSTAR(12)=   15.503340
  1  13        XSTAR(13)=    3.300486
  2   1        XSTAR(14)=    4.222932
  2   2        XSTAR(15)=   53.008652
  2   3        XSTAR(16)=  143.524261
  2   4        XSTAR(17)=  242.857651
  2   5        XSTAR(18)=   91.554749
  2   6        XSTAR(19)=  401.968262
  2   7        XSTAR(20)=    3.910188
  2   8        XSTAR(21)=    8.858018
  2   9        XSTAR(22)=   56.222809
  2  10        XSTAR(23)=    2.467501
  2  11        XSTAR(24)=  235.408829
  2  12        XSTAR(25)=   29.251709
  2  13        XSTAR(26)=    4.744399
  3   1        XSTAR(27)=    4.665435
  3   2        XSTAR(28)=   47.770721
  3   3        XSTAR(29)=  116.120239
  3   4        XSTAR(30)=  196.958542
  3   5        XSTAR(31)=   72.754181
  3   6        XSTAR(32)=  253.780426
  3   7        XSTAR(33)=    4.253148
  3   8        XSTAR(34)=    9.440684
  3   9        XSTAR(35)=   82.166809
  3  10        XSTAR(36)=    2.742437
  3  11        XSTAR(37)=  212.147675
  3  12        XSTAR(38)=   23.244934
  3  13        XSTAR(39)=    4.948591


Z IS OBSERVED TABLE AND X IS INITIAL DIST.

2I(XSTAR:X)= 4414.953125

2I(Z:XSTAR)=  235.134644

TAU( 1)=-0.405032
TAU( 2)=-0.105642
TAU( 3)=-0.058922
TAU( 4)= 2.225374
TAU( 5)= 3.113586
TAU( 6)= 3.683890
TAU( 7)= 2.624479
TAU( 8)= 3.448016
TAU( 9)=-0.151443
TAU(10)= 0.624358
TAU(11)= 2.264472
TAU(12)=-0.611822
TAU(13)= 2.479711
TAU(14)= 1.546985
TAU(15)= 0.005991
```

characteristics (type, number of axles, weight) nevertheless appear to be still more important. The rejection of all three hypotheses shows that at least some three-way interactions among these latter variables with accident occurrence must also be included in a statistically acceptable log-linear model. Of some additional interest is the result that, as one would expect, the inclusion of the induced exposure estimates allows a larger explanation of the variation than that of direct estimates.

5.6.2.4. Accident Involvement Rates

Having established the requirement for the inclusion of exposure in the explanation of the accident frequencies, it is now of interest to examine explicitly the predicted accident involvement rates, i.e., the accident involvement frequencies divided by the exposure estimates, in terms of accident involvement per million miles traveled for each commercial vehicle category. Here the accident frequencies are the predicted or "smoothed" values given by the best available model, that associated with the hypothesis H_c for each of the direct exposure and induced exposure application cases.

Table 5-26 exhibits the results for the direct exposure case; it is obtained by dividing the XSTAR values in Table 5-23 by the corresponding direct exposure values in Table 5-19. Similarly, Table 5-27 gives the results for the induced exposure case, obtained by dividing the Table 5-25 values by those in Table 5-20.

The striking feature of interest in both Tables 5-26 and 5-27 is the relatively high involvement rates associated with the heaviest-weight vehicles (where the estimates of these rates have been determined). However, in view of the many approximations and relatively low confidence data employed in the exposure estimates (see Section 6), too much should not be made of this point at present. In some instances, these rates clearly result from very low

TABLE 5-26. 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	0.68	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	7.5	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 5-27. 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+
10,000–25,000	ND	0.87	1.3	ND	3.1	1.2	0.66	ND	ND	0.48	0.87	ND	ND	0.94	ND	ND
25,001–60,000	0.26*	1.3	2.4	ND	4.6	1.4	1.2	1.1	ND	0.83	1.2	0.69	ND	0.95	0.52	0.45
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.

exposure estimates dividing the accident frequencies and may therefore be spurious. Nevertheless, the pattern is consistent, and so perhaps indicative of actuality.

A second feature of interest in both tables is the pattern of relatively high involvement rates of tractor/semi-trailer combinations. Since these combinations generally have large exposure estimates, it should be possible to consider this result real with some confidence.

5.8. Conclusions

Contingency table analysis has been shown to be a powerful procedure for investigating the significant interactions among accident variables. Greater detail in these investigations is feasible, but a larger data base is required to overcome data sparseness as the number of cells in the contingency tables is increased. Enhanced procedures for the introduction of exposure, and of economic costs of accidents, are also needed.

Nevertheless, it has already been possible to establish certain implications for accident causation.

a) Road surface is the most important factor in the occurrence of JKBA. But two drive-axles significantly decrease the jackknife occurrence odds, and by a factor independent of both road surface and wheel lockup.

b) Accident severity depends most strongly on the type of road, much less so on vehicle configuration and weight.

c) The occurrence of brakes-related accidents depends primarily on road direction (downhill or not), and secondarily on vehicle configuration. It is insensitive to vehicle weight.

d) The same results arise if only "high-cost" brakes-related accidents are considered. It is found in addition, however, that whereas single-unit, two-axle trucks have about the same odds of brakes-related accidents in general, five-axle tractor/semi-trailers have significantly decreased such odds for high-cost brakes-related accidents compared to brakes-related accidents in general.

A virtually unlimited number of additional analyses of this character is now possible with the existing data base and operational programs. The level of detail in such analyses is limited only by the data sample sizes applicable at that level. A growing data base should therefore be a long-term objective for the future.

6. 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 state 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.

The two approaches are developed in detail in this section. Their results have been applied in the KULLITR contingency table analyses discussed in Section 5.

6.1. Direct Exposure Estimation

Many attempts have been made to establish a useful measure of accident exposure that would be applicable to accidents in general and to truck accidents in particular. Unfortunately, no satisfactory measure has yet been developed. Some understanding, however, of the variables that contribute significantly to accident exposure and accident causation has been established. Total VMT is known to be a reasonable basic measure of exposure to accident. There are many other variables, but their functional relationship to exposure is unclear. Accepting VMT as a useful measure of exposure for commercial vehicles, in particular, a method for its estimation will now be discussed. The method is put forward not as a fully satisfactory, accurate one, but rather as a usable and well-defined framework that clarifies points of uncertainty and inaccuracy and so points the way to specific areas of improvement.

6.1.1. Estimation Process

While the truck's odomter reading is the best method for estimating the VMT for a truck during a given period, odometer data collection for all trucks is clearly impractical. (It would be feasible, however, for estimating exposure of trucks in large fleets, whose records could be made available.)

The estimation problem becomes even more complex when VMT is to be estimated for a particular category of trucks of a given type (e.g., single-unit truck, tractor/semi-trailer, etc.), number of axles, and weight class. Therefore, an extrapolation technique has been developed for the direct estimation of VMT. The extrapolation method used AADT data, by number of axles, and TWS data, by category, to estimate truck traffic for different categories.

6.1.1.1. Data Presentation Format, Available Data and Desired Estimates

Before proceeding with an outline of the approach to estimation, consider the data presentation format, the available data, and what it is desired to estimate.

The truck counts categorized by type, number of axles, and weight may be presented as in Table 6-1. The cell entries are truck volumes counted or extrapolated over a specified time interval and for a specified set of roads. An alternative, more aggregated categorization scheme is by truck type and number of axles only, as is shown in Table 6-2. Finally, truck count categorization, even more aggregated so as to provide truck volume vs. number of axles only, is shown in Table 6-3.

Other variables besides truck volume count, such as VMT and number of accidents, will also be entered into tables with these three formats during the course of the estimation process. Tables 6-1 to 6-3 should therefore be considered to be generic, to be called upon in different applications as the analysis proceeds.

Available data for use in the exposure estimation process are:

a) Annual Average Daily Traffic of Trucks by Number of Axles (AADTT/A) is presented in a table such as Table 6-3, where the

TABLE 6-1. ENTRIES CATEGORIZED BY TRUCK TYPE, TRUCK CONFIGURATION AND WEIGHT CLASS S

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		*														
25,001–60,000																
60,001 +																

*Entry Variable: This table is applied with several different entry variables (e.g., truck volume count, VMT, et al.)

TABLE 6-2. ENTRIES CATEGORIZED BY TRUCK TYPE AND NUMBER OF AXLES

	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+
Entry Variable*																

*This table is applied with several different entry variables.

TABLE 6-3. ENTRIES CATEGORIZED BY NUMBER OF AXLES

	Number of Axles			
	2	3	4	5+
Entry variable*				

*This table is applied with several different entry variables.

entries are AADTT for a particular road segment or system.

b) Truck Weight Study Data (TWD) consists of counts of categories of trucks defined by the cells of a table such as Table 6-1, where the entries are based on a particular eight-hour observation at a particular weigh station.

c) Truck Weight Study Volume Counts (TVC) similarly consist of counts of categories defined by the cells of a table such as Table 6-2, where the entries are three combined eight-hour counts at a particular weigh station.

What is desired are the VMT estimates for each cell of a Table 6-1, over a given road network and during a given period of time. How to obtain these estimates step-by-step, and as well as possible, from a combination of the foregoing data is described next. In the process, the input data and the extrapolation procedures that must be used are critiqued.

6.1.1.2. AADTT/A

CALTRANS conducts truck and bus traffic volume counts at the mileposts and other locations on the entire network of state highways, consisting of approximately 15,000 miles. AADTT/A consists of estimated truck volumes for all count locations. Trucks are categorized by number of axles. Buses are considered separately. The truck traffic volumes listed are combined from counts for both directions at an observation location.

The data collection procedure and the process that the raw data go through before going into the data base are explained next. CALTRANS' data collection procedure for truck counts is by visual observation. A data collector sits at the side of the freeway at a specified count site, usually at a milepost. Mileposts are usually at an intersection. He counts the number of vehicles and categorizes them as buses or as trucks with two, three, four, five, six, and seven axles or more. The accumulated count in one hour is recorded on a special form. These forms contain information such as count location, date, time, direction, and milepost leg (the road segment on each side of the milepost). The volume counts on the two sides of an intersection milepost are generally different because of the natural difference between incoming and outgoing traffic.

Volume counts are recorded for six hours only. There are a few count locations where volume counts are recorded for 24 hours. A 24-hour volume count is not a continuous record of any one day, but consists of three eight-hour counts during three different shifts on different days. According to the CALTRANS Los Angeles office, there are now only two count locations at which 24-hour records are collected in Southern California.

CALTRANS' data processing consists of (a) adjusting the accumulated six-hour volume for trends in traffic volume; (b) adjusting the accumulated six-hour volume of a particular category of vehicle (defined only by number of axles) on the basis of experience and purely subjective judgment; and (c) expansion of the adjusted six-hour volume to 24 hours. The outcome of the last step is then added to its counterpart for the opposite direction. The total is rounded up to the nearest 10, and the outcome is the listed AADTT/A data on trucks. Figure 6-1 illustrates the steps of the CALTRANS data processing procedure.

6.1.1.3. TWS and TWD

CALTRANS conducts the TWS yearly.[1] This study consists of recording the weight for each axle of every truck that passes through each of a selected set of weigh stations during an eight-

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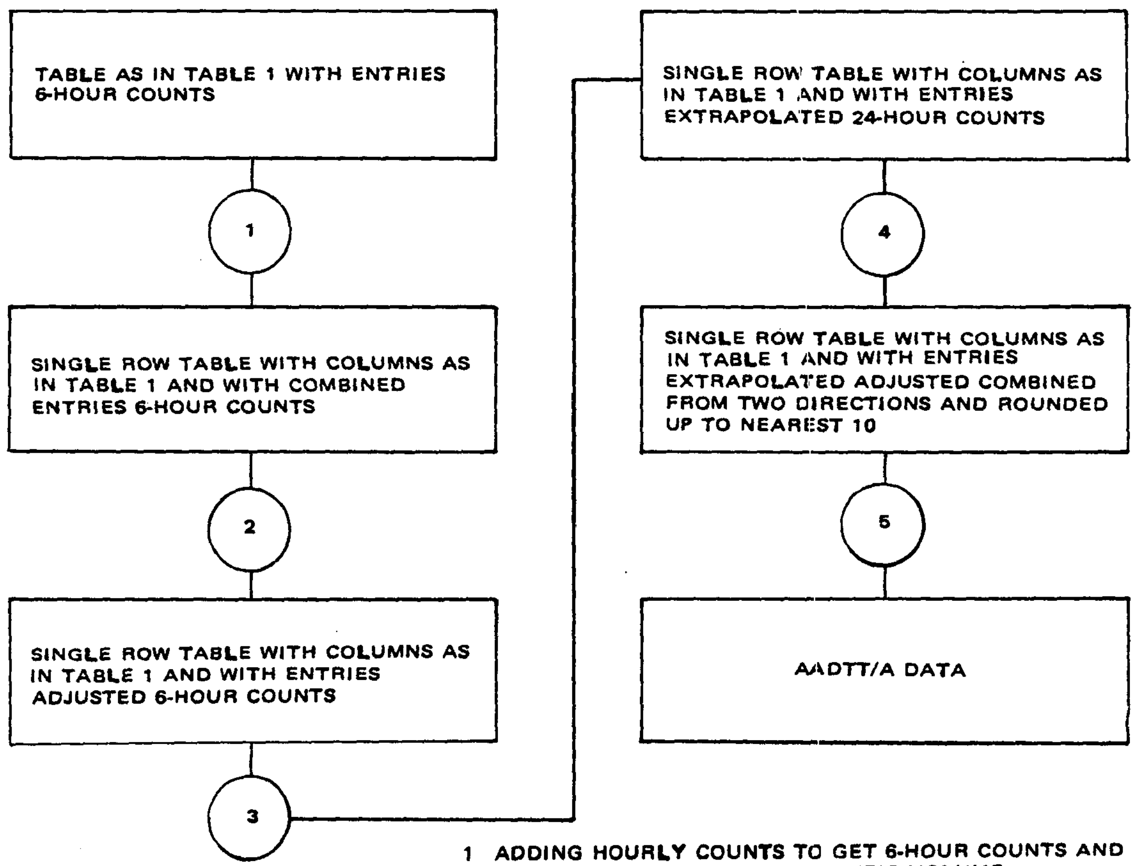
[1]Beginning in the fall of 1977, the TWS is to be conducted only biennially.



1 ADDING HOURLY COUNTS TO GET 6-HOUR COUNTS AND ADJUSTING FOR TREND IN TRAFFIC VOLUME

2 SUBJECTIVE ADJUSTMENT OF HEAVY TRUCK VOLUMES

3 EXTRAPOLATION OF 6-HOUR DATA TO 24-HOUR

4 ADDING OF TRUCK TRAFFIC IN TWO DIRECTIONS AND ROUNDING UP TO NEAREST 10

5 SUBJECTIVE ADJUSTMENT OF TRUCK VOLUME FOR SHARP CHANGES

FIGURE 6-1. FLOW DIAGRAM FOR AADT DATA PROCESSING BY CALTRANS hour period, and also counting the truck traffic flow past each location for a total of 24 hours. No attempt is made to select weigh stations so as to establish a representative sampling of the truck population.

The CALTRANS TWS group collects TWD (and, in the past, also recorded load status) at only some weigh stations on the state's highway and freeway system. CALTRANS employees operate each selected weigh station during an eight-hour data collection period.

The data collection procedure is as follows:

a) For a 15-20-minute period, trucks in a certain type/number of axles category are directed to the weigh station. For successive periods, different truck categories are weighed. Trucks with unusual configurations, such as construction trucks, always go through the weigh station, without exception. The configuration (and thus type and number of axles) of each truck passing through the weigh stations and the weight for each axle are recorded.

b) Should the weighing queue become long, the operators, using their discretion, direct incoming trucks to bypass the weigh station and continue on their way.

This data collection operation continues for a block of eight hours. The starting time may vary at different weigh stations.

In this way a table with the format of Table 6-1 for the counts of weighed trucks is constructed for an eight-hour period at a given weigh station. To establish a Table 6-1 for a 24-hour period, extrapolation is required, as described in Section 6.1.1.4 below.

The TWS group also records truck traffic volume for each type/number of axles (but not weight) category for three time periods. At each station, each volume count period covers a non-overlapping eight hours of a combined 24-hour period. The eight-hour periods are not consecutive, however, but are established at different hours on different days to reach a total of 24 hours. A Table 6-2 is then constructed for each such 24-hour TVC by adding the three eight-hour counts.

6.1.1.4. Truck Characteristics Estimate

Twenty-four-hour truck volume estimates at a given weigh station, in terms of weight, type, and number of axles, are obtained from a completed eight-hour Table 6-1 after a simple linear extrapolation process. A Truck Characteristics Table (TCT), also with the cells of a Table 6-1, but with entries now being counts for a 24-hour period, is thereby established. The linear expansion coefficients are the ratios of the 24-hour TVC, in a Table 6-2, to a similar type Table 6-2 obtained from aggregation of the eight-hour Table 6-1 over weight classes. When each column of an eight-hour TWD table is then multiplied by the corresponding ratios, we obtain the 24-hour TCT Table 6-1.

Figures 6-2 and 6-3 are flow diagrams that summarize the foregoing process of obtaining truck characteristics estimates, applied during 1975 to each of nine weigh stations in or near CHP Zone II, and six stations in or near Zone V, respectively. The truck traffic at these stations is taken to be representative of that within the zones.

A TCT of 24-hour truck characteristics estimates may be obtained in this way for any location where TWD and TVC are available. There have been only a few locations with these data, however. Thus, further extrapolation is required to estimate truck characteristics data for any particular area. As noted earlier, implementation of the present Truck Accident Study has involved two geographically separated areas within the state of California. The southern 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.

Table 6-4 shows the locations in the two CHP Valley and Southern

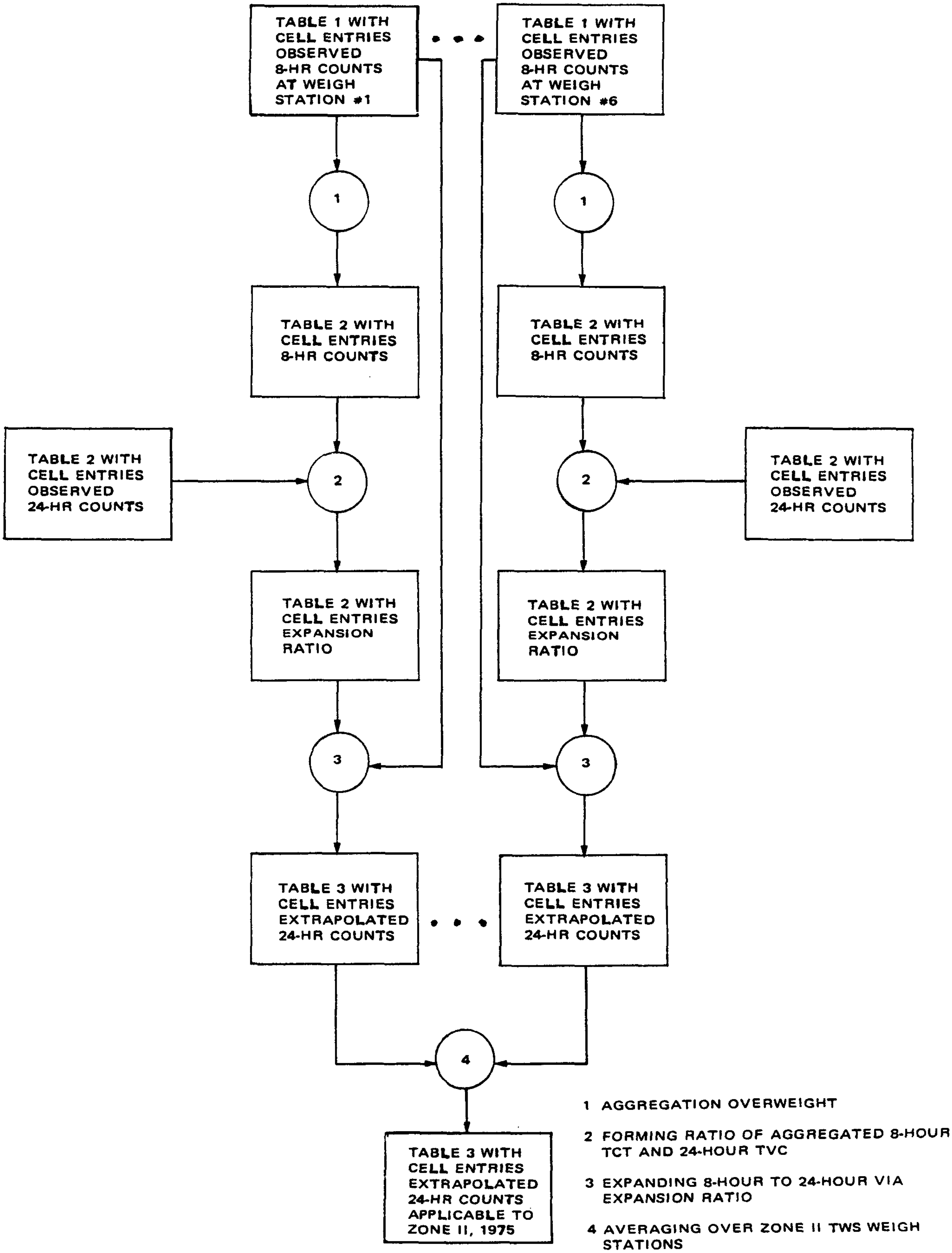


FIGURE 6-2. FLOW CHART OF TRUCK CHARACTERISTIC ESTIMATION PROCESS FOR ZONE II IN 1975

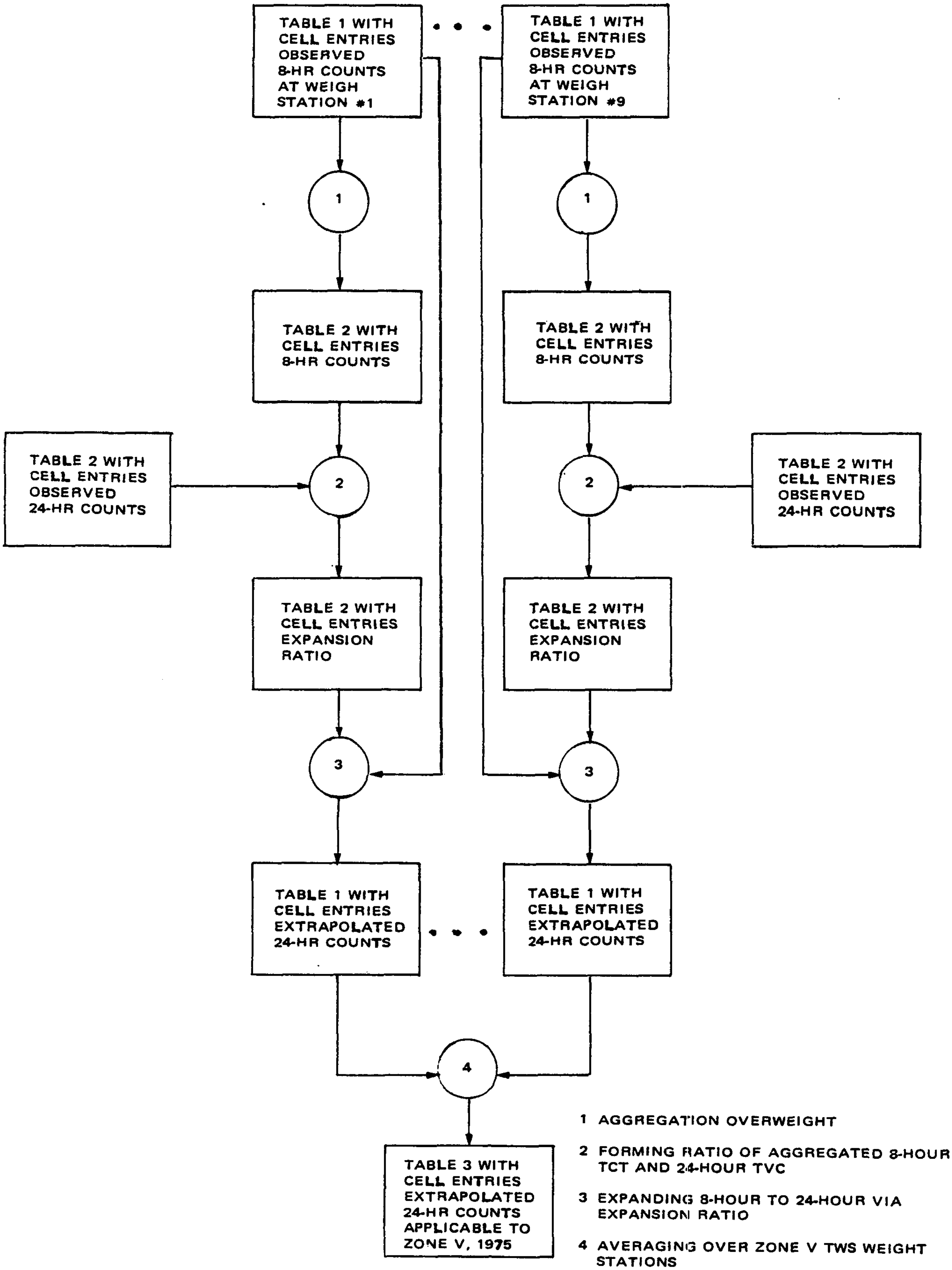


FIGURE 6-3. FLOW CHART OF TRUCK CHARACTERISTICS ESTIMATION PROCESS FOR ZONE V IN 1975

TABLE 6-4. TRUCK WEIGHT STUDY LOCATIONS IN OR NEAR ZONES II AND V

Zone	Station Name	Location	1974-1975	1975-1976
II	Antelope	I-80	x	
	Camino	ED-50	x	x
	Cottonwood	I-5	x	
	Livermore	I-580	x	
	Linvingston	SR-99	x	
	San Luis*	SR-152	x	
V	Banning	I-10	x	
	Cajon	I-15	x	
	Carson	I-405	x	x
	Castaic	I-5	x	x
	Conejo	US-101	x	
	Fontana	I-10	x	
	Peralta	SR-91	x	x
	San Onofre	I-5	x	
	Wheeler Ridge	I-5	x	

*Portable scale site.

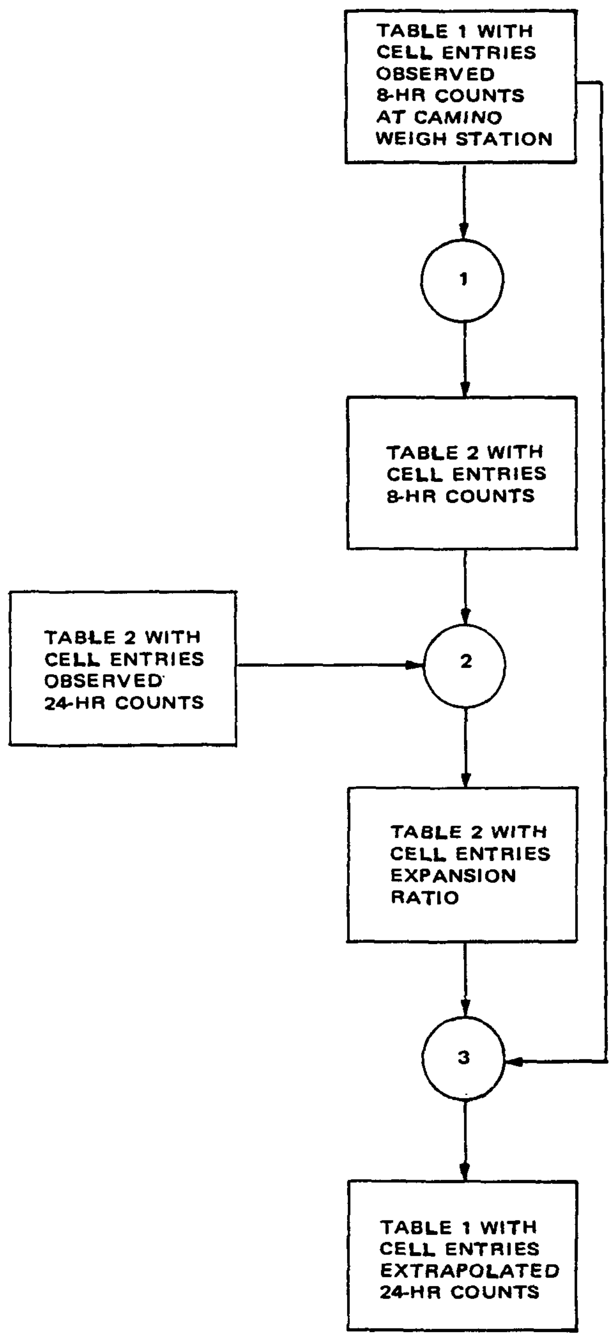
Divisions (formerly Zones II and V), or reasonably close to them, in the northern and southern areas, respectively, where TWD and TVC are available for the years 1975 and 1976. The objective now is to estimate the truck characteristics volume estimates applicable to any road segment in each CHP Division or Zone.

Obviously, to gather and process an adequate direct sampling of such truck characteristics counts for many individual road segments would require a very large effort and far more automation than CALTRANS now employs. For present purposes, therefore, the volumes assumed to apply to each entire zone are estimated by averaging the truck characteristics counts that are available at each weigh station associated with the zone. For example, truck characteristics volumes for each zone in 1975 are estimated by averaging the six TCT's for Zone II and the nine TCT's for Zone V, as indicated by the last operation in Figures 6-2 and 6-3.

This approach is less satisfactory in the case of the 1976 TWD, however, because in that period there were only one count site for Zone II and three count sites for Zone V. As shown in Figures 6-4 and 6-5, a modified approach is necessary for obtaining the TCT for 1976. It remains the same as for 1975 up to the 24-hour TCT calculation. At this point, however, the ratio between the 24-hour TCT of 1975 and that of 1976 is found for each location. The 1976 TCT for each entire zone is then obtained by adjusting the 1975 TCT by this ratio. These special last steps are shown in Figures 6-6 and 6-7.

6.1.1.5. VMT Estimate

AADT data in general, and those for trucks (AADTT/A) in particular, provide an opportunity to compute VMT vs. number of axles only. The combination of the results with TCT data via linear extrapolation then allows extrapolation to VMT estimates vs. type and weight as well. The process is as follows.



1 AGGREGATION OVERWEIGHT

2 FORMING RATIO OF AGGREGATED 8-HOUR TCT AND 24-HOUR TVC

3 EXPANDING 8-HOUR TO 24-HOUR VIA EXPANSION RATIO

FIGURE 6-4. FLOW CHART OF TRUCK CHARACTERISTICS ESTIMATION PROCESS FOR ZONE II WEIGH STATION, YEAR 1976, PART A

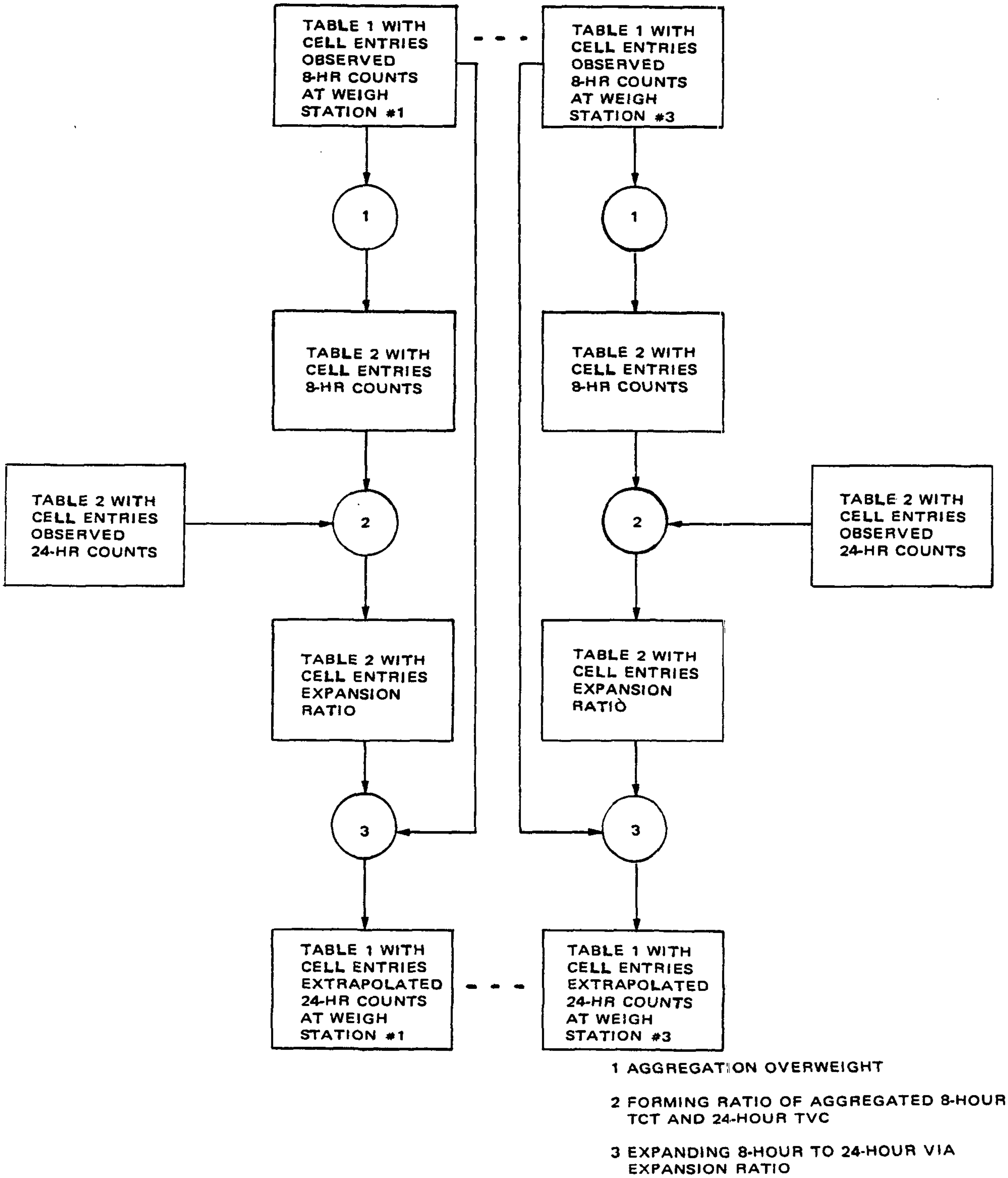


FIGURE 6-5. FLOW CHART OF TRUCK CHARACTERISTICS ESTIMATION PROCESS FOR EACH ZONE V WEIGHT STATION, YEAR 1976, PART A

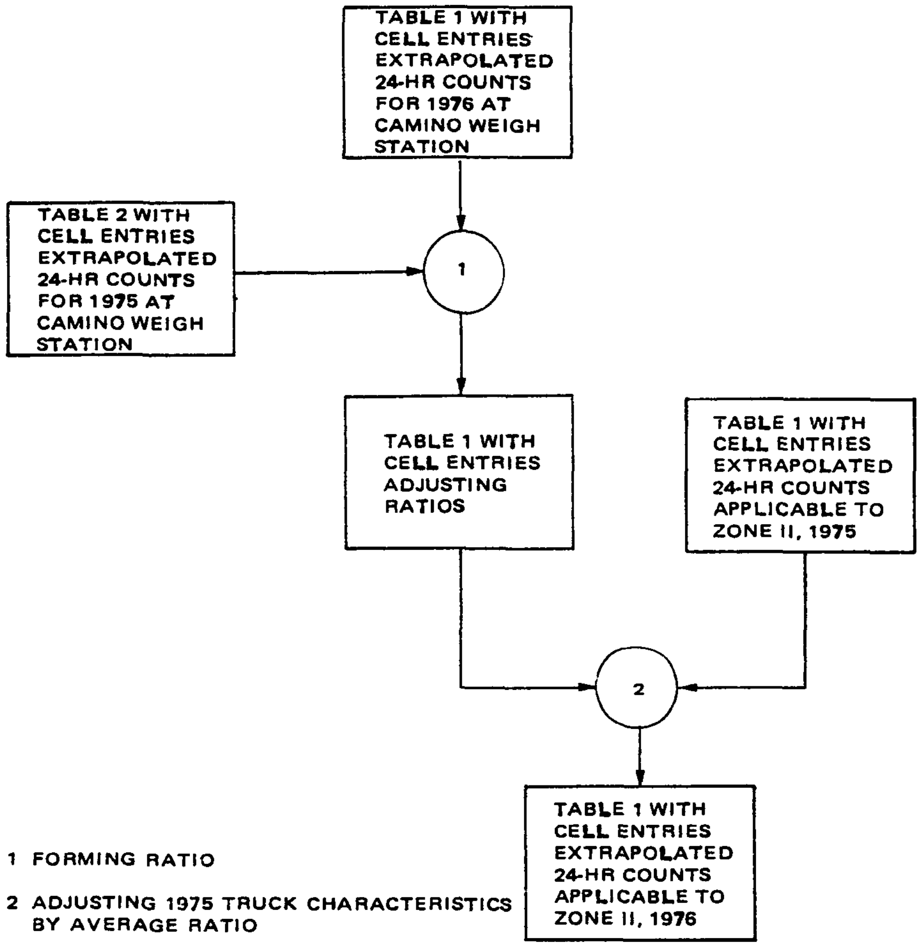


FIGURE 6-6. FLOW CHART OF TRUCK CHARACTERISTICS ESTIMATION PROCESS FOR ZONE II IN 1976, PART B

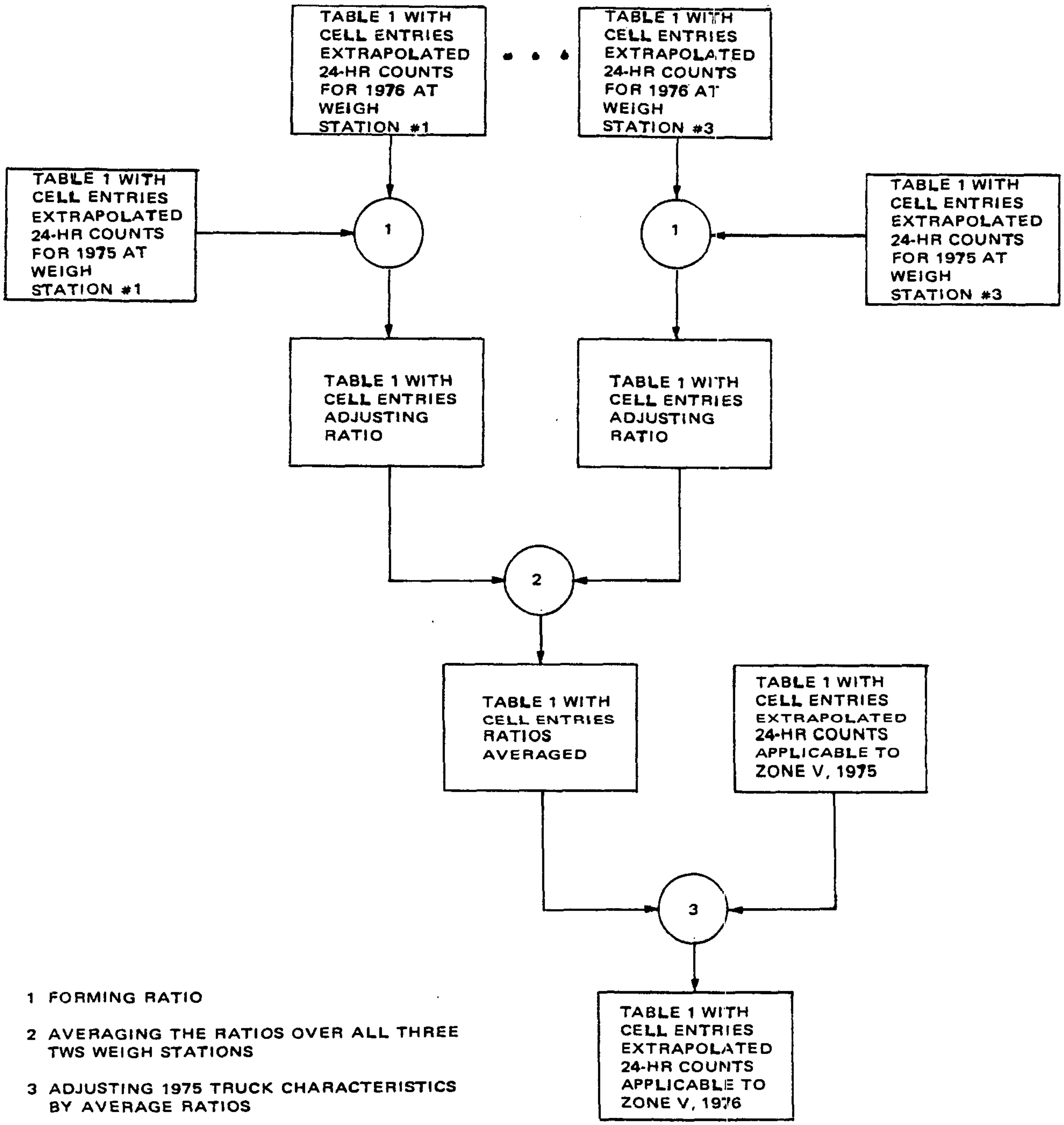


FIGURE 6-7. FLOW CHART OF TRUCK CHARACTERISTICS ESTIMATION PROCESS FOR ZONE V IN 1976, PART B

6.1.1.5.1. VMT Extrapolation Process

A Table 6-3 of VMT estimates (vs. number of axles) is first established, as described in Section 6.1.1.5.2. below, for those portions of the state highway system within CHP Zone II and Zone V.

These VMT estimates vs. number of axles only are then extrapolated to the desired VMT estimates vs. truck type, axles, and weight (in a Table 6-1). As illustrated in Figure 6-8, this extrapolation begins with the following steps:

a) Aggregating the TCT (a Table 6-1 of volume counts) over all weight classes (giving a Table 6-2)

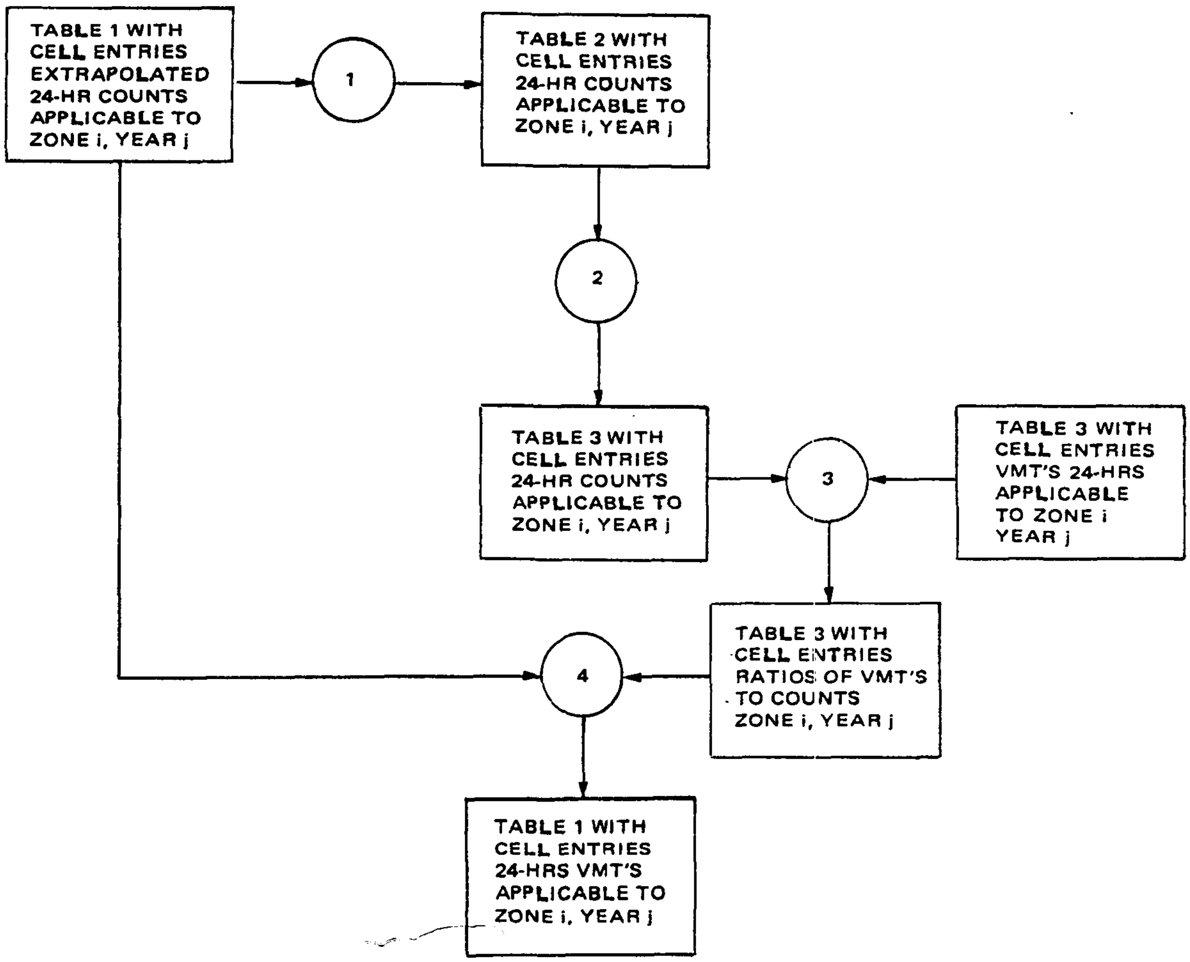
b) Aggregating further over all columns with equal numbers of axles.

The outcome of this two-step aggregation is a table with the format of a Table 6-3. The entries are daily truck traffic volume counts, categorized by the number of axles only, and averaged for each CHP zone.

The estimated VMT's from AADTT/A data (thus vs. number of axles only) are also arranged in a Table 6-3. The linear extrapolation coefficients are then a row table also with a Table 6-3 format. The entries, however, are ratios of corresponding elements of the VMT table to the table obtained in (b) above. This last set of ratios is then applied to the columns of the TCT. The outcome is a VMT value for each of the cells of a Table 6-1. This is the desired set of final VMT estimates.

6.1.1.5.2. Basic VMT Estimates from AADTT/A Data

As has been stated, the VMT estimation procedure begins with a Table 6-3 of VMT estimates for a given section of highway. This is obtained by adding the VMT's obtained from AADTT/A data (also given in Table 6-3's) for the two legs of each adjacent milepost contained in that section.



1 AGGREGATION OVERALL WEIGHT CLASSES

2 AGGREGATION OVERALL COLUMNS WITH EQUAL NUMBER OF AXLES

3 FORMING RATIO OF VMT'S TO COUNTS

4 MULTIPLICATION COLUMNS OF TABLE 2-1 WITH CELL ENTRIES EXTRAPOLATED 24-HR BY THE COUNTS RATIOS OF TABLE 2-3

NOTE: i=II,V
j=1975, 1976

FIGURE 6-8. VMT ESTIMATION PROCESS BY TRUCK TYPE, NUMBER OF AXLES AND WEIGHT

The formulation is as follows:

$$VMT = \sum_{j=1}^{n} VMT_j \qquad (6\text{-}1)$$

where VMT is the vehicle miles traveled (for a given number of axles) for a given section; VMT_j is the vehicle miles traveled between two adjacent mileposts in the section, j and j + 1; and n is the number of mileposts within the section. VMT_j can be defined in terms of the volume counts at two mileposts and the distance between them.

$$VMT_j = 1/2\ [AADTT/A_j(1) + AADTT/A_{j+1}(2)] \cdot (MP_{j+1} - MP_j) \qquad (6\text{-}2)$$

where $AADTT/A_j(1)$ is Annual Average Daily Traffic by Number of Axles at the jth count location, right leg, established for a 24-hour period from the six-hour data, as previously described. MP_j is the milepost's index, increasing with j, so $MP_{j+1}-MP_j$ is the distance in miles between mileposts j+1 and j. Figure 6-9 shows the parameters associated with the above formula.

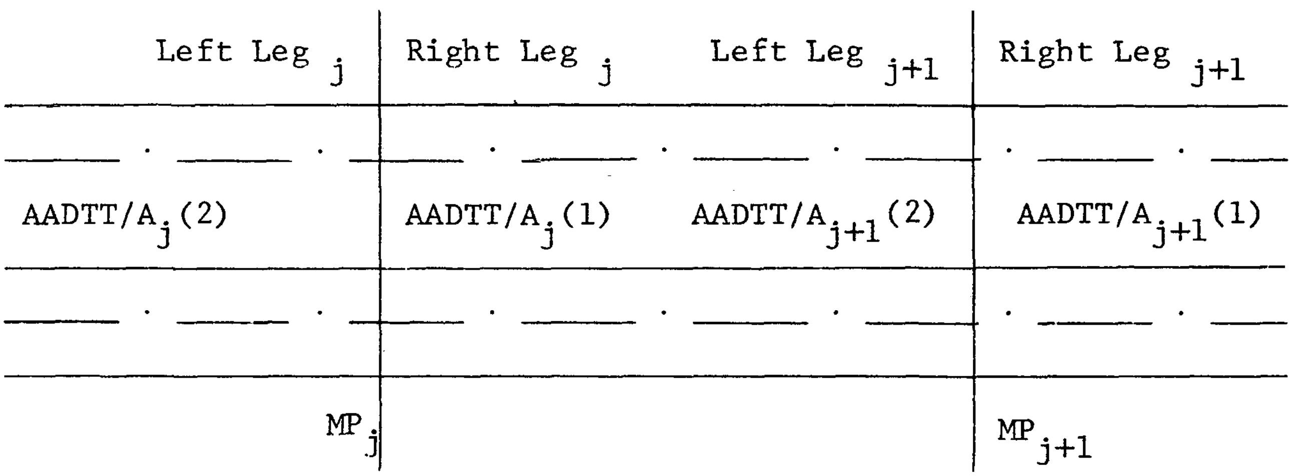


FIGURE 6-9. VMT CALCULATION PARAMETERS

Equations (6-1) and (6-2) both correspond to daily VMT. VMT (vs. number of axles) for any time duration, T, in days, will simply be obtained as

$$VMT_T = VMT \times T \qquad (6\text{-}3)$$

Summing over j for each CHP zone, as in Equation (6-1), then provides the Table 6-3's, one for each zone, of VMT vs. number of axles that are needed to begin the final extrapolation, as described in Section 6.1.1.5.1.

6.1.1.5.3. Comments and Special Cases

The goodness of these Table 6-3 estimates of VMT vs. number of axles as outlined above is not better than that of the AADTT/A data used as input. Additionally, averaging AADTT/A over the corresponding legs of adjacent mileposts is based on the assumption that the number of trucks exiting is, on the average, the same as the number of trucks entering at the mileposts in the section of road under study.

The computations described above can be applied to the bulk of the available AADTT/A data from CALTRANS. In some instances, however, the data format deviates slightly from the above typical format. In such cases, special procedures must be applied to generate data in the typical format, so that the above computations can be applied. The following describes these special cases and the procedures necessary for modifying the data.

a) Only $AADTT/A_j(1)$ is given for a milepost MP_j: In this case the missing $AADTT/A_j(2)$ is taken equal to the $AADTT/A_{j+1}(1)$ for the following intersection at MP_{j+1}.

b) Only $AADTT/A_j(2)$ is given for a milepost MP_j: In this case the missing $AADTT/A_j(1)$ is taken equal to the $AADTT/A_{j-1}(2)$ for the previous intersection at MP_{j-1}.

c) More than one $AADTT/A_j(1)$ and/or more than one $AADTT/A_j(2)$ are given for a milepost: In this case only the first $AADTT/A_j(1)$

and the last $AADTT/A_j(2)$ are taken for this milepost.

d) The given volume is labeled AADTT/A(0): In this case both the missing $AADTT/A_j(1)$ and $AADTT/A_j(2)$ are taken equal to the given AADTT/A(0).

e) Between two mileposts, the data contain the comment "Break in Route": In this case the comment is ignored.

f) The county code changes between two consecutive mileposts: In this case the highway has passed a county line, which means that the mileposts are reset at zero at the county line and the difference $(MP_{j+1} - MP_j)$ does not yield the true distance between the two intersections. The true distance then has to be computed by the expression

$$(MP_{j+1} - MP_j) + MP_{CL}$$

where MP_{CL} is the milepost of the county line. Since the milepost of the county line is not contained in the given data file, it must be added to the given data set. Generally this difficulty causes only a minor error and it has been ignored.

g) The boundary of the region in which the accident study is performed does not coincide with a given milepost: In this case the effective milepost of the boundary must be added to the available data. For this additional milepost the necessary $AADTT/A_j$ must be generated by the same procedure outlined in (b) above. The resultant error from this assumption is also negligible.

6.1.2. Critique of AADTT and TWD Data Collection and Potential Improvements

AADT and TWD data shortcomings are reviewed first, and some means for improving them, and therefore the VMT estimation process, are described.

6.1.2.1. AADT Data Shortcomings

AADT data are collected and processed by CALTRANS. The following are some points of concern.

a) The subjective adjusting factor for heavy trucks to compensate for the unobserved volume in early morning or late night traffic is based only on some past observations. The dynamic nature of the freeway system and the industries it supports could introduce new factors in the distribution of trucks on the freeway system. Calculation of an adjusting factor annually, or even biannually, though costly, would improve the quality of the extrapolation.

b) Observing the passing trucks and counting the number of axles at the same time may not be an easy task. There are no concrete estimates of associated errors, but it is suspected that significant errors will be particularly associated with the counting of trucks with odd configurations. A sample study may be sufficient to present some evidence regarding the extent of this error and its distribution.

c) As discussed in Section 6 of Appendix C, every year AADTT/A values from the year before are used to expand six-hour shifts of observational data to daily volume counts for that year. To compensate for trends in truck volume, the value from the year before is used again. Apparently, on some occasions, subjective views are also of significance. While this approach is convenient and a reasonable estimate may be made in the case of gradual changes, there is a danger that sudden changes are not well accounted for. For example, the sudden change in fuel costs and increase of load limit per axle are two variables suspected to have had a direct impact on truck volume.

d) One of the last adjustments made occurs when the expanded and interpolated value for truck volume at each location is compared with its counterpart from the year before. If the difference is too high, the figure for the current year is changed so that it is closer to the number from the preceding year. While replacing a count with another number based on the previous year may compensate for gross errors, it ignores the fact that an actual increase or decrease in truck volume may indeed exist due to the reason noted in (a) above.

e) Finally, the last step in AADTT/A preparation is rounding up the numbers to the nearest 10. While this rounding up cannot introduce much error in the large volume counts of trucks with common numbers of axles, it may be an important source of error in the case of trucks with fewer axles.

6.1.2.2. TWD Data Shortcomings

TWD data are also collected by CALTRANS. This data base consists of two independent parts. The first part is the data collected at weigh stations where axle weight, total weight, truck type, and truck configuration are recorded for eight hours. The second part is truck volume counts done in three eight-hour shifts. These three eight-hour counts are on different days, are not overlapping in hours, and cover a 24-hour period. They are then used to represent the count for one full day.

The following are potential sources of error and bias.

a) Apparently, some trucks bypass the weigh station when they can by driving on parallel roads in the vicinity of the weigh station. Therefore, TWD shows truck traffic as less than true volume. Moreover, a bias toward lower observed weights probably occurs, as drivers of trucks they think might be overweight are more likely to avoid the station.

b) Statewide data collection is conducted in a short period of time. For example, the 1974-75 TWD were collected in the fall of 1974 and the 1975-76 TWD were obtained during the months of April, May, June, and July 1976. Considering the fact that truck traffic on the road is distributed seasonally, short periods of sampling may not result in truly representative statistics. For example, the number of auto carriers on the roads is considerably higher in

September and October than in July and August.

c) While in the 1974-75 study, 33 weigh stations (including portable stations and the 15 that have been associated with CHP Zones II and V) provided the sites for data collection, TWD were collected at only 16 weigh stations for the 1975-76 study. The direct result of data collection at fewer weigh stations is that reliable truck characteristics data are not available for Zone II of the CHP (now the Valley Division), since TWD are available for only one weigh station in 1975-76.

d) As explained previously about TWD collection, trucks of a particular configuration are directed to the weigh station for 15-20 minutes. Trucks with odd configurations, such as construction trucks, always go through the weigh station. And finally, should the queue of trucks waiting to be weighed become too long, all trucks are directed past the weigh station for a time. The non-uniform nature of the truck volume distribution over the hours of the day may well cause bias errors in sampling. TWD are collected over a period of eight hours only. In the present process of linear extrapolation and expansion of the eight-hour data into 24-hour data, an inherent assumption was that the mixture of trucks in terms of type and number of axles remains constant. If the assumption of constant mixture does not hold, a weighting function may be required.

6.1.2.3. Impacts of Errors and Mutual Improvements

The presence of such errors as have been noted clearly degrades the quality of the data and the statistical analyses that follow. The extent of this degradation depends on the detailed characteristics of the errors and on their statistical significance. Nevertheless, in the absence of any quantitative information on the errors, sensitivity analysis may shed some light on their potential significance. The analysis may consist of changing the counts by some small percentages, such as $\pm$ 10%, and studying the sensitivity of the VMT estimate for each category. Sensitivity analysis is, therefore, a recommendation for future studies.

The extrapolation process that has been described, requiring repeated aggregation and disaggregation, is needed partly because of the inconsistencies in the AADT and TWD data sets. This process obviously may transfer errors from one set to the other. The following are some suggestions that may result in more consistency between TWD and AADTT/A, and thus diminish these errors.

a) AADTT/A are collected for six hours, while TWD are collected for eight hours. Unless some adjustments are made (that are basically arbitrary and subjective), the two raw data bases are not comparable. If the AADTT/A were also collected for eight hours, the comparison of the two raw data sets would be aided.

b) The comparison in (a) above is more meaningful when the truck classifications are identical in the two sets. Unfortunately, this is not the case. AADTT/A data give the number of trucks when classified by axles. Revision of the AADTT/A data acquisition process to cause the counts to be made by configuration instead of number of axles would be very helpful.

6.1.3. Numerical Results

The application of the exposure estimation procedure described above leads to the numerical results summarized in Table 6-5. The table exhibits the estimated VMT for each category of truck configuration and weight (aggregated into three classes for simplicity), for the roads in the two CHP zones of interest, and for the study period of 350 days, 15 May 1975–1 May 1976. (This period is used to correspond to that of the accident reports.) The greatest amount of travel by far appears for the smaller, two-axle trucks; the travel amounts for intermediate-weight three-axle trucks, and for intermediate-weight five-axle tractor/semi-trailer/full-trailer

TABLE 6-5. 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	9.4	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

combinations are each about 40% as large. Five-axle, intermediate-weight tractor/semi-trailer combinations; five-axle, heavy-weight tractor/semi-trailer combinations; and five-axle, heavy-weight tractor/semi-trailer/full trailer combinations fall into the next group in order, each with about 15-20% of the two-axle trucks' VMT.

The VMT values in Table 6-5 are employed as inputs in certain of the contingency table analyses described in Section 5.

6.2. Induced Exposure Estimation

In 1964, J. D. Thorpe [3] suggested a procedure for, in effect, estimating the relative exposure of classes of vehicle-driver combinations using only accident report data. This procedure has since been termed "induced exposure" estimation.

Its basis is as follows: *Consider a class of vehicle-driver* units (e.g., commercial vehicles) on a given set of roads and driving a given period of time. Let the class be made up of a set of subclasses of such units with specified combinations of characteristics of interest (e.g., vehicle configuration). Let F_i be the fraction of all units in the class that are in the subclass with the combination of characteristics i. Let A be the number of all accidents involving one of the units of the given overall class and one other vehicle not in the class (e.g., commercial vehicle/automobile accidents), and in which the unit in the class is not responsible. Let A_i be the fraction of all such accidents in which the units in the subclass with the combination of characteristics i are involved. Then the basic induced exposure assumption is that an estimate of F_i is A_i/A, enabling the inference of F_i from accident reports data only. Generally, the procedure also requires first estimating the fraction of accidents in which the given combination i <u>is</u> responsible, by assuming it is the same as the fraction of all <u>single</u>-vehicle accidents in which combination i is involved. (This assumption has been particularly difficult to justify.)

Once F_i is estimated, various measures of exposure can be calculated. Vehicle miles traveled by combination i, on the given roads and during the given time, for instance, is estimated as F_i times the total VMT by all combinations. This total, in turn, is generally estimated, more or less well, from registration or gasoline sales data, or other such information. (Alternatively, the use only of the ratios of different F_i's permits the analysis of the relative involvement of the different combinations.)

In Haight's terminology [4], a simpler "quasi-induced" exposure estimate is possible if the accident records already determine the responsible combination in each accident. Then the second assumption above is unnecessary. This simpler procedure is the one employed in the present study, since this study's accident data source, the CHP commercial vehicle accident reports, do usually include the identification by the CHP of the responsible party in each reported accident. In the present study, a "combination" is now a truck "category," defined as a particular combination of configuration (or vehicle type and number of axles) and weight. Total VMT, over all categories, is estimated as it was in Section 6.1 above as the sum of the VMT's of the categories.

It is to be appreciated that if an induced exposure estimation process could be decided to be reasonably valid in principle, it would permit estimates of exposure for any category of truck for which non-responsible accidents are reported. Thus, any set of characteristics of the vehicle, driver, road, and environment that are described in the accident reports could be considered, in principle, as a category or combination of interest. The simple exposure estimation process would proceed for the several categories as has been described. Of course, the process would be limited by sparse data concerns as category definitions became more complex, and thus fewer accident cases could be found for each one.

The assumptions underlying the induced exposure process lead one to expect the resulting estimates will not generally be very accurate. They may have some utility, however. Moreover, the availability in the present study of direct exposure estimates enables interesting comparisons of the induced exposure with direct estimates. These comparisons may shed some valuable light on whether induced exposure estimation, with its flexibility in treating category definitions, but also with its questionable accuracy, can have a useful role in truck accident studies in the future.

6.2.1. Outline of the Simplified Procedure

a) Define A = Total number of truck[1] accidents in the reports file in which (i) exactly two vehicles, one of which is a truck in a category of interest, and one a car or other non-commercial vehicle, are involved, (ii) the responsible vehicle is identified, and (iii) the commercial vehicle is not responsible. (Accident reports are derived from two given CHP Divisions, formerly Zones, for a given period of time.)

Assume A represents a sample of all accidents involving a truck, random over all truck categories (described by configuration and weight; other descriptive factors in the accident reports could be added). Also assume that all neglected accidents (unidentified responsibility; single vehicle; three or more vehicles; two vehicles, both of which are trucks; unreported accident) involve each category of truck in the same proportion as in the car/truck accidents that are considered (an imperfect

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[1]Throughout this section, buses are also intended to be included in all references to trucks.

assumption, which can be checked partially from the reports file).

b) Define A_i = Number of the A accidents for which truck category i is identified as not responsible (so $A = \Sigma_i A_i$).

c) Fundamental Assumption of Induced Exposure Estimation

Define F_i = Fraction of the A accidents given by $A_i = A_i/A$.

Then assume F_i = also the fraction of all trucks (in all categories considered) operating at any time in the given CHP Divisions and during the given time period, that are category i.

Note that this assumption is equivalent to that of all trucks operating in a random "stream" in the highway's network, with each truck category having a frequency of non-responsible involvement in an accident proportional to the number of trucks in that category. An analogy is that of a shooting gallery, with non-commercial vehicles (the second vehicle in each accident considered) randomly "shooting" at the trucks and causing an accident (in which the truck in the accident is not responsible) with the same chance for every truck. This assumes that differences in truck characteristics among the categories have no effect on the probability of non-responsible involvement of a truck in such an accident (a second imperfect assumption).

d) Define VMT_{Total} = Total vehicle miles traveled by all the categories of trucks in the two given CHP Divisions and the given time period. In the present study, this has been estimated as part of the direct exposure estimation process described in Section 6.1.

Then $VMT_i = F_i \times VMT_{Total}$ is the induced exposure estimate for the ith truck category. (This assumes, imperfectly, but consistently with the fundamental assumption, that the categories' VMT's depend only on the numbers of trucks in a category, and not on the different categories' characteristics.)

e) The validity of the VMT_i estimates can be tested in two ways:

(i) Calculate VMT_i via F_i from two different randomly selected subsets, N(1) and N(2), of the N accident reports of interest, and compare the two sets of estimates for consistency.

(ii) Compare VMT_i obtained through the induced exposure estimation process with the corresponding values obtained from the direct estimation process, described in Section 6.1.

6.2.2. The Available Data Base

A cross-tabulation is performed of the CHP truck and bus accident reports file for the Valley and Southern Divisions (formerly Zones II and V) and the period 15 May 1975–1 May 1976. This leads to Table 6-6, containing the numbers of accidents reported for each truck or bus category, and in which each category is identified as non-responsible. The number of accidents for which each category is responsible, and the number required to be ignored because their reports do not identify responsibility, are also provided.

6.2.3. Critique

As has been pointed out, the underlying assumption in the quasi-induced exposure estimation procedure is that every truck has the same probability of being involved as a non-responsible party in an accident with a non-commercial vehicle (on the given set of roads during the given time period). Thus, the non-responsible accident involvement process is in fact assumed to be a

TABLE 6-6. ACCIDENT COUNTS VERSUS RESPONSIBILITY, TRUCK CATEGORIES (TYPE, NUMBER OF AXLES, AND WEIGHT)

Weight, lbs.	Type															
	I No. Axles				II No. Axles				III No. Axles				IV No. Axles			
10–25,000	x/y/z*															
25–60,000																
60,000																

*Cell x/y/z

x = No. of Two-Vehicle, Commercial/Non-Commercial Accidents, with Cell Category Identified as Non-Responsible

y = No. of Accidents with Cell Category Involved and Identified as Responsible

z = No. of Accidents with Cell Category Involved but no Identification of Responsibility simple Bernoulli process.

Let p = The constant non-responsible accident probability (for a given road network and period of time)

C_i = ith truck category of interest

N_i = Unknown number of trucks in C_i

N = Unknown total number of trucks of all categories, $N = \Sigma_i N_i$

F_i = N_i/N = desired fraction of all trucks that are in C_i, to be estimated

A_i = Observed (in reporting file) number of accidents involving a C_i truck as the non-responsible party

A = Total observed number of accidents in file involving trucks as non-responsible parties, $A = \Sigma_i A_i$

Then an unbiased, maximum likelihood estimate of p is

$$\hat{p} = A/N$$

and of N_i,

$$\hat{N}_i = A_i/\hat{p} = A_i N/A$$

Therefore, an estimate of F_i is

$$\hat{F}_i = A_i/A$$

as stated in the fundamental induced exposure assumption.

Note that if errors in the counts of accidents are distributed randomly over the categories, so that the true numbers of accidents in the categories are XA_i for some X, then

$$\hat{F}_i = XA_i/XA$$

and so $\hat{F}_i$ is independent of such errors.

An obvious weakness in this procedure for estimating F_i is the assumption that p is independent of category. Clearly some categories of trucks (e.g., very large trucks, or those spending more time on the road) could be individually more likely to be non-responsibly involved in an accident with a non-commercial vehicle than are some other categories, but this possibility is ignored in the procedure. A more general, if less practical, process would allow a different probability, p_i, for each category. Then,

$$\hat{N}_i = A_i/p_i$$

$$\hat{F}_i = A_i/Np_i$$

Writing

$$p_i = \pi_i p$$

then gives

$$F_i = \frac{1}{\pi_i}(A_i/A)$$

with the π_i measuring the variation in non-responsible accident involvement over category.

Estimates of the π_i can be made by comparing

$$\begin{aligned} VMT_i &= F_i VMT_{Total} \\ &= \frac{1}{\pi_i}\left(\frac{A_i}{A}\right) VMT_{Total} \end{aligned}$$

from this induced exposure estimation procedure with the VMT_i estimates developed from the direct exposure estimation process, as given in Section 6.1. To the extent their accuracy permits, these estimates of the π_i then provide some assessment of the relative likelihoods of non-responsible accident involvements by different categories of trucks. The closer they are to unity, the better may be the fundamental induced exposure assumption.

6.2.4. Numerical Estimates and Tests

Tables 6-7, 6-8, and 6-9 present the steps of the induced exposure estimation process. The first table exhibits $x = A_i$, the number of two-vehicle accidents involving one commercial and one non-commercial vehicle, with the commercial vehicle judged by the CHP to be not responsible for the accident; y, the number of such accidents in which the commercial vehicle is judged responsible; and z, the number of such accidents where responsibility was not assigned.[1] These numbers, determined for each of the truck categories by a cross-tabulation from the present accident reports data base, are the inputs for the estimation process. Buses have been deleted in this to avoid some complexities in the cross-tabulation procedure.

Table 6-8 shows the resulting $F_i = A_i/A$ ratios, where $A = \Sigma x + \Sigma y + \Sigma y$ is the total number of the accidents of interest.

Table 6-9 then exhibits the estimated VMT values for the 48 commercial vehicle categories. The values are obtained as F_i times the total VMT for all these categories. The total VMT used here, 2,412 million miles, is that established in the direct estimation process.[2] Usually this would be obtained from some independent data on vehicle registrations such as gasoline sales.

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[1]The accident frequencies in this table exhibit several minor inconsistencies with those in Table 5-18 of Section 5,obtained by a different cross-tabulation procedure. The present table's cell frequency totals should in all cases not exceed the cell frequencies of Table 5-18 since the latter represent all accidents, whereas those here represent only accidents involving exactly one commercial vehicle and one car. This is not the case for a few cells with small frequencies. However, it is believed that the effects of these discrepancies on final results are negligible.

[2]Excluding the 16.8 million miles estimated by the direct process for buses.

TABLE 6-7. NUMERICAL VALUES OF ACCIDENT COUNTS VERSUS RESPONSIBILITY AND TRUCK CATEGORY

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		117	33	0	17	16	33	0	2	4	14	0	0	17	0	0
	ND	179	62	0	27	33	47	2	3	11	17	1	0	34	6	0
		10	3	0	4	5	8	0	0	0	4	0	0	3	0	0
25,001–60,000		12	17	0	15	19	98	1	0	3	13	1	0	71	16	3
	ND	38	36	0	17	26	138	2	1	2	21	2	0	89	11	3
		1	5	0	4	4	15	0	0	0	6	0	0	11	0	1
60,001 +		2	2	0	0	3	71	0	0	1	26	1	0	61	0	0
	ND	6	1	2	2	7	123	3	0	1	49	0	0	92	8	2
		1	0	0	1	1	11	0	0	0	8	0	0	9	0	1

ND = Not Determined. KEY: Not responsible; Responsible; Unknown

TABLE 6-8. F_i RATIOS FOR 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+
10,000–25,000	ND	0.1698	0.0479	0	.0247	.0232	.0479	0	.0029	.0058	.0203	0	0	.0247	0	0
25,001–60,000	ND	0.0174	0.0247	0	.0218	.0276	.1422	.0015	0	.0044	.0188	.0015	0	.1030	.0232	.0044
60,001 +	ND	0.0029	0.0029	0	0	.0044	.1031	0	0	.0015	.0377	.0015	0	.0885	0	0

ND = Not Determined.

TABLE 6-9. 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+
10,000–25,000	ND	409.5	115.5	0	60	56	115.5	0	7.0	14.0	49	0	0	60	0	0
25,001–60,000	ND	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 +	ND	7	7	0	0	10.6	248.6	0	0	3.6	91.0	3.6	0	213.4	0	0

ND = Not Determined

Total VMT = 2,412
(Exclusive of Buses)

7. CRITIQUE OF ACCIDENT REPORTING AND CODING PROCEDURES

This section includes (a) a qualitative evaluation of the standard CHP Traffic Collision Report (Form 555) and the CVARS or "Green Sheet," and (b) a list of recommended improvements for both reports. These latter are derived from the experience of both the CHP and the project staff. Section 7.1 presents the evaluation and 7.2 the recommendations for improvement.

7.1. 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

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 standards, highway design standards, or driver education or 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 7-1, 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 analytical tools required for analysis, then 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 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 present evaluations in retrospect of the CHP Form 555 Traffic Collision Report and the CVARS form therefore attempt to identify areas or variables where it is believed that additional or otherwise changed data would yield better accident analysis results.

7.1.1. Evaluation of CHP Traffic Collision Report (Form 555)

The CHP's Traffic Collision Report (Form 555) is again reproduced for convenience in the following pages, Figures 7-2 through 7-5 (see also Section 2). Form 555 consists of four pages:

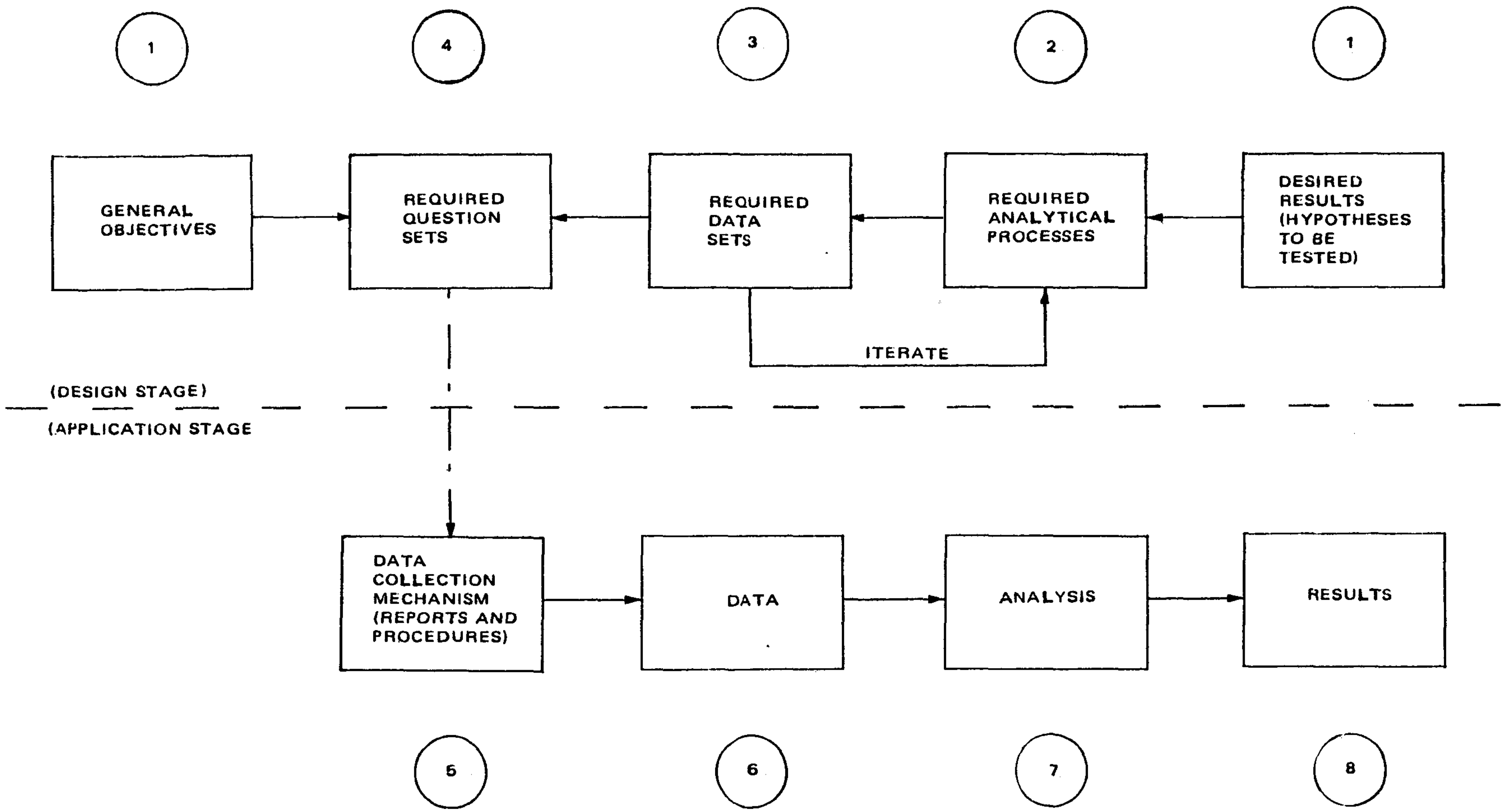

FIGURE 7-1. METHODOLOGY FOR DESIGN AND IMPLEMENTATION OF AN EFFECTIVE ACCIDENT DATA COLLECTION AND ANALYSIS SYSTEM

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

SPECIAL CONDITIONS	NO. INJ.	H & R FELONY ☐	CITY	JUDICIAL DISTRICT	No.
	NO. KILLED	H & R MISD ☐	COUNTY	REPORTING DISTRICT / BEAT	

LOCATION

COLLISION OCCURRED ON	MO. DAY YR.	TIME (2400)	CII NO.	OFFICER I.D.
☐ AT INTERSECTION WITH / ☐ OR: ______ FEET/MILES ______ OF		INJURY, FATAL OR TOW AWAY ☐ YES ☐ NO		STATE HWY ☐ YES ☐ NO

PARTY 1 (☐ DRIVER, ☐ PEDESTRIAN, ☐ PARKED VEH., ☐ BICYCLIST, ☐ OTHER)

NAME (FIRST, MIDDLE, LAST)	STREET ADDRESS
DRIVER'S LICENSE NO. / STATE / BIRTHDATE MO. DAY YR. / SEX / RACE	CITY / STATE / PHONE
VEHICLE YR. / MAKE / LICENSE NO. / STATE	OWNER'S NAME ☐ SAME AS DRIVER
DIRECTION OF TRAVEL / ON/ACROSS (STREET OR HIGHWAY)	OWNER'S ADDRESS ☐ SAME AS DRIVER
SPEED LIMIT / DISPOSITION OF VEHICLE ☐ BY DRIVER / ON ORDERS OF	VEHICLE DAMAGE: EXTENT ☐ MINOR ☐ MOD. ☐ MAJOR ☐ TOTAL; LOCATION / VIOLATION CHARGED 1 ______ 2 ______

PARTY 2 (☐ DRIVER, ☐ PEDESTRIAN, ☐ PARKED VEH., ☐ BICYCLIST, ☐ OTHER)

NAME (FIRST, MIDDLE, LAST)	STREET ADDRESS
DRIVER'S LICENSE NO. / STATE / BIRTHDATE MO. DAY YR. / SEX / RACE	CITY / STATE / PHONE
VEHICLE YR. / MAKE / LICENSE NO. / STATE	OWNER'S NAME ☐ SAME AS DRIVER
DIRECTION OF TRAVEL / ON/ACROSS (STREET OR HIGHWAY)	OWNER'S ADDRESS ☐ SAME AS DRIVER
SPEED LIMIT / DISPOSITION OF VEHICLE ☐ BY DRIVER / ON ORDERS OF	VEHICLE DAMAGE: EXTENT ☐ MINOR ☐ MOD. ☐ MAJOR ☐ TOTAL; LOCATION / VIOLATION CHARGED 1 ______ 2 ______

PROPERTY

DESCRIPTION OF DAMAGE		
OWNER'S NAME	ADDRESS	NOTIFIED ☐ YES ☐ NO

INJURED/WITNESS

WITNESS ONLY	AGE	SEX	EXTENT OF INJURY: FATAL INJURY	SEVERE WOUND DISTORTED MEMBER	OTHER VISIBLE INJURIES	COMPLAINT OF PAIN	INJURED WAS (*check one*): DRIVER	PASS.	PED.	BICYCLIST	OTHER	IN VEH. NUMBER
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
NAME									PHONE			
ADDRESS							TAKEN TO (INJURED ONLY)					
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
NAME									PHONE			
ADDRESS							TAKEN TO (INJURED ONLY)					
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
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 (Rev 11-71)

FIGURE 7-2a. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, PAGE 1

PAGE ______ | No.

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

1	2	3	4	TYPE OF VEHICLE
				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 ______
1	**2**	**3**	**4**	**OTHER ASSOCIATED FACTOR** (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

1	2	3	4	MOVEMENT PRECEDING COLLISION
				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 ______
1	**2**	**3**	**4**	**SOBRIETY - DRUG - PHYSICAL** (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

FIGURE 7-2b. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, PAGE 2

			PAGE ____	ORIGINAL NO.		
CHECK ONE	**SUPPLEMENTAL**	DATE OF ORIGINAL INCIDENT MO. DAY YR.	TIME (2400)	CII NUMBER	OFFICER I.D.	
	SUPPLEMENTS FORM 555 TRAFFIC COLLISION REPORT	LOCATION/SUBJECT			CITATION NO.	
	OTHER:				BEAT	
	FORM 555 NARRATIVE CONTINUATION ONLY	CITY	COUNTY	REPORTING DISTRICT		

PREPARED BY	I.D. NUMBER	PREPARED	REVIEWED - APPROVED BY	I.D. NUMBER	DATE
NAME/RANK		MO. DAY YR.	NAME/RANK		MO. DAY YR.

FIGURE 7-2c. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, SUPPLEMENT, PAGE 1

PAGE ____

No.

SKETCH - NARRATIVE CONTINUATION

ALL MEASUREMENTS ARE APPROXIMATE AND NOT TO SCALE UNLESS STATED (SCALE =   )

INDICATE NORTH

1'' 2'' 3'' 4'' 5'' 6''

1'' 2'' 3'' 4'' 5'' 6'' 7''

NARRATIVE CONTINUATION *(Use reverse side as necessary)*

POINT OF IMPACT
VEHICLE (NOT PARKED)
PEDESTRIAN
TRAIN
PARKED VEHICLE
FIXED OBJECT
HEAD-ON
HEAD-ON SIDESWIPE
REAR END
OVERTAKING SIDESWIPE
BROADSIDE
APPROACH TURN
OVERTAKING TURN
OUT OF CONTROL
OVERTURNED
VEHICLE BACKING

556 (REV.3-73)

FIGURE 7-2d. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, SUPPLEMENT, PAGE 2

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 Narrative Continuation Data

Page 4: Supplemental Data

and identifies data for 44 specific accident variables. Multiple copies of pages 1 through 4 are used by the traffic officers, if necessary, to set forth data on multiple vehicles or involved passengers or pedestrians.

The following items identify specific shortcomings or areas of Form 555 that it is believed should be improved.

7.1.1.1. Accident Location

Frequently the accident location by milepost number is omitted or not clearly defined.

7.1.1.2. Truck-Car History

Additional exposure data concerning the truck and other involved vehicle mileage and trip generation history would be useful. This should include historical data on VMT, but more broadly, the general trip-making characteristics of all parties involved.

7.1.1.3. Driver Record or History

Additional data should be collected concerning the driver's history, e.g.: How many years experience as driver since first license? How many months/years experience in driving the involved vehicle?

7.1.1.4. Lack of Codes for Recording Narrative and Collision Diagram Data

The Traffic Collision Report data system does not include a convenient set of codes for extraction of the frequently extensive data incorporated into the collision diagrams and narratives. It is ironic that the CHP traffic officer probably devotes 60% to 70% of his data reporting activity to completing the last two pages of the form involving "supplemental" and "sketch-narrative continuation" data. While these data may be useful in litigation, little use is made of them in accident research analysis (very few of these data are extracted for the CHP-SWITRS File or CALTRANS TASAS file, for instance).

7.1.1.5. Insufficient Property Damage Only (PDO) Data

Form 555 contains only scant coded or narrative type data describing the property damage involved in each accident. A brief code is used to identify location and extent of vehicle damage, and a similar brief narrative is used to assess non-vehicular property damages. It should not be a difficult task to train traffic officers to make reasonably accurate visual assessments of PDO for most, if not all, accidents. Sufficient data are available to provide curriculum material for this training program. Current PDO data, recorded on Form 555, are essentially worthless for analytical research.

7.1.1.6. Insufficient Injury Severity Data

Similarly, Form 555 contains only brief coded data on injury severity (four codes), and usually little supplemental narrative to reinforce these coded data. Since emergency services for highway accidents have been enhanced in recent years by the development of various paramedical training programs and medical support services, the reported traffic collision data could be upgraded by introducing medically trained personnel into the reporting system.

7.1.1.7. Sketch (Page 1 of Form 555)

The "Sketch" section of Form 555 is too small for a fully usable diagram of the accident situation. Further, this sketch is to some extent redundant, since the graphic codes describing the collision situation are given on page 3 of the form, adjacent to a larger sketch area (6" x 8"). Thus the small sketch represents a poor utilization of space in the form and of the reporting officer's time.

7.1.1.8. Miscellaneous (Page 1 of Form 555)

The "Miscellaneous" section contained in the lower right-hand corner appears to have questionable value since in practice it is seldom used. Data occasionally presented can be better presented in the narrative section of the form, on pages 3 or 4.

7.1.1.9. Vehicle Type Data (Page 1 of Form 555)

This "Vehicle Type" code section can be better integrated with the specific accident data shown on page 2 of the form or in the party-type data given in the top half of page 1 of the form.

7.1.1.10. Road Type Data (Page 1 of Form 555)

The "Road Type" data (five codes) should be integrated with the page 2 data sections on "Roadway Surface" or "Roadway Conditions" for better continuity of subject matter.

7.1.1.11. Collision Narrative Section (Page 2 of Form 555)

The Collision Narrative section commencing at the top of page

2 should be moved to page 3 since it properly refers to the collision diagram shown on that page. Use of a portion of page 2 for narrative further results in the full narrative being presented in a piecemeal manner, with parts contained on several pages. Greater continuity would be obtained by integrating it with the collision diagram. The narratives usually are broken into four or more subsections, namely, "Facts," "Statements," "Opinions and Conclusions," and "Recommendations." Additional subsections may reflect data on "Subject Vehicle," "Inspection of Vehicle," etc.

7.1.1.12. Collision Coded Data (Page 2 of Form 555)

Page 2 presents coded sections for 13 selected variables ranging from (1) Primary Collision Factor to (13) Sobriety-Drug-Physical factors. Criticisms of this section of Form 555 focus more on failures to include other vital data, rather than on the merits of the data selected for coding. While the included variables are useful, it is believed they are insufficient for conducting detailed analytical research on accidents. Several of the previously cited accident variables and associated codes could more effectively be relocated to this page of the form. Further, a number of additional variables should be added to this page, and if possible another page or more of vital data codes should be included.

7.1.1.13. Sketch-Narrative Continuation (Page 3 of Form 555)

The primary criticisms of the "Sketch" portion of page 3 of Form 555 are as follows:

a) General failure to define the specific milepost location of the accident reference point, i.e., the point of first impact.

b) Failure to present a two-level sketch description showing both a coarse and fine scale presentation. (This would require use of two copies of page 3.) Use of a coarse and fine scale set of sketches would allow inclusion of both downstream and upstream features of the highway geometry as well as unusual characteristics of the traffic flow in the vicinity of the accident.

c) Use of only 16 graphic symbols to portray spatial or dynamic features of vehicle motions restricts definition of the collision process.

d) General failure to depict unusual roadside or highway features or other distractions obviates the use of such factors in subsequent accident analysis.

Section 7.2. below notes, and Appendix E describes, a suggested procedure for encoding the accident system characteristics directly with the collision diagrams.

7.1.1.14. Narrative Continuation (Page 3 of Form 555)

The lower portion of page 3 presents a continuation of the narrative started on page 2. No particular criticism of this location or purpose can be suggested, except that this space could better be used for citing other collision symbols or codes.

7.1.1.15. Supplemental (Page 4 of Form 555)

No particular criticism of the use of this supplemental page can be advanced other than to observe that most accident reports are altogether too brief. CHP officers should be encouraged, and trained, to provide the maximum amount of useful additional data on this page.

7.1.2. Evaluation of CVARS

The development by the earlier USC project staff of the CVARS or "Green Sheet" (Figure 7-3) 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.

COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT

ACCIDENT REPORT IDENTIFIER					
MO	DAY	YR	TIME (2400)	CII NUMBER	OFFICER ID NO

NUMBER OF COMMERCIAL POWER UNITS INVOLVED ☐ TOWED SPECIAL VEHICLE ☐ COMMERCIAL VEHICLE NO. (TO BE THE SAME AS PARTY NUMBER IN ACCIDENT REPORT) ☐ RECORD THE TOTAL NUMBER UNINJURED PASSENGERS IN EACH VEHICLE INVOLVED IN THIS ACCIDENT ☐ COMMERCIAL ☐ OTHER

UNIT	AXLES			BODY TYPE							CARGO		BRAKES					1975 OR LATER
		2	3	CAB OVER	VAN	RACK	FLAT	TANK	AUTO CARR	OTHER	EMPTY	LADEN	AIR	HYDR	ELEC	OTHER	SPRING	
TRUCK																		
TRACTOR																		
SEMI TRAILER																		
FULL TRAILER																		
DOLLY (LOG POLE)																		
BUS																		
SCHOOL BUS																		
FARM LABOR BUS																		
FARM LABOR TRUCK																		

SPEED THIS VEHICLE mph PRIOR TO ACCIDENT WHEN HAZARD RECOGNIZED	FRONT AXLE BRAKES	YES	NO	SINGLE BRAKE CONTROL	YES	NO	DRIVE AXLES	1	2	DRIVER EXPERIENCE YRS THIS VEHICLE TYPE	ODOMETER READING MILES

LOAD TYPE

REGULATED
- BALED HAY & STRAW ☐
- BALED COTTON, PAPER JUTE ☐
- LOGS & POLES ☐
- JUNK & SCRAP METAL ☐
- STEEL COILS ☐
- STEEL PLATE, SHEET, TINPLATE ☐
- EMPTY WOODEN BOXES ☐
- DETACHABLE FREIGHT VANS ☐
- LUMBER & LUMBER PRODUCTS ☐

NON-REGULATED
- SACKED MATERIAL ☐
- BOXED MATERIAL ☐
- AGRICULTURAL PRODUCTS ☐
- HAZARDOUS MATERIALS ☐
- BULK COMMODITIES ☐
- PERMITTED LOADS ☐
- OTHER ☐

PASSENGERS
- FARM LABOR EMPLOYEES ☐
- OTHER PERSONS ☐

SUPPLEMENTAL INFORMATION
- JACKKNIFE
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- SEPARATION OF UNITS
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- CARGO SPILL
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- CARGO SHIFT
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- ROLLAWAY (DRIVERLESS) ☐
- SPRING BRAKES NOT RELEASABLE ☐
- SPRING BRAKES ACTIVATED WHILE MOVING ☐
- CAR UNDERRIDE (REAR ENDER) ☐
- TRUCK OVERRIDE (FRONT ENDER) ☐

ROADWAY ALIGNMENT
- LEVEL ☐
- UPHILL ☐
- CREST OF HILL ☐
- DOWNHILL ☐
- BOTTOM OF HILL ☐
- STRAIGHT ☐
- CURVED LEFT ☐
- CURVED RIGHT ☐

REAR LAMPS
- NO APPARENT DEFECTS ☐
- TAIL LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐
- STOP LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐
- CLEARANCE LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐

BRAKING PERFORMANCE
- BRAKING IN LANE ☐
- STEERING ONLY ☐
- BRAKING & STEERING ☐
- NO BRAKE CAUSED LOSS OF CONTROL ☐
- WHEEL LOCK UP
  - MOTOR VEHICLE ☐
  - TOWED VEHICLE ☐
- BRAKE FADE ☐
- RUNAWAY (GRADE) ☐
- BRAKE CAUSED
  - SWERVING ☐
  - WEAVING ☐
  - UNCONTROLLED SKID ☐
  - LEAVING TRAVELED LANE ☐

FIFTH WHEEL POSITION	FWD CL	OVER CL	REAR CL

VEHICLE TOTAL WEIGHT (DRIVERS ESTIMATE)					
UNIT	LBS				
1					
2					
3					
ALL					

ACCIDENT CAUSE
- THIS VEHICLE DRIVER ☐
- OTHER VEHICLE DRIVER ☐
- THIS VEHICLE EQUIPMENT ☐
- OTHER VEHICLE EQUIPMENT ☐
- OTHER ☐

CAUSES AND CONTRIBUTING FACTORS

If one of the ITEMS below, relating to the Commercial Vehicle, caused the accident or contributed to its severity check the item

DRIVER CONDITION
- FATIGUE ☐
- EXCESSIVE DRIVING HOURS ☐
- DRUGS OR ALCOHOL ☐
- OTHER IMPAIRMENT ☐

BRAKES
- INOPERATIVE (ONE OR MORE) ☐
- OUT OF ADJUSTMENT ☐
- AIR LOSS ☐
- BREAKAWAY BRAKES ☐
- RUPTURED LINE ☐
- WHEEL LOCKUP ☐
- PARKING BRAKE ☐
- EMERGENCY STOP SYSTEM ☐
- VACUUM SYSTEM FAILURE ☐
- HYDRAULIC SYSTEM FAILURE ☐
- OTHER BRAKE DEFECTS ☐

LOADING
- INADEQUATE SECUREMENT ☐
- LOAD BINDER FAILURE ☐
- REGULATED LOAD ☐
- NON REGULATED LOAD ☐

OTHER EQUIPMENT
- SAFETY CHAIN ☐
- DRAWBAR ☐
- TRAILER HITCH ☐
- FIFTH WHEEL ☐
- STEERING SYSTEM ☐
- TIRES ☐
- WHEELS ☐
- FRAME ☐
- SPRINGS & HANGERS ☐
- AXLE ☐
- LAMPS ☐
- CAB LATCH ☐
- OTHER ☐

SIZE
- HEIGHT ☐
- WIDTH ☐
- WEIGHT ☐
- LENGTH ☐
- PERMIT LOAD ☐
- PERMIT VIOLATION ☐
- VC SIZE VIOLATION ☐

FIGURE 7-3. CALIFORNIA HIGHWAY PATROL COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT

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. (These instructions are reproduced in Appendix B.)

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, as shown in Table 7-1. 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.

The following are evaluations of the principal variables contained in the CVARS form.

7.1.2.1. Commercial Vehicle Description Variables

The four variables (number of axles, body type, cargo, and brakes) generally represent a satisfactory, reasonably sized set of vehicle descriptors; however, a few improvements can be cited. For example, the body type codes for tractors do not clearly reflect

TABLE 7-1. PRELIMINARY LIST OF VARIABLES FOR DEVELOPMENT OF CVARS FORM (SHEET 1 OF 7)

HUMAN

1.	Driver (case vehicle) experience on involved or tractor unit.	☐ Less than 1 month ☐ 1 month to 1 year ☐ Over 1 year
2.	Driver experience (case vehicle on towed trailer	☐ Less than 1 month ☐ 1 month to 1 year ☐ Over 1 year
3.	Driver training on FMVSS-121 impacts, or effects, on vehicle operations.	☐ General training ☐ Specific training ☐ None
4.	Driver experience on FMVSS-232 equipped vehicles.	☐ Less than 1 month ☐ 1 month to 1 year ☐ Over 1 year
5.	Driver knowledge of tractor/trailer "compatibility" effects.	☐ Aware ☐ Uncertain
6.	Driver work day schedule on accident date.	☐ Less than 8 hours ☐ 8 hours ☐ From 8 to 9 hours ☐ From 9 to 10 hours ☐ Over 10 hours
7.	Number of work hours prior to accident.	☐ Number of hours
8.	Number of miles traveled prior to accident, this trip.	☐ Number of miles
9.	Number of stops prior to accident, this trip.	☐ Fewer than 10 ☐ More than 10
10.	Did brakes function normally during pre-accident maneuvering prior to the accident?	☐ Yes ☐ No ☐ Uncertain
11.	Did driver detect wheel lock up during pre-accident maneuvering prior to the accident?	☐ Yes ☐ No ☐ Uncertain
12.	Wheel lock up—driver observation	

		WHEEL R	WHEEL L
☐	Axle	☐	☐
☐	Axle	☐	☐
☐	Axle	☐	☐
☐	Other	☐	☐
☐	All	☐	☐

TABLE 7-1 (SHEET 2 OF 7)

13. Any driver indication of case vehicle weaving (due to brake application) within traveled lane?
- ☐ Yes
- ☐ No
- ☐ Minor
- ☐ Uncertain

14. Any driver indication of case vehicle weaving (due to brake application in other traffic lanes?
- ☐ Yes
- ☐ Less than ¼ of adjacent lanes
- ☐ Less than ½ of adjacent lanes
- ☐ All of next adjacent lane or lanes

15. Other driver evidence of case vehicle in-lane stability characteristics?

Observed by:
- ☐ Vehicle #2
- ☐ Vehicle #3
- ☐ Vehicle #4
- ☐ Other

16. Other driver's observation on extent of weaving oscillations by case vehicle prior to accident.

Other Driver #2	#3	#4	Other	
☐	☐	☐	☐	Traveled-lane oscillations only
☐	☐	☐	☐	Out-of-lane oscillations

17. Did driver (case vehicle) experience brake system fade?
- ☐ Yes
- ☐ No
- ☐ Minor
- ☐ Uncertain

18. Did drive (case vehicle) experience cargo shift prior to crash?
- ☐ Yes
- ☐ No
- ☐ Minor
- ☐ Uncertain

19. Did driver (case vehicle) attempt to modulate brake application prior to the collision?
- ☐ Yes
- ☐ No
- ☐ Uncertain

20. Did driver (case vehicle) observe warning light signal on anti-skid system prior to the accident?
- ☐ Yes
- ☐ No
- ☐ Uncertain

21. Cargo weight. ☐☐☐☐☐ lbs

VEHICLE

1. GVWR of case vehicle. ☐☐☐☐☐ lbs.
2. Number of axles. ☐☐ Number
3. Number of axles with dual wheels. ☐☐ Number

TABLE 7-1. (SHEET 3 OF 7)

4. Estimated (traffic officer/driver) cargo weight distribution by axles.

Percent of Total Over Axle	Axle
☐☐	☐ 1
☐☐	☐ 2
☐☐	☐ 3
☐☐	☐ 4
☐☐	☐ 5
☐☐	☐ 6
☐☐	☐ 7
☐☐	☐ 8
☐☐	☐ 9
☐☐	☐ 10
Total 100%	

5. Estimated (T.O./driver) cargo weight distribution by vehicle unit.

Percent of Total Cargo on Vehicle Unit	
☐☐	☐ Truck
☐☐	☐ Tractor
☐☐	☐ #1 Trailer
☐☐	☐ #2 Trailer
☐☐	☐ #3 Trailer
Total 100%	

6. Make and Year of vehicles involved.

Year	Make	Vehicle No.
		#1
		#2
		#3
		#4
		#5

7. Make and year of trailer vehicle unit.

Year	Make	Trailer Unit
		#1
		#2
		#3

8. Are front axle brakes installed on Vehicle #1?

☐ Yes
☐ No

9. Type of brake system on truck or tractor unit of Vehicle #1?

☐ Air
☐ Hydraulic
☐ Vacuum
☐ Air-Hydraulic
☐ Combination

TABLE 7-1. (SHEET 4 OF 7)

10.	Does single control apply to all brakes?	☐ Yes ☐ No
11.	Is case vehicle equipped with anti-skid system?	☐ Yes ☐ No
12.	Anti-skid equipment on vehicle units.	Yes ☐ No ☐ Truck Yes ☐ No ☐ Tractor Yes ☐ No ☐ Trailer #1 Yes ☐ No ☐ Trailer #2 Yes ☐ No ☐ Trailer #3 Yes ☐ No ☐ Dolly
13.	If equipped with air brakes, does truck, tractor, and trailer units also have spring loaded parking brakes?	Yes ☐ No ☐ Truck Yes ☐ No ☐ Tractor Yes ☐ No ☐ Trailer #1 Yes ☐ No ☐ Trailer #2 Yes ☐ No ☐ Trailer #3
14.	Does T.O. conclude that brake system of Vehicle #1 contributed to the accident?	☐ Yes ☐ No ☐ Uncertain
15.	Are skid marks evident?	☐ Yes ☐ No ☐ Uncertain
16.	Point of initiation of skid marks.	☐ 0-10′ before POI ☐ 10-20 before POI ☐ 20-50 before POI ☐ 50-100 before POI ☐ Over 100′ before POI
17.	Point of termination of skid marks.	☐ Before POI ☐ At POI ☐ After POI ☐ 0-10′ after POI ☐ 10-20 after POI ☐ 20-50 after POI ☐ 50-100 after POI ☐ Over 100′ after POI
18.	Nature of skid marks.	☐ Solid continuous line ☐ Intermittant ☐ Straight ☐ Curved ☐ Lateral ☐ Other
19.	T.O.'s observations on wheel lock-up	☐ No locking evident ☐ Lockup occurred ☐ Uncertain

TABLE 7-1. (SHEET 5 OF 7)

20.	If lockup occurred (T.O.'s observations) as to wheel and axle.	Wheel / Axle 1 2 3 4 5 6 7 8 All R ☐☐☐☐☐☐☐☐☐ L ☐☐☐☐☐☐☐☐☐
21.	Evidence of tire abrasion	Minor Extensive ☐ Yes ☐ No ☐ Uncertain
22.	Wheel/axle exhibiting abrasion.	☐ Minor ☐ Moderate ☐ Severe Wheel / Axle 1 2 3 4 5 6 7 8 9 All ☐ R ☐☐☐☐☐☐☐☐☐☐ ☐ L ☐☐☐☐☐☐☐☐☐☐
23.	Extent of tire abrasion	☐ Heavy (tread visible) ☐ Medium (1/16" to 1/8") ☐ Minor (not measurable) ☐ None
24.	Evidence of under inflated tires on Vehicle #1.	☐ None ☐ Minor ☐ Moderate
25.	Wheel/axle exhibiting under inflation.	Wheel / Axle 1 2 3 4 5 6 7 8 9 ☐ R ☐☐☐☐☐☐☐☐☐ ☐ L ☐☐☐☐☐☐☐☐☐
26.	Does Vehicle #1 have cam or wedge operated brake shoes?	☐ Cam ☐ Wedge
27.	Slack adjustment on cam type air brakes. (closest ¼")	Wheel / Axle 1 2 3 4 5 6 7 8 9 ☐ R ☐☐☐☐☐☐☐☐☐ ☐ L ☐☐☐☐☐☐☐☐☐
28.	Slack adjustment on wedge type air brakes. (lining displacement	☐ Small ☐ Large Wheel / Axle 1 2 3 4 5 6 7 8 9 ☐ R ☐☐☐☐☐☐☐☐☐ ☐ L ☐☐☐☐☐☐☐☐☐
29.	Air pressure supply.	☐ Functioning ☐ Damaged ☐ Static tank pressure (psi-truck gauge) ☐ Operating tank pressure (psi-truck gauge)

TABLE 7-1. (SHEET 6 OF 7)

30.	Tractor protection valve status.	☐ Operates trailer brake at psi ☐ Prevents air escape through service line at psi
31.	General classification of accident	☐ Jackknife ☐ Hits-to-rear of #1 by #2 ☐ Hits-to-rear of #2 by #1 ☐ Rollover ☐ Spilled cargo ☐ Skid of #1 into #2 ☐ Other
32.	Evidence of front axle damage	☐ Yes ☐ No ☐ Uncertain
33.	Evidence of suspension system damage.	☐ Yes ☐ No ☐ Uncertain
34.	Evidence of steering instability of Vehicle #1, pre-crash.	☐ Yes ☐ No ☐ Uncertain
35.	Evidence of fifth-wheel malfunction.	☐ Yes ☐ No ☐ Uncertain
36.	*Maintenance of Vehicle #1.*	☐ Uncertain ☐ Appears normal ☐ Poor
37.	Condition of brake hoses and fittings.	☐ Good ☐ Poor ☐ Damaged
ENVIRONMENT		
1.	Highway grade at POI. (relative to direction of travel of Vehicle #1)	Grade / Straight / Curved ☐ Level ☐ ☐ ☐ Down ☐ ☐ ☐ Up ☐ ☐
2.	Posted grade.	☐ Yes ☐ No
3.	Grade length. (nearest tenth of mile)	☐☐☐ Miles
4.	± grade (direction of travel) at POI.	☐ 1% ☐ 3% ☐ 6% ☐ Over 6%

TABLE 7-1. (SHEET 7 OF 7)

5. POI location relative to grade
   - ☐ Near bottom
   - ☐ Center
   - ☐ Near top

6. POI lane and lane width.

Lane	Width: 10 Ft	11 Ft	12 Ft	Over 12 Ft
#1 ☐				
#2 ☐				
#3 ☐				
#4 ☐				
#5 ☐				
#6 ☐				
Other ☐				

7. POR lane of Vehicle #1

   Lane
   - ☐ #1
   - ☐ #2
   - ☐ #3
   - ☐ #4
   - ☐ #5
   - ☐ #6
   - ☐ Center median
   - ☐ Right median
   - ☐ Left median

8. Lane # at POI

   Lane
   - ☐ #1
   - ☐ #2
   - ☐ #3
   - ☐ #4
   - ☐ #5
   - ☐ #6

Road Total Lane Width

Type of Road Surface

Road Alignment

Surface Covering

Crosswind

Visibility Limitation

Visibility Obstruction

Cargo Class (e.g., dry freight, liquid, gaseous, etc.

Cargo Hazard Class

multiple use of some tractors as cargo-carrying vehicles (i.e., as "trucks") as well as simple prime movers; also, the body type codes do not reflect whether a truck or tractor unit may be in the chassis configuration only (i.e., in transit from manufacturer to distributor or user). Further, the full trailer body type codes do not indicate clearly that a full trailer is an integral unit (i.e., a permanently mounted, steerable front axle unit), rather than one that employs a converter dolly for conversion of a semi- to a full-trailer configuration. Integral front axle units may provide greater structural integrity than attachable converter dollys. Clearer definitions and coding could permit statistical analysis to indicate correlation of the data on these specific aspects.

Also, the limitation of coding only two or three axles per trailer vehicle is a shortcoming. Large equipment movers frequently have more than three axles.

The use of only two cargo codes (i.e., empty or laden) prevents any data collection on half-laden or other partially laden conditions. It is possible that some accidents are caused by shifting of partially laden cargos, for example, when the driver fails to retie the remaining cargo adequately after making a partial delivery, or by the sloshing of partial liquid tanker loads.

7.1.2.2. Load Type

No particular evaluation can be made in reference to Regulated and Non-regulated loads. Passenger loads could be defined to enable identification of passengers according to commercial, intra- or intercity bus passengers, and whether public or private school bus passengers were involved.

7.1.2.3. Supplemental Information

The major comment that can be made concerning the supplemental information section of the CVARS form is its brevity. Many additional accident characteristics could be considered worth including.

7.1.2.4. Roadway Alignment

Additional variables could be included to give a clearer picture of the accident scene's roadway aspects, such as codes for highway obstructions, distracting factors, etc.

7.1.2.5. Rear Lamps

No particular observations can be made concerning the content and scope of the rear lamp codes.

7.1.2.6. Braking Performance

Since braking performance is vital, it would appear useful to collect additional data by conducting an operational check, when feasible, either by operating the commercial vehicle or by using a portable dynamometer. Additional codes could then be used to describe the resultant data for braking torque, fade, etc.

7.1.2.7. Fifth Wheel Location

The fifth wheel location codes are somewhat incomplete; e.g., the fifth wheel location for an auto carrier cannot be satisfactorily represented. It is usually well aft of the truck's rear axle, and mounted only about one to two feet above ground level.

7.1.2.8. Vehicle Total Weight Estimates

The vehicle total weight estimate is a useful set of codes; however, an additional code denoting actual or measured weight, if this is known, should be provided. This might be available from the driver's trip report, bill of lading, or other weight document.

Special training of, and/or reference manuals for use by highway traffic investigators to aid in estimating weights would also be valuable.

7.1.2.9. Accident Cause

This set of codes is highly useful in the analysis of accident causation. However, the codes should be much more extensive.

7.1.2.10. Causes and Contributing Factors

Again, these five variables and 39 codes are considered too limited. Perhaps the coding could also reflect the possibility of rank ordering the probable causes and contributing factors.

7.2. Recommendations

The following recommendations for reporting forms improvements are made as means for enhancing truck accident analysis capabilities. Certain general recommendations can be derived from the foregoing evaluations. Then 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 (see Section 2).

7.2.1. General Recommendations

7.2.1.1. 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 $\pm$ one to five feet, accident location to this level of precision is feasible.

7.2.1.2. 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

7.2.1.3. Driver Record or History

Considerable additional driver record 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

7.2.1.4. 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.

7.2.1.5. 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.

7.2.1.6. 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 the existing Form 555. An addendum on injury severity could be appended to the form.

7.2.1.7. 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. This is considered a vital step toward advancing accident causation analysis and modeling of accident events. This training program could be established as an ongoing program in which trained instructors would travel throughout a state or region, continually upgrading the graphic skills of traffic officers in portraying the details of an accident situation. This effort should commence with a study project to establish a curriculum and instructional materials for the program.

7.2.1.8. 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.

7.2.2. Detailed Recommendations

a) At the top of the CVARS, change "passengers" to "occupants." This is how the CHP officer has generally interpreted the data item, but the ambiguity has caused some coding errors.

b) Also at the top of the CVARS, change the "Commercial" box to "This Vehicle." A form is completed individually for every commercial vehicle involved in the accident. Similarly, change the "Other" box to "Other Vehicle."

c) A "1" should head the first column for "Axles."

d) Under Body Type, add "Concrete Transit Mixer," "Rubbish

Compactor," and "Trailer Coach."

e) The "Cargo" boxes for "Tractor" should be lined out. If a tractor carries a load on its structure, it is considered a "Truck."

f) The "Single Brake Control" item in the middle of the CVARS can be deleted. Only an insignificant number of multiple-unit vehicles are not equipped with single brake controls. Errors in analysis can arise from the inclusion of this item, since it is therefore completed as "Yes" only for single-unit vehicles (trucks).

g) Under "Load Type," "Regulated" should be replaced by "Regulated, Title 13, CAC."

h) Under "Causes and Contributing Factors, Loading," add "Shifting of Liquid Load in Tanker."

i) Under "Other Equipment," add "Spare Tire or Tire Carrier" prior to "Other."

j) Under "Braking Performance," change "No Brake Caused Loss of Control" to "Brake Caused Loss of Control." All blanks in the coded items are interpreted in the processing as <u>non-occurrence</u> of the item. Since the negative is presented here, blanks are interpreted as the occurrence of brake-caused loss of control. This clearly can lead to much more significant errors, potentially increasing the apparent number of occurrences, than if the positive had been presented, so that blanks would be interpreted as contributors only to the much larger number of non-occurrences.

k) There is a large number of errors associated with the variable Road Type on Form 555, most of them resulting from coder's judgment. Road Type is categorized into five groups, the last of which is referred to as "Other." Generally, if the road type is of the "Other" type, it is further explained in the narrative of the form. It is suggested that the "Other" type be explained where the road type is reported, rather than in the narrative, since coders often forget to search for it in the narrative.

l) The Event Profile (Card No. 2) is presently coded by the coders from information given in the narrative of Form 555. Narratives are not written uniformly and coders interpret them differently. It is suggested that, if possible, CHP officers code an event profile (similar to the one used in the USC Summary Forms) in addition to explaining the events in the narrative. It is anticipated that this extra coding would not be very time-consuming for the CHP officers, as it would follow from their thinking through the narrative they must already prepare.

m) "Vehicle Make" and "Vehicle Registration" are generally given for the power unit. However, they are often not given for trailers, etc. It is suggested that the CHP officers be requested to state clearly the vehicle make and registration for the trailers.

n) As shown in Section 2.4, there is a 14% coding error probability associated with the variable "Speed Prior to Involvement." This information is sometimes given in the narrative. At other times, coders may infer the value of this variable from other parts of the accident report, thus giving rise to a sizable judgmental error associated with this variable. Hence it is suggested that "Speed Prior to Involvement" be explicitly reported on Form 555 or the CVARS, as is currently being done for the "Posted Speed Limit."

o) There is a great deal of error associated with many of the variables on cards 4, 5, and 6. (Cards 4, 5, and 6 are directly keypunched from the CVARS form, and such errors are primarily due to keypunching.) The primary reasons behind such errors can be divided into the following categories:

i) Illegible marks

ii) Misplacement of templates on CVARS forms

Illegible marks generally result from photocopying the original CVARS forms. Forms are photocopied since the original copies must be kept at CHP headquarters in Sacramento. To obviate most of such illegible marks, it is suggested that numerical codes always be used for variables having mutually exclusive levels. For instance, numerical codes could be assigned to levels of variable such as "Vehicle No. of Axles," "Vehicle Body Type," etc. This would eliminate improper marking. It would also make the keypunching much easier as the keypunchers would then need to consider fewer columns (or filled boxes in this case).

Templates are primarily used to identify the column number associated with each box on the CVARS forms. This not only increases the processing time, it creates errors if the templates are not properly placed on the forms or if they accidentally slip relative to the form. To avoid the use of templates, it is suggested that small numbers be printed next to each box on the CVARS form. These numbers would represent the columns of an IBM card. Templates would then no longer be required.

Additionally, vehicle party numbers are not presently reported on cards 5 and 6. This creates problems in sorting cards 4, 5, and 6 in accident cases with more than one involved commercial vehicle. (There will be multiple sets of cards 4, 5, and 6 for accident cases with more than one commercial vehicle.) The vehicle party numbers are important as they are the only means of relating specific cards to specific vehicles. Hence, it is suggested that vehicle party numbers also be reported on cards 5 and 6 as well as on card 4.

REFERENCES

1. 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.

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

3. 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.

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

5. Fisher, Martin; Ireland, C. Terrence; Keegel, John; Kullback, Solomon; Nolan, John; and Scheuren, Frederick. Computer Programs or Contingency Table Analysis. Washington, D.C.: George Washington University, n.d.

6. Huhel, J. G. Tables of Confidence Bounds for Failure Probabilities. Report No. UCRL-51990. Livermore, Calif.: University of California, January 1976.

BIBLIOGRAPHY

1. Articles, Reports, and Books

Brown, Morton B. "Screening Effects in Multidimensional Contingency Tables." Applied Statistics 25, No. 1 (1976): 47.

California Department of Motor Vehicles. Past and Current California Department of Motor Vehicles Research Studies, Program Development and Evaluation. Sacramento, Calif., February 1976.

California Department of Public Works, Division of Highways. Traffic Report Covering the Results of a Special 6-16-24 Manual Truck Classification Survey Conducted on Freeways in Ventura County, Los Angeles County and Orange County. Supplement No. 1. Sacramento, Calif., February 1972.

California Department of Transportation, Division of Maintenance and Operations. 1975 Traffic Volumes on the California State Highway System. Sacramento, Calif.: Office of Traffic, 1976.

________. 1976 Traffic Volumes on California State Highways. Sacramento, Calif.: Office of Traffic, 1977.

California Highway Patrol. Annual Report of Fatal and Injury Motor Vehicle Traffic Accidents. Sacramento, Calif., 1975.

________. Collision Report Manual. HPM 110.5. Sacramento, Calif., n.d.

________. Commercial Vehicle Accident Report Supplement (CVARS). Sacramento, Calif., n.d.

Campbell, B. J. The Use of North Carolina Accident Records for Research. Report presented to the North Carolina Conference on Highway Safety, Chapel Hill, North Carolina, November 20-21, 1974.

Campbell, Kenneth L. "Assessing Accident Rates for Air-Braked Trucks." HSRI [Highway Safety Research Institute] Research 6, No. 4 (March-April 1976): 1-2.

Carlson, William L. "Induced Exposure Revisited." HIT Lab Reports 1, No. 3 (November 1970): 1-4.

Carr, B. R. "A Statistical Analysis of Rural Ontario Traffic Accidents Using Induced Exposure." Proceedings of the Symposium on the Use of Statistical Methods in the Analysis of Road Accidents. Crowthorne, England: Transport and Road Research Laboratory, n.d., pp. 86-91. See also Accident Analysis and Prevention 1, No. 4 (1969): 343-57.

Carroll, Philip S. "Classifications of Driving Exposure and Accident Rates for Highway Safety Analysis." Accident Analysis and Prevention 5, No. 2 (June 1973): 81-94.

________. "Identifying Unique Accident-Rate Classifications." HIT LAB Reports 3, No. 1 (September 1972): 7-11.

________. "The Meaning of Driving Exposure." HIT LAB Reports 1, No. 8 (April 1971).

________, et al. Acquisition of Information on Exposure and on Non-Fatal Crashes, Vol. 1: Exposure Survey Considerations. Final Report for U.S. Department of Transportation Contract No. FH-11-1793, May 12, 1971.

Cerrelli, Ezio C. "Driver Exposure: The Indirect Approach for Obtaining Relative Measures." Accident Analysis and Prevention 5, No. 2 (June 1973): 147-56.

Chapman, Roger. "The Concept of Exposure." Accident Analysis and Prevention 5, No. 2 (June 1973): 95-110.

Cohen, Jacob. "Multiple Regression as a General Data-Analytic System." Psychological Bulletin 70, No. 6 (1968): 426-43.

Coppin, R. S.; McBride, R. S.; and Peck, R. C. "The 1964 California Driver Record Study." Part 9 of The Prediction of Accident Involvement from Driver Record and Biographical Data. Report No. 20, March 1964.

Craw, Alexander R., and Ku, Richard. "The Sensitivity of Certain Indices Associated with Two-Vehicle Accidents." Accident Analysis and Prevention 5, No. 2 (June 1973): 137-46.

Creswell, W. L., and Froggath, P. The Causation of Bus Driver Accidents: An Epidemiological Study. Report published for the Nuffield Provincial Hospital Trust. Oxford: Oxford University Press, 1963.

de Savornin Lohman, Lorraine S., and Waller, Patricia F. Trucks: An Analysis of Accident Characteristics by Vehicle Weight. Chapel Hill: University of North Carolina Highway Safety Research Center, September 1975.

Drusch, Robert L. "Estimating Annual Average Daily Traffic from Short-Term Traffic Counts." Highway Research Record No. 118, Statistical Mathematical Aspects of Traffic, 1966.

Dunlop, Duane F., and O'Day, James. "Large Truck Accidents Involving Tire Failure." HIT LAB Reports 5, No. 6 (February 1975): 1-17.

Dyson, Richard B. An Essay on the Fallacy of Economic Costs of Accidents. Washington, D.C.: National Highway Traffic Safety Administration, May 15, 1975.

Erwin, R. D., and Cristopher, B. "Tire Properties and Truck Handling: Some Surprising New Findings." HSRI Research 7, No. 1 (July-August 1976): 3-12.

Fleischer, G. A., and Jones, George P. Cost-Benefit and Cost-Effectiveness Analyses in Determining Priorities Among Motor Vehicle Safety Standards, Programs and Projects. Los Angeles: University of Southern California, July 14, 1975.

Frane, James W., and Hill, Mary Ann. Annotated Computer Output for Factor Analysis: A Supplement to the Writeup for Computer Program BMDP4M. Los Angeles: Health Sciences Computing Facility, University of California, Los Angeles, April 17, 1975.

Glauber, Robert R., and Farrar, Donald E. "Multicollinearity in Regression Analysis: The Problem Revisited." Review of Economics and Statistics 49 (February 1967): 1.

Godley, M. J. The Incidence of Burst Tyres Prior to Injury Accidents on M1 and M4 Motorways. TRRL Report LR 498. Crowthorne, England: Transport and Road Research Laboratory, 1972.

Goodman, Leo A. "The Multivariate Analysis of Qualitative Data: Interactions Among Multiple Classifications." Journal of the American Statistical Association 65, No. 17 (March 1970).

Green, David A. An Error Analysis of Average Annual Daily Traffic Estimation. Publication TPO 40121, prepared for presentation at the Forty-Eighth Annual Meeting of the Highway Research Board, Washington, D.C., January 13-17, 1969.

Gwynn, David W. "Relationship of Accident Rates and Accident Involvements with Hourly Volumes." Traffic Quarterly, July 1967, pp. 407-18.

Hall, William K. "An Empirical Analysis of Accident Data Using Induced Exposure." HIT LAB Reports 1, No. 1 (September 1970).

Heimbach, Clinton L.; Hunter, William W.; and Chao, George C. "Paved Highway Shoulders and Accident Experience." Transportation Engineering Journal 100, No. TE4 (November 1974): 889-907.

Hochberg, Yosef. On The Variance Estimate of a Mann-Whitney Statistic for Ordered Grouped Data. Chapel Hill: University of North Carolina Highway Safety Research Center, February 1975.

________. Two-Stage Randomized Response Schemes for Estimating a Multinomial. Chapel Hill: University of North Carolina Highway Safety Research Center, February 1975.

Irwin, J. O. "The Generalized Waring Distribution Applied to Accident Theory." Journal of the Royal Statistical Society 131, No. 2 (1968): 205-25.

Joksch, Hans C. "A Pilot Study of Observed and Induced Exposure to Traffic Accidents." Accident Analysis and Prevention 5, No. 2 (June 1973): 127-36.

Jorgensen, N. O. "A Model for Forecasting Traffic Accidents." Accident Analysis and Prevention 1 (1969): 261-66.

Kent, P., and Bishop, H. 1974 National Truck Characteristic Report. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, April 1976.

Kihlberg, J. K., and Tharp, K. J. Accident Rates as Related to Design Elements of Rural Highways. National Cooperative Research Program Report 47. Washington, D.C.: Highway Research Board, n.d.

Koornstra, Matthijs J. "A Model for Estimation of Collective Exposure and Proneness from Accident Data." Accident Analysis and Prevention 5, No. 2 (June 1973): 157-73.

Kullback, Solomon, and Ku, Harry H. "Loglinear Models in Contingency Table Analysis." The American Statistician 28, No. 4 (November 1974): 115-22.

Kwong, K. W.; Kuan, J.; and Peck, R. C. Longitudinal Study of California Driver Accident Frequencies I: An Exploratory Multivariate Analysis. Final Report 55. Sacramento, Calif.: California Department of Motor Vehicles, Office of Program Development and Evaluation, June 1976.

Matsura, Robert J. "Improving the Researcher's Effectiveness: How Readability and Information Factors Affect Computerized Accident Data Analysis." HIT LAB Reports 2, No. 4 (December 1971): 41-42.

McMichael, Judith. School Bus Accidents and Driver Age. Chapel Hill: University of North Carolina Highway Safety Research Center, December 1974.

Milosevic, Stanisa, and Vucinic, Snezana. "Statistical Study of Tram Driver Accidents." Accident Analysis and Prevention 7 (1975): 1-7.

National Safety Council, Statistics Division. National Safety Council Estimating Procedures for the Annual Cost of Accidents. Chicago: National Safety Council, July 1974.

O'Day, James. "Analyses of Truck Crash Data." HIT LAB Reports 1, No. 2 (October 1970).

________. "Highway Behemoths: Dump Trucks and Transit Mix Trucks Compared." HIT LAB Reports 1, No. 11 (July 1971): 6-7.

________, and Scott, Robert E. "An Analysis of Truck Accident Involvement." HIT LAB Reports 4, No. 8 (April 1974).

Orne, Donald E., and Yang, Arthur H. "An Investigation of Weather Factor Effects on Traffic Accidents." Traffic Engineering 43 (1972).

Pfundt, Konrad. "Three Difficulties in the Comparison of Accident Rates." Accident Analysis and Prevention 1 (1969): 253-59.

Reinfurt, Donald W., and Campbell, B. J. Mileage Crash Rates for Certain Car Make and Model Year Combinations: A Preliminary Study. Chapel Hill: University of North Carolina Highway Safety Research Center, December 1974.

Reiss, Martin L.; Luenfeld, Harold; and Morton, George. Field of View, Directly Behind Trucks and Buses. Final Report HS-112-1162, AIL, February 1972.

Robinson, H.; Kihlberg, J.; and Garrett, J. W. Trucks in Rural Injury Accidents. Cornell Aeronautical Laboratory Report VJ-2721-R5. Ithaca, N.Y.: Cornell University, July 1969.

Sabey, B. E. Accidents on the London-Birmingham Motorway Resulting from Tyre Failures. Laboratory Report No. LN/407/BES. Crowthorne, England: Transport and Road Research Laboratory, August 1963.

Sanders, James H.; Berger, Wallace G.; and Hanscom, Fred R. "The Traffic Evaluator System: An Innovative Data Collection Tool." Public Roads 40, No. 4, pp. 149-55.

Satterthwaite, S. P. "An Assessment of Seasonal and Weather Effects on the Frequency of Road Accidents in California." Accident Analysis and Prevention 8 (1976): 87-96.

Silvey, S. D. "Multicollinearity and Imprecise Estimation." Journal of the Royal Statistical Society B 31, No. 3 (1969): 539-52.

Stewart, J. Richard, and Campbell, B. J. The Statistical Association between Past and Future Accidents and Violations. Chapel Hill: University of North Carolina Highway Safety Research Center, December 1972.

Thorpe, John D. "Calculating Relative Involvement Rates in Accidents without Determining Exposure." Traffic Safety Research Review 11, No. 1 (1967): 3-8.

U.S. Department of Transportation. Secondary Impacts and Consequences of Highway Projects. Final Report under Contract DOT-OS-50043. Washington, D.C.: Department of Transportation, October 1976.

________, Federal Highway Administration. Guide for Truck Weight Study Manual. Washington, D.C.: Department of Transportation, April 1971.

van der Zwaag, Donald D. "A Determination of the Relative Collision Involvement of Trucks and Other Vehicles." HIT LAB Reports 1, No. 11 (July 1971): 1-5.

________. "A Vehicle Interaction Model: A Method for Determining Exposure to Several Types of Accident Situations." HIT LAB Reports 1, No. 10 (June 1971): 3-6.

Waller, Patricia F.; Reinfurt, Donald W.; et al. Methods for Measuring Exposure to Automobile Accidents. Report presented at the 101st Annual Meeting of the American Public Health Association, San Francisco, Calif., November 8, 1973.

Washington State Patrol. Heavy Truck Accident Study. Olympia: Washington State Patrol, 1972.

2. Computer Programs for Contingency Table Analysis[1]

1.[†] Grower, J. C. "The Handling of Multiway Tables in Computers." Computer Journal 4 (1962): 280-86.

2.[†] Goodman, Leo A. "A Short Computer Program for the Analysis of Transaction Flows." Behavioral Science 9 (1964): 176-86.

3.[Φα] Bishop, Yvonne M. M. "Multidimensional Contingency Tables: Cell Estimations." Ph.D. dissertation, Harvard University, 1967.

4.[Φ∇α] Haberman, S. J. "MNBISH. A Computer Program for Maximum Likelihood Estimation in Multidimensional Contingency Tables." Department of Statistics, University of Chicago, 1970.

5.[Π∇α] Forthofer, R. N.; Starmer, C. F.; and Grizzle, J. "A Program for the Analysis of Categorical Data by Linear Models (CATLIN/LINCAT)." J. Med. Systems 2, No. 6 (1971).

6.[Π∇] Varner, R. N., and Ku, H. H. "Three Computer Programs for the Analysis of Contingency Tables." NBS Statistical Engineering Laboratory, Washington, D.C., 1972.

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[1]Contributed by Raymond C. Peck and Jensen Kuan, Research, Development and Consultation, California Department of Motor Vehicles, Sacramento, California.

7.[Π∇] Ireland, C. T. "CONTAB II. A Computer Program for Analyzing Contingency Tables." Department of Statistics, George Washington University, Washington, D.C. (Supplement prepared to accompany S. E. Feinberg, "The Analysis of Multidimensional Contingency Tables," Ecology 51, No. 2 [1972].)

8.[Φα] Haberman, S. J. "Log-linear Fit for Contingency Tables." Applied Statistics 21 (1971): 218-25, Algorithm AS51. (See also Haberman, S. J., "Printing Multidimensional Tables," Applied Statistics 22 [1972]: 118-26, Algorithm AS57.)

9.[§] Haberman, S. J. "C-TAB. Analysis of Multidimensional Contingency Tables by Log-Linear Models." National Educational Resources, Inc., 215 Kenwood Ave., Ann Arbor, Michigan, 1973.

10.[Πα] Ireland, C. T. "CONTAB Contingency Table Analysis." Department of Statistics, George Washington University, Washington, D.C., 1975.

11.[†] Bishop, Y. M. M., et al. Discrete Multivariate Analysis: Theory and Practice. Cambridge, Mass.: MIT Press, Computer Programs, 1975.

12.[Π∇α] Landis, L. R.; Standish, W. M.; and Koch, G. G. "A Computer Program for the Generalized Chi-square Analysis of Categorical Data Using Weighted Least Squares to Computer Wald Statistics." Biostatistics Technical Report No. 8. Department of Biostatistics, University of Michigan, Ann Arbor, Michigan, 1972.

Legend

† No program source listing

Φ With program source listing

Π Card deck or tape available from the originating institutions

§ Announcement only

∇ Contains highway safety related sample program printouts

α Available, in particular, in California Department of Motor Vehicles library

APPENDIX A

UNIVARIATE FREQUENCY TABLES, HISTOGRAMS, AND DESCRIPTIVE STATISTICS

This appendix contains the univariate frequency tables, and corresponding histograms and certain statistics, that describe the accident reports data base established for this study. Summary views on the more significant aspects of the tables can be found in Section 3 of the main report. Information on the procedures employed to develop the tables is provided in Appendix C.

A Table of Contents that facilitates the location of any particular material in this appendix follows.

Because of the extraordinary length of this appendix (534 pages), the complete text is attached as a separate volume. This is identified as Volume I, Part II.

1. 'ACCIDENT FACTORS'

VARIABLE	VARIABLE CODE
MONTH	C1001
DAY OF MONTH	C1002
YEAR	C1003
TIME	C1004
REPORTING JURISDICTION	C1005
REPORTING DISTRICT	C1006
COUNTY	C1007
NO. OF PRINCIPAL PARTIES	C1008
NO. OF FATALITIES	C1009
NO. OF INJURIES	C1010
ROAD TYPE	C1011
PRIMARY COLLISION FACTOR-PCF	C1012
PARTY RESPONSIBLE FOR PCF	C1013
WEATHER	C1014
LIGHTING	C1015
ROAD SURFACE	C1016
HOLES AND RUTS	C1017
LOOSE MATERIALS IN ROADWAY	C1018
OBSTRUCTION IN ROADWAY	C1019
CONSTRUCTION ZONE	C1020
REDUCED ROADWAY WIDTH	C1021
FLOODED	C1022
OTHERS	C1023
NO UNUSUAL CONDITIONS	C1024
RIGHT OF WAY CONDITIONS	C1025
EVENT CODED BY CHP	C2031
TOTAL NO. OF EVENTS IN ACCIDENT	C2032

2. 'COMMERCIAL VEHICLE FACTORS'

A. 'COMMERCIAL VEHICLE DATA'

NO. OF COMMERCIAL POWER UNITS INVOLVED	C4101
TOWED SPECIAL VEHICLE	C4102
COMMERICIAL VEHICLE PARTY NO.	C4103
TOTAL NO. UNINJURED PASSENGERS IN COMM. UNIT	C4104
TOTAL NO. INJURED PASSENGER IN OTHER UNIT	C4105
FRONT AXLE BRAKE-YES	C5101
FRONT AXLE BRAKE-NO	C5102
SINGLE BRAKE CONTROL-YES	C5103
SINGLE BRAKE CONTROL-NO	C5104
DRIVE AXLE-ONE	C5105
DRIVE AXLE-TWO	C5106
LOAD TYPE-BAILED HAY & STRAW	C5107
LOAD TYPE-BAILED COTTON PAPER JUTE	C5108
LOAD TYPE-LOGS & POLES	C5109
LOAD TYPE-JUNK & SCRAP METAL	C5110
LOAD TYPE-STEEL COILS	C5111
LOAD TYPE-STEEL PLATE SHEET	C5112
LOAD TYPE-EMPTY WOODEN BOXES	C5113
LOAD TYPE-DETACHABLE FREIGHT VANS	C5114
LOAD TYPE-LUMBER PRODUCTS	C5115
LOAD TYPE-SACKED MATERIAL	C5116
LOAD TYPE-BOXED MATERIAL	C5117
LOAD TYPE-AGRICULTURAL PRODUCTS	C5118
LOAD TYPE-HAZARDOUS MATERIALS	C5119
LOAD TYPE-BULK COMMODITIES	C5120
LOAD TYPE-PERMITTED LOADS	C5121
LOAD TYPE-OTHERS	C5122
PASSENGER-FARM LABOR EMPLOYEE	C5123
PASSENGERS-OTHERS	C5124
JACKKNIFE-PRIOR TO COLLISION	C5125
JACKKNIFE-AFTER COLLISION	C5126
SEPARATION OF UNIT BEFORE COLLISION	C5127
SEPARATION OF UNIT AFTER COLLISION	C5128
CARGO SPILL BEFORE COLLISION	C5129
CARGO SPILL AFTER COLLISION	C5130
CARGO SHIFT BEFORE COLLISION	C5131
CARGO SHIFT AFTER COLLISION	C5132
ROLLAWAY-DRIVERLESS	C5133
SPRING BRAKES NOT RELEASABLE	C5134
SPRING BRAKES ACTIVATED WHILE MOVING	C5135
CAR UNDERRIDE-REAR ENDER	C5136
TRUCK OVERRIDE-FRONT ENDER	C5137
ROADWAY ALIGNMENT-LEVE	C5138
ROADWAY ALIGNMENT-UPHILL	C5139
ROADWAY ALIGNMENT-CREST OF HILL	C5140
ROADWAY ALIGNMENT-DOWNHILL	C5141
ROADWAY ALIGNMENT-BOTTOM OF HILL	C5142
ROADWAY ALIGNMENT-STRAIGHT	C5143
ROADWAY ALIGNMENT-CURVED LEFT	C5144
ROADWAY ALIGNMENT-CURVED RIGHT	C5145
REAR LAMPS-NO APPARENT DEFECTS	C5146
TAIL LAMPS-INOPERATIVE	C5147
TAIL LAMPS-BROKEN LENSES	C5148
TAIL LAMPS-OBSCURED LENSES	C5149
STOP LAMPS-INOPERATIVE	C5150

STOP LAMPS-BROKEN LENSES	C5151
STOP LAMPS-OBSCURED LENSES	C5152
CLEARANCE LAMPS-INOPERATIVE	C5153
CLEARANCE LAMPS-BROKEN LENSES	C5154
CLEARANCE LAMPS-OBSCURED LENSES	C5155
BRAKING IN LANE	C5156
STEERING ONLY	C5157
BRAKING AND STEERING	C5158
NO-BRAKE CAUSED LOSS OF CONTROL	C5159
WHEEL LOCK UP-MOTOR VEHICLE	C5160
WHEEL LOCK-UP TOWED VEHICLE	C5161
BRAKE FADE	C5162
RUNAWAY-GRADE	C5163
BRAKE-CAUSED SWAVING	C5164
BRAKE-CAUSED WEAVING	C5165
BRAKE-CAUSED UNCONTROLLED SKID	C5166
BRAKE-CAUSED LEAVING TRAVELED LANE	C5167
ODOMETER READING	C6101
FIFTH WHEEL POSITION-FWD CL	C6102
FIFTH WHEEL POSITION-OVER CL	C6103
FIFTH WHEEL POSITION-REAR CL	C6104
VEHICLE TOTAL WEIGHT-UNIT 1	C6105
VEHICLE TOTAL WEIGHT-UNIT 2	C6106
VEHICLE TOTAL WEIGHT-UNIT 3	C6107
VEHICLE TOTAL WEIGHT-ALL	C6108
ACCIDENT CAUSE-THIS VEHICLE DRIVER	C6109
ACCIDENT CAUSE-OTHER VEHICLE DRIVER	C6110
ACCIDENT CAUSE-THIS VEHICLE EQUIPMENT	C6111
ACCIDENT CAUSE-OTHER VEHICLE EQUIPMENT	C6112
ACCIDENT CAUSE-OTHERS	C6113
DRIVER CONDITION-FATIGUE	C6114
DRIVER CONDITION-EXCESSIVE DRIVING HOURS	C6115
DRIVER CONDITION-DRUGS OR ALCHOL	C6116
DRIVER CONDITION-OTHER IMPAIRMENTS	C6117
BRAKES INOPERATIVE	C6118
BRAKES-OUT OF ADJUSTMENTS	C6119
BRAKES-AIR LOSS	C6120
BRAKES-BREAKAWAY BRAKES	C6122
BRAKES-RUPTURED LINE	C6122
BRAKES-WHEEL LOCKUP	C6123
BRAKES-PARKING BRAKES	C6124
BRAKES-EMERGENCY STOP SYSTEM	C6125
BRAKES-VACCUM SYSTEM FAILURE	C6126
BRAKES-HYDRAULIC SYSTEM FAILURE	C6127
BRAKES-OTHER BRAKE DEFECTS	C6128
LOADING-INADEQUATE SECUREMENT	C6129
LOADING-LOAD BINDER FAILURE	C6130
LOADING-REGULATED LOAD	C6131
LOADING-NON REGULATED LOAD	C6132
SAFETY CHAIN	C6133
DRAWBAR	C6134
TRAILER HITCH	C6135
FIFTH WHEEL	C6136
STEERING SYSTEM	C6137
TIRES	C6138
WHEELS	C6139
FRAMES	C6140
SPRING AND HANGOVERS	C6141
AXLE	C6142
LAMPS	C6143
CAB LATCH	C6144

OTHER EQUIPMENTS	C6145
HEIGHT	C6146
WIDTH	C6147
WEIGHT	C6148
LENGTH	C6149
PERMIT LOAD	C6150
PERMIT VIOLATION	C6151
VC SIZE VIOLATION	C6152

B. 'COMMERCIAL VEHICLE (PARTY) DATA'

PRINCIPAL PARTY NO.	C3101
PARTY DESCRIPTION-POWER UNIT	C3102
PARTY DESCRIPTION-POWER UNIT 2	C3103
PARTY DESCRIPTION-UNIT 3	C3104
PARTY DESCRIPTION-UNIT 4	C3105
VEHICLE YEAR-POWER UNIT	C3106
VEHICLE YEAR-UNIT 2	C3107
VEHICLE YEAR-UNIT 3	C3108
VEHICLE YEAR-UNIT 4	C3109
VEHICLE MAKE-POWER UNIT	C3110
VEHICLE MAKE-UNIT 2	C3111
VEHICLE MAKE-UNIT 3	C3112
VEHICLE MAKE-UNIT 4	C3113
VEHICLE REGISTRATION-POWER UNIT	C3114
VEHICLE REGISTRATION-UNIT 2	C3115
VEHICLE REGISTRATION-UNIT 3	C3116
VEHICLE REGISTRATION-UNIT 4	C3117
COMMERCIAL VEHICLE CONFIGURATION CODE	C3118
POSTED SPEED LIMIT	C3119
SPEED PRIOR TO INVOLVEMENT	C3120
VEHICLE MAOVEMENT PRECEDING INVOLVEMENT	C3121
VC-CODE EQUIPMENT VIOLATIONS -1	C3122
VC-CODE EQUIPMENT VIOLATIONS -2	C3123
VC-CODE EQUIPMENT VIOLATIONS -3	C3124
VEHICLE DAMAGES	C3125
DIRECTION OF TRAVEL	C3126

C. 'COMMERCIAL VEHICLE - TRUCK ONLY DATA'

TRUCK-NO OF AXLES	C4106
TRUCK-CABOVER	C4107
TRUCK-BODY TYPE	C4121
TRUCK-EMPTY OR LADEN	C4122
TRUCK-BRAKE TYPPE	C4132
TRUCK-SPRING BRAKES	C4133
TRUCK-1975 OR LATER	C4134

D. 'COMMERCIAL VEHICLE - TRACTOR ONLY DATA'

TRACTOR-NO. OF AXLES	C4108
TRACTOR-CABOVER	C4109
TRACTOR-EMPTY OR LADEN	C4123
TRACTOR-BRAKE TYPE	C4135
TRACTOR-SPRING BRAKES	C41[illegible]5
TRACTOR -1975 OR LATER	C4137

E. 'COMMERCIAL VEHICLE - SEMI.-TRAILER DATA'

SEMI-TRAILER NO. OF AXLES	C4110
SEMI-TRAILER BODY TYPE	C4124
SEMI-TRAILER EMPTY OR LADEN	C4125
SEMI-TRAILER BRAKE TYPE	C4138
SEMI-TRAILER SPRING BRAKES	C4139
SEMI-TRAILER 1975 OR LATER	C4140

F. 'COMMERCIAL VEHICLE - FULL TRAILER DATA'

FULL-TRAILER NO. OF AXLES	C4111
FULL-TRAILER BODY TYPE	C4126
FULL-TRAILER EMPTY OR LADEN	C4127
FULL-TRAILER BRAKE TYPE	C4141
FULL-TRAILER SPRING BRAKES	C4142
FULL-TRAILER 1975 OR LATER	C4143

G. 'COMMERCIAL VEHICLE-DOLLY DATA'

DOLLY-NO OF AXLES	C4112
DOLLY-BRAKE TYPE	C4144
DOLLY-SPRING BRAKES	C4145
DOLLY-1975 OR LATER	C4146

H. 'COMMERCIAL VEHICLE - BUS DATA'

BUS-NO. OF AXLES	C4113
BUS-CABOVER	C4114
BUS-EMPTY OR LADEN	C4128
BUS-BRAKE TYPE	C4147
BUS-SPRING BRAKES	C4148
BUS-1975 OR LATER	C4149

I. 'COMMERCIAL VEHICLE - SCHOOL BUS DATA'

SCHOOL BUS-NO. OF AXLES	C4115
SCHOOL BUS-CABOVER	C4116
SCHOOL BUS-EMPTY OR LADEN	C4129
SCHOOL BUS-BRAKE TYPE	C4150
SCHOOL BUS SPRING BRAKES	C4151
SCHOOL BUS-1975 OR LATER	C4152

3. 'NON-COMMERCIAL VEHICLE FACTORS'

PRINCIPAL PARTY NO.	C3101
PARTY DESCRIPTION-POWER UNIT	C3102
PARTY DESCRIPTION-UNIT 2	C3103
PARTY DESCRIPTION-UNIT 3	C3104
PARTY DESCRIPTION-UNIT 4	C3105
VEHICLE YEAR-POWER UNIT	C3106
VEHICLE YEAR-UNIT 2	C3107
VEHICLE YEAR-UNIT 3	C3108
VEHICLE YEAR-UNIT 4	C3109
VEHICLE MAKE-POWER UNIT	C3110
VEHICLE MAKE-UNIT 2	C3111
VEHICLE MAKE-UNIT 3	C3112
VEHICLE MAKE-UNIT 4	C3113
VEHICLE REGISTRATION-POWER UNIT	C3114
VEHICLE REGISTRATION-POWER UNIT	C3115
VEHICLE REGISTRATION-UNIT 2	C3116
VEHICLE REGISTRATION-UNIT 3	C3117
VEHICLE REGISTRATION-UNIT 4	C3118
POSTED SPEED LIMIT	C3119
SPEED PROIOR TO INVOLVEMENT	C3120
VEHICLE MOVEMENT PRECEDING INVOLVEMENT	C3121
VC-CODE EQUIPMENT VIOLATIONS - 1	C3122
VC-CODE EQUIPMENT VIOLATIONS - 2	C3123
VC-CODE EQUIPMENT VIOLATIONS - 3	C3124
VEHICLE DAMAGES	C3125
DIRECTION OF TRAVEL	C3126
PEDESTRIAN ACTION	C3127

4. 'HUMAN FACTORS'

A. 'COMMERCIAL VEHICLE DRIVER AND PASSENGERS FACTORS'

1) COMMERCIAL VEHICLE DRIVERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107
VEHICLE OCCUPANY ROLE	C7108
STATE OF DR LICENSE	C7109
DOES DR OWN VEHICLE	C7110
VEHICLE CODE VIOLATION AGAINST PERSON-1	C7111
VEHICLE CODE VIOLATION AGAINST PERSON-2	C7112
VEHICLE CODE VIOLATION AGAINST PERSON-3	C7113
VISION OBSCUREMENT	C7114
INATTENTION	C7115
STOP AND GO TRAFFIC	C7116
ENTERING-LEAVING RAMP	C7117
PREVIOUS COLLISION	C7118
UNFAMILIAR WITH ROAD	C7119
OTHER	C7120
NON APPARENT	C7121
DRIVER EXPERIENCE-YEARS	C7122

2) 'COMMERCIAL VEHICLE PASSENGERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON-ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107

B. 'NON-COMMERCIAL VEHICLE DRIVER AND PASSENGERS FACTORS'

1) 'NON-COMMERCIAL VEHICLE DRIVERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON-ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107
VEHICLE OCCUPANY ROLE	C7108
STATE OF DR LICENSE	C7109
DOES DR OWN VEHICLE	C7110
VEHICLE CODE VIOLATION AGAINST PERSON-1	C7111
VEHICLE CODE VIOLATION AGAINST PERSON-2	C7112
VEHICLE CODE VIOLATION AGAINST PERSON-3	C7113
VISION OBSCUREMENT	C7114
INATTENTION	C7115
STOP AND GO TRAFFIC	C7116
ENTERING-LEAVING RAMP	C7117
PREVIOUS COLLISION	C7118
UNFAMILIAR WITH ROAD	C7119
OTHER	C7120
NON APPARENT	C7121

2) 'NON-COMMERCIAL VEHICLE PASSENGERS'

PRINCIPAL-PARTY NO.	C7101
SEX	C7102
AGE	C7103
DRUG INFLUENCE - ALCOHOL	C7104
DRUG INFLUENCE - NON-ALCOHOL	C7105
PHYSICAL IMPAIRMENT	C7106
INJURY SEVERITY	C7107

APPENDIX B

ACCIDENT REPORT FORMS AND INSTRUCTIONS FOR COMPLETION AND CODING

Following a set of definitions of general terms, the CHP traffic accident report form (Form 555) is exhibited first, together with certain vehicle type codes required for its use. The CVARS, or "Green Sheet," is next presented, with the instructions for its completion that were provided to the CHP.

The process for transferring the data from the Form 555's and Green Sheets to a coded Summary Form is described next. The summary data are finally entered into magnetic tape data files.

The material presented in this appendix is organized as follows:

- B.1 Definitions
- B.2 The Traffic Collision Report (Form 555)
- B.3 The CVARS, or "Green Sheet," and instructions for its completion by CHP officers
- B.4 Coding of Form 555 and CVARS data in the Summary Form
    - B.4.1 Accident Data
    - B.4.2 Vehicle/Party Data
    - B.4.3 Human Factors Data

TABLE B-1.—DEFINITIONS

ACCIDENT CODING FORMS: Summary Form Green Sheet, Summary Form Accident Data, Summary Form Vehicle Data, and Summary Form Human Factors Data. These are the forms that information from the Traffic Collision Report is transferred to.

CARD NUMBER: This is a predetermined number already printed on the coding form. It refers to the sequential arrangement of the data and will be put in the designated card column.

CASE NUMBER: The number assigned to each case as it is received in the truck research section. This number will always appear in the upper right-hand corner in red ink.

CATEGORY: The assignment of various names to the data extracted from the Traffic Collision Report.

COLUMN: The column number on the IBM card (1 to 80) in which a category is placed.

COMMERCIAL VEHICLE: Truck, bus or tractor/trailer combination defined on the Green Sheet.

GREEN SHEET: The supplemental form, Commercial Vehicle Accident Report Supplement (CVARS), that accompanies the Traffic Collision Report. One form is filled out for each commercial vehicle involved in the accident.

INJURED PARTY: Any person described in the Extent of Injury section. Note: There must be one Human Factors sheet for each injured person, whether driver or passenger.

KEYPUNCHING: Transferring the data accumulated on the Summary Forms to IBM cards.

PARTY NUMBER: The number assigned to each vehicle in the accident. This is usually an arbitrary number assigned by the officer at the scene of the collision.

TRAFFIC COLLISION REPORT: The report that is filled out by the officer at the scene of the accident. It is also referred to as Form 555.

TRUCK STUDY REFERENCE LIST: A set of codes used to transform data from the Traffic Collision Report to accident coding forms.

B.2. The Traffic Collision Report (Form 555)

This is the basic form completed by a CHP officer at the scene of an accident. Preceding the form, the standard vehicle type codes that are employed in the reports are listed.

Passenger Vehicles

01 Passenger car, S/W, jeep
02 Motorcycle
03 Motor-driven cycle
04 Bicycle

Buses

11 Commercial
12 Farm labor bus
13 School bus

Truck/Truck Tractors

21 Trucks
22 Pickups and panels
23 Pickup with camper
24 Farm labor truck
25 Truck tractors

Trailers

31 Semi
32 Full
33 Two trailers (includes semi & trailer)
34 Boat
35 Utility
36 Trailer coach
37 Overwidth trailer coach
38 Pole, pipe, or logging dolly
39 Three trailers

Specialized Vehicles

41 Ambulance
42 Dune buggy
43 Fire truck
44 Fork lift
45 Highway construction equipment
46 Implement of husbandry
47 Motor home
48 Police car
49 Police motorcycle
50 Special mobile equipment

Miscellaneous

98 Emergency vehicle on emergency run or in pursuit of a violator
99 Other

FIGURE B-1. CALIFORNIA HIGHWAY PATROL VEHICLE TYPE CODES

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

SPECIAL CONDITIONS | NO. INJ. | H & R FELONY ☐ | CITY | JUDICIAL DISTRICT | No.

NO. KILLED | H & R MISD ☐ | COUNTY | REPORTING DISTRICT | BEAT

LOCATION

COLLISION OCCURRED ON | MO. DAY YR. | TIME(2400) | CII NO. | OFFICER I.D.

☐ AT INTERSECTION WITH | INJURY, FATAL OR TOW AWAY ☐ YES ☐ NO | STATE HWY ☐ YES ☐ NO

☐ OR: ______ FEET/MILES ______ OF

PARTY 1

DRIVER ☐ | PEDESTRIAN ☐ | PARKED VEH. ☐ | BICYCLIST ☐ | OTHER ☐

NAME (FIRST, MIDDLE, LAST) | STREET ADDRESS

DRIVER'S LICENSE NO. | STATE | BIRTHDATE MO. DAY YR. | SEX | RACE | CITY | STATE | PHONE

VEHICLE YR. | MAKE | LICENSE NO. | STATE | OWNER'S NAME ☐ SAME AS DRIVER

DIRECTION OF TRAVEL | ON/ACROSS (STREET OR HIGHWAY) | OWNER'S ADDRESS ☐ SAME AS DRIVER

SPEED LIMIT | DISPOSITION OF VEHICLE ☐ BY DRIVER | ON ORDERS OF | VEHICLE DAMAGE EXTENT ☐ MINOR ☐ MOD. ☐ MAJOR ☐ TOTAL LOCATION | VIOLATION CHARGED 1 ______ 2 ______

PARTY 2

DRIVER ☐ | PEDESTRIAN ☐ | PARKED VEH. ☐ | BICYCLIST ☐ | OTHER ☐

NAME (FIRST, MIDDLE, LAST) | STREET ADDRESS

DRIVER'S LICENSE NO. | STATE | BIRTHDATE MO. DAY YR. | SEX | RACE | CITY | STATE | PHONE

VEHICLE YR. | MAKE | LICENSE NO. | STATE | OWNER'S NAME ☐ SAME AS DRIVER

DIRECTION OF TRAVEL | ON/ACROSS (STREET OR HIGHWAY) | OWNER'S ADDRESS ☐ SAME AS DRIVER

SPEED LIMIT | DISPOSITION OF VEHICLE ☐ BY DRIVER | ON ORDERS OF | VEHICLE DAMAGE EXTENT ☐ MINOR ☐ MOD. ☐ MAJOR ☐ TOTAL LOCATION | VIOLATION CHARGED 1 ______ 2 ______

PROPERTY

DESCRIPTION OF DAMAGE

OWNER'S NAME | ADDRESS | NOTIFIED ☐ YES ☐ NO

INJURED/WITNESS

WITNESS ONLY	AGE	SEX	EXTENT OF INJURY: FATAL INJURY	SEVERE WOUND DISTORTED MEMBER	OTHER VISIBLE INJURIES	COMPLAINT OF PAIN	INJURED WAS (check one): DRIVER	PASS.	PED.	BICYCLIST	OTHER	IN VEH. NUMBER
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
NAME									PHONE			
ADDRESS						TAKEN TO (INJURED ONLY)						
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
NAME									PHONE			
ADDRESS						TAKEN TO (INJURED ONLY)						
☐			☐	☐	☐	☐	☐	☐	☐	☐	☐	
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 (REV 11-71)

FIGURE B-2a. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, PAGE 1

PAGE ______ | No.

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

1	2	3	4	TYPE OF VEHICLE
				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 ______

1	2	3	4	OTHER ASSOCIATED FACTOR (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

1	2	3	4	MOVEMENT PRECEDING COLLISION
				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 ______

1	2	3	4	SOBRIETY - DRUG - PHYSICAL (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

FIGURE B-2b. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, PAGE 2

PAGE ____

ORIGINAL NO.

CHECK ONE	SUPPLEMENTAL	DATE OF ORIGINAL INCIDENT MO. DAY YR.		TIME (2400)	CII NUMBER	OFFICER I.D.
	SUPPLEMENTS FORM 555 TRAFFIC COLLISION REPORT	LOCATION/SUBJECT				CITATION NO.
	OTHER:					BEAT
	FORM 555 NARRATIVE CONTINUATION ONLY	CITY	COUNTY		REPORTING DISTRICT	

PREPARED BY	I.D. NUMBER	PREPARED	REVIEWED - APPROVED BY	I.D. NUMBER	DATE
NAME/RANK		MO. DAY YR.	NAME/RANK		MO. DAY YR.

FIGURE B-3a. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, SUPPLEMENT, PAGE 1

PAGE ______

No.

SKETCH - NARRATIVE CONTINUATION

ALL MEASUREMENTS ARE APPROXIMATE AND NOT TO SCALE UNLESS STATED (SCALE =)

INDICATE NORTH

1'' 2'' 3'' 4'' 5'' 6'' 7''

NARRATIVE CONTINUATION *(Use reverse side as necessary)*

POINT OF IMPACT
VEHICLE (NOT PARKED)
PEDESTRIAN
TRAIN
PARKED VEHICLE
FIXED OBJECT
HEAD-ON
HEAD-ON SIDESWIPE
REAR END
OVERTAKING SIDESWIPE
BROADSIDE
APPROACH TURN
OVERTAKING TURN
OUT OF CONTROL
OVERTURNED
VEHICLE BACKING

556 (REV.3-73)

FIGURE B-3b. CALIFORNIA HIGHWAY PATROL TRAFFIC COLLISION REPORT, SUPPLEMENT, PAGE 2

COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT

ACCIDENT REPORT IDENTIFIER

MO	DAY	YR	TIME (2400)	CII NUMBER	OFFICER ID NO

NUMBER OF COMMERCIAL POWER UNITS INVOLVED ☐ TOWED SPECIAL VEHICLE ☐ COMMERCIAL VEHICLE NO. (TO BE THE SAME AS PARTY NUMBER IN ACCIDENT REPORT) ☐ RECORD THE TOTAL NUMBER UNINJURED PASSENGERS IN EACH VEHICLE INVOLVED IN THIS ACCIDENT ☐ COMMERCIAL ☐ OTHER

	AXLES			BODY TYPE							CARGO		BRAKES					1975 OR LATER
UNIT		2	3	CAB OVER	VAN	RACK	FLAT	TANK	AUTO CARR	OTHER	EMPTY	LADEN	AIR	HYDR	ELEC	OTHER	SPRING	
TRUCK																		
TRACTOR																		
SEMI-TRAILER																		
FULL TRAILER																		
DOLLY (LOG/POLE)																		
BUS																		
SCHOOL BUS																		
FARM LABOR BUS																		
FARM LABOR TRUCK																		

SPEED THIS VEHICLE – mph PRIOR TO ACCIDENT WHEN HAZARD RECOGNIZED	FRONT AXLE BRAKES	YES	NO	SINGLE BRAKE CONTROL	YES	NO	DRIVE AXLES	1	2	DRIVER EXPERIENCE – YRS THIS VEHICLE TYPE	ODOMETER READING	MILES

LOAD TYPE

REGULATED
- BALED HAY & STRAW ☐
- BALED COTTON, PAPER/JUTE ☐
- LOGS & POLES ☐
- JUNK & SCRAP METAL ☐
- STEEL COILS ☐
- STEEL PLATE, SHEET, TINPLATE ☐
- EMPTY WOODEN BOXES ☐
- DETACHABLE FREIGHT VANS ☐
- LUMBER & LUMBER PRODUCTS ☐

NON-REGULATED
- SACKED MATERIAL ☐
- BOXED MATERIAL ☐
- AGRICULTURAL PRODUCTS ☐
- HAZARDOUS MATERIALS ☐
- BULK COMMODITIES ☐
- PERMITTED LOADS ☐
- OTHER ☐

PASSENGERS
- FARM LABOR EMPLOYEES ☐
- OTHER PERSONS ☐

SUPPLEMENTAL INFORMATION
- JACKKNIFE:
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- SEPARATION OF UNITS
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- CARGO SPILL
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- CARGO SHIFT
  - PRIOR TO COLLISION ☐
  - AFTER COLLISION ☐
- ROLLAWAY (DRIVERLESS) ☐
- SPRING BRAKES NOT RELEASABLE ☐
- SPRING BRAKES ACTIVATED WHILE MOVING ☐
- CAR UNDERRIDE (REAR-ENDER) ☐
- TRUCK OVERRIDE (FRONT-ENDER) ☐

ROADWAY ALIGNMENT
- LEVEL ☐
- UPHILL ☐
- CREST OF HILL ☐
- DOWNHILL ☐
- BOTTOM OF HILL ☐
- STRAIGHT ☐
- CURVED LEFT ☐
- CURVED RIGHT ☐

REAR LAMPS
- NO APPARENT DEFECTS ☐
- TAIL LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐
- STOP LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐
- CLEARANCE LAMPS
  - INOPERATIVE (1 OR MORE) ☐
  - BROKEN LENSES ☐
  - OBSCURED LENSES ☐

BRAKING PERFORMANCE
- BRAKING IN LANE ☐
- STEERING ONLY ☐
- BRAKING & STEERING ☐
- NO BRAKE CAUSED LOSS OF CONTROL ☐
- WHEEL LOCK UP
  - MOTOR VEHICLE ☐
  - TOWED VEHICLE ☐
- BRAKE FADE ☐
- RUNAWAY (GRADE) ☐
- BRAKE CAUSED
  - SWERVING ☐
  - WEAVING ☐
  - UNCONTROLLED SKID ☐
  - LEAVING TRAVELED LANE ☐

FIFTH WHEEL POSITION	FWD CL	OVER CL	REAR CL

VEHICLE TOTAL WEIGHT (DRIVERS ESTIMATE)					
UNIT	LBS				
1					
2					
3					
ALL					

ACCIDENT CAUSE
- THIS VEHICLE DRIVER ☐
- OTHER VEHICLE DRIVER ☐
- THIS VEHICLE EQUIPMENT ☐
- OTHER VEHICLE EQUIPMENT ☐
- OTHER ☐

CAUSES AND CONTRIBUTING FACTORS

If one of the ITEMS below, relating to the Commercial Vehicle, caused the accident or contributed to its severity check the item.

DRIVER CONDITION
- FATIGUE ☐
- EXCESSIVE DRIVING HOURS ☐
- DRUGS OR ALCOHOL ☐
- OTHER IMPAIRMENT ☐

BRAKES
- INOPERATIVE (ONE OR MORE) ☐
- OUT OF ADJUSTMENT ☐
- AIR LOSS ☐
- BREAKAWAY BRAKES ☐
- RUPTURED LINE ☐
- WHEEL LOCKUP ☐
- PARKING BRAKE ☐
- EMERGENCY STOP SYSTEM ☐
- VACUUM SYSTEM FAILURE ☐
- HYDRAULIC SYSTEM FAILURE ☐
- OTHER BRAKE DEFECTS ☐

LOADING
- INADEQUATE SECUREMENT ☐
- LOAD BINDER FAILURE ☐
- REGULATED LOAD ☐
- NON-REGULATED LOAD ☐

OTHER EQUIPMENT
- SAFETY CHAIN ☐
- DRAWBAR ☐
- TRAILER HITCH ☐
- FIFTH WHEEL ☐
- STEERING SYSTEM ☐
- TIRES ☐
- WHEELS ☐
- FRAME ☐
- SPRINGS & HANGERS ☐
- AXLE ☐
- LAMPS ☐
- CAB LATCH ☐
- OTHER ☐

SIZE
- HEIGHT ☐
- WIDTH ☐
- WEIGHT ☐
- LENGTH ☐
- PERMIT LOAD ☐
- PERMIT VIOLATION ☐
- VC SIZE VIOLATION ☐

USCAR 15-1 4 75

FIGURE B-4. CALIFORNIA HIGHWAY PATROL COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT

B.3. The CVARS and Instructions for Completion

The Commercial Vehicle Accident Report Supplement is designed to serve two purposes:

a) Identify load types, equipment defects and other miscellaneous information relating to commercial vehicles involved in accidents.

b) Identify equipment, loading, size, and driver conditions, which cause or contribute to commercial vehicle accidents or accident severity.

This report is designed to provide information for use by the Department, the University of Southern California, and the Motor Vehicle Manufacturers Association of the United States. The conclusions derived from the information provided by the reports may have a significant influence on future legislation and Federal Motor Vehicle Safety Standards. The importance of completing the reports accurately cannot be overemphasized. If in the officer's opinion equipment failure was a factor requiring an in-depth examination, it is anticipated that the Area Commercial Officer or the Zone Motor Carrier Safety Unit will be called to assist in completing the report.

A report supplement is required for each commercial vehicle involved in an accident, with the exception of pickups and vans with single rear tires. (A report is required for other small, two-axle, double rear-tire trucks such as rental trucks.) A report shall be filed even if the commercial vehicle is only indirectly involved in the accident, e.g., a truck is stalled on the road and an accident occurs due to the resulting congestion, or if a lost load causes an accident. The report supplement consists of some items which describe the accident and the vehicles involved, and others which should be completed only if they are considered to have caused or contributed to the accident or its severity. For these latter items, it is not essential that a violation be provable beyond a reasonable doubt. For example, if interrogation or driver condition indicates that a driver was using drugs, it is not necessary that a blood or urine analysis prove positive in order to indicate on this form that drugs were a contributing factor.

ACCIDENT AND VEHICLE DESCRIPTORS

Accident report identifier is the 19-digit number on the accident report comprising 10 date-time digits, the four-digit CII number, and the identification number of the investigating officer.

NUMBER OF COMMERCIAL POWER UNITS INVOLVED

This number should be equal to the number of report supplements required by the accident. It will generally be the same as the number of drivers of commercial vehicles involved in the accident.

TOWED SPECIAL VEHICLE

Check this item if the vehicle is special mobile equipment, special construction equipment, an implement of husbandry, a towed fork lift, or similar equipment being towed.

INJURED PASSENGERS

Use the Party Number (P-1, P-2, etc.) assigned to the commercial vehicle in the Form 555 report of the accident.

UNINJURED PASSENGERS

Record total uninjured passengers this commercial vehicle, record all uninjured in all other vehicles.

COMMERCIAL VEHICLE DESCRIPTION

Single-unit vehicles will be either "trucks," "truck tractors," or "buses." Double-unit vehicles will be "truck tractor" or "truck" towing another single vehicle. Three-unit vehicles will be a "truck tractor" or "truck" towing two or more vehicles. A "semitrailer" with auxiliary dolly will be classed as a "trailer." Specialized towed vehicles will be classed as "trailers" or "semitrailers," according to the type vehicle they most closely resemble. For example, a roofer's tar pot would be classed as a "semitrailer," also check "towed special vehicle."

Check the appropriate "axle," "body type," "cargo," "brake," and "75 or later" model boxes for each unit in the commercial vehicle combination. The body type is to be marked as the type the vehicle most nearly resembles. (The term "conventional" is used indirectly in the form to construe a vehicle with the engine mounted forward of the driver's compartment.) The term "cabover" box refers to a vehicle that does not have the engine mounted forward of the driver's cab. The "cabover" box should be marked also for buses with the driver's cab located over the engine and for all rear-engine bus types. The vehicle is "laden" if it carries any cargo or portion of a cargo other than equipment used with the vehicle, e.g., tire chains, mats used by furniture movers, etc.

The appropriate brake system type for each vehicle or unit is to be marked "Air" when the brake system uses air pressure acting on brake chambers at the wheels to apply brakes.

"Hydr" is to be marked when the brakes at the wheels are hydraulic, including brake systems which are air or vacuum assisted.

"Elec" is to be marked when the brakes are applied electrically (e.g., mobile homes).

"Other" is to be marked when the brake system consists of types other than air, hydraulic, or electric or a combination of these on a single vehicle unit.

"Spring" is to be marked if the vehicle or unit is equipped with spring brakes for parking or emergency stopping purposes.

"75 or Later" refers to the year model of the vehicle or unit. The purpose is to assist in identifying vehicles, power units, and trailers with air brake systems conforming to new federal requirements for air brake systems (FMVSS 121).

"Speed This Vehicle." This item refers to the speed of the commercial vehicle at the time the hazard was recognized. It is to be an estimate based on skid marks, or witnesses' statements, or the driver's estimate of his speed at the time he first became aware of the hazardous situation. It may be left blank if a reasonably close (within 10 mph) estimate cannot be made.

"Front Axle Brakes." If the front axle is obviously equipped with brake drums or disc brake rotors and chambers or has visible brake fluid lines indicating the presence of brakes, check the "Yes" box regardless of their operating status. In the absence of any devices indicating front wheel brakes, check the "No" box.

"Single Brake Control." This item applies only to combinations of vehicles and refers to the requirement that a single control in the cab will apply both the power unit and trailing unit brakes. It is normally the foot brake control. Full air brake systems, with rare exceptions, are so equipped. Power units with hydraulic brake systems often are not so equipped and must be checked. If trailers are equipped with surge brakes, mark the "No" box.

"Drive Axles." This item should be checked as appropriate to indicate the number of drive axles on the power unit. If the motor vehicle is equipped with two rear axles, check the "2" box regardless of whether one or both axles are "driving axles." A two-axle tractor with an auxiliary dolly installed (jeep, Jo-dog converter gear) to convert it to a three-axle is considered as having two drive axles.

"Driver Experience." Enter the number of years of experience that the driver has been driving this type vehicle or combination based on interrogation of the driver. If driver experience is less than one year, put in the fraction which most nearly represents the time driving. Example: 1/2 would represent 6 months, 2/3 would represent 8 months, and 3/4 would represent 9 months.

"Odometer Reading." Check odometer reading and note in appropriate mileage boxes.

LOAD TYPE

Check the appropriate "load" type description unless all units of the commercial vehicle are empty of freight and passengers.

"Regulated Load." "Regulated loads" are those cargo loads subject to loading and securement regulation by the Department of the California Highway Patrol. If a "regulated load" is carried, check the appropriate box.

"Nonregulated Load" types are loads not subject to loading and securement regulation by the Department. Check the box which most closely describes the nonregulated load type. Check the "other" box for miscellaneous loads that do not fit the generalized categories.

"Permitted Loads." Check this item if the load is oversized or overweight but operated under a permit issued by the California Department of Transportation or local highway authority.

"Passengers." Check the "farm labor employees" box if the passengers riding in the commercial vehicle are so designated. Check the "other" box if this applies.

SUPPLEMENTAL INFORMATION

Check the appropriate boxes under this item.

"Jackknife" refers to a condition of uncontrolled misalignment between the towed and towing vehicles. Check either the "prior to collision" box or "after collision" box if the jackknife occurred prior to or after the collision.

"Separation of Units" refers to inadvertent disconnection of the fifth wheel halves between a tractor and semitrailer resulting in a separation of the semitrailer from the tractor, or a failure of a drawbar, hitch, or coupling device. When the connection is a trailer hitch or drawbar, the term refers to a failure in the hitch or drawbar connection, which causes separation of this equipment regardless of whether the safety chain holds the units together. If the safety chain also fails, a check must be made in the appropriate box under "Causation or Contributing Factors." Check the appropriate box noting if the separation occurred "prior to" or "after the collision."

"Cargo Spill." Check the appropriate "prior" or "after" box if the cargo was spilled prior to or after the collision event.

"Cargo Shift." Check the appropriate "prior" or "after" box if the cargo obviously shifted position on the vehicle prior to or after the collision.

"Rollaway" refers to a vehicle which is driverless and rolls away from a parked position.

"Spring Brakes Not Releasable." (Emergency Stopping System.) Refers to a condition where the truck is stalled on the roadway with the spring brakes locked and they cannot be released by the control valves in the cab of the vehicle.

"Spring Brakes Activated While Moving." Refers to a condition when the spring brakes are activated inadvertently while the commercial vehicle is in motion under normal operating circumstances.

"Car Underride." Refers only to rear-end collisions wherein the car struck the rear of the truck and has gone under or partially under the truck.

"Truck Override." Refers only to a commercial vehicle front-end collision wherein the truck strikes the rear end of a car or other vehicle and has gone over or partially over the struck vehicle bumper.

ROADWAY ALIGNMENT

Check two boxes under this item to indicate grade and road curvature at the scene of the accident, as it appeared to the commercial vehicle driver, e.g., if the commercial vehicle is going downhill into a curve to the left, mark the "Downhill" and "Curved Left" boxes.

REAR LAMPS

Check the "no apparent defect" box if the various rear lamp types are functioning normally. Check the appropriate status of "tail," "stop," and "clearance" lamps of the rear unit of the vehicle combination whether or not rear lamps appeared to be a contributing factor to the accident. Check the "inoperative" box for each lamp type if one (1) or more of the lamp units are not functioning. Check "broken" if appropriate.

BRAKING PERFORMANCE

Responses to items in this category should be based on the commercial vehicle driver's response to questions directed to him by the investigator. It should be left blank if interrogation at the scene of the accident is not possible unless skid marks from the involved vehicles are discernible. The purpose of this item is to determine how the brakes performed and whether braking caused abnormal deviations from the line of travel, or loss of control of the vehicle.

"Braking in Lane" box is to be checked if the driver applied brakes and did not attempt to steer the vehicle from its normal line of travel.

"Steering Only" box is to be checked if the driver steered the vehicle only but did not operate the brakes prior to or during the collision.

"Braking and Steering" box is to be checked if the driver steered the vehicle from its normal path while applying brakes.

"No Brake Caused Loss of Control." This item is to be checked when the vehicle under braking conditions does not abnormally deviate from the line of travel.

"Wheel Lockup." The "Wheel Lockup" box is to be checked if brake application caused one or more wheels to lockup as determined by skid marks of other indications. Some 1975 model and later vehicles using air brake systems are equipped with anti-lock systems; therefore, if there are no skid marks when locked up, the registration should be checked for year/model. Check the appropriate box if lockup may have occurred on either the power unit or trailer unit(s).

"Brake Fade." This item is to be checked only when there is evidence that the brake system is in good condition, the brakes are properly adjusted, and that either water or excessive heat caused the brakes to be ineffective. This item should not be checked for air brake systems unless it is established that the brakes are in proper adjustment.

"Runaway (Grade)" refers to a condition where the driver cannot stop or retard the movement of the vehicle down a grade. In air brake systems the cause is usually brake adjustment. In hydraulic systems the cause is normally heat fade.

"Brake Caused." The purpose of this item is to record when brake application caused an unusual and uncontrolled deviation from the normal line of travel caused by brake application and not related to steering or other action by the driver, road conditions, or external forces such as wind. The term, controlled steering, does not refer to a lockup of wheel caused by braking action. It refers to a condition of uncontrolled skidding out of the normal line of travel. Check the box which most nearly describes the vehicle motion when brake application resulted in "swerving," "weaving," "uncontrolled skidding," or "leaving traveled lane."

"Out of Adjustment." Check this item if the brake pedal on the hydraulic system contacts the floor on first application or if the slack adjusters on air brake systems exceed the permitted travel specified on the Vehicle Equipment Inspection Guide. This item should be inspected (and checked if relevant) in each case of truck runaway if the truck has an air brake system. (See HPG 83.2 Par. 3.6.20.)

"Air Loss." Check this item if the air loss was of a sufficient magnitude to cause the brakes to become inoperative or to cause application of spring or trailer brakes.

"Breakaway Brakes." Check this item if there was a separation between units and the power unit was left without service brakes or there was no brake application of the trailer brakes.

"Ruptured Line." Check this item if a line ruptured in the brake system. This item applies only to hydraulic systems. Look for fluid discharge near the wheels.

"Wheel Lockup." Check this item if the service brakes locked one or more wheels and this caused a loss of control or other condition which caused or contributed to the accident.

"Parking Brake." This item would normally be checked when a parking brake failed to hold a parked vehicle resulting in a rollaway driverless vehicle.

"Emergency Stopping System." This item is to be checked if an emergency stopping system (spring brakes) locked up causing loss of control or a stall on the roadway which contributed to an accident.

"Vacuum System Failure." This item is applicable to vacuum over hydraulic and vacuum brake systems. It is to be checked when there was a failure in the vacuum system which interfered with the stopping capabilities of the vehicle. Check for broken or disconnected hoses to the vacuum booster unit, usually in the engine compartment.

"Hydraulic System Failure." This item is to be checked when there is a failure in the hydraulic system which renders the system inoperative, such as master cylinder, wheel cylinder, or pedal linkage failure. Brake lockup of a hydraulic system is to be included in this category.

"Other Brake Defects." This item is to be checked when other defects in the braking system, not listed above, caused or contributed to the accident.

LOADING

"Inadequate Securement." Check this item if there was improper load securement or if a load was tied and a portion of the load not restrained by ties was lost from the vehicle, or if racks, blocking or other securement devices were inadequate to restrain the load.

"Load Binder Failure." Check this item if a load binder failed causing a load loss.

"Regulated Load." If a regulated load was involved, and contributed to the accident or its severity, check this item whether or not Inadequate Securement or Load Binder Failure has been checked.

"Nonregulated Load." If the load was not a regulated load, but it contributed to the accident or its severity, check this item whether or not Inadequate Securement or Load Binder Failure has been checked.

OTHER EQUIPMENT

"Safety Chain." This would normally be a contributing factor and would be checked when a safety chain was not connected or did not hold after a failure of a drawbar or trailer hitch.

"Drawbar." Check this item if the drawbar has broken or become detached.

"Trailer Hitch." This item is to be checked if the trailer hitch was released, was pulled from the frame, or if the trailer hitch was broken.

"Fifth Wheel." This item is to be checked when a fifth wheel or the fifth wheel mounting bolts failed and the semi-trailer became disconnected or when a semi-trailer was not properly connected to the fifth wheel and the semi-trailer became disconnected.

"Steering System." This item is to be completed when there is a failure of the steering system components, excluding spindles and kingpins.

"Tires." This item is to be completed if a blow-out or flat caused the vehicle to become involved in an accident or created a vehicle fire. It is also to be completed if a recap tread became separated from the tire casing and caused an accident.

"Wheels." This item is to be completed when a wheel fails or comes loose from a vehicle.

"Frame." This item is to be completed if the vehicle frame completely collapses or if a break in the frame causes a condition which interfered with the operation of the vehicle.

"Springs and Hangers." This item is to be completed when a collapse or break of a spring or spring hanger or air suspension system interfered with the operation of the vehicle.

"Axles." This item is to be completed for broken spindles on steering axles or the collapse of an axle or an axle bearing seizure.

"Lamps." Check this item if a lighting defect on the commercial vehicle caused or contributed to the accident. Examples: driving lamps blinded an oncoming driver. No rear lamps—rear-end accident.

"Cab Latch." Check this item if latch or latches holding a tilt cab down failed and permitted the cab to tilt forward.

"Other." Check this item for any equipment failure not specifically listed above.

SIZE

"Height, Width, Length, Weight." Check the appropriate box if the height, width, length, or weight of the vehicle caused or contributed to the accident. A violation is not necessary. For example, if a tractor/semi combination damages a traffic signal light due to off tracking while making a turn, a check in the length category is appropriate.

"Permit Load." Check this item if the vehicle was operated under permit issued by the Department of Transportation.

"Permit Violation." Check this item if the size of the vehicle or load exceeded permit limits.

"Vehicle Code Violation." Check this item if the size or weight of the vehicle or load exceeded statutory limits and was operated without a permit.

PROCESSING AND HANDLING ALL FORM 555'S ON COMMERCIAL VEHICLES AND THE COMMERCIAL VEHICLE ACCIDENT REPORT SUPPLEMENT

Area offices will forward a copy of the CHP Form 555 and the original of the Commercial Vehicle Accident Report Supplement, when completed, for each commercial vehicle, school bus, farm labor bus, and farm labor truck accident to the University of Southern California, Truck Accident Research Project in the pre-addressed, postage paid envelopes provided.

B.4. Coding of the Form 555 and CVARS

The data in the two report forms are combined and coded in a Summary Form, suitable for keypunching. The information is established in three categories, discussed individually below:

B.4.1 Accident Data

B.4.2 Vehicle/Party Data

B.4.3 Human Factors Data

B.4.1. Accident Data

The Summary Form/Accident Data begins with

Case number a. Columns 1-5

Case number b. Column 6

Category 1

Month: Taken from the top of the CVARS under Accident Report Identifier. The code is placed in column 7-8 of coding form card #1.

Category 2

Day of Month: Taken from the CVARS under Accident Report Identifier and placed in columns 9-10 of coding form card #1.

Category 3

Year: The current year, which appears under Accident Identifier on the CVARS green sheet. Place last two digits of year in column 11-12 of coding form card #1.

Category 4

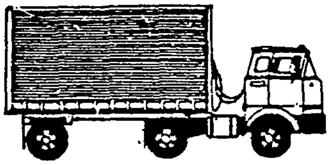
Time: Taken from the CVARS under Accident Report Identifier and placed in columns 13-16 of coding form card #1. Time is recorded in 2400 hours.

Category 5

Reporting Jurisdiction: This is defined as follows:

a. California Highway Patrol

b. Los Angeles Police Department (very limited number of cases)



TRUCK ACCIDENT STUDY
Summary Form
Accident Data

CASE NUMBER — 1 2 3 4 5

CARD NUMBER — 6

1. MONTH — 7 8

01.	January	07.	July
02.	February	08.	August
03.	March	09.	September
04.	April	10.	October
05.	May	11.	November
06.	June	12.	December

2. DAY OF MONTH — 9 10

3. YEAR — 11 12

4. TIME (24 hour military designation) — 13 14 15 16

5. REPORTING JURISDICTION — 17
   1. State (CHP)
   2. Local (LAPD)

6. CII NUMBER (CHP *or* REPORTING DISTRICT (LAPD) — 18 19 20 21

7. COUNTY (Reference List B, California County Codes) — 22 23

8. NUMBER OF PRINCIPAL PARTIES — 24 25

9. NUMBER OF FATALITIES — 26 27

10. NUMBER OF INJURED — 28 29

11. ROAD TYPE — 30
    1. Conventional, one-way
    2. Conventional, two-way
    3. Expressway
    4. Freeway
    5. On-ramp
    6. Off-ramp
    7. Intersection
    8. Other

12. PRIMARY COLLISION FACTOR (Reference List C, Primary Collision Factors) — 31 32

13. PARTY RESPONSIBLE FOR PRIMARY COLLISION FACTOR — 33 34

14. WEATHER — 35

1.	Clear	4.	Snow
2.	Cloudy	5.	Fog
3.	Rain	6.	Other

15. LIGHTING — 36
    1. Daylight
    2. Dusk/Dawn
    3. Dark—street lights
    4. Dark—NO street lights

16. ROAD SURFACE — 37
    1. Dry
    2. Wet
    3. Snowy/Icy
    4. Slippery (muddy, oily, etc.)

17. ROADWAY CONDITIONS (Code 1 for each item checked)
    - A. Holes, ruts — 38
    - B. Loose material on roadway — 39
    - C. Obstructions in roadway — 40
    - D. Construction zone — 41
    - E. Reduced roadway width — 42
    - F. Flooded — 43
    - G. Other — 44
    - H. No unusual conditions — 45

18. RIGHT OF WAY CONTROL — 46
    1. Controls functioning
    2. Controls inoperative
    3. Controls obscured
    4. No controls present

If accident on state highway or at intersection of two state highways:

19. PRIMARY ROAD
    - A. Route number — 47 48 49
    - B. Postmile prefix — 50
    - C. Postmile — 51 52 53 54 55
    - D. USC suffix — 56

20. SECONDARY ROAD
    - A. Route number — 57 58 59
    - B. Postmile prefix — 60
    - C. Postmile — 61 62 63 64 65
    - D. USC suffix — 66

FIGURE B-5. TRUCK ACCIDENT STUDY SUMMARY FORM--ACCIDENT DATA

Accident Data 2

CASE NUMBER — 1 2 3 4 5

CARD NUMBER — 6

21. ACCIDENT EVENT PROFILE (in order of occurrence)

EVENT	INITIATING PARTY	TYPE OF EVENT	RECEIVING PARTY
1	7 8	9 10	11 12
2	13 14	15 16	17 18
3	19 20	21 22	23 24
4	25 26	27 28	29 30
5	31 32	33 34	35 36
6	37 38	39 40	41 42
7	43 44	45 46	47 48
8	49 50	51 52	53 54
9	55 56	57 58	59 60
10	61 62	63 64	65 66

Type

Motor Vehicle Collisions

1. Head on
2. Rear end
3. Sideswipe
4. Angle
5. Broadside
6. Other collisions

Non-Collisions

7. Ran off road
8. Overturn
9. Jacknife
10. Separation of units
11. Separation of cargo
12. Cargo shift
13. Fire
14. Explosion
15. Thrown debris
16. Catalytic vehicle
17. Other

Party

Party Number or

50. Animal in roadway
51. Fixed object in roadway
52. Moving object in roadway
53. Object off roadway
54. Unknown

22. EVENT CODED AS *Collision* BY CHP/LAPD — 67

23 TOTAL NUMBER OF EVENTS — 68 69

FIGURE B-5. (SHEET 2 OF 2)

All reports coded in Truck Research section will be

a) CHP and will therefore take a #1 in column 17 of the coding form card #1.

Category 6

CII Number references the CII number columns under the accident identifier. This number is placed in columns 18-21 of the coding form card #1.

Category 7

County: Refers to the county bounding the scene of the accident. The county can be taken from 555 and transformed into a code by looking at reference list B. Place the code in column 22-23 of coding form card #1.

Category 8

Number of Principal Parties: This is an actual count of the number of separate vehicles and/or pedestrians involved in the accident. Place this code in columns 24-25 of coding form card #1. Note: We do not count separate persons in 1 vehicle as they are included under the same number assigned to the vehicle.

Category 9

Number of Fatalities: This is extracted from the 555 in the upper left corner under number of injured. Place the code for this category in column 26-27 of coding form card #1.

Category 10

Number Injured: Same as above taken from 555 under number killed and coded in column 28-29 of coding form card #1.

Category 11

Road Type: Given in lower right corner of 555 under the category of road type. This code is placed in column 30 of coding form card #1.

Category 12

Primary Collision Factor: This is the reason that the officer has cited as being the cause of the traffic collision. It can be obtained from the category of Primary Collision Factor on the 555. Take the vehicle violation cited and refer to reference list C and select the code that the violation falls under. Place this code in columns 31-32 of coding form card #1.

Category 13

Party Responsible for Primary Collision Factor: Party or vehicle that is cited under Primary Collision Factor for the violation. This number should correspond to one of the assigned party numbers to one of the vehicles involved in the traffic collision. Place this number in columns 33-34 of the coding form card #1.

Category 14-18

The coding categories of:

14. Weather
15. Lighting
16. Road Surface
17. Roadway Condition
18. Right of Way Control

These can all be copied directly from the 555 fact section and placed in columns 35-45 of coding form card #1.

This completes card #1 of the coding form.

We begin card #2 in the same way as card #1 with the case number and a pre-typed #2 in the card number box.

Category 21

Accident Event Profile: This section is probably one of the most important sections with regard to a detailed description of what actually happens at the Traffic Collision site. At this point, we take the 555 and thoroughly go through the narrative and extract all the data on:

1. Party responsible for traffic collision
2. What type of collision occurred
3. How many collisions were involved
4. How many parties were involved
5. What city property was damaged
    a) Any property such as guardrail, paddle markers, traffic signals, street signs, etc.

Refer again to the coding form card #2.

Accident Event Profile: Having extracted all data relating to the actual collisions and the parties involved, we describe in numbers according to Type and Party (see next page) which party did initiating action, what type of action was done, and what party received the action. One complete description of the party initiating the action, type of action, and party receiving the action is called an event. When all the events have been described, look under Primary Collision Factor on the Traffic Collision Report to obtain the event that the officer has coded as the type of collision.

Category 22

Event Coded as "Collision": As per the 555 will be the event that will be selected from the Accident Event Profile listed under Type of Collision on the 555 and placed in category 22. Category 22 is placed in column 67.

Category 23

Total Number of Events: We will place the actual number of events that we have described in the Accident Event Profile in column 68-69. Note: This number does not have to agree with the number coded as the Event Coded as "Collision" in category 22.

B.4.2. Vehicle/Party Data

Begin card #3 the same way as cards #1 and #2.

Case number a. column 1-5

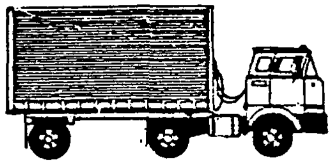
Card number b. already pre-printed on the form as #3 in column 6

Category 1

Principal-Party Number: This is the number of the party that you are going to provide vehicle data on. There must be one sheet of Vehicle Data for each party in the accident. Place code in columns 7-8.

Category 2

Party Description: Found in the description section of the 555, this information can be taken straight from reference list D



TRUCK ACCIDENT STUDY
Summary Form
Vehicle/Party Data

CASE NUMBER — 1 2 3 4 5

CARD NUMBER — 6

1. PRINCIPAL-PARTY NUMBER (CHP/LAPD) — 7 8

2. PARTY DESCRIPTION (Reference List D, Principal-Party Description Codes)
   - POWER UNIT — 9 10
   - UNIT 2 — 11 12
   - UNIT 3 — 13 14
   - UNIT 4 — 15 16

3. VEHICLE YEAR
   - POWER UNIT — 17 18
   - UNIT 2 — 19 20
   - UNIT 3 — 21 22
   - UNIT 4 — 23 24

4. VEHICLE MAKE (Reference List E, Vehicle Make Codes)
   - POWER UNIT — 25 26
   - UNIT 2 — 27 28
   - UNIT 3 — 29 30
   - UNIT 4 — 31 32

5. VEHICLE REGISTRATION (Reference List A, State Codes)
   - POWER UNIT — 33 34
   - UNIT 2 — 35 36
   - UNIT 3 — 37 38
   - UNIT 4 — 39 40

6. COMMERCIAL VEHICLE CONFIGURATION CODE (Reference List F, Vehicle Type Codes) — 41 42 43 44 45

7. POSTED SPEED LIMIT — 47 48

8. SPEED PRIOR TO INVOLVEMENT — 49 50

9. VEHICLE MOVEMENT PRECEDING INVOLVEMENT — 51 52
   - 01 Stopped
   - 02 Proceeding straight
   - 03 Making right turn
   - 04 Making left turn
   - 05 Making U turn
   - 06 Backing
   - 07 Slowing-stopping
   - 08 Passing other vehicle
   - 09 Changing lanes
   - 10 Parking maneuver
   - 11 Entering traffic from shoulder, median, parking strip or private drive
   - 12 Other unsafe turning
   - 13 Crossed into opposing lane
   - 14 Parked
   - 15 Merging
   - 16 Traveling wrong way
   - 17 Stalled in roadway
   - 18 Drifting
   - 19 Evasive action
   - 20 Unknown

10. VEHICLE-CODE EQUIPMENT VIOLATIONS

	NUMBER	LETTER	
1.	53 54 55 56 57	58	59
2.	60 61 62 63 64	65	66
3.	67 68 69 70 71	72	73

11. VEHICLE DAMAGE — 74
    1. None
    2. Minor
    3. Moderate
    4. Major
    5. Total

12. DIRECTION OF TRAVEL — 75

1.	N	5.	NE
2.	S	6.	NW
3.	E	7.	SE
4.	W	8.	SW

13. PEDESTRIAN ACTION — 76
    1. Crossing in crosswalk at intersection
    2. Crossing in crosswalk—not at intersection
    3. Crossing—not in crosswalk
    4. In road—include shoulder
    5. Not in road
    6. Approaching/leaving school bus

FIGURE B-6. TRUCK ACCIDENT STUDY SUMMARY FORM--VEHICLE/ PARTY DATA at the back of this manual. This is a list of the types of parties that are being used in this study. The code will appear as follows:

Power unit	Columns 9-10
Power unit 2	Columns 11-12
Power unit 3	Columns 13-14
Power unit 4	Columns 15-16

Category 3

Vehicle Year: This is the year that is located in the vehicle description section on the 555. Place this number in columns 17-18 of coding form card #3. If there is more than one year for any particular vehicle, indicate so by placing a second year in the columns 19-20, which references the year of the second unit. Likewise use 21-22 and 22-23 for three units or four units, respectively.

Category 4

Vehicle Make: Refers to the company that builds the vehicle. This information will be placed in column 25-26 for a power unit and for second unit and/or other units it will be placed in columns 27-28 and so forth. The code for vehicle make can be found at the end of this manual in reference list E.

Category 5

Vehicle Registration: Refers to the state the license of the vehicle is registered in. The state codes are placed in columns 33-34 for power unit, 35-36 for second unit, and so forth. The codes we have designated for the states can be obtained from the state code section of reference list A.

Category 6

Commercial Vehicle Configuration Code: This is determined by looking at the supplemental green sheet under Axles.

a) Number axles first unit

b) Number axles second unit

c) Number axles third unit

There may be only one unit, in which case we use the number of axles for that unit. If there is more than one unit, on a scratch piece of paper write down in consecutive order the number of axles per unit. For example, suppose you have a two unit vehicle, the first unit has two axles and the second unit has three axles. Taking our information from category 5, vehicle make, for the commercial vehicle as truck, tractor, semi, etc., we then match each unit with the number of axles checked on the green sheet.

Example: Tractor 2 axle

Semi 1 axle

Reference list F, go down the column until coming to the tractor section starting with 32100, proceed down the column until coming to a two axle tractor connected to a two axle semi. The code for this vehicle is 32200. For any truck as first power unit look under the Truck Category and for any tractor as first power unit, look under the Tractor Category. After we have found the first power unit, we proceed in the same manner to locate the second and/or other power units. This information is placed in columns 41-44.

Category 7

Posted Speed Limit: This is the speed limit for that given roadway. Place this in column 47-48 of coding form card #3, and take this information from the vehicle description section of the 555.

Category 8

Speed Prior to Involvement: This would be the speed that the officer has put on the CVARS for the commercial vehicle. If there is more than one commercial vehicle involved, there will be a speed for each vehicle on its accompanying CVARS. Unless stated in the narrative of the 555, the non-commercial vehicle will not have a speed given prior to involvement. This information is placed in column 49-50 of card #3.

Category 9

Vehicle Movement Preceding Involvement: This category references the action being taken by the vehicles before any indication of a traffic collision took place. This information is obtained from the fact section of the 555 and/or based on conclusions by the officer in the narrative. This information is placed in columns 51-52 on coding form card #3.

Category 10

Vehicle Code Equipment Violations: This is a section where the officer has written in the fact section of the 555 any violations against the Vehicle for Vehicle Equipment. This information can also be taken from the narrative if a specific violation code is given. If there are any violations, they go in columns 53-59 on card #3 of the coding form.

Category 11

Vehicle Damage: The damage to the commercial vehicle or the non-commercial vehicle is found in the vehicle description section of the 555. The correct damage estimate is placed in column 74 of the coding form on card #3.

Category 12

Direction of Travel: Also found in the vehicle description section of the 555 and is marked in column 75 of the coding form on card #3.

Category 13

Pedestrian Action: This section is only referenced when there is a pedestrian involved in the accident. The code would appear in column 76 of the coding form. If no pedestrian is involved in the accident, this column is left blank.

B.4.3. Human Factors Data

As has been done on all previous cards, start this card with

Case number a. column 1-5

Card number b. already pre-printed on the form as #7 in column 6

Category 1

Principal Party Number

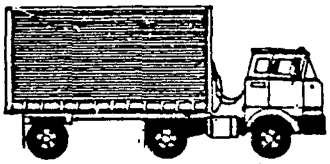
a) the number assigned by the officer at the accident site to each vehicle in the accident.

1. There must be one Human Factors Data sheet for:

   a. Each party

   b. Each injured passenger in the corresponding vehicle

Place this information in column 7-8 on coding form for card #7.



TRUCK ACCIDENT STUDY
Summary Form
Human Factors Data

CASE NUMBER [ ][ ][ ][ ][ ] 1 2 3 4 5

CARD NUMBER [ ] 6

1. PRINCIPAL-PARTY NUMBER (CHP/LAPD) [ ][ ] 7 8

2. SEX [ ] 9
   1. Male
   2. Female

3. AGE [ ][ ][ ] 10 11 12

4. DRUG INFLUENCE
   A. ALCOHOL [ ] 13
      1. Had not been drinking
      2. HBD—under influence
      3. HBD—not under influence
      4. HBD—impairment unknown
   B. NON-ALCOHOL [ ] 14
      1. Not under non-alcohol drug influence
      2. Under non-alcohol drug influence

5. PHYSICAL IMPAIRMENT [ ] 15
   Code 1 if physical impairment noted

6. INJURY SEVERITY [ ] 16
   1. Not injured
   2. Complaint of pain
   3. Minor visible injuries
   4. Severe/major injury
   5. Fatal

7. VEHICLE-OCCUPANT ROLE [ ] 17
   1. Driver
   2. Passenger

8. STATE OF DRIVER'S LICENSE [ ][ ] 18 19
   (Reference List A, State Codes)

9. DOES DRIVER OWN VEHICLE? [ ] 20
   1. Yes
   2. No

10. VEHICLE-CODE VIOLATIONS AGAINST PERSON

	NUMBER		LETTER	
1.	[ ][ ][ ][ ][ ] 21 22 23 24 25	.	[ ] 26	[ ] 27
2.	[ ][ ][ ][ ][ ] 28 29 30 31 32		[ ] 33	[ ] 34
3.	[ ][ ][ ][ ][ ] 35 36 37 38 39		[ ] 40	[ ] 41

11. ASSOCIATED FACTORS
    (Code 1 for each item checked)
    E. Vision obscurements [ ] 42
    F. Inattention [ ] 43
    G. Stop and Go traffic [ ] 44
    H. Entering/leaving ramp [ ] 45
    I. Previous collision [ ] 46
    J. Unfamiliar with road [ ] 47
    M. Other [ ] 48
    N. None apparent [ ] 49

12. DRIVER EXPERIENCE THIS TYPE OF VEHICLE
    A. Years [ ][ ] 50 51
    B. Months [ ][ ] 52 53
    C. Days [ ][ ] 54 55

FIGURE B-7. TRUCK ACCIDENT STUDY SUMMARY FORM--HUMAN FACTORS DATA

Category 2

Sex: Whether the party being described is male or female, obtained from the 555 vehicle description section. This information is placed in column 9 on the coding form for card #7.

Category 3

Age: Also taken directly from the 555 vehicle description section and placed in columns 10-12 of coding form card #7.

Category 4

Drug Influence

a. Alcohol

b. Non-alcohol

These two categories are given in the fact section of the 555 and will already be classified for each party involved in the traffic collision. The classification number for (a) will go in column 13 and the classification for (b) will go in column 14 of the Human Factors sheet in card #7.

Category 5

Physical Impairment is reserved for specific physical deviations from acceptable driving conditions.

a. Fell asleep at wheel

b. Headache

c. Stomachache

d. On medication

e. Any other conditions that can result in unsafe driving conditions

Place a 1 in column 15 if any of the above deviations occur.

Category 6

Injury Severity: Located beneath the vehicle description on the 555. There should be one complete description for each injured person of either party involved in the accident. Place the injury severity for the Human Factor card of the party you are describing in column 16 of coding form for card #7.

Category 7

Vehicle Occupant Role: In the vehicle description section of the 555 the principal party/drivers are given. If there are any passengers that are injured, they will appear beneath the vehicle description in the Extent of Injury section; do not use a human factors sheet for uninjured passengers. Therefore, unless you are describing an injured passenger column 17 of card #7 will have a 1. If the vehicle was parked or unoccupied, then leave column 17 blank.

Category 8

State of Driver's License: This is based on the same state code reference list we used to describe the state of registration of vehicle. See reference list A. This code will go in column 18-19 of coding form card #7.

Category 9

Does the Driver Own the Vehicle: Ownership of the vehicle is determined by whether the driver is the same person as the registered owner of the vehicle. If the two are the same, put a 1 in column 20 of coding form card #7. If the answer is no, put a 2 in column 20 of coding form card #7.

Category 10

Vehicle Code Violations Against Person: In the fact section and/or the narrative, the officer will specify certain vehicle code violations against the party(ies) responsible for the collision. For each party, these codes are placed in columns 21-27, 28-34, or 35-41 of the human factors data sheet, card #7.

Category 11

Associated Factors: These factors involve indirect reasons for the traffic collision. There is rarely a time when both parties have no associated factors apparent. Usually, there is at least inattention on the part of one of the parties. Be sure to include any associated factors you extracted from the narrative that have been overlooked by the officer. These factors are coded in columns 42-49 of coding form card #7.

Category 12

Driver's Experience This Type Vehicle: This category applies only to the commercial vehicle for which we have a CVARS. On the

CVARS, there is a column for driver's experience, and all we do is place that number in the correct column:

Years	50-51
Months	52-53
Days	54-55

of the coding form for card #7.

APPENDIX C

DESCRIPTIONS OF THE COMPUTATIONS IN THE VARIOUS AREAS OF ANALYSIS OF THE STUDY

This appendix describes the computer operations and/or provides examples of the computations carried out in the following phases:

C.1 Data Base Development

C.2 Univariate Analysis

C.3 Cross-Tabulation Studies

C.4 Linear Regression Analyses

C.5 Contingency Table Analyses

C.6 Exposure Estimation

C.1. Development of the Data Base

Truck accident data have been collected and classified into the following four categories:

a) General Accident Data

b) Vehicle/Party Data

c) Human Factors Data

d) Commercial Vehicle Supplement Data

The information is first collected on standard reporting forms, then transferred to punched cards, and eventually to magnetic tapes. Because multiple vehicles and/or parties can be involved in an accident, multiple cards are necessary to represent and store the information.

The basic structure of the resulting data base is designed for fixed-length records, and is as follows:

Each record (i.e., each accident report, or case) has a total of 16 cards, and the cards are arranged thus:

$$1 - 2 - 3_1 3_2 3_3 3_4 - 7_1 7_2 7_3 7_4 - 4_1 5_1 6_1 4_2 5_2 6_2$$

as illustrated in Table C-1 below.

TABLE C-1. CARD ARRANGEMENT

Card No.	Information
1, 2	General Accident Data
3[a]	Vehicle/Party Data
7[a]	Human Factors Data
4,5,6[b]	Commercial Vehicle Supplement Data

[a]A total of four in each record.

[b]A total of two in each record.

There may be only one card #1 and card #2 in any particular accident, since their information relates to the entire accident. But for card #3, card #7, and cards #4, #5, and #6, whose information relates to each individual vehicle or person involved, several of each card are necessary when multiple parties are involved. As discussed in Section 2, accidents of concern in the analysis have been limited to those with involvements of up to four vehicles and/or parties, four persons (including drivers of vehicles), and two commercial vehicles (resulting in the deletion of 92 out of 3,022 cases) to facilitate the establishment of fixed length records. In deciding on these constraints, it was found that:

a) In the data base, the maximum number of persons involved in any accident is 21. However, accidents with more than four persons (including drivers) comprise less than 3% of the entire data base. Hence, only those accidents with four or fewer persons were retained in the file. The remainder were set aside for any manual analysis that may be desired.

b) Only a maximum of four vehicles (commercial and non-commercial) need be considered. It is attained only when the four persons involved in the accident are all drivers.

c) By screening the entire data base, it was found that accidents that satisfied both of the above conditions and certain other basic study requirements (e.g., commercial vehicle weight must be greater than 10,000 lbs.) are those that involve two or fewer commercial vehicles.

A last constraint is therefore that only accidents with one or two commercial vehicles are treated.

Note that the second and third constraints, although implemented separately in the processing, are essentially implicit in the first constraint. Hence, a total of only about 3% of all cases are rejected by the constraints.

Each vehicle/party involved, and each person involved in an accident, requires one card for storage of pertinent information. Each commercial vehicle description supplement requires three cards.

It follows from the foregoing considerations that there will always be four cards for Human Factors Data, four cards for Vehicle/Party Data, and six cards for Commercial Vehicle Data. The fixed-length record format is shown in Table C-2.

TABLE C-2. FIXED-LENGTH RECORD FORMAT

	Card No.			
	1 2	3_1 3_2 3_3 3_4	7_1 7_2 7_3 7_4	$4_1 5_1 6_1$ $4_2 5_2 6_2$
Type of Data	General Accident Data	Vehicle/Party Data	Human Factor Data	Commercial Vehicle/Party Data
No. of Cards	4	4	4	6

For example, for an accident involving three vehicles—two commercial and one non-commercial—and one injured passenger, the record would appear as follows:

$$1\ 2\ 3_1 3_2 3_4 3_{\emptyset}\ 7_1 7_2 7_3 7_{4*}\ 4_1 5_1 6_1\ 4_2 5_2 6_2$$

where $3_{\emptyset}$ = blank card and the asterisk (*) = injured passenger.

As indicated, some of the card 3's, 7's, and 4,5,6's can be blanks, since not all accidents involve four vehicles, or two commercial vehicles.

C.2. Univariate Analysis

The univariate analysis procedures are divided into four sections, as shown below and in Figure C-1:

a) General Accident Data

b) Commercial Vehicle Data

   i) General Information

   ii) Truck
       Tractor
       Semi-Trailer
       Full Trailer
       Dolly
       Bus
       School Bus
       Farm Labor Bus
       Farm Labor Truck

c) Non-Commercial Vehicle Data

d) Human Factors Data

   i) Commercial Vehicle Driver

   ii) Commercial Vehicle Passenger

   iii) Non-Commercial Vehicle Driver

   iv) Non-Commercial Vehicle Passenger

The General Accident Data univariate table is obtained from cards 1 and 2 through an SPSS program (CRD1237.SPSS.CNTL). Using

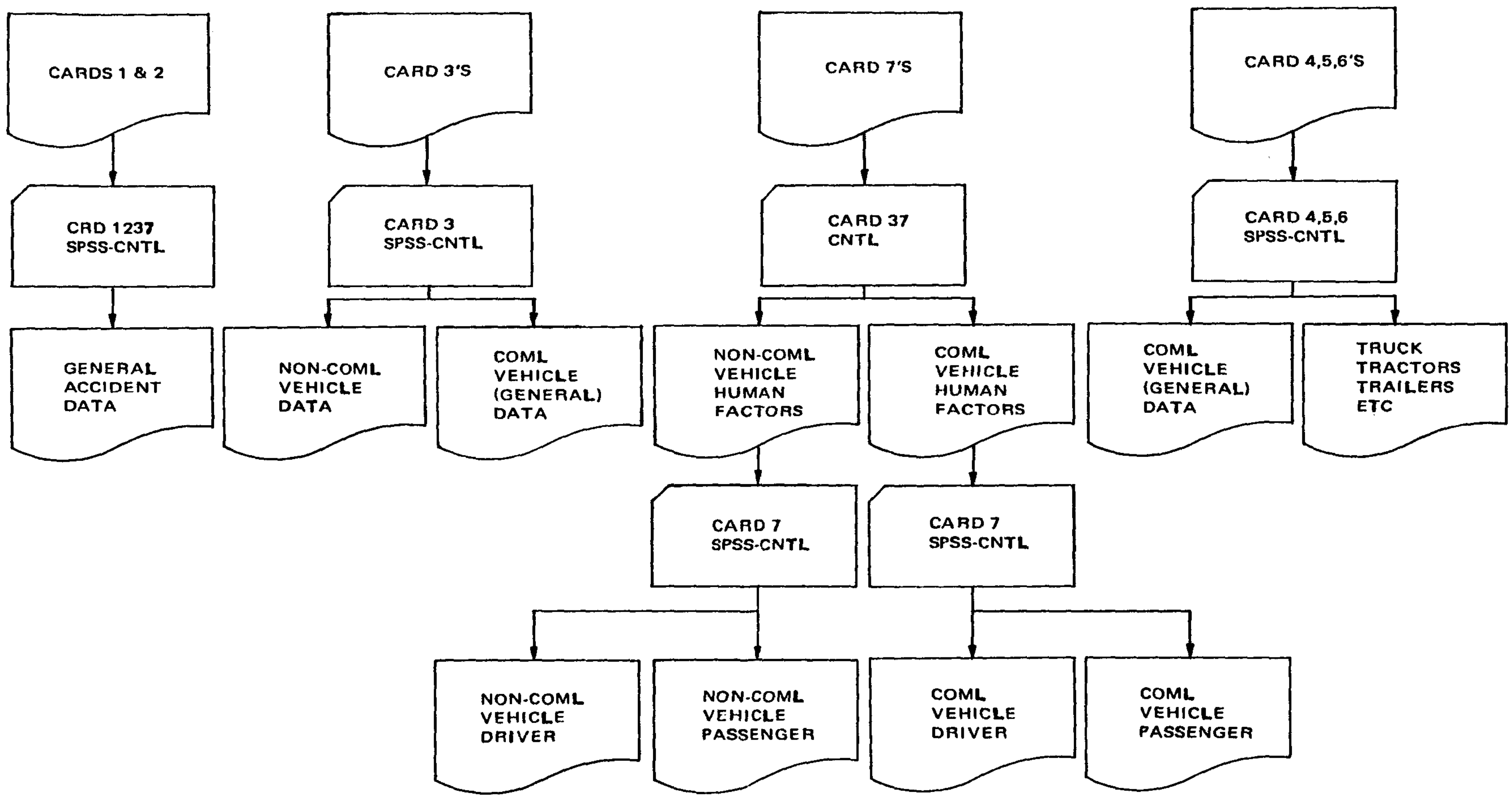


FIGURE C-1. UNIVARIATE TABLES GENERATION PROCEDURE the program CARD37.CNTL, two sub-files are created: for non-commercial vehicle and commercial vehicle human factors, respectively. The program CARD37.CNTL, through both cards 3's and 7's, and by screening and matching party numbers in each accident, separates the human factor information into the two sub-files. Each sub-file is then run through an SPSS program (card 7.SPSS. CNTL) to create its own univariate tables. Each of the two human factor files in turn has two sets of univariate tables—one for the driver and the other for passengers only.

Since card 3's also contain vehicle/party data for both commercial and non-commercial vehicles, it is necessary to use the commercial vehicle configuration code (item 6 on each card 3) to distinguish the two during the process of generating the univariate tables for commercial vehicle data and non-commercial vehicle data. The SPSS program used for both commercial and non-commercial vehicles is then CARD3.SPSS.CNTL.

Cards 4, 5, and 6 contain only commercial vehicle information. Using the SPSS program—CARD456.SPSS.CNTL—the univariate tables for both general commercial vehicle information and for information specific to each configuration, e.g., truck, tractor, etc., are generated.

C.3. Cross-Tabulation Studies

The cross-tabulations are performed using the SAS. SAS is chosen because of its extensive capabilities for data manipulation. Since the present data base is composed of multiple cards and is structured with a fixed-length record format with embedded blanks to fulfill the missing and not applicable items, the selection of the variables involved requires a number of steps.

Consider, for example, the cross-tabulation of Cabover vs. Commercial Vehicle Occupants Injury Severity (see Section 3). To generate this table, it is necessary to involve the following variables:

a) Cabover or not

b) Party number

c) Injury severity

Because Cabover applies only to a truck, tractor, bus, school bus, or farm bus, and <u>not</u> to a trailer or dolly, it is necessary to do the following:

a) Check whether Cabover applies or not in the commercial vehicle section of the record.

b) If it applies, note the party number of the vehicle with the Cabover configuration.

c) Check the human factors section for the corresponding party number's level(s) of personal injury severity.

d) With these necessary pieces of information, the cross-tabulation can be produced using the SAS/FREQ package, and employing the following commands:

```
PROC FREQ DATA = TRUCK DATA
TABLES CABOVER * INJURY SEVERITY
```

The entire procedure can be illustrated with the diagram and flow-diagram in Figures C-2 and C-3:

Card No.			
1 2	3_1 3_2 3_3 3_4	7_1 7_2 7_3 7_4	$4_1 5_1 6_1$ $4_2 5_2 6_2$
General Accident Data	Vehicle Data	Commercial Vehicle Data	Human Factors Data

FIGURE C-2. STRUCTURE OF DATA BASE.

C.4. Regression Analysis

The regression analyses have been performed using SAS also.

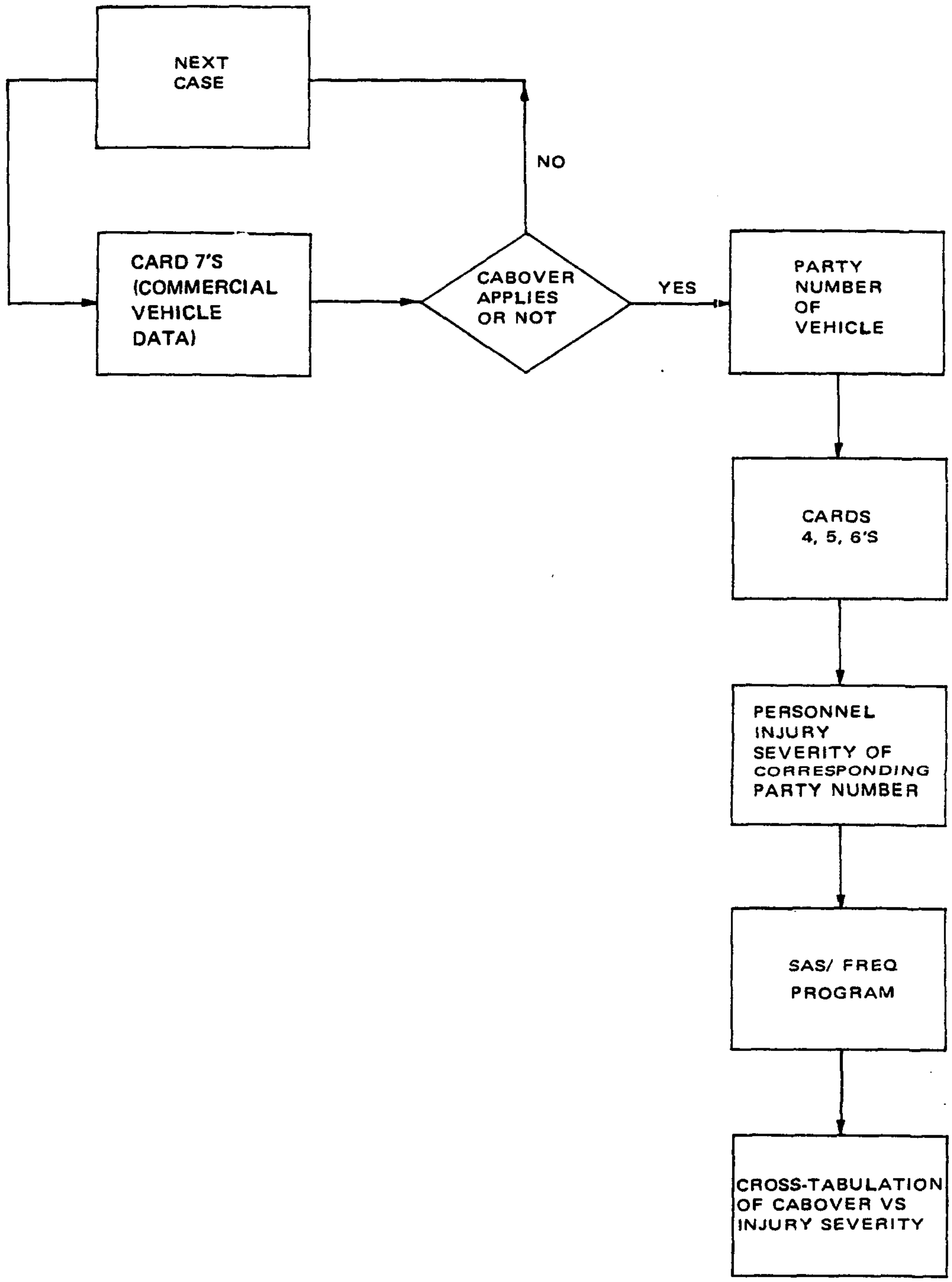


FIGURE C-3. FLOW-DIAGRAM OF GENERATION OF CROSS-TABULATION OF CABOVER VERSUS INJURY SEVERITY

The SAS STEPWISE package is employed. In this particular approach, the technique used to find which variables of a collection of independent variables should most likely be included in a regression model is as follows:

a) One finds first the single-variable model that produces the largest R^2 statistic. R^2 is the square of the multiple correlation coefficient. For each of the independent variables, STEPWISE also calculates an F-statistic reflecting that variable's contribution to the model were it to be included.

b) If the F-statistic for any particular variable has a significance probability less than the specified "significance level for entry," then the variable is added to the model.

c) After a variable is added, however, STEPWISE looks at all the variables already included in the model. Any variable not producing a partial F-statistic significant at the specified significance level for staying in, is then deleted from the model. Only after any required deletions are accomplished can another variable be added to the model. This process terminates when no variable not already in the model meets the condition for inclusion in the model.

In all of the regression analyses, the significance level for entry is 0.50, and the significance level for staying in is 0.10. For all regression computations, STEPWISE prints out the analysis of variation table, regression coefficients, partial sums of squares, F-values, and significance probabilities associated with the partial sums of squares.

As discussed in Section 4.1, since regression analysis requires that all variables be expressible numerically, and since it is desirable to avoid the assigning of some arbitrary "scale" to the levels of categorical, or qualitative, variables, each level of a categorical variable is treated as a separate "independent" variable, with the values 1 or 0 assigned if that level occurs or not. Consider, for example, the variable Road Type; it has eight levels:

a) Conventional, one-way
b) Conventional, two-way
c) Expressway
d) Freeway
e) On-ramp
f) Off-ramp
g) Intersection
h) Other

It is treated as eight independent variables, such as

a) Road type—conventional one-way
   (1) Yes
   (0) No
b) Road type—conventional two-way
   (1) Yes
   (0) No

etc.

A typical SAS STEPWISE procedure is shown by the flow-diagram of Figure C-4. The particular commands for the regression of Underride vs. Vehicle Weight, Road Surface, etc., are, for example:

```
// EXEC SAS, CASDSN = 'TRUCK.DATA'
DATA  SASDATA;
INFILE = CAS;
INPUT ⟨........................
...............................
.................(Record format).
...............................
...............................⟩
⟨Logical statement (if any)⟩

PROC STEPWISE
MODEL C5R36 = C1004 ............
```

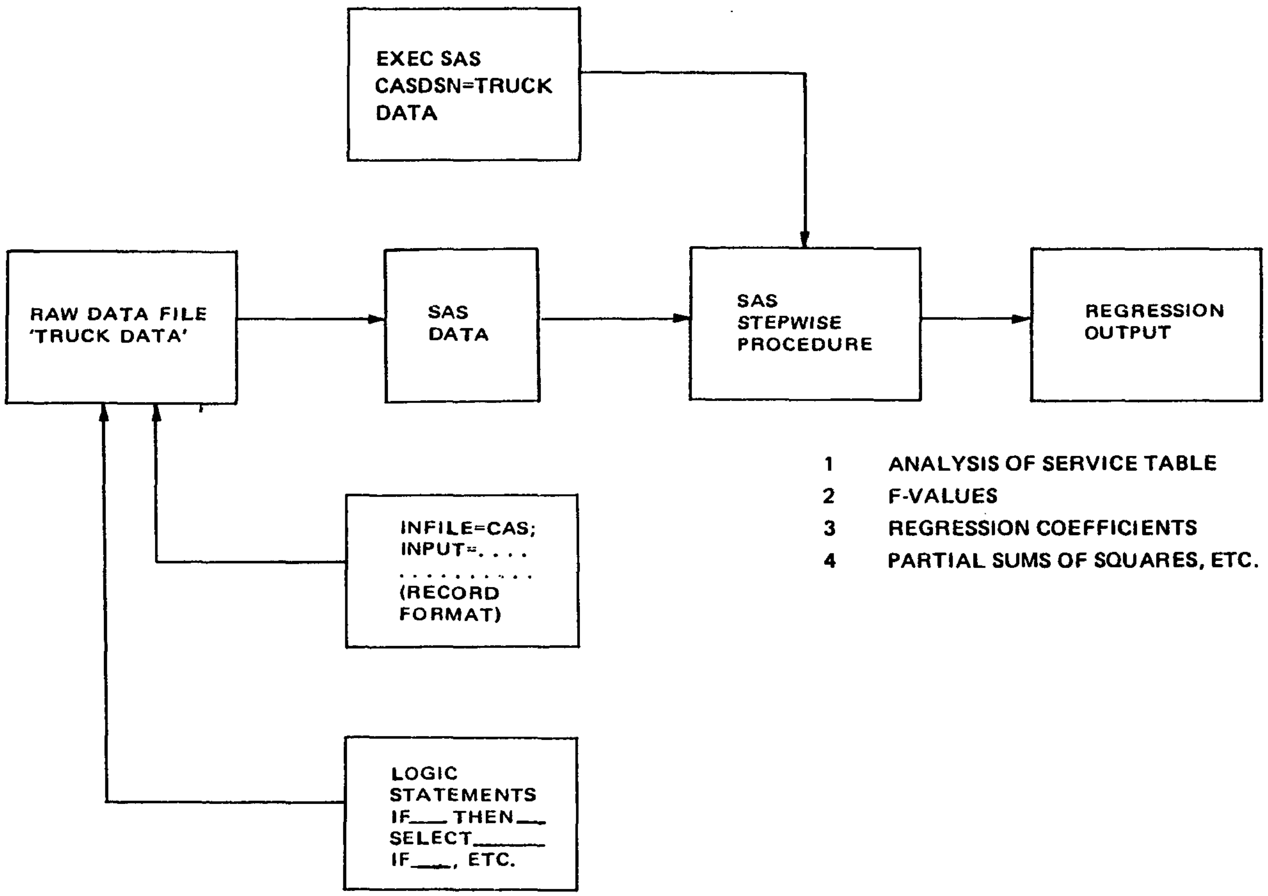


FIGURE C-4. FLOW DIAGRAM OF ILLUSTRATIVE REGRESSION ANALYSIS

```
................................
............................C3F21
TITLE HITS TO THE REAR.
```

The command,

```
EXEC SAS, CASDSN = 'TRUCK.DATA'
```

is used first to initiate SAS procedures, and at the same time designates the data file to be employed. Then, the record format of the data file is specified through:

```
DATA SASDATA
INFILE = CAS;
INPUT <......................
..............(Record format).
.............................>
```

After the record formats are specified, the variables to be used in the regression are selected. Through a set of logic statements, e.g., if _____ then _____, select _____ if _____, etc., the selected variables are arranged in the format that can be processed by SAS. Once this is completed, the regression is executed through the following commands:

```
PROC STEPWISE
MODEL C5R36 = C1004  C1050 ...
..............................
.........................C3F21
TITLE HITS TO THE REAR
```

where C5R36 = Dependent variable (e.g., Underride)

C1004 }
C1056 } = Independent variables (e.g., Weight, Road Type, Road Surface, etc.)
C3F21 }

TITLE ... = give the regression a title.

C.5. Contingency Table Analysis

In this study, contingency table analysis is performed by using CONTAB and KULLITR, two of a series of computer programs for contingency table analysis prepared at George Washington University. (For further information see Reference 5.)

CONTAB and KULLITR are used to analyze joint frequency count data. The counts are presented in a form called a contingency table. A contingency table is generally multidimensional. Each observation (a joint frequency value in a particular cell in the table) is described by several characteristics (dimensions of the table). For instance, the following is a contingency table representing weather over a 364-day period [5].

TABLE C-3. SAMPLE CONTINGENCY TABLE

Weather	Mon	Tue	Wed	Thur	Fri	Sat	Sun
Rain	26	29	23	17	18	37	32
Shine	26	23	29	35	34	15	20

C.5.1. CONTAB

CONTAB is capable of handling several tables with one run and testing more than one hypothesis against each table. CONTAB input is divided into table parameters, table data, hypothesis parameters, and hypothesis data (for details see Reference 5). Further, each table and hypothesis is defined by keywords. These keywords have default values that remain in effect until changed.

Once the program is catalogued in a program library, a deck set-up similar to the following can be used to invoke it.

```
// JOB NAME JOB etc.
// STEPNAME EXEC PGM = CONTAB, REGION = 240K
```

```
// SYSPRINT DD SYSOUT = A
// PRINT DD SYSOUT = A
// SYSIN DD *

     Table parameters and data

// LABELS DD * (optional)

     Level labels (optional)
```

The order of input is as follows:

a) Table key words and their values, followed by a semi-colon, ";"

b) Table data values

c) Hypothesis key words and their values, followed by a semicolon, ";"

d) Hypothesis data values

Then, another set of hypothesis key words and their values, or a new table of key words and their values, can be stated.

The input steps can be illustrated with the help of the following example. This example uses the data provided in the above contingency table. Since this is a two-factor table, the only useful hypothesis is that of factor independence.

```
// JOB NAME JOB etc.
// STEPNAME EXEC PGM = CONTAB, REGION = 240K
// STEPLIB DD DSN = LIBRARY, DISP = SHR
// SYSPRINT DD SYSOUT = A
// PRINT DD SYSOUT = A
// SYSIN DD *
FACTORS = 2, FL(1) = 'WEATHER,' FL(2) = 'DAY'
LIST = 'DMEO,' TITLE = 'WEATHER CONTINGENCY TABLE';
2 7
26 29 23 17 18 37 32 26 23 29 35 34 15 20
TERMS = 2; 1 1    1 2
```

Note that the statement starting with TERMS describes the hypothesis. For instance, in the above example, TERMS = 2 states that there are two fixed marginals (i.e., marginals to be fitted) in the model. Then, numbers following the semicolon describe these marginals. The first and second numbers state that each marginal set involves one factor. The third and fourth numbers (1 2) state the fixed marginals. In this case, for instance, 1 corresponds to the marginal of the first factor and 2 corresponds to the marginal of the second factor.

Following are other examples of hypothesis data:

a) Three-way independence

TERMS = 3; 1 1 1   1 2 3

The hypothesis implies that each factor is independent of all other factors. Marginals not fixed are: (1,2), (1,3), (2,3), (1,2,3).

b) Independence of the third factor from the first two

TERMS = 2; 2 1   1 2   3

This hypothesis involves two marginal sets, the first with two factors and the second with one. Marginal sets not fixed are: (1,3), (2,3), and (1,2,3).

The output of the CONTAB program consists of the following by default: (1) results of applying the particular hypothesis to the table, (2) a summary of all hypotheses applied to the table. Moreover, if one requests other options (see Reference 5 for details), other outputs, such as original data, marginals, residuals, effects, outliers listing, etc. will also be produced.

The evaluation of the various hypotheses can be made by at least considering the following outputs:

a) Information Statistic

b) Degrees of freedom of the model

c) The probability of a greater value (establishing the statistical significance of the model), assuming a χ^2 approximation, with the model evaluated by comparing the Information Statistic with the χ^2 distribution with the stated D.F.

C.5.2. KULLITR

KULLITR extends the capabilities of CONTAB, which provides the basic techniques for the analysis of multidimensional contingency tables. The KULLITR program is more flexible and can accommodate a variety of experimental situations. It is, however, somewhat less convenient to use.

By properly setting appropriate parameters, each cell of the contingency table will be coded lexicographically. The input to the program is divided into three segments:

a) Parameters, followed by a semicolon, ";"

b) Factor names, followed by a semicolon, ";"

c) Table data and constraints

(Note that each marginal is described by one or a series of constraints, as explained below.)

Input to KULLITR can perhaps be best explained by the following hypothetical example. Suppose that a number of trucks involved in accidents are classified according to weight and configuration. Also, for each cell there is available the estimated number of "vehicle miles traveled," V(i,j). The fictitious table is as follows:

TABLE C-4. HYPOTHETICAL KULLITR INPUT

		Configuration		
		1	2	2
Weight	1 V(i,j)	40 (15)	90 (35)	20 (22)
	2 V(i,j)	60 (26)	110 (12)	80 (15)

with the numbers in parentheses being VMT for the categories of vehicles defined by the configuration-weight combinations.

The following log-linear model can be used to describe each problem of interest.

$$\ell n\ p(ij) = L + \tau_i^A\ T_i^A(i,j) + \tau_j^B T_j^B(i,j)$$

$$+ \tau_{ij}^{AB} T_{ij}^{AB}(i,j) + \beta\ V(i,j)$$

$$i = 1,2;\ j = 1,2,3$$

Assume that it is desired to test the following hypothesis:

$$H_o\ :\ \tau_{ij}^{AB} = 0,\ \text{for all } i,j$$

To be able to explain the marginals the so-called "design matrix" must be set up. The following table presents the design matrix for the above example.

TABLE C-5. DESIGN MATRIX

Cell	L	τ_1^A	τ_1^B	τ_2^B	τ_{11}^{AB}	τ_{12}^{AB}	β
11	1	1	1	0	1	0	15
12	1	1	0	1	0	0	35
13	1	1	0	0	0	0	22
21	1	0	1	0	0	1	26
22	1	0	0	1	0	0	12
23	1	0	0	0	0	0	15

Notice that two columns, namely τ_1^B and τ_2^B, are used to explain the B factor, Configuration. This is necessary since Configuration has three levels, and to define the marginal corresponding to configuration, two of them must be fixed.

Following is the input for the above example. Note that the design matrix actually provided in the input is the transpose of the above matrix. In other words, the rows, rather than the columns, of the following design matrix describe the marginals.

```
// JOB NAME JOB etc.
// STEPNAME EXEC PGM = KULLITR, REGION = 240K
// STEPLIB DD DSN = LIBRARY, DISP = SHR
// SYSPRINT DD SYSOUT = A
// PRINT DD SUSOUT = A
// PRINT DD SYSOUT = A
// SYSIN DD *
TITLE = 'KULLITR EXAMPLE PROBLEM'
OBS = 6 CNSTRNT = 5  FACTORS = 2
MATDIF = '1'B  INTERNAL = '1'B  UNIF = '1'B
TOPCOUNT = 50  CONFID = '1'B  NUMSET = '1'B;
FACNAME (1) = WEIGHT  FACNAME (2) = 'CONFIG';
     2    3
     1    1    1    1    1    1  \
     1    1    1    0    0    0  |
     1    0    0    1    0    0  |    Constraint matrix
     0    1    0    0    1    0  |     (Design matrix)
    15   35   22   26   12   15  /
    40   90   20   60  110   80       cell frequencies
```

(For details on the options given above, see Reference 5.)

The model can be evaluated by comparing the MDI (Information-Statistic, outputed as 2I(Z:X*), with the χ^2 distribution. The D.F. for 2I(Z:X*) is n-m, where the C design matrix is m x n. Hence, the D.F. for the above example is 6 - 5 = 1.

C.6. Exposure Estimation: Additional Notes on CALTRANS' AADT Calculation Process

This section provides some additional details on the numerical methods employed for the processing of AADT data by CALTRANS. As was explained in Section 6.2, processing consists of a sequence of adjustments for the traffic growth trends and for necessary expansions from six-hour observational count data to 24-hour estimates. The expansion coefficient for each location is read off the plot in Figure C-5, given a value for the AADT for the year of data collection. However, this AADT value, of course, is not yet known but must be estimated. This estimate is obtained by multiplying the previous year's AADT for the particular location where the observation is made by the traffic trend from the year before. In other words, as a first approximation it is assumed that traffic trend remains constant, and that this year's AADT is approximated by last year's multiplied by the trend.

For example, using in this way an AADT estimate of 35,000 cars for the eastbound Highway 405 in Torrance, California, and a value of 1.05 for the traffic trend in the year 1975, one has:

First approximation to AADT for the year 1976 (in the one direction):

$$= \frac{35,000}{2} \times 1.05$$

$$= 18,375$$

Now the expansion ratio from six hours to 24 hours is read off the vertical axis in Figure C-5 corresponding to 18,375 on the horizontal axis. This value is 2.55. Multiplying each observed volume count by 2.55 then results in the 1976 AADT estimates for 24-hour truck traffic at the given location.

The only exception is for five-axle trucks. The counts for these trucks are multiplied instead by 2.55 x 1.1 = 2.81. That is, subjective judgment by CALTRANS employees is additionally applied

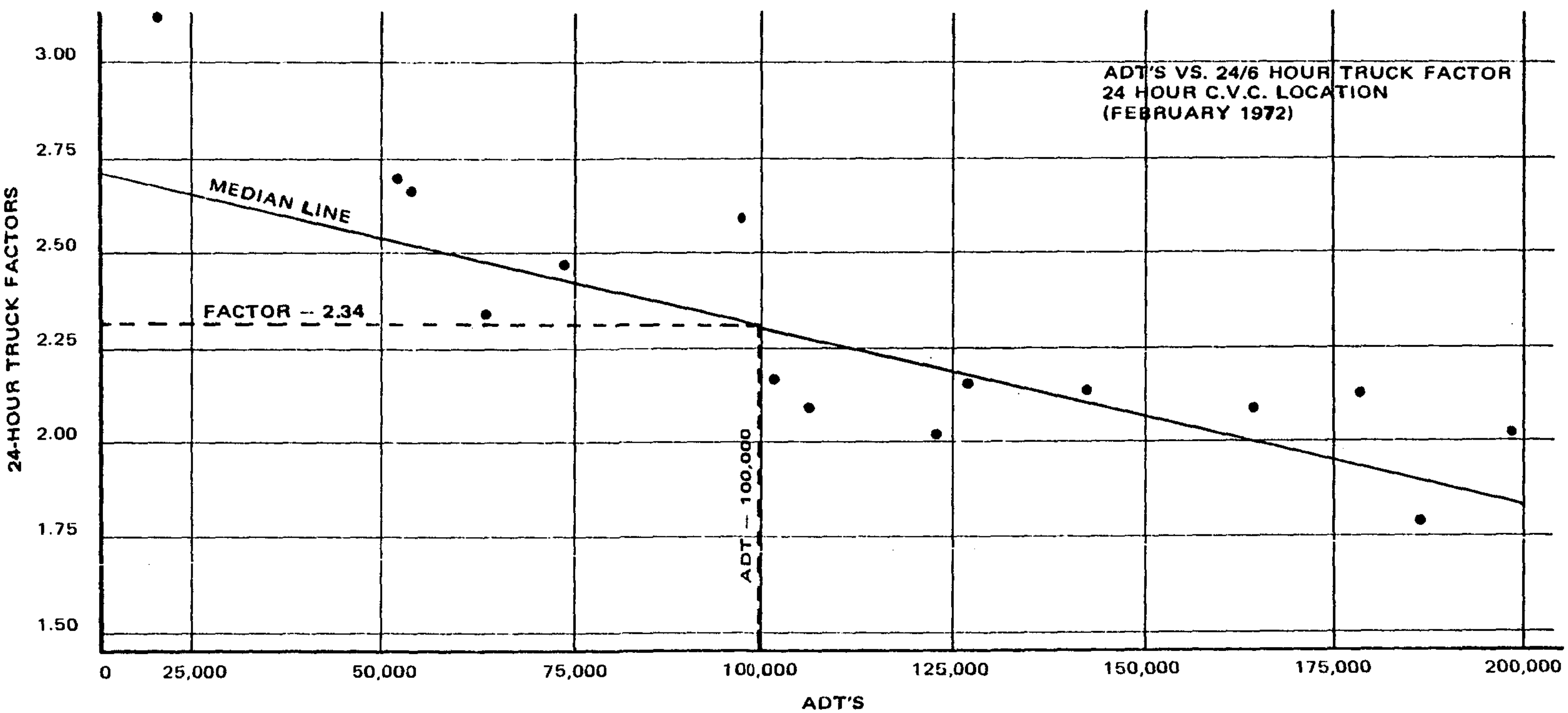


FIGURE C-5. AADT EXPANSION FACTOR CHART

for this particular truck type. It is judged that this truck type has relatively more usage late at night and early in the morning than other types, so that the initial six-hour count is a relatively underestimated value requiring an increased expansion.

The remaining part of the process consists of straightforward addition and rounding off, as explained in Section 6.2.

APPENDIX D

OTHER POTENTIAL EXPOSURE DATA SOURCES

There exist several sources of published data that are potentially relevant to the general commercial vehicle exposure estimation problem. These sources have been briefly surveyed in the present project, but time did not permit a thorough investigation of their best application. This investigation is recommended for future consideration. The results of the survey are given in this appendix.

D.1. Potential Exposure Value of California DMV Commercial Truck Registration Data

The DMV commercial truck registration data identify only the intrastate commercial trucks operating solely within the state. Thus, these data are not a good measure by themselves for large truck exposure unless combined with the Prorate truck data (see Section D.3) to give the total large truck population. The following discussion describes the status of the DMV commercial registration data for the period 15 May 1975–1 May 1976.

a) Complete registration data are available for the 1974 and 1975 calendar year and are now filed at USC. However, calendar year 1976 will never be available. This has come about because of the introduction of year-round registration in the state. The best that can be done for the 1 January 1976–1 May 1976 time period of the present study would be to extrapolate the two-year 1974-75 time interval.

b) The DMV breaks out (up to 1976) the intrastate truck registration according to two classes of trucks, i.e., Regular Commercial and B.E. Commercial. The B.E. Commercial includes a portion of the trucks that are taxed according to the State Board of Equalization requirements. There are 20 body types in each as well as two- to four-axle configurations.

c) The typical DMV data for the population of large trucks (regular commercial—intrastate) are shown by the following set of tables for unladen weights from 1,999 to over 20,000 lbs. for 20 truck/vehicle body types.

Page 3	....	Regular	Commercial/all axles	
Page 4	....	"	"	two axles
Page 5	....	"	"	three axles
Page 6	....	"	"	four axles

d) The corresponding data for B.E. Commercial truck registrations are given in the following tables.

Page 7	....	B.E.	Commercial/all axles	
Page 8	....	"	"	two axles
Page 9	....	"	"	three axles
Page 10	....	"	"	four axles

e) The DMV data do not show a combined tabulation for both Regulation Commercial and B.E. Commercial. This combined tabulation can be easily compiled for the 20 body types and two-, three-, and four-axle vehicle configurations. For example, the total number of tractors (Regular and B.E. Commercial and two to four axles) is shown as follows:

Regular Commercial	32,238
B.E. Commercial	38,617
Total	70,855

This number does not reflect the Prorate truck registrations operating within the state. The Prorate population is considerably larger—about two to three times as large; the exact number is not directly available from any source in the state.

f) The county-by-county distributions of Regular and B.E. trucks by type and axles are not available anywhere in the DMV. The best that is available is an annual listing of total Regular

TABLE D-1. REGULAR COMMERCIALS: JANUARY 1 THROUGH JUNE 30, 1974, MOTIVE POWER AND TYPE VEHICLE WITHIN BODY TYPE

Body Type Code-Description	Type Vehicle				Motive Power					
	New-Res.	Old-Res.	Non-Res.	Total	Butane	Diesel	Electric	Gas	Propane	Total
0 Comml Auto	322	1,360	132	1,814		25		1,788	1	1,814
A Ambulance	67	839	6	912		6		905	1	912
B Bus	68	706	120	894		221		673		894
D Dump	855	22,371	135	23,361	26	3,095		20,188	52	23,361
E Pnl Delivry	426	39,204	175	39,805	7	37	1	39,756	4	39,805
F Flat Bed	4,606	140,852	812	146,270	95	2,296	33	143,603	243	146,270
G Tractor	2,425	23,297	6,516	32,238	34	22,808	3	9,209	184	32,238
H Chassis	614	4,615	57	5,286	6	183		5,082	15	5,286
K Tank	297	6,806	337	7,440	112	1,512		5,414	402	7,440
L Log Bunk	184	1,303	30	1,517		945		571	1	1,517
M Military	2	96	2	100		6		94		100
N Transit Mix	182	2,199	22	2,403		1,551		852		2,403
P Pickup	74,752	1,465,838	10,397	1,550,987	254	247	11	1,550,282	193	1,550,987
R Refrig	142	8,018	26	8,186	15	317		7,846	8	8,186
S Station Wag	1,429	14,818	62	16,309	2	29	1	16,277		16,309
V Van	21,347	200,283	6,408	228,038	60	1,822	4	226,019	133	228,038
W Transport	60	658	60	778	1	136		638	3	778
X Taxi	55	499	7	561	1	3	1	556		561
Y Misc	1,170	20,613	122	21,905	17	613	11	21,242	22	21,905
Z Spec Equip	41	2,259	9	2,309	5	142		2,158	4	2,309
Final Total	109,044	1,956,634	25,435	2,091,113	635	35,994	65	2,053,153	1,266	2,091,113

NOTE: Butane includes commercials with natural gas.

TABLE D-2. REGULAR COMMERCIALS: JANUARY 1 THROUGH JUNE 30, 1974, WEIGHT WITHIN BODY TYPE—2 AXLE

Body Type Code-Description	1,999-Under	2,000-3,000	3,001-4,000	4,001-5,000	5,001-6,000	6,001-7,000	7,001-8,000	8,001-9,000	9,001-10,000	10,001-11,000	
O Comml Auto	2	309	945	419	55	24	6	7	7	7	
A Ambulance	2	3	80	69	216	510	16	5	1	2	
B Bus		24	104	185	75	35	33	38	41	17	
D Dump	5	39	182	568	1,330	1,557	3,068	4,438	3,631	1,823	
E Pnl Delivry	96	9,302	24,990	2,829	1,243	691	330	181	56	26	
F Flat Bed	77	534	10,979	34,945	29,041	18,181	15,788	13,028	8,498	4,759	
G Tractor	2	82	377	454	588	742	1,693	2,249	2,642	3,015	
H Chassis	1	10	868	1,689	636	652	467	317	214	121	
K Tank	1		49	84	180	338	503	739	798	697	
L Log Bunk		4	6	14	29	38	114	99	78	38	
M Military			6	51	23	4		1			
N Transit Mix		3	28	43	28	37	25	15	7	8	
P Pickup	1,730	211,165	979,079	349,186	6,752	1,134	501	324	244	125	
R Refrig	1	8	173	291	904	1,036	639	516	721	928	
S Station Wag	63	2,555	4,771	8,163	673	12	3	12	5	5	
V Van	176	15,042	131,112	29,565	9,545	9,152	5,012	8,443	7,290	5,111	
W Transport	3	6	40	66	92	78	103	91	63	33	
X Taxi	3	48	352	97	37	9	2	2	3	1	
Y Misc	12	273	3,626	5,802	4,564	1,851	1,046	1,012	738	466	
Z Spec Equip		4	60	140	243	231	269	266	220	136	
Total	2,174	239,411	1,157,827	434,660	56,254	36,312	29,638	31,783	25,257	17,318	

	11,001-12,000	12,001-13,000	13,001-14,000	14,001-15,000	15,001-16,000	16,001-17,000	17,001-18,000	18,001-19,000	19,001-20,000	20,001-Over	Total
O Comml Auto	4	5	1	2						5	1,798
A Ambulance		1	1			2					908
B Bus	14	24	14	10	7	6	17	18	37	103	802
D Dump	904	491	216	121	61	55	46	31	13	25	18,624
E Pnl Delivry	8	12	5	2	3	1		1	1		39,777
F Flat Bed	2,641	1,578	753	568	325	215	70	38	19	59	142,096
G Tractor	4,765	2,874	575	154	60	18	9	6	7	12	20,324
H Chassis	86	62	17	19	7	5	2	1	1	1	5,176
K Tank	802	653	330	201	85	37	16	11	10	14	5,548
L Log Bunk	24	13	5	2	4	2	2				472
M Military		2			2	1					90
N Transit Mix	13	13	7	2		1	1		1	8	240
P Pickup	89	57	21	17	9	8	3	2	3	5	1,550,454
R Refrig	934	935	471	188	66	16	12	3	1	2	7,845
S Station Wag	5	2		1		1					16,271
V Van	3,296	1,883	825	464	180	102	26	31	16	26	227,297
W Transport	32	17	7	4	6	3	2		1	1	648
X Taxi	1	2					1				558
Y Misc	404	299	222	236	163	194	38	25	27	84	21,082
Z Spec Equip	136	90	51	62	42	22	14	8	8	15	2,017
Total	14,158	9,013	3,521	2,053	1,020	689	259	175	145	360	2,062,027

TABLE D-3. REGULAR COMMERCIALS: JANUARY 1 THROUGH JUNE 30, 1974, WEIGHT WITHIN BODY TYPE—3 AXLE

Body Type Code-Description	1,999-Under	2,000-3,000	3,001-4,000	4,001-5,000	5,001-6,000	6,001-7,000	7,001-8,000	8,001-9,000	9,001-10,000	10,001-11,000	
O Comml Auto				1							
A Ambulance											
B Bus											
D Dump			2	3	2	2	9	27	59	87	
E Pnl Delivry		2	2	2							
F Flat Bed			4	14	22	15	17	51	109	197	
G Tractor			3			1	3	5	24	104	
H Chassis				2	1		1		4	6	
K Tank				1		1		2	3	11	
L Log Bunk			1				1		3	7	
M Military										1	
N Transit Mix				1	2	1	3	6	10	38	
P Pickup		31	194	128	6	1		3	1	1	
R Refrig						1		1	1	1	
S Station Wag			7	14							
V Van		5	38	11	1	2	1	6	12	9	
W Transport								2		2	
X Taxi											
Y Misc	1			4	3	2	10	20	18	30	
Z Spec Equip				1	3	3	9	10	11	15	
Total	1	38	251	182	40	29	54	133	255	509	
	11,001-12,000	12,001-13,000	13,001-14,000	14,001-15,000	15,001-16,000	16,001-17,000	17,001-18,000	18,001-19,000	19,001-20,000	20,001-Over	Total
O Comml Auto		1	4	3	3	1		2		1	16
A Ambulance					1					3	4
B Bus	1		3	3	2				1	82	92
D Dump	219	472	651	396	331	577	577	567	263	271	4,731
E Pnl Delivry	3	1	4	2	1	6		1		3	27
F Flat Bed	411	706	379	356	480	481	368	217	120	224	4,171
G Tractor	256	841	2,251	3,870	2,780	1,067	370	151	87	101	11,914
H Chassis	11	9	15	12	12	8	6	5	4	9	105
K Tank	13	35	83	183	302	431	309	133	104	281	1,892
L Log Bunk	21	13	25	61	94	258	320	163	38	40	1,045
M Military	2	4	2	1							10
N Transit Mix	328	686	460	126	26	25	26	5	19	83	1,845
P Pickup	11	18	12	32	8	14	13	14	9	15	510
R Refrig	7	6	18	21	99	51	67	39	18	10	340
S Station Wag			5	5	5	2					38
V Van	26	62	64	74	90	65	104	59	25	82	736
W Transport	2	4	4	4	4	7	30	19	25	27	130
X Taxi										2	2
Y Misc	31	41	56	76	61	49	62	55	57	241	817
Z Spec Equip	19	32	29	25	11	16	9	11	9	78	291
Total	1,361	2,931	4,065	5,250	4,310	3,058	2,477	1,441	778	1,553	28,716

TABLE D-4. REGULAR COMMERCIALS: JANUARY 1 THROUGH JUNE 30,1974, WEIGHT WITHIN BODY TYPE—4 AXLE

Body Type Code-Description	1,999-Under	2,000-3,000	3,001-4,000	4,001-5,000	5,001-6,000	6,001-7,000	7,001-8,000	8,001-9,000	9,001-10,000	10,001-11,000	
D Dump											
E Pnl Delivry					1						
F Flat Bed				1							
H Chassis											
N Transit Mix								2	1	9	
P Pickup		1	8	13	1						
R Refrig											
V Van					3						
X Taxi											
Y Misc											
Z Spec Equip											
Total		1	8	14	5			2	1	9	
	11,001-12,000	12,001-13,000	13,001-14,000	14,001-15,000	15,001-16,000	16,001-17,000	17,001-18,000	18,001-19,000	19,001-20,000	20,001-Over	Total
D Dump										6	6
E Pnl Delivry											1
F Flat Bed										2	3
H Chassis							5				5
N Transit Mix	2	4	54	59	34	71	47	29	3	3	318
P Pickup											23
R Refrig							1				1
V Van				1						1	5
X Taxi					1						1
Y Misc						4	1			1	6
Z Spec Equip										1	1
Total	2	4	54	60	35	75	54	29	3	14	370

TABLE D-5. BOARD OF EQUALIZATION COMMERCIALS: JANUARY 1 THROUGH JUNE 30, 1974, MOTIVE POWER AND TYPE VEHICLE WITHIN BODY TYPE

Body Type Code-Description	Type Vehicle				Motive Power					
	New-Res.	Old-Res.	Non-Res.	Total	Butane	Diesel	Electric	Gas	Propane	Total
0 Comml Auto		319	2	321		7		313		321
A Ambulance	2	754		756		1		755		756
B Bus	2	1,400	690	2,092		1,783		308	1	2,092
D Dump	7	4,454	36	4,497	6	2,494		1,995	2	4,497
E Pnl Delivry		1,255		1,255		6		1,249		1,255
F Flat Bed	7	6,192	218	6,417	12	1,447		4,940	18	6,417
G Tractor	13	31,539	7,065	38,617	95	30,053	2	8,301	166	38,617
H Chassis		408	82	490		84		406		490
K Tank	2	1,657	366	2,025	4	1,250		766	5	2,025
L Log Bunk	10	1,891	32	1,933		1,814		119		1,933
M Military		11		11		6		5		11
N Transit Mix		2,296	5	2,301	14	1,933		352	2	2,301
P Pickup	25	2,687	18	2,730	2	75		2,651	2	2,730
R Refrig		151	2	153		44		108	1	153
S Station Wag		604		604		14		590		604
V Van	8	12,767	104	12,879	23	1,465		11,282	109	12,879
W Transport		683	271	954		499		454	1	954
X Taxi	1	4,082	15	4,098	2	5		4,091		4,098
Y Misc	1	5,387	29	5,417	5	354		5,054	4	5,417
Z Spec Equip		155	1	156		30		126		156
Final Total	78	78,692	8,936	87,706	163	43,364	2	43,865	312	87,706

NOTE: Butane includes commercials with natural gas.

TABLE D-6. BOARD OF EQUALIZATION COMMERCIALS: JANUARY 1 THROUGH JUNE 30, 1974, WEIGHT WITHIN BODY TYPE—2AXLE

Body Type Code-Description	1,999- Under	2,000- 2,999	3,000- 4,000	4,001- 5,000	5,001- 6,000	6,001- 7,000	7,001- 8,000	8,001- 9,000	9,001- 10,000	10,001- 11,000	
0 Comml Auto		13	252	22	22	2					
A Ambulance			5	126	274	340	8	1			
B Bus	1	1	3	16	34	4	27	14	13	13	
D Dump			3	5	12	18	100	196	171	149	
E Pnl Delivry		40	150	457	31	177	320	57	10	4	
F Flat Bed		5	64	402	453	698	973	855	586	265	
G Tractor		3	9	31	245	946	3,073	1,998	2,174	4,142	
H Chassis			15	44	22	94	142	42	33	29	
K Tank			1	1	4	11	27	65	103	144	
L Log Bunk				1	2	10	16	19	9	7	
M Military						4			1		
N Transit Mix				1	2		4	1	1	2	
P Pickup	1	289	1,356	776	72	50	31	19	21	15	
R Refrig			3	2	6	6	7	7	19	19	
S Station Wag	2	73	182	288	37	2	2	1		1	
V Van		82	1,002	739	378	542	962	1,598	2,936	2,494	
W Transport			5	34	33	13	23	15	25	29	
X Taxi	2	52	3,605	247	174	5			1		
Y Misc		3	343	1,666	1,387	596	371	229	199	101	
Z Spec Equip			10	19	14	11	10	11	8	8	
Total	6	561	7,008	4,877	3,202	3,529	6,096	5,128	6,310	7,422	
	11,001- 12,000	12,001- 13,000	13,001- 14,000	14,001- 15,000	15,001- 16,000	16,001- 17,000	17,001- 18,000	18,001- 19,000	19,001- 20,000	20,001- Over	Total
0 Comml Auto	1										312
A Ambulance	1										755
B Bus	15	28	25	26	19	20	34	148	217	784	1,442
D Dump	176	68	18	3	8	15	17	6	4	2	971
E Pnl Delivry	4									1	1,251
F Flat Bed	222	88	42	25	6	5	3	3	1	1	4,697
G Tractor	7,830	3,869	793	151	27	17	2	6	1	8	25,325
H Chassis	18	11	1		1						452
K Tank	136	133	41	32	18	5	3	2	2	3	731
L Log Bunk	10	6	1	2	1		1			1	86
M Military											5
N Transit Mix	1	11	2	1			1	5	1		33
P Pickup	19	9	2	2	1			1	1	2	2,667
R Refrig	27	19	15	1			2		1		134
S Station Wag	6	4	1							1	600
V Van	1,336	434	151	60	30	6	3	1	2	3	12,759
W Transport	37	45	38	22	22	2					343
X Taxi	1			1							4,088
Y Misc	91	71	27	13	6	7	3	1	1	8	5,123
Z Spec Equip	3	3	6	1		1					105
Total	9,934	4,799	1,163	340	139	78	69	173	231	814	61,879

TABLE D-7. BOARD OF EQUALIZATION COMMERCIALS: JANUARY 1 THROUGH JUNE 30,1974, WEIGHT WITHIN BODY TYPE–3 AXLE

Body Type Code-Description	1,999- Under	2,000- 3,000	3,001- 4,000	4,001- 5,000	5,001- 6,000	6,001- 7,000	7,001- 8,000	8,001- 9,000	9,001- 10,000	10,001- 11,000	
0 Comml Auto											
A Ambulance											
B Bus											
D Dump						1		1	2	7	
E Pnl Delivry											
F Flat Bed						1	1	13	33	60	
G Tractor							6	7	30	130	
H Chassis										3	
K Tank									1	1	
L Log Bunk										1	
M Military											
N Transit Mix								1	3	11	
P Pickup											
R Refrig											
S Station Wag											
V Van					1		1		2	6	
W Transport											
X Taxi			3			1					
Y Misc			1	1		1	3		3	6	
Z Spec Equip					1		1				
Total			4	1	2	4	12	22	74	225	
	11,001- 12,000	12,001- 13,000	13,001- 14,000	14,001- 15,000	15,001- 16,000	16,001- 17,000	17,001- 18,000	18,001- 19,000	19,001- 20,000	20,001- Over	Total
0 Comml Auto		2	1	1		2	2			1	9
A Ambulance			1								1
B Bus			1	2		2		1	1	643	650
D Dump	6	33	75	140	379	801	1,197	621	186	76	3,525
E Pnl Delivry		1	1		1	1					4
F Flat Bed	80	72	87	187	253	339	297	135	88	74	1,720
G Tractor	428	1,031	2,695	4,353	2,738	1,003	450	211	111	96	13,289
H Chassis	2	7	8	5	5	1	2	1	2	1	37
K Tank	4	12	35	122	191	384	228	89	66	161	1,294
L Log Bunk	2	5	18	76	166	633	593	243	64	46	1,847
M Military		1	3	1							5
N Transit Mix	199	1,015	443	53	41	70	35	6	9	19	1,905
P Pickup	1	2	3	14	9	7	14	12	1		63
R Refrig			1	2	3	2	3	2	1	4	18
S Station Wag	1			1	1			1			4
V Van	12	11	10	13	10	8	15	9	6	16	120
W Transport	3	9	13	60	96	124	113	67	86	40	611
X Taxi	1		1		1			1			8
Y Misc	9	34	27	34	36	22	22	21	4	58	282
Z Spec Equip	1	4	3	7	3	5	7	4	5	10	51
Total	749	2,239	3,426	5,071	3,933	3,404	2,978	1,424	630	1,245	25,443

TABLE D-8. BOARD OF EQUALIZATION COMMERCIALS: JANUARY 1 THROUGH JUNE 30, 1974, WEIGHT WITHIN BODY TYPE—4 AXLE

Body Type Code-Description	1,999-Under	2,000-3,000	3,001-4,000	4,001-5,000	5,001-6,000	6,001-7,000	7,001-8,000	8,001-9,000	9,001-10,000	10,001-11,000	
D Dump											
G Tractor											
H Chassis											
M Military											
N Transit Mix											
R Refrig											
X Taxi											
Y Misc											
Total											
	11,001-12,000	12,001-13,000	13,001-14,000	14,001-15,000	15,001-16,000	16,001-17,000	17,001-18,000	18,001-19,000	19,001-20,000	20,001-Over	Total
D Dump						1					1
G Tractor										3	3
H Chassis			1								1
M Military					1						1
N Transit Mix			57	95	89	84	30	1		7	363
R Refrig					1						1
X Taxi						2					2
Y Misc			1		3	3	5				12
Total			59	95	94	90	35	1		10	384

and B.E. trucks county-by-county (not broken down by type and axle) and for the years 1970 through 1976. A crude estimate could be made on a truck type/axle count basis by applying the 1974-75 Regular and B.E. distributions if desired.

D.2. Potential Exposure Value of California County-by-County DMV Vehicle Registrations

The seven tables D-9 through D-15 identify the county-by-county registrations of trucks and trailers (plus autos and motorcycles) for the calendar years 1970 through 1976. Caution must be used in considering these tables for exposure, since

a) The registrations do not include the Prorate License category of interstate operating vehicles

b) A truck may be registered in one county but may actually operate in one or all other counties.

Nonetheless, these county-by-county numbers can portray a crude measure of use or exposure. A seven-year trend of registrations for CHP Zones II and V can be easily compiled, if needed.

D.3. Potential Exposure Value of California Prorate Truck Data

The Truck Prorate Section of the California DMV provides a source of data that may have some potential value in making truck exposure measurements. Section records are not computerized but consist of forms describing each of some 286,000 large trucks (mostly diesel) operating in interstate commerce. It would be possible to computerize these data and make reasonably accurate truck configuration profile distributions based on truck unladen weights by truck types. It should be recognized that these 286,000 registered prorate large trucks (1976) are excluded from the normal DMV listing of regular commercial trucks (38,000 in 1974) operating in intrastate commerce. Thus, the DMV Regular Commercial registrations give a poor exposure measurement considering only population

TABLE D-9. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1976

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	792,955	159,722	99,221	34,694	1,086,592
Alpine	484	194	110	28	816
Amador	11,314	6,588	3,854	943	22,699
Butte	88,214	37,756	38,220	6,367	170,557
Calaveras	11,242	6,693	4,641	816	23,392
Colusa	9,217	6,501	3,348	572	19,638
Contra Costa	477,013	92,143	61,912	21,737	652,805
Del Norte	10,478	5,258	4,847	607	21,190
El Dorado	45,219	19,802	13,390	3,066	81,477
Fresno	320,418	118,953	72,236	15,078	526,685
Glenn	14,254	9,089	6,206	1,043	30,692
Humbolt	72,686	32,064	23,258	4,271	132,279
Imperial	54,934	23,549	17,285	2,403	98,171
Inyo	12,155	6,919	7,130	1,004	27,208
Kern	246,799	101,988	69,175	17,275	435,237
Kings	41,290	18,533	10,581	2,814	73,218
Lake	22,332	10,103	16,032	1,492	49,959
Lassen	11,329	7,412	6,091	1,010	25,842
Los Angeles	5,428,632	937,884	462,459	218,125	7,047,100
Madera	31,649	16,766	10,873	1,664	60,952
Marin	183,776	27,200	15,269	7,621	233,866
Mariposa	6,990	3,325	3,316	463	13,094
Mendocino	40,088	21,268	15,447	2,624	79,427
Merced	75.744	32,291	20,342	3,950	132,327
Modoc	4,854	3,967	2,222	276	11,319
Mono	4,304	2,461	2,200	291	9,256
Monterey	189,481	47,689	30,706	7,227	275,103
Napa	69,470	20,799	19,059	3,770	113,098
Nevada	27,462	12,758	10,194	2,005	52,419
Orange	1,409,351	266,974	189,483	70,556	1,936,364
Placer	72,801	29,592	21,032	4,967	128,392
Plumas	10,027	5,922	5,031	695	21,675
Riverside	385,886	111,495	126,065	20,084	643,530
Sacramento	533,627	135,433	91,109	26,602	786,771
San Benito	13,991	6,401	3,431	548	24,371
San Bernardino	511,514	147,699	112,474	30,087	801,774
San Diego	1,176,360	256,256	178,845	57,385	1,668,846
San Francisco	397,441	72,084	31,348	10,910	511,783
San Joaquin	219,633	77,281	52,589	10,802	360,305
San Luis Obispo	93,590	32,422	30,572	5,553	162,137
San Mateo	513,662	85,058	48,740	18,457	665,917
Santa Barbara	215,756	49,753	34,592	11,257	311,358
Santa Clara	962,414	185,980	121,267	42,660	1,312,321
Santa Cruz	125,591	34,626	26,949	5,833	192,999
Shasta	66,582	33,746	34,275	4,426	139,029
Sierra	1,714	1,141	733	117	3,705
Siskiyou	24,067	15,982	10,849	1,462	52,360
Solano	135,591	33,849	24,746	7,266	201,452
Sonoma	195,331	62,898	47,214	10,137	315,580
Stanislaus	161,930	62,456	45,991	8,640	279,017
Sutter	33,044	15,645	10,378	2,138	61,205
Tehama	22,206	12,599	11,421	1,560	47,786
Trinity	5,850	4,053	3,786	635	14,324
Tulare	136,799	60,609	38,117	8,351	243,876
Tuolumne	19,410	10,632	8,786	1,479	40,307
Ventura	335,642	77,271	56,790	18,038	487,741
Yolo	70,891	26,870	19,559	4,112	121,432
Yuba	29,666	12,676	9,121	2,128	53,591
Out of State	73,664	73,664	125,760	2,876	279,481
Total	16,257,814	3,794,259	2,570,677	752,997	23,375,747

Total Fee Paid Registrations	23,375,747
Total Exempt Registrations	232,415
Total Vehicles Registered	23,608,162

TABLE D-10. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1975

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	548,750	110,610	72,383	30,888	762,631
Alpine	358	154	79	29	620
Amador	7,398	4,356	2,473	744	14,971
Butte	58,739	24,951	24,950	5,283	113,923
Calaveras	7,423	4,402	2,879	639	15,343
Colusa	6,234	4,424	2,284	508	13,450
Contra Costa	322,512	61,823	43,655	18,945	446,935
Del Norte	7,221	3,555	3,326	548	14,650
El Dorado	29,515	12,680	8,759	2,403	53,357
Fresno	220,962	80,032	49,872	13,597	364,463
Glenn	9,626	6,062	4,115	855	20,658
Humboldt	50,238	22,286	16,245	3,687	92,456
Imperial	37,656	15,802	11,676	2,116	67,250
Inyo	8,475	4,870	4,841	862	19,048
Kern	170,185	68,795	46,711	15,206	300,897
Kings	29,802	12,772	7,359	2,851	52,784
Lake	14,229	6,337	10,087	1,155	31,808
Lassen	7,681	4,927	3,858	889	17,355
Los Angeles	3,775,427	644,575	330,634	194,355	4,944,991
Madera	21,604	11,196	7,241	1,389	41,430
Marin	124,331	18,421	10,602	6,791	160,145
Mariposa	3,833	2,088	1,955	370	8,246
Mendocino	27,202	14,291	10,487	2,188	54,168
Merced	52,585	21,893	13,733	3,549	91,760
Modoc	3,447	2,792	1,550	247	8,036
Mono	2,863	1,669	1,469	242	6,243
Monterey	1 30,450	32,387	20,762	6,618	190,217
Napa	46,525	13,919	13,068	3,363	76,875
Nevada	17,553	8,072	6,414	1,623	33,662
Orange	943,220	178,996	128,179	61,492	1,311,887
Placer	48,050	19,157	13,558	4,217	84,982
Plumas	6,911	407	3,409	589	14,982
Riverside	257,763	73,486	80,685	16,846	428,780
Sacramento	362,673	90,044	62,548	23,281	538,546
San Benito	9,293	4,311	2,363	479	16,446
San Bernardino	345,662	99,038	75,096	25,686	545,482
San Diego	793,646	171,257	120,786	51,820	1,137,509
San Francisco	278,258	50,592	22,279	9,441	360,570
San Joaquin	150,183	52,543	36,779	9,546	249,051
San Luis Obispo	61,790	21,213	19,433	4,697	107,133
San Mateo	352,084	58,052	33,287	15,965	459,388
Santa Barbara	146,042	33,417	23,510	9,588	212,557
Santa Clara	654,980	125,707	83,250	37,497	901,434
Santa Cruz	83,613	23,126	17,977	4,741	129,457
Shasta	44,084	22,233	22,679	3,671	92,667
Sierra	1,153	796	510	97	2,556
Siskiyou	16,385	10,962	7,246	1,293	35,886
Solano	92,100	22,248	16,936	6,403	137,687
Sonoma	129,500	42,133	32,001	8,604	212,238
Stanislaus	109,836	42,052	31,630	7,478	190,996
Sutter	22,443	10,436	7,158	1,919	41,956
Tehema	14,875	8,459	7,618	1,199	32,151
Trinity	3,803	2,641	2,505	543	9,492
Tulare	93,617	40,546	25,852	7,141	167,156
Tuolumne	12,703	7,083	5,804	1,177	26,767
Ventura	222,373	51,067	37,832	15,445	326,717
Yolo	48,015	18,340	13,971	3,570	83,896
Yuba	20,717	8,517	6,108	1,937	37,279
Out-of-State	50,967	75,359	115,403	2,929	244,658
Total	11,119,563	2,588,025	1,789,859	661,231	16,158,678
Total Fee Paid Registration		16,158,678			
Total Exempt Registration		246,185			
Total Vehicles Registered		16,404,863			

TABLE D-11. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1974

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	551,428	106,654	84,193	31,690	773,965
Alpine	349	145	72	20	586
Amador	7,134	4,065	2,318	736	14,253
Butte	57,140	23,573	23,692	5,375	109,778
Calaveras	7,208	4,160	2,781	579	14,728
Colusa	6,299	4,134	2,167	522	13,122
Contra Costa	317,135	58,263	42,252	19,118	436,768
Del Norte	7,370	3,346	3,242	573	14,531
El Dorado	27,799	11,550	8,368	2,352	50,069
Fresno	219,182	75,607	46,982	13,891	355,662
Glenn	9,471	5,814	3,823	884	19,992
Humboldt	50,033	21,609	15,940	3,780	91,362
Imperial	37,514	14,959	11,031	2,168	65,672
Inyo	8,458	4,605	4,867	878	18,808
Kern	167,438	64,290	44,100	15,183	291,011
Kings	29,922	12,045	6,962	2,906	51,835
Lake	13,877	5,841	9,577	1,106	30,401
Lassen	7,636	4,726	3,622	894	16,878
Los Angeles	3,821,798	625,638	329,235	199,733	4,976,404
Madera	20,973	10,577	6,842	1,452	39,844
Marin	122,523	17,623	10,096	6,512	156,754
Mariposa	3,606	1,913	1,891	331	7,741
Mendocino	26,820	13,433	10,064	2,225	52,542
Merced	51,957	20,748	12,658	3,576	88,939
Modoc	3,421	2,752	1,497	232	7,902
Mono	2,620	1,559	1,454	224	5,857
Monterey	127,554	30,596	20,480	6,328	184,958
Napa	45,422	13,016	12,637	3,351	74,426
Nevada	16,460	7,368	6,109	1,512	31,449
Orange	919,916	165,717	128,616	62,007	1,276,256
Placer	46,411	17,921	12,718	4,281	81,331
Plumas	6,732	3,919	3,301	585	14,537
Riverside	252,928	68,293	76,394	16,495	414,110
Sacramento	358,290	85,311	60,660	23,139	527,400
San Benito	9,119	4,066	2,215	470	15,870
San Bernardino	343,264	92,753	72,623	25,656	534,296
San Diego	777,306	161,796	118,122	51,381	1,108,605
San Francisco	285,318	51,649	24,951	9,430	371,348
San Joaquin	148,029	49,947	34,888	9,325	242,189
San Luis Obispo	59,481	19,674	18,090	4,485	101,730
San Mateo	348,201	54,223	37,915	15,680	456,019
Santa Barbara	145,398	31,432	22,626	9,538	208,994
Santa Clara	645,074	120,507	80,399	36,661	882,641
Santa Cruz	81,859	21,774	17,403	4,957	125,993
Shasta	42,264	20,829	21,247	3,616	87,956
Sierra	1,154	770	532	87	2,543
Siskiyou	16,377	10,411	6,825	1,314	34,927
Solano	90,828	20,745	16,264	6,220	134,057
Sonoma	126,618	40,191	30,962	8,698	206,469
Stanislaus	107,075	39,620	29,894	7,506	184,095
Sutter	21,913	9,853	6,733	1,940	40,439
Tehama	14,639	8,095	7,304	1,242	31,280
Trinity	3,639	2,454	2,308	511	8,912
Tulare	92,171	38,280	24,608	7,365	162,424
Tuolumne	12,222	6,559	5,360	1,076	25,217
Ventura	216,423	47,558	35,837	15,009	314,827
Yolo	46,919	17,138	13,326	3,434	80,817
Yuba	20,374	7,876	5,783	1,829	35,862
Out-of-State	53,380	64,886	104,968	3,207	226,441
Total	11,061,869	2,454,856	1,751,824	665,273	15,933,822

Total Fee Paid Registrations	15,933,822
Total Exempt Registrations	235,426
Total Vehicles Registered	16,169,248

TABLE D-12. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1973

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	556,398	93,127	70,229	29,740	749,494
Alpine	314	114	59	18	505
Amador	7,239	3,563	2,128	671	13,601
Butte	57,854	20,496	21,538	4,891	104,779
Calavaras	7,377	3,639	2,545	554	14,115
Colusa	6,515	3,764	2,007	513	12,799
Contra Costa	315,852	50,525	40,384	18,113	424,874
Del Norte	7,836	2,900	3,082	542	14,360
El Dorado	27,641	9,906	7,635	2,129	47,311
Fresno	220,611	65,680	42,654	13,350	342,295
Glenn	9,703	5,155	3,514	788	19,160
Humboldt	52,143	18,730	14,974	3,711	89,558
Imperial	37,705	12,898	10,284	1,921	62,808
Inyo	8,820	4,125	4,719	875	18,539
Kern	171,165	55,243	41,230	14,812	282,450
Kings	30,465	10,258	6,471	2,719	49,913
Lake	13,847	5,097	9,040	964	28,948
Lassen	7,864	4,197	3,187	880	16,128
Los Angeles	3,870,284	539,741	317,302	191,183	4,918,510
Madera	21,163	9,432	6,407	1,428	38,430
Marin	123,382	15,065	9,523	6,276	154,246
Mariposa	3,670	1,637	1,741	287	7,335
Mendocino	27,746	11,707	9,323	2,059	50,835
Merced	51,901	18,004	11,305	3,429	84,639
Modoc	3,627	2,533	1,396	180	7,736
Mono	2,547	1,322	1,387	206	5,462
Monterey	127,333	25,918	19,093	6,103	178,447
Napa	45,500	10,887	11,930	2,937	71,254
Nevada	16,525	6,295	5,496	1,304	29,620
Orange	914,044	129,947	120,345	56,361	1,220,697
Placer	46,001	15,072	11,810	3,995	76,878
Plumas	7,092	3,517	2,976	498	14,083
Riverside	258,397	56,599	71,173	15,695	401,864
Sacramento	359,347	72,521	56,401	21,924	510,193
San Benito	9,230	3,745	2,127	485	15,587
San Bernardino	352,334	78,097	68,046	24,300	522,777
San Diego	777,588	129,430	110,705	46,738	1,064,461
San Francisco	291,002	49,390	24,500	9,384	374,276
San Joaquin	149,214	44,884	32,782	8,515	235,395
San Luis Obispo	59,904	16,098	16,392	4,198	96,592
San Mateo	343,914	50,257	34,761	14,358	443,290
Santa Barbara	147,092	26,249	21,286	9,131	203,758
Santa Clara	639,509	100,515	74,431	32,898	847,353
Santa Cruz	81,684	18,389	16,402	4,213	120,688
Shasta	43,260	18,336	19,420	3,409	84,425
Sierra	1,212	588	471	78	2,449
Siskiyou	17,057	9,404	6,156	1,204	33,821
Solano	90,935	17,081	14,634	5,900	128,550
Sonoma	125,935	34,280	28,834	7,825	196,874
Stanislaus	107,344	35,291	27,717	7,206	177,558
Sutter	22,358	8,669	6,236	1,881	39,144
Tehama	15,157	7,206	6,721	1,167	30,251
Trinity	3,775	2,173	2,126	441	8,515
Tulare	93,825	33,500	22,724	7,142	157,191
Tuolumne	12,410	5,687	5,012	1,015	24,124
Ventura	214,992	38,452	32,983	13,705	300,132
Yolo	46,799	15,173	12,638	3,245	77,855
Yuba	21,329	6,773	5,428	1,749	35,279
Out-of-State	55,753	68,617	103,146	3,452	230,968
Totals	11,141,520	2,107,998	1,638,966	624,695	15,513,179

Total Fee Paid Registrations	15,513,179
Total Exempt Registrations	225,762
Total Vehicles Registered	15,738,941

TABLE D-13. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1972

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	542,125	88,326	75,577	29,461	735,489
Alpine	282	108	62	19	471
Amador	6,698	3,234	1,913	628	12,473
Butte	54,521	18,661	19,007	4,604	96,793
Calaveras	7,062	3,343	2,309	477	13,191
Colusa	6,252	3,621	1,845	521	12,239
Contra Costa	305,711	47,241	38,512	18,117	409,581
Del Norte	7,519	2,724	2,782	576	13,601
El Dorado	25,478	8,945	6,729	1,966	43,118
Fresno	212,018	60,469	38,560	12,621	323,668
Glenn	9,501	4,738	3,159	792	18,190
Humboldt	49,900	17,218	13,479	3,651	84,248
Imperial	36,604	11,853	9,600	1,833	59,890
Inyo	8,582	3,881	4,443	919	17,825
Kern	166,850	51,591	38,543	14,304	271,288
Kings	29,263	9,381	6,062	2,434	47,140
Lake	12,954	4,642	8,206	883	26,685
Lassen	7,844	3,978	2,797	802	15,421
Los Angeles	3,797,929	509,677	304,739	191,341	4,803,686
Madera	20,015	8,422	5,562	1,443	35,442
Marin	118,064	13,698	9,178	6,274	147,214
Mariposa	3,496	1,513	1,530	241	6,780
Mendocino	26,486	10,745	8,481	1,898	47,610
Merced	49,546	16,693	10,406	3,214	79,859
Modoc	3,589	2,406	1,221	159	7,375
Mono	2,162	1,193	1,289	180	4,824
Monterey	121,251	23,545	17,179	6,173	168,148
Napa	43,348	10,018	10,876	2,868	67,110
Nevada	15,442	5,576	4,855	1,183	27,056
Orange	847,182	114,272	111,609	52,338	1,125,401
Placer	43,468	13,738	10,609	3,785	71,600
Plumas	6,507	3,254	2,605	523	12,889
Riverside	245,018	51,449	63,697	15,588	375,752
Sacramento	343,517	67,556	52,946	21,606	485,625
San Benito	9,025	3,543	2,007	533	15,108
San Bernardino	342,937	72,767	68,839	24,288	503,831
San Diego	735,677	115,900	102,621	45,051	999,249
San Francisco	292,165	49,347	24,791	9,397	375,700
San Joaquin	145,354	41,974	30,502	8,203	226,033
San Luis Obispo	55,963	14,170	14,264	3,933	88,330
San Mateo	328,031	43,716	31,174	14,210	417,131
Santa Barbara	141,543	23,916	19,904	8,823	194,186
Santa Clara	605,746	91,513	68,150	32,007	797,416
Santa Cruz	76,473	16,671	14,854	4,108	112,106
Shasta	40,900	16,932	17,328	3,224	78,384
Sierra	1,215	660	407	70	2,352
Siskiyou	16,387	8,875	5,472	1,179	31,913
Solano	88,848	15,647	13,792	5,816	124,103
Sonoma	118,089	31,266	26,408	7,528	183,291
Stanislaus	103,097	32,387	25,434	6,820	167,738
Sutter	21,405	7,964	5,753	1,767	36,889
Tehama	14,234	6,617	5,839	1,104	27,794
Trinity	3,465	1,941	1,780	406	7,592
Tulare	90,734	30,969	21,596	7,049	150,348
Tuolumne	11,929	5,241	4,489	923	22,582
Ventura	203,766	35,467	30,261	13,152	282,646
Yolo	44,678	14,013	11,725	3,209	73,625
Yuba	21,015	6,394	5,031	1,747	34,187
Out-of-State	56,121	61,050	99,413	3,611	220,195
Totals	10,744,981	1,946,649	1,537,201	611,580	14,840,411

Total Fee Paid Registrations	14,840,411
Total Exempt Registrations	216,412
Total Vehicles Registered	15,056,823

TABLE D-14. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1971

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	526,912	84,822	81,881	29,593	723,208
Alpine	287	89	51	13	440
Amador	6,000	2,927	1,602	605	11,134
Butte	51,063	17,481	16,586	4,490	89,620
Calaveras	6,701	3,086	2,007	446	12,240
Colusa	6,107	3,584	1,665	488	11,844
Contra Costa	293,653	44,947	36,533	17,630	392,763
Del Norte	7,238	2,608	2,430	606	12,882
El Dorado	23,182	8,279	5,783	1,848	39,092
Fresno	202,958	56,959	35,230	12,017	307,184
Glenn	9,175	4,539	2,814	830	17,358
Humboldt	47,772	16,394	12,383	3,644	80,193
Imperial	35,159	11,344	8,544	1,833	56,880
Inyo	8,073	3,648	3,844	891	16,456
Kern	160,486	49,639	35,432	14,228	259,785
Kings	27,803	8,872	5,629	2,255	44,559
Lake	12,000	4,425	6,648	809	23,882
Lassen	7,347	3,793	2,498	712	14,350
Los Angeles	3,747,856	490,771	300,365	195,093	4,734,085
Madera	19,288	7,979	4,937	1,351	33,555
Marin	112,538	12,861	8,705	6,293	140,397
Mariposa	3,207	1,408	1,180	223	6,018
Mendocino	24,938	10,140	7,438	1,741	44,257
Merced	47,597	15,765	9,571	3,134	76,067
Modoc	3,399	2,289	1,078	163	6,929
Mono	1,828	1,062	1,088	156	4,134
Monterey	115,150	22,306	16,068	6,263	159,787
Napa	41,225	9,383	9,501	2,584	62,693
Nevada	14,248	5,153	4,123	1,078	24,602
Orange	794,306	102,377	102,047	50,169	1,048,899
Placer	40,477	12,576	9,352	3,500	65,905
Plumas	5,944	3,050	2,161	468	11,623
Riverside	235,219	48,039	56,231	15,899	355,388
Sacramento	327,648	62,392	48,461	21,455	459,956
San Benito	8,578	3,449	1,874	526	14,427
San Bernardino	332,266	68,897	58,518	24,790	484,471
San Diego	690,489	103,709	93,196	44,617	932,011
San Francisco	290,627	49,097	26,662	9,650	376,036
San Joaquin	139,744	40,148	28,114	7,891	215,897
San Luis Obispo	52,423	13,056	12,533	3,904	81,916
San Mateo	317,781	40,545	29,734	14,319	402,379
Santa Barbara	136,603	22,540	18,391	9,042	186,576
Santa Clara	573,428	84,843	63,113	31,133	752,517
Santa Cruz	70,494	15,241	13,276	3,951	102,962
Shasta	38,803	15,770	15,235	3,120	72,928
Sierra	1,127	634	339	67	2,167
Siskiyou	15,618	8,707	4,945	1,121	30,391
Solano	85,280	14,826	12,844	5,502	118,452
Sonoma	110,563	29,253	23,555	7,066	170,437
Stanislaus	98,020	30,614	23,354	6,476	158,464
Sutter	20,541	7,620	5,226	1,678	35,065
Tehama	13,685	6,182	4,996	1,120	25,983
Trinity	3,213	1,829	1,517	345	6,904
Tulare	86,366	29,175	19,938	7,269	142,748
Tuolumne	11,149	4,786	3,805	764	20,504
Ventura	191,437	32,835	27,061	13,051	264,384
Yolo	42,366	13,255	10,782	3,150	69,553
Yuba	20,892	6,120	4,675	1,778	33,465
Out-of-State	57,077	57,142	70,473	3,342	188,034
Totals	10,375,354	1,835,260	1,418,022	608,180	14,236,816

Total Fee Paid Registrations	14,236,816
Total Exempt Registrations	207,429
Total Vehicles Registered	14,444,245

TABLE D-15. STATE OF CALIFORNIA DEPARTMENT OF MOTOR VEHICLES NUMBER OF VEHICLES REGISTERED 1 JANUARY THROUGH 31 DECEMBER 1970

Counties	Autos	Trucks	Trailers	Motor/ Cycles	Total Vehicles
Alameda	511,764	81,446	66,894	26,997	687,101
Alpine	195	77	35	14	321
Amador	5,853	2,770	1,447	489	10,559
Butte	48,697	16,839	14,468	3,961	83,965
Calaveras	6,472	3,005	1,766	386	11,629
Colusa	6,126	3,539	1,654	467	11,786
Contra Costa	281,929	43,062	34,585	15,650	375,226
Del Norte	6,807	2,620	2,308	602	12,337
El Dorado	21,630	7,846	5,212	1,646	36,334
Fresno	195,153	54,467	32,520	10,497	292,637
Glenn	8,965	4,409	2,705	801	16,880
Humboldt	46,370	15,873	11,560	3,572	77,375
Imperial	34,261	11,050	8,079	1,643	55,033
Inyo	7,675	3,575	3,604	791	15,645
Kern	156,869	48,169	32,967	13,343	251,348
Kings	27,164	8,414	5,100	1,940	42,618
Lake	11,142	4,162	5,518	717	21,539
Lassen	7,072	3,628	2,264	561	13,525
Los Angeles	3,670,496	477,075	290,231	183,444	4,621,246
Madera	18,564	7,640	4,358	1,127	31,689
Marin	108,072	12,273	8,100	5,770	134,215
Mariposa	2,948	1,334	1,017	185	5,484
Mendocino	23,830	9,805	6,673	1,556	41,864
Merced	45,838	15,031	8,758	2,634	72,261
Modoc	3,322	2,223	974	152	6,671
Mono	1,637	965	1,015	148	3,765
Monterey	109,145	21,283	14,870	5,879	151,447
Napa	39,285	8,997	8,491	2,291	59,064
Nevada	13,377	4,838	3,575	951	22,741
Orange	748,217	95,107	89,610	45,509	978,443
Placer	37,971	11,895	8,709	3,271	61,846
Plumas	5,611	2,948	1,829	424	10,812
Riverside	223,570	45,023	49,653	15,378	333,624
Sacramento	312,774	58,491	44,301	19,256	434,822
San Benito	8,313	3,392	1,761	484	13,950
San Bernardino	319,870	65,547	54,085	23,622	463,124
San Diego	644,452	95,824	83,780	42,160	866,216
San Francisco	288,056	48,866	22,788	9,249	368,959
San Joaquin	135,465	38,468	26,338	7,182	207,453
San Luis Obispo	49,790	12,487	11,299	3,658	77,234
San Mateo	308,460	39,243	29,468	13,689	390,860
Santa Barbara	131,625	21,491	17,196	8,466	178,778
Santa Clara	542,650	79,020	57,667	28,185	707,522
Santa Cruz	67,003	14,677	12,220	3,570	97,470
Shasta	37,421	15,386	13,891	2,706	69,404
Sierra	1,110	627	293	76	2,106
Siskiyou	15,284	8,467	4,605	1,083	29,439
Solano	81,427	13,937	11,878	4,525	111,767
Sonoma	104,213	27,530	21,365	6,275	159,383
Stanislaus	94,336	28,959	21,491	5,781	150,567
Sutter	19,555	7,426	4,814	1,383	33,178
Tehama	13,434	5,899	4,506	1,004	24,843
Trinity	2,955	1,755	1,322	350	6,382
Tulare	84,043	28,153	18,931	6,675	137,802
Tuolumne	10,584	4,579	3,385	611	19,159
Ventura	180,946	31,154	24,466	11,787	248,353
Yolo	40,658	12,947	10,221	2,756	66,582
Yuba	20,532	6,028	4,237	1,424	32,221
Out-of-State	52,902	56,944	62,859	2,868	175,573
Totals	10,004,155	1,758,685	1,299,716	561,621	13,624,177

Total Fee Paid Registrations	13,624,177
Total Exempt Registrations	194,692
Total Vehicles Registered	13,818,869

as the criterion. It would therefore be necessary to use both files.

The material in Tables D-16 through D-20 describes the data compiled by the Truck Prorate Section, California DMV, on large truck operations in California and its potential value as exposure data for use on the truck project.

D.3.1. General Data Content

The Truck Prorate Section of DMV keeps records on all large trucks operating in interstate commerce in and out of California.

a) Twenty-Second Annual Report to the California State Legislature, 1977: Pages D-27 and D-28 contain a brief annual report of the California Reciprocity Commission showing number of prorate fleets, prorate vehicles, and associated revenues (Figures D-1 and D-2).

b) Uniform Proration Application-Form PRI (Schedules A and B (Figures D-1 and D-2): Figures D-3 through D-8 give sample completed forms from a typical fleet owner. It is noted that the two most interesting columns (9 and 10), "Declared Gross Weight" and "Declared Combined GW," are ignored by the fleet operators.

c) Individual Vehicle Mileage Report (IVMR): The state Prorate operation also requires each fleet owner to maintain a daily or trip log or record showing trip mileage for each vehicle. This IVMR must be held by each fleet operator for one year but is not filed with the state prorate office. Figures D-9 and D-10 are copies of the IVMR form.

TABLE D-16. MONTHLY SUMMARY OF COMMERCIAL ACTIVITIES

	Zone I		Zone II		Zone III		Zone IV		Zone V		Zone VI		Statewide	
	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date
1. Operational Hours														
A. Inspection Fac.	308	4055	—	—	604	7887	440	5938	456	5899	960	12902	2768	36681
B. Platform Scales	827	12068	517	5474	1873	23761	1036	13597	977	9029	882	12072	6112	76001
C. Mobile Read Enf.	637	15037	942	14195	1341	17155	732	10619	1557	21273	581	7058	5790	85337
D. Loadometer Pits	8	1158	7	7	17	485	—	95	—	—	17	490	49	2235
2. Officer Hours	2509	41458	1617	22406	4949	63947	3215	43601	4013	48050	3933	51116	20236	270579
3. Civilian Hours	1236	15163	—	—	1903	25658	2082	29413	2078	25690	3104	49652	10403	145576
4. Total Man-Hours	3745	56621	1617	22406	6852	89605	5297	73015	6091	73740	7037	100768	30639	416155
5. Trks. Insp.-Brakes	767	9622	—	—	1300	16568	1294	22835	1283	19267	2111	35943	6755	104235
6. Trks. Insp.-Reg./Mech.	767	9622	—	—	1300	16581	1286	22969	1279	19282	2111	35809	6743	104263
7. Vehs. Insp.-Brakes	1759	22048	—	—	2434	32983	2923	53556	2470	38011	4104	69543	13690	216141
Brake Viols. Detected	672	7261	—	—	1419	20329	1301	24171	1840	27936	2906	46787	8138	126484
8. Veh. Insp.-Reg./Mech.	1759	22072	—	—	2434	32956	2914	53625	2461	38003	4104	69245	13672	215901
A. Reg. Viols. Detected	146	1915	—	—	385	4855	389	6561	334	4880	850	11444	2104	29655
B. Loading	24	149	—	—	13	88	14	459	45	589	11	465	107	1750
C. Lamps	536	6246	—	—	1175	16404	623	11035	1126	16329	2745	36563	6205	56577
D. Other Equipment	289	3537	—	—	626	7244	365	7810	471	7329	1873	27399	3624	53319
E. Motor Carrier	199	1683	—	—	22	4621	322	4233	326	4153	774	11442	2043	26137
F. Other	12	276	—	—	39	1121	43	660	69	879	136	2389	299	5325
9. Trks. Checked	2113	37301	1736	24364	5114	78760	3210	50155	3847	49431	4875	68444	20895	308455
10. Trks. Weighed	18995	310299	8813	105560	96503	1499551	50674	677466	54947	670949	77631	1043702	307564	4302527
11. Trks. Thru Facility	9348	131931	—	—	60336	935400	34950	483166	30085	500953	83076	1223901	217795	3275351
12. Trks. Thru Plat. Scales	12047	210459	9998	120790	70326	999587	27474	378671	119419	853834	33682	446335	272946	3009676
13. Total 215s	791	14075	371	7014	2411	27810	1613	21580	1597	19512	2085	23761	8868	113752
14. Total 281s	726	10687	410	6041	2349	32957	1559	27455	2287	30360	2416	38219	9747	145719
15. Total Enf. Docs.	1517	24762	781	13055	4760	60767	3172	49035	3884	49872	4501	61980	18615	259471
16. Viols. by Type:														
A. Size	81	1250	40	683	135	1607	177	2097	116	1332	119	1377	668	8346
B. Weight	348	7458	113	2732	1291	14023	743	9093	633	6503	992	10082	4120	49891
C. Loading	89	1465	16	741	71	1008	104	1613	140	1688	43	696	463	7211
D. Brakes	579	8056	161	3295	1601	24576	1053	17926	1584	20531	2326	39584	7304	113988
E. Lamps	653	8254	248	2888	2642	32762	960	14744	2218	29466	1975	35469	8696	199583
F. Registration	297	4886	161	1992	891	12532	755	13311	811	10486	1219	13819	4154	55028
G. Other Equipment	422	6477	330	4399	1769	21877	776	13548	1274	18824	1983	29778	6554	94903
H. Motor Carrier	300	3917	139	2582	715	9678	434	6550	724	8024	761	11218	3073	41969
I. Other	82	1651	86	1800	403	4977	261	4291	307	4095	233	3674	1372	19988
J. Total	2851	43416	1314	21612	9518	123040	5263	83173	7807	100949	9651	145697	36404	517867
17. Reinspections	511	6360	214	2776	1840	26381	989	14325	1390	18114	1953	25507	6897	93463
18. Stickers Issued	1041	14265	—	—	1358	18077	1896	35750	1103	18109	1643	28800	7041	115001

NOTE: CHP Form 407-Registration, Mechanical and Equipment Inspection.

TABLE D-17. COMMERCIAL VEHICLE INSPECTION FACILITY MONTHLY ACTIVITY--DECEMBER 1973

	Mt. Shasta		Cordelia E/R		Cordelia W/B		Wheeler Ridge		Castaic		Banning		San Onofre N/B		San Onofre S/B		Statewide	
	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date
1. Operational Hours	308	4065	303	3816	301	4071	440	5938	456	5899	400	5756	252	3399	308	3747	2768	56681
2. Supervisor Hours	114	1521	76	814	76	821	138	1740	125	1251	—	—	60	755	60	837	649	7739
3. Officer Hours	532	6834	426	5876	484	6603	827	11821	784	10383	848	13271	193	4831	611	6403	4805	66022
4. BIS Hour	562	6269	384	4267	323	4817	764	11566	785	9993	488	9201	256	3776	358	5172	3861	55861
5. CVIS Hours	502	6576	356	4352	304	4508	825	11709	868	10136	512	9305	278	3907	360	5421	4035	55914
6. PSO Hours	232	2262	304	3715	202	3937	365	4528	424	5561	266	4521	232	3284	272	4051	2297	31859
7. Total Man Hours	1882	23462	1576	19024	1389	20686	2919	41364	2987	37324	2114	36298	1119	16553	1661	21884	15047	216595
8. Trks. Insp. Brakes	767	9806	695	8012	605	8528	1294	22835	1283	19267	888	18188	515	7461	708	10294	6755	104191
9. Trks. Insp. Reg./Mech.	767	9606	695	8025	605	8533	1286	22960	1279	19382	888	18067	515	7449	708	10292	6743	014224
10. Vehs. Insp.-Brakes	1759	22016	1272	15603	1162	17305	2923	53656	2470	38011	1686	34296	1003	14916	1415	20331	13690	218934
11. Brake Viols. Detected	672	7237	733	9305	686	10936	1301	14171	1840	27936	1472	26534	587	8682	847	11571	8138	126372
12. Vehs. Insp.-Reg./Mech.	1759	22040	1272	15610	1162	17282	2914	53625	2461	38003	1686	34085	1003	14882	1415	20270	18672	218805
13. Reg. Viols. Detected	148	1913	249	2489	136	2361	389	6561	334	4860	315	5235	261	2638	274	3571	2104	29648
14. Loading Viols.	24	149	8	38	5	27	14	459	45	589	6	302	1	26	4	137	107	1727
15. Lamp Viols.	526	6230	702	8532	473	7868	623	11035	1126	16329	1593	19609	514	7061	638	9592	6705	66657
16. Other Equipment	283	3612	359	3677	267	3562	365	7810	471	7329	910	15088	350	4944	613	7367	3624	55289
17. Motor Carrier Regs.	199	1631	298	2311	124	2299	322	4233	326	4153	371	5693	193	2312	210	3437	2043	26119
18 Other Viols	12	275	–	448	39	667	43	060	69	879	62	1344	23	379	61	666	299	5815
19. Trks. Checked	582	8161	514	10761	711	12954	897	12921	1095	14641	1071	13128	685	9786	608	11546	6221	93897
20. Trks Weighed	7925	104977	21775	353367	18403	356867	26249	350435	22747	335192	18074	249102	10637	162637	23689	313419	149399	2213996
21. Trks. Thru Facility	9348	131931	31802	467195	28534	468205	34950	483166	30085	509953	27746	384189	29356	428951	30974	410761	217795	3275951
22. Total 215s	257	2227	360	3598	237	3418	523	7010	472	6871	617	7932	99	1699	315	3156	2880	33911
23. Total 281s	600	5718	555	6772	376	6318	883	10403	934	13424	764	14931	356	5540	644	7362	5012	70476
24. Total Enf. Docs.	757	7945	915	10370	613	9736	1406	23413	1406	20295	1391	22863	455	7247	959	10513	7892	110287
25. Viols. by Type:																		
A. Size	39	157	20	193	23	295	78	982	32	330	33	397	5	101	21	160	251	2615
B. Weight	76	605	264	2473	96	1579	152	1972	200	2287	235	2451	54	700	195	1876	1272	12842
C. Loading	11	268	3	35	1	116	33	918	9	227	16	149	2	31	2	43	77	1787
D. Brakes	529	5349	589	7467	517	8200	909	15065	1006	14688	1050	19769	420	6548	551	8390	5571	85475
E. Lamps	464	4887	606	6771	380	6700	516	8710	996	14085	713	14620	404	5016	448	7475	4523	66564
F. Registration	166	1732	154	1993	99	1709	433	7338	218	3225	401	5224	111	1029	193	1800	1775	24650
G. Other Equipment	259	3176	345	3540	316	4097	349	6495	378	5881	757	12034	769	4029	419	5598	3092	44550
H. Motor Carrier	195	1575	217	2024	152	2419	302	4171	294	3508	364	5349	99	1530	144	1601	1767	22157
I. Other	23	631	55	877	20	348	72	1086	59	739	53	1081	14	277	42	446	339	5464
J. Total	1762	18379	2854	25373	1610	25413	2844	46737	3192	45560	3622	61074	1378	20661	2015	27520	18677	274325
26. Reinspections	397	4264	491	6501	537	8716	454	7885	570	9036	781	12721	721	4028	145	4054	4080	57405
27. Stickers Issued	1041	14213	619	8576	739	9493	1896	35750	1103	18109	624	12920	416	7192	607	8688	7041	114931
Vehs. Insp. 407A/Brake Viols.	2.6		1.7		1.7		2.2		1.3		1.1		1.7		1.7		1.7	
Vehs. Insp. 407/Reg. Viols	12.0		6.1		8.5		7.5		7.4		5.4		3.8		5.2		6.5	
Vehs. Insp. 407/Lamp Viols.	3.3		1.8		2.5		4.7		2.9		1.1		2.0		2.2		2.2	
Vehs. Insp. 407/Other Equip.	6.1		3.5		4.4		8.0		5.2		1.9		2.9		2.3		3.8	
Vehs. Insp. 407/Motor Carriers	8.8		4.3		9.4		9.1		7.5		4.5		5.2		6.7		6.7	
Vehs. Insp. 407/Other Viols.	146.6		–		29.8		67.8		36.7		27.2		43.6		27.7		45.7	
Trks. Weighed/Wt. Viols.	103.0		82.6		191.7		172.7		113.7		76.9		107.0		121.5		117.6	
Trks. Insp. 407A/BIS Hours	1.5		1.8		1.9		1.7		1.6		1.8		2.0		2.0		1.7	
Vehs. Insp. 407A/BIS Hours	3.5		3.3		3.6		3.8		3.1		3.6		3.9		4.0		3.5	
Trks. Insp 407/CVIS Hours	1.6		1.8		2.0		1.6		1.5		1.7		1.9		1.9		1.7	
Vehs. Insp. 407/CVIS Hours	3.5		3.3		3.8		3.5		2.8		3.3		3.6		3.9		3.4	
Officer Hours/215	2.1		1.2		2.0		1.6		1.7		1.4		3.0		1.9		1.7	
Officer Hours/281	1.1		.8		1.4		.9		.8		1.1		.8		.9		1.0	
Officer Hours/Enf. Doc.	.7		.5		.8		.6		.6		.0		.6		.6		.6	
Man Hours/Enf. Doc.	2.5		1.7		2.3		2.1		2.1		1.5		2.5		1.7		2.0	
Man Hours/Veh. Insp. 407A	1.1		1.2		1.2		1.0		1.2		1.3		1.1		1.2		1.1	
Man-Hours/Veh. Insp. 407	1.1		1.2		1.2		1.0		1.2		1.3		1.1		1.2		1.1	

NOTE: CHP Form 407-Registration, Mechanical and Equipment Inspection.

TABLE D-18. MONTHLY SUMMARY OF PLATFORM SCALE ACTIVITY—DECEMBER 1973

		Zone I		Zone II		Zone III		Zone IV		Zone V		Zone VI		Statewide	
		This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date
1.	Operational Hours	627	12068	517	5521	1873	23761	1036	13597	977	9120	882	12072	6112	76061
2.	Supervisor Hours	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3.	Officer Hours	1111	14687	606	6953	2288	29426	1422	17982	1369	13164	1213	13801	8009	95859
4.	BIS Hours	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5.	CVIS Hours	—	—	—	—	—	—	128	1610	—	—	—	16	128	1626
6.	PSO Hours	—	—	—	—	—	—	—	—	—	—	82	719	82	719
7.	Total Man-Hours	1111	14687	606	6953	2288	19426	1550	19592	1369	13164	1295	14536	8219	98204
8.	Trks. Insp.-Brakes	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.	Trks. Insp.-Req./Mech.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.	Vehs. Insp.-Brakes	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.	Brake Viols. Detected	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12.	Vehs. Insp.-Reg./Mech.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13.	Reg. Viols. Detected	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14.	Loading Viols.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15.	Lamp Viols.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16.	Other Equipment	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17.	Motor Carrier Regs.	—	1	—	—	—	—	—	—	—	—	—	—	—	1
18.	Other Viols.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19.	Trks. Checked	1175	13813	823	8308	1881	28142	1796	28268	1221	11725	1378	13796	8274	103961
20.	Trks. Weighed	11032	191675	8605	99081	55856	781836	24128	324276	31923	334277	24881	319943	156425	2047772
21.	Trks Thru Facility	12047	210459	9998	120740	70326	999587	27474	378671	119419	859465	33682	446335	272946	3009626
22.	Total 215s	437	6380	171	2600	1157	13147	776	9708	583	5215	788	6781	3912	43756
23.	Total 281s	133	1857	152	1651	689	10047	523	7494	714	6489	343	4555	2554	32033
24.	Total Enf. Docs.	570	8237	323	4251	1846	23194	1299	17202	1297	11704	1131	11336	6466	75799
25.	Viols. by Type:														
	A. Size	34	425	23	282	57	567	80	875	25	294	33	374	252	2814
	B. Weight	246	4280	79	1372	811	8740	509	6023	328	2673	461	4469	2434	27524
	C. Loading	47	510	9	119	35	476	59	473	33	269	1	88	184	1919
	D. Brakes	16	544	36	573	118	1280	63	901	290	1719	98	813	621	5795
	E. Lamps	111	1025	37	425	551	8476	294	3348	548	4780	136	1602	1677	17623
	F. Registration	97	1641	59	849	295	4496	239	3906	290	2645	363	2891	1343	16410
	G. Other Equipment	85	945	88	947	354	5493	248	3469	418	4819	157	2009	1350	17619
	H. Motor Carrier	56	630	50	581	107	1336	67	1126	194	1678	72	963	546	6291
	I. Other	41	428	30	273	117	1377	63	1453	104	1085	67	726	422	5335
	J. Total	733	10428	411	5421	2445	30241	1622	21574	2230	19962	1388	13935	8829	101340
26.	Reinspections	98	1190	139	1512	585	8157	384	5225	579	5666	177	2207	1962	23922
27.	Stickers Issued	—	1	—	—	—	—	—	—	—	—	—	—	—	1
	Vehs. Insp. 407A/Brake Viols.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Reg. Viols.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Lamp Viols.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Other Equip.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Motor Carriers	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Other Viols.	—		—		—		—		—		—		—	
	Trks. Weighed/Wt. Viols.	44.8		108.9		68.9		47.4		97.3		54.0		64.3	
	Trks. Insp. 407A/BIS Hours	—		—		—		—		—		—		—	
	Vehs. Insp. 407A/BIS Hours	—		—		—		—		—		—		—	
	Trks. Insp. 407/CVIS Hours	—		—		—		—		—		—		—	
	Vehs. Insp. 407/CVIS Hours	—		—		—		—		—		—		—	
	Officer Hours/215	2.5		3.5		2.0		1.8		2.3		1.5		2.0	
	Officer Hours/281	8.4		4.0		3.3		2.7		1.9		3.5		3.1	
	Officer Hours/Enf. Doc.	1.9		1.9		1.2		1.1		1.1		1.1		1.2	
	Man-Hours/Enf. Doc.	1.9		1.9		1.2		1.2		1.1		1.1		1.3	
	Man-Hours/Veh. Insp. 407A	—		—		—		—		—		—		—	
	Man-Hours/Veh. Insp. 407	—		—		—		—		—		—		—	

NOTE: CHP Form 407-Registration, Mechanical and Equipment Inspection.

TABLE D-19. MONTHLY SUMMARY OF MOBILE ROAD ENFORCEMENT ACTIVITY—DECEMBER 1973

		Zone I		Zone II		Zone III		Zone IV		Zone V		Zone VI		Statewide	
		This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date
1.	Operational Hours	637	15037	942	14789	1341	17155	732	10619	1557	21273	581	7058	5790	85991
2.	Supervisor Hours	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3.	Officer Hours	736	16957	1003	16090	1582	19895	828	11913	1735	23356	824	10538	6708	95719
4.	BIS Hours	—	24	—	—	—	62	—	—	—	—	—	—	—	86
5.	CVIS Hours	—	32	—	—	—	—	—	—	—	—	—	16	—	48
6.	PSO Hours	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7.	Total Man-Hours	736	17013	1003	16090	1582	19957	828	11913	1735	23356	824	10554	6705	96683
8.	Trks. Insp.-Brakes	—	16	—	—	—	28	—	—	—	—	—	—	—	44
9.	Trks. Insp.-Reg./Mech.	—	16	—	—	—	23	—	—	—	—	—	—	—	39
10.	Vehs. Insp.-Brakes	—	32	—	—	—	75	—	—	—	—	—	—	—	107
11.	Brake Viols. Detected	—	24	—	—	—	88	—	—	—	—	—	—	—	112
12.	Vehs. Insp.-Reg./Mech.	—	32	—	—	—	64	—	—	—	—	—	—	—	96
13.	Reg. Viols. Detected	—	2	—	—	—	5	—	—	—	—	—	—	—	7
14.	Loading Viols.	—	—	—	—	—	23	—	—	—	—	—	—	—	23
15.	Lamp Viols.	—	16	—	—	—	4	—	—	—	—	—	—	—	20
16.	Other Equipment	—	25	—	—	—	5	—	—	—	—	—	—	—	30
17.	Motor Carrier Regs.	—	6	—	—	—	11	—	—	—	—	—	—	—	17
18.	Other Viols.	—	1	—	—	—	6	—	—	—	—	—	—	—	7
19.	Trks. Checked	331	13201	902	16731	1932	24222	517	8885	1531	23112	1037	16598	6250	102729
20.	Trks. Weighed	103	9404	192	6869	441	6430	298	2455	277	4464	280	4454	1591	34976
21.	Trks. Thru Facility	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22.	Total 215s	90	4617	197	4550	650	7362	314	4751	542	7474	260	3932	2053	32666
23.	Total 281s	93	2794	257	4595	720	9430	153	3544	639	10482	295	4970	2157	35815
24.	Total Enf. Docs.	183	7411	454	9145	1370	16792	467	8295	1181	17956	555	8902	4210	68591
25.	Viols. by Type:														
	A. Size	8	560	17	412	35	535	19	239	59	710	27	335	165	2791
	B. Weight	21	1966	31	1388	120	1276	82	1008	105	1563	44	581	403	7582
	C. Loading	31	629	7	625	32	372	12	219	98	1197	22	370	202	3412
	D. Brakes	34	1992	124	2800	374	7494	81	1955	288	4144	198	3754	1099	22139
	E. Lamps	78	2183	211	2581	1091	12446	150	2673	674	10133	266	5508	2470	35524
	F. Registration	34	1355	122	2193	341	4251	83	2054	303	4630	147	2097	1030	16550
	G. Other Equipment	77	2208	241	3617	743	8509	179	3566	478	8171	370	5514	2058	31555
	H. Motor Carrier	48	1526	89	2068	237	3710	65	1253	236	2761	77	1425	752	12853
	I. Other	18	551	56	1073	210	2326	126	1752	144	2278	55	1087	609	9367
	J. Total	349	13030	898	16757	3183	40919	797	14719	2385	35587	1206	20671	8818	141683
26.	Reinspections	16	572	74	1329	237	2951	151	1196	241	3432	122	1685	841	11185
27.	Stickers Issued	—	42	—	—	—	18	—	—	—	—	—	—	—	60
	Vehs. Insp. 407A/Brake Viols.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Reg. Viols	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Lamp Viols.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Other Equip.	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Motor Carriers	—		—		—		—		—		—		—	
	Vehs. Insp. 407/Other Viols.	—		—		—		—		—		—		—	
	Trks. Weighed/Wt. Viols.	4.9		6.2		3.7		3.6		2.6		6.4		4.0	
	Trks. Insp. 407A/BIS Hours	—		—		—		—		—		—		—	
	Vehs. Insp. 407A/BIS Hours	—		—		—		—		—		—		—	
	Trks. Insp. 407/CVIS Hours	—		—		—		—		—		—		—	
	Vehs. Insp. 407/CVIS Hours	—		—		—		—		—		—		—	
	Officer Hours/215	8.2		5.1		2.4		2.6		3.2		3.2		3.3	
	Officer Hours/281	7.9		4.0		2.2		5.4		2.7		2.8		3.1	
	Officer Hours/Enf. Doc.	4.0		2.2		1.2		1.8		1.5		1.5		1.6	
	Man-Hours/Enf. Doc.	4.0		2.2		1.2		1.8		1.5		1.5		1.6	
	Man-Hours/Veh. Insp. 407A	—		—		—		—		—		—		—	
	Man-Hours/Veh. Insp. 407	—		—		—		—		—		—		—	

NOTE: CHP Form 407-Registration, Mechanical and Equipment Inspection.

TABLE D-20. MONTHLY SUMMARY OF LOADOMETER PIT ACTIVITY—DECEMBER 1973

	Zone I		Zone II		Zone III		Zone IV		Zone V		Zone VI		Statewide	
	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date	This Month	Year to Date
1. Operational Hours	8	1158	7	7	17	485	–	95	–	–	17	490	49	2325
2. Supervisor Hours	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. Officer Hours	16	1459	8	8	17	512	–	146	–	–	24	700	65	2825
4. BIS Hours	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5. CVIS Hours	–	–	–	–	–	–	–	–	–	–	–	263	–	263
6. PSO Hours	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7. Total Man-Hours	16	1459	8	8	17	512	–	146	–	–	24	963	65	3088
8. Trks. Insp.-Brakes	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9. Trks. Insp.-Reg./Mech.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10. Vehs. Insp.-Brakes	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11. Brake Viols. Detected	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12. Vehs. Insp.-Reg./Mech.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13. Reg. Viols. Detected	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14. Loading Viols.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15. Lamp Viols.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16. Other Equipment	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17. Motor Carrier Regs.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18. Other Viols.	–	–	–	–	–	–	–	–	–	–	–	–	–	–
19. Trks. Checked	25	2126	11	11	76	2681	–	81	–	–	38	3610	150	8509
20. Trks. Weighed	35	4243	16	16	28	1051	–	300	–	–	70	4148	149	9758
21. Trks. Thru Facility	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22. Total 215s	7	851	3	3	7	285	–	111	–	–	6	264	23	1514
23. Total 281s	–	318	1	1	9	390	–	14	–	–	14	859	24	1532
24. Total Enf. Docs.	7	1169	4	4	16	675	–	125	–	–	20	1123	47	3096
25. Viols. by Type:														
A. Size	–	108	–	–	–	17	–	1	–	–	–	11	–	137
B. Weight	5	607	3	3	–	5	–	90	–	–	3	55	11	760
C. Loading	–	58	–	–	–	9	–	3	–	–	–	15	–	55
D. Brakes	–	172	1	1	3	135	–	5	–	–	9	313	13	626
E. Lamps	–	159	–	–	8	369	–	13	–	–	8	455	16	986
F. Registration	–	160	–	–	2	83	–	13	–	–	4	180	6	236
G. Other Equipment	1	148	1	1	11	238	–	18	–	–	11	501	24	906
H. Motor Carrier	1	126	–	–	2	189	–	–	–	–	5	260	8	575
I. Other	–	41	–	–	–	49	–	–	–	–	2	59	2	149
J. Total	7	1579	5	5	26	1094	–	143	–	–	42	1849	80	4670
26. Reinspections	–	243	1	1	–	56	–	19	–	–	7	219	8	538
27. Stickers Issued	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vehs. Insp. 407A/Brake Viols.	–		–		–		–		–		–		–	
Vehs. Insp. 407/Reg. Viols.	–		–		–		–		–		–		–	
Vehs. Insp. 407/Lamp Viols.	–		–		–		–		–		–		–	
Vehs. Insp. 407/Other Equip.	–		–		–		–		–		–		–	
Vehs. Insp. 407/Motor Carriers	–		–		–		–		–		–		–	
Vehs. Insp. 407/Other Viols.	–		–		–		–		–		–		–	
Trks. Weighed/Wt. Viols.	7.0		5.3		–		–		–		23.3		13.5	
Trks. Insp. 407A/BIS Hours	–		–		–		–		–		–		–	
Vehs. Insp. 407A/BIS Hours	–		–		–		–		–		–		–	
Trks. Insp. 407/CVIS Hours	–		–		–		–		–		–		–	
Vehs. Insp. 407/CVIS Hours	–		–		–		–		–		–		–	
Officer Hours/215	2.3		2.7		2.4		–		–		4.0		2.8	
Officer Housr/281	–		8.0		1.9		–		–		1.7		2.7	
Officer Hours/Enf. Doc.	2.3		2.0		1.1		–		–		1.2		1.4	
Man-Hours/Enf. Doc.	2.3		2.0		1.1		–		–		1.2		1.4	
Man-Hours/Veh. Insp. 407A	–		–		–		–		–		–		–	
Man-Hours/Veh. Insp. 407	–		–		–		–		–		–		–	

NOTE: CHP Form 407-Registration, Mechanical and Equipment Inspection.

C A L I F O R N I A

R E C I P R O C I T Y

C O M M I S S I O N

Twenty-Second Annual Report

to the

California State Legislature
For the Calendar Year 1976

Hon. Herman Sillas, Director of Motor Vehicles, Chairman
Hon. Mervyn Dymally, Lieutenant Governor, Member
Hon. Kenneth Cory, State Controller, Member
Hon. Adriana Gianturco, Director of Transportation, Member
Hon. Glen B. Craig, Commissioner, California Highway Patrol, Vice Chairman

COMMISSION BUSINESS

California, along with nineteen other states and two Canadian Provinces, is a member of the Uniform Vehicle Registration Proration and Reciprocity Agreement. The other jurisdictions in the agreement are: Alaska, Alberta, Arizona, British Columbia, Colorado, Idaho, Illinois, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. California also has a bilateral prorate agreement with the States of Oklahoma, Wisconsin, Texas, and Tennessee.

Although negotiations with several states were initiated in the Department of Motor Vehicles during 1976, none were completed in time for the Reciprocity Commission to act. There was no Commission business transacted during the year.

A statistical summary of workload and revenue categories involving prorate operators for the calendar year 1976, and comparison with 1975 follows:

	1976	1975
Total Number of Prorate Fleets	4,432	3,878
Total Number of Prorate Vehicles	286,912	238,269
Prorate Revenue	$15,132,701	$16,437,392
Total Interchange Trailer Operators	18	18
Interchange Trailer Fee	$12,233.24	$29,970.00
Commercial Trip Permits	$2,602,350	$2,098,430

Respectfully submitted,

CALIFORNIA RECIPROCITY COMMISSION

By_______________________________

Herman Sillas
Chairman

UNIFORM PRORATION APPLICATION—FORM PR 1 | **SCHEDULE "A"** | **LICENSE YEAR_____ FLEET NO._____ PRORATE NO. _____**

Name of Applicant ____________________ (Operator)

Business Address ____________________ (Street)
(Where Records are Maintained)

(City) (County) (State) (Zip Code)

MAILING ADDRESS

____________________ (Street)

(City) (State) (Zip Code)

Name of person to contact regarding this application____________________

Telephone No.____________________ ( ) (Area No.)

City____________________

STATE OFFICE USE ONLY

1 (A)	2 State to Be Base Licensed in	3 Owner's Equipment Number	4 Year and Make	5 Vehicle Serial or Identification Number (B)	6 Type of Vehicle (C)	7 No. of Axl.	8 Unladen Weight	9 Declared Gross Weight	10 Declared Combined GW (D)	11 Type of Power	12 Cost of Vehicle	13 Date of Purchase	14 Date of Lease	15 (E)	16 (F)	17 Fees
																$

(A) Enter California Base License Plate, if any.
(B) Enter number under which vehicle is titled.
(C) See each state's instructions.
(D) Means weight of combination of power and trailing units plus load.
(E) See each state's instructions.
(F) See each state's instructions.

Subscribed and sworn to before me this____________________

day of ____________________ 19_____

____
Notary Public

Note: *States of California, Colorado, Montana, Nevada, and Oregon do not require a proration application to be notarized.*

Declaration: The undersigned declares, under penalty of perjury, that the information on this Application and attached Schedules, is true and correct.

____
Signature Title

____
City State Date

For California applicants only—The signature of an agent, who is not a bona fide employee of of the business, must be authorized in writing. An owner, partner, or corporate officer must complete the authorization prior to the agent affixing his signature on the application.

The undersigned hereby appoints____________________,
as the agent authorized to sign this Proration Application for the 19_____ licensing year.

____
Owner's Name, Partnership Name, or Corporation Name Signature Title

Notice: Report immediately to the Department of Motor Vehicles when this authorization is cancelled or terminated. This authorization is valid only for the licensing year indicated above.

Number of Power Vehicles in Fleet_____

Number of Trailers in Fleet_____

Total Number of Vehicles in Fleet_____

Total this application	
Mileage percentage	
Dollar proration	
Stickers	
Cab cards	
Title fees	
Total fees due	$

FIGURE D-1. UNIFORM PRORATION APPLICATION, SCHEDULE "A"

SCHEDULE "B"

LIST MILEAGE [illegible]EACH STATE IN WHICH THIS [illegible]EET TRAVELED — DO NOT LIST "OTHER" M[illegible]EAGE

State	Miles	%	State	Miles	%	State	Miles	%
Alabama			Maryland			South Carolina		
Alaska			Massachusetts			S. DAKOTA		
ARIZONA			Michigan			Tennessee		
Arkansas			MINNESOTA			Texas		
BRITISH COL.			Mississippi			Utah		
CALIFORNIA			MISSOURI			Vermont		
COLORADO			MONTANA			Virginia		
Connecticut			NEBRASKA			WASHINGTON		
Delaware			NEVADA			West Virginia		
District of Col.			New Hampshire			Wisconsin		
Florida			New Jersey			Wyoming		
Georgia			NEW MEXICO			Alberta		
IDAHO			New York			Manitoba		
ILLINOIS			North Carolina			New Brunswick		
Indiana			N. DAKOTA			Newfoundland		
IOWA			Ohio			Nova Scotia		
KANSAS			Oklahoma			Ontario		
Kentucky			OREGON			Prince Ed. Is.		
Louisiana			Pennsylvania			Quebec		
Maine			Rhode Island			Saskatchewan		
						TOTALS		

REG. 466 (REV. 8-72) CALIFORNIA

TO BE COMPLETED BY CARRIER

Check (X) the prorate compact states with which [illegible] are filing an application for this fleet:

Arizona	______	Missouri	______
British Columbia	______	Montana	______
California	______	Nebraska	______
Colorado	______	Nevada	______
Illinois	______	New Mexico	______
Idaho	______	North Dakota	______
Iowa	______	Oregon	______
Kansas	______	South Dakota	______
Minnesota	______	Washington	______

TYPE OF OPERATION:

Common Carrier with I.C.C. Permit______
Common Carrier Exempt Commodities______
Exempt Commodity Livestock______
Produce______ Grain______ Logs______
Ore______ Other______
Back Haul Commodity______
Contract Carrier I.C.C. Permit______
Private Carrier______
Back Haul Commodity______
Haul For Hire______
Explain in detail your operation if any mileage is estimated:

______
______
______
______

STATE OFFICE USE ONLY

ACTION	DATE
CHECKED	
FIGURED	
FEE LETTER TYPED	
DECALS ISSUED	
CAB CARDS TYPED	
CAB CARDS PUNCHED	
APPROVED	

FIGURE D-2. UNIFORM PRORATION APPLICATION, SCHEDULE "B"

SCHEDULE A

LICENSE YEAR 1977 FLEET NO. 001 PRORATE NO. PR3399

...ne of Applicant: Industrial Commodities (Operator)

...iness Ad... ...ere Reco... ...aintained): 5510 S. 300 West (Street)

...rray (City) · Salt Lake (County) · Utah (State) · 84107 (Zip Code)

MAILING ADDRESS

(Str...)

(City) (State) (Zip Code)

Name of person to contact regarding this application: Nancy Jeffs

Telephone No. 262-5523 (801) (Area No.)

City: Salt Lake City Utah

...TE OFFICE USE ONLY

1 (A)	2 State File Base Licensed in	3 Owner's Equipment Number	4 Year and Make	5 Vehicle Serial or Identification Number (B)	6 Type of Vehicle (C)	7 No. of Axl.	8 Unladen Weight	9 Declared Gross Weight	10 Declared Combined GW (D)	11 Type of Power	VL CLASS	FEES SF	RF	WTF	VLF	TOTAL
	Nevada	8	1969 Mack	FL763LST4354	Trac	3	14,670			D	[illegible]	9	[illegible]	[illegible]	[illegible]	$ [illegible]
	Nevada	22	74 White	CA213HP087667	Trac	3	14,180			D	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
	Nevada	22A	70 Cook	A5815	Dump	2	11,860			D			[illegible]	[illegible]	[illegible]	[illegible]
	Nevada	22B	73 Brown	S734813	Flat Bed	2	9,520			D	[illegible]	15	[illegible]	[illegible]	[illegible]	[illegible]
	Nevada	N50A	63 Fruehauf	193802	Dump	1	5,720			D	[illegible]	[illegible]	55	[illegible]	[illegible]	[illegible]
	Nevada	N50B	63 FRUhauf	172210	Dump	2	8,400			D						
	Nevada	N 57	76 Kenworth	152832 S	TRac	2	13,560			D						
	Nevada	N 58	76 Kenworth	152833 S	Trac	2	13,460			D						
	Nevada	N 58C	65 Fruhauf	FRE254503	TRLR	2	7,960			D						
	Nevada	N 59	68 White	W 35061	Trac	2	11,630			D						
	Nevada	N 59A	66 LOA	66862	Dump	1	5,060			XX						
	Nevada	N 59B	66 LOA	66863	Dump	2	7,080			XX	Sub-Total	42	[illegible]	[illegible]	[illegible]	[illegible]

(A) Enter California Base License Plate, if any.
(B) Enter number under which vehicle is titled.
(C) See each state's instructions.
(D) Means weight of combination of power and trailing units plus load.
(E) See each state's instructions.
(F) See each state's instructions.

...ribed and sworn to before me this ______________

of ______________ 19____

Notary Public

...e states of California, Colorado, Montana, Nevada, and Oregon do not require a proration application to be notarized.

Declaration: The undersigned declares, under penalty of perjury, that the information on this Application and attached Schedules, is true and correct.

[illegible] (Signature) · [illegible] (Title)

[illegible] (City) · [illegible] (State) · 2-9-77 (Date)

For California applicants only—The signature of an agent, who is not a bona fide employee of the business, must be authorized in writing. An owner, partner, or corporate officer must complete the authorization prior to the agent affixing his signature on the application.

The undersigned hereby appoints ______________,

as the agent authorized to sign this Proration Application for the 19____ licensing year.

Owner's Name, Partnership Name, or Corporation Name · Signature

Notice: Report immediately to the Department of Motor Vehicles when this authorization is cancelled or terminated. This authorization is valid only for the licensing year indicated above.

REG. 3007 (REV. 1/72)

Total This Page	$ [illegible]
Mileage Percentage	[illegible]
Dollar Proration	[illegible]
ID Fee	[illegible]
Service Fee	[illegible]
Misc. Fee	
Total Fees Due	$ [illegible]

FIGURE D-3. UNIFORM PRORATION APPLICATION-FORM PRI, SCHEDULE "A", PAGE 1

UNIFORM PRORATION APPLICATION—FORM PR 1

SCHEDULE "A"

LICENSE YEAR 1977 FLEET NO. 001 PRORATE NO. PR 3399

Name of Applicant Industrial Commodities (Operator)

Business Address 5510 South 3rd West (Street)

Murray SLC Utah 84107 (City) (County) (State) (Zip Code)

MAILING ADDRESS

(Street)

(City) (State) (Zip Code)

Name of person to contact regarding this application Nancy Jeffs

Telephone No. 262-5523 (801) (Area No.)

City Salt Lake City, Utah

STATE OFFICE USE ONLY

1 (A)	2 State to Be Base Licensed in	3 Owner's Equipment Number	4 Year and Make	5 Vehicle Serial or Identification Number (B)	6 Type of Vehicle (C)	7 No. of Axl.	8 Unladen Weight	9 Declared Gross Weight	10 Declared Combined GW (D)	11 Type of Power	12 Cost of Vehicle	13 Date of Purchase	14 Date of Lease	15 (E)	16 (F)	17 Fees
	Nevada	N 60A	74 Fruhauf	FRS 577904	Dump	1	5,480				7,308	10/74	10/76			160
	Nevada	N 60 B	74 Fruhauf	FRS 578004	Dump	2	7,600				9,308	10/74	10/76			239
	Nevada	N 61A	74 Fruhauf	FRS 577903	Dump	1	5,480				7,308	10/74	10/76			160
	Nevada	N 61B	74 Fruhauf	FRS 578003	Dump	2	7,400				9,308	10/74	10/76			222
	Nevada	N 62A	74 Fruhauf	566902	Dump	2	10,350				10,200	2/74	10/76			340
	Nevada	N 63	76 Kenworth	151509 S	Trac	2	16,840			D	47,500	6/76	10/76			923
	Nevada	15 A	63 TRLMO	507908	TA	2	11,800				7,900	11/74	10/76			352
	Nevada	27	73 Kenworth	132827	TRAC	3	15,820			D	22,500	11/75	10/76			552
	Nevada	27 A	73 Brown	S 734814	FB	2	10,720				4,950	1975	10/76			312
	Nevada	6	73 GMC	DC 92A-A133743	TRAC	2	15,180			D	22,000	1/73	10/76			391
	Nevada	6A	55 Fruhauf	C 34840	Dump	1	5,106				2,500	3/74	10/76			123
	Nevada	6 B	55 TRMO	200948	Dump	1	5,990				1,500	1/75	10/76			123

A Enter and mark Base License Plate, if any.
B Enter serial number which vehicle is titled.
C See each state's instructions.
D Means gross combination of power and trailing units.
E See each state's instructions.
F See each state's instructions.

Subscribed and sworn to before me this ______

day of ______ 19____

Notary Public

Note: States of California, Colorado, Montana, Nevada, and Oregon do and require a proration application to be notarized.

Declaration: The undersigned declares, under penalty of perjury, that the information on this Application and attached Schedules, is true and correct.

Signature ______ Title ______

City ______ State ______ Date ______

For California applicants only—The signature of an agent, who is not a bona fide employee of of the business, must be authorized in writing. An owner, partner, or corporate officer must complete the authorization prior to the agent affixing his signature on the application.

The undersigned hereby appoints ______

as the agent authorized to sign this Proration Application for the 19____ licensing year.

Owner's Name, Partnership Name, or Corporation Name ______ Signature ______ Title ______

Notice: Report immediately to the Department of Motor Vehicles when this authorization is cancelled or terminated. This authorization is valid only for the licensing year indicated above.

Number of Power Vehicles in Fleet ______

Number of Trailers in Fleet ______

Total Number of Vehicles in Fleet ______

Total this application	3731
Mileage percentage	
Dollar proration	
Stickers	
Cab cards	
Title fees	
Total fees due	$

FIGURE D-4. UNIFORM PRORATION APPLICATION--FORM PRI, SCHEDULE "A", PAGE 2

FORM PRORATION APPLICATION—FORM PR 1

SCHEDULE "A"

LICENSE YEAR 1977 FLEET NO. 001 PRORATE NO. PR 3599

Name of Applicant: Industrial Commodities (Operator)

Business Address: 5510 South 300 West (Street)

Murray SLC (County) Utah (State) 84107 (Zip Code)

MAILING ADDRESS

(Street)

(City) (State) (Zip Code)

Name of person to contact regarding this application Nancy Jeffs

Telephone No. 262-5523 (801) (Area No.)

City Salt Lake City Utah

STATE OFFICE USE ONLY

1	2 State to Be Base Licensed in	3 Owner's Equipment Number	4 Year and Make	5 Vehicle Serial or Identification Number (B)	6 Type of Vehicle (C)	7 No. of Axl.	8 Unladen Weight	9 Declared Gross Weight	10 Declared Combined GW (D)	11 Type of Power	12 Cost of Vehicle	13 Date of Purchase	14 Date of Lease	15 (E)	16 (F)	17 Fees $
	Nevada	6C	63 FRuhauf	FRD 213702	Dump	2	12410				5,280	6/11/75	10/76			378
	Nevada	14 A	64 TRLMO	216196	Dump	1	5,280				900	1/75	10/76			113
	Nevada	14 B	64 TRLMO	216216	Dump	2	8,470				900	1/75	10/76			207
	Nevada	15	75 PETE	74612 P	TRAC	2	13,240			D	37,828	2/11/75	10/76			656
	Nevada	16	74 Pete	51675 P	TRAC	2	13,300			D	27,000	6/74	10/76			456
	Nevada	16 A	58 TLRMO	205175	Dump	1	6,207				1,500	3/74	10/76			147
	Nevada	16 B	51 Fruhauf	C 27804	Dump	1	10,030				3,000	10/74	10/76			283
	Nevada	9 A	74 Fruhauf	FRR544901	Dump	2	11,160				7,000	1974	10/76			346
	Nevada	9 B	70 TRM	G 22596	Dump	2	5,820				2,800	1970	10/76			109
	Nevada	9 C	70 TRM	G 22598	Dump	2	7,900				2,800	1970	10/76			178
	Nevada	19	76 Kenworth	151508S	TRAC	2	17,320			D	47,500	6/28/76	10/76			923
	Nevada	10	73 Kenworth	131209	TRAC	2	11,750			D	26,300	1973	10/76			343

A. Enter number on Base License Plate, if any.
B. ... state in which vehicle is titled.
C. ... see each state's instructions.
D. Means weight of combination of power and trailing units ...
E. See each state's instructions.
F. See each state's instructions.

Subscribed and sworn to before me this ______ day of ______ 19__

Notary Public

Note: States of California, Colorado, Montana, Nevada, and Oregon do not require a proration application to be notarized.

Declaration: The undersigned declares, under penalty of perjury, that the information on this Application and attached Schedules, is true and correct.

Signature ______ Title ______

City ______ State ______ Date ______

For California applicants only—The signature of an agent, who is not a bona fide employee of of the business, must be authorized in writing. An owner, partner, or corporate officer must complete the authorization prior to the agent affixing his signature on the application.

The undersigned hereby appoints ______ as the agent authorized to sign this Proration Application for the 19____ licensing year.

Owner's Name, Partnership Name, or Corporation Name ______ Signature ______ Title ______

Notice: Report immediately to the Department of Motor Vehicles when this authorization is cancelled or terminated. This authorization is valid only for the licensing year indicated above.

Number of Power Vehicles in Fleet ______

Number of Trailers in Fleet ______

Total Number of Vehicles in Fleet ______

Total this application	4124
Mileage percentage	
Dollar proration	
Stickers	
Cab cards	
Title fees	
Total fees due	$

FIGURE D-5. UNIFORM PRORATION APPLICATION--FORM PRI, SCHEDULE "A", PAGE 3

UNIFORM PRORATION APPLICATION—FORM PR 1

SCHEDULE "A"

LICENSE YEAR 1977 FLEET NO. [illegible] PRORATE NO. ______

Name of Applicant [illegible]strial Commodities (Operator)

Business Address 5510 South 300 West (Where Records are Maintained) (Street)

Murray (City) SLC (County) Utah (State) 84107 (Zip Code)

MAILING ADDRESS

______ (Street)

______ (City) ______ (State) ______ (Zip Code)

Name of person to contact regarding this application Nancy Jeffs

Telephone No. 262-5523 (801) (Area No.)

City Salt Lake City, Utah

STATE OFFICE USE ONLY

1 (A)	2 State to Be Base Licensed in	3 Owner's Equipment Number	4 Year and Make	5 Vehicle Serial or Identification Number (B)	6 Type of Vehicle (C)	7 No. of Axl.	8 Unladen Weight	9 Declared Gross Weight	10 Declared Combined GW (D)	11 Type of Power	12 Cost of Vehicle	13 Date of Purchase	14 Date of Lease	15 (E)	18 (F)	17 Fees
	NEVADA	10 A	66 Fruhauf	FRF 279904	Dump	1	5,480				4,000	1966	10/76	[illegible]	[illegible]	107.00
	NEVADA	10 B	66 Fruhauf	FRF 280004	Dump	2	7,570				5,000	1956	10/76	[illegible]	[illegible]	172.00
	NEVADA	11	74 Fruhauf	123740037	DLY	1	2,360				2,100	1974	10/76	17	17	45.00
	NEVADA	11 A	64 UTI	41271HOPER	Dump	1	5,520				4,000	1964	10/76		[illegible]	~~125.00~~ 131
	NEVADA	11 B	64 UTI	41272HOPER	DUMP	2	7,400				1,200	8/76	10/76	[illegible]	[illegible]	184
	NEVADA	3 A	67 HOBBS	FH 4460506	Dump	2	12,000				6,250	3/1/75	10/76	[illegible]	[illegible]	359.00
	NEVADA	28	70 Kenworth	119549	TRAC	3	17,700				18,900	11/75	10/76		[illegible]	572.00
	NEVADA	17A	68 Fruhauf	FRG 304606	TRLR	2	7,430				3,750	6/75	10/76	[illegible]	[illegible]	227
	NEVADA	17 B	68 Fruhauf	FRG 304506	TRLR	1	5,040				3,750	6/75	10/76	[illegible]	[illegible]	144
	NEVADA	17 C	65 Fruhauf	FRE 254403	SEMI	1	5,620				2,810	10/75	10/76	[illegible]	[illegible]	135
	NEVADA	18	76 Kenworth	153125 S	TRAC	2	15,800			D	44,800	10/11/76	10/76	[illegible]	[illegible]	[illegible]
	NEVADA	1	74 MAR	01074896	TRAC	3	15,500			D	28,000	3/74	10/76	[illegible]		[illegible]

(A) Enter California Base License Plate, if any.
(B) Enter number under which vehicle is titled.
(C) See each state's instructions.
(D) Means weight of combination of power and trailing units plus load.
(E) See each state's instructions.
(F) See each state's instructions.

Subscribed and sworn to before me this ______

______ 19___

______
Notary Public

States of California, Colorado, Montana, Nevada, and Oregon do not require a proration application to be notarized.

Declaration: The undersigned declares, under penalty of perjury, that the information on this Application and attached Schedules, is true and correct.

______ Signature ______ Title

______ City ______ State ______ Date

For California applicants only—The signature of an agent, who is not a bona fide employee of the business, must be authorized in writing. An owner, partner, or corporate officer must complete the authorization prior to the agent affixing his signature on the application.

The undersigned hereby appoints ______

as the agent authorized to sign this Proration Application for the 19____ licensing year.

______ Owner's Name, Partnership Name, or Corporation Name ______ Signature ______ Title

Notice: Report immediately to the Department of Motor Vehicles when this authorization is cancelled or terminated. This authorization is valid only for the licensing year indicated above.

Number of Power Vehicles in Fleet ______

Number of Trailers in Fleet ______

Total Number of Vehicles in Fleet ______

Total this application	[illegible]
Mileage percentage	
Dollar proration	
Stickers	
Cab cards	
Title fees	
Total fees due	$

FIGURE D-6. UNIFORM PRORATION APPLICATION--FORM PRI, SCHEDULE "A", PAGE 4

'IFORM PRORATION APPLICATION—FORM PR 1

SCHEDULE "A"

LICENSE YEAR 1977 FLEET NO. 001 PRORATE NO PR 3399

Name of Applicant dustrial Commodities (Operator)

Business Address 5510 South 300 West (Street) (Where Records are Maintained)

Murray (City) SLC (County) Utah (State) 84107 (Zip Code)

MAILING ADDR

_____ (Street)

_____ (City) _____ (State) _____ (Zip Code)

Name of person to contact regarding this application Nancy Jeffs

Telephone No. 262-5523 (801) (Area No.)

City Salt Lake City Utah

STATE OFFICE USE ONLY

1 (A)	2 State to Be Base Licensed in	3 Owner's Equipment Number	4 Year and Make	5 Vehicle Serial or Identification Number (B)	6 Type of Vehicle (C)	7 No. of Axl.	8 Unladen Weight	9 Declared Gross Weight	10 Declared Combined GW (D)	11 Type of Power	12 Cost of Vehicle	13 Date of Purchase	14 Date of Lease	15 (E)	16 (F)	17 Fees
	NEVADA	E 2 B	72 Brown	M 720992	FB	2	10,720				4,100	9/74	10/76	[illegible]	[illegible]	$ 296
	NEVADA	4	77 Pete	85725 P	TRAC	2	13,160				40,000	11/5/76	11/76	[illegible]	[illegible]	800
	NEVADA	4 A	67 TLRMO	D-20586	TLR	2	5,535				1,300	11/5/76	11/76	[illegible]	18	121
	NEVADA	4 B	67 TLRMO	D-20589	TLR	2	8,110				2,350	11/5/76	11/76	[illegible]	[illegible]	227
	NEVADA	27 B	64 Beall	66464	FB	3	16,000				10,000	1/1/77	1/77	[illegible]	[illegible]	596
	NEVADA															
														[illegible]	[illegible]	[illegible]

A) Enter California Base License Plate, if any.
B) Enter number under which vehicle is titled.
C) See each state's instructions.
D) Means weight of combination of power and trailing units plus load.
E) See each state's instructions.
F) See each state's instructions.

Subscribed and sworn to before me this_____

_____ 19_____

_____
Notary Public

States of California, Colorado, Montana, Nevada, and Oregon do not require a proration application to be notarized.

Declaration: The undersigned declares, under penalty of perjury, that the information on this Application and attached Schedules, is true and correct.

_____ Signature _____ Title

_____ City _____ State _____ Date

For California applicants only—The signature of an agent, who is not a bona fide employee of of the business, must be authorized in writing. An owner, partner, or corporate officer must complete the authorization prior to the agent affixing his signature on the application.

The undersigned hereby appoints_____;
as the agent authorized to sign this Proration Application for the 19_____ licensing year.

Owner's Name, Partnership Name, or Corporation Name _____ Signature _____ Title

Notice: Report immediately to the Department of Motor Vehicles when this authorization is cancelled or terminated. This authorization is valid only for the licensing year indicated above.

Number of Power Vehicles in Fleet_____

Number of Trailers in Fleet_____

Total Number of Vehicles in Fleet_____

Total the application	
Mileage percentage	
Dollar proration	
Stickers	
Cab cards	
Title fees	
Total fees due	$

FIGURE D-7. UNIFORM PRORATION APPLICATION--FORM PRI, SCHEDULE "A", PAGE 5

SCHEDULE "B"

LIST MILEAGE IN EACH STATE IN WHICH THIS FLEET TRAVELED — DO NOT LIST "OTHER" MILEAGE

	Miles	%	State	Miles	%		Miles	%
Alabama	XXXXXXXX	XXXXX	Maryland			South Carolina		
Alaska			Massachusetts			S. DAKOTA		
ARIZONA	240	00.012	Michigan			Tennessee		
Arkansas			MINNESOTA			Texas		
BRITISH COL.			Mississippi			Utah	92441	04.995
CALIFORNIA	358,888	19.392	MISSOURI			Vermont		
COLORADO	168	00.009	MONTANA			Virginia		
Connecticut			NEBRASKA			WASHINGTON		
Delaware			NEVADA	1,397221	75,497	West Virginia		
District of Col.			New Hampshire			Wisconsin		
Florida			New Jersey			Wyoming	1466	00.079
Georgia			NEW MEXICO	227	00.012	Alberta		
IDAHO			New York			Manitoba		
ILLINOIS			North Carolina			New Brunswick		
Indiana			N. DAKOTA			Newfoundland		
IOWA			Ohio			Nova Scotia		
KANSAS			Oklahoma			Ontario	[illegible]	
Kentucky			OREGON			Prince Ed. I	[illegible]	
Louisiana			Pennsylvania			Quebec		
Maine			Rhode Island			off road XXXXXXXX	48	00.002
						TOTALS	1,850,699	100.00

REG. 466 (REV. 8-72) CALIFORNIA

TO BE COMPLETED BY CARRIER

Check (X) the prorate compact states with which you are of an application for this fleet:

Arizona	______	Missouri	______
British Columbia	______	Montana	______
California	______	Nebraska	______
Colorado	______	Nevada	______
Illinois	______	New Mexico	______
Idaho	______	North Dakota	______
Iowa	______	Oregon	______
Kansas	______	South Dakota	______
Minnesota	______	Washington	______

TYPE OF OPERATION:

Common Carrier with I.C.C. Permit______
Common Carrier Exempt Commodities______
Exempt Commodity Livestock______
Produce______ Grain______ Logs______
Ore______ Other______
Back Haul Commodity______
Contract Carrier I.C.C. Permit______
Private Carrier______
Back Haul Commodity______
Haul For Hire______
Explain in detail your operation if any mileage is estimated______

STATE OFFICE USE ONLY

ACTION	DATE
CHECKED	
FIGURED	
FEE LETTER TYPED	
DECALS ISSUED	
CAB CARDS TYPED	
CAB CARDS PUNCHED	
APPROVED	

FIGURE D-8. UNIFORM PRORATION APPLICATION--FORM PRI, SCHEDULE "B"

INDIVIDUAL VEHICLE MILEAGE RECORD

(I.V.M.R.)

DRIVER'S NAME	STARTING DATE MO. DAY YEAR	ENDING DATE MO. DAY YEAR	START
	/ /	/ /	(CITY) (STATE) DESTINATION:
			(CITY) (STATE)

TRUCK NO.	YEAR	MAKE	SERIAL NO.	FLEET NO.	TOTAL MILES

STATE NO. STATE NAME	ROUTE: START	ODOMETER READING BEGINNING	ENDING	TOTAL TRIP MILES/DATE

	TOTAL

FIGURE D-9. INDIVIDUAL MILEAGE RECORD FORM

ANNUAL RECAPITULATION

SEPTEMBER 1, ______ TO AUGUST 31, ______

OPERATOR'S NAME	OPERATOR'S NO.	TRIP STARTING DATE	ENDING DATE

FLEET NO.	TRUCK NO.	ODOMETER READINGS		TOTAL MILES
		BEGINNING	ENDING	
SERIAL NO'	YEAR			

STATE NO.	STATE NAME	TOTAL TRIP MILES
		TOTAL

FIGURE D-10. ANNUAL RECAPITULATION FORM

D.3.2. Potential Value as Exposure Data

The following discussion identifies several exposure measures that might be developed by analysis of the prorate data in toto or on a sample basis.

a) Average Annual Fleet/Vehicle Mileage. Use of Schedule B forms (100% or smaller sample) will permit identification of the average annual fleet mileage (AAFM) and average annual vehicle mileage (AAVM) for the 286,000 registered prorate trucks. Since there are only 4,432 prorate fleets (or Schedule B forms), this would not entail a particularly large data processing effort to Xerox, code, punch, edit, and load to form a convenient data base for analysis along with Schedule A. If the analysis were restricted to just determining AAFM and AAVM from Schedule B forms, then it would not be necessary to computerize the data. A simple extraction of the total fleet mileage from Schedule B and number of vehicles per fleet from Schedule A would provide the data base. Computing AAMV would then be an easy operation. Since the 286,000 registered prorate vehicles are primarily large tractors and trucks, the resultant AAVM numbers per fleet could be averaged across the total of all fleets to give a single AAVM for the entire state. This, in turn, could be applied to the total California large truck population to yield the total VMT for the entire state's large truck population. This VMT exposure measure may be useful in predicting total large truck accidents, but this needs to be proven.

b) Large Truck Type Distributions for California. Use of Schedule A will permit compilation of a set of distribution tables for the 286,000 large prorate trucks in the state according to vehicle make, year, type of vehicle, number of axles, and unladen weight, etc. These data could be sampled to minimize the data processing. Unfortunately, columns 9 and 10 showing Declared Gross Weight and Declared Combined Weight data are not provided by the fleet operators. These distribution tables could indicate how valid the truck weight distribution tables are in representing statewide distribution.

c) IVMR. Figures D-9 and D-10, shown previously, include O & D (Origin/Destination) trip making characteristics of the 286,000 prorate trucks. These data, however, are not collected by the Prorate Section, but are held by the fleet operators for a period of one year.

These data will, nonetheless, permit establishment of O & D trip making characteristics according to truck make, year, etc. The problem is in contacting a representative sample of fleet operators and extracting the data. These data can be correlated with the preceding Schedule A and Schedule B data.

D.4. Potential Exposure Value of CHP Commercial Vehicle Inspection Facility Activity

The following discussion identifies a new set of CHP compiled data on statewide large truck operations that may contain some exposure measures of value to the truck accident study.

D.4.1. Data Content

The CHP maintains an ongoing (daily) vehicle weight and inspection program at eight major vehicle inspection facilities and compiles monthly data on trucks (power units and trailers) according to CHP zones. Data on some 44 variables of truck operating/performance status are collected and compiled. The five following charts (typical format) identify:

a) Monthly summary of commercial activities: 29 variables of vehicle status, violations, enforcement measures, etc., according to six CHP zones plus the statewide totals.

b) Commercial vehicle inspection facility monthly activity: Contains inspection data on 44 variables by location, plus statewide totals.

c) Monthly summary of platform scale activity: Contains selected data on 44 variables collected at other platform scale sites, other than inspection facility locations, according to zones.

d) Monthly summary of mobile road enforcement activity: Contains selected data on 44 variables collected by way of a mobile vehicle inspection program according to zones.

e) Monthly summary of loadometer pit activity: Contains selected data on 44 variables at various loadometer sites in each zone.

D.4.2. Data Availability

In 1974 the CHP shifted the data compilation to a quarterly rather than a monthly basis. Thus, the 1975/76 study period is covered by quarterly summaries. The data are derived from the following site locations distributed throughout the six zones.

a) Vehicle inspection facilities: eight sites

b) Platform scales: 40 sites

c) Mobile road enforcement: everywhere or random

d) Loadometer pits: 50 or 60

D.4.3. Potential Value

These data on vehicle status (registration, mechanical, and equipment inspection) provide an opportunity to study the impact of enforcement of vehicle conditions on truck accident safety for Zones II and V. It could be possible to analyze the variations in vehicle inspection activities over the 12-month truck project period for 1975/76 and to correlate these enforcement patterns with accident data and other vehicle exposure (VMT, etc.) measures. It is not sufficient to conclude that lowered accident rates are directly dependent upon vehicle exposure or use in any given area. Heavy law enforcement activities as exposed by the cited five charts on vehicle inspections may well play a role in modifying accident distributions.

These data could also be investigated to determine whether the "traffic" through each of the four inspection/weight types of enforcement facilities correlates with AADT's and VMT's in Zones II and V, local CHP areas, or immediate state highway links centered on each respective inspection facility.

D.5. Potential Exposure Value of U.S. Census of Transportation of the California Trucking Industry

The following identifies the general characteristics of the California and national trucking industry as developed by the U.S. Census of Transportation. The data have some utility for defining measures of exposure for large trucks according to truck type, size, operational characteristics, commodity, etc.

a) Now available in the files at USC are three excerpts from the U.S. Census of Transportation for the five-year intervals of 1963-1967-1972. Included are separate tables for California and national compilations.

b) Vehicle size classes reflect both light/medium/light-heavy/heavy-heavy weight categories as well as axle categories according to two, three, four, and five axles. Distributions of California and national truck populations are listed.

c) The 1977 census data are evidently being developed currently but would probably not be available until 1979. Thus, use of the three census compilations would require an extrapolation of the 1963-1967-1972 data in order to span the 15 May 1975–1 May 1976 truck study period.

d) Use of these data permits a crude evaluation to be made on the representativeness of the California exposure data to broad national truck usage.

APPENDIX E

POTENTIAL PROCEDURE FOR EXTRACTING ACCIDENT DATA FROM THE COLLISION DIAGRAM AND ASSOCIATED NARRATIVE IN FORM 555 REPORTS

Time in the present study did not permit investigation of the utility of new procedures developed earlier for deriving information from the collision diagrams. This investigation is recommended for future consideration. The coding forms that have been developed for the purpose are provided in this appendix.

TABLE E-1. VEHICLE LANE POSITION, SPEED, TMPC AND TMFC

Vehicle Lane Position

Center Divider	0
Lane 1	1
Lane 2	2
Lane 3	3
Lane 4	4
Lane 5	5
Median	6
Shoulder	7
On-ramp	8
Off-ramp	9
Collector Road	10
Intersection	11
Driveway	12
Sidewalk	13
Acceleration Lane	14
Deceleration Lane	15
Hit and Run	16
Moved Prior to Arrival	17
Off Road	18
Unknown	19
Fled Scene	20

Movement Preceding or Following Collision or Impact

Stopped	30
Proceeding Straight	31
Ran Off Road	32
Making Left Turn	33
Making Right Turn	34
Making U Turn	35
Backing	36
Slowing—Stopping	37
Passing Other Vehicle	38
Changing Lanes	39
Parking Maneuver	40
Other Unsafe Turning	41
Crossed Into Opposing Lane	42
Parked	43
Merging—Lane Drop	44
Mergining—Construction Zone	45
Mergining—Intersection or Transition	46
Mergining from Shoulder or Median	47
Traveling Wrong Way	48
Being Shoved	49
Shoving	50
In-Lane Weaving	51
Spinning or Turning Out of Control	52
Changing Lanes to Avoid Spilled Debris or Cargo	53
Stopped to Avoid Debris or Spilled Cargo	54
Proceeding Straight but Spilling Cargo	55
Maneuvering Toward Right Shoulder Following Impact	56
Maneuvering Toward Left Shoulder or Median Following Impact	57
Maneuvering to Minimize Further Collision Damage	58

CASE NUMBER ☐☐☐☐☐ CARD ☐

POINT OF IMPACT/REST POSITIONS

Collision Location Reference (Feet) ☐☐☐☐ ☐☐☐☐

			*				+ *
POI-1	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐ ☐	POR-P_1	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐☐ ☐☐
POI-2	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐ ☐	POR-P_2	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐☐ ☐☐
POI-3	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐ ☐	POR-P_3	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐☐ ☐☐
POI-4	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐ ☐	POR-P_4	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐☐ ☐☐
POI-5	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐ ☐	POR-P_5	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐☐ ☐☐
POI-6	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐ ☐	POR-P_6	Longitudinal Lateral	☐☐☐☐ ☐☐☐☐	☐☐ ☐☐

*1 (Cited by T.O.)
*2 (Interpreted by Coder)
+3 (At end of Collision)
+4 (After voluntary relocation)
+5 (Fled Scene)

COLLISION DESCRIPTION

	HEAD ON	REAR END	ANGLE	ROLLOVER	JACKKNIFE	BROADSIDE	HIT OBJECT	SIDESWIPE	AUTO-PEDESTRIAN	OTHER	FRONT END	INITIATOR OF EVENT
POI-1	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐
POI-2	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐
POI-3	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐
POI-4	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐
POI-5	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐
POI-6	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐	☐☐

FIGURE E-1. POINT OF IMPACT/REST POSITIONS FORM

CASE NUMBER ☐☐☐☐☐ CARD ☐

VEHICLE LANE POSITION, SPEED DATA, TMPC AND TMFC

IMPACT #1

	V_1	V_2	V_3	V_4	V_5	V_6
Point of Start						
Point of Start Speed						
Point of Impact						
Point of Impact Speed						
Point of Rest						
Type Movement Preceding Collision						
Type Movement Following Collision						

IMPACT #2

	V_1	V_2	V_3	V_4	V_5	V_6
Point of Start						
Point of Start Speed						
Point of Impact						
Point of Impact Speed						
Point of Rest						
Type Movement Preceding Collision						
Type Movement Following Collision						

IMPACT #3

	V_1	V_2	V_3	V_4	V_5	V_6
Point of Start						
Point of Start Speed						
Point of Impact						
Point of Impact Speed						
Point of Rest						
Type Movement Preceding Collision						
Type Movement Following Collision						

IMPACT #4

	V_1	V_2	V_3	V_4	V_5	V_6
Point of Start						
Point of Start Speed						
Point of Impact						
Point of Impact Speed						
Point of Rest						
Type Movement Preceding Collision						
Type Movement Following Collision						

FIGURE E-2. VEHICLE LANE POSITION, SPEED DATA, TMPC AND TMFC FORM

CASE NUMBER ☐☐☐☐☐ CARD ☐

ROAD DESCRIPTION

SURFACE TYPE	CENTER DIVIDER	LANE 1	LANE 2	LANE 3	LANE 4	LANE 5	SHOULDER	OFF RAMP	ON RAMP	COLLECTOR ROAD	INTERSECTION	DRIVEWAY	SIDEWALK	ACCELERATION LANE
Primary*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Secondary	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

ROAD WIDTH**

Primary ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Secondary ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

ALIGNMENT

		(1)	(2)(3)
Primary	1	☐	☐☐
	2	☐	☐☐
	3	☐	☐☐
Secondary	1	☐	☐☐
	2	☐	☐☐
	3	☐	☐☐

(1) *Highway Azimuth* (Relative to Party #1 Dir.)
- N 6
- S 7
- E 8
- W 9

(2) *Grade Def.*
- Uphill . . . 10
- Downhill . . . 11
- Level 12
- Crest of Hill . . 13
- Bottom of Hill . 14

(3) *Alignment*
- Straight . . . 15
- Curved Left . . 16
- Curved Right . . 17

SURFACE TYPE
- Asphalt . . . 1
- Concrete . . . 2
- Gravel . . . 3
- Dirt 4
- Other 5

*Party #1 Road (Half of cited road if 2-way. Full road if 1-way reading from left to right from Party #1 direction.)

**Width closest to foot.

SKID MARK DESCRIPTION

	Point Initiation	Length to Point of Impact	Point of Termination	Length from Point of Impact	Description
V1	☐☐☐	☐☐☐☐	☐☐	☐☐☐☐	☐☐
V2	☐☐☐	☐☐☐☐	☐☐	☐☐☐☐	☐☐
V3	☐☐☐	☐☐☐☐	☐☐	☐☐☐☐	☐☐

INITIATION–TERMINATION
- Before Point of Impact . . . 18
- At Point of Impact 19
- After Point of Impact 20

DESCRIPTION
- Solid Continuous . . . 21
- Intermittent 22
- Straight 23
- Curved 24
- Lateral 25
- Other 26

Length (to) or (from) Point of Impact (Closest even foot)

FIGURE E-3. ROAD DESCRIPTION FORM

CASE NUMBER ☐☐☐☐☐ CARD ☐

ORIENTATION OF MULTIPLE UNITS AT IMPACT(S)

POI		STRAIGHT	CONTROLLED TURN	JACKKNIFED	CONTROLLED MANEUVER	SEPARATED	OVERTURN	OTHER
1		☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐
2		☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐
3		☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐
4		☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐
5		☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐
6		☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐	☐☐☐☐☐☐

	Veh #1	Veh #2	Veh #3
Straight			
Aligned straight or parallel and within lane of travel	10	30	50
Aligned straight or parallel but not in original lane of travel	11	31	51
Controlled Turn			
Aligned parallel within lane of travel	12	32	52
Aligned parallel to original lane of travel but partially or completely outside original lane of travel	13	33	53
Jackknifed			
Tractor—Semi only	14	34	54
3rd unit trailer Jackknifed only	15	35	55
Tractor+Semi+Trailer (Full Jackknife)	16	36	56

	Veh #1	Veh #2	Veh #3
Controlled Maneuver			
Controlled turn into other roadway	17	37	57
Controlled turn into driveway	18	38	58
Separated			
Semi or Trailer Only	19	39	59
3rd unit only	20	40	60
Semi + 3rd unit	21	41	61
Overturn			
Truck or tractor only	22	42	62
Semi or trailer only	23	43	63
Semi and trailer	24	44	64
Other	25	45	65

FIGURE E-4. ORIENTATION OF MULTIPLE UNITS AT IMPACT FORM

APPENDIX F

MATHEMATICAL FRAMEWORK OF THE CONTINGENCY TABLE ANALYSIS METHODOLOGY BASED ON MINIMUM DISCRIMINATION INFORMATION

F.1. Background on "Information"

Consider two probability distributions $\underline{p}$ and $\underline{\pi}$ on Ω. Given a cell ω, $p(\omega)$ is the probability that an individual is classified in cell ω under $\underline{p}$. Corresponding probability for $\underline{\pi}$ is $\pi(\omega)$.

For fixed ω,

$$p(\omega)/\pi(\omega)$$

measures the odds in favor of p compared to π. Thus if $p(\omega) = 0.2$ and $\pi(\omega) = 0.02$, an individual is 10 times more likely to be classified in cell ω under $\underline{p}$ than under $\underline{\pi}$. If $p(\omega) = \pi(\omega)$, the cell ω offers no discrimination between $\underline{p}$ and $\underline{\pi}$. Since ln x is a 1:1 function of x, we can alternatively consider

$$\ln[p(\omega)/\pi(\omega)]$$

as log-odds, for each ω in Ω.

If we want an overall index of discrimination information considering all ω's, a simple choice is the average (w.r.t. $\underline{p}$ since we have odds in favor of $\underline{p}$) of quantities like $\ln[p(\omega)/\pi(\omega)]$. The quantity

$$\Sigma_{\omega\varepsilon\Omega} p(\omega) \ln \frac{p(\omega)}{\pi(\omega)} = I(\underline{p}:\underline{\pi})$$

is called the (average/mean) discrimination information between $\underline{p}$ and $\underline{\pi}$.

If $\underline{p}$ and $\underline{\pi}$ are such that $\pi(\omega) > 0$ whenever $p(\omega) > 0$, we have the following:

Theorem: $I(\underline{p}:\underline{\pi}) \geq 0$ with equality if and only if $p(\omega) = \pi(\omega)$ for all ω; i.e., the two distributions are the same.

Hence $I(\underline{p}:\pi)$ can be looked upon as a measure of closeness between $\underline{p}$ and $\underline{\pi}$.

F.2. Use of I(p:π) in Contingency Table Analysis

Let $\underline{\pi}$ be a fixed distribution (choice of $\underline{\pi}$ will be discussed later) and assume that the distribution $\underline{p}$ satisfies a given set of linear constraints, i.e.,

$$\underline{B}\underline{p} = \underline{\theta}$$

Here $\underline{B}$ is a matrix of order $(r+1) \times \Omega$ (the "design matrix") and $\underline{\theta}$ is $(r+1) \times 1$. The first row of $\underline{B}$ is $(1,1,1,\ldots..1)$ and the first element of $\underline{\theta}$ is 1. This constraint simply says that the sum of the probabilities is 1, and is called the natural constraint. The remaining r constraints are given by the problem under investigation.

Problem: Find p which satisfies the constraints $\underline{B}\underline{p} = \underline{\theta}$ and minimizes $I(\underline{p}:\underline{\pi})$ (i.e., $\underline{p}$ is as "close" to $\underline{\pi}$ as possible). If such a $\underline{p}$ is denoted by $\underline{p}^*$, we want

$$\underline{B}\underline{p}^* = \underline{\theta}$$

and

$$I(\underline{p}^*:\underline{\pi}) = \min_{\underline{p}:\underline{B}\underline{p}=\underline{\theta}} I(\underline{p}:\underline{\pi})$$

Solution: If there is a probability vector with positive probabilities for each ω that satisfies $\underline{B}\underline{p} = \underline{\theta}$, then $\underline{p}^*$ exists uniquely and is given by

$$\ln[\underline{p}^*/\underline{\pi}] = \underline{B}'\underline{\tau}$$

where

$$\ln[\underline{p}^*/\underline{\pi}] = ((\ln[p^*(\omega)/\pi(\omega)]))_{\Omega x1}$$

and τ is a vector of Lagrangian multipliers determined so that $\underline{B}\underline{p}^* = \theta$.

Remark: There are efficient computer programs (e.g., CONTAB) to find $\underline{p}^*$.

F.3. Log-Linear Models

In analogy with the form of $\underline{p}^*$, the model given by

$$\ln \frac{\underline{p}}{\underline{\pi}} = \underline{B}'\underline{\tau}$$

for some parameters $\underline{\tau}$ is called a general log-linear model. Note that

$$\ln \frac{p(\omega)}{\pi(\omega)} = \Sigma_{j=1}^{r+1} b_j(\omega)\tau_j \qquad \omega\epsilon\Omega$$

If $\underline{\pi}$ is the uniform distribution; $\pi(\omega) = 1/\Omega$ for all ω, we can absorb $\ln \Omega$ in τ_1 above and write

$$\ln p(\omega) = b_1(\omega)L + \Sigma_{j=2}^{r+1} b_j(\omega)\tau_j$$

where $L = \tau_1 - \ln \Omega$ and $b_1(\omega) = 1$.

This is the usual log-linear model.

F.4. Log-Linear Models for Marginals

This is a special case of the usual log-linear model.

Since there are Ω cells, any distribution on Ω is completely and uniquely determined by Ω parameters.

In the present set-up one parameter is included for each independent marginal total, as shown in Table F-1.

TABLE F-1. 2x2 TABLE: FOUR CELLS

Cell Index	L	τ_1^i	τ_1^j	τ_{11}^{ij}
(1 1)	1	1	1	1
(1 2)	1	1	0	0
(2 1)	1	0	1	0
(2 2)	1	0	0	0

L is the parameter corresponding to the natural constraint.

τ_1^i is the parameter for the i-marginal. Only one parameter is introduced, since given N and x(11) + x(12) = x(1.), the other marginal total is fixed. (If this were a 3x2 table, one more parameter τ_2^i would be introduced.)

τ_1^j is the parameter for j-marginal.

τ_{11}^{ij} is the parameter for the two-way marginal, which for a 2x2 table corresponds to a cell. Here it corresponds to the cell (11). This is the <u>interaction</u> parameter.

Note that higher order columns can be written down by multiplying appropriate lower order columns. The matrix $\underline{B}$ is

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

and the actual model is

$$\ln p(11) = L + \tau_1^i + \tau_1^j + \tau_{11}^{ij}$$

$$\ln p(12) = L + \tau_1^i$$

$$\ln p(21) = L + \tau_1^j$$

$$\ln p(22) = L$$

Then

$$\tau_1^i = \ln[p(12)/p(22)]$$

$$\tau_1^j = \ln[p(21)/p(22)]$$

$$\tau_{11}^{ij} = \ln[\underbrace{p(12)\ p(21))/(p(11)p(22))}_{\text{"cross-product-ratio"}}]$$

Note that the τ parameters are determined uniquely by p. Also note that, if N, x(1.), x(.1), and x(11) are fixed, the complete table is determined uniquely.

TABLE F-2. EXAMPLE OF 2x2x2x2 TABLE

Parameter(s)	Corresponding to
L	Total
τ_1^h, τ_1^i, τ_1^j, τ_1^k	One-way marginals
τ_{11}^{hi}, τ_{11}^{hj}, τ_{11}^{hk}, τ_{11}^{ij}, τ_{11}^{ik}, τ_{11}^{jk}	Two-way marginals
τ_{111}^{hij}, τ_{111}^{hik}, τ_{111}^{hjk}, τ_{111}^{ijk}	Three-way marginals
τ_{1111}^{hijk}	Four-way marginals

The 16 parameters (or the 16 marginals) determine the distribution uniquely.

$\underline{B}$ has 16 rows.

The higher order columns are products of lower order columns.

If a higher order marginal is fixed, all the included lower order marginals are fixed.

F.5. Fitting Models to Data

We look for a log-linear model that

a) is as simple as possible, i.e., has as few parameters as possible

b) approximates the observed distribution "satisfactorily"

c) has some marginal totals the same as the observed distribution.

Since the uniform distribution has the smallest number of parameters required for its complete determination (just L), in order to have (a) we should choose the model as close to the uniform distribution as possible, i.e., we should consider the usual log-linear models.

To measure the goodness of fit in (b), we use $I(\hat{\underline{\pi}}:\underline{p}^*)$ where $\hat{\underline{\pi}}$ is the observed distribution and $\underline{p}^*$ is the model. It turns out that $I(\hat{\underline{\pi}}:p^*)$ is equivalent to the "likelihood-ratio statistic" and that $2N(\hat{\underline{\pi}}:\underline{p}^*) = 2I(\underline{x}:\underline{x}^*)$ has a χ^2 distribution with appropriate D.F., for large samples. By imposing (c) we try to reproduce a good approximation in terms of information contained in smaller dimensions ("summary" measures) of the observed distribution.

For example, consider again Table F-1. Suppose we want a model with no interaction. We set $\tau_{11}^{ij} = 0$ and postulate that the one-way marginals of the estimated distribution be the same observed marginals as N, x(1.) and x(.1). Now, there are several distributions satisfying these constraints. Which of such distributions minimizes $I(\underline{p}:\underline{\pi})$, where $\underline{\pi}$ is the uniform distribution?

The constraints can be written in terms of estimated frequencies $\underline{x}^*$ as

$$\underline{B}(N\underline{p}^*) = N\underline{\theta}$$

i.e.,

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \end{bmatrix} \bullet \begin{bmatrix} x^*(1\ \ 1) \\ x^*(1\ \ 2) \\ x^*(2\ \ 1) \\ x^*(2\ \ 2) \end{bmatrix} = \begin{bmatrix} N \\ x(1.) \\ x(.1) \end{bmatrix}$$

Further,

$$x^*(11) = Np^*(11) = Ne^{L+\tau_1^i+\tau_1^j}$$

$$x^*(12) = Np^*(12) = Ne^{L+\tau_1^i}$$

$$x^*(21) = Np^*(21) = Ne^{L+\tau_1^j}$$

$$x^*(22) = Np^*(22) = Ne^{L}$$

It can be shown that for this no-interaction model,

$$x^*(ij) = \frac{x(i.)x(.j)}{N},\ i,j = 1,2$$

equivalent to the <u>independence</u> hypothesis

$$p^*(ij) = p(i.)\ p(.j)$$

F.6. Example

TABLE F.3. EXPERIMENT TO STUDY RELATIONSHIPS BETWEEN CAR SIZE AND VARIABLES RELATED TO ACCIDENT INJURY SEVERITY

Characteristic (Variable)	Index	1	2
Severity	h	Not severe	Severe
Driver ejected	i	No	Yes
Accident type	j	Collision	Rollover
Car weight	k	Small	Standard

F.6.1. Methods of Collecting Data

a) Look at a certain number of accidents. Classify each one in the right category (hijk).

b) Controlled experiments (simulation experiments).

i) Fix in advance the number of cars to be tested in each category, e.g., 200 "small" and 350 "standard," or

ii) Fix in advance the number of cars tested in each of the four combinations of accident type and car size, e.g., 150 in (collision, small), 50 in (rollover, small), 200 in (collision, standard), and 150 in (rollover, standard).

The present methods of analysis are applicable to either case.

In order to be able to use matrix notation we will represent table-entries as a vector. For this purpose we need a systematic way of ordering the table entries. We follow the convention of the lexicographic order of arrangement. For example, in the present 2x2x2x2 table, the cells will be ordered as (1111), (1112), (1121), (1122), ... (2221), (2222). Observed frequencies are denoted by x(hijk). Marginal totals are denoted by x(hij.) = Σ_kx(hijk), etc. A cell will be generically denoted by ω. The set of all cells in a particular table will be denoted by Ω.

F.6.2. Data: 2x2x2x2 Table

See next page for Table F-4.

An example of a "sub-table" of two-way marginals is:

TABLE F-5. CAR WEIGHT AGAINST SEVERITY

Car weight	Accident injury not severe	Accident injury severe
Small	455	365
Standard	2,159	1,852

TABLE F-4. 2x2x2x2 TABLE

Car weight (k)	Accident type (j) / Severity (h) / Driver ejected (i)	Collision			Rollover			Total
		Not severe	Severe	Sub-total	Not severe	Severe	Sub-total	
Small	No	350	150	500	60	112	172	672
	Yes	26	23	49	19	80	99	148
	Sub-total	376	173	549	79	192	271	820
Standard	No	1878	1022	2900	148	404	552	3452
	Yes	111	161	272	22	265	287	559
	Sub-total	1989	1183	3172	170	669	839	4011
Total		2365	1356	3721	249	861	1110	4831

These data derive from J. K. Kihlberg, E. A. Narragon, and B. J. Campbell, "Automobile Crash Injury in Relation to Car Size," Cornell Aeronautical Laboratory, Report No. VJ-1823-R11, 1964.

This is a table of marginals x(..kh); e.g., x(..12) = $\sum_{h,i}$ x(hi12) = 150 + 112 + 23 + 80 = 365, etc.

F.6.3. Questions of Interest

a) Are there any significant associations among the variables?

b) If so, for each car size are the injury variables independent?

c) Are the injury variables homogeneous over car size?

d) Is it enough to consider only pairwise ("two-way") interactions among the variables in the model?

F.6.4. Log-Linear Design Matrix

See Table F-6 on next page.

F.6.5. Analysis

We begin with the simplest structure from the complete log-linear presentation, consistent with the sampling scheme.

It is assumed that the data were collected so that each marginal total was a random variate (not fixed by sampling scheme). We may then start by fitting the one-way marginals only. Thus, we assume that all the interaction parameters (11 in all) are zero. Let us index this hypothesis by (a). Then

(a) x(h...), x(.i..), x(..j.), x(...k)

enumerates the marginals fitted. This corresponds to the hypothesis of mutual independence of h, i, j, and k. The MDI statistic $2I(\underline{x}:\underline{x}^*_a)$ can be also looked upon as the "unexplained variation or disparity" between $\underline{x}$ and $\underline{x}^*_a$. The log-linear model (a) uses only the first five parameters and their respective columns in Table F-6. If this model does not provide a good fit, as measured by $2I(\underline{x}:\underline{x}^*_a)$, distributed approximately χ^2 with 16 - 5 = 11 D.F., the

TABLE F-6. LOG-LINEAR DESIGN MATRIX

Cell Index	L	τ_1^h	τ_1^i	τ_1^j	τ_1^k	τ_{11}^{hi}	τ_{11}^{hj}	τ_{11}^{hk}	τ_{11}^{ij}	τ_{11}^{ik}	τ_{11}^{jk}	τ_{111}^{hij}	τ_{111}^{hik}	τ_{111}^{hjk}	τ_{111}^{ijk}	τ_{1111}^{hijk}
1 1 1 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1 1 1 2	1	1	1	1		1	1		1			1				
1 1 2 1	1	1	1		1	1		1		1			1			
1 1 2 2	1	1	1			1										
1 2 1 1	1	1		1	1		1	1			1			1		
1 2 1 2	1	1		1			1									
1 2 2 1	1	1			1			1								
1 2 2 2	1	1														
2 1 1 1	1		1	1	1				1	1	1				1	
2 1 1 2	1		1	1					1							
2 1 2 1	1		1		1					1						
2 1 2 2	1		1													
2 2 1 1	1			1	1					1						
2 2 1 2	1			1												
2 2 2 1	1				1											
2 2 2 2	1															
Marginals Fitted																
(a) x (h . . .) x (. i . .) x (. . j .) x (. . . k)	✓	✓	✓	✓	✓											
(b) x (h . . h) x (. i . k)	✓	✓	✓	✓	✓			✓		✓	✓					
(c) x(hij .) x (. . . k)	✓	✓	✓	✓	✓	✓	✓		✓			✓				
(d) x (hi . .) x (h. j .) etc. all two way	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					

next model to try corresponds to (b).

Model (b) postulates conditional independence of injury variables given car size. Thus

$$p(hijk) = \frac{p(h..k)\ p(.i.k)\ p(..jk)}{p^2(...k)}$$

This is equivalent to constraining the marginals x(h..k), x(.i.k), and x(..jk). The log-linear model (b) would use the first five parameters and the others whose columns have check-marks under them in Table F-6. The estimates of frequencies under this model are denoted by $\underline{x}_b^*$. As before, $2I(\underline{x}:\underline{x}_b^*)$ gives the goodness of fit. For large samples, it is χ^2 with 8 D.F.

Further, the difference

$$2I(\underline{x}:\underline{x}_a^*) - 2I(\underline{x}:\underline{x}_b^*)$$

is equal to $2I(\underline{x}_b^*:\underline{x}_a^*)$ and measures the contribution due to constraints in (b) that are not in (a). It is distributed approximately as χ^2 with 3 D.F. Successively more complex models can be considered until one is found whose contribution makes this difference sufficiently small.

F.6.6. Computation

The CONTAB program can be applied for this example, since the sequence of models consists of fittings of marginals only.

TABLE F-7.—CONTAB RESULTS, MODELS A AND B

Model	Statistic	D.F.
(a) x(h...) x(.i..) x(..j.) x(...k)	$2I(\underline{x}:\underline{x}_a^*) = 1193.11$	11
(b) x(h..k) x(.i.k)	$2I(\underline{x}^*:\underline{x}_a^*) = 1130.59$	8
Effect	$2I(\underline{x}_b^*:\underline{x}_a^*) = 62.52$	3

The "explained variation" by (b) relative to (a) can be measured by

$$\frac{2I(\underline{x}:\underline{x}^*_a) - 2I(\underline{x}:\underline{x}^*_b)}{2I(\underline{x}:\underline{x}^*_a)} = 0.052$$

It is clear that model (a) does not provide a good fit to the data. Neither does model (b) and the variation explained by the additional constraints is only 5.2%, though it is significant at the 5% level.

For a next least complex model (c) we have the following analysis:

TABLE F-8 —CONTAB RESULTS, MODELS A AND C

Model	Statistic	D.F.
(a) x(h...), x(.i..) x(..j.), x(...k)	$2I(\underline{x}:\underline{x}^*_a)$ = 1193.11	11
(c) x(hij.), x(...k)	$2I(\underline{x}:\underline{x}^*_c$ = 74.70	7
Effect	$2I(\underline{x}^*_c:\underline{x}^*_a$ = 1118.41	4

The variation explained due to model (c), compared to model (a), is 93.7%. Model (c) does not yet fit the data well in the sense that $2I(\underline{x}:\underline{x}^*_c)$ = 74.70 is still highly significant. However, the analysis shows that interactions among the injury variables account for 93.7% variation; only 6.3% remains to be explained by the factor car size.

Model (d), which includes all pairwise interactions, gives the following analysis (see Table F-9, next page). The percentage variation explained, with respect of model (a), is 99.4% Moreover, its Information Statistic is not significant. Thus, model (d) provides an excellent fit and shows that no second order interactions need to be considered. The observed and the estimated (or "smoothed") frequencies for model (d) are shown in Table F-10.

TABLE F-9.—CONTAB RESULTS, MODELS A AND D

Model	Statistic	D.F.
(a) x(h...), x(.i..) x(..j.), x(...k)	$2I(\underline{x}:\underline{x}^*_a) = 1193.11$	11
(d) All two-way marginals	$2I(\underline{x}:\underline{x}^*_d) = 7.34$	5
Effect	$2I(\underline{x}^*_d:\underline{x}^*_a) = 1185.77$	6

TABLE F-10.—OBSERVED AND ESTIMATED FREQUENCIES FOR MODEL D

Cell index	Observed frequency x	Estimated frequency x*
1111	350	359.00
1112	1878	1874.80
1121	60	57.37
1122	148	144.63
1211	26	23.75
1212	111	107.36
1221	19	14.87
1222	22	32.46
2111	150	140.32
2112	1022	1025.81
2121	112	115.30
2122	404	406.88
2211	23	25.93
2212	161	164.06
2221	80	83.47
2222	265	254.99

It can be verified that the estimated table has the same marginal totals as the observed table (within round-off errors) as given by the columns included in model (d).

Once the estimated frequencies are obtained, many relevant questions can be answered quickly. For example, for small cars (k = 1), if the accident is rollover type (j = 2) and the driver is not ejected (i = 1), the odds in favor of the accident's being not severe (h = 1) are:

$$\frac{x_d^*(1121)}{x_d^*(2121)} = \frac{57.37}{115.30} = 0.4976 \qquad \text{(i.e., about 1 to 2)}$$

The corresponding odds for standard cars (k = 2) are:

$$\frac{x_d^*(1122)}{x_d^*(2122)} = \frac{144.63}{406.88} = 0.3555 \qquad \text{(i.e., about 7 to 20)}$$

This reflects the slight disadvantage of small cars.

F.6.7. More General Analyses Employing the KULLITR Program

In the example discussed in the preceding section the estimate p* of the underlying probability distribution was obtained so that the marginal totals of p* (or of the estimated frequencies Np*) were equal to those in the table of corresponding observed values. Parameters in the model corresponded to marginal totals, starting from one-way marginals and going to two-way and higher order marginals. Referring to the log-linear design matrix of Section F.6.4, it can be seen that the column under τ_{11}^{ik}, for example, corresponds to the marginal x(1111) + x(1121) + x(2111) + x(2121) = x(.1.1); etc.

When such "usual marginals" are to be fitted, the CONTAB program can be used to obtain the estimates p* and the MDI statistics under different hypotheses. Note that the design matrix of Section F.6.4 is a special case of the design matrix C in the system of equation

$$C\underline{p} = \underline{\theta} = C\hat{\underline{\pi}}$$

where $\hat{\underline{\pi}}$ is the observed distribution, applying only to the case where the rows of C (or the columns of the design matrix) correspond to the usual marginals.

There are many situations, however, in which the rows of the matrix C do not just consist of zeroes and ones corresponding to a marginal total, but have other numbers in them. For example, in the model H_c of Section 5.7.1.2, involving vehicle exposure as well as accident frequency,

$$\ln p(ij) = L + \tau_i^A T_i^A(ij) + \tau_j^B T_j^B(ij) + \beta V(ij)$$

$$i = 1,2, \; k = 1,2,3$$

the C matrix is:

TABLE F-11.—C-MATRIX FOR MODEL H_c (SECTION 5.7.1.2)

Cell Index	Parameters				
	L	τ_1^A	τ_1^B	τ_2^B	β
11	1	1	1	0	V(11)
12	1	1	0	1	V(12)
13	1	1	0	0	V(13)
21	1	0	1	0	V(21)
22	1	0	0	1	V(22)
23	1	0	0	0	V(23)

where the column under the parameter β consists of V(ij) numbers, different, of course, from 0 or 1.

For fitting such a model, the CONTAB program cannot be used. The program KULLITR, on the other hand, inputs the C matrix directly and thus can be used to analyze the postulated model.[1]

Thus when the estimate $\underline{p}^*$ is to be obtained under constraints of the form

$$C\underline{p} = \underline{\theta}$$

where C contains rows of elements that do not correspond directly to some marginal totals of a table, the KULLITR program provides the means of analysis.

Another feature of the KULLITR program is that it provides, in any case, the estimates of the τ-parameters of the model and their covariance-matrix in a convenient form. This feature was used in Section 5.3.3.

KULLITR is, however, less convenient (in inputting) and more expensive to use than CONTAB, so the latter is usually preferred when it can be used.

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[1]Note, however, that if the last column of the design matrix is omitted in the model (setting $\beta = 0$), the fitting problem reduces to fitting one-way marginals to the data. CONTAB could have been employed for this model.

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