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Characteristics of Large-Truck Accidents as Represented in Texas Accident Data at HSRI

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16. Abstract

HSRI-maintained data on large-truck accidents were assessed to establish which files contain the most useful information, to establish what those data show about large-truck accidents, and to develop recommendations on means of improving the quality of data collection on large-truck accidents. Police-reported accident data for the State of Texas were found to be the best available data, but they contain several weaknesses, which are discussed. Findings concerning large-truck accidents are presented in terms of temporal, roadway, weather, accident configuration, truck type, injury frequency and severity factors. In addition, truck and passenger car involvements are compared. Recommedations are presented concerning the necessity of improving the classification of truck types, the collection of vehicle data, and the development of a truck damage scale.

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1. INTRODUCTION

This report describes an HSRI study designed to assess existing accident data pertaining to large-truck accidents, to establish the strengths and weaknesses of the best available data, to derive whatever significant findings the data may show about large-truck accidents, and to recommend means of improving data-collection and analysis of large-truck accidents. The study was conducted during the period February to June, 1975 with general research support funds contributed by the Motor Vehicle Manufacturers Association.

Section 2 contains a summary of the study findings. Section 3 discusses the accident data available concerning large-truck accidents and the reasons why the best available data—police-reported data for the State of Texas—are less than ideal. Section 4 presents what the data show about large-truck accidents. Section 5 presents what the Texas data show about truck accidents as compared with passenger-car accidents. Section 6 contains recommendations on means of improving data-collection efforts.

2. SUMMARY OF FINDINGS

A number of findings have resulted from the descriptive study of large-truck accidents documented in this report. These results are referred to as findings rather than conclusions, emphasizing that the purpose of the study was broad in concept, aimed at delineating the characteristics of large-truck involvements and their relationships to passenger-car involvements.

The findings are listed below with section number references, where they are applicable, to indicate where in the report the relevant data in support of this finding may be found.

2.1 Deficiencies and Problems in the Data

A) A major finding of this study is that the categorization of trucks in the mass data files is generally poor. In the HSRI accident files, only data from the states of Texas and Washington use a categorization scheme of any sophistication whatever (Section 3.2).

B) In the Texas Truck File, the majority of trucks with semi-trailers were of unidentified type (Table 2). Thus, the categorization problem discussed above (i.e., Section 2.1, part A) is worse for semi-trailer trucks than for straight trucks. This is troublesome, since these unidentified types account for more than a third of the truck involvements recorded in the file.

C) The occurrence of large-truck accidents is a relatively rare event, so that very large data samples are required to obtain meaningful statistics. For example, data from the state of Texas show 33,000 large-truck involvements out of 460,000 accidents: a rate of one involvement for nearly 14 accidents.

D) The percentage of missing data for the TAD vehicle damage scale, developed by the National Safety Council's Traffic Accident Data Project, is over twice as large for trucks as it is for passenger cars (Section 5.3). This statistic highlights the difficulties involved in applying a common scale to passenger cars and to a wide variety of trucks with considerable structural variations.

E) Police-reported occupant injury information is generally completely recorded only for accidents involving fatal injuries. The less severe the occupant injuries in a given accident, the more likely it is that occupant injury information will be lost.

2.2 Characteristics of Large-Truck Accidents

A) Multiple traffic-unit accidents tend to occur during the regular 40-hour work week while single-traffic unit accidents are more heavily represented at other times (Section 4.1). This finding is most probably a reflection of the much higher traffic densities which occur during the day.

B) Single traffic-unit accidents are somewhat more likely to occur under less ideal driving conditions than those typical of multiple vehicle accidents. (Section 4.2). That is, a smaller percentage of single traffic-unit accidents occur in clear weather on dry roads in good condition.

C) In multiple traffic-unit accidents, the casualty rate (i.e., number killed or injured per accident) for all collision configurations is about the same for car-car, car-truck, and truck-truck collisions. For certain configurations (i.e., head-on) this is not true (Table 5).

D) The rate of all injuries and fatalities for occupants of trucks involved in multiple traffic-unit accidents is much lower than that of the "other" vehicle involved in the collision (Section 4.6).

E) The rate of all injuries and fatalities for occupants of trucks involved in truck-truck collisions is much higher than that of trucks involved in truck-car collisions and is about the same as that of single traffic-unit truck accidents (Section 4.6).

F) As a result of (C), (D), and (E), single and multiple traffic-unit accidents are comparable in terms of most serious injury for all involved vehicles.

2.3 Comparison of Passenger Car and Truck Involvements

A) Truck involvements tend to occur during the regular work week. In particular, the percentage of trucks involved in accidents drops sharply on weekends (Section 5.1).

B) Trucks were found to be overinvolved in all the vehicle defect categories recorded in the Texas data with the exception of faulty windshield wipers. Less than two percent of the passenger cars in the Texas Sample File had a listed defect, while the comparable value for trucks is 6.4 percent.

C) Trucks are likely to receive little damage in an accident as measured by the TAD damage extent scale. However, trucks are over-represented in comparison to passenger cars in accidents where severe damage occurred (Section 5.3). In terms of the findings of Section 2.2, it is probable that low damage involvements are generally associated with car-truck multiple traffic unit collisions, while severe damage arises in single traffic unit accidents or in truck-truck multiple traffic unit accidents.

D) Driving a large truck is a predominantly male occupation. In the accident-involved population, only 1.2 percent of the involved drivers were female.

3. STRENGTHS AND WEAKNESSES OF THE DATA

Data derived from police reports of accidents are a comprehensive, widely used source of information on the full gamut of these destructive events. These reports contain hundreds of descriptive factors on essentially all notable accidents. The data consequently are a valuable resource to determine the frequency of various events and to describe, for instance, the differences between car and truck accidents.

Police reports, however, were never conceived with research applications in mind so that the data are, in many respects, less than ideal. For instance, the categorization of trucks by type is generally poor. In this section, the strengths and weaknesses of the data with regard to truck investigations are discussed and the rationale for selecting Texas data is presented.

A. Strengths of the Data

In order to obtain an accurate estimate of descriptive statistics concerning trucks, it is necessary to have a data sample that is not biased on some characteristic that would clearly distort the results. For example, the widely used CPIR file, which is excellent in its detail of vehicle damage information, is of little value in a study of large trucks simply because they are systematically excluded from the data. Police-reported data, on the other hand, approximate a census of accidents and consequently reflect the distribution of event occurrences. In a presentation of descriptive statistics, mass data files represent the best available source of accident information.

A second value of the mass data files with respect to the study of trucks derives from the sheer volume of such data. Accidents themselves are relatively rare events within the framework of the total vehicle exposure miles that constantly occur on our roadways. Within the accident population, moreover, the occurrence of large truck collisions is itself a rare event. In studying the descriptive measures of these accidents, then, it becomes quickly apparent that there are simply too few occurrences of some configurations of interest to provide reliable frequency-of-occurrence estimates unless a very large sample is used. As an example, the data presented in Section 4 indicate that there were only 31 large truck fatalities in multiple traffic unit accidents during 1973 in the entire state of Texas. In a total accident population on the order of 460,000 cases, it is evident that a set of sampled data might completely miss these cases. A data base of the magnitude of the Texas truck file is thus deemed necessary for successful investigation of many aspects of a truck study.

The data files generated by HSRI from the Texas data also provide a means of comparing certain characteristics in a well defined but geographically diverse area. The 5% sample file, derived from a random sampling of the entire state accident population for the year, provides a useful source from which to determine frequencies of gross categories without processing the entire accident population. As discussed above, however, such a sample is inadequate to address the detail required in a study of rare events—such as large truck collisions. The special purpose files developed by HSRI contain all the information available from the entire state's experience on certain selected events. Files of this type are the Fatal, Large Truck, and Vehicle Defect files. By using such special purpose files in combination with the 5% sample data, it is possible to investigate selected accident factors in detail using the special purpose data, and to infer the relationship of these factors with the entire population through the sample file.

B. Weaknesses of the Data

Many of the biases, underreportings, and other common failures of police data in accident investigation and research are well known, and need not be discussed further here.* Certain aspects of this problem bear more directly upon a study of trucks (or at least have more significant implications there) and will be discussed in more detail in this section.

One important aspect of truck accident research is the categorization of truck types into a set of somewhat standardized groups. This categorization can be comsidered as the basis for a successful and meaningful reporting of results. It is difficult, if not impossible, to relate results between data sets that employ different groupings. Nor can one be ever completely sure of the reported results in terms of vehicle types when the categorization is not well defined.

There are at least two aspects of the categorization problem that are important: (1) a simple method is needed for recording all the information necessary for

*See, for example, "HSRI's Oakland County 1971 Data File: A Critique," Thomas Lawson, HIT Lab Reports, Volume 3, Number 11, July 1973.

categorization under field conditions, and (2) there is a need for the compilation and grouping of existing truck types by the manufacturers.

The most damaging aspects of the study of truck data in police files are the failure of police reports to use adequate definitions of truck types and the wide differences in existing categorizations used by the various police jurisdictions. To illustrate these conclusions, truck type codes used by some of the police jurisdictions from which HSRI obtains data are shown in Table 1. Only data from the states of Washington and Texas contain any meaningful breakdown of truck types. The other states do little more than differentiate trucks from cars. Even Washington and Texas use coding schemes that differ in many respects. It is, of course, unreasonable to expect an officer under emergency conditions on a 10° night at 4 am. to be aware of truck subtleties that require an engineer to classify. What is needed is some selected item or items of information that could be quickly recorded in the field and later decoded under laboratory conditions to provide the needed grouping.

The basic categorization of truck types is complicated by the diversity of configurations that exist and post-manufacture alterations that may completely modify the structural or dynamic handling capabilities of the vehicles after they have been sold. Because of the modular nature of truck construction there is a tremendous amount of variation in manufactured trucks as buyers employ a "design your own" approach. In many areas, it is not even clear what constitutes a truck.

Table 1 - Truck Type Categories in Police Data

COLORADO

Pick-up Truck
Pick-up Truck With Camper
Truck - Self Contained
Truck Tractor
Truck Tractor - Semi Trailer

FLORIDA

Truck or Truck Tractor
Truck Tractor and Semi Trailer
Other Truck Combination

MICHIGAN

Pickup or Panel Truck
Straight Truck
Truck Tractor (Semi) or Road Tractor

TEXAS

Beverage
Bob-Tail
Dump
Fire Truck
Flatbed
Float (Lowboy, Grain, Gondola)
Garbage
Mixer
Panel (Small Van)
Pickup
Pole (Log)
Refrigerator
Stake
Van (Large, Furniture, Etc.)
Wrecker
Truck N.E.C. or type unk.
Truck and Trailer
Truck and Semi Trailer
Truck and House Trailer
Other Truck Combinations

WASHINGTON

Carryall, Panel, or Travelall
Chassis-cab
Dump
Flat-bed or Platform
Flat Rack
Stake or Rack
Tank
Fire Truck
Tractor Trailer
Pickup
Van
Vanette (includes Metro, Step Van, & Handy Van)
Pickup with Camper
Truck with chassis-mounted Camper
Garbage Truck

Many modifications performed on trucks after manufacture can only be detected by an engineer after careful perusal. Braking systems, for instance, are commonly computer-selected for each vehicle at the time of manufacture. Later modifications to the vehicle braking system, tires, or load distribution characteristics could result in a behavior in accidents that was completely unanticipated from design information. Because of the resulting variations that occur, a first step in the development of a truck grouping scheme is the cataloging and definition of existing truck types and modifications. The entire categorization task is not a trivial problem and is certainly one that is beyond the scope of the current study.

4. CHARACTERISTICS OF LARGE-TRUCK ACCIDENTS

The HSRI large-truck file for Texas describes accidents in which at least one of the vehicles involved in the accident is a large truck (as defined below). The 1973 file records 32,014 accidents involving 56,651 vehicles. Table 2 shows the breakdown of vehicles in the file by type.

Table 2 - Vehicle Types in the 1973 Texas Large-Truck File

Type	Number	Percent
Large Trucks of Defined Type	10,899	19.2
Large Trucks of Unknown Type	9,595	16.9
Semi-Trailer Trucks-Unk. Type	12,588	22.2
Total Large Trucks	33,082	58.4
Passenger Cars	19,006	33.5
Small Trucks	3,904	6.9
Other Traffic Units	592	1.0
Unknown Type	67	0.1
Total "Other" Vehicles	23,569	41.6
Total Vehicles	56,651	100%

The definition of large trucks has been made in terms of two variables used by the Texas police agencies: Variable 60 (Vehicle Body Style) and Variable 61 (Specific Vehicle Type). Table 3 shows the large-truck types used in this study in terms of their code value descriptions in the Texas Truck File. Single traffic-unit accidents in this file are necessarily large-truck accidents while multiple traffic-unit collisions may involve pedestrians, bicyclists, or any other traffic units defined by the Texas police codes. For conciseness, the term "Traffic-Unit" will be denoted by "TU" in the remainder of this section. Single TU accidents account for 7,654 or 13.5 percent of the 56,651 involved vehicles. Of the remaining 48,997 vehicles involved in multiple TU accidents, 25,428 or 44.9 percent were "large trucks" as defined in Table 3, 23,502 or 41.5 percent "other" motor vehicles, and 67 or 0.1 percent missing data. Truck-Truck two-vehicle accidents account for 5,291 or 17.9 percent of the 33,082 recorded large-truck involvements.

Table 3 - Definition of Large Trucks in the HSRI Texas Truck File

	Code Values	
Description	V60	V61
Beverage	20	4-8
Bob-Tail	21	4-8
Dump	22	4-8
Fire Truck	23	4-8
Flatbed	24	4-8
Float	25	4-8
Garbage	26	4-8
Mixer	27	4-8
Pole (Log)	31	4-8
Refrigerator	32	4-8
Stake	33	4-8
Van	34	4-8
Semi-Trailer (Unknown Type)	99	6
Unknown Type	99	4,5,7,8

Distinctions between single and multiple TU accidents were investigated as a function of a number of police-reported variables. These can be grouped, for purposes of discussion, into several categories:

1. Time of Accident (Month, Day, Hour, Etc.),
2. Site Description Factors (Weather, Road Surface, Etc.),
3. Accident Configuration (Type, Maneuver, Etc.),
4. Injuries Sustained by Occupants.

4.1 Temporal Factors

Differences between single and multiple TU accidents have been found as a function of time. Figures 1, 2, and 3 show the percentage of single and multiple TU accidents as a function of month, day of week, and hour of day.

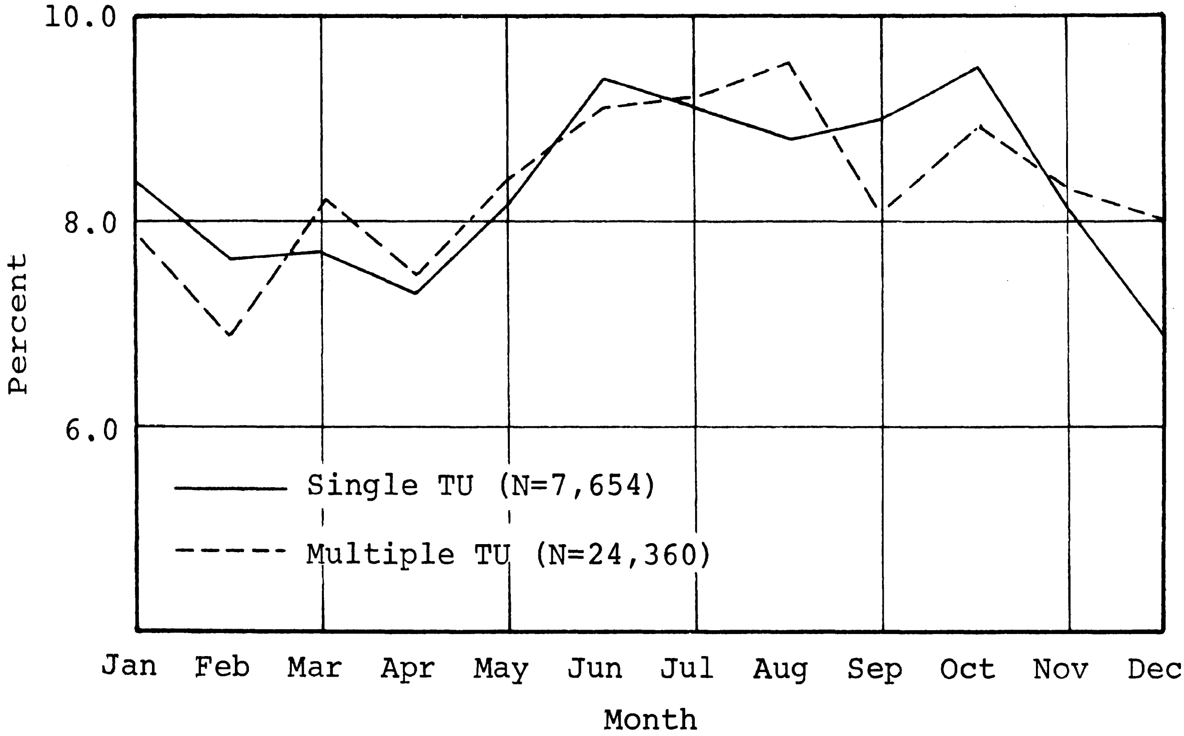

Figure 1 - Single and Multiple Traffic Unit Accidents by Month

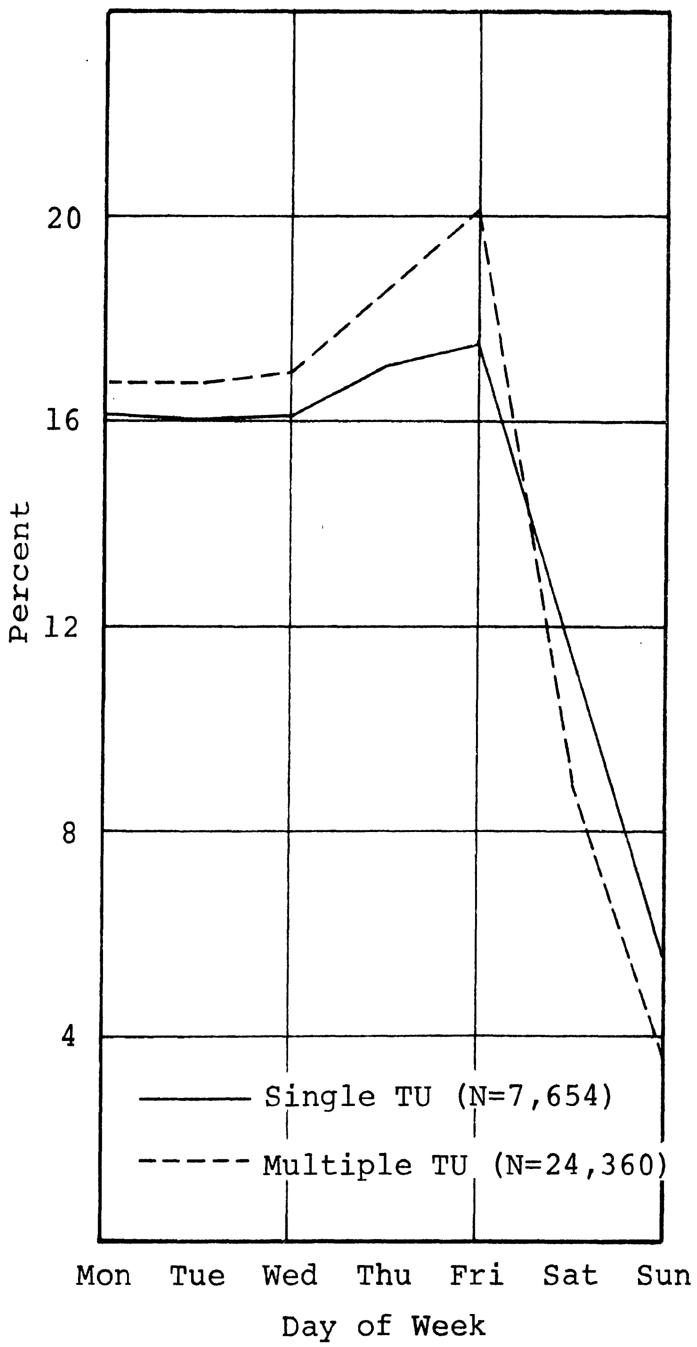

Figure 2 - Single and Multiple Traffic Unit Accidents by Day of Week

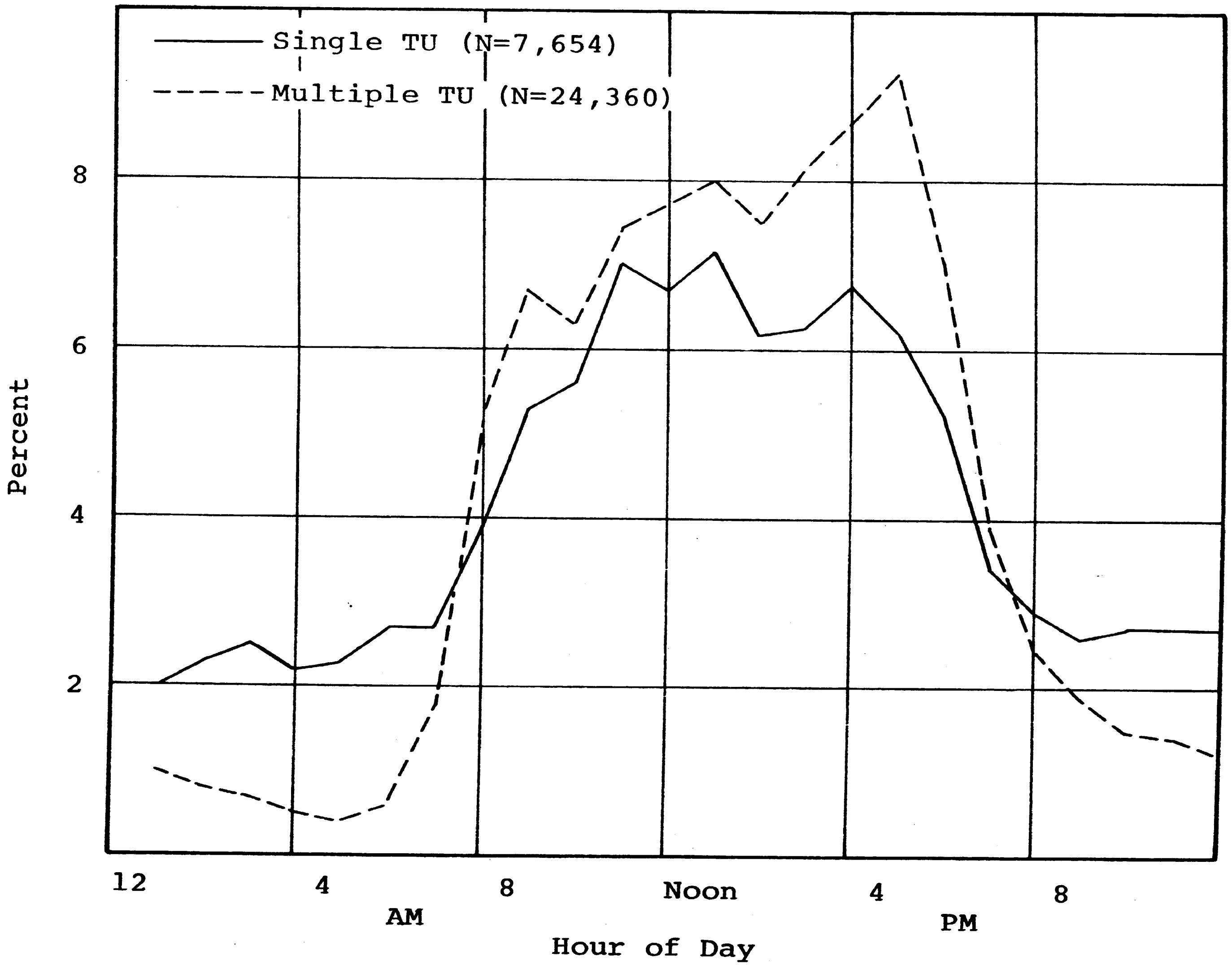

Figure 3 - Single and Multiple Traffic Unit Accidents by Hour of Day

Variations by month do not show any consistent differences. However, Figure 2 shows that while both multiple and single TU accidents occur mainly on weekdays, multiple TU accidents are slightly more prevalent in that period (Monday - Friday), while single TU accidents predominate on weekends.

Time of day (Figure 3) also illustrates a consistent difference between categories although passenger cars and trucks show a great deal of similarity (both categories have the greatest concentration of accidents between 8 am. and 7 pm.). From 7 pm. to 6 am. (that is, essentially during the non-business hours) single TU accidents are more heavily represented. From 7 am. to 6 pm. multiple TU accidents are more heavily represented. Multiple TU accidents have their peak occurrence at 4 pm. when single traffic unit accidents are already beginning to taper off.

In summary then, the time variables indicate a greater representation of multiple TU truck accidents during the regular 40-hour work week. Single TU accidents, conversely, are more heavily represented during non-business hours.

4.2 Roadway and Weather Conditions

Single TU accidents appear somewhat more likely to occur under less than ideal conditions. For instance, 80.4 percent of single TU accidents take place in clear weather in contrast to 87.5 percent of multiple TU's. The corresponding fractions for dry road surface are 75.8 percent and 83.5 percent and for no defects in road conditions are 89.5 percent and 95.2 percent. These factors all indicate to some degree then, that a greater percentage of single TU accidents take place when conditions are not favorable than is true for multiple TU's.

The classification of accidents according to road alignment (i.e., straight/curved, level/hilly) uncovers large differences. For single TU accidents 86.5 percent occurred on straight, level roads in contrast to 95.1 percent for multiple TU accidents. Much of the difference can be attributed to the level/curve configuration which involved 10.5 percent of the single TU accidents but only 3.9 percent of the multiple TU's.

If the distribution of accidents by road classification is considered, then the percentage of single TU accidents that occur on county and state secondary roads is greater than the corresponding percentage of multiple TU accidents. On Interstate highways and US or State routes the situation is reversed. Cities rank about the same for both categories. The actual percentages are shown in Table 4.

Table 4 - Percentages of Single and Multiple TU Accidents by Road Classification

	Single TU	Multiple TU
Interstate/US/State Routes	56.7%	59.3%
State Secondary & County Roads	11.0	7.3
Cities	32.3	33.4
	100%	100%

4.3 Accident Configuration

The distribution of single and multiple TU accidents by accident configuration is strongly (and in some cases exclusively) determined by the categorization into single or multiple TU itself. For instance, "object struck" cannot be another traffic unit in single TU accidents, but is assured of being another TU in multiple accidents. Considering only single TU accidents, therefore, 58.6 percent involved a collision with some fixed object while 28.5 percent were rollover or ran-off-the-road types. The remaining 12.9 percent involved collisions with an animal or were non-collision accidents. In the pre-crash phase of these accidents, 75.2 percent of the vehicles were reported as going straight. For multiple TU accidents, 76.6 percent involved a collision between a car and a truck and 20.0 percent were Truck-Truck collisions.

The vehicle mix variable available in the Texas 5% file was used to compare accidents and resultant casualty rates for various truck and passenger car combinations. The results are shown in Table 5. Unfortunately, the Texas file has vehicle mix grouped into the categories shown and the striking and struck vehicles are not identified. Car-car head-on collisions had the highest casualty rate of all the collision configurations and vehicle combinations. Car-truck head-on collisions had the second highest casualty rate, probably because truck drivers in such collisions were not injured as severely as passenger car occupants and, perhaps, because there are generally fewer occupants in trucks than in cars. Angle and head-on accidents have a fairly high casualty rate for all the vehicle combinations while rear-end collisions were always the most common and always had the second lowest casualty rate. Overall, the casualty rates for the different vehicle combinations are quite similar.

Table 5 - Casualty Rate by Vehicle Mix and Collision Configuration

		Collision Configuration					
		Angle	Head-on	Sideswipe	Rear-end	Other	Total
	Freq.	3729	1360	767	4329	411	10595
CAR/CAR	Row %	35.2	12.8	7.2	40.9	3.9	100.0
	Casualty Rate*	.35	.48	.10	.18	.01	.27
	Freq.	1304	591	461	1750	157	4263
CAR/TRUCK	Row %	30.6	13.9	10.8	41.1	3.7	100.0
	Casualty Rate*	.29	.41	.10	.19	.04	.24
	Freq.	174	84	58	211	6	533
TRUCK/TRUCK	Row %	32.6	15.8	10.9	39.6	1.1	100.0
	Casualty Rate*	.33	.29	.16	.27	0	.28

$$\text{*Casualty Rate} = \frac{\text{Total Number Injured + Total Number Killed}}{\text{Total Number of Accidents}}$$

$$X^2 = 85.7,\ df = 8,\ p<0.001$$

4.4 Truck Type

The relative involvement of large trucks in fatal and injury-producing accidents was determined for both single and multiple TU accidents.

Given the vehicle-type categorization shown in Table 3, it is evident that meaningful involvement figures for these trucks must take into consideration the utilization of each vehicle type in the driving population. Fire Trucks, for example, are certainly subject to less accident exposure than dump trucks or large vans. Such exposure data is not included in this report.

As stated in Section 4.0, the 56,651 vehicles involved in large-truck accidents were divided into 7,654 single TU and 48,997 multiple TU involvements. In single TU accidents, there were 6,386 no-injury involvements, 89 fatal involvements (75 known large trucks), and 1,179 injury involvements (873 known large trucks). For multiple TU accidents, there were 43,948 no-injury involvements, 355 fatal involvements and 4,694 injury involvements.

Tables 6 and 7 show the percentages of each vehicle type involved in fatal or injury-producing accidents for both single and multiple TU configurations.

Only 31 or 8.7 percent of the 355 vehicles whose occupants sustained fatal injury in multiple vehicle collisions were large trucks. As one would expect, therefore, the collision of a large truck with another vehicle results in more severe injuries to the occupants of the other vehicles. Based on the occurrence frequencies shown in Table 2, semi-trailer truck occupants sustain injuries at a rate far in excess of their representation in the accident population.

Table 6 - Percentages of Truck Types With Fatalities for Single and Multiple TU Collisions

	Single TU	Multiple TU
Beverage	0.0%	0.0%
Bob Tail	1.3	3.2
Dump	10.7	0.0
Fire	0.0	0.0
Flatbed	13.3	9.7
Float (Lowboy, Grain, Gondola)	2.7	3.2
Garbage	4.0	0.0
Mixer	0.0	0.0
Pole (Log)	0.0	0.0
Refrigerator	1.3	3.2
Stake	5.3	0.0
Van (Large, Furniture, Etc.)	5.3	3.2
Semi Trailer (Unknown Type)	56.0	77.5
	100%	100%
Total Frequency	75	31

Table 7 - Percentages of Truck Types with Injuries for Single and Multiple TU Collisions

	Single TU	Multiple TU
Beverage	0.8%	0.7%
Bob Tail	3.6	3.7
Dump	10.3	11.4
Fire	0.2	0.7
Flatbed	6.0	9.8
Float (Lowboy, Grain, Gondola)	1.8	1.9
Garbage	1.3	2.1
Mixer	2.5	0.9
Pole (Log)	0.8	1.1
Refrigerator	1.9	2.1
Stake	6.5	7.2
Van (Large, Furniture, Etc.)	5.7	5.4
Semi Trailer (Unknown Type)	58.5	53.0
	100%	100%
Total Frequency	873	570

Only 570 or 12.1 percent of the 4,694 vehicles whose occupants sustained A, B, or C injuries in multiple-vehicle collisions were large trucks. Based on the occurrence frequencies shown in Table 2, semi-trailer trucks are overrepresented in occupant injury involvements in both single and multiple TU accidents.

4.5 Frequency and Severity of Injuries

Occupant injuries in Texas are recorded on a K, A, B, C scale commonly used by police agencies. These injury levels have the following definitions:

K - Fatality,

A - Incapacitating injury (unable to walk, drive, etc.),

B - Non-incapacitating injury,

C - Possible injury (complaint of pain or momentary unconsciousness).

Such injury scales lack a great deal in preciseness of injury definition, and are applied by persons without professional medical training. Results derived from such data should consequently be used with regard to these inherent limitations. Furthermore, detailed injury information for specific occupants is generally available in any degree of completeness only for fatal accidents. The less severe the injuries received by a given occupant, the less likely these injuries are to be recorded. Injury information for specific occupant injuries is thus biased toward more severe injury levels. It is not known how this bias affects the summary measures of accident severity (i.e., total accident severity, total injured in accident, etc.).

The percentage of single and multiple TU truck accidents recorded at different levels of overall accident severity is recorded in Table 8. In accidents involving large trucks, therefore, multiple TU accidents generally result in the most severe injury to vehicle occupants. Chi-Square tests show that the differences, while small, are statistically significant (χ^2 = 59.8, df = 4, p = 0). The major contribution to the χ^2 statistic comes from the "C" injury level.

Table 8 - Percentage of Single and Multiple Traffic Unit Accidents at Different Accident Severity Levels

	Single TU	Multiple TU
Fatal	1.2%	1.4%
A Injury	3.4	3.9
B Injury	7.9	6.7
C Injury	4.1	6.1
No Injury	83.4	81.8
	100%	100%
Total Frequency	7,654	24,360

4.6 Occupant Injury

The analysis of occupant injury has been treated in three separate parts as described below. In single TU accidents, the involved vehicle is necessarily a large truck. In multiple TU accidents, injuries sustained in large trucks and in "other" vehicles have been treated separately.

4.6.1 Occupant Injuries in Other Vehicles. Table 9 shows the injuries sustained by occupants of these other vehicles as a function of vehicle type. In this table the percentage figures represent the portion of injuries of a given type as a function of the total involvements for that vehicle type.

Table 9 - Most Serious Injury in an "Other" Traffic Unit Involved in a Multiple Traffic Unit Large-Truck Accident

	No Injury	K	A	B	C	Frequency
Coach	83.6	1.2	3.3	6.1	5.8	6597
2-Door Hardtop	82.5	1.4	3.4	6.1	6.7	2057
2-Door Coupe	82.9	0.0	1.8	4.5	10.8	111
4-Door Sedan	83.0	1.3	3.1	5.8	6.8	6873
4-Door Hardtop	81.8	1.7	4.6	6.8	5.2	658
Station Wagon	84.6	1.0	4.1	5.3	5.1	1564
Convertible	77.7	1.7	3.4	10.6	6.7	179
Minibus	86.8	0.0	0.0	7.9	5.3	38
Ambulance	100.0	0.0	0.0	0.0	0.0	8
Motor Home/Camper	84.2	0.0	2.6	5.3	7.9	38
Panel (Small Van)	85.1	0.9	2.8	6.4	4.7	530
Pickup	81.1	1.3	4.9	7.0	5.7	3336
Wrecker	79.2	0.0	4.2	4.2	12.5	24
Farm Tractor	75.0	0.0	3.6	17.9	3.6	28
Road Machinery	86.7	0.0	6.7	0.0	6.7	15
Bus - Commercial	82.3	1.3	2.5	6.3	7.6	79
Bus - School	90.4	0.0	3.8	1.9	3.8	52
Motorcycle	23.6	6.1	25.0	35.8	9.5	148
Pedestrian	0.0	19.3	24.7	34.7	21.3	150
Other TU	0.0	6.3	18.8	38.5	36.4	96
Total Percent	81.6	1.4	3.9	6.7	6.4	100.0
Total Frequency	18,435	316	885	1505	1440	22,581

Many of the vehicle categories showed fewer than 100 involvements in accidents with trucks. This means that the percentage figures for such vehicles are likely to display large chance variations.

From Table 9 we see that the passenger car with the largest percentage of no injury collisions with trucks in the over-100-involvement-group is the station wagon (84.6 percent). The vehicle with the second largest percentage of no-injury collisions overall is the school bus (90.4 percent). This statistic attests to the safety of this vehicle even in collisions with large trucks. Overall, motorcycles (23.6 percent) have the lowest percentage of no-injury involvements for vehicles. For collisions between motorcycles and large trucks, it is not surprising to find that motorcycle drivers suffer injury or death in 76.4 percent of the recorded cases.

4.6.2 Occupant Injuries in Large Trucks in Multiple-TU Accidents. Large trucks involved in multiple-vehicle collisions (including truck-truck collisions) have an injury rate well below that of the "other" vehicles involved in these collisions. In Table 10 the overall percentage of trucks with no injury to the occupants is 96.6 percent compared to 81.6 percent for "other" vehicles as shown in Table 9. Due to the low frequency of injuries for any particular truck type it is difficult to draw any conclusions about differential injury rates by truck type in these accidents.

From Table 10 it can be seen that dump and flatbed trucks are involved in more multiple-vehicle collisions than other truck types. Without information concerning the number of these vehicles on the road or some other exposure measure, it is not possible to conclude that these vehicles are overinvolved in these accidents. Float, pole, stake, and van trucks, on the other hand, have a lower multiple-vehicle accident frequency but seem to be overrepresented on occupant injury.

Table 10 - Most Serious Injury in a Large Truck Involved in a Multiple Traffic Unit Large-Truck Accident

	No Injury	K	A	B	C	Frequency	(Semi)*
Beverage	99.0	0.0	0.5	0.2	0.2	419	(28)
Bob-Tail	98.1	0.1	0.4	0.6	0.8	1183	(2)
Dump	97.0	0.0	0.4	1.2	1.5	2155	(167)
Fire	95.8	0.0	1.1	1.1	2.1	95	(0)
Flatbed	96.3	0.2	0.5	1.2	1.8	1589	(207)
Float	95.3	0.4	0.8	2.3	1.2	256	(247)
Garbage	97.7	0.0	0.2	1.1	0.9	533	(8)
Mixer	98.8	0.0	0.2	0.2	0.7	434	(15)
Pole	94.5	0.0	0.9	2.7	1.8	110	(92)
Refrigerator	96.7	0.3	0.5	1.0	1.5	399	(113)
Stake	95.1	0.0	0.8	2.0	2.0	838	(113)
Van	95.3	0.1	0.9	1.8	1.9	677	(666)
Semi-Trailer Type Unknown	96.4	0.3	0.7	1.5	1.1	9125	
Total Percent	96.6	0.17	0.6	1.4	1.3	100.0	
Total Frequency	17,212	31	104	242	224	17,813	

*Frequency of Semi-Trailer Trucks of Identified Type

4.6.3 Comparison of Occupant Injuries in Large Trucks in Single-Vehicle Accidents. Table 11 shows the injury and fatality rates for various large-truck types involved in single vehicle accidents. It is interesting to note that the overall injury rate in this class of accidents is very similar to the injury rate of "other" vehicles in truck/"other" vehicle accidents.

Stake and dump trucks experience a high frequency of involvements and are overrepresented on injuries.

Table 11 - Most Serious Injury in a Large Truck Involved in a Single Traffic Unit Large-Truck Accident

	No Injury	K	A	B	C	Frequency	(Semi)*
Beverage	93.1	0.0	2.0	1.0	4.0	101	(7)
Bob-Tail	88.1	0.4	2.2	8.6	0.7	269	(3)
Dump	78.7	1.7	4.6	9.5	5.4	461	(58)
Fire	91.7	0.0	4.2	4.2	0.0	24	(0)
Flatbed	80.9	3.1	4.6	6.8	4.6	325	(91)
Float	83.3	1.9	3.7	7.4	3.7	108	(105)
Garbage	91.1	1.9	1.3	4.4	1.3	158	(1)
Mixer	72.2	0.0	3.8	17.7	6.3	79	(5)
Pole	81.1	0.0	8.1	5.4	5.4	37	(29)
Refrigerator	82.5	1.0	1.9	11.7	2.9	103	(41)
Stake	70.8	1.9	8.1	12.0	7.2	209	(75)
Van (Large)	84.0	1.2	3.3	7.4	4.2	337	(329)
Semi-Trailer Type Unknown	84.0	1.2	3.1	7.4	4.3	3463	
Total Percent	83.3	1.3	3.4	7.7	4.2	100.0	
Total Frequency	4,726	75	195	439	239	5,674	

*Frequency of Semi-Trailer Trucks of identified type.

5. A COMPARISON OF TRUCK AND PASSENGER CAR INVOLVEMENTS

The 5% sample file for the state of Texas maintained by HSRI records 22,531 accidents and 39,164 traffic units for the year 1973. Since this file documents a random sample of all accidents that occur in the state, it represents a useful source of information to compare the characteristics of trucks involved in accidents with the corresponding characteristics of other traffic units that are involved.

For the purposes of comparison, large-truck involvements are compared to passenger car involvements. The definition of large trucks in the Texas file is given in Table 3. The passenger car categorization used is shown in Table 12.

Table 12 - Passenger Car Categories in the Texas Files

Code*	Vehicle Body Style
01	Coach (2-Door Conventional)
02	2-Door Hardtop
03	2-Door Coupe
04	4-Door Sedan
05	4-Door Hardtop
06	Station Wagon
07	Convertible

*Codes refer to values of Variable 60 (Vehicle Body Style) in the Texas Sample File. The restriction that Variable 61 (Specific Vehicle Type) have the value 1, 2, or 3 is also used in this definition.

With these indicated groups there are a total of 32,401 vehicles represented: 30,817 passenger cars (95.1 percent) and 1,584 large trucks (4.9 percent).

To determine the difference between trucks and passenger cars in accidents, the percentage of trucks involved in accidents was calculated as a function of selected variables. An overinvolvement factor Ω has been defined as a comparative measure equal to the difference in the percentage of trucks involved at a given variable code value to the percentage of trucks for all non-missing code values of the variable. That is:

$$\Omega(i) = \left\{ \frac{f_t(i)}{f_t(i) + f_c(i)} - \frac{F_t}{F_t + F_c} \right\} \cdot 100,$$

where:

$f_t(i)$ = frequency of trucks at code value i,

$f_c(i)$ = frequency of passenger cars at code value i,

$$F_T = \sum_i f_t(i),$$

$$F_C = \sum_i f_c(i),$$

and, the sums are taken for non-missing code values only. With the definition used here, the overinvolvement Ω may have a positive or negative value. A negative Ω then is equivalent to an underinvolvement. This terminology will be used throughout this section.

To clarify this concept, consider the variation of truck accidents by month. The number of truck involvements in May, for example, as a percentage of the total involved vehicles in May was found to be 5.0 percent. The mean percentage of trucks for all cases used was 4.9 percent (i.e., 1,584/32,401). The factor Ω is then defined to be Ω = 5.0 - 4.9 = 0.1 percent for May. Note that with this definition of overinvolvement, trucks may be overinvolved because the number of truck involvements is greater for a particular code value, or because passenger car involvements are lower.

The statistical validity of variations in overinvolvement was determined by means of a standard analysis of variance technique using a dichotomous dependent variable with the binary values:

0 = Passenger Car

1 = Truck

For a discussion of the use of dichotomous variables with ANOVA, see Schultz and O'Day.*

5.1 Temporal Factors

Truck overinvolvement as a function of month, day of week, and hour of day have been investigated. The data for these factors are shown in Figures 4 to 6. All three time factors produced statistically significant variations in Ω at a five percent level. The associated F-ratio and significance level α are shown in each figure.

The variation in overinvolvement Ω by month of year (see Figure 4) indicates periods of relatively large positive values of Ω in February, July, and August and large negative values in January and April. Table 13 shows the vehicle involvement by month for cars and trucks separately. Comparing Figure 4 and Table 13, the truck overinvolvement in July and

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*"Analysis of Variance with Dichotomous Dependent Variable: A Tool for Gaining Insight From Traffic Accident Data," Samuel Schultz II and James O'Day, HIT Lab Reports, November 1972, Volume 3, Number 3.

August is due to an increase in truck involvements during those months while the February peak is mainly the result of a decrease in passenger car involvements. The January and April underinvolvement periods are the result of reduced truck involvements in these months. The monthly variations shown in Figure 4 do not suggest any simple pattern that is readily interpretable. Table 13 does show, however, that truck involvements vary more widely from month-to-month than passenger car involvements.

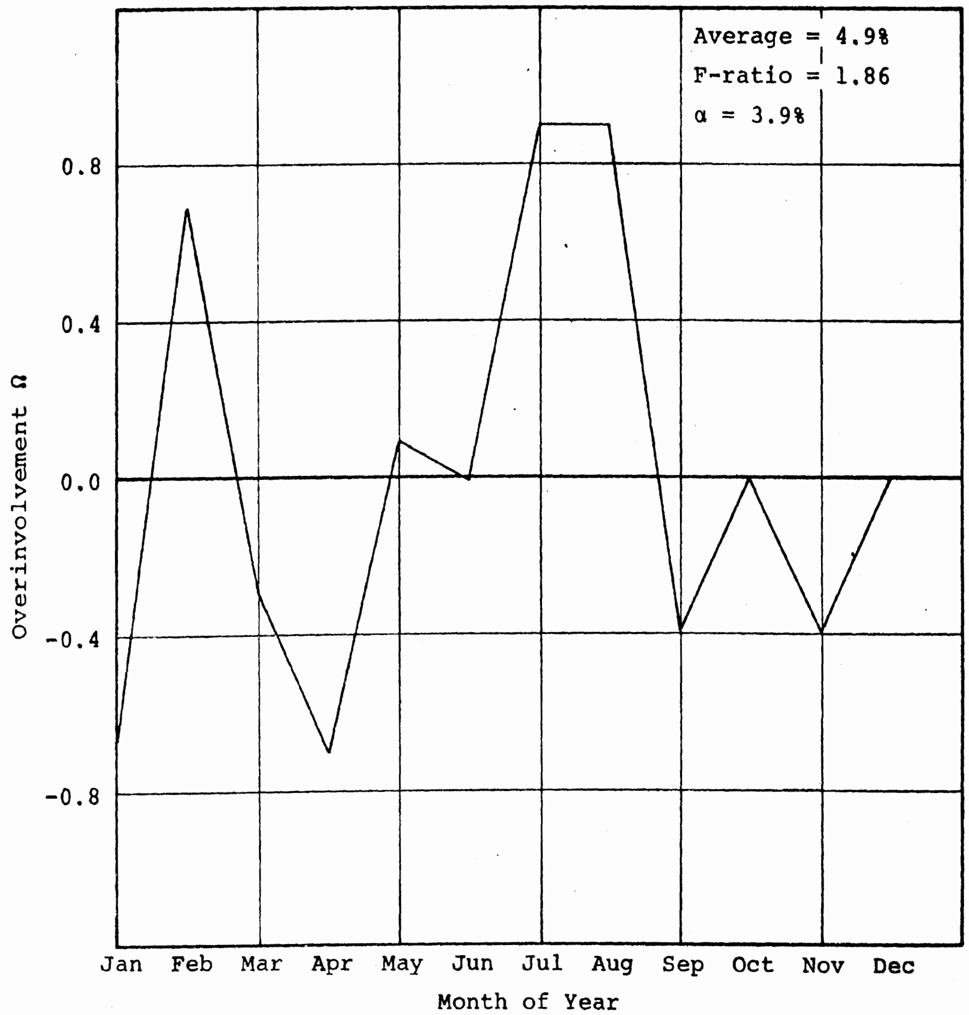

Figure 4 - Truck Overinvolvement by Month

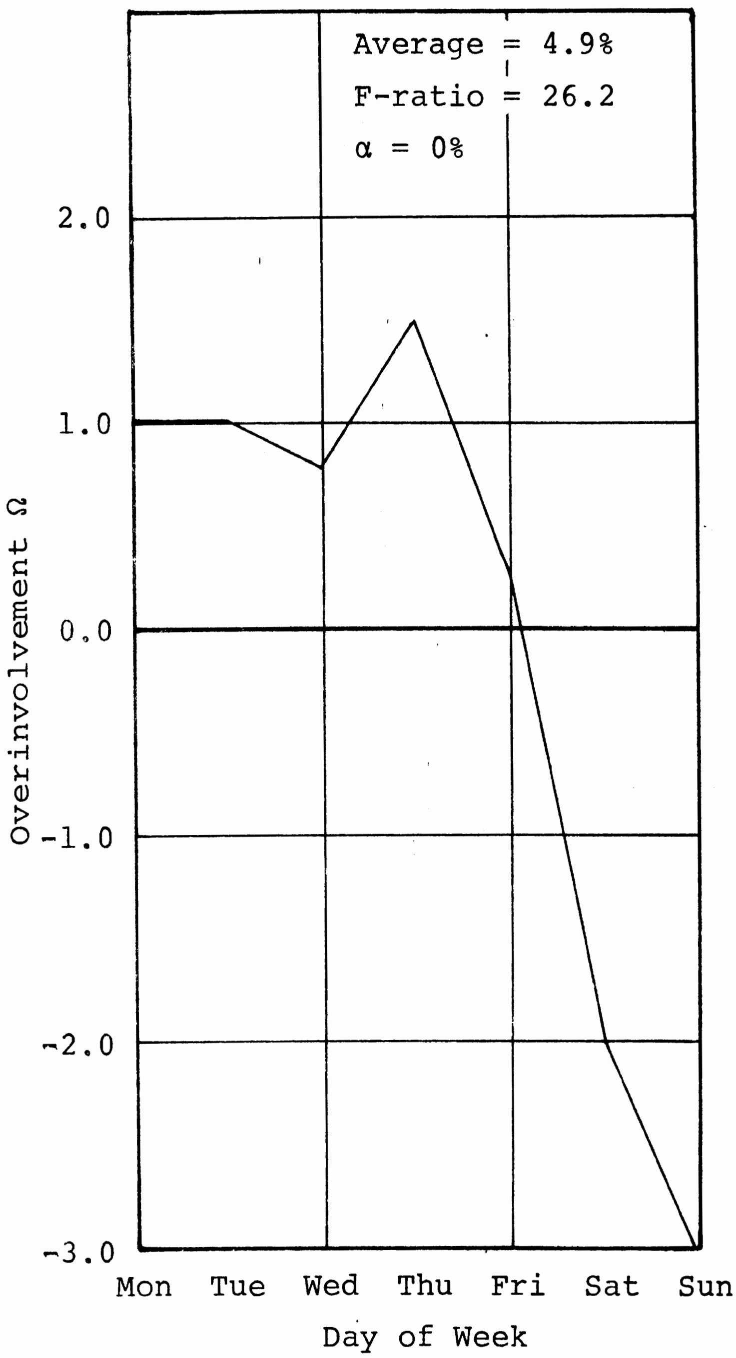

Figure 5 - Truck Overinvolvement by Day

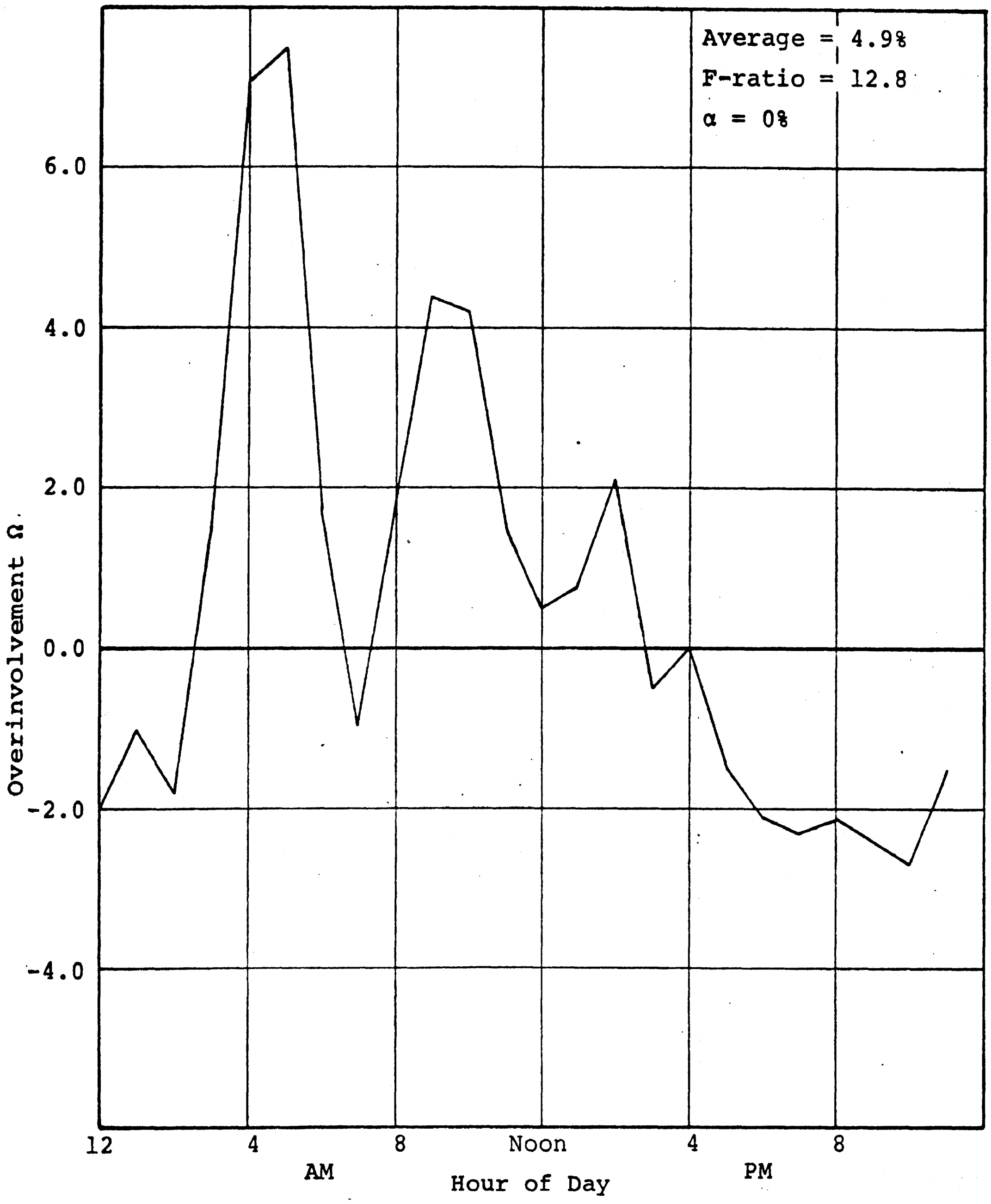

Figure 6 - Truck Overinvolvement by Hour of Day

Table 13 - Vehicle Involvements by Month

Month	Cars*	Trucks*
January	8.7%	7.3%
February	7.4	8.5
March	8.8	8.3
April	8.4	7.1
May	8.3	8.5
June	8.3	8.2
July	8.1	9.7
August	8.4	10.1
September	8.6	7.8
October	9.0	9.0
November	8.1	7.4
December	8.0	8.0
	100%	100%
Total Frequency	30817	1584

*Percentage of total involved vehicles of the given type.

As a function of day of the week, trucks were sharply underinvolved ($\Omega<0$) on weekends and overinvolved during the five-day work week as shown in Figure 5. Table 14 shows the percentages for each vehicle type as a proportion of total vehicles of the given type. It could be anticipated that overinvolvement is lower on weekends because of a combination of two factors: (1) Trucks tend to be involved in business activities that predominate during the normal five-day work week, and (2) passenger cars are used for private or family uses that tend to increase on the weekends. Table 14 shows the involvement percentages for each vehicle type. These data show that truck involvements do drop sharply on weekends after rising moderately at the end of the work week. Passenger car involvements are also higher on Fridays and Saturdays but drop well below their weekday levels on Sunday. The large under-involvement on Sunday shows that both passenger car and truck involvements are low but that truck involvements undergo a much sharper decrease.

Table 14 - Vehicle Involvements by Day of Week

Day	Cars*	Trucks*
Monday	13.6%	16.4%
Tuesday	13.4	16.5
Wednesday	13.7	16.0
Thursday	13.6	18.2
Friday	18.5	19.2
Saturday	16.3	9.6
Sunday	10.9	4.1
	100%	100%
Total Frequency	30,817	1584

*Percentage of Total Involved vehicles of the given type.

Overinvolvement by time of day is shown in Figure 6. Trucks tend to be overinvolved in the mornings and early afternoon (5 am. - 2 pm.), with a pronounced dip in Ω at 7 am. and at noon. Figures 7 and 8 show the truck and passenger car involvements, respectively, as a percentage of all vehicles of that type for the day. Note that the truck distribution is approximately two-valued, i.e., it is about 1-2 percent during the night and 7-9 percent during the day. Passenger car involvements, on the other hand, dip to near zero in the early morning then rise uniformly to a 5 pm. peak with subsidiary peaks occurring at the morning rush hour and at noon time. In combination, then, Figures 6-8 show that the positive overinvolvement at 4-6 am. is due to the large reduction of passenger car involvements at this hour, while the decreases at 7 am. and at noon are caused by rush-hour increases in passenger car involvements.

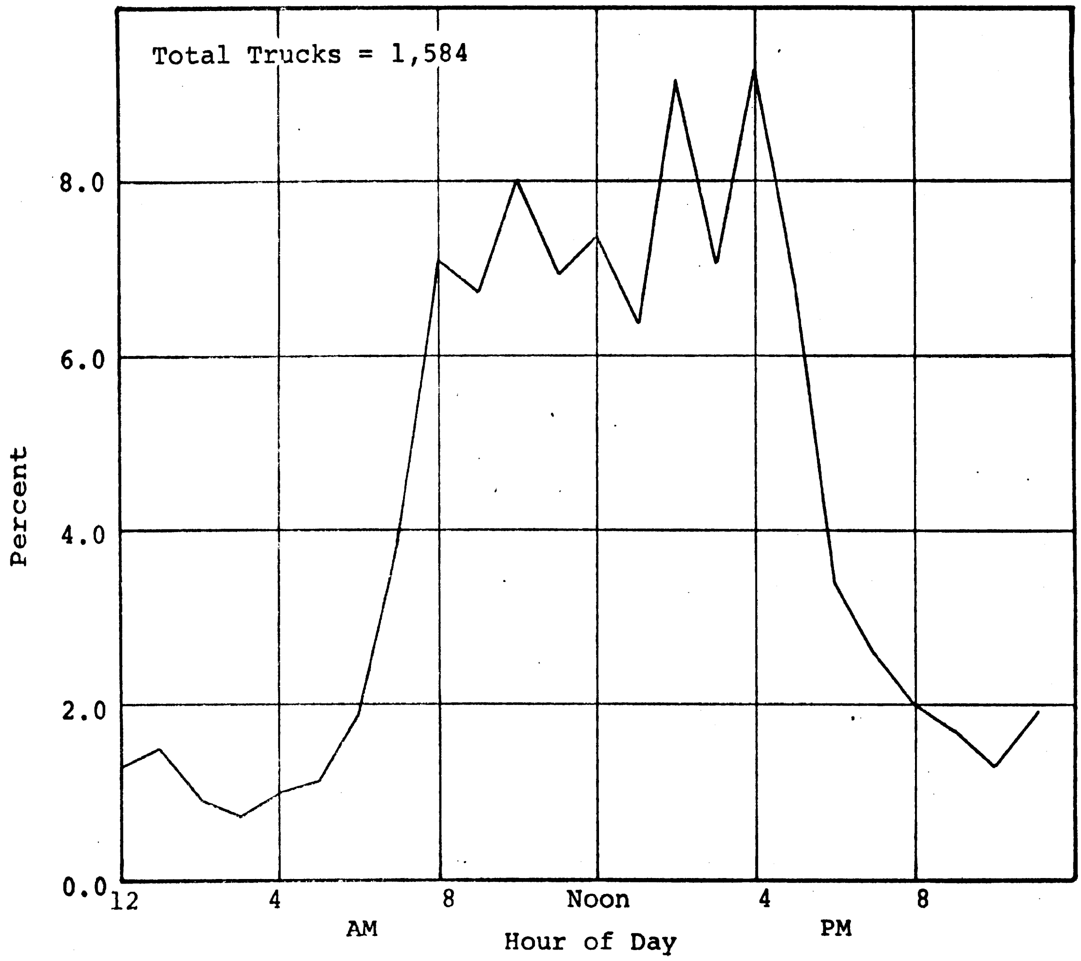

Figure 7 - Truck Involvements by Hour of Day

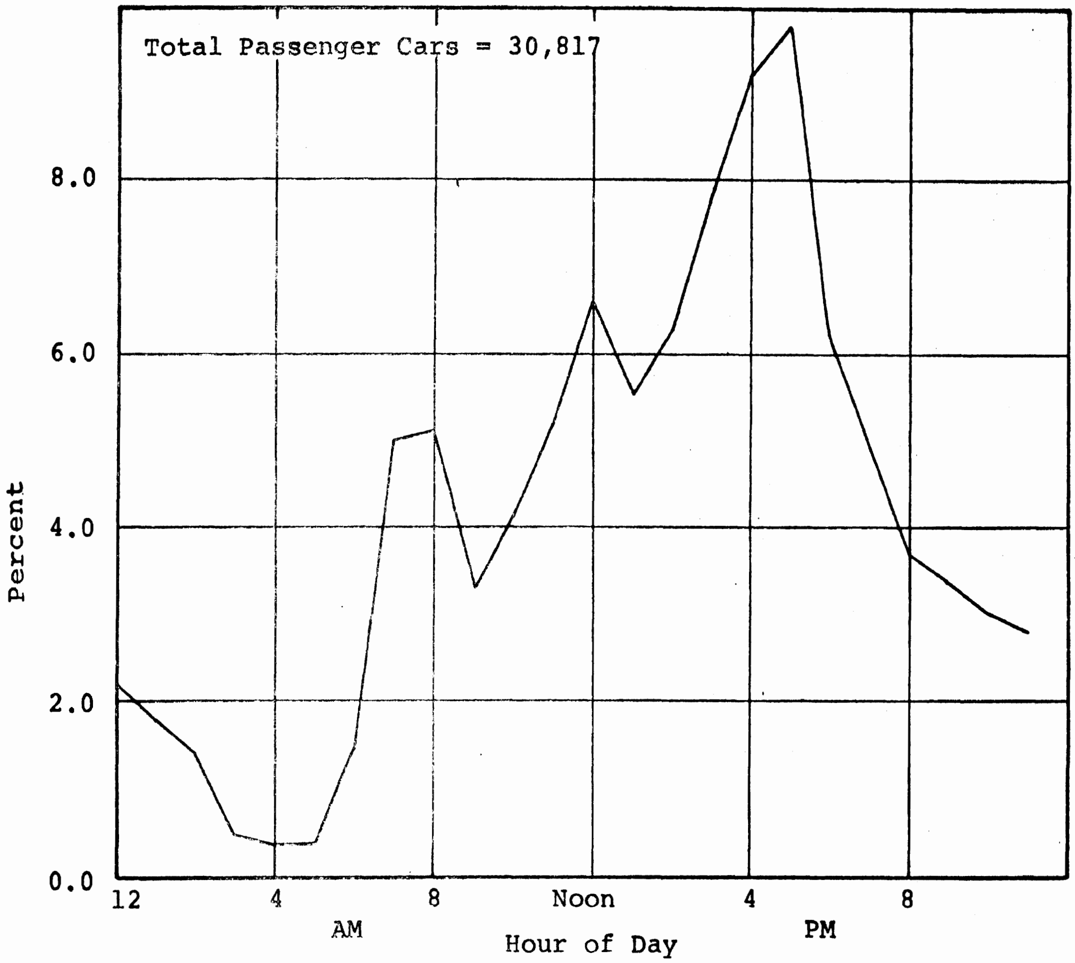

Figure 8 - Passenger Car Involvements by Hour of Day

5.2 Roadway and Weather Conditions

In this category, variations in Ω that result from changes in weather, road surface, road condition, and intersection type were studied. Only variations due to intersection type were found to be significant at the five percent level.

The categories for the "weather" variable in the Texas file are "clear," "raining," "snowing," "foggy," "dust," and "other." Clear weather accidents accounted for 83.8 percent of the vehicle involvements. The weather variable did not show statistically significant changes in Ω.

Overinvolvement does not depend significantly on road surface (dry, wet, etc.) or road condition factors either, but does depend upon the intersection classification of the roadway. Overinvolvement is positive where no intersections are present or where there is an intersection with a main highway, with the frontage road of a main highway, or with a ramp. It is negative at the intersection of city or county roads.

5.3 Vehicle Defects and Vehicle Damage

Over 98 percent of the vehicles involved in the study were found to have no reported defects. However, 6.4 percent of the trucks had reported defects in contrast to 1.7 percent for the passenger cars. Of the defective vehicles, overinvolvement Ω was positive in all of the defect categories listed except windshield wipers. Wipers are not included in Table 15 because only one passenger car with defective wipers was noted in the entire data file. In many categories, the number of cases is small and consequently the overinvolvement factor is not statistically stable. The number of involved cars and trucks and the overinvolvement for all defect types recorded are shown in Table 15.

Of the seven factors shown in Table 15, only the "defective trailer equipment" category applies more generally to trucks than to cars and understandably we find an overinvolvement of 31 percent for that category. Fourty-four percent of the vehicles that lost a wheel were trucks, however, even though less than five percent of the total vehicles were trucks.

Table 15 - Overinvolvement by Vehicle Defects

Defect	Ω	Cars	Trucks
Brakes	7.8	295	43
Steering	12.3	24	5
Lights	3.4	11	1
Tires	8.4	91	14
Trailer Equipment	31.1	16	9
Stop/Turn Signals	11.8	15	3
Wheel Came Off	38.9	18	14
Other or MD		51	12
No Defect		30296	1483
Total Frequency		30,817	1,584

Vehicle damage in Texas accidents is recorded by the TAD method.* The TAD scale records both the vehicle damage area, and a numerical indication of damage severity. Overinvolvement by damage area is given in Table 16. Note that, because of missing data, only 3.9 percent of the vehicles for which damage data are available are trucks. Of the 30,817 passenger cars used in the study, 14.5 percent had no vehicle damage area information. Of the 1,584 trucks, however, 31.8 percent had missing data for this variable. It is evident, then, that truck damage is less frequently

*Vehicle Damage Scale for Traffic Accident Investigators, TAD Project Technical Bulletin Number 1, Traffic Accident Data Project, National Safety Council, Chicago, 1971.

reported, undoubtedly because of the greater difficulty in categorizing truck damage. In interpreting the data in Table 16, it should be remembered that a bias may exist as a result of the missing data exclusion.

Table 16 - Overinvolvement by Vehicle Damage Area

Area	Ω	Cars	Trucks
Right Side and Top	10.6	159	27
Left Side and Top	6.2	161	18
Left Side Distributed	4.4	511	46
Right Side Distributed	2.7	610	43
Back Left	1.8	873	53
Back Right	0.9	851	43
Right Side-Back Quarter	0.7	1313	64
Left Passenger Compartment	0.5	1033	47
Front Right	0.2	2665	113
Left Side-Back Quarter	-0.1	1359	53
Left Side-Front Quarter	-0.3	2286	85
Right Side-Front Quarter	-0.3	2266	85
Right Passenger Compartment	-0.3	1121	42
Front Left	-0.4	2585	93
Front Distributed	-0.7	4545	150
Back Distributed	-0.9	2834	87
Front Center	-1.2	1167	32
Missing Data		4478	503
Total Frequency		30,817	1,584

In interpreting the damage data for trucks, there are several problems that come immediately to mind. A main concern is that, due to the essentially different construction of trucks and cars, the damage scales are probably applied differently by the police for the two vehicle types.

Keeping the ambiguity in mind, side and top damage for trucks represented an area of overinvolvement for these vehicles. It is also evident that the trucks were high on left and right side distributed damage but low in front and rear distributed damage.

Overinvolvement as a function of the TAD damage scale is shown in Figure 9. The ambiguities of interpretation and the missing data bias mentioned above hold as well for the damage scale. Because of a truck's inherent structural strength, it is not surprising to find large positive values of Ω at a damage scale of zero. Table 17 shows the involvement of cars and trucks as a percentage of the total vehicles of each type. For non-zero damage values, both passenger cars and trucks show a monotonic decrease in the number of vehicles with increasing damage scale up to a value of six. At a TAD scale of seven there is an increase in the number of trucks leading to an overinvolvement of trucks with severe damage. These heavily-damaged vehicles are no doubt associated with single traffic unit or truck-truck accidents.

5.4 Driver Factors

A number of driver-related factors are available in the sample file which permit a comparison between cars and trucks. Driver age, sex, and violation will be considered below. The effects of driver impairment (bad eyesight or hearing, fatigue, etc.) were considered also, but variations in overinvolvement due to this factor were not statistically significant.

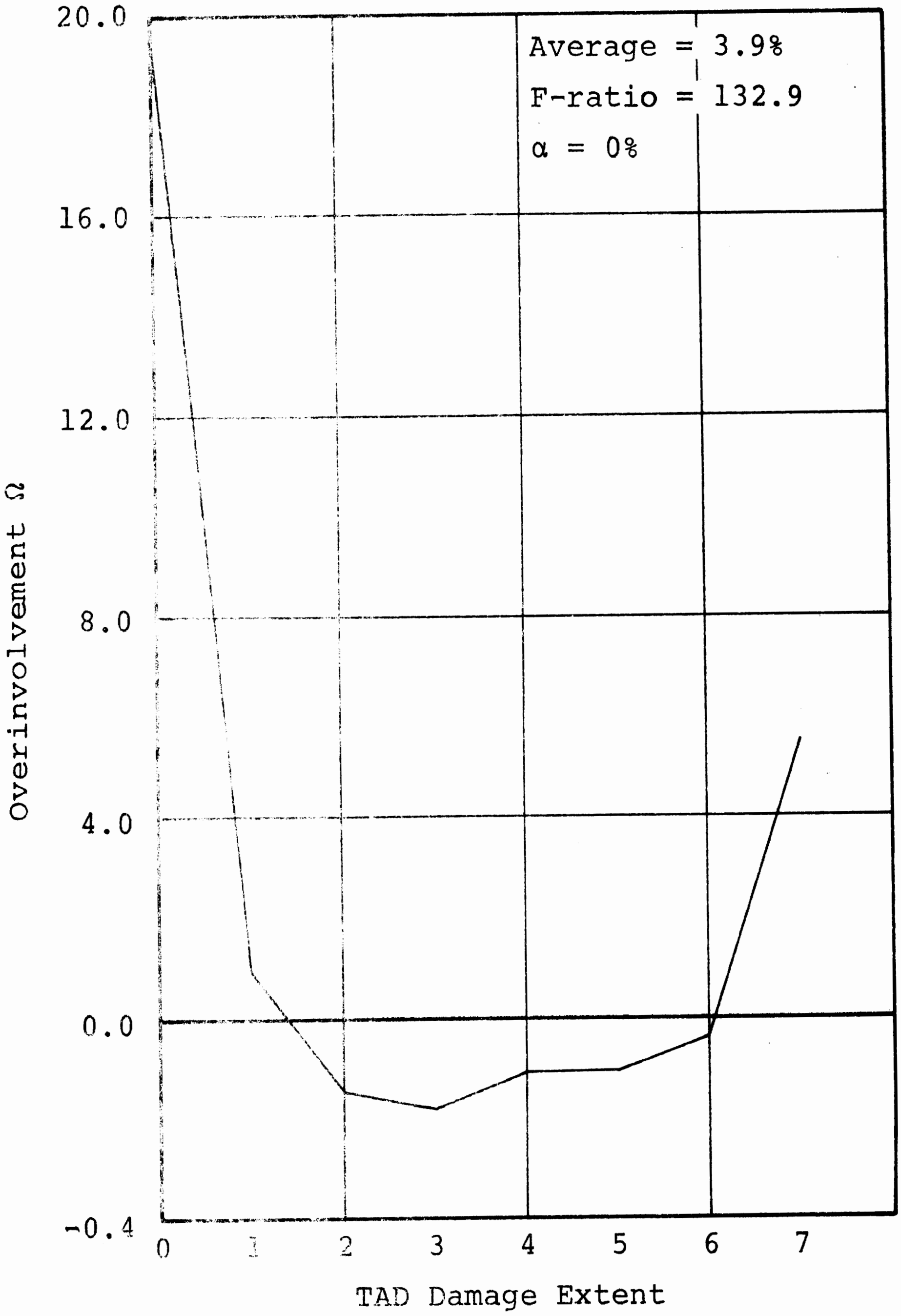

Figure 9 - Truck Overinvolvement by TAD Damage Scale

Table 17 - Vehicle Involvements by TAD Damage Scale

TAD Damage Scale	Cars*	Trucks*
0	1.8%	10.9%
1	32.8	31.9
2	24.5	11.6
3	16.8	7.0
4	5.2	2.9
5	2.0	1.1
6	1.3	0.9
7	1.0	2.0
	100%	100%
Total Frequencies	26,339	1,081

*Percentage of the total vehicles of the given type.

The variation of overinvolvement Ω with driver age is shown in Figure 10. From these data, it is seen that trucks are overinvolved for driver ages between 25 and 64. An examination of the actual involvement of each vehicle type shows that there is a high percentage of passenger cars with drivers below age 25 and a sharp drop off in truck involvements above a driver age of 65 that causes the pattern shown in Figure 10.

A plausible explanation for the indicated pattern is as follows: The poor accident record of 15-24 year old drivers results in an underinvolvement in this age bracket. Above 65 years old, many truck drivers have retired, reducing the population of trucks so that these vehicles are again underinvolved in accidents for this age group. The variations with age are very large as indicated in Figure 10 involving swings of ±4 percent about a 4.7 percent total-sample truck involvement.

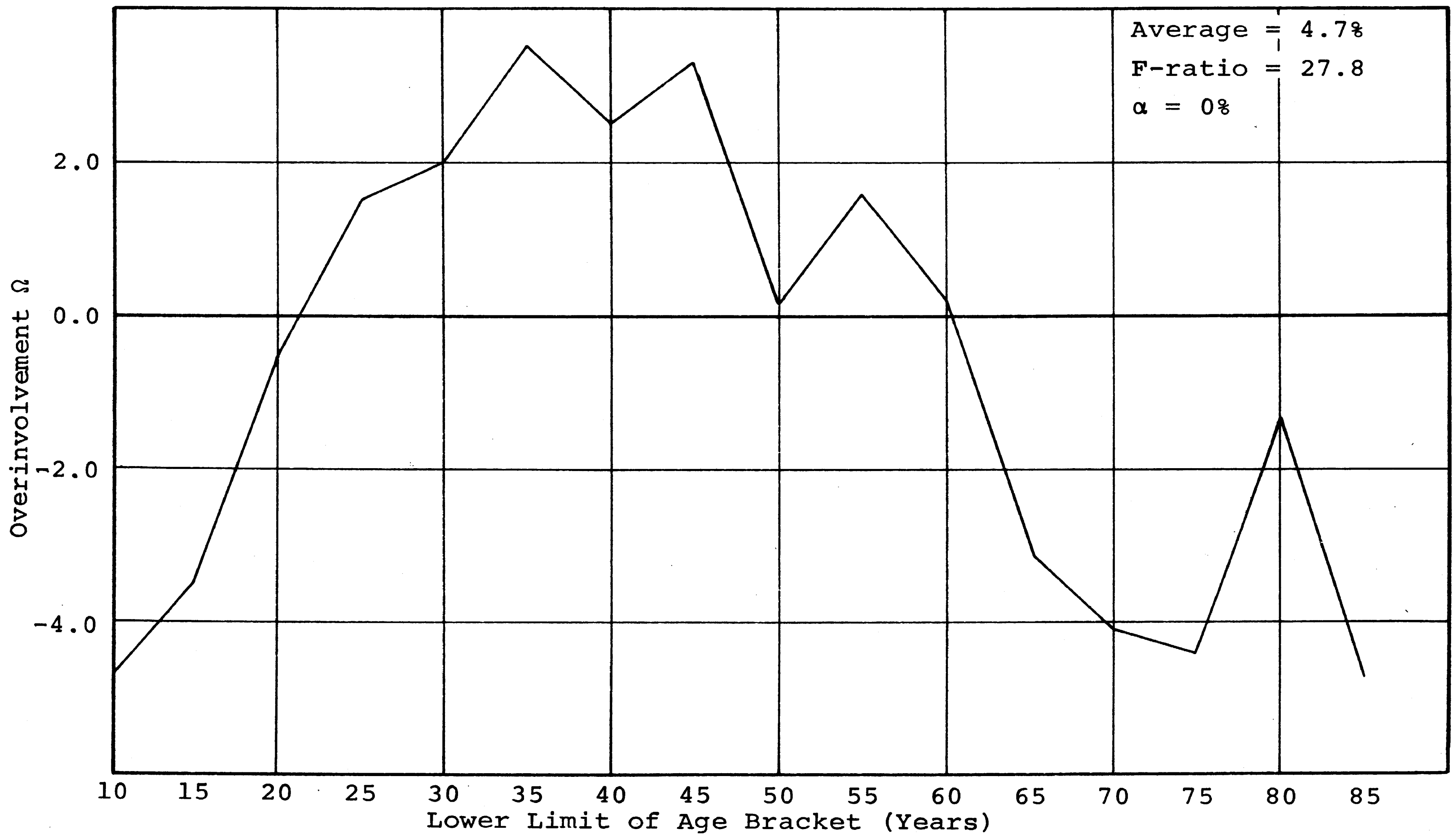

Figure 10 - Truck Overinvolvement by Driver Age

Examining truck accidents, it was found as one might expect, that most truck drivers were men. Of the 1,481 large trucks for which data were available, only 18 (1.2 percent) were driven by females.

Data for two possible driver violations are coded by the Texas police agencies. However, the number of involvements where no violation is indicated amounts to over 2/3 of the total. Trucks represent 4.2 percent of the involved vehicles with violations in contrast to 4.9 percent of the total population. Consequently, there are no apparent severe biases as a result of the missing data. Improper turns were the major violation for which trucks were overinvolved.

5.5 Occupant Injury

The overinvolvement as a function of the most severe injury sustained by occupants of the vehicle is shown in Table 18, together with the actual involvement frequencies of cars and trucks.

Table 18 - Overinvolvement by Most Severe Injury

Injury	Ω	Cars	Trucks
Fatal	1.8	97	7
A Injury	-0.5	650	30
B Injury	-2.4	1603	41
C Injury	-2.8	1390	30
No Injury	0.3	27,077	1476
Total Frequency		30,817	1,584

From Table 18, trucks are overinvolved in both fatal occupant injury involvements and in no-injury involvements.

This conclusion is compatible with other findings in this report: In multiple vehicle accidents, trucks fare very well in contrast to the "other" vehicles and consequently have a high number of no-injury involvements. At the same time, the occupants of a truck involved in a single vehicle collision or a truck-truck collision are more likely to receive severe injuries because these collisions are generally serious.

6. RECOMMENDATIONS

As a result of the large-truck investigation presented in this report, a number of recommendations have been formulated. These recommendations involve new areas of study that should be pursued, as well as developmental work that needs to be accomplished before further investigation can profitably be carried out.

As a general comment, it can be stated that the mass data files (typified by the Texas data used in this report) were designed primarily for reporting factors pertinent to passenger car accidents. For example, occupant seating positions are based on automobiles and damage scales are derived from automobile crush experience. For analytic purposes, this means that factors describing the various traffic units involved in an accident provide readily interpretable information for cars, but their recorded values for trucks, buses, motorcycles, pedestrians, and other traffic units are often ambiguous.

6.1 Truck-Type Categorization

The difficulty of successfully categorizing the numerous truck types that exist as a result of manufacturing options and post-manufacture alterations has been discussed in Section 3. The meaningful analysis of most accident data, however, and the relationship of accident data to other aspects of the transportation field, requires a useful categorization.

Consequently, it is recommended that a four-part program be instituted to provide the needed categorization. The successful development of such a categorization is not a trivial task and could involve federal and state governments—particularly police agencies, manufacturers, technical associations, and research organizations. The four tasks that are envisioned follow:

a) Catalog existing truck types as they are found in the actual highway traffic population throughout the country.

b) Group the vehicle types that have been cataloged into a number of categories with similar characteristics. A determination of the defining characteristics for each category must come from the various users to be served by the proposed categorization.

c) Evaluate the proposed categorization with existing data.

d) Develop a simple identification system that will permit operational field personnel to classify an accident-involved vehicle as a member of one of the categories described in (b). The form of this identification system will depend upon the complexity of the proposed categorization and the ability of field personnel to identify differences among vehicles in different categories.

The recommendation is straightforward to formulate but not trivial to carry out, since it has significant organizational interactions as well as technical difficulties. In particular, steps (b) and (d) may present a considerable taxonomic challenge.

6.2 The Collection of Detailed Vehicle Data

In the engineering design of vehicles or in an analysis of the effects of Federal Standards on vehicle safety, it is usually highly important, and often critical to the analysis, to have detailed vehicle damage and occupant injury information available. Thus, typical important questions relative to truck design might be "Did the seat back yield when the vehicle was impacted in the rear?", or, "What component of the vehicle was contacted by the occupant, causing injury?". Such questions generally require a detailed explanation of the condition of an accident-involved vehicle and its occupants in comparison to their pre-crash condition.

It is evident that these types of questions can not be answered by the descriptive analysis presented in this report. In fact, detailed vehicle and injury information is generally not available for large trucks. Data files that record this detailed information (e.g., the HSRI CPIR Revision 3 file) do not include large trucks. Police data, on the other hand, generally lack any of the detailed information required.

It is recommended, therefore, that data comparable in depth to the CPIR file be gathered for an adequate sample of large trucks to permit analysis of these vehicles in the same depth used for passenger cars.

6.3 Truck Damage Scale

The investigation of vehicle damage using the TAD scale showed a wide difference in the missing-data rate for trucks and passenger cars: the percentage of trucks where damage extent was missing was found to be twice as high as the corresponding percentage for passenger cars. This statistic highlights a basic difficulty in the application of the TAD scale to trucks and to cars.

Because of the inherent structural differences in trucks and passenger cars, it is difficult to assign a common damage index to both vehicle types that will accurately reflect the severity of the accident. In addition, the widely different degrees of crush resistance at different parts of the truck body dilute the absolute meaning of a damage scale.

At the same time, a vehicle-damage index of some sort is currently one of the most useful measures of accident severity that is available. It is recommended, then, that effort be put into an analysis of existing damage scales for trucks. Such an analysis could illuminate the differences that exist between cars and trucks and pave the way for improvement of the truck damage scale.

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