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Short-Haul Trucks and Driver Fatigue

Final Report

Task D: Short Haul Analysis
Engineering, Analytic and Research Support for Motor Carrier Safety Activities
Contract No. DTFH61-96-C-00038

submitted to
The Office of Motor Carriers
Federal Highway Administration

September, 1997

prepared by

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UMTRI The University of Michigan Transportation Research Institute

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2901 Baxter Rd.
Ann Arbor, MI 48109-2150

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16. Abstract

This report has two main objectives. The first is to present data that may be used to create a definition of short-haul trucks in computerized data files. The second is to examine the prevalence of driver fatigue as coded in crash data files and relate it to parameters that define short-haul trucking operations.

Tabulations were made of the numbers of large trucks registered in the United States and their annual travel using data from the 1992 Truck Inventory and Use Survey. Truck crash statistics were derived from the 1991–1993 Trucks Involved in Fatal Accidents file and, to a lesser extent, 1995 SafetyNet data. These tabulations were cross-classified by gross vehicle weight rating (GVWR) class, area of operation and vehicle type, and crash involvement rates per truck and per mile were generated.

Three possible definitions of short-haul trucks are proposed and the different definitions are compared in terms of percentage of registered trucks and miles traveled, fatal crash involvements, fatal involvement rates per truck and per mile, and prevalence of fatigue-related fatal crash involvements. The results may assist others in making decisions about hours of service regulations for the short-haul segment of the trucking industry.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0 305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

Contents

Executive Summary

This report has two main objectives. The first is to present data that may be used to create a definition of short-haul trucks in computerized data files. This is done through tabulations of descriptive statistics on the crashes, travel, and registered numbers of large trucks in the United States. The second aim is to examine the prevalence of driver fatigue as coded in crash data files and relate it to parameters that define short-haul trucking operations.

Defining Short-Haul Trucks

To form a basis for defining short-haul trucks, distributions of GVWR class, area of operation, and vehicle type were generated. The profile of large trucks in the US in terms of registered vehicles differs from the profile according to total mileage. Class 3-6 trucks outnumber class 7-8 trucks 55% to 45% in terms of vehicle registrations, but heavy-duty trucks log 75% of truck mileage compared with just 25% for medium-duty trucks. Similarly, local service (trips under 50 miles) trucks make up 58% of the large truck population, and over-the-road trucks comprise 36%, but in terms of miles traveled each year, over-the-road trucks dominate local service trucks 72% to 28%. Straight trucks outnumber tractors 71% to 29% in terms of registrations, but tractors log 67% of the mileage and straight trucks log just 33%.

Looking at these same parameters in terms of fatal crash experience, class 7-8 trucks account for 86% of large truck fatal involvements, compared with 12% for class 3-6 trucks. Local service trucks comprise 38% of fatal involvements versus 56% for over-the-road trucks. Straight trucks account for 30% of fatal involvements, compared with 68% for tractors.

This report proposes three possible definitions of short-haul trucks and compares fatal involvement rates, per truck and per mile, between the different definitions and other groups of trucks. The most restrictive definition of short-haul trucks is class 3-6 single-unit straight trucks in local service. Per registered truck, this group has a lower fatal involvement rate than all the categories of class 7-8 trucks, and its rate is comparable with the other categories of class 3-6 trucks. Class 3-6 single-unit straight trucks in local service also have a lower fatal involvement rate per mile than any of the class 7-8 subgroups. However, their rate per mile is higher than class 3-6 single-unit straight trucks in over-the-road service and also higher than medium-duty tractors, both those in local and over-the-road service.

If short-haul trucks are defined as class 3-6 single-unit straight trucks, then this group has very low fatal involvement rates compared with other trucks. Whether rates are calculated per truck or per mile, and whether for local or over-the-road service, class 3-6 single-unit straight trucks have a lower rate than virtually any other GVWR class/vehicle type combination considered.

Another possible definition of short-haul trucks would simply be those in local service, without regard to GVWR class or vehicle type. The fatal involvement rate per truck for

local service trucks is only 43% as high as the rate for over-the-road trucks. However, when rates are calculated per mile, local service trucks have a fatal involvement rate 1.8 times as high as the rate for over-the-road trucks.

Driver Fatigue in Truck Crashes

Fatigue is not commonly coded as a contributing factor in truck crashes. Police reports often include a space to indicate a fatigued or asleep driver, but the reported data may be incomplete because the evidence is often circumstantial. The prevalence of truck driver fatigue coded in fatal involvements was found to be 1.9% and the prevalence in personal injury or towaway involvements was 1.3%. The majority of these fatigue-related involvements were single-vehicle crashes, with 71% of the fatal involvements and 72% of the less severe involvements. Rollover and fixed object collisions were especially common types of fatigue-related fatal involvements. Distributions of fatigue-related involvements over the hours of the day showed a sharp peak from 4-7 A.M. for fatal involvements and a broader peak from 3-7 A.M. for less severe involvements.

The prevalence of driver fatigue in fatal involvements was calculated according to levels of GVWR class, area of operation, and vehicle type. Prevalence was defined as the percentage of all fatal involvements in each category that were coded fatigue-related. The prevalence of driver fatigue was the same for medium-duty and heavy-duty trucks. Some variation was seen according to vehicle type, with 1.2% of the fatal involvements of single-unit straight trucks coded fatigue-related, compared with 2.2% for tractors. The most variation was seen for intended trip distance at the time of the fatal crash. Driver fatigue prevalence was 0.4% for trucks making trips of 50 miles or less, compared with 3.0% for trucks making longer trips. This disparity in prevalence according to trip distance was maintained when only daytime fatal involvements were considered, as well as when only nighttime fatal involvements were examined.

Fatigue-related fatal involvement rates per truck and per mile were generated, but they are of limited utility. Since there are so few fatal crashes coded fatigue-related to begin with, the rates cannot be considered very reliable once the cases are further split according to GVWR class, area of operation, and vehicle type. Still, the numbers seem to indicate that class 7-8 tractors in over-the-road service have higher fatigue-related fatal involvement rates, per truck or per mile, than the other categories of trucks that were considered.

Tables

Figures

1 INTRODUCTION

This report presents descriptive statistics on the crashes, travel, and numbers of large trucks in the United States in order to define the short-haul truck population, assess the role of driver fatigue in crashes of short-haul trucks, and identify targets of opportunity for reducing the number of short-haul truck crashes. The report should be considered a preliminary exploration of the available data. Section 2 describes the databases that were analyzed. Section 3 describes the US truck fleet in terms of population numbers, annual mileage, fatal crashes, and fatal involvement rates. Section 4 focuses on driver fatigue in the crash experience of trucks. Section 5 offers more detail on the types of fatal involvements experienced by trucks by describing the crashes in terms of road class, land use, and collision type. Section 6 outlines the conclusions that can be made based on the tabulations in this report.

2 DATA SOURCES

Several truck databases were reviewed for this report. The Truck Inventory and Use Survey (TIUS) was analyzed to provide population and mileage statistics and to supply exposure numbers for calculating crash rates. The Trucks Involved in Fatal Accidents (TIFA) file contains physical data for all trucks involved in fatal crashes each year in the US. The SafetyNet file includes crash data for trucks involved in a much broader range of collisions. Each of these databases is described below.

2.1 TIUS

The Truck Inventory and Use Survey (TIUS) is conducted every five years by the Bureau of the Census as part of the Census of Transportation. Data describe the physical and operational characteristics of private and commercial trucks in the United States. The information collected includes the number of vehicles, annual miles, model year, body type, vehicle size, range of operation, major use, and products carried.

A probability sample of 153,914 trucks was selected from an estimated universe of over 60 million trucks registered in the United States during 1992. The sample was drawn from active registrations in each state between July 1 and December 31, 1992. Unlicensed and government-owned vehicles, as well as ambulances, motor homes, buses, and farm tractors were excluded from the TIUS sample. The trucks were selected using a stratified, random sample design. The population of trucks within each state was divided into five strata: pickup, van, single-unit light, single-unit heavy, and truck tractor.

For each selected truck, a report form was mailed to the owner identified in the state's registration records. Owners of 123,641 selected trucks responded to the survey forms, producing an overall response rate of 80%. The respondents were asked to characterize the typical physical configuration and use of their trucks over the previous year. The information received on the returned questionnaires was processed through an extensive computer edit. Reports which contained questionable responses were reviewed and corrected if necessary.

2.2 TIFA

The Center for National Truck Statistics (CNTS) at UMTRI has annually produced the Trucks Involved in Fatal Accidents (TIFA) dataset since the 1980 data year (Blower and Pettis, 1997). The TIFA database provides coverage of all medium and heavy trucks recorded in NHTSA's Fatality Analysis Reporting System (FARS) file. Trucks with a gross vehicle weight rating (GVWR) of 10,000 pounds or less, primarily pickups, are not included. While the FARS file includes detail on the crash environment and events, the information on the vehicles involved, particularly for trucks, is limited. TIFA combines crash, vehicle, and driver records from FARS with information about the physical configuration and cargo of the truck collected through a telephone survey. CNTS does not alter in any way data from the FARS records that are included in TIFA. Rather, the FARS data provide the starting point for the TIFA database, and additional information is then collected for each truck.

The TIFA data collection effort begins with a case listing of truck involvements from FARS. All cases coded medium or heavy trucks by FARS are listed, as well as certain other vehicle categories where medium/heavy trucks are likely to be classified by mistake. Nonsample vehicles are removed from the list by checking the Vehicle Identification Number (VIN). Police accident reports (PARs) are obtained from the states for all the remaining vehicles. The PARs provide the names of individuals to contact for further information. The survey is conducted primarily by telephone interview. If a telephone interview proves impossible, then a mail questionnaire is sent. The first person or company contacted is, when possible, the owner of the truck as listed in the police report. If that fails, an attempt is made to reach the driver. If neither the owner nor the driver can be reached, as much information as possible is collected from other parties, such as the investigating police officer or the tow truck operator, if the vehicle was towed from the scene. Finally, if no knowledgeable respondent can be found, as much information as possible is coded from the police report.

Each completed interview is carefully checked by an editor. For each case the VIN is decoded to confirm that the make and model information and the power unit description conform to published model specifications. The model series information allows the editors to crosscheck the manufacturer's specifications with the reported weights and dimensions. UMTRI-developed editing manuals are used to evaluate information obtained from interviews to ascertain the accuracy of the reporting, especially concerning the types of freight hauled, the necessary equipment, and the typical hardware configurations used in such conditions. Reported weights are compared with typical weight ranges for similar cargoes and body styles. Extensive consistency checking is performed on all cases as well. A set of computerized algorithms checks for total accuracy of elements in each individual case. If inconsistencies are found, the case is returned to an interviewer for follow-up calls to gather direct involvement information.

The scrutiny given each case assures the accuracy and validity of the information in the resulting TIFA dataset. A prime benefit of this procedure is that the level of missing data in TIFA is on the order of 1 to 2% for most variables, an exceptionally low rate for this kind of data. The combination of the FARS crash level variables with the physical detail of the TIFA survey produces the most complete account of fatal truck crashes available.

2.3 SafetyNet

SafetyNet is a data management system administered through the Federal Highway Administration's (FHWA) Office of Motor Carriers (OMC) in support of federal and state motor carrier safety programs (CNTS, 1997). The SafetyNet crash system replaces data previously obtained from the carrier self-reporting forms MCS 50-T and 50-B. All crashes reported to SafetyNet should meet the following severity threshold: the crash must have resulted in either a fatality; an injured person transported from the scene for medical attention; or at least one vehicle towed from the scene because of disabling damage. SafetyNet reports on trucks and buses involved in crashes meeting these criteria. The definition of a truck is a motor vehicle equipped for carrying property and having at least two axles and six tires, or a vehicle displaying a hazardous materials placard.

Data collected in SafetyNet conform to the set of data elements for truck and bus crashes recommended by the National Governors' Association (NGA) to the states in 1990. This recommendation was written into federal law in 1991 with the Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA mandated that all states must participate in the SafetyNet truck and bus reporting system by January 1, 1994. SafetyNet has been phased in gradually, so some reporting of crashes took place prior to that date. About 30% of reportable cases were actually reported in 1993; this figure has improved to about 50% for 1994 and close to 75% for 1995 an 1996 (CNTS, 1997).

SafetyNet is an automated system to collect carrier, driver, and vehicle inspection data as well as crash information. Crash data are coded from state PARs or from supplemental data forms developed to comply with SafetyNet reporting requirements. Data are electronically submitted through the SafetyNet system and combined into an analysis file. When all states are fully reporting, SafetyNet will provide a census of truck and bus crashes meeting the reporting criteria. In its current stage of implementation, however, there are several problems with SafetyNet data aside from incomplete reporting. Not all states seem to be following the reporting criteria in terms of crash severity or vehicle type. Also, there are various anomalies in the data that suggest that some states are incorrectly translating data from their PARs to the coding scheme required by SafetyNet.

3 LARGE TRUCK DESCRIPTIVE STATISTICS

The first question in a discussion of short-haul operations is, what is the definition of a short-haul truck? Tables were generated to show distributions of GVWR class, area of operation, and vehicle type and how categories of these variables overlap with each other. These tables indicate what percentage of large trucks can be considered short-haul, depending on which definition is chosen. The same categorizations of trucks are used throughout this section in presenting descriptive statistics on truck population, mileage, fatal involvements, and fatal involvement rates.

3.1 Large Truck Population and Mileage

The 1992 TIUS file was analyzed to provide a profile of the population and mileage of large trucks in the United States. The first step in preparing the analysis file was to exclude light trucks. This was done by first including only trucks in Polk gross vehicle weight classes 3 and above (over 10,000 pounds). Next, vehicles coded pickup, van, mini-van, sport utility, or station wagon on body type were excluded. In addition, trucks with empty weights of 6,000 pounds or less and with only four tires were excluded. Despite these filters, it is possible that some light trucks remain in the analysis file.

3.1.1 Large Truck Population Estimates. The first set of distributions from TIUS concerns population estimates. These are the number of trucks (power units) registered in the US during 1992. Trucks that logged all of their miles off-road were excluded from these distributions. Table 1 indicates that the medium-duty/heavy-duty split in the national truck population is 55%/45%. Area of Operation indicates the category where a truck's greatest percentage of miles was traveled. The categories are less than 50 miles from the vehicle's home base, 50 miles or more from home base, and off-road or unknown. Nearly 58% of trucks logged most of their miles within a 50-mile radius, 36% beyond a 50-mile radius, and 6% logged most of their miles off-road or did not supply the information. Vehicle Type, indicating the typical truck configuration, was split into single-unit straight trucks, straight trucks with any number of trailers, and tractors, including bobtails and tractors hauling any number of trailers. About 65% of trucks were single-unit straight trucks, 5.4% were straight trucks with trailers, and tractors comprised 29.5% of the population.

Table 1
Large Truck Population Estimates
1992 TIUS

GVWR	Number	Percent
Class 3-6	2,127,102	54.9
Class 7-8	1,748,161	45.1
Total	3,875,263	100.0
Area of Operation	**Number**	**Percent**
< 50 miles	2,241,882	57.9
50+ miles	1,409,779	36.4
Off-road/unk	223,602	5.8
Total	3,875,263	100.0
Vehicle Type	**Number**	**Percent**
S-U straight	2,523,000	65.1
Straight+trailer	210,697	5.4
Tractor-trailer	1,141,566	29.5
Total	3,875,263	100.0

Table 2 splits the trucks into medium- and heavy-duty and then shows distributions of Area of Operation versus Vehicle Type. Single-unit straight trucks comprise 88% of the class 3-6 trucks, and single-unit straight trucks with area of operation less than 50 miles comprise 63% of class 3-6 trucks. The class 7-8 trucks are somewhat more diverse. Nearly 59% are tractors, 37% single-unit straights, and 4% straights with trailers. Over 53% of the class 7-8 trucks had a radius of at least 50 miles, and 42% had a radius less than 50 miles. Of the cells created by crossing Vehicle Type and Area of Operation, the most common was tractors with a radius of at least 50 miles, comprising 44% of heavy-duty trucks, followed by single-unit straights with a radius less than 50 miles, with 27%.

Table 2
Large Truck Population Estimates
Area of Operation by Vehicle Type
for Medium-Duty Trucks and Heavy-Duty Trucks
1992 TIUS

Class 3-6 Trucks

	Vehicle Type							
Area of	S-U straight		Straight+trailer		Tractor-trailer		Total	
Operation	N	Pct.	N	Pct.	N	Pct.	N	Pct.
< 50 miles	1,343,32	63.	103,81	4.	55,37	2.	1,502,50	70.
50+ miles	393,49	18.	31,46	1.	57,00	2.	481,95	22.
Off-road/unk	134,23	6.	5,42	0.	2,97	0.	142,63	6.
Total	1,871,05	88.	140,70	6.	115,34	5.	2,127,10	100.

Class 7-8 Trucks

	Vehicle Type							
Area of	S-U straight		Straight+trailer		Tractor-trailer		Total	
Operation	N	Pct.	N	Pct.	N	Pct.	N	Pct.
< 50 miles	467,19	26.	39,23	2.	232,94	13.	739,37	42.
50+ miles	127,26	7.	28,37	1.	772,17	44.	927,82	53.
Off-road/unk	57,48	3.	2,38	0.	21,09	1.	80,96	4.
Total	651,94	37.	69,99	4.	1,026,22	58.	1,748,16	100.

Table 3 presents the same data as Table 2 arranged a different way. In Table 3 trucks are split into area of operation less than 50 miles (local service) and trucks with area of operation 50 miles or more (over-the-road). For both groups GVWR Class is crossed with Vehicle Type. Single-unit straight trucks dominate the local service group, with 81%, and class 3-6 single-unit straights make up 60% of the local service truck population. Among the over-the-road trucks, 59% are tractors and 37% are single-unit straight trucks. Almost 55% are class 7-8 tractors and 28% are class 3-6 single-unit straight trucks.

Table 3
Large Truck Population Estimates
GVWR by Vehicle Type
for Local Service Trucks and Over-the-Road Trucks
1992 TIUS

Trucks with Area of Operation < 50 Miles

	Vehicle Type							
	S-U straight		Straight+trailer		Tractor-trailer		Total	
GVWR	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Class 3-6	1,343,32	59.	103,81	4.	55,37	2.	1,502,50	67.
Class 7-8	467,19	20.	39,23	1.	232,94	10.	739,37	33.
Total	1,810,51	80.	143,05	6.	288,31	12.	2,241,88	100.

Trucks with Area of Operation 50+ Miles

	Vehicle Type							
	S-U straight		Straight+trailer		Tractor-trailer		Total	
GVWR	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Class 3-6	393,49	27.	31,46	2.	57,00	4.	481,95	34.
Class 7-8	127,26	9.	28,37	2.	772,17	54.	927,82	65.
Total	520,75	36.	59,84	4.	829,17	58.	1,409,77	100.

3.1.2 Large Truck Annual Mileage Estimates. This set of distributions from TIUS concerns annual mileage estimates. These are the number of miles logged by registered trucks in the US during 1992. All off-road mileage was excluded. Tables 4, 5, and 6 are the mileage companion tables to Tables 1, 2, and 3. The Area of Operation categories were derived by multiplying a truck's total annual mileage by the percent of the truck's miles in each radius category.

Table 4 illustrates that the profile of large trucks according to mileage is much different than according to population. In terms of annual mileage, heavy-duty trucks dominate medium-duty by about 3:1. Over-the-road mileage tops local service mileage by nearly the same ratio. Tractors account for 67% of all large truck mileage, single-unit straight trucks for almost 30%, and straight trucks with trailers 3.4%. So, by number of registered trucks, medium-duty, local service, and straight trucks all prevail, but most large truck mileage is logged by heavy-duty trucks, over-the-road trucks, and tractors.

Table 4
Large Truck Annual Mileage Estimates
1992 TIUS

GVWR	Annual Miles (Millions)	Percent
Class 3-6	25,884	25.1
Class 7-8	77,116	74.9
Total	103,000	100.0

Area of Operation	Annual Miles (Millions)	Percent
< 50 miles	28,408	27.6
50+ miles	74,592	72.4
Total	103,000	100.0

Vehicle Type	Annual Miles (Millions)	Percent
S-U straight	30,521	29.6
Straight+trailer	3,465	3.4
Tractor-trailer	69,014	67.0
Total	103,000	100.0

As Table 5 shows, among class 3-6 trucks, 55% of the mileage is local service and 45% is over-the-road. Single-unit straight trucks dominate the class 3-6 mileage with 79%, but tractors account for 15% of the miles. Among class 7-8 trucks, the mileage is more concentrated, with tractors on trips of 50 miles or more from home base accounting for 75% of the mileage.

Table 5
Large Truck Annual Mileage Estimates (Millions of Miles)
Area of Operation by Vehicle Type
for Medium-Duty Trucks and Heavy-Duty Trucks
1992 TIUS

Class 3-6 Trucks

Area of Operation	S-U straight N	S-U straight Pct.	Straight+trailer N	Straight+trailer Pct.	Tractor-trailer N	Tractor-trailer Pct.	Total N	Total Pct.
< 50 miles	12,17	47.	86	3.	1,22	4.	14,26	55.
50+ miles	8,37	32.	57	2.	2,66	10.	11,61	44.
Total	20,55	79.	1,44	5.	3,89	15.	25,88	100.

Class 7-8 Trucks

Area of Operation	S-U straight N	S-U straight Pct.	Straight+trailer N	Straight+trailer Pct.	Tractor-trailer N	Tractor-trailer Pct.	Total N	Total Pct.
< 50 miles	6,38	8.	76	1.	6,99	9.	14,14	18.
50+ miles	3,58	4.	1,26	1.	58,12	75.	62,97	81.
Total	9,97	12.	2,02	2.	65,12	84.	77,11	100.

Table 6 splits the mileage into local service mileage and over-the-road mileage and then runs GVWR against vehicle type. While class 3-6 single-unit straight trucks have the largest share of the local mileage, they account for less than half of the miles, with 43%. Class 7-8 single-unit straight trucks log 22.5% of the miles, and class 7-8 tractors account for 25% of the miles. In fact, local mileage is split about 50-50 between medium- and heavy-duty trucks. For over-the-road mileage, class 7-8 tractors account for 78% of the miles, with the next largest share logged by class 3-6 single-unit straight trucks, with 11%.

Table 6
Large Truck Annual Mileage Estimates (Millions of Miles)
GVWR by Vehicle Type
for Local Service Trucks and Over-the-Road Trucks
1992 TIUS

Trucks with Area of Operation < 50 Miles

	Vehicle Type							
	S-U straight		Straight+trailer		Tractor-trailer		Total	
GVWR	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Class 3-6	12,17	42.	86	3.	1,22	4.	14,26	50.
Class 7-8	6,38	22.	76	2.	6,99	24.	14,14	49.
Total	18,55	65.	1,63	5.	8,21	28.	28,40	100.

Trucks with Area of Operation 50+ Miles

	Vehicle Type							
	S-U straight		Straight+trailer		Tractor-trailer		Total	
GVWR	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Class 3-6	8,37	11.	57	0.	2,66	3.	11,61	15.
Class 7-8	3,58	4.	1,26	1.	58,12	77.	62,97	84.
Total	11,96	16.	1,83	2.	60,79	81.	74,59	100.

3.2 Large Truck Fatal Involvements

The same kinds of descriptive statistics generated from the TIUS file were repeated using TIFA data. While TIFA is obviously limited to fatal truck crashes, its data is more accurate and detailed than any other truck crash data file. TIFA is also the only crash file that codes area of operation. Three years of TIFA data were analyzed to provide a robust sample size. The years 1991-1993 were selected to match with the 1992 TIUS data year. Government-owned vehicles were excluded from the TIFA analysis file since these trucks are not covered by TIUS. TIFA is limited from the outset to trucks over 10,000 pounds GVWR, so it was not necessary to filter on that variable. Tables 7, 8, and 9 present fatal truck involvements categorized to correspond to the TIUS tables presented earlier. The TIFA tables show total fatal involvements over the three years, not annual averages.

Table 7 shows that heavy-duty trucks account for 86% of fatal involvements, compared with 11.5% for medium-duty trucks. Trip Distance categorizes involvements according to the length of the trip the truck was making at the time of the crash. This is not the same as the TIUS Area of Operation variable, which indicates the range where the greatest percentage of a truck's miles was logged over the course of a year. The TIFA Trip Distance variable only indicates the length of one particular trip, but it is the closest variable to Area of Operation in the TIFA dataset. Also, in TIFA trips of exactly 50 miles are included in the lower radius range, whereas in TIUS they are placed in the higher range. TIFA shows that 38.5% of the fatal involvements occurred on local trips and 55.6% on over-the-road trips. In terms of vehicle type, tractors accounted for 68% of the fatal involvements, single-unit straight trucks 26%, and straight trucks with trailers 4%.

Table 7
Large Truck Fatal Involvements
1991-1993 TIFA

GVWR	Number	Percent
Class 3-6	1,467	11.5
Class 7-8	10,993	86.4
Unknown	264	2.1
Total	12,724	100.0

Trip Distance	Number	Percent
≤ 50 miles	4,898	38.5
> 50 miles	7,070	55.6
Unknown	756	5.9
Total	12,724	100.0

Vehicle Type	Number	Percent
S-U straight	3,310	26.0
Straight+trailer	488	3.8
Tractor-trailer	8,690	68.3
Unknown	236	1.9
Total	12,724	100.0

Table 8 shows that fatal involvements of medium-duty trucks are primarily single-unit straight trucks with 83%. Single-unit straights on local trips make up 63% of the medium-duty fatal involvements. For fatal involvements of heavy-duty trucks, tractors on over-the-road trips comprise 56.5%, tractors on local trips 18.5%, and single-unit straight trucks on local trips 14%.

Table 8
Large Truck Fatal Involvements
Trip Distance by Vehicle Type
for Medium-Duty Trucks and Heavy-Duty Trucks
1991-1993 TIFA

Class 3-6 Trucks

	Vehicle Type									
	S-U straight		Straight+trailer		Tractor-trailer		Unknown		Total	
Trip Distance	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
≤ 50 miles	91	62.	10	7.0	2	1.		0.0	1,04	71.
> 50 miles	24	16.	5	4.0	1	1.		0.0	31	21.
Unknown	6	4.	1	0.7		0.	3	2.4	11	7.
Total	1,22	83.	17	11.7	3	2.	3	2.4	1,46	100.

Class 7-8 Trucks

	Vehicle Type									
	S-U straight		Straight+trailer		Tractor-trailer		Unknown		Total	
Trip Distance	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
≤ 50 miles	1,56	14.	16	1.5	2,03	18.		0.0	3,76	34.
> 50 miles	35	3.	13	1.3	6,20	56.		0.0	6,70	61.
Unknown	7	0.		0.1	30	2.	14	1.3	53	4.
Total	1,99	18.	30	2.8	8,54	77.	14	1.3	10,99	100.

Table 9 splits fatal involvements according to trip distance. For trucks on local trips, 52% of the involvements were single-unit straight trucks and 42% were tractors. Class 3-6 trucks accounted for 21% of the fatal involvements and class 7-8 trucks 77%. For trucks on over-the-road trips, the great majority of fatal involvements were class 7-8 tractors with 88%.

Table 9
Large Truck Fatal Involvements
GVWR by Vehicle Type
for Local Service Trucks and Over-the-Road Trucks
1991-1993 TIFA

Trucks with Trip Distance ≤ 50 Miles

	Vehicle Type									
	S-U straight		Straight+trailer		Tractor-trailer		Unknown		Total	
GVWR	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Class 3-6	91	18.8	10	2.1	2	0.	0	0.	1,041	21.
Class 7-8	1,56	32.0	16	3.3	2,03	41.	0	0.	3,761	76.
Unknown	6	1.2		0.1	2	0.	0	0.	96	2.
Total	2,54	52.0	27	5.6	2,07	42.	0	0.	4,898	100.

Trucks with Trip Distance > 50 Miles

	Vehicle Type									
	S-U straight		Straight+trailer		Tractor-trailer		Unknown		Total	
GVWR	N	Pct.	N	Pct.	N	Pct.	N	Pct.	N	Pct.
Class 3-6	24	3.4	5	0.8	1	0.	0	0.	316	4.
Class 7-8	35	5.0	13	2.0	6,20	87.	0	0.	6,701	94.
Unknown	1	0.2		0.0	3	0.	0	0.	53	0.
Total	61	8.7	20	2.8	6,25	88.	0	0.	7,070	100.

3.3 Large Truck Fatal Involvement Rates

Thus far the number of registered large trucks, their annual mileage, and their fatal involvements have been described in terms of GVWR, area of operation, and vehicle type. It is possible to combine the TIUS and TIFA data to produce fatal involvement rates. Tables 10 and 11 show rates both per registered truck and per mile traveled. Both types of rates yield useful information. Mileage-based rates indicate the risk of crash involvement when vehicles are actually on the road. Vehicle-based rates in a sense combine the risk per mile with the amount that the vehicles are driven. For example, two groups of vehicles may have the same rate per mile, but the group that accumulates fewer miles over the course of a year will have the lower rate per vehicle. Vehicle-based rates are relevant if one wants to know the expected annual number of crash involvements for a group of vehicles.

Tables 10 and 11 show annual rates; the TIFA involvement figures were divided by three before the rates were calculated. Also, cases in TIFA and TIUS with unknown values on GVWR class, vehicle type, or type of service were excluded from the rates shown in Tables 10 and 11.

The upper half of Table 10 shows fatal involvement rates per 1000 registered trucks, first for class 3-6 trucks and then for class 7-8 trucks. The class 3-6 rates per truck are all low. The rate is about the same for over-the-road trucks and those in local service. There is some variation according to vehicle type, but it may not be meaningful. The class 7-8 rate per truck is 9 times the rate for class 3-6 trucks. One would expect a higher per truck rate for heavy-duty than medium-duty trucks, since heavy-duty trucks typically log more miles, but this is a large difference. Within the class 7-8 trucks, those in local service have a somewhat lower rate than over-the-road trucks. Single-unit straight trucks have a rate less than half that of tractors.

The lower portion of Table 10 shows fatal involvement rates per 100 million miles. Now within class 3-6 trucks, those in local service have a rate 2.7 times over-the-road trucks. Single-unit straight trucks have a rate much higher than tractors. The per mile rate for class 7-8 trucks is 2.6 times the rate for class 3-6 trucks. Within class 7-8 trucks, over-the-road trucks have a more favorable fatal involvement rate than local service trucks. The rate for local service trucks is 2.5 times the rate for over-the-road trucks. Also, the rate for single-unit straight trucks is 1.5 times the rate for tractors.

Table 10
Large Truck Fatal Involvement Rates
Repetitions According to GVWR Class
1991-1993 TIFA/1992 TIUS

Fatal Involvements per 1000 Registered Trucks
<u>Class 3-6 Only</u>

Type of Service	Vehicle Type S-U straight	Straight+trailer	Tractor-trailer	Total
Local	0.23	0.33	0.12	0.23
OTR	0.21	0.63	0.09	0.22
Total	0.22	0.40	0.10	0.23

Fatal Involvements per 1000 Registered Trucks
<u>Class 7-8 Only</u>

Type of Service	Vehicle Type S-U straight	Straight+trailer	Tractor-trailer	Total
Local	1.12	1.38	2.90	1.70
OTR	0.92	1.63	2.68	2.41
Total	1.08	1.49	2.73	2.09

Fatal Involvements per 100 Million Miles
<u>Class 3-6 Only</u>

Type of Service	Vehicle Type S-U straight	Straight+trailer	Tractor-trailer	Total
Local	2.52	3.91	0.54	2.43
OTR	0.96	3.44	0.19	0.91
Total	1.88	3.72	0.30	1.75

Fatal Involvements per 100 Million Miles
<u>Class 7-8 Only</u>

Type of Service	Vehicle Type S-U straight	Straight+trailer	Tractor-trailer	Total
Local	8.19	7.14	9.67	8.86
OTR	3.28	3.67	3.56	3.55
Total	6.42	4.97	4.22	4.52

Table 11 contains essentially the same data as Table 10 arranged a different way. The upper half of Table 11 shows fatal involvement rates per 1000 registered trucks, first for local service trucks and then for over-the-road trucks. Looking at the rates per registered truck in local service, it is not surprising to find that tractors have a much higher fatal involvement rate than straight trucks, and class 7-8 trucks have a much higher rate than class 3-6 trucks. Tractors typically log more miles than straight trucks, and heavy-duty trucks log more miles than medium-duty trucks, so rates per truck should favor straight trucks and medium-duty trucks. The overall over-the-road rate is over twice the local service rate per truck. Again this is to be expected since the typical truck in over-the-road service puts on more miles than the typical local service truck, so the rate per truck should be lower for local service trucks. Within over-the-road trucks, the patterns are similar to those of local service trucks; rates for tractors greatly exceed rates for straight trucks, and rates for heavy-duty trucks are much higher than rates for medium-duty trucks.

The lower portion of Table 11 presents fatal involvement rates per 100 million miles. One change from the rates per registered truck is that the rate per mile for local service trucks is 1.8 times the rate per mile for over-the-road trucks. Undoubtedly, differences in operating environment contribute to the higher rate for local service trucks. Per mile traveled, fewer fatal crashes occur on limited access roads than on other types of roads. Only 14% of the fatal involvements of local service trucks took place on limited access roads, compared with 34% of over-the-road trucks. Mileage data cross-classified by operating environment is required to better assess risk differences between local service and over-the-road trucks. TIUS does not have data on miles traveled according to road type or rural/urban.

Within local service trucks, class 3-6 single-unit straight trucks have a per mile rate that is less than half the overall rate. Tractors have a rate nearly twice that of single-unit straight trucks, and heavy-duty trucks have a rate 3.6 times that of medium-duty trucks. For over-the-road trucks, class 3-6 single-unit straight trucks again have a very low rate. Tractors have a higher rate than straight trucks and heavy-duty trucks have a higher rate than medium-duty trucks.

Table 11
Large Truck Fatal Involvement Rates
Repetitions According to Area of Operation
1991-1993 TIFA/1992 TIUS

Fatal Involvements per 1000 Registered Trucks
Local Service Only

	Vehicle Type			
GVWR	S-U straight	Straight+trailer	Tractor-trailer	Total
Class 3-6	0.23	0.33	0.12	0.23
Class 7-8	1.12	1.38	2.90	1.70
Total	0.46	0.62	2.37	0.71

Fatal Involvements per 1000 Registered Trucks
Over-the-Road Only

	Vehicle Type			
GVWR	S-U straight	Straight+trailer	Tractor-trailer	Total
Class 3-6	0.21	0.63	0.09	0.22
Class 7-8	0.92	1.63	2.68	2.41
Total	0.38	1.10	2.50	1.66

Fatal Involvements per 100 Million Miles
Local Service Only

	Vehicle Type			
GVWR	S-U straight	Straight+trailer	Tractor-trailer	Total
Class 3-6	2.52	3.91	0.54	2.43
Class 7-8	8.19	7.14	9.67	8.86
Total	4.47	5.42	8.31	5.63

Fatal Involvements per 100 Million Miles
Over-the-Road Only

	Vehicle Type			
GVWR	S-U straight	Straight+trailer	Tractor-trailer	Total
Class 3-6	0.96	3.44	0.19	0.91
Class 7-8	3.28	3.67	3.56	3.55
Total	1.66	3.60	3.41	3.14

The safety record of short-haul trucks, as measured by involvement in fatal crashes, varies depending on the definition of short-haul. If short-haul trucks are defined as class 3-6 single-unit straight trucks, then this group has very low fatal involvement rates compared with other trucks. Whether rates are calculated per truck or per mile, and whether for local or over-the-road service, class 3-6 single-unit straight trucks have a lower rate than any other GVWR class/vehicle type combination considered, except for medium-duty tractor-trailers. However, medium-duty tractor-trailers are so uncommon in TIFA that their rate estimates cannot be considered very precise. (As an aside, medium-duty trucks have substantially higher representation in TIUS mileage than they do in TIFA involvements. While part of this is to be expected due to differences in operating environment between medium- and heavy-duty trucks, incorrect vehicle classifications in TIUS may also contribute.)

If the definition of short-haul is further restricted to class 3-6 single-unit straight trucks in local service, the fatal involvement picture is somewhat more mixed although still favorable. Per registered truck, this group has a lower fatal involvement rate than all the categories of class 7-8 trucks, and its rate is about comparable with the other categories of class 3-6 trucks. Class 3-6 single-unit straight trucks in local service also have a lower rate of fatal involvements per mile than any of the class 7-8 subgroups. However, their rate per mile is higher than class 3-6 single-unit straight trucks in over-the-road service and also higher than medium-duty tractors, both those in local and over-the-road service.

Another possible definition of short-haul trucks would simply be those in local service, without regard to GVWR class or vehicle type. The fatal involvement rate per truck for local service trucks is only 43% as high as the rate for over-the-road trucks. However, as was discussed before, when rates are calculated per mile, local service trucks have a fatal involvement rate 1.8 times as high as the rate for over-the-road trucks.

4 DRIVER FATIGUE AND TIME OF DAY

Fatigue among truck drivers is a current item of concern within the trucking industry, in government, and with the general public. Gauging the scope of the problem is difficult because of shortcomings in the data. While police reports often include a space to indicate a fatigued or asleep driver, the reported data may not be reliable because the evidence is often circumstantial. On the exposure side the situation is worse. Collecting data on fatigued drivers on the road requires very expensive special studies, typically based on a small number of subjects and not necessarily reflective of the entire industry (Wylie et al., 1996). To assess the risk of driving while fatigued would require mileage data cross-classified by fatigue status, truck type, and operating environment, which is not practical. A first step would be to have mileage data split by day versus night, but this is not available in the TIUS file.

Because of these problems, fatigue will be primarily examined here by analyzing the crash data. FARS contains a variable called Driver Related Factors, for which up to three responses may be coded. To look at the prevalence of driver fatigue in TIFA, a case was considered fatigue-related if the level "drowsy, sleepy, asleep, fatigued" was coded as any one of these three responses. A total of 1.9% of truck drivers in TIFA was coded fatigued.

The SafetyNet file codes a Driver Condition variable, and 1.3% of the drivers in SafetyNet were coded "fatigue" or "asleep." Fatigue is much more likely to be coded in single-vehicle crashes. In TIFA, 71% of the fatigue-related involvements were single-vehicle, and 22% were two-vehicle. Only 17% of all the involvements in TIFA were single-vehicle. In SafetyNet, 72% of the fatigue-related involvements were single-vehicle, and 25% were two-vehicle. It should also be mentioned that 64% of the drivers in fatigue-related involvements in TIFA were themselves killed, compared with 12% of all drivers in TIFA. This is to be expected given that most fatigue-related involvements are single-vehicle.

4.1 Time of Day Distributions

Obviously, fatigue-related crashes are more likely to occur at night than during the day. To look at this in detail, distributions of all fatal involvements, fatigue-related fatal involvements, and fatigue-related involvements in SafetyNet were generated across hours of the day. These distributions may assist in making decisions about how to counteract driver fatigue.

Figure 1 shows the distribution by hour of the day of all fatal involvements in TIFA and those coded fatigue-related. The two distributions differ markedly. The overall fatal involvements are distributed much more evenly over the hours of the day than the fatigue-related fatal involvements. Fatal involvements are at their lowest from about 8 P.M. to 5 A.M. The numbers then rise through the midday hours before falling again in the evening. The percentages range from a low of 2.4% from 9 to 10 P.M. to a high of 6.4% between 2 and 3 P.M. This pattern probably reflects the distribution of both truck travel and overall traffic density.

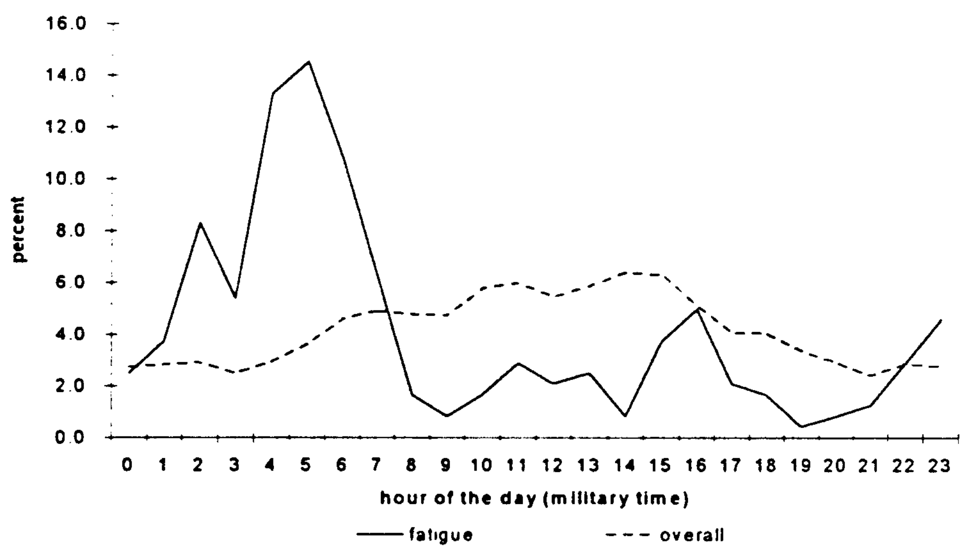

Figure 1
Distribution of Fatigue-Related and Overall Fatal Involvements
1991-1993 TIFA

In contrast, the distribution of fatigue-related fatal involvements varies much more by hour of the day. There is a large peak in the three-hour time period from 4-7 A.M., when 38.6% of all fatigue-related involvements occur. A secondary peak occurs from 3-5 P.M., when an additional 8.7% of fatigue-related involvements take place. The overall range goes from a low of 0.4% from 7 to 8 P.M. to a high of 14.5% between 5 and 6 A.M. It is clear that the distribution of fatigue-related fatal involvements does not reflect the distribution of overall truck travel.

Figure 2 compares the distribution and prevalence of fatigue-related involvements in TIFA. The solid line, replicated from Figure 1, shows the distribution of fatigue-related involvements over each hour of the day. The dashed line in Figure 2 plots the prevalence of fatigue-related involvements. This is the percentage of all fatal involvements in each hour block that were coded fatigue-related. The pattern of prevalence follows the distribution pattern fairly closely.

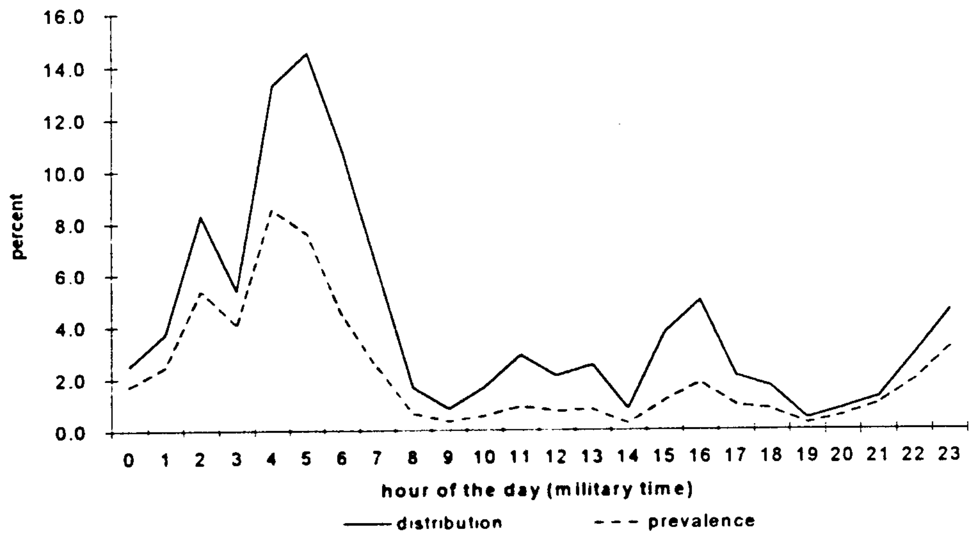

Figure 2
Distribution and Prevalence of Fatigue-Related Fatal Involvements
1991-1993 TIFA

Figure 3 compares the distribution of fatigue-related involvements in TIFA and the 1995 SafetyNet file. The solid line in Figure 3 is the TIFA distribution, repeated from Figures 1 and 2. The dashed line shows the SafetyNet distribution. The lines show the same overall pattern, but there are some differences. The early morning peak in SafetyNet is broader than in TIFA. Nearly 40% of the fatigue-related involvements in SafetyNet took place in the four-hour block between 3-7 A.M. The late afternoon peak observed in the TIFA data is not apparent in SafetyNet.

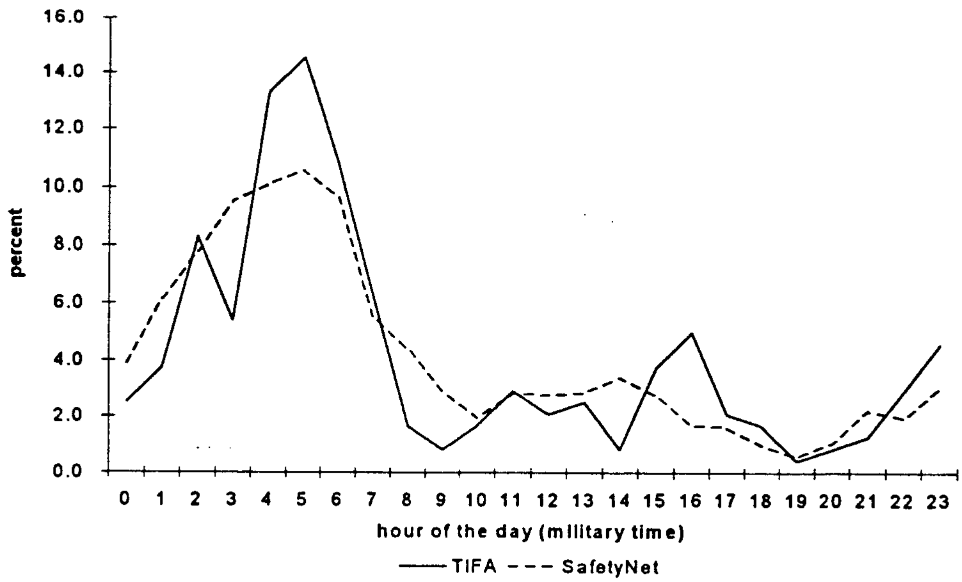

Figure 3
Distribution of Fatigue-Related Involvements
1991-1993 TIFA and 1995 SafetyNet

4.2 Fatigue-Related Involvements and Truck Characteristics

To see how fatigue-related involvements relate to possible definitions of short-haul trucks, fatigue-related involvements were examined with respect to GVWR class, trip distance, and vehicle type. Tables 12 and 13 show the vehicle type distribution of fatigue-related involvements in TIFA and SafetyNet, respectively. If the SafetyNet involvements are limited to those with known truck type, the tractor-trailer percentage is virtually identical to that in TIFA. SafetyNet has relatively fewer single-unit straight trucks and more straight trucks with trailers in fatigue-related involvements than TIFA. Comparing Table 7 with Table 12 indicates that straight trucks are under-represented and tractors over-represented in fatigue-related fatal involvements compared with fatal involvements overall.

Table 12
Fatigue-Related Fatal Involvements
by Vehicle Type
1991-1993 TIFA

Vehicle Type	Number	Percent
S-U straight	39	16.2
Straight+trailer	7	2.9
Tractor-trailer	195	80.9
Total	241	100.0

Table 13
Fatigue-Related Involvements by Vehicle Type
1995 SafetyNet

Vehicle Type	Number	Percent
S-U straight	142	11.5
Straight+trailer	81	6.5
Tractor-trailer	948	76.6
Bus	15	1.2
Unknown truck	38	3.1
Missing data	13	1.1
Total	1,237	100.0

Table 14 looks at driver fatigue status in TIFA for different levels of GVWR class, trip distance, and vehicle type. As the table shows, the proportion of fatigued drivers in fatal involvements did not vary according to GVWR class. There was a great difference in fatigue according to trip distance. Only 0.4% of drivers making trips of 50 miles or less were coded fatigued, compared with 3.0% of drivers making longer trips. Fatigue showed some variation according to vehicle type. Only 1.2% of single-unit straight truck drivers were coded fatigued, 1.4% of drivers of straight trucks with trailers, and 2.2% of tractor drivers.

Table 14
Fatigue-Related Fatal Involvements
1991-1993 TIFA

	Driver Fatigued?			Driver Fatigued?		
GVWR	Yes	No	Total	Yes	No	Total
Class 3-6	29	1,438	1,467	2.0	98.0	100.0
Class 7-8	208	10,785	10,993	1.9	98.1	100.0
Unknown	4	260	264	1.5	98.5	100.0
Total	241	12,483	12,724	1.9	98.1	100.0
Trip	Driver Fatigued?			Driver Fatigued?		
Distance	Yes	No	Total	Yes	No	Total
≤ 50 miles	20	4,878	4,898	0.4	99.6	100.0
> 50 miles	215	6,855	7,070	3.0	97.0	100.0
Unknown	6	750	756	0.8	99.2	100.0
Total	241	12,483	12,724	1.9	98.1	100.0
Vehicle	Driver Fatigued?			Driver Fatigued?		
Type	Yes	No	Total	Yes	No	Total
S-U straight	39	3,271	3,310	1.2	98.8	100.0
Straight+trailer	7	481	488	1.4	98.6	100.0
Tractor-trailer	195	8,495	8,690	2.2	97.8	100.0
Unknown	0	236	236	0.0	100.0	100.0
Total	241	12,483	12,724	1.9	98.1	100.0

In order to add a time of day dimension to the prevalence of fatigue according to GVWR class, trip distance, and vehicle type, the TIFA cases were split into two time blocks. Daytime was defined as 6 A.M. to 9 P.M. and nighttime as 9 P.M. to 6 A.M. Table 15 shows the percent of fatal involvements in each time period that involved a fatigued truck driver. Overall, fatigue was nearly four times more likely to be coded at night than during the day. Interestingly, local service trucks had a very low percentage of fatigue-related involvements both during the day and at night. Their nighttime percentage was just 1.1%, much lower than any other category of truck that was examined.

Table 15
Percentage of Fatigue-Related Fatal Involvements
by Time of Day
1991-1993 TIFA

	Time of Day		
Truck Type	6am -9pm	9pm -6am	All
Class 3-6	1.6	4.4	2.0
Class 7-8	1.0	4.2	1.9
≤ 50 miles	0.3	1.1	0.4
> 50 miles	1.9	5.2	3.0
S-U straight	0.9	3.1	1.2
Straight+trailer	1.0	4.2	1.4
Tractor-trailer	1.3	4.4	2.2
All	1.1	4.2	1.9

In interpreting Table 15, one should keep in mind that the overall number of fatal involvements coded fatigue-related is very small. This number totaled just 241 involvements over the three years of data, an average of 80 per year. There were 104 fatigue-related fatal involvements during the daytime and 136 at night. The true number of fatigue-related involvements could well be higher, since fatigue is probably under-reported on the typical PAR.

It is interesting to compare the profile of fatigue-related involvements in TIFA with results from the Federal Highway Administration's landmark driver fatigue and alertness study (Wylie et al., 1996). The FHWA study concluded that the time of day of driving was the most significant factor affecting driver fatigue and alertness, of the factors that were studied. Peak drowsiness in drivers was found to occur during the eight hours from late evening until dawn. This result corresponds well with TIFA data, which show nighttime involvements much more likely to be coded fatigue-related than daytime involvements. The FHWA study also concluded that number of hours driving was not a good predictor of observed fatigue in drivers. The TIFA data indicate that drivers on trips of over 50 miles were much more likely to be coded fatigued than drivers on shorter trips. This was true both during the day and at night. The likely explanation is that the FHWA study was only able to compare differences between drivers on 10-hour versus 13-hour trips, both during the daytime. The drivers were making over-the-road, inter-city trips, in the first case driving 250 miles each way, and in the second case 331 miles each way. Drivers making local trips were not studied.

4.3 Fatigue-Related Fatal Involvement Rates

It would be informative to generate fatigue-related fatal involvement rates cross-classified by GVWR class, area of operation, and vehicle type as was done for overall fatal involvement rates in Tables 10 and 11. This has been done in Tables 16 and 17, but the resulting rates are probably of very limited value. As stressed above, only 241 fatal involvements were coded fatigue-related out of three years of TIFA data. Very small sample sizes result when these involvements are split across the cells in Tables 16 and 17. To emphasize this, the actual number of cases in the numerators are shown in parentheses for each cell in Tables 16 and 17. (The numbers in parentheses are three-year totals; these were first divided by 3 to arrive at the annual rates shown in the tables.) Another difficulty is that fatigue status is not considered in the denominators of the rates. For example, miles traveled are not limited to those miles where the driver was in fact fatigued, but are instead the total number of miles used in Tables 10 and 11. The rates in Tables 16 and 17 exclude cases in TIFA and TIUS with unknown values on GVWR class, vehicle type, or type of service.

That said, a few interesting patterns emerge from Tables 16 and 17. When fatigue-related fatal involvement rates are calculated per truck, class 7-8 tractors in over-the-road service have the highest rates. This group also has the highest rate per mile, except for class 3-6 straight trucks with trailers in over-the-road service, but the latter rate is based on only 4 involvements. Table 17 shows that class 7-8 tractors have higher fatigue-related fatal involvement rates than class 3-6 single-unit straight trucks, whether the trucks are in local service or over-the-road service, and whether the rates are calculated per truck or per mile.

Table 16
Large Truck Fatigue-Related Fatal Involvement Rates
Repetitions According to GVWR Class
1991-1993 TIFA/1992 TIUS

Fatigue-Related Fatal Involvements per 1000 Registered Trucks
Class 3-6 Only

Type of Service	Vehicle Type: S-U straight		Straight+trailer		Tractor-trailer		Total	
Local	(9)	0.0022	(0)	0.0000	(1)	0.0060	(10)	0.0022
OTR	(15)	0.0127	(4)	0.0424	(0)	0.0000	(19)	0.0131
Total	(24)	0.0046	(4)	0.0099	(1)	0.0030	(29)	0.0049

Fatigue-Related Fatal Involvements per 1000 Registered Trucks
Class 7-8 Only

Type of Service	Vehicle Type: S-U straight		Straight+trailer		Tractor-trailer		Total	
Local	(1)	0.0007	(1)	0.0085	(7)	0.0100	(9)	0.0041
OTR	(10)	0.0262	(2)	0.0235	(181)	0.0781	(193)	0.0693
Total	(11)	0.0062	(3)	0.0148	(188)	0.0623	(202)	0.0404

Fatigue-Related Fatal Involvements per 100 Million Miles
Class 3-6 Only

Type of Service	Vehicle Type: S-U straight		Straight+trailer		Tractor-trailer		Total	
Local	(9)	0.0246	(0)	0.0000	(1)	0.0272	(10)	0.0234
OTR	(15)	0.0597	(4)	0.2329	(0)	0.0000	(19)	0.0545
Total	(24)	0.0389	(4)	0.0925	(1)	0.0086	(29)	0.0373

Fatigue-Related Fatal Involvements per 100 Million Miles
Class 7-8 Only

Type of Service	Vehicle Type: S-U straight		Straight+trailer		Tractor-trailer		Total	
Local	(1)	0.0052	(1)	0.0438	(7)	0.0334	(9)	0.0212
OTR	(10)	0.0930	(2)	0.0528	(181)	0.1038	(193)	0.1022
Total	(11)	0.0368	(3)	0.0494	(188)	0.0962	(202)	0.0873

Table 17
Large Truck Fatigue-Related Fatal Involvement Rates
Repetitions According to Area of Operation
1991-1993 TIFA/1992 TIUS

Fatal Involvements per 1000 Registered Trucks
Local Service Only

GVWR	S-U straight		Straight+trailer		Tractor-trailer		Total	
Class 3-6	(9)	0.0022	(0)	0.0000	(1)	0.0060	(10)	0.0022
Class 7-8	(1)	0.0007	(1)	0.0085	(7)	0.0100	(9)	0.0041
Total	(10)	0.0018	(1)	0.0023	(8)	0.0092	(19)	0.0028

Fatal Involvements per 1000 Registered Trucks
Over-the-Road Only

GVWR	S-U straight		Straight+trailer		Tractor-trailer		Total	
Class 3-6	(15)	0.0127	(4)	0.0424	(0)	0.0000	(19)	0.0131
Class 7-8	(10)	0.0262	(2)	0.0235	(181)	0.0781	(193)	0.0693
Total	(25)	0.0160	(6)	0.0334	(181)	0.0728	(212)	0.0501

Fatal Involvements per 100 Million Miles
Local Service Only

GVWR	S-U straight		Straight+trailer		Tractor-trailer		Total	
Class 3-6	(9)	0.0246	(0)	0.0000	(1)	0.0272	(10)	0.0234
Class 7-8	(1)	0.0052	(1)	0.0438	(7)	0.0334	(9)	0.0212
Total	(10)	0.0180	(1)	0.0204	(8)	0.0324	(19)	0.0223

Fatal Involvements per 100 Million Miles
Over-the-Road Only

GVWR	S-U straight		Straight+trailer		Tractor-trailer		Total	
Class 3-6	(15)	0.0597	(4)	0.2329	(0)	0.0000	(19)	0.0545
Class 7-8	(10)	0.0930	(2)	0.0528	(181)	0.1038	(193)	0.1022
Total	(25)	0.0697	(6)	0.1090	(181)	0.0992	(212)	0.0947

5 FATAL INVOLVEMENTS BY ROAD CLASS, LAND USE, AND COLLISION TYPE

This section will consider fatal truck crashes in terms of road class and land use (rural/urban) and also in terms of collision type. Different kinds of trucks travel in different operating environments. Some environments are safer than others. For example, Interstates are generally the safest class of road, mile for mile. In addition, operating environment may influence driver fatigue, whether it be a long stretch of open highway inducing boredom or busy urban streets raising the level of driver stress. It would be ideal to have mileage distributions across the different operating environments for various types of trucks, but TIUS does not collect this data. Still, tabulations of fatal involvements from the TIFA file can suggest differences in operating environment among truck types.

5.1 Road Class/Land Use Distributions

The FARS variables describing the road class and land use where the crash took place are included as part of the TIFA file. These variables were combined to create six levels that describe the crash environment. Three classes of road were defined: 1) limited access - Interstate highways and other freeways and expressways; 2) major arterials - primarily US and State highways; and 3) other roads - all other road classes, including county roads and local streets. Land use was simply split into rural and urban areas, following the FHWA classification. The three road types and two land use categories create six categories of crash environment, abbreviated in Figures 4-6 as lim/urb, lim/rur, maj/urb, maj/rur, oth/urb and oth/rur. Cases with unknown values on road class or land use were excluded from the distributions in the figures.

Figure 4 shows the distribution of road class/land use for fatal truck involvements separately for class 3-6 and class 7-8 trucks. Heavy-duty trucks had a higher share of involvements on limited access roads than did medium-duty trucks, 28% to 18%, and a lower share on other roads, 16% to 33%. The most common road class/land use category for both classes of trucks was major arteries in rural areas, accounting for 36% of class 3-6 involvements and 46% of class 7-8 involvements. Heavy trucks experienced relatively more fatal involvements in rural areas compared with medium trucks. Rural areas accounted for 69% of the involvements for heavy trucks and 58% for medium trucks.

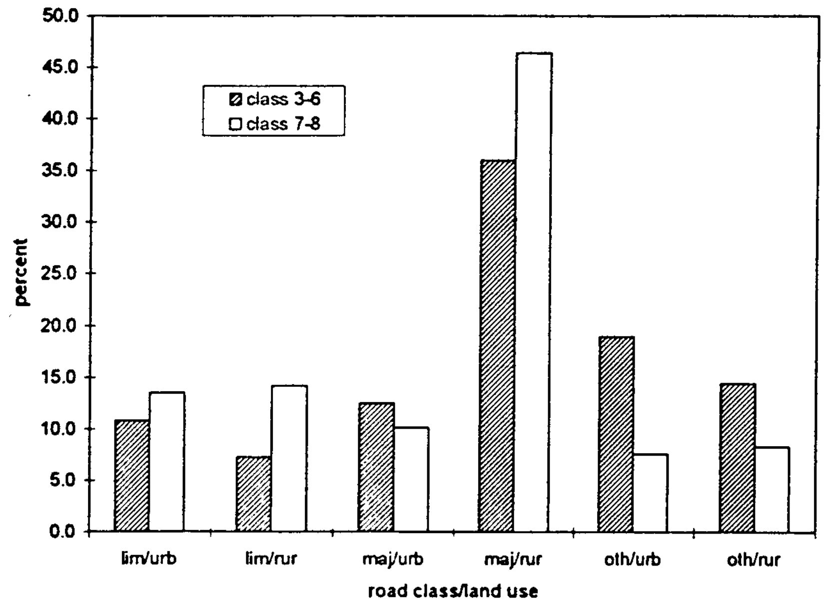

Figure 4
Road Class/Land Use Distribution of Fatal Involvements
According to GVWR Class
1991-1993 TIFA

Figure 5 shows the road class/land use distributions for trucks making local versus over-the-road trips. The differences in the distributions are not surprising. For example, 21% of the involvements of trucks on trips over 50 miles took place on rural limited access roads, compared with only 3% of the trucks on shorter trips. Limited access roads comprised 35% of the involvements for trucks on over-the-road trips and 15% for trucks on local trips. At the other end of the road class scale, other roads accounted for just 9% of the involvements for trucks on over-the-road trips and 31% for trucks making local trips. Relatively more involvements of trucks on over-the-road trips took place in rural areas (73%) than involvements of trucks on local trips (60%).

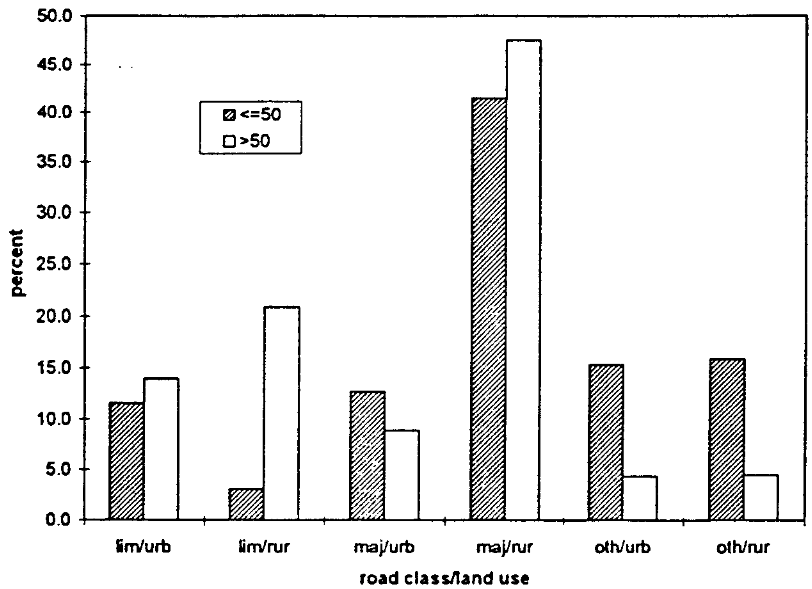

Figure 5
Road Class/Land Use Distribution of Fatal Involvements
According to Trip Distance
1991-1993 TIFA

Figure 6 depicts the road class/land use distributions for each of three vehicle types. The three truck configurations show little difference in the percentage of fatal involvements on major arteries, although single-unit straight trucks had relatively more involvements on urban major arteries compared with straight trucks with trailers or tractors. There are large differences among the truck types in terms of involvements on limited access roads and other roads. Limited access road involvements accounted for 16% of the fatal involvements of single-unit straight trucks, 20% of the involvements of straight trucks with trailers, and 31% of tractor involvements. Conversely, other roads made up 33% of the single-unit straight truck involvements, 27% of the involvements of straight trucks with trailers, and 12% of the tractor involvements. Interestingly, the rural/urban split is identical for straight trucks with trailers and tractors at 70% rural, 30% urban. Single-unit straight trucks had 60% of their fatal involvements in rural areas and 40% in urban areas.

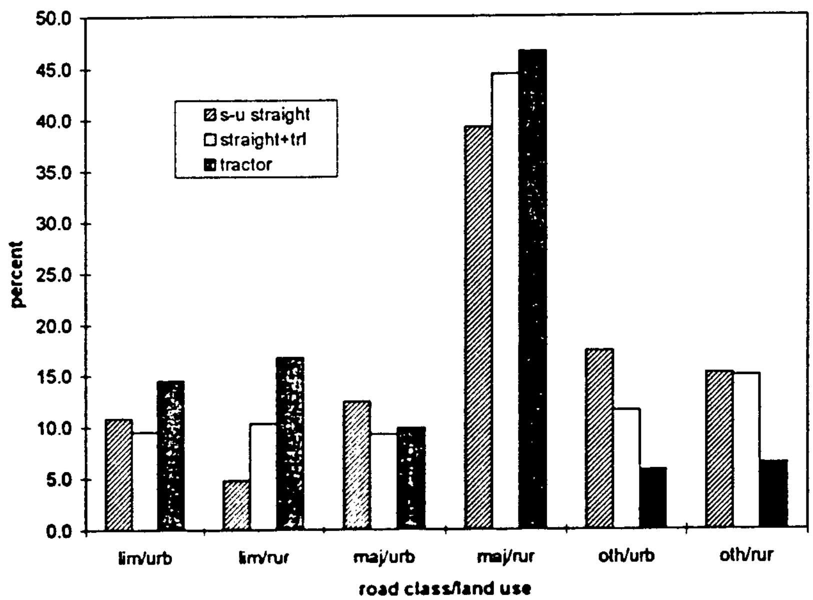

Figure 6
Road Class/Land Use Distribution of Fatal Involvements by Vehicle Type
1991-1993 TIFA

5.2 Collision Type Distributions

Truck fatal involvements from the TIFA file were also categorized according to type of collision. Single-vehicle collisions were grouped according to the FARS First Harmful Event variable as either rollover, striking a pedestrian or bicyclist, striking a fixed object, or some other type of single-vehicle crash, including fire/explosion, immersion, or colliding with a train or parked vehicle. The FARS Manner of Collision variable was used to split collisions involving another motorized vehicle into rear-end, head-on, angle, or some other type of multi-vehicle crash, such as sideswipe or rear-to-rear.

Figure 7 shows the collision type distribution for involvements of GVWR class 3-6 trucks and Figure 8 does the same for class 7-8 trucks. The main difference is that medium-duty trucks had relatively more single-vehicle collisions and relatively fewer rear-end collisions than heavy-duty trucks. Pedestrian/bicyclist collisions accounted for 11% of medium truck involvements compared with just 8% of heavy truck involvements. These differences are likely related to operating environment. With more urban driving, class 3-6 trucks are exposed more to pedestrians and other non-motorists. Class 7-8 trucks log relatively more miles on limited access roads, where rear-end collisions are one of the more likely collision configurations to occur.

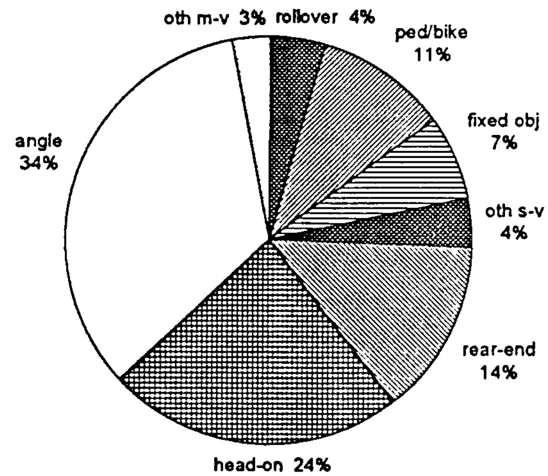

Figure 7
Collision Type Distribution
Class 3-6 Trucks Only
1991-1993 TIFA

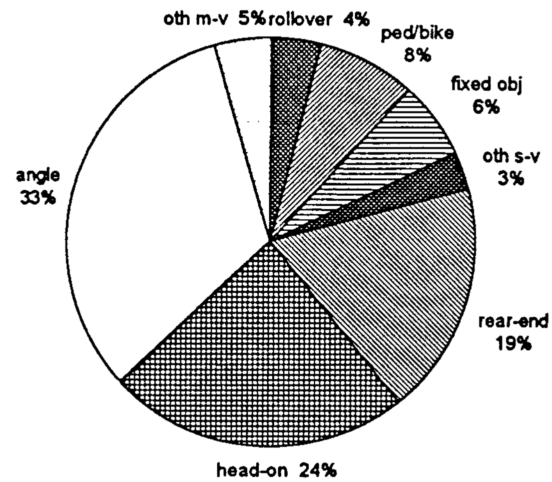

Figure 8
Collision Type Distribution
Class 7-8 Trucks Only
1991-1993 TIFA

Figures 9 and 10 contrast collision type distributions between trucks on local versus over-the-road trips at the time of the fatal crash. Major differences are seen in the percentages of rear-end and angle collisions between the two groups. Rear-end crashes accounted for 14% of the involvements of trucks on local trips and 20% for trucks on trips over 50 miles. Angle collisions comprised 38% of the involvements of trucks on local trips and 29% for trucks on over-the-road trips. Again the relation of the distributions to operating environments is apparent. For example, the trucks making trips of 50 miles or less operate relatively more in urban areas and on local streets, thus receiving more exposure to intersections. This shows up in their much higher percentage of angle collisions compared with trucks on over-the-road trips.

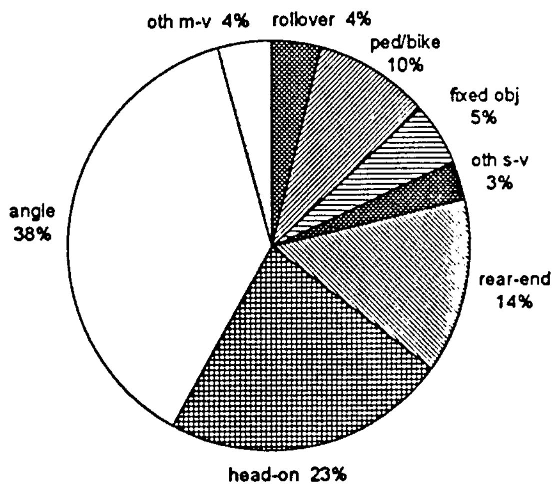

Figure 9
Collision Type Distribution
Trucks with Trip Distance ≤ 50 Miles Only
1991-1993 TIFA

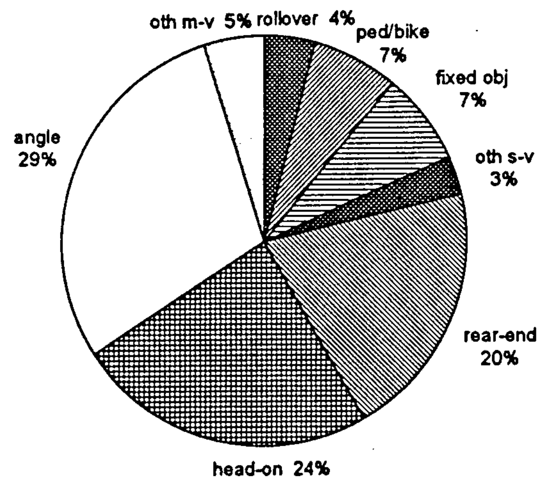

Figure 10
Collision Type Distribution
Trucks with Trip Distance > 50 Miles Only
1991-1993 TIFA

Collision type distributions for single-unit straight trucks, straight trucks with trailers, and tractors are shown in Figures 11, 12, and 13, respectively. The three distributions show minor differences. Rear-end collisions account for 15% of the involvements of both types of straight trucks and 19% of tractor involvements. Head-on collisions represent 23% of the fatal involvements of single-unit straight trucks and of tractors but 27% of the involvements of straight trucks with trailers. Angle collisions comprise 36% of the single-unit straight truck involvements, 33% for straight trucks with trailers, and 31% of the tractor involvements.

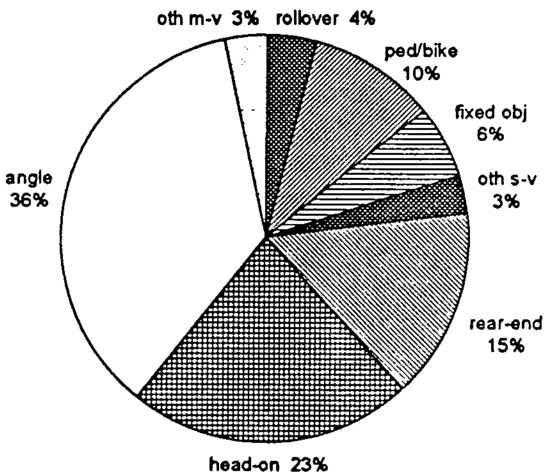

Figure 11
Collision Type Distribution
Single-Unit Straight Trucks Only
1991-1993 TIFA

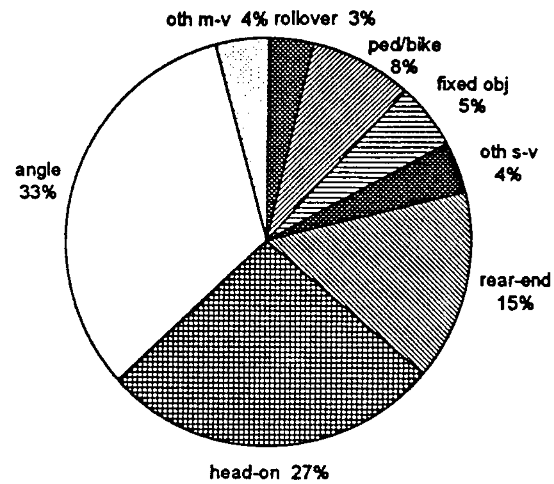

Figure 12
Collision Type Distribution
Straight Trucks with Trailers Only
1991-1993 TIFA

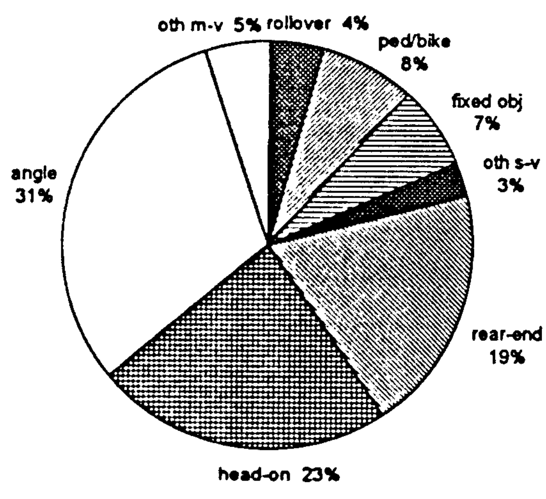

Figure 13
Collision Type Distribution
Tractors Only
1991-1993 TIFA

Finally, Table 18 compares collision type distributions for drivers who were and were not considered fatigued at the time of the fatal crash. As noted earlier, fatigue-related fatal involvements were much more likely to be single-vehicle collisions than were involvements where the truck driver was not coded fatigued. This is readily apparent in Table 18, which shows greatly higher percentages of rollover and fixed object collisions for fatigued truck drivers. Correspondingly, the fatigued drivers have much lower percentages of all the multi-vehicle collision types than do the non-fatigued drivers. However, given that a multi-vehicle collision occurred, fatigued drivers had a much higher percentage of rear-end collisions and a much lower percentage of angle collisions than non-fatigued drivers.

Table 18
Collision Type by Driver Fatigue Status
1991-1993 TIFA

	Driver Fatigued?			Driver Fatigued?		
Collision Type	Yes	No	Total	Yes	No	Total
Rollover	49	459	508	20.3	3.7	4.0
Ped/bike	3	1,038	1,041	1.2	8.3	8.2
Fixed object	104	698	802	43.2	5.6	6.3
Other S-V	23	354	377	9.5	2.8	3.0
Rear-end	35	2,248	2,283	14.5	18.0	17.9
Head-on	20	2,976	2,996	8.3	23.8	23.5
Angle	6	4,117	4,123	2.5	33.0	32.4
Other M-V	1	555	556	0.4	4.4	4.4
Unknown	0	38	38	0.0	0.3	0.3
Total	241	12,483	12,724	100.0	100.0	100.0

6 SUMMARY

- The short-haul segment of the trucking industry may be defined in different ways. One option is to use the most restricted definition of short-haul that is possible in the data files. That definition would be class 3-6 single-unit straight trucks in local service. This definition accounts for:

  34.7% of the large truck population
  11.8% of large truck mileage
  7.2% of large truck fatal involvements
  3.7% of large truck fatigue-related fatal involvements (9/241)
  This group annually experiences 0.0022 fatigue-related fatal involvements per 1,000 vehicles.

- For purposes of comparison, the most restricted definition of trucks in long-haul operations would be class 7-8 tractors in over-the-road service. These vehicles are the "opposite" of the trucks described under the first bullet. Long-haul trucks defined in this manner comprise:

19.9% of the large truck population
56.4% of large truck mileage
48.8% of large truck fatal involvements
75.1% of large truck fatigue-related fatal involvements (181/241)
This group annually experiences 0.0781 fatigue-related fatal involvements per 1,000 vehicles.

- An alternative definition of short-haul trucks would be class 3-6 single-unit straight trucks. These account for:

  48.3% of the large truck population
  20.0% of large truck mileage
  9.6% of large truck fatal involvements
  10.0% of large truck fatigue-related fatal involvements (24/241)
  This group annually experiences 0.0043 fatigue-related fatal involvements per 1,000 vehicles.

- Another alternative definition is simply trucks in local service. These account for:

  57.9% of the large truck population
  27.6% of large truck mileage
  38.5% of large truck fatal involvements
  8.3% of large truck fatigue-related fatal involvements (20/241)
  This group annually experiences 0.0030 fatigue-related fatal involvements per 1,000 vehicles.

- Class 3-6 single-unit straight trucks comprise:

  59.9% of the local service truck population
  42.9% of local service truck mileage
  18.8% of local service truck fatal involvements
  45.0% of local service truck fatigue-related fatal involvements (9/20)

- One important measure of truck safety is the fatal involvement rate *per vehicle*. This varies according to how short-haul trucks are defined:

  Class 3-6 single-unit straight trucks in local service: 0.23 fatal involvements per thousand trucks per year. This rate is lower than all other categories of trucks except class 3-6 single-unit straight trucks in over-the-road service (the rates are virtually identical) and both local and over-the-road class 3-6 tractors.

  Class 3-6 single-unit straight trucks: 0.22 fatal involvements per thousand trucks per year. This is a lower fatal rate per vehicle than all other categories of trucks except class 3-6 tractors.

  Local service trucks: 0.71 fatal involvements per thousand trucks per year. Local service trucks have lower fatal rates per vehicle than over-the-road trucks overall (1.66 involvements per thousand trucks). This rate difference is primarily found within class 7-8 trucks. Within class 3-6 trucks, the rates for local service and over-the-road trucks are about the same.

- Another important measure of truck safety is the fatal involvement rate *per mile*. This rate also varies with the definition of short-haul trucks:

  Class 3-6 single-unit straight trucks in local service: 2.52 fatal involvements per 100 million miles. This rate is lower than all other categories of trucks except class 3-6 single-unit straight trucks in over-the-road service and both local and over-the-road class 3-6 tractors.

  Class 3-6 single-unit straight trucks: 1.88 fatal involvements per 100 million miles. This is a lower fatal rate per mile than all other categories of trucks except class 3-6 tractors.

  Local service trucks: 5.63 fatal involvements per 100 million miles. This is a higher fatal rate than over-the-road trucks overall, with a rate of 3.14. Local service trucks also have higher mileage-based rates than over-the-road trucks within categories of vehicle type (single-unit straight, straight+trailer, and tractor), and within categories of GVWR (class 3-6, class 7-8).

- The prevalence of driver fatigue in fatal involvements shows no variation according to GVWR class and some according to vehicle type (higher percentage for tractors than straight trucks). The most variation is seen for trip distance. Driver fatigue is coded for 0.4% of trucks on trips of 50 miles or less compared with 3.0% of trucks on longer trips.

- Fatigue-related fatal involvement rates per 1,000 vehicles vary tremendously in terms of these three factors, although these rates are generated from a small number of fatigue-related fatal involvements. Class 7-8 trucks have a fatigue-related fatal involvement rate 8 times higher than class 3-6 trucks; over-the-road trucks have a rate 18 times higher than local service trucks; and the rate for tractors exceeds the rate for single-unit straight trucks by a factor of 11.

- The distribution of fatal involvements across different environments varies among truck types. Class 7-8 trucks, over-the-road trucks, and tractors all have a greater share of their fatal involvements on limited access roads and in rural areas, compared with class 3-6 trucks, local service trucks, and single-unit straight trucks, respectively. Crash location should be considered when addressing the driver fatigue issue.

- The collision type distribution of fatal involvements also varies among truck types, although the differences are fairly subtle. Tremendous differences in the distribution of collision type is seen between the involvements of fatigued and non-fatigued truck drivers, with the fatigued drivers having exceptionally high percentages of rollover and fixed object collisions.

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Acronyms

CNTS - Center for National Truck Statistics

FARS - Fatality Analysis Reporting System

FHWA - Federal Highway Administration

GVWR - gross vehicle weight rating

ISTEA - Intermodal Surface Transportation Efficiency Act

NGA - National Governor's Association

NHTSA - National Highway Traffic Safety Administration

OMC - Office of Motor Carriers

OTR - over-the-road

PAR - police accident report

TIFA - Trucks Involved in Fatal Accidents

TIUS - Truck Inventory and Use Survey

UMTRI - University of Michigan Transportation Research Institute

VIN - Vehicle Identification Number