U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

DOT HS 809 569 June 2003

Technical Report

An Analysis of Fatal Large Truck Crashes

Published by:

National Center for Statistics and Analysis
Advanced Research and Analysis

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1. Report No. DOT HS 809 569	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle An Analysis of Fatal Large Truck Crashes		5. Report Date March 2003
		6. Performing Organization Code NPO-121
7. Author(s) Ramal Moonesinghe, Anders Longthorne, Umesh Shankar, Santohk Singh, Rajesh Subramanian, and Joseph Tessmer		8. Performing Organization Report No.
9. Performing Organization Name and Address Mathematical Analysis Division, National Center for Statistics and Analysis National Highway Traffic Safety Administration U.S. Department of Transportation NRD-31, 400 Seventh Street, S.W. Washington, D.C. 20590		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Mathematical Analysis Division, National Center for Statistics and Analysis National Highway Traffic Safety Administration U.S. Department of Transportation NRD-31, 400 Seventh Street, S.W. Washington, D.C. 20590		13. Type of Report and Period Covered NHTSA Technical Report
		14. Sponsoring Agency Code
15. Supplementary Notes		

Abstract

The objective of this study by the National Center for Statistics and Analysis (NCSA) was to examine the characteristics of large truck fatal crashes. Fatal crashes involving single-unit trucks and combination trucks were studied. Two-vehicle crashes consisting of a large truck and one other vehicle were examined for vehicle-related factors and driver-related factors. Using data from the Fatality Analysis Reporting System (FARS) 1996-2000 and from the University of Michigan Transportation Research Institute's Trucks Involved in Fatal Accidents Survey (TIFA), characteristics of large truck crashes, including rollovers and jackknifes were analyzed.

17. Key Words rollover, jackknife, single-unit trucks, combination trucks, large trucks, fatalities, logistic regression, trends	18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, VA 22161 http//:www.ntis.gov		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 41	22. Price

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EXECUTIVE SUMMARY

In 2000, there were 4,930[1] large trucks involved in fatal crashes, 101,000 large trucks involved in injury crashes, and 351,000 large trucks involved in property damage-only crashes for a total of 457,000 large trucks involved in crashes. Large trucks are defined as trucks with a gross vehicle weight of at least 10,000 pounds.

Since the late 1970s, approximately 12 to 13 percent of all traffic-related fatal crashes were the result of a crash involving a large truck; see Figure 6, pg. 6.

Large truck fatalities are classified as occupant fatalities in single-vehicle crashes or multiple-vehicle crashes and non–occupant fatalities. Single-vehicle fatalities, multiple-vehicle fatalities, and non-occupant fatalities in combination truck crashes account for 7 percent, 63 percent and 6 percent, respectively, of all large truck fatalities. By comparison, the portion of all large truck fatalities associated with single-unit trucks are 2 percent, 20 percent, and 2 percent for single-vehicle, multiple-vehicle and non-occupant fatalities, respectively; see Table 2 pg. 7.

Just over half of all large truck fatalities occur on non-divided 2-lane roadways, that is, conventional 2-lane roads with one lane in each direction; see Table 7b pg. 13.

Analysis of geometrical data was used to analyze two-vehicle crashes involving a large truck. The data suggest that for some types of crashes, the driver of the other vehicle may have contributed more to the crash than did the driver of the large truck; see Tables 15a and 15b pgs. 26-27.

A speed limit of 55 mph or higher, poor weather, and a curved road significantly increase the odds of both a rollover and a jackknife for large trucks. As the weight of the large truck and its cargo increases, the odds of a rollover increase, but the odds of a jackknife decrease. Conversely, as the length of a large truck increases, the odds of a rollover decrease, but the odds of a jackknife increase; see Tables 27, 28, and 29, pgs.39-40.

1 As Reported in Traffic Safety Facts 2000

1. INTRODUCTION

Crashes involving large trucks are a serious traffic safety problem. In 2000, there were 4,930 large trucks involved in fatal crashes, 101,000 large trucks involved in injury crashes, and 351,000 large trucks involved in property damage-only crashes for a total of 457,000 large trucks involved in all crashes. Large trucks are defined as trucks with a gross vehicle weight of at least 10,000 pounds.

Large trucks are partitioned into two main subsets, single-unit trucks and combination trucks. A single-unit truck (SUT) is a truck without a trailer. A common example of a single-unit truck is the familiar United Parcel Service (UPS) truck. A combination truck is a truck that tows another vehicle, such as tractor trailers. By convention, a tractor by itself, often called a "bobtail", is considered a combination truck. In addition, if a single-unit truck tows another vehicle, it is a combination truck.

The Fatality Analysis Reporting System (FARS) and the Trucks Involved in Fatal Accidents survey (TIFA) were the sources of data for this analysis. FARS consists of a census of all fatal crashes that occurred on a public roadway, and is not a representative sample of all crashes on US roadways. Fatalities are included in FARS if they occur within 30 days of the crash to which they are associated.

The TIFA survey is conducted by the Center for National Truck Statistics at the University of Michigan Transportation Research Institute. The file contains a random sample of large trucks, specifically straight trucks without trailers and tractor trailers (as recorded in FARS), that were involved in a fatal crash within the United States. TIFA data collection is augmented through telephone interviews with individuals who have knowledge of the truck at the time of the crash. Interviews are typically carried out with the driver, owner, safety director of the carrier operating the truck, the reporting police officer, and other involved parties. The combination of the FARS records and the additional data collected by these telephone interviews forms the TIFA file. The most recent TIFA data are from 1999.

TIFA also includes geometrical information, which can be used to classify two-vehicle crashes between a large truck and a passenger vehicle. These classified crashes help to determine which vehicle contributed more to the crash. For example, there were 1,696 fatalities in head-on crashes involving a large combination truck and a passenger vehicle where the passenger vehicle was in the combination truck's lane. There were only 177 fatalities in head-on crashes involving a large combination truck and a passenger vehicle where the combination truck was in the passenger vehicle's lane: see (Tables 15a and 15b) pgs. 26-27.

2. TRENDS

Since the inception of FARS in 1975, the number of large truck fatal involvements had a minimum value of 3,977 in 1975 and a maximum of 6,084 in 1979. In 2000 4,930 large trucks were involved in fatal crashes; see Figure 1 pg 4.

Since 1989, the number of large trucks involved in fatal crashes has ranged from 4,035 in 1992 to 4,984 in 1989. To gain additional insight, the raw data of Figure 1 are adjusted by the vehicle miles traveled, (VMT), Figure 2, pg 4 and number of registered vehicles, Figure 3, pg5. In both cases there is a general downward trend since 1979.

From Figures 2 and 3 one sees that the number of large trucks involved in fatal crashes when adjusted for VMT or registered vehicles has been declining since 1979. Over the past twenty years, many improvements have been made in traffic safety contributing to the observed reductions seen in Figures 2 and 3.

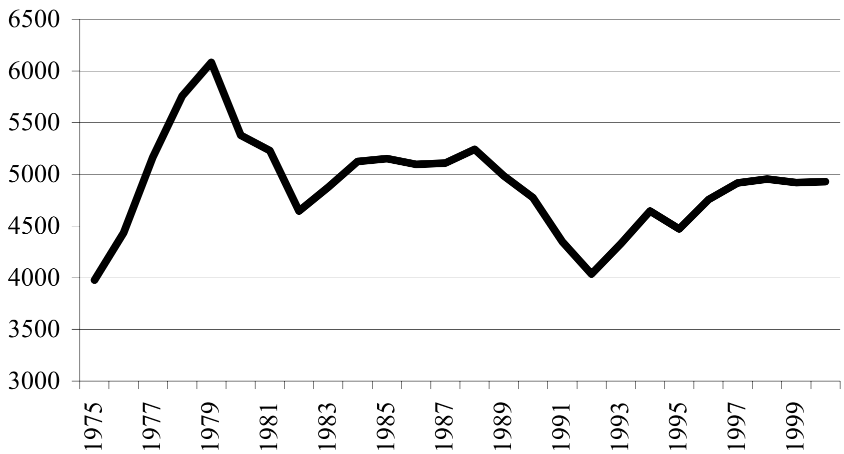
The data of Figures 2 and 3 also exist for passenger cars. The relative risk[2] of large truck fatal involvements compared to passenger cars appears in Figures 4 and 5 pgs 5 and 6.. When the data are adjusted by VMT, Figure 4, one sees that the relative risk of a crash involving a large truck compared to a passenger car is 1.20 to 1.55. In other words, large trucks are 20 percent to 55 percent more likely to be involved in a fatal crash than a passenger car. Note that between 1975 and 1985 the relative risk is generally above 1.4, but between 1986 and 2000 the relative risk is generally below 1.4.

When adjusting for the number of registered vehicles, one sees that the relative risk of a crash involving a large truck, compared to a passenger car, is two to three times as great.

Figure 6, pg 6, shows the percent of large truck fatal crashes as a percent of all fatal crashes. Since the late 1970s, approximately 12 to 13 percent of all traffic-related fatal crashes are the result of a crash involving a large truck. Figures 5 and 6 suggest that the decrease in fatalities associated with large trucks may be due to the overall improvement in highway safety.

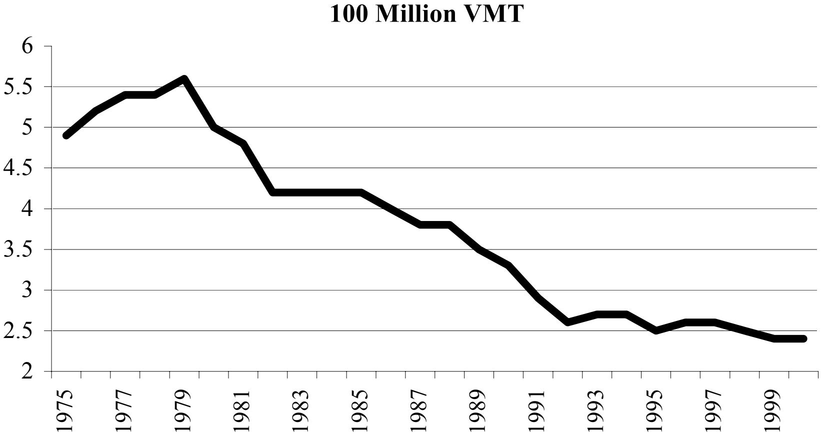
2 The relative risk is defined as ((number of large truck fatal involvements ÷ number of registered large trucks) ÷ (number of passenger car fatal involvements ÷ number of registered passenger cars)).

Figure 1. Large Truck Fatal Involvements



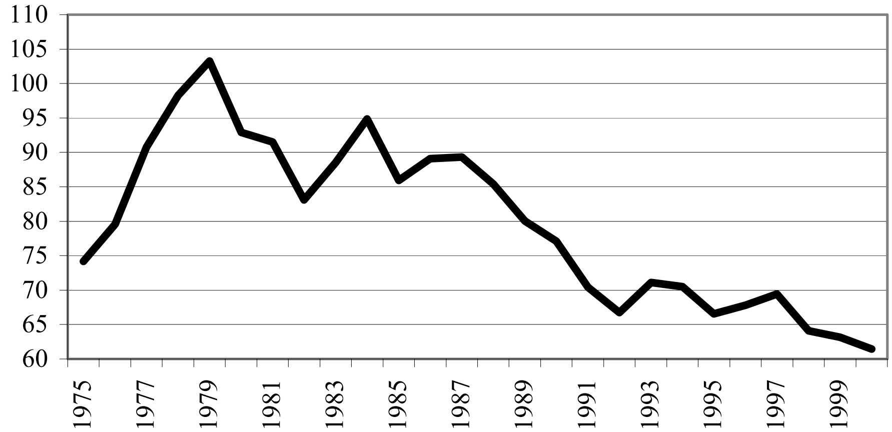
Source: **NHTSA, NCSA, FARS 1975-2000**

Figure 2. Large Truck Fatal Involvements Per 100 Million VMT



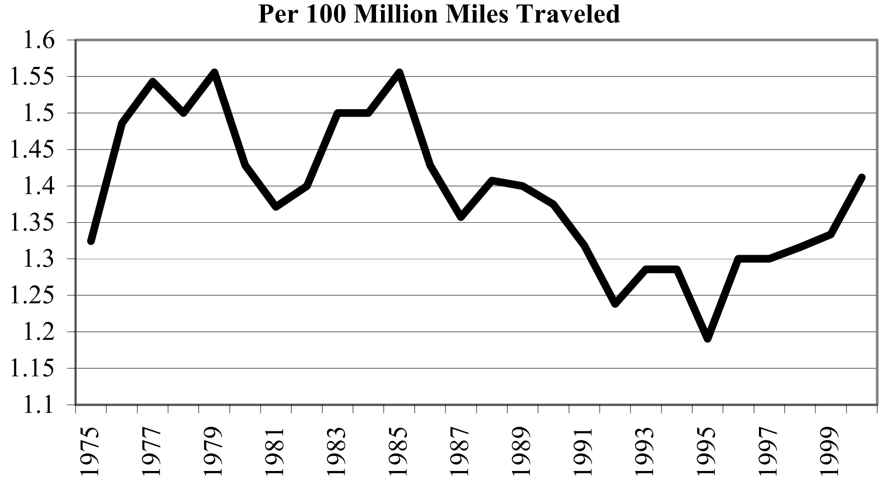
Source: **NHTSA, NCSA, FARS, and FHWA, VMT data 1975-2000**

Figure 3. Large Truck Fatal Involvements Per 100,000 Registered Vehicles



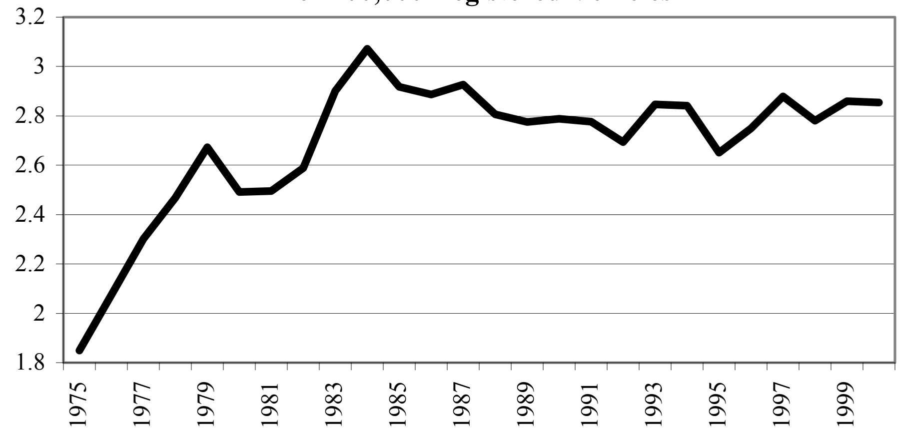
Source: **NHTSA, NCSA, FARS 1975-2000**

Figure 4. Relative Risk of Large Truck Fatal Involvement Compared to Passenger Cars Per 100 Million Miles Traveled



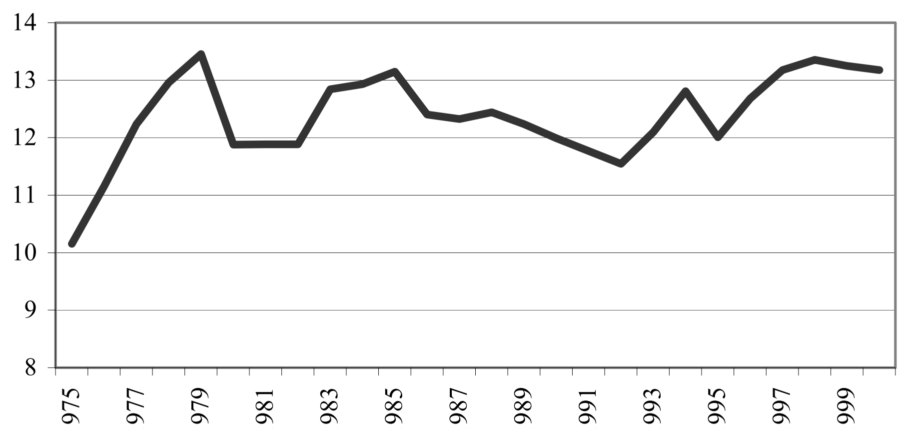
Source: **NHTSA, NCSA, FARS, and FHWA, VMT data 1975-2000**

Figure 5. Relative Risk of Large Truck Fatal Involvement Compared to Passenger Cars Per 100,000 Registered Vehicles



Source: **NHTSA, NCSA, FARS 1975-2000**

Figure 6. Large Truck Fatal Crashes as a Percent of All Fatal Crashes



Source: **NHTSA, NCSA, FARS 1975-2000**

3. CHARACTERISTICS OF LARGE TRUCK FATALITIES 1996-2000

The portion of large truck single-vehicle crashes to all large truck crashes is much smaller than the portion of single-vehicle crashes involving other vehicles. Over the five year period, 1996-2000, one out of six large truck crashes, 18 percent, is a single-vehicle crash, whereas 62 percent of crashes not involving a large truck are single-vehicle crashes.

Table 1
Fatal Crashes by Truck and Crash Types 1996-2000

	Crash Type				
Truck Type	Single Vehicle	Multiple Vehicle	Total	% Single Vehicle	% Multiple Vehicle
Large Truck Crashes	4,057	18,628	22,685	18%	82%
Non-Large Truck Crashes	100,747	63,042	163,789	62%	38%
Total	104,804	81,670	186,474	56%	44%

Source: NHTSA, NCSA, FARS

Fatalities due to large truck crashes may be partitioned into three distinct types: occupant fatalities of single-vehicle crashes, occupant fatalities of multiple-vehicle crashes, and non-occupant fatalities, i.e., a pedestrian or a cyclist is killed. In the remainder of this report, these crash fatalities will be referenced as Single-vehicle, Multiple-vehicle, and Non-Occupant fatalities. The distribution of large truck fatalities by this partition appears in Table 2. Approximately 90 percent (= 22,462/(22,462+2,460)) of occupant fatalities in large truck fatal crashes occur in multiple-vehicle crashes.

Table 2
Large Truck Fatalities by Truck Type and Fatality Type 1996-2000

	Fatality Type					
Truck Type	Single Vehicle	Multiple Vehicle	Non Occupant	% Single Vehicle	% Multiple Vehicle	% Non Occupant
Combination Trucks	1,790	17,066	1,431	7%	63%	6%
Single-unit Trucks	670	5,396	642	2%	20%	2%
Total	2,460	22,462	2,073	9%	83%	8%

Source: NHTSA, NCSA, FARS

The 1996-2000 FARS data for large trucks are partitioned by day of the week, Saturday-Sunday and Monday-Friday; see Table 3. Fatality type is partitioned into non-occupant fatalities and occupant fatalities. Most large truck crashes with a non-occupant fatality do not have any other type of fatality. Most large truck non-occupant fatalities are usually pedestrians or cyclists. Large truck crashes involving an occupant fatality have different characteristics than non-occupant fatality crashes. Occupant fatalities have been sup-partitioned into single-vehicle crashes and multiple-vehicle crashes due to the different characteristics of large truck single-vehicle crashes and multiple-vehicle crashes.

A smaller portion of large combination truck occupant fatalities occur from Monday to Friday (about 83 percent) than the portion of large single-unit truck fatalities (about 88 percent). The difference between large truck occupant fatalities and large truck non-occupant fatalities is consistent across truck types, i.e., combination trucks and single-unit trucks.

Table 3
Large Truck Fatalities by Truck Type, Occupant Type, and Period of Week 1996-2000

Combination Trucks-Combined Day of Week					
Fatality Type	Sat+Sun	Mon-Fri	Total	Sat+Sun(%)	Mon-Fri(%)
Occupant					
Single-vehicle	312	1,478	1,790	17%	83%
Multiple-vehicle	2,952	14,114	17,066	17%	83%
Total	3,264	15,592	18,856	17%	83%
Non-Occupant	248	1,183	1,431	17%	83%
Single-unit Trucks-Combined Day of Week					
Fatality Type	Sat+Sun	Mon-Fri	Total	Sat+Sun(%)	Mon-Fri(%)
Occupant					
Single-vehicle	90	580	670	11%	89%
Multiple-vehicle	651	4,745	5,396	12%	88%
Total	741	5,325	6,066	12%	88%
Non-Occupant	72	570	642	11%	89%

Source: NHTSA, NCSA, FARS

The adjusted daily fatality rate, is computed by dividing the Sat+Sun period column of Table 3, by 520 (=2 days of the week times 52 weeks per year times 5 years) and dividing the Mon-Fri period column, of Table 3, by 1,300 (= 5 days of the week times 52 weeks per year times 5 years). Table 4 is the result. The adjusted daily fatality rate for combination trucks is approximately twice as high for Mon-Fri period compared to the Sat+Sun period. For single-unit trucks, the Mon-Fri period adjusted daily fatality rate is almost three times as high as the Sat+Sun period rate.

Table 4
Large Truck Adjusted Daily Fatality Rate by Truck Type and Fatality Type 1996-2000

Combination Trucks		
Fatality Type	Sat+Sun	Mon-Fri
Occupant		
Single-vehicle	0.60	1.14
Multiple-vehicle	5.68	10.86
Total	6.28	11.99
Non-Occupant	0.48	0.91

Single-unit Trucks		
Fatality Type	Sat+Sun	Mon-Fri
Occupant		
Single-vehicle	0.17	0.45
Multiple-vehicle	1.25	3.65
Total	1.42	4.10
Non-Occupant	0.14	0.44

Source: NHTSA, NCSA, FARS

The "Day" partition is determined by the light condition and refers to daylight, dawn or dusk. The "Night" partition refers to night and night but lighted.

Single-unit trucks are more likely to have crashes during the day, by about 19 percent, than combination trucks. This is true for all crash groups; see Table 5.

Table 5
Large Truck Fatalities by Fatality Type and Day vs. Night
1996-2000

Combination Trucks-Day vs. Night					
Fatality Type	Day	Night	Total	Day(%)	Night(%)
Occupant					
Single-vehicle	1,000	790	1,790	56%	44%
Multiple-vehicle	11,097	5,969	17,066	65%	35%
Total	12,097	6,759	18,856	64%	36%
Non-Occupant	757	674	1,431	53%	47%

Single-unit Trucks-Day vs. Night					
Fatality Type	Day	Night	Total	Day(%)	Night(%)
Occupant					
Single-vehicle	473	169	642	81%	19%
Multiple-vehicle	4,479	917	5,396	83%	17%
Total	4,952	1,086	6,038	82%	18%
Non-Occupant	545	125	670	74%	26%

Source: NHTSA, NCSA, FARS

The FARS crash data are partitioned by crash location, rural and urban, using data provided by the Federal Highway Administration. Larger portions of combination truck fatalities occur in rural areas (71 percent) than single-unit truck fatalities (60 percent). The data show that approximately 3 out of 4 large truck single-vehicle occupant fatalities occur in rural areas, (79 percent for single-vehicle, combination truck fatalities and 74 percent for single-vehicle, single-unit truck fatalities). There is a shift away from rural crashes where non-occupants are concerned. Less than half of the non-occupant fatalities involving combination trucks, 45 percent, occur in rural areas. The rural non-occupant fatalities involving single-unit trucks drops to 26 percent.

Table 6
Large Truck Fatalities By Truck Type, Fatality Type, and Rural vs. Urban 1996-2000

Combination Trucks					
Fatality Type	Rural	Urban	Total	Rural(%)	Urban(%)
Occupant					
Single-vehicle	1,397	376	1,773	79%	21%
Multiple-vehicle	12,306	4,644	16,950	73%	27%
Total	13,703	5,020	18,723	73%	27%
Non-Occupant	633	789	1422	45%	55%
Grand Total	14,336	5,809	20,145	71%	29%
Single-unit Trucks					
Fatality Type	Rural	Urban	Total	Rural(%)	Urban(%)
Occupant					
Single-vehicle	491	178	669	74%	26%
Multiple-vehicle	3,314	2,035	5.349	62%	38%
Total	3,805	2,213	6,018	63%	37%
Non-Occupant	163	475	638	26%	74%
Grand Total	3,968	2,688	6,656	60%	40%

Source: NHTSA, NCSA, FARS

Almost half, 48 percent, of fatalities involving combination trucks occur on non-divided 2-lane trafficways[3], that is, conventional 2-lane roads with one lane in each direction.

Table 7a
Large Truck Fatalities by Truck Type, Fatality Type, Trafficway Division, and 2-Lane vs. Other 1996-2000

Combination Trucks							
Fatality Type	Division	2-Lane	Other	Total	2-Lane(%)	Other(%)	Total(%)
Occupant							
Single-vehicle	Not Divided	748	50	798	42%	3%	45%
	Divided	683	299	982	38%	17%	55%
Total		1,431	349	1,780	80%	20%	100%
Occupant							
Multiple-vehicle	Not Divided	8,464	1,017	9,481	50%	6%	56%
	Divided	4,592	2,889	7,481	27%	17%	44%
Total		13,056	3,906	16,962	77%	23%	100%
Non-Occupant							
	Not Divided	448	127	575	32%	9%	41%
	Divided	458	372	830	33%	26%	59%
Total		906	499	1,405	65%	35%	100%
Combination Trucks							
	Not Divided	**9,660**	**1,194**	**10,854**	**48%**	**6%**	**54%**
	Divided	**5,733**	**3,560**	**9,293**	**28%**	**18%**	**46%**
Total Combination Trucks		**15,393**	**4,754**	**20,147**	**76%**	**24%**	**100%**

Source: NHTSA, NCSA, FARS

3 Roadways are defined as a continuous cross section of pavement but do ***not*** include the shoulders. Trafficways are from right-of-way to right-of-way and may have one or more roadways and include the shoulders.

Just over half of all large truck fatalities and 59 percent of all large single-unit truck fatalities occur on non-divided 2-lane roadway, that is, conventional 2-lane roads with one lane in each direction.

Table 7b
Large Truck Fatalities by Truck Type, Fatality Type, Trafficway Division, and 2-Lane vs. Other 1996-2000

Single-unit Trucks

Fatality Type	Division	2-Lane	Other	Total	2-Lane(%)	Other(%)	Total(%)
Occupant							
Single-vehicle	Not Divided	447	15	462	68%	2%	70%
	Divided	124	76	200	19%	11%	30%
Total		571	91	662	86%	14%	100%
Occupant							
Multiple-vehicle	Not Divided	3,184	428	3,612	59%	8%	67%
	Divided	975	773	1,748	18%	14%	32%
Total		4,159	1,201	5,360	77%	22%	100%
Non-Occupant							
	Not Divided	298	110	408	47%	18%	65%
	Divided	100	119	219	16%	19%	35%
Total		398	229	627	63%	37%	100%
Single-unit Trucks							
	Not Divided	**3,929**	**553**	**4,482**	**59%**	**8%**	**67%**
	Divided	**1,199**	**968**	**2,167**	**18%**	**15%**	**33%**
Total Single-unit Trucks		**5,128**	**1,521**	**6,649**	**77%**	**23%**	**100%**
All Large Trucks							
	Not Divided	**13,589**	**1,747**	**15,336**	**51%**	**7%**	**57%**
	Divided	**6,932**	**4,528**	**11,460**	**26%**	**17%**	**43%**
Grand Total All Large Trucks		**20,521**	**6,275**	**26,796**	**77%**	**24%**	**100%**

Source: NHTSA, NCSA, FARS

A partial list of traffic control devices includes: traffic lights, warning/flashing lights, stop signs, yield signs, warning signs, school signs, officers, crossing guards, and flagmen. The portion of combination truck fatalities at traffic controls (27 percent) is less than the portion of single-unit truck fatalities at traffic controls (33 percent). The approximate 7 percent difference in fatalities is constant for crash types: multi-vehicle and non-occupant.

Table 8
Large Truck Fatalities by Truck Type, Fatality Type and No Traffic Controls vs. Any Traffic Control 1996-2000

Combination Trucks					
Fatality Type	No Controls	Any Controls	Total	No Controls(%)	Any Controls(%)
Occupant					
Single-vehicle	1,511	279	1,790	84%	16%
Multiple-vehicle	12,222	4,844	17,066	72%	28%
Total	13,733	5,123	18,856	73%	27%
Non-Occupant	1,117	314	1,431	78%	22%

Single-unit Trucks					
Fatality Type	No Controls	Any Controls	Total	No Controls(%)	Any Controls(%)
Occupant					
Single-vehicle	557	113	670	83%	17%
Multiple-vehicle	3,506	1,890	5,396	65%	35%
Total	4,063	2,003	6,066	67%	33%
Non-Occupant	448	194	642	70%	30%

Source: NHTSA, NCSA, FARS

Junctions are intersections, driveways, ramps, crossings, etc. Approximately 80 percent of large truck single-vehicle crashes, both combination trucks and single-unit trucks, occur away from a junction. The percent of fatalities of single-unit trucks for both multi-vehicle related fatalities and non-occupant fatalities is 8 to 9 percent lower than the corresponding percent for combination trucks.

Table 9
Large Truck Fatalities by Truck Type, Fatality Type and Relation to Junction 1996-2000

Combination Trucks					
Fatality Type	Non-Junction	Any Junction	Total	Non-Junction(%)	Any Junction(%)
Occupant					
Single-vehicle	1,431	359	1,790	80%	20%
Multiple-vehicle	10,733	6,330	17,063	63%	37%
Total	12,164	6,689	18,853	65%	35%
Non-Occupant	1,007	424	1,431	70%	30%

Single-unit Trucks					
Fatality Type	Non-Junction	Any Junction	Total	Non-Junction(%)	Any Junction(%)
Occupant					
Single-vehicle	564	106	670	84%	16%
Multiple-vehicle	2,994	2,402	5396	55%	45%
Total	3,558	2,508	6,066	59%	41%
Non-Occupant	394	247	641	61%	39%

Source: NCSA, NHTSA, FARS

4. FATAL LARGE TRUCK CRASHES BY STATE

Table 10 lists the frequency of large trucks involved in fatal crashes by state from 1996 to 2000. Eleven states account for 51 percent of the combination trucks involved in fatal crashes, and ten states account for 52 percent of the single-unit trucks involved in fatal crashes. Texas had more combination trucks involved in fatal crashes than any other state. However, Texas also has more miles of public roads than any other state, 300,507 miles; see Table 11.

A coding problem in the classification of large trucks may exist within the FARS data. Note, for example, the case of Mississippi, in Table 10, which reports 522 large combination truck fatal crashes, but only 2 single-unit truck crashes.

Table 10

Large Trucks Involved in Fatal Crashes by Truck Type and State 1996-2000

	Combination Trucks					Single-unit Trucks			
	State	**No. Veh.**	**Cum.**	%Total		**State**	**No. Veh.**	**Cum**	**%Total**
1	TEXAS	1,639	1,639	8.9%		FLORIDA	484	484	8.0%
2	CALIFORNIA	1,337	2,976	7.2%		CALIFORNIA	446	930	7.4%
3	FLORIDA	1,021	3,997	5.0%		TEXAS	437	1,367	7.3%
4	OHIO	775	4,772	4.8%		NEW YORK	327	1,694	5.3%
5	GEORGIA	749	5,521	4.0%		GEORGIA	305	1,999	5.2%
6	NORTH CAROLINA	709	6,230	3.9%		PENNSYLVANIA	288	2,287	4.7%
7	INDIANA	674	6,904	3.6%		NORTH CAROLINA	244	2,531	4.1%
8	ILLINOIS	673	7,577	3.6%		OHIO	203	2,734	3.4%
9	PENNSYLVANIA	651	8,228	3.6%		MICHIGAN	192	2,926	3.1%
10	ALABAMA	621	8,849	3.5%		INDIANA	183	3,109	3.1%
11	TENNESSEE	592	9,441	3.2%		ILLINOIS	182	3,291	3.0%
12	MISSOURI	588	10,029	3.2%		KENTUCKY	179	3,470	3.0%
13	MISSISSIPPI	522	10,551	2.8%		MISSOURI	176	3,646	2.4%
14	MICHIGAN	519	11,070	2.8%		TENNESSEE	161	3,807	2.7%
15	LOUISIANA	469	11,539	2.6%		VIRGINIA	158	3,965	2.5%
16	SOUTH CAROLINA	458	11,997	2.5%		NEW JERSEY	142	4,107	2.4%
17	ARKANSAS	451	12,448	2.5%		WISCONSIN	134	4,241	2.3%
18	NEW YORK	409	12,857	2.2%		ALABAMA	133	4,374	2.2%
19	VIRGINIA	398	13,255	2.2%		MARYLAND	124	4,498	2.0%
20	OKLAHOMA	393	13,648	2.1%		LOUSIANA	119	4,617	2.0%
21	ARIZONA	376	14,024	2.0%		WASHINGTON	110	4,727	1.8%
22	IOWA	328	14,352	1.8%		IOWA	97	4,824	1.7%
23	KENTUCKY	311	14,663	1.7%		MINNESOTA	90	4,914	1.5%
24	KANSAS	306	14,969	1.6%		OKLAHOMA	87	5,001	1.5%
25	MINNESOTA	303	15,272	1.6%		ARIZONA	81	5,082	1.3%
26	WISCONSIN	302	15,574	1.6%		MASSACHUSETTS	80	5,162	1.3%
27	OREGON	239	15,813	1.3%		COLORADO	78	5,240	1.3%
28	NEW JERSEY	238	16,051	1.3%		KANSAS	76	5,316	1.3%
29	COLORADO	229	16,280	1.2%		OREGON	71	5,387	1.2%
30	WASHINGTON	229	16,509	1.2%		WEST VIRGINIA	67	5,454	1.1%
31	MARYLAND	220	16,729	1.2%		ARKANSAS	66	5,520	1.1%
32	NEW MEXICO	205	16,934	1.1%		CONNECTICUT	58	5,578	0.9%
33	NEBRASKA	198	17,132	1.1%		SOUTH CAROLINA	57	5,635	0.9%
34	WEST VIRGINIA	181	17,313	0.9%		MAINE	46	5,681	0.8%
35	UTAH	176	17,489	0.9%		NEBRASKA	46	5,727	0.8%
36	NEVADA	143	17,632	0.8%		IDAHO	37	5,764	0.6%
37	MASSACHUSETTS	111	17,743	0.6%		NEVADA	35	5,799	0.6%
38	IDAHO	106	17,849	0.6%		NEW MEXICO	34	5,833	0.6%
39	WYOMING	96	17,945	0.5%		UTAH	33	5,866	0.6%
40	CONNECTICUT	84	18,029	0.4%		SOUTH DAKOTA	26	5,892	0.5%
41	MONTANA	77	18,106	0.4%		MONTANA	23	5,915	0.4%
42	SOUTH DAKOTA	61	18,167	0.4%		DELAWARE	22	5,937	0.4%
43	DELAWARE	59	18,226	0.3%		VERMONT	18	5,955	0.3%
44	MAINE	58	18,284	0.3%		NEW HAMPSHIRE	15	5,970	0.3%
45	NORTH DAKOTA	54	18,338	0.3%		RHODE ISLAND	15	5,985	0.3%
46	NEW HAMPSHIRE	38	18,376	0.2%		WYOMING	12	5,997	0.2%
47	VERMONT	32	18,408	0.2%		HAWAII	10	6,007	0.2%
48	ALASKA	16	18,424	0.1%		ALASKA	8	6,015	0.2%
49	HAWAII	12	18,436	0.1%		WASHINGTON, DC	6	6,021	0.1%
50	WASHINGTON, DC	7	18,443	0.0%		NORTH DAKOTA	5	6,026	0.1%
51	RHODE ISLAND	6	18,449	0.0%		MISSISSIPPI	2	6,028	0.0%

Source: NHTSA, NCSA, FARS

For each state, Table 11 lists the number of large trucks involved in fatal crashes, the miles of public road, and the annual rate of large trucks involved in fatal crashes per 1,000 miles of public road. California, Delaware, Florida, Georgia, Louisiana, Maryland, New Jersey, and North Carolina, all have a large number of trucks involved in fatal crashes and an annual rate of at least 1.9 trucks involved in fatal crashes per 1,000 miles of public road. The number of vehicle miles traveled, VMT, for large trucks is not available by state, which means that the popular measure of fatal crashes per 100 million vehicle miles traveled cannot be calculated.

Table 11				
Fatal Truck Involvements per 1,000 Miles of Public Road Length by State 1996-2000				
	State	**No. Vehicles**	**Public Road Length**	**Annualized Rate/1000 Miles**
1	DELAWARE	81	5,747	2.8
2	FLORIDA	1,505	115,956	2.6
3	MARYLAND	344	30,322	2.3
4	CALIFORNIA	1,783	166,973	2.1
5	NEW JERSEY	380	35,941	2.1
6	LOUISIANA	588	60,828	1.9
7	NORTH CAROLINA	953	99,302	1.9
8	GEORGIA	1,054	113,894	1.9
9	INDIANA	857	93,605	1.8
10	WASHINGTON, DC	13	1,425	1.8
11	TENNESSEE	753	87,259	1.7
12	ARIZONA	457	54,454	1.7
13	OHIO	978	116,371	1.7
14	ALABAMA	754	94,247	1.6
15	PENNSYLVANIA	939	119,384	1.6
16	VIRGINIA	556	70,327	1.6
17	SOUTH CAROLINA	515	64,901	1.6
18	MISSISSIPPI	524	73,318	1.4
19	TEXAS	2,076	300,507	1.4
20	CONNECTICUT	142	20,788	1.4
21	WEST VIRGINIA	248	36,339	1.4
22	KENTUCKY	49	74,121	1.3
23	NEW YORK	736	112,659	1.3
24	ILLINOIS	855	138,246	1.2
25	MISSOURI	764	122,831	1.2
26	MICHIGAN	711	121,722	1.2
27	MASSACHUSETTS	191	35,265	1.1
28	ARKANSAS	517	97,562	1.1
29	HAWAII	22	4,257	1.0
30	NEVADA	178	35,871	1.0
31	UTAH	209	41,456	1.0
32	MAINE	104	22,664	0.9
33	OREGON	310	66,879	0.9
34	OKLAHOMA	480	112,511	0.9
35	WASHINGTON	339	80,256	0.8
36	NEW MEXICO	239	59,913	0.8
37	WYOMING	108	26,777	0.8
38	WISCONSIN	436	111,906	0.8
39	IOWA	425	112,904	0.8
40	COLORADO	307	85,149	0.7
41	NEW HAMPSHIRE	53	15,173	0.7
42	VERMONT	50	14,265	0.7
43	RHODE ISLAND	21	6,052	0.7
44	IDAHO	143	45,802	0.6
45	MINNESOTA	393	131,996	0.6
46	KANSAS	382	133,963	0.6
47	NEBRASKA	244	92,798	0.5
48	ALASKA	24	12,667	0.4
49	MONTANA	100	64,662	0.3
50	SOUTH DAKOTA	87	83,410	0.2
51	NORTH DAKOTA	59	86,615	0.1
Source: NHTSA, NCSA, FARS				

5. TWO-VEHICLE CRASHES INVOLVING A LARGE TRUCK (FARS)

Over 95 percent of two-vehicle crashes involving a large truck involve either the front of the truck and/or the front of the other vehicle. The point of impact of the large truck is the front of the truck in approximately two out of three two-vehicle crashes involving a large truck. About half of these crashes are front-to-front crashes.

Table 12
Impact Points for Two-Vehicle Large Truck Crashes by Truck Type
1996-2000

Combination Trucks							
Impact Point of	-------------------Impact Point of the Other Vehicle---------------						
the Comb. Truck	Front	Side	Rear	% Front	% Side	% Rear	Total
Front	3,219	2,894	778	30%	27%	7%	64%
Side	1,648	230	35	15%	2%	0%	17%
Rear	1,755	80	25	16%	2%	0%	18%
Total	6,622	3,204	838	61%	31%	7%	100%

Single-unit Trucks							
Impact Point of	------------------Impact Point of the Other Vehicle----------------						
the SUT	Front	Side	Rear	% Front	% Side	% Rear	Total
Front	1,223	1,199	174	34%	33%	5%	72%
Side	346	50	6	10%	1%	0%	11%
Rear	577	31	6	16%	1%	0%	17%
Total	2,146	1,280	186	60%	35%	5%	100%

Source: NHTSA, NCSA, FARS

Within the police accident report, officers can refer to the condition of vehicle components, i.e., the vehicle-related factors. The report may indicate that a component is inadequate, inoperative, faulty, damaged or defective. The condition may be due to owner/user neglect, poor or sub-standard maintenance, tampering or defective manufacturing. The vehicle-related factor(s) noted, within the police accident report, indicates the existence of the condition(s). The condition may or may not have played a role in the crash. The table below is for two-vehicle crashes consisting of a large truck and one other vehicle.

The first sub-table provides data on any reported vehicle-related factors. The brake system data, of the second sub-table, is a proper subset of any vehicle-related factor. Looking at any vehicle-related factors, one notes that 70 percent of the reported vehicle factors, cited by the investigating officer, were attributed to a large truck. However, there were only 833 factors listed for two-vehicle crashes involving a large truck from 1996 to 2000. In the special case of brake system citations, 86 percent of the reported brake system vehicle factors were attributed to a large truck. It is of interest to compare Table 13 with Tables 14, 15a and 15b. Table 13 reports on mechanical problems cited. Most of the citations are against the truck. This, in part, may be due to the vigilance of the investigating officer.

Table 13
Related Factors for Two-Vehicle Large Truck Crashes by Truck Type and Vehicle Type 1996-2000

Any Vehicle-Related Factor

Truck type	Truck	Other	Total	Truck(%)	Other(%)
Combination	388	216	604	64%	36%
Single-unit	160	69	229	77%	23%
Total	548	285	833	70%	30%

Brake System

Truck type	Truck	Other	Total	Truck(%)	Other(%)
Combination	193	30	223	87%	13%
Single-unit	69	11	80	86%	14%
Total	262	41	303	86%	14%

Source: NHTSA, NCSA, FARS

On the other hand, Tables 14, 15a and 15b report on actions taken by the drivers of the vehicle. These four tables examine two independent parts of large truck crashes, namely maintenance and driver actions. There does not appear to be an association between the two.

Related factors are also collected for drivers involved in fatal crashes. The data of Table 14 are for two-vehicle crashes involving a large truck and another vehicle. The first sub-table provides data for any driver-related factor. The following three sub-tables provide similar data for the driver-related factors of speeding, drowsy/asleep/inattentive, and failure to yield. These three sub-tables are mutually exclusive proper subsets of the set of any driver-related factors.

Considering any driver-related factor, one notes that 26 percent of the citations are attributed to the drivers of the large trucks. Similarly, the portion of factors attributed to speeding, drowsy/asleep/inattentive, and failure to yield, are 22 percent, 20 percent, and 24 percent, respectively.

Regardless of the variable examined, the driver of the other vehicle, that is the non-large truck vehicle, has the preponderance of driver-related factors cited. For example, 74 percent for any driver-related factor is coded for the other vehicle.

The TIFA survey is conducted by the Center for National Truck Statistics at the University of Michigan Transportation Research Institute. The file contains a random sample of large trucks, specifically straight trucks without trailers and tractor trailers (as recorded in FARS) that were involved in a fatal crash in the United States.

The TIFA data collection is accomplished through a detailed examination of the police accident report and telephone interviews with individuals who have knowledge of the truck at the time of the crash. Interviews are typically carried out with the driver, owner, safety director of the carrier operating the truck, the reporting police officer, and other involved parties. The combination of the FARS records, the police accident report, and the additional data collected by these telephone interviews forms the TIFA file. The most recent TIFA data are from 1999.

Crashes involving large trucks often leave physical evidence. Some of this physical evidence is captured in the TIFA crash data, which is not dependent on the reports of the driver or any other individual. In many fatal crashes, the point of impact combined with the relative position of the vehicles, suggests that one driver contributed more to the crash than the other driver; for example, a head-on crash in which one vehicle is in its proper lane and the other vehicle is not. For the purpose of analysis, it is reasonable to assume that the principal contributing error of the crash can be attributed to the driver of the vehicle in the incorrect lane. To be sure, one can construct situations where this would not be the case, but they would be exceptions rather than the rule.

Table 14
Two-Vehicle Large Truck Crashes by Driver-Related Factors, Truck Type, and Vehicle Type 1996-2000

Any Driver-Related Factor

Truck type	Truck	Other	Total	Truck(%)	Other(%)
Combination	2,943	8,896	11,839	25%	75%
Single-unit	1,133	2,869	4,002	28%	72%
Total	4,076	11,765	15,841	26%	74%

Speeding

Truck type	Truck	Other	Total	Truck(%)	Other(%)
Combination	463	1,738	2,201	22%	78%
Single-unit	142	555	697	20%	80%
Total	605	2,293	2,898	22%	78%

Drowsy/Asleep/Inattentive

Truck type	Truck	Other	Total	Truck(%)	Other(%)
Combination	354	1,462	1,816	19%	81%
Single-unit	123	439	562	22%	78%
Total	477	1,901	2,378	20%	80%

Failure to Yield

Truck type	Truck	Other	Total	Truck(%)	Other(%)
Combination	600	2,032	2,632	23%	77%
Single-unit	268	785	1,053	25%	75%
Total	868	2,817	3,685	24%	76%

Source: NHTSA, NCSA, FARS

6. ANALYSIS OF TRUCKS IN FATAL ACCIDENTS (TIFA)

The physical evidence of two-vehicle rear-end, sideswipe and head-on crashes combined with the relative position of the vehicles suggest that one driver may have contributed to the crash more than the other. Drivers of the striking vehicle for rear-end crashes may contribute more to crashes than drivers of the struck vehicles. Drivers of sideswipe vehicles that encroached into the lane of the other sideswiped vehicle may contribute more to crashes than drivers of vehicles that remained in the proper lane. Drivers of vehicles for head-on crashes where the vehicle is in the lane of the oncoming vehicle may contribute more to crashes than drivers of vehicles that remain in the proper lane. Drivers of vehicles that turn across the path of an oncoming vehicle may contribute more to the crash than drivers of the oncoming vehicle, although right-of-way considerations can be a complicating factor. The straight path crashes require more information than that which is available here to determine which driver contributed most to the crash. The data on straight path crashes do not identify right-of-way violations.

Tables 15a and 15b contain the TIFA fatality crash type data from 1996 to 1999 for two-vehicle crashes consisting of one large truck and one passenger vehicle. The first ten data rows of both tables consist of five pairs of similar crash types. The highlighted row, within each pair, identifies the more prevalent crashes of the pair, that is, the set of crashes with the most fatalities. In general this means that the highlighted crashes have more passenger vehicle driver fatalities (columns 2 and 3), more truck driver fatalities (columns 4 and 5) and more total fatalities (columns 6 and 7). For some crash types, there are more than five times the fatalities for the gray highlighted row of crashes. The one exception to this rule is combination trucks, specifically truck driver fatalities for rear-end crashes; see the heavy boxed area of Table 15a.

For each pair of rows, the highlighted rows are crashes where the passenger vehicle drivers seem to have contributed more to the crash than the driver of the large truck. These results are based on the point of impact combined with the relative position of the vehicles, and confirm the results based on the driver-related factors. These data suggest that a contributing factor of two-vehicle crashes involving a large truck and a passenger vehicle is the poor judgment of the driver of the passenger vehicle. For example, there were 1,085 fatalities in two-vehicle crashes involving a sideswipe of a large combination truck and another vehicle in which the other vehicle encroached into the truck's lane, but only 58 fatalities involving a sideswipe of a large combination truck and another vehicle where the large combination truck encroached into the other vehicles lane.

With this information available, examine Table 1 again. One sees that 18 percent of fatal crashes involving large trucks are single-vehicle crashes; where as 62 percent of fatal non-large truck crashes are single-vehicle crashes. This suggests that a problem with some two-vehicle large truck crash types may lie with the drivers of the non-large truck vehicles involved in the crash.

In the case of straight path crashes more information is needed before any determination is made. When examining fatal two-vehicle crashes involving a large truck and a passenger vehicle, where one vehicle backs into another, ones sees far more fatalities where the large truck driver backed into the passenger car, rather than the other way around.

Table 15a
Two-Vehicle Combination Truck Fatalities by Crash Type 1996-1999

Crash Type	Passenger Vehicle Driver Fatalities		Truck Driver Fatalities		Total Fatalities	
	N	(%)	N	(%)	N	(%)
Rear-end, truck striking passenger vehicle	207	3%	25	15%	427	4%
Rear-end, passenger vehicle striking truck	786	11%	1	1%	1,070	11%
Sideswipe opposite direction, truck encroached	69	1%	6	3 %	101	1%
Sideswipe opposite direction, passenger vehicle encroached	843	12%	6	3%	1,085	11%
Sideswipe same direction, truck encroached	21	0 %	9	5%	58	1%
Sideswipe same direction, passenger vehicle encroached	114	2%	11	6%	193	2%
Head-on truck in passenger vehicle lane	130	2%	3	2%	177	2%
Head-on passenger vehicle in truck lane	1,324	19%	14	8%	1,696	17%
Truck turned across path of passenger vehicle	332	5%	1	1%	465	5%
Passenger vehicle turned across path of truck	566	8%	10	6%	829	8%
Other turning related	54	1%	0	0%	87	1%
Straight path, truck into passenger vehicle	931	13%	20	12%	1,416	14%
Straight path, passenger vehicle into truck	453	6%	5	3%	634	6%
Truck backed into passenger vehicle	70	1%	0	0%	87	1%
Passenger vehicle backed into truck	1	0%	0	0%	2	0%
Other crash type	821	12%	55	32%	1,337	13%
Unknown crash type	304	4%	7	4%	428	4%
Total Combination Trucks	7,026	100 %	173	100%	10,092	100%

Source: NHTSA, NCSA, FARS, TIFA

Table 15b
Two-Vehicle Single-unit Truck Fatalities by Crash Type 1996-1999

Crash Type	Passenger Vehicle Driver Fatalities		Truck Driver Fatalities		Total Fatalities	
	N	(%)	N	(%)	N	(%)
Rear-end, truck striking passenger vehicle	39	2%	1	2%	60	2%
Rear-end, passenger vehicle striking truck	269	13%	3	5%	367	12%
Sideswipe opposite direction, truck encroached	22	1%	1	2%	32	1%
Sideswipe opposite direction, passenger vehicle encroached	201	9%	2	3%	276	9%
Sideswipe same direction, truck encroached	3	0%	3	5%	14	0%
Sideswipe same direction, passenger vehicle encroached	12	1%	3	5%	25	1%
Head-on truck in passenger vehicle lane	76	4%	2	3%	113	4%
Head-on passenger vehicle in truck lane	461	22%	4	7%	551	18%
Truck turned across path of passenger vehicle	90	4%	0	0%	148	5%
Passenger vehicle turned across path of truck	255	12%	0	0%	334	11%
Other turning related	13	1%	5	9%	14	1%
Straight path, truck into passenger vehicle	395	19%	7	12%	595	20%
Straight path, passenger vehicle into truck	112	5%	12	21%	178	6%
Truck backed into passenger vehicle	11	0%	0	0%	11	0%
Passenger vehicle backed into truck	1	0%	1	2%	5	0%
Other crash type	147	7%	14	24%	259	9%
Unknown crash type	22	1%	0	0%	32	1%
Total Single-unit Trucks	2,129	100%	58	100%	3,014	100%

Source: NHTSA, NCSA, FARS, TIFA

More large truck crash fatalities occur in the first hour after a break of at least eight hours than during any other hour. In general, as the number of hours increase, after the required break of at least eight hours, there are fewer fatal crashes. Note that some columns are for one hour and some columns are for multiple hours. The category “12+" collapses data for 12 or more hours.

Table 16
Large Truck Fatalities by Truck Type, Fatality Type, and Hours Driven Before the Crash 1996-1999

Combination Trucks									
Fatality Type	**Hours Driven Before the Crash**								
Occupant	1	2	3-4	5-6	7-8	9-10	11	12+	Unknown
Single-vehicle	233	158	207	137	71	28	2	10	587
Multiple-vehicle	2,407	1,649	2,310	1,549	790	352	24	48	5,528
Non-Occupant	194	86	163	126	90	22	1	9	457

Single-unit Trucks									
Fatality Type	**Hours Driven Before the Crash**								
Occupant	1	2	3-4	5-6	7-8	9-10	11	12+	Unknown
Single-vehicle	86	41	71	29	15	4	1	0	240
Multiple-vehicle	859	328	439	322	199	43	6	10	1,966
Non-Occupant	87	34	56	26	12	4	3	0	253

Source: NHTSA, NCSA, FARS, TIFA

The distributions of the intended one-way trip distance reflect the difference in travel patterns between the two types of large trucks. The entire one-way trip distance is coded even if the trip requires multiple days of travel. The known intended one-way trip distance for single-unit truck fatalities is concentrated at the local level, that is within a radius of 50 miles, whereas the distribution of combination truck fatalities by intended one-way trip distance is much flatter and more uniform.

Table 17
Fatalities by Trip Distance for Large Truck Crashes by Truck Type and Fatality Type 1996-1999

Combination Trucks

Fatality Type	**Trip Distance (In Miles)**					
Occupant	Local	51-100	101-200	201-500	>500	Unknown
Single-vehicle	283	157	160	257	299	277
Multiple-vehicle	3,229	1,842	1,743	2,466	2,762	2,615
Non-Occupant	271	126	104	176	204	267

Single-unit Trucks

Fatality Type	**Trip Distance (In Miles)**					
Occupant	Local	51-100	101-200	201-500	>500	Unknown
Single-vehicle	236	58	15	17	6	155
Multiple-vehicle	2,294	344	145	97	36	1,237
Non-Occupant	258	31	11	8	4	163

Source: NHTSA, NCSA, FARS, TIFA

Over 64 percent of the single-vehicle occupant fatalities occurred in crashes with a rollover, but less than 2 percent of the non-occupant fatalities occurred in crashes with a rollover.

Table 18
Large Truck Fatalities by Truck Type, Fatality Type and Rollover 1996-1999

Combination Trucks		
Fatality Type	**Rollover**	
Occupant	No	Yes
Single-vehicle	531	902
Multiple-vehicle	13,427	1,230
Non-Occupant	1,119	29

Single-unit Trucks		
Fatality Type	**Rollover**	
Occupant	No	Yes
Single-vehicle	164	323
Multiple-vehicle	3,704	468
Non-Occupant	474	1

Grand Total		
Fatality Type	**Rollover**	
	No	Yes
Single-vehicle	695(36%)	1,225(64%)
Multiple-vehicle	17,131(91%)	1,698(9%)
Non-Occupant	1,593(98%)	30(2%)

Source: NHTSA, NCSA, FARS, TIFA

The mean gross weight is positively associated with rollovers. Combination trucks involved in fatal crashes that experience a rollover have trailers with higher gross mean weights than combination trucks that do not experience a rollover. A similar result exists for single-unit trucks. Namely, single-unit trucks that experience a rollover during a fatal crash have higher mean power unit gross weights than those that do not rollover (see Tables 27 and 28 for the effect of weight on a large truck's propensity to rollover in a single-vehicle fatal crash). Contrast this result with jackknifes, Tables 24 and 29, where the relationship is in the opposite direction.

Table 19
Mean Gross Weight (lbs) of Large Trucks by Truck Type, Crash Type, Number of Trailers, and Rollover 1996-1999

Combination Trucks

Crash Type	Power Unit		1st Trailer		2nd Trailer	
	Rollover	No Rollover	Rollover	No Rollover	Rollover	No Rollover
Single-vehicle						
1 Trailer	17,397	16,994	50,551	33,184	N/A	N/A
2 Trailers	14,431	14,982	23,406	23,244	23,578	21,722
Multiple-vehicle						
1 Trailer	17,947	17,297	46,938	35,343	N/A	N/A
2 Trailers	15,861	15,766	25,273	23,613	22,216	21,142

Single-unit Trucks

Crash Type	Power Unit		1st Trailer		2nd Trailer	
	Rollover	No Rollover	Rollover	No Rollover	Rollover	No Rollover
Single-vehicle	28,341	22,978				
Multiple-vehicle	30,469	25,688	N/A	N/A	N/A	N/A

Source: NHTSA, NCSA, FARS, TIFA

There is no appreciable difference in the length of large trucks involved in fatal crashes between single-vehicle crashes and multiple-vehicle crashes. However, the mean length of the power unit of combinations trucks with two trailers is approximately 3 feet less than the length of the power unit of combination trucks with a single trailer, the overall length of a combination truck with two trailers is 9 feet longer. The mean length of each unit of a combination truck with 2 trailers is shorter than the mean length of each unit of a combination truck with a single trailer, but the overall length is longer.

Table 20
Mean Unit Length of Large Trucks by Truck Type, Fatality Type, and Length in Feet 1996-1999

Combination Trucks			
Fatality Type	Length in Feet		
	Power Unit	1st Trailer	2nd Trailer
Single-vehicle			
1 Trailer	24.0	44.6	N/A
2 Trailers	21.0	29.8	27.2
Multiple-vehicle			
1 Trailer	24.3	44.7	N/A
2 Trailers	21.6	29.5	27.0

Single-unit Trucks			
Fatality Type	Length in Feet		
	Power Unit	1st Trailer	2nd Trailer
Single-vehicle	26.8	N/A	N/A
Multiple-vehicle	26.8	N/A	N/A

Source: NHTSA, NCSA, FARS, TIFA

Most of the fatalities attributed to crashes involving combination trucks with two trailers have trailers of equal length. This pattern is consistent for all fatality types, occupant and non-occupant fatalities.

Table 21
Combination Truck Fatalities by Fatality Type and Relation of Trailer Length 1996-1999

	Combination Trucks		
	Relation of Trailer Lengths		
Fatality Type	1st < 2nd	1st = 2nd	1st > 2nd
Occupant			
Single-vehicle	1	51	12
Multiple-vehicle	12	466	143
Non-Occupant	1	55	14

Source: NHTSA, NCSA, FARS, TIFA

Approximately 10 percent of combination truck occupant fatalities are associated with a jackknife; see Table 22. Over 90 percent of these jackknife fatalities involved a combination truck with a single trailer; see Table 23. Only 4 percent of combination truck non-occupant fatalities are associated with a jackknife. Of these jackknife fatalities, 83 percent involved a combination truck with a single trailer.

Table 22
Large Truck Fatalities 1996-1999

Combination Trucks by Jackknife*

Fatality Type	**Jackknife**	
Occupant	No	Yes
Single-vehicle	1139	157
Multiple-vehicle	12,138	1,312
Total	13,277(90%)	1,469(10%)
Non-Occupant	968(96%)	36(4%)

Source: NCSA, NHTSA, FARS, TIFA

* Some combination trucks are not articulated, e.g., bobtails.

Table 23
Combination Truck Fatalities by Occupant Type and Number of Trailers 1996-1999

Combination Truck Jackknife
Jackknife by Number of Trailers

Fatality Type	**No. of Trailers**	
Occupant	1	>1
Single-vehicle	145	12
Multiple-vehicle	1,198	114
Total	1,343(91%)	126(9%)
Non-Occupant	30(83%)	6(17%)

Source: NCSA, NHTSA, FARS, TIFA

The mean total trailer weight, of large combination trucks that experience a jackknife, tends to be less than the mean total trailer weight of large combination trucks that do ***not*** experience a jackknife. This finding suggests that as the total trailer weight decreases, the probability of a jackknife increases (see Table 29 for the effect of weight on a large combination truck's propensity to experience a jackknife in a single-vehicle fatal crash). This is confirmed by the multivariate analysis; see Table 29. The exception is single-vehicle crashes with one trailer; however, the difference in mean trailer weight is less than 150 pounds. This result can be contrasted with the relation between weight and rollover. As weight increases, rollovers increase and jackknives decrease; see Tables 19, 24, 27, 28 and 29.

Table 24
Mean Gross Weight (lbs) of Units for Combination Trucks by Type of Crash, Number of Trailers, and Jackknife 1996-1999

	Power Unit		1st Trailer		2nd Trailer	
	No Jackknife	Jackknife	No Jackknife	Jackknife	No Jackknife	Jackknife
Single-vehicle						
1 Trailer	16,980	17,432	40,709	40,857	N/A	N/A
2 Trailers	14,829	14,616	24,011	20,563	22,864	22,344
Multiple-vehicle						
1 Trailer	17,169	16,756	37,501	28,366	N/A	N/A
2 Trailers	15,735	15,471	25,390	16,615	22,586	14,787

Source: NHTSA, NCSA, FARS, TIFA

Most occupant fatalities related to large truck sideswipe crashes occur with opposite direction sideswipes. Approximately 76 percent of occupant sideswipe-related fatalities involving a combination truck are opposite direction sideswipes. For single-unit trucks, the portion is 82 percent. Non-occupant fatalities involving a sideswipe are quite rare and no conclusions should be drawn from the data.

Table 25
Large Truck Fatalities by Truck Type, Fatality Type, and Sideswipe Direction
1996-1999

Combination Trucks		
Fatality Type	**Sideswipe**	
Occupant	Same Direction	Opposite Direction
Multiple-vehicle	727(24%)	2,348(76%)
Non-Occupant	6	4
Single-unit Trucks		
Fatality Type	**Sideswipe**	
Occupant	Same Direction	Opposite Direction
Multiple-vehicle	114(18%)	516(82%)
Non-Occupant	4	0

Source: NHTSA, NCSA, FARS, TIFA

7. PROPENSITY TO ROLL OVER/JACKKNIFE

Rollover and jackknife crashes are complex events influenced by driver characteristics, the driving environment, the vehicle, and the interaction among the three. This section investigates the effects of the driving environment and the vehicle on a large truck's propensity to roll over or jackknife in a single-vehicle fatal crash.

The National Highway Traffic Safety Administration (NHTSA) has developed a five-star rating system to inform consumers about the rollover resistance of passenger cars, light multipurpose passenger vehicles, and trucks. The ratings are derived from the relationship between measured values of the static stability factor (SSF) and corresponding rollover rates determined from single-vehicle crash data. SSF is defined as the vehicle's track width, T, divided by twice its center of gravity height, H; i.e., SSF=T/2H. For large trucks, the height of an unloaded vehicle with a driver as the only occupant is used in this calculation. However, the actual center of gravity does fluctuate with the load. Therefore, instead of using the SSF, the weight (including the cargo weight) and the dimensions of the truck are used in the analysis. Single large truck fatal crashes served as the exposure measure for assessing the relative magnitude of the rollover (jackknife) problem, i.e., number of rollover (jackknife) events / number of single-large-truck fatal crashes. The crashes included in the analysis are single-vehicle fatal crashes for large trucks in TIFA between 1996 and 1999.

The binary response model, for rollovers (jackknifes), states that the probability of a rollover (jackknife), given that a single-truck fatal crash has occurred, is a function of selected explanatory variables. If Y denotes the dependent variable in a binary-response model for rollovers (jackknifes), Y is equal to 1 if there is a rollover (jackknife) and 0 otherwise. The statistical problem is to estimate the probability that Y=1, considered as a function of the explanatory variables. TIFA data are analyzed using a logit model, which is a widely used binary-response model. The logit model is as follows:

$$\Pr(Y=1 \mid \mathbf{X}= \mathbf{x}) = 1/ [1+\exp(\alpha + \boldsymbol{\beta}\, \mathbf{x})].$$

Taking the natural logarithm of both sides, this model can be written as

$$\ln(P / (1-P)) = \alpha + \boldsymbol{\beta}\, \mathbf{x}$$

where P/ (1-P) is the *odds ratio*. TIFA is a stratified random sample of large truck fatal crashes. Therefore, the RLOGIST procedure in the SUDAAN software is used to estimate the parameters in the logit model. All single-vehicle crashes within the TIFA survey were used in this analysis. The explanatory variables used in the models are WEATHER, LIGHT, SPLIMIT, CURVE, WEIGHT, LENGTH, and WIDTH; see Table 26. An analysis of the parameters of the model showed that the variable WIDTH is not significant in predicting rollovers of large trucks. Multiple-vehicle crashes are far more complex than single-vehicle crashes. Unfortunately, the additional necessary variables to analyze rollovers and jackknifes in multiple-vehicle crashes are not available, hence the analysis is limited to single-vehicle crashes. Table 27 and Table 28 give results obtained for single-unit trucks and combination trucks, respectively, for single-vehicle fatal crashes.

Table 26
Variables Used for Inclusion in Rollover and Jackknife Rate Models

VARIABLE	DEFINITION
ROLLOVER	ROLLOVER = 1 if single-truck fatal crash involved a rollover; ROLLOVER = 0 otherwise.
SPLIMIT	Posted speed limit in Miles Per Hour.
CURVE	CURVE = 2 if roadway alignment is curved; Curve = 1 otherwise.
WEATHER	WEATHER = 1 if no adverse atmospheric condition; WEATHER = 2 otherwise.
LIGHT	LIGHT = 1 if daylight or dark but lighted; LIGHT = 2 otherwise.
WEIGHT	Total weight of the truck (including the cargo weight) in pounds.
LENGTH	Length of the truck in feet
WIDTH	Width of the truck in inches.
Source: NHTSA, NCSA, FARS, TIFA	

In a single-vehicle fatal crash, the odds of a rollover on a curved road are approximately six times the odds of a rollover on a straight road for both single-unit trucks and combination trucks. The odds of a rollover for a single-unit truck during adverse weather conditions are three times the odds of a rollover in good weather. However, the odds of a rollover, for combination trucks, are 37 percent higher during adverse weather conditions than in good weather.

Poor lighting conditions are associated with a 12 percent increase in the predicted odds of a rollover for combination trucks, whereas the odds of a rollover decline by 40 percent for single-unit trucks. A 10 mph increase in the posted speed limit contributes to a 172 percent = (exp(10x0.1)) increase in the odds of a rollover for single-unit trucks and a 49 percent = (exp(10x0.04)) increase in the odds of a rollover for combination trucks. An increase of 10 percent in cargo weight increases the odds of a rollover by 10 percent = (exp(1.03*ln(1.1))) and 23 percent = (exp(2.18*ln(1.1))) for single-unit trucks and combination trucks, respectively. On the other hand, an increase of 10 percent in length of a truck reduces the odds of a rollover by 10 percent = (exp(-1.16*ln(1.1))) and 21 percent = (exp(-2.42*ln(1.1))) for single-unit trucks and combination trucks, respectively. This may be due to the fact that a truck's physical center of gravity height increases as the cargo weight increases, and decreases as the length of the truck increases. These results are consistent with Table 19.

In the multivariate analysis of fatal passenger vehicle crashes, one often sees that bad weather decreases the propensity of a rollover. In the case of large truck fatal crashes, the opposite is true: bad weather increases the propensity of rollover. One hypothesis to explain this difference is that during bad weather, the less experienced drivers of the passenger vehicle may reduce their travel speed more than professional large truck drivers.

Table 27 Rollover Propensity of Single-unit Trucks Multivariate Analysis-Logit Model Results 1996-1999					
EFFECTS	BETA COEFF.	ODDS RATIO	SE BETA	T-TEST	P-VALUE
INTERCEPT	-12.2	0.0	1.06	-11.49	< 0.0001
SPLIMIT	0.10	1.10	0.00	22.23	< 0.0001
CURVE	1.78	5.91	0.15	11.61	< 0.0001
WEATHER	1.10	3.00	0.23	4.68	<0.0001
LIGHT	-0.51	0.60	0.16	-3.22	0.0013
ln(WEIGHT)	1.03	2.80	0.10	10.12	< 0.0001
ln(LENGTH)	-1.16	0.31	0.37	-3.18	0.0015
Source: NHTSA, NCSA, FARS, TIFA					

Table 28 Rollover Propensity of Combination Trucks Multivariate Analysis-Logit Model Results 1996-1999					
EFFECTS	BETA COEFF.	ODDS RATIO	SE BETA	T-TEST	P-VALUE
INTERCEPT	-16.64	0.0	0.88	-18.95	< 0.0001
SPLIMIT	0.04	1.04	0.00	14.20	< 0.0001
CURVE	1.80	6.03	0.07	27.61	< 0.0001
WEATHER	0.31	1.37	0.08	3.96	<0.0001
LIGHT	0.11	1.12	0.06	1.95	0.0516
ln(WEIGHT)	2.18	8.80	0.07	31.41	< 0.0001
ln(LENGTH)	-2.42	0.09	0.18	-13.34	< 0.0001
Source: NHTSA, NCSA, FARS, TIFA					

We now investigate the effects of the factors listed in Table 26 on the propensity of a large combination truck jackknife, in a single-vehicle fatal crash.

The binary response model for a jackknife indicates that the probability of a jackknife, given that a fatal crash involving a single combination truck has occurred, is a function of the selected explanatory variables. If Y denotes the dependent variable in a binary-response model for jackknifes, Y is equal to 1 if there is a jackknife and 0 otherwise. The logit model estimates the probability that Y=1, considered as a function of the explanatory variables. Table 29 gives results obtained for combination trucks involved in single-vehicle crashes.

In a single-vehicle fatal crash, the odds of a jackknife are 3.22 times higher during adverse weather conditions. The odds of a jackknife on a curved roadway are 86 percent higher than the odds of a jackknife on a straight roadway. Poor lighting conditions increase the odds of a jackknife by 43 percent. A 10 mph increase in the posted speed limit increases the odds of a jackknife by 49 percent (exp(10x0.04)) for combination trucks. An increase of 10 percent in the total weight of the truck corresponds to a 2 percent (exp(-0.23*ln(1.1))) decline in the odds of a jackknife. Whereas a 10 percent increase in the total length of the truck corresponds to an increase of 14 percent (exp(1.33*ln(1.1))) in the odds of a jackknife for combination trucks (these results are also consistent with Table 24). Thus, one sees that as the number of trailing units increase, the total length of the truck increases, and the propensity for a jackknife increases.

Table 29
Jackknife Propensity of Combination Trucks
Multivariate Analysis-Logit Model Results 1996-1999

EFFECTS	BETA COEFF.	ODDS RATIO	SE BETA	T-TEST	P-VALUE
INTERCEPT	-8.27	0.0	1.43	-5.78	< 0.0001
SPLIMIT	0.04	1.04	0.00	8.54	< 0.0001
CURVE	0.62	1.86	0.08	8.19	< 0.0001
WEATHER	1.17	3.22	0.09	13.55	<0.0001
LIGHT	0.36	1.43	0.07	4.85	<0.0001
ln(WEIGHT)	-0.23	0.80	0.10	-2.21	0.0271
ln(LENGTH)	1.33	3.79	0.43	3.11	0.0019

Source: NCSA, NHTSA, FARS, TIFA

8. CONCLUSIONS

No significant clusters of large truck crashes became apparent during the analysis. However, we have been able to extract a great deal of interesting characteristics of large truck crashes contained in the agency's large fatal crash files. More detailed information is required, much of which is currently being collected for the Large Truck Crash Causation Study. We have been able to extract the following conclusions:

- Just over half of all large truck fatalities occur on non-divided 2-lane roadways. Clearly, the large truck fatal crash problem is neither on interstates, nor on major roadways; it is on non-divided 2-lane roads.

- When the geometry of fatal crashes is analyzed, one sees that the relative positions of the vehicles, just prior to the crash, can be a contributing factor to the crash. For example, using all fatalities as an outcome measure, approximately 10 times as many fatalities result in sideswipe opposite direction crashes where the passenger vehicle encroached into the truck's lane, compared to sideswipe opposite direction crashes where the truck encroached into the passenger vehicle's lane. This might suggest that the drivers of the passenger vehicles are somewhat more reckless or over confident than the large truck drivers.

- A speed limit of 55 mph or higher, poor weather, and a curved road significantly increase the odds of both a rollover and a jackknife for large trucks. As the weight of the large truck and its cargo increases, the odds of a rollover increase, but the odds of a jackknife decrease. Conversely, as the length of a large truck increases, the odds of a rollover decrease, while the odds of a jackknife increase.

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