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Road Class and Large Truck Involvements in Fatal Accidents

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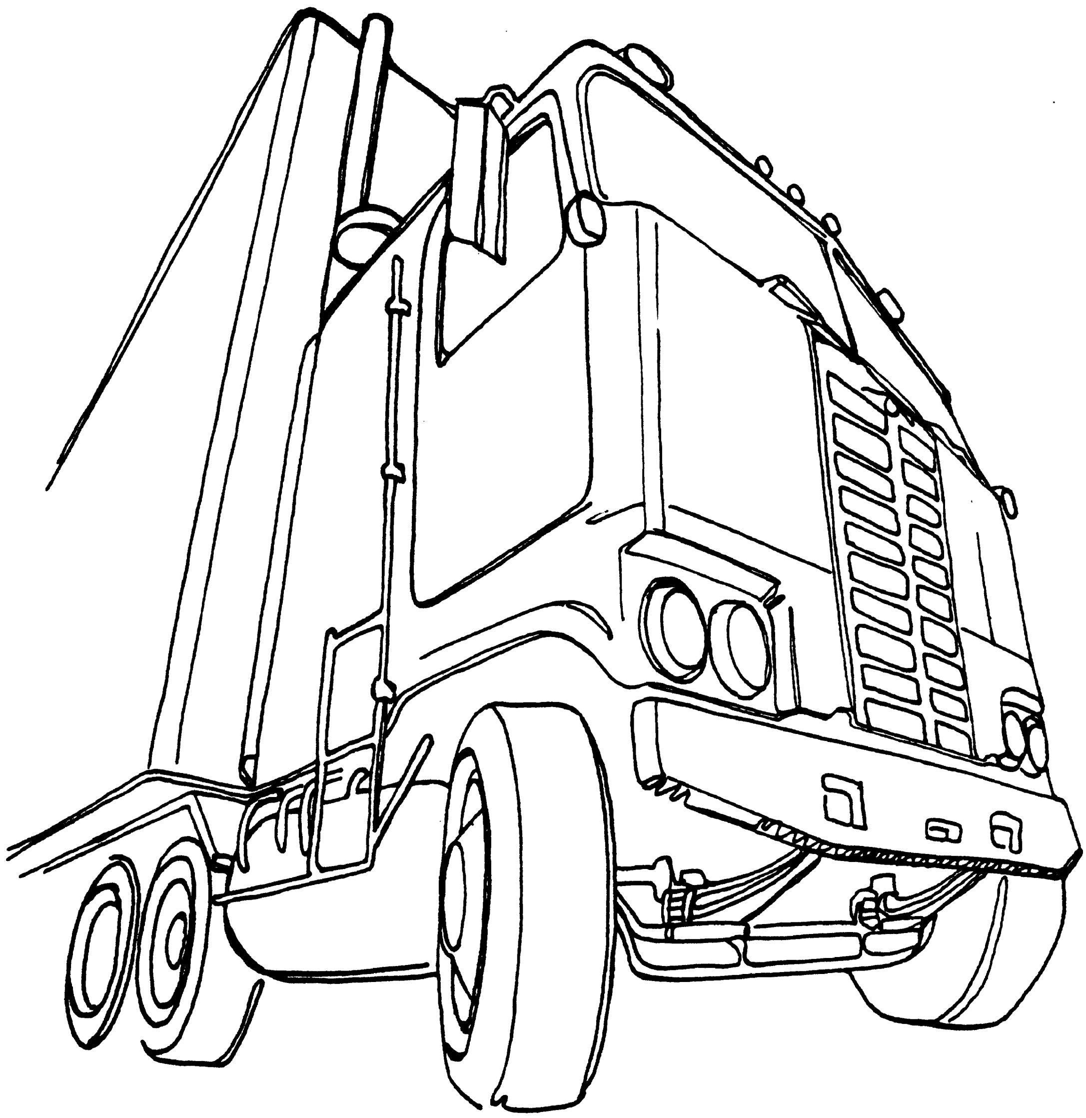

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UMTRI The University of Michigan Transportation Research Institute

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UMTRI Truck Study

The University of Michigan
Transportation Research Institute
Ann Arbor, Michigan 48109

May 1987

The research reported herein was conducted under general research funds provided by the Motor Vehicle Manufacturers Association, the Western Highway Institute, and the American Trucking Associations. The opinions, findings, and conclusions expressed in this publication are not necessarily those of the MVMA, WHI, or ATA.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-87-19		

4. Title and Subtitle
Road Class and Large Truck Involvements in Fatal Accidents

5. Report Date
May 1987

6. Performing Organization Code

7. Author(s)
Oliver Carsten

8. Performing Organization Report No.
UMTRI-87-19

9. Performing Organization Name and Address
The University of Michigan
Transportation Research Institute
2901 Baxter Road
Ann Arbor, Michigan 48109-2150

10. Work Unit No.

11. Contract or Grant No.
6165

12. Sponsoring Agency Name and Address
Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Michigan 48202

13. Type of Report and Period Covered
Special Report

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The data that have been collected by the University of Michigan Transportation Research Institute through a follow-up on large trucks involved in fatal accidents provide the opportunity to examine the relationship between road class and fatal accident involvement. The fatal accident involvement rate per mile travelled for combination trucks is calculated from University of Michigan and Federal Highway Administration data. The rate is higher on rural non-interstates than on the other road types.

For the rest of the report, a four-way breakdown of road class is examined. This categorizes roads into urban and rural and divided and undivided. Significant differences in the distribution of accident factors are observed between road classes. This has important implications for the selection of accident countermeasures in that a countermeasure is unlikely to reduce involvements equally on all classes of road. Certain types of accident, seemingly involving fatigue, are observed to be relatively more common at dawn; however, this fatigue cannot be attributed to exhaustion after long hours of driving.

17. Key Words	18. Distribution Statement
Medium trucks, heavy trucks, accidents, road type	Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
None	None	35	

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INTRODUCTION

Since the advent of the new national data reporting systems, such as the Fatal Accident Reporting System (FARS), the Bureau of Motor Carrier Safety (BMCS) truck accident file and the National Accident Sampling System (NASS), little has been published on the effect of road class on truck accidents. Hedlund's 1977 paper on the severity of accidents involving a large articulated truck and at least one car used reports on truck accidents filed with the Bureau of Motor Carrier safety (BMCS) for 1973 and 1974 (1). The dependent variable here was the odds of a fatality to a car occupant, i.e. the ratio of the number of accidents with at least one such fatality to the number of accidents with no such fatality. Four variables were examined as candidate predictors: road class, truck type (which divided the trucks into doubles units and three-axle, four-axle, and five-axle semitrailer units), truck gross weight, and the year of the accident. The findings were that, once road class had been introduced into the predictive model, little further explanatory power was added by the other variables. Road class had four categories depending on whether the road was rural or residential/business and whether the road had two lanes or four or more lanes.

More recently, FHWA's work on two-lane rural highway safety did not place any particular emphasis on accidents involving trucks and concentrated mainly on a cost-benefit analysis of road improvements (2). However, Chirachavala et al. did examine road class as a predictor (along with other variables) of the severity of accidents involving at least one large truck (3). They looked at accidents in 1980 reported to BMCS for trucks in over-the-road use. Among the findings were that accident severity, measured by the probability of a fatality given an accident and by the probability of injury, varied significantly by road class. Thus truck collisions with cars on rural undivided roads were particularly severe regardless of the environmental conditions. But the authors were constricted by the limitations in the BMCS data and, in addition, were more interested in using the analysis to demonstrate a statistical methodology than in using it to examine the reasons for the differences they found. They provide no discussion of the likely relationship between road class and other factors directly linked to accident severity such as travel speed, accident environment, and traffic flow.

There remains a need, then, for an in-depth investigation of the differences in accidents involving large trucks by road class. The existence of UMTRI's new Trucks Involved in Fatal Accidents database offers the opportunity to respond to that need. The new database provides the first detailed and comprehensive description of *all* large trucks involved in fatal accidents: it has the coverage of FARS combined with the detail of BMCS. By combining the TIFA data with FHWA estimates of truck travel preliminary estimates of fatal accident involvement rates for large trucks by road class can be calculated. Equally important is the ability to describe the accident population accurately and in detail. Such a description can be used to divide the accident data into homogeneous subsets and to make suggestions about accident causation. This kind of analysis is a necessary prologue to further analysis using both accident and future exposure data in that it identifies significant groups of accidents. In the selection of accident countermeasures, accident data alone are at least of equal importance to the combination of accident and exposure data. Frequency of occurrence must be weighed against risk of occurrence in making future policy decisions. It may well be more beneficial to take preventative measures against a type of accident that is relatively common but whose risk of occurrence is only moderate as compared to a type of accident that is highly unusual but whose risk of occurrence is extremely high.

THE TRUCKS INVOLVED IN FATAL ACCIDENTS DATABASE

Until the last few years there were only three important national databases that provided information on accidents involving large trucks and each database had significant problems. The most detailed major data source on truck accidents was the computerized file of reports on accidents submitted by interstate motor carriers. These reports contain a detailed description of the truck involved, but they do not cover accidents by intrastate motor carriers and are frequently not filed by private, interstate carriers. They therefore constitute a biased subset of all truck accidents. The second major source is the FARS data collected by the National Highway Traffic Safety Administration (NHTSA). Here, while coverage is presumably complete, there is some reason to doubt the accuracy of the vehicle description for large trucks, and that description is in any case inadequate in many respects. For example, no data are supplied on the body style of the truck or trailer, on the actual gross weight of the vehicle, or on the kind of carrier operating the truck. The third potential data source is NHTSA's National Accident Sampling System (NASS) which has been in full operation since 1980. NASS investigators collect information on a sample of all the police-reported accidents in the United States. Accidents involving large trucks are sampled at a higher rate than most other accidents, but, even so, large trucks constitute only some 11 percent of all the vehicles involved in NASS-reported accidents. In 1983 this amounted to 2,010 large trucks which is hardly sufficient for studying truck accidents at all levels of severity. In addition, NASS suffers from some of the same problems as FARS in that the description of the truck is insufficiently detailed and missing data rates are high for important parts of the vehicle description.

The lack of a suitable large database on truck accidents has led UMTRI to compile its own data base in fatal truck accidents beginning with accidents that occurred in 1980. The information is obtained through extensive follow-up on all large trucks that are recorded by FARS. The dataset produced is called Trucks Involved in Fatal Accidents (TIFA) and is in a three-year combined file covering calendar years 1980 through 1982. The dataset provides detailed descriptions of all medium and heavy trucks (greater than 10,000 lbs. gross vehicle weight rating) that were involved in a fatal accident in the continental United States, excluding Alaska. To produce the file BMCS reports are first matched to FARS cases; for cases that cannot be matched, telephone interviews are conducted to obtain company and vehicle descriptions. BMCS descriptions of vehicle type are checked for reasonableness and consistency with FARS. The dataset documents a total of 15,018 involvements. Each of these involvements was originally obtained from FARS, but some cases were subsequently dropped because they were identified as not being medium or large trucks or because they were not involved as traffic units.

In addition to the main TIFA dataset, special data files have been prepared for all two-vehicle accidents. These data files are accident level files and, as such, each record contains information on each of the two vehicles involved in the accident and on their respective drivers. The first of these files is called Truck-Truck Fatal Accidents, 1980-82. It provides detailed descriptions on all fatal accidents involving two medium or heavy trucks in the continental United States, excluding Alaska, during the years 1980 through 1982. For this file, both vehicles are medium or heavy trucks so that all of the vehicle descriptive information from the TIFA file is available for each vehicle. The value of a data file in this format is that it allows comparison of the descriptive characteristics, such as the weight, cabstyle, trailer body style, operating authority, etc., of the two vehicles involved in each accident. This data file contains information on total of 438 accidents involving two medium or heavy trucks for calendar years 1980 through 1982.

The remaining two-vehicle accidents from the 1980-82 TIFA file, those involving a collision between a medium or heavy truck and some other type of vehicle (mostly passenger cars), are contained in a file called Truck-Other Fatal Accidents, 1980-82. The information on each of these accidents has been formatted to give first the information on the medium or heavy truck and its driver from the TIFA file, followed by the FARS descriptive information on the other vehicle and its driver. This format is necessary because the UMTRI follow-up was only conducted for the medium and heavy trucks. This data file contains information on a total of 8,889 accidents involving a medium or heavy truck and some other type of vehicle for calendar years 1980 through 1982. The combination of the truck-truck file and the truck-other file describes all two-vehicle fatal accidents occurring in calendar years 1980 through 1982.

The existence of these three truck accident files (the main TIFA file, the truck-truck file, and the truck-other file) opens up new possibilities for the researcher who wishes to examine truck accidents by road class.

THE ROAD CLASS PROBLEM

Many possible classifications exist for road class; however, for the purpose of analyzing accident data, it seems reasonable to use a classification that is likely to be related to accident type. Here a classification that separates two-way roadways from one-way roadways would seem sensible. Roadways where all the traffic is flowing in a single direction are likely to have very different kinds of accidents than roadways where traffic is flowing in two directions. In addition, it would seem sensible to separate urban roads, with their dense traffic and comparative lack of truck travel at night, from rural roads, with sparser traffic and more constant truck travel round the clock. Therefore, for most of this study a four-way classification of road class has been used. This classification separates roads by whether they are urban or rural and by whether they are physically divided (one-way streets are included here) or are undivided. The FARS variables "Land Use" and "Trafficway Flow" were used to create this categorization. "Land Use" information for each accident location is obtained by FARS analysts from the various state highway departments and is defined by the FHWA classification for the particular highway.

Table 1

TIFA 1980–82:
Involvements by Road Class

Road Type	Number of Involvements	Percent of Involvements
Urban divided . .	2,344	15.6%
Urban undivided	2,216	14.8
Rural divided . . .	3,027	20.2
Rural undivided .	7,218	48.1
Unknown	213	1.4
Total	15,018	100.0%

Table 1 shows the TIFA distribution of involvements by this four-way categorization of road class. Most noticeable here is that almost half the involvements occur on undivided rural roads. However, without controlling for exposure, it cannot be concluded that such roads are inherently more dangerous than other types of road. After all the number of involvements might just be a reflection of the proportion of truck travel that occurs on undivided rural roads. Pending the completion of UMTRI's National Trucks Trip Information Survey (NTTIS), which is designed to provide information on truck travel by road class, the only information on truck exposure by road type is the annual estimates generated by the Federal Highway Administration for its annual *Highway Statistics* publication. However, FHWA separates roads not into divided and undivided, but into interstate and non-interstate. Table 2 shows TIFA involvements by this categorization, which, although it has less analytical appeal, is the only one that can currently be used to calculate involvement *rates* by road class. The proportions are not that different from those in the previous table: the proportion of involvements on interstates is naturally somewhat smaller than the proportion on all divided highways, but overall interstate would appear to be a reasonable surrogate for divided.

Table 2

TIFA 1980-82:
Involvements by Rural/Urban and Interstate/Non-Interstate

Road Type	Number of Involvements	Percent of Involvements
Urban interstate . . .	1,136	7.6%
Urban non-interstate	3,402	22.7
Rural interstate	1,964	13.1
Rural non-interstate	8,113	54.0
Unknown	403	2.7
Total	15,018	100.0%

There is a further problem in that FHWA estimates of truck travel include travel by light trucks. The only large truck group that is distinguished in the annual statistics is combination trucks, which FHWA defines as tractors or straight trucks pulling commercial (i.e. non-utility) trailers. Table 3 shows TIFA involvements for combination trucks. As might be expected, the proportion of combination truck involvements on interstates is higher than the comparable proportion for all large trucks. The proportion of involvements on non-interstate rural roads is, however, almost identical at 54 percent.

Table 3

TIFA 1980-82:
Combination Truck Involvements
by Rural/Urban and Interstate/Non-Interstate

Road Type	Number of Involvements	Percent of Involvements
Urban interstate . . .	917	8.7%
Urban non-interstate	1,979	18.7
Rural interstate	1,750	16.5
Rural non-interstate	5,678	53.6
Unknown	276	2.6
Total	10,600	100.0%

Table 4 shows the FHWA estimates of annual combination truck travel for 1980, 1981, and 1982 (4). Also presented is the sum of the three years' travel. The figures indicate a steady increase in urban mileage, but a substantial decrease in rural non-interstate mileage from 1980 to 1981. It is not clear how much of this apparent decrease is real and how much is attributable to the new calculation methods adopted in 1982. Table 5 shows the fatal accident involvement rates for combination trucks obtained by combining the TIFA number of involvements from Table 3 with the mileage estimates from Table 4. The table indicates that not only do rural non-interstate roads account for over half of all combination truck involvements but they also have the highest rate of involvement per mile traveled.

The remainder of this report attempts to shed some light on these differences in involvement rates. A number of accident and vehicle factors are examined in order to identify differences both between and within road classes. Because of its greater analytical appeal the divided/undivided distinction is used in preference to the interstate/non-interstate distinction.

Table 4

FHWA Estimates of Total Combination Truck Travel
by Rural/Urban and Interstate/Non-Interstate

Road Type	1980		1981[a]		1982		1980–82	
	Millions of Miles	Percent	Millions of Miles	Percent	Millions of Miles	Percent	Millions of Miles	Percent
Urban interstate . . .	7,500	12.5%	8,875	15.0%	9,176	15.2%	25,551	14.2%
Urban non-interstate	7,350	12.3	9,702	16.4	10,112	16.8	27,164	15.1
Rural interstate	20,200	33.7	20,036	33.9	20,318	33.7	60,554	33.8
Rural non-interstate	24,950	41.6	20,424	34.6	20,704	34.3	66,078	36.8
Total	60,000	100.0%	59,037	100.0%	60,310	100.0%	179,347	100.0%

[a]The estimates for 1981 are the revised figures published in *Highway Statistics, 1982*.

Table 5

TIFA 1980–82:
Combination Truck Involvement Rate
by Rural/Urban and Interstate/Non-Interstate

Road Type	Number of Involvements	Total VMT in Millions	Involvement Rate per 10 million VMT
Urban interstate . . .	917	25,551	0.36
Urban non-interstate	1,979	27,164	0.73
Rural interstate	1,750	60,554	0.29
Rural non-interstate	5,678	66,078	0.86
Unknown	276	–	–
All	10,600	179,347	0.59

ACCIDENTS IN GENERAL

This section discusses the general picture for large truck involvement in fatal accidents. Two-vehicle and single-vehicle accidents are discussed in more detail below. Table 6 shows the distribution of involvements by road class and by the number of vehicles involved in the accident.[1] It should be noted that, as in all the tables in this section, the table here shows percents of *involvements* rather than percents of *accidents*. Thus an accident involving two large trucks and no other vehicle will be counted twice in the "two vehicles involved" row, once for each large truck. According to the table, single-vehicle accidents are relatively less common on undivided rural roads than on the other kinds of road, while two-vehicle involvements are relatively more common. Involvements in multi-vehicle accidents with at least five vehicles are, not surprisingly, much more frequent on divided than on undivided highways.

Table 6

TIFA 1980–82:
Percentage Distribution of Number of Vehicles Involved by Road Class

Number of Vehicles Involved	Divided Urban	Undivided Urban	Divided Rural	Undivided Rural	Unknown	All
1	25.5	24.8	27.6	19.9	31.0	23.2
2	56.8	64.0	60.3	70.4	53.1	65.0
3	11.0	8.8	7.7	8.1	12.7	8.6
4	3.9	1.6	1.7	1.1	1.4	1.7
5 or more ..	2.9	0.7	2.8	0.5	0.0	1.4
Unknown ..	0.0	0.0	0.0	0.0	1.9	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	15.6	14.8	20.2	48.1	1.4	100.0
N	2,344	2,216	3,027	7,218	213	15,018

Table 7 presents the distribution of the combination type of the large truck for each road class. As might be expected, tractor and semi-trailer combinations account for a relatively large number of involvements on divided rural roads. Here the numbers shown in Table 5 should be borne in mind, because they indicated that combination vehicles had

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[1] All the data presented in this table and in subsequent tables are from a census of fatal accident involvements and are therefore not subject to sampling variance. However, in order to establish that the two dimensions shown in each of these tables were not independent of each other, the chi-square test was run for each table. For every table the chi-square was significant at the .001 level or less.

comparatively low involvement rates on rural interstates. Table 7 also shows that involvements by straight trucks with no trailer are, not surprisingly, over-represented on undivided urban roads, but are also common on undivided rural roads. Bobtail tractor involvements are most common on undivided urban roads. Until better exposure data is available these numbers can only be suggestive, since the number of involvements is closely related to travel patterns.

Table 7

TIFA 1980-82:
Involvements by Combination Type and Road Class

Combination Type	Divided Urban	Undivided Urban	Divided Rural	Undivided Rural	Unknown	All
Straight only	21.5	37.9	10.9	26.2	33.3	24.2
Straight and full .	1.2	1.1	1.0	2.0	0.9	1.5
Straight and other	0.7	1.4	0.6	1.2	0.9	1.0
Bobtail tractor ...	3.1	4.2	1.8	2.2	2.3	2.5
Tractor and semi .	68.3	51.5	79.9	64.1	59.6	66.0
Tractor and semi and full	3.5	1.8	4.4	2.7	0.9	3.0
Other	0.5	0.6	0.8	0.9	0.0	0.8
Unknown	1.2	1.6	0.7	0.8	1.9	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	15.6	14.8	20.2	48.1	1.4	100.0
N	2,344	2,216	3,027	7,218	213	15,018

The distributions of light condition by road class, shown in Table 8 must again be presumed to be attributable in large part to exposure patterns. Even so, the large number of involvements in the dark on divided rural roads stands out. It is highly unlikely that over half the truck travel on these roads is by night and it is therefore almost certain that the fatal accident involvement rate is higher by night than by day on divided rural roads. The comparatively large number of involvements at dawn on the same roads is also noticeable.

Table 8

TIFA 1980–82:
Involvements by Light Condition and Road Class

Light Condition	Divided Urban	Undivided Urban	Divided Rural	Undivided Rural	Unknown	All
Daylight ..	53.5	67.1	43.7	62.4	56.3	57.9
Dark	43.5	29.9	51.7	33.8	37.6	38.4
Dawn	1.7	1.8	3.2	2.1	2.3	2.2
Dusk	1.1	1.2	1.3	1.6	2.3	1.4
Unknown ..	0.2	0.0	0.0	0.0	1.4	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	15.6	14.8	20.2	48.1	1.4	100.0
N	2,344	2,216	3,027	7,218	213	15,018

TWO-VEHICLE ACCIDENTS

There were 9,327 fatal accidents that involved at least one large truck in 1980, 1981, and 1982. Of these accidents, 438 involved two large trucks, while 8,889 involved one large truck and one vehicle of some other type. Most of this section will therefore examine the latter type of accident, which will be called, for convenience, a "truck/other" accident.

Tables 9 through 12 show the relationship between light condition and manner of collision for each of the four road classes. On divided urban highways, shown in Table 9, head-on collisions are appropriately rare. They are, however, over-represented at dawn as are rear-end collisions, although the dawn accidents represent only 1.9 percent of the total. On undivided urban roads, shown in Table 10, head-on collisions are much more frequent. Angle collisions are over-represented by day and at dusk, while rear-end collisions are more common than usual on dark but lighted streets. Head-on collisions constitute a proportionately larger share of accidents in the dark and at dawn. On divided rural roads, as shown in Table 11, head-on collisions are again comparatively rare. Rear-end collisions are unusually common at dawn and in the dark, while angle collisions are unusually common by day. The distributions for undivided rural roads in Table 12 show that head-on collisions are over-represented at dawn, while angle collisions are over-represented on dark but lighted roads. Head-on collisions account for 41 percent of fatal accidents between a large truck and some other kind of vehicle on undivided rural roads and angle collisions for 43 percent. Overall this set of tables shows that less than half of these two-vehicle accidents on divided roads occur by day.

Table 9

1980–82 Truck/Other Fatal Accidents on Divided Urban Roads:
Light Condition by Manner of Collision

Manner of Collision	Daylight	Dark	Dark but Lighted	Dawn	Dusk	Unknown	All
Rear-end	21.7	44.6	42.4	60.9	15.4	0.0	33.1
Head-on	7.3	13.5	8.5	21.7	7.7	0.0	9.5
Rear-to-rear	0.0	0.3	0.0	0.0	0.0	0.0	0.1
Angle	54.2	31.8	42.1	17.4	61.5	100.0	45.0
Sideswipe, same dir	6.8	3.7	1.1	0.0	7.7	0.0	4.6
Sideswipe, opp. dir	0.2	0.3	1.1	0.0	0.0	0.0	0.4
Not applicable	9.3	5.2	4.8	0.0	7.7	0.0	7.0
Unknown	0.5	0.6	0.0	0.0	0.0	0.0	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	48.2	26.7	22.1	1.9	1.1	0.1	100.0
N	590	327	271	23	13	1	1,225

Table 10

1980–82 Truck/Other Fatal Accidents on Undivided Urban Roads:
Light Condition by Manner of Collision

Manner of Collision	Daylight	Dark	Dark but Lighted	Dawn	Dusk	All
Rear-end	5.7	18.7	24.8	13.3	11.8	12.1
Head-on	27.1	33.9	21.1	40.0	11.8	27.2
Angle	60.9	39.4	46.7	40.0	58.8	53.7
Sideswipe, same dir	1.0	0.4	1.1	0.0	0.0	0.9
Sideswipe, opp. dir	2.2	4.0	2.6	3.3	0.0	2.6
Not applicable	3.0	3.6	3.7	3.3	11.8	3.3
Unknown	0.1	0.0	0.0	0.0	5.9	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	58.8	18.2	19.6	2.2	1.2	100.0
N	809	251	270	30	17	1,377

Table 11

1980–82 Truck/Other Fatal Accidents on Divided Rural Roads:
Light Condition by Manner of Collision

Manner of Collision	Daylight	Dark	Dark but Lighted	Dawn	Dusk	Unknown	All
Rear-end	29.8	44.5	36.8	45.5	36.8	100.0	37.1
Head-on	12.8	15.9	8.0	6.8	10.5	0.0	13.7
Rear-to-rear	0.0	0.2	0.0	0.0	0.0	0.0	0.1
Angle	44.2	29.0	41.4	31.8	42.1	0.0	37.1
Sideswipe, same dir	5.4	3.1	10.3	6.8	5.3	0.0	4.8
Sideswipe, opp. dir	0.9	1.2	0.0	2.3	0.0	0.0	1.0
Not applicable	6.4	5.9	2.3	6.8	5.3	0.0	6.0
Unknown	0.6	0.2	1.1	0.0	0.0	0.0	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	47.0	42.9	5.8	2.9	1.3	0.1	100.0
N	702	641	87	44	19	1	1,494

Table 12

1980–82 Truck/Other Fatal Accidents on Undivided Rural Roads:
Light Condition by Manner of Collision

Manner of Collision	Daylight	Dark	Dark but Lighted	Dawn	Dusk	Unknown	All
Rear-end	6.7	11.9	9.2	9.9	11.7	0.0	8.6
Head-on	37.5	47.6	21.4	52.7	39.0	0.0	40.6
Rear-to-rear	0.1	0.2	0.0	0.0	0.0	0.0	0.1
Angle	47.7	31.5	63.4	28.6	44.2	100.0	42.5
Sideswipe, same dir	1.6	1.0	1.5	0.0	0.0	0.0	1.4
Sideswipe, opp. dir .	4.0	5.1	0.8	5.5	2.6	0.0	4.3
Not applicable	2.3	2.3	3.1	3.3	2.6	0.0	2.3
Unknown	0.2	0.3	0.8	0.0	0.0	0.0	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	61.8	31.8	2.8	1.9	1.6	0.0	100.0
N	2,896	1,492	131	91	77	1	4,688

Further analysis of the FARS coding of the truck/other accidents on undivided rural roads indicates that both the vehicles involved are consistently coded more often "striking" than "struck," which is consistent with the large number of head-on and angle collisions. Of the cases for which a vehicle maneuver was coded, the truck was going straight in 70 percent of the accidents and the other vehicle was going straight in 66 percent of the accidents. There is, however, a large amount of missing data on this variable in FARS. Table 13 shows the distribution of relation to junction by light condition for truck/other accidents on undivided rural roads. Fully 60 percent of the accidents were non-junction related. Intersection related accidents were more common by day and on lighted roads at night, but the latter phenomenon is probably a reflection of where lighting is installed.

Tables 14 and 15 examine truck/truck accidents, i.e. two-vehicle accidents where both the vehicles are large trucks. Almost half of these accidents are on undivided rural roads. Table 14 shows that most of these accidents occur by day except on divided rural roads. On both kinds of rural roads a rather large share, relative to likely exposure, seems to occur at dawn. Table 15 examines the kinds of trucks involved in these accidents. On divided highways, collisions between two tractor-semitrailer combinations are relatively more frequent. Collisions between two straight trucks are comparatively more common on undivided rural roads.

Table 13

1980–82 Truck/Other Fatal Accidents on Undivided Rural Roads:
Light Condition by Relation to Junction

Relation to Junction	Daylight	Dark	Dark but Lighted	Dawn	Dusk	Unknown	All
Non-junction .	54.2	73.1	32.1	75.8	50.6	0.0	59.9
Intersection . .	35.4	17.6	49.6	17.6	36.4	100.0	29.8
Intersection rel	2.1	1.2	3.8	0.0	5.2	0.0	1.9
Interchange . .	0.1	0.1	0.8	0.0	0.0	0.0	0.1
Driveway	8.0	7.8	13.7	6.6	7.8	0.0	8.1
Ramp	0.1	0.1	0.0	0.0	0.0	0.0	0.1
Rail crossing .	0.1	0.1	0.0	0.0	0.0	0.0	0.1
Unknown	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Row percent . .	61.8	31.8	2.8	1.9	1.6	0.0	100.0
N	2,896	1,492	131	91	77	1	4,688

Table 14

1980–82 Truck/Truck Fatal Accidents:
Light Condition by Road Class

Light Condition	Divided Urban	Undivided Urban	Divided Rural	Undivided Rural	Unknown	All
Daylight . .	62.3	71.4	37.6	61.0	50.0	52.7
Dark	37.7	28.6	57.6	34.9	50.0	43.6
Dawn	0.0	0.0	4.8	3.6	0.0	3.4
Dusk	0.0	0.0	0.0	0.5	0.0	0.2
Unknown . .	0.5	0.0	0.0	0.1	1.5	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	12.1	4.8	37.7	44.5	0.9	100.0
N	53	21	165	195	4	438

Table 15

1980–82 Truck/Truck Fatal Accidents:
Collision Type by Road Class

Collision Type	Divided Urban	Undiv Urban	Divided Rural	Undiv Rural	Unknown	All
Trac & semi/ trac & semi	54.7	28.6	66.1	43.1	75.0	52.7
Trac & semi/ strt only . . .	17.0	33.3	15.8	28.2	25.0	22.4
Strt only/ strt only	1.9	4.8	2.4	14.9	0.0	8.0
Other	26.4	33.3	15.8	13.8	0.0	16.9
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	12.1	4.8	37.7	44.5	0.9	100.0
N	53	21	165	195	4	438

SINGLE-VEHICLE ACCIDENTS

From Table 6 it can be observed that single-vehicle accidents account for almost a quarter of large-truck involvements in fatal accidents. It was also noted earlier that they are somewhat under-represented on undivided rural roads. This may be attributable to the relatively small risk of collision with a pedestrian on these roads and to the reduced risk of such high-speed events as rollovers and run-off-the road accidents on these roads as compared to divided rural roads. Nevertheless, Table 16 indicates that undivided rural roads account for 41.3 percent of the single-vehicle large-truck fatal accidents, more than any other road class.

Table 16 also shows that single-vehicle large truck fatal accidents have very different distributions of light condition by road class from the overall picture presented in Table 8. The accidents on undivided urban roads are almost entirely daytime events, while those on divided rural roads are mainly nighttime events. Divided urban and undivided rural roads fall in between. The explanation for this lies largely in the fact that 59 percent of the single-vehicle accidents on undivided urban roads are collisions with a pedestrian, while a further 16 percent are collisions with a bicyclist. Pedestrian collisions constitute 49 percent of the accidents on divided urban highways. By contrast only 26 percent of the accidents on divided rural highways and 19 percent of the accidents on undivided rural roads have a collision with a pedestrian coded as the most harmful event. Overturn is coded as the most harmful event for 42 percent of the accidents on undivided rural roads.

Table 16

1980–82 Single-Vehicle Truck Fatal Accidents:
Light Condition by Road Class

Light Condition	Divided Urban	Undivided Urban	Divided Rural	Undivided Rural	Unknown	All
Daylight . .	51.6	82.4	34.3	59.3	60.6	55.7
Dark	44.7	16.0	60.0	36.4	33.3	40.2
Dawn	1.8	0.7	3.7	2.4	1.5	2.4
Dusk	1.3	0.9	2.0	1.8	3.0	1.7
Unknown . .	0.5	0.0	0.0	0.1	1.5	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent	17.1	15.8	24.0	41.3	1.9	100.0
N	597	550	835	1,438	66	3,846

Table 17 shows the distribution of rollover by road class in more detail. The numbers here do not correspond exactly with the percentage of most harmful events coded as overturns. In this table, rollovers are shown regardless of whether they were the most harmful event. From the table it can be observed that rollovers almost never occur on undivided urban streets where trucks rarely attain the speeds needed for rollover. They are more frequent on divided urban roads, occur in almost half of the accidents on divided rural roads, and occur in over half of the accidents on undivided rural roads. Thus, while the typical single-vehicle fatal truck accident on undivided urban streets is a collision with a pedestrian in which the pedestrian is killed, the typical such accident on undivided rural roads is a rollover in which the truck driver is killed.

Table 17

1980–82 Single-Vehicle Truck Fatal Accidents:
Rollover by Road Class

Rollover	Divided Urban	Undivided Urban	Divided Rural	Undivided Rural	Unknown	All
None	70.5	89.8	52.3	46.6	77.3	59.5
First event	12.7	4.7	23.7	34.6	15.2	23.1
Subsequent event	16.8	5.5	24.0	18.8	7.6	17.4
Total	100.0	100.0	100.0	100.0	100.0	100.0
Row percent . . .	17.1	15.8	24.0	41.3	1.9	100.0
N	597	550	835	1,438	66	3,846

These single-vehicle accidents provide some more evidence of what might be termed the "dawn phenomenon," the tendency for accidents at dawn to look different from accidents at other times. Collisions with parked vehicles account for almost 10 percent of the accidents on divided rural roads at dawn, as compared to six percent overall. Similarly, driver drowsiness is coded as a contributing factor in 17 percent of the single-vehicle accidents on undivided rural roads at dawn compared to 5 percent for all time periods; driver inattention is coded for 14 percent of the dawn accidents in contrast to 7 percent overall. Drowsiness is coded for 29 percent of the accidents on divided rural roads at dawn as compared to 16 percent for all time periods, but inattention is coded for none of these dawn accidents.

THE "DAWN PHENOMENON"

It seems reasonable to associate some kind of fatigue with the over-representation of certain kinds of accidents at dawn. The question then arises as to whether this fatigue is explained by long hours at the wheel. The TIFA file contains information on the number of hours the driver of the truck had been driving at the time the accident occurred. It seemed reasonable to examine the distribution of this variable by light condition.

Table 18 shows this relationship. The cumulative percent of involvements is shown by light condition for all involvements in the 1980–82 TIFA file with known hours driving and known light condition. The percentage of involvements attributable to drivers who had been behind the wheel for more than a given number of hours can readily be ascertained. The results do not confirm any abnormal number of involvements at dawn by drivers who had been driving long hours. Indeed only 14.4 percent of the involvements at dawn occurred to drivers who had been driving for six or more hours as compared to 27.5 percent overall and 39.1 percent at dusk. More than half the involvements at dawn occurred to drivers who had been at the wheel for only one or two hours.

Table 18

TIFA 1980–82:
Cumulative Percent of Involvements by Hours Driving and Light Condition

Hours Driving	Daylight	Dark	Dark but Lighted	Dawn	Dusk	All
11 or more	0.8	1.6	2.1	0.8	1.9	1.1
10 or more	1.5	3.8	4.3	1.5	6.2	2.5
9 or more	3.4	7.6	7.5	2.3	11.2	5.0
8 or more	8.5	14.4	13.8	3.0	18.0	10.7
7 or more	14.9	21.1	20.2	8.7	27.3	17.2
6 or more	25.4	30.8	32.0	14.4	39.1	27.5
5 or more	35.6	40.9	40.6	20.1	47.8	37.4
4 or more	48.9	53.0	52.9	27.7	63.4	50.2
3 or more	62.0	65.0	62.6	41.3	72.0	62.6
2 or more	76.9	77.9	74.4	57.2	80.7	76.7
1 or more	100.0	100.0	100.0	100.0	100.0	100.0
N	6,950	3,583	845	264	161	11,803

NOTE: In addition to the chi-square test, the Kruskal-Wallis test was run for this table, since hours driving is an ordinal rather than a nominal scale. The test statistic was significant at the .001 level, indicating that the distribution of hours driving does vary by light condition. For the Kruskal-Wallis test and its appropriateness for contingency table analysis, see W.J. Conover, *Practical Nonparametric Statistics*, 2nd ed. (New York: John Wiley & Sons, 1980), pp. 232–3.

Examination of hours driving by road class indicated that the percentage of involvements attributable to drivers who had been driving for six or more hours was consistently smaller at dawn than the overall percentage for the road class. Thus on divided urban roads 19.4 percent of the dawn involvements were to drivers who had been behind the wheel for six hours or more as compared to 27.4 percent overall. On undivided urban roads the comparable figures were 0.0 percent at dawn and 26.5 percent overall; on divided rural roads they were 21.1 percent at dawn and 30.4 percent overall; and on undivided rural roads they were 13.3 percent at dawn and 26.6 percent overall.

Thus there seems little reason to attribute any excessive fatigue of drivers at dawn to long hours at the wheel, i.e. to driving through the night. Instead, most of these drivers appear, when they are involved in fatal accidents, to be at the start of their work day. The apparent fatigue may then be a result of diurnal rhythms rather than of exhaustion at the end of long work days. This makes the selection of appropriate countermeasures much more problematic than it would be if the major cause were excessive hours of driving.

CONCLUSIONS

Road class is an important environmental factor in determining both probability of an accident and accident type. A data set on the safety of large trucks, whether it contains accident or exposure data, neglects road class at its peril. This is perhaps the greatest shortcoming of those databases such as the Truck Inventory and Use Survey that collect mileage only in annual aggregates. Although the four-way breakdown of road class that has been generally used here is not the only possible one, it seems reasonable to use a classification that at least separates limited-access or divided roads from other roads, and that distinguishes rural from urban roads.

In examining the contribution of the various types of road to the overall number and rate of fatal accident involvements by large trucks, accidents on rural undivided or non-interstate roads emerge as constituting a large share of the problem. While in the public perception the most common type of fatal accident involving a large truck is probably an accident on a rural interstate, such roads account for only 13 percent of the fatal accident involvements of large trucks. On the other hand rural non-interstate roads account for 54 percent of the involvements, and rural undivided roads account for 48 percent. If exposure is taken into account, rural non-interstate roads appear to have higher fatal accident involvement rates for combination trucks than any other class of road at 0.86 involvements per 10 million VMT; rural interstates have the lowest rate at 0.29 involvements per 10 million VMT.

It has also been found that accident type varies significantly by road class. This has important ramifications for the selection of countermeasures: a countermeasure that reduces rollovers by large trucks will have little impact on the number of single-vehicle fatal truck accidents on city streets, and a countermeasure that increases truck conspicuity to reduce nighttime accidents may have a greater benefit on divided rural roads than on undivided rural roads.

Finally, one somewhat curious factor has emerged. In both the single-vehicle accidents and the two-vehicle accidents, the dawn period frequently stands out as different in some important respects from other time periods. Thus in single-vehicle accidents on divided rural roads, crashes into parked vehicles are over-represented at dawn. In accidents involving a truck and another kind of vehicle on undivided rural roads, head-on collisions are over-represented at dawn. While some kind of fatigue seems a likely explanation of this "dawn phenomenon," the fatigue does not appear to be caused by long hours at the wheel, but rather by disturbance of natural diurnal rhythms. This topic clearly merits further research.

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