Standard Title Page — Report on State Project

Report No. VTRC 93-R11	Report Date Mar. 1993	No. Pages 20	Type Report: Final Report	Project No. : 9281-062-940
			Period Covered:	Contract No. :

Title and Subtitle

The Effect of Trailer Width and Length on Large-Truck Accidents

Key Words

accident rates, large trucks, trailer widths, trailer lengths, lane widths

Author(s)

Nicholas J. Garber, Surbhi Patel, & Ravi Kalaputapu

Performing Organization Name and Address:

Virginia Transportation Research Council
Box 3817, University Station
Charlottesville, Virginia 22903-0817

Sponsoring Agencies' Names and Addresses

Virginia Department of Transportation
1401 E. Broad Street
Richmond, Virginia 23219

University of Virginia
Charlottesville
Virginia 22903

Supplementary Notes

None

Abstract

In 1982, Congress passed the Surface Transportation Assistance Act (STAA), which authorized the use of longer (14.63 m, or 48.0 ft) trailers and wider (2.6 m, or 102 in) trucks. In addition, it proposed a network of STAA-designated highways on which these larger vehicles would be allowed access. The use of the wider and longer trucks on primary and secondary routes is questioned due to the lower geometric standards of such routes compared to those of interstate highways, particularly lane width and curvature. The purpose of this study was to develop guidelines for state and local governments to determine the lane-width requirements for primary roads to allow the safe operation of different sizes of trucks.

Data on truck size collected at permanent and temporary weigh stations along various primary routes in Virginia were used with accident data to compute truck accident rates by type and size. The rates were analyzed using the t test at $\alpha = .05$ and analysis of variance to determine whether significant differences among accident rates existed for different sizes of trucks on different lane widths. The rates were higher on roads with lane widths of 3.05 m (10.0 ft) and 3.20 m (10.5 ft) than on roads with lane widths of 3.35 m (11.0 ft) and 3.51 m (11.5 ft). Also, rates were higher on roads with lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) than on roads with lane widths $\geq$3.66 m (12.0 ft). In addition, trucks with widths >2.44 m (8 ft) had higher accident rates on roads with lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft) and on roads with lane widths $\geq$3.66 m (12 ft); however, these rates were not significantly different than those for trucks with widths $\leq$2.44 m (8 ft). Overall, trailers with a length of 14.63 m (48 ft) had significantly higher accident rates than trailers with lengths <14.63 m (48 ft). Single-unit trucks had a significantly higher accident rate than passenger cars for all lane widths. Although the accident rate for tractor-trailers was higher than that for passenger cars, the difference was not significant.

FINAL REPORT

THE EFFECT OF TRAILER WIDTH AND LENGTH ON LARGE-TRUCK ACCIDENTS

Nicholas J. Garber
Faculty Research Engineer

Surbhi Patel
Graduate Research Assistant

Ravi Kalaputapu
Graduate Research Assistant

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

March 1993
VTRC 93-R11

902

SAFETY RESEARCH ADVISORY COMMITTEE

W. H. LEIGHTY, Chairman, Deputy Commissioner, Department of Motor Vehicles
J. D. JERNIGAN, Executive Secretary, Senior Research Scientist, VTRC
J. L. BLAND, Chief Engineer, Department of Aviation
R. J. BREITENBACH, Director, Transportation Safety Training Center, VCU
J. L. BUTNER, Traffic Engineering Division Administrator, VDOT
MAJ. J. K. COOKE, Assistant Chief of Law Enforcement, Department of Game and Inland Fisheries
M. L. EDWARDS, Executive Assistant, Office of the Secretary of Transportation
W. S. FELTON, JR., Adm. Coordinator, Commonwealth's Attorneys' Services and Training Council
P. D. FERRARA, Ph.D., Director, Division of Forensic Sciences, Department of General Services
D. R. GEHR, Assistant Commissioner—Operations, VDOT
J. T. HANNA, Assistant Professor, Transportation Safety Training Center, VCU
T. A. JENNINGS, Safety/Technology Transfer Coordinator, FHA
B. G. JOHNSON, Associate Specialist, Driver Education, Department of Education
SGT. P. J. LANTEIGNE, Operations & Tactics Bureau, Virginia Beach Police Department
W. T. McCOLLUM, Executive Director, Commission on VASAP
S. D. McHENRY, Director, Division of Emergency Medical Services, Department of Health
MAJ. R. P. MINER, Commander, Traffic Division, Fairfax County Police Department
COMM. S. E. NEWTON, Patrol Division, Albemarle County Police Department
J. T. PHIPPS, Director, Roanoke Valley ASAP
LT. COL. C. M. ROBINSON, Director, Bureau of Field Operations, Department of State Police
J. A. SPENCER, ESQ., Assistant Attorney General, Office of the Attorney General
E. W. TIMMONS, Director of Public Affairs, Tidewater AAA of Virginia
A. R. WOODROOF, ESQ., Manakin-Sabot, Virginia

TRAFFIC & PLANNING RESEARCH ADVISORY COMMITTEE

L. C. TAYLOR, Chairman, Salem District Traffic Engineer, VDOT
B. H. COTTRELL, JR., Executive Secretary, Research Scientist, VTRC
M. G. ALDERMAN, Regional Sign Shop Co-ordinator, VDOT
W. S. BLACK, Fredericksburg District Traffic Engineer, VDOT
J. BROWN, Bowling Green Resident Engineer, VDOT
J. L. BUTNER, Traffic Engineering Division Administrator, VDOT
J. CHU, Transportation Engineer Program Supervisor, VDOT TMS Center
B. R. CLARKE, Assistant Transportation Planning Engineer, VDOT
C. A. CLAYTON, Transportation Engineer Program Supervisor, VDOT–Traffic Engineering
D. E. COLE, Bristol District Traffic Engineer, VDOT
G. R. CONNER, Assistant Rail & Public Transportation Administrator, VDOT
J. C. DUFRESNE, Culpeper District Traffic Engineer, VDOT
Q. D. ELLIOTT, Williamsburg Resident Engineer, VDOT
D. L. FARMER, Chief Transportation Planner, Hampton Roads Planning Dist. Commission
C. F. GEE, State Construction Engineer, VDOT
C. D. HALL, Assistant State Traffic Engineer, VDOT
J. T. HARRIS, Transp. Eng. Program Supervisor, VDOT—Location & Design
S. D. HENSHAW, Suffolk District Traffic Engineer, VDOT
K. J. JENNINGS, Senior Transportation Engineer, VDOT—Maintenance Division
T. A. JENNINGS, Safety/Technology Transfer Co-ordinator, FHA
Y. LLORT, Northern Va. District Planning & Operations Engineer, VDOT
T. W. NEAL, JR., Chemistry Lab Supervisor, VDOT
R. L. SAUVAGER, Assistant Urban Division Administrator, VDOT
W. W. WHITE, District Tunnel & Tolls Engineer, VDOT

ABSTRACT

In 1982, Congress passed the Surface Transportation Assistance Act (STAA), which authorized the use of longer (14.63 m, or 48.0 ft) trailers and wider (2.6 m, or 102 in) trucks. In addition, it proposed a network of STAA-designated highways on which these larger vehicles would be allowed access. The use of the wider and longer trucks on primary and secondary routes is questioned due to the lower geometric standards of such routes compared to those of interstate highways, particularly lane width and curvature. The purpose of this study was to develop guidelines for state and local governments to determine the lane-width requirements for primary roads to allow the safe operation of different sizes of trucks.

Data on truck size collected at permanent and temporary weigh stations along various primary routes in Virginia were used with accident data to compute truck accident rates by type and size. The rates were analyzed using the *t* test at $\alpha = .05$ and analysis of variance to determine whether significant differences among accident rates existed for different sizes of trucks on different lane widths. The rates were higher on roads with lane widths of 3.05 m (10.0 ft) and 3.20 m (10.5 ft) than on roads with lane widths of 3.35 m (11.0 ft) and 3.51 m (11.5 ft). Also, rates were higher on roads with lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) than on roads with lane widths ≥3.66 m (12.0 ft). In addition, trucks with widths >2.44 m (8 ft) had higher accident rates on roads with lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft) and on roads with lane widths ≥3.66 m (12 ft); however, these rates were not significantly different than those for trucks with widths ≤2.44 m (8 ft). Overall, trailers with a length of 14.63 m (48 ft) had significantly higher accident rates than trailers with lengths <14.63 m (48 ft). Single-unit trucks had a significantly higher accident rate than passenger cars for all lane widths. Although the accident rate for tractor-trailers was higher than that for passenger cars, the difference was not significant.

FINAL REPORT

THE EFFECT OF TRAILER WIDTH AND LENGTH ON LARGE-TRUCK ACCIDENTS

Nicholas J. Garber
Faculty Research Engineer

Surbhi Patel
Graduate Research Assistant

Ravi Kalaputapu
Graduate Research Assistant

INTRODUCTION

The federal government passed the Surface Transportation Assistance Act (STAA) in 1982, to become effective on January 1, 1983. It was passed in an attempt to increase the productivity of the trucking industry by removing restrictive limits on truck size in certain states and creating uniformity in national minimum standards.[1] With the enactment of the STAA, all states were required to increase any size limits that were lower than those of the federal government. Trailer length could not be limited to less than 14.63 m (48.0 ft), truck width was authorized up to 2.59 m (8.5 ft), and twin-trailers were legalized in all states. Virginia was one of the states with more restrictive size and weight regulations. Before the STAA, Virginia permitted the use of trucks with a maximum trailer length of 13.72 m (45.0 ft) and a maximum width of 2.44 m (8 ft) and did not allow the use of twin-trailer trucks.

In 1983, for the first time, the rate of increase of large-truck vehicle miles of travel (VMT) in Virginia exceeded that of passenger cars. Between 1979 and 1982, large-truck VMT increased approximately 1 percent annually, whereas that for passenger cars, vans, and pickups increased by about 2.6 percent. Between 1983 and 1990, these figures jumped to 8.5 percent for trucks and 6.5 percent for passenger cars, vans, and pickups. At the same time VMTs increased for trucks, their fatal and total accident rates exceeded those for passenger cars, vans, and pickups. In 1990, for example, the fatal accident rate per 100 million VMT for all large trucks on the primary highways in Virginia was 4.49 and for tractor-trailers was 5.36; that for passenger cars, vans, and pickups was 1.84. In 1990, the total accident rate for all large trucks on the primary highways in Virginia was 202.4 per 100 million VMT, and that for passenger cars, vans, and pickups was 181.8. It is likely that these accident rates reflect the incompatibility of the roadway geometric characteristics and the characteristics of large trucks.

The design of roadways is influenced by vehicle characteristics and performance, which may include the minimum turning radius, offtracking, length, width, braking, and weight-to-power ratio.[2] The turning radius and offtracking are particularly important in the design of curves and turns. With the change in size of trucks, the design criteria change, thus presenting a question as to the adequacy of the existing primary highways, which have design standards less than those for interstate highways. Since these roads were designed to meet the needs of the smaller vehicles, the main concern is whether the existing roads provide a safe traveling environment for the larger trucks. Unfortunately, there have been very few studies conducted on the relationships between lane width, vehicle size, and accident rate. The studies carried out thus far relate to either the effect of lane and shoulder width on accident rates or the accident rates of different vehicle types. For example, a number of studies have investigated the accident characteristics of different types of vehicles (passenger cars, single-unit trucks, tractor-trailers) with different lane and shoulder widths.[3–5] In general, the results of these studies suggest that accident rates increase with decreased lane width. For example, Garber and Joshua[3, 4] found that lane width has the greatest effect on the probability that a truck accident will occur and that the probability of a truck accident increases as lane width decreases. They developed regression models to describe the relationship between large-truck involvement in accidents and associated traffic and geometric variables. They concluded that the Poisson regression models developed adequately describe the relationship between large-truck involvement in accidents and associated traffic and geometric variables.

Zeeger and Perkins,[6] Rinde,[7] and Turner et al.[8] classified accidents into the following categories:

- run-off road (ROR)
- opposite direction (OD)
- rear end
- passing vehicle
- driveway and intersection.

They found that only ROR and OD accidents were associated with lane width. An increase in lane width from 2.43 m (7 ft) to 3.96 m (13 ft) was associated with a decrease in the percentage of ROR and OD accidents from more than 90 percent to around 31 percent. Zeeger and Deacon also found that lane widening can result in greater accident reductions (from 10 to 39 percent, depending on the amount of widening) and that a decrease of 32 percent in accident rates occurred when lane widths were increased from 2.74 m (9 ft) to 3.66 m (12 ft).[5] The TRB special report on twin-trailers suggested that lane widths suitable for trucks 2.44 m (8 ft) wide were also suitable for trucks 2.59 m (8.5 ft) wide, though offtracking will be greater by about 0.15 m (6 in).[2]

The studies completed so far regarding the implications of shoulder width for accidents have been inconclusive and their results contradictory.[3–5] Engineering guidelines concerning shoulder width have placed more emphasis on the minimum shoulder width necessary for emergency parking than on the effect of shoulder width on accident rates. Although some studies concluded that wider shoulders are associated with an increased number of accidents, others found that shoulder width had little or no effect on accident rates.[3,4] Still other studies indicated significantly fewer accidents on roadways with wide or paved shoulders than on those with narrow or unpaved shoulders. The contradictions can be related to the discrepancies in the analysis of the accident data.[5] For example, one important drawback of all studies of lane and shoulder width has been that none of them considered the effect of various combinations of lane and shoulder width on accident reduction.

In considering the impact on accidents of the absence of a shoulder, Turner et al. noted a higher frequency of ROR accidents on two-lane road sections with no shoulder.[8] Rogness et al. found a decrease in single-vehicle accidents when shoulders were added on low-volume, two-lane roads (ADT levels of 1,000 to 3,000).[9]

Zeeger and Perkins, in their evaluation of several studies, concluded that studies noting an association between wider shoulders and safer conditions were more reliable than those that did not note this association.[6] They arrived at this conclusion based on a set of criteria concerning the type of analysis used, the reliability of the data, the sample size, and the importance of relating shoulder width and different accident types.

Accident relationships developed by Garber and Sarath in Virginia,[3,4] Zeeger et al. in Kentucky,[10] Rinde in California,[7] and Rogness et al. in Texas[9] indicated the relative importance of lane width and shoulder width on accident rates. These studies indicated that lane width has a greater effect on accident rates than shoulder width. Wider shoulders were generally found to be effective in reducing accident rates at curves and winding sections because offtracking by large trucks, which results in lane encroachment, is prevented. Since ROR and OD accidents were found to be directly affected by lane and shoulder conditions, some of these studies selected ROR and OD accidents as the primary dependent variable for developing accident relationships. For example, Zeeger et al. found wider shoulders to be associated with 6 to 21 percent lower rates for ROR and OD accidents (depending on the amount of widening).[10]

The literature review identified no research or historical data sources that would allow direct comparisons of accident rates of the longer and wider vehicles with those of other combinations of vehicles. Very little data have been compiled on size characteristics of trucks. Also, few sources of accident records identify the length and width of the trucks involved. Consequently, the literature review identified no prior research that compared accident rates of trucks of different sizes on roadways of varying widths.

PURPOSE AND SCOPE

The primary purpose of this study was to determine whether there were significant differences in the accident rates of different sizes of single-unit and tractor-trailer trucks on roads with different lane widths. Based on the results, guidelines were to be developed for state and local governments to define reasonable access to trucks on primary roads and to establish lane width requirements for the safe operation of different sizes of trucks.

The scope of this study was limited to all the primary road sections within which permanent weigh stations are located in Virginia, and two additional roads where a temporary weigh station was installed, and the large-truck accident experience between 1987 and 1989 on these roads. The specific objectives of the study were the following:

1. Determine the trends in total accident and fatal accident rates for single-unit and tractor-trailer trucks for the period 1987 to 1989.
2. Determine the effect of lane width and truck width on accident rates for all trucks.
3. Determine the effect of lane width, truck width, and trailer length on accident rates for tractor-trailers.
4. Determine the effect of lane width, truck width, and truck length on the accident rate for single-unit trucks.
5. Determine whether there are significant differences in the accident rates of single-unit trucks and tractor-trailers of different sizes.

METHODOLOGY

Data Collection

AADT by Truck Type and Size

Sites on Virginia Routes 11, 13, 50, 58, and 301 were selected for the study as they carry the permanent weigh stations in the primary road system. Routes 17 and 20 were also chosen and monitored by the use of a temporary checkpoint with the aid of a portable weigh crew. All of the routes, with the exception of Route 50, are STAA-designated primary routes. The design criteria for primary roads in Virginia are set at slightly lower standards than for interstate highways in response to their differing functions. Interstates accommodate through movement exclusively, whereas primary roads facilitate through movement as well as some land access. Designated and nondesignated routes are defined according to the extent of land access permitted to trucks. Route 50 is nondesignated; thus, the state can put restrictions on truck access around the neighboring area. On designated routes, the longer and wider trucks can travel without state restrictions.

These seven routes have varying geometric characteristics: the lane widths vary from 3.05 m (10.0 ft) to more than 3.66 m (12.0 ft), and they carry approximately 24 percent of the total truck VMT in the primary system in Virginia. The lane widths for each section of roadway in the study were obtained from graphic logs provided by the Virginia Department of Transportation. The weigh station along each route was first located on the graphic logs. The route was then traced in each direction away from the station to the point of its first major intersection. These intersections represented points of entrance and exit of trucks along the roadway that might affect the control area. The distance between those two points of intersection, one on each side of the station, was the selected length of roadway to be analyzed. The reasoning behind this procedure is that the number and type of trucks traveling along this length of highway during any single day is a fixed quantity. A vehicle counted was assumed to traverse the entire section in which it was counted. Consequently, the truck-size data collected at the weigh station, together with the truck annual average daily traffic (TAADT) for each road section, can be used to determine the distribution and the VMT of each category of truck width and truck length on each section of road. Any truck accidents occurring within that distance can be attributed to that known quantity and type of truck, thus allowing the calculation of truck accident rates for different widths and lengths of trucks.

Data on truck sizes (widths and lengths) were collected at the weigh station on each route for 8-hour periods on 2 consecutive days. Where scales are set up for both directions, each 8-hour period was spent on a different direction. On the other hand, at the locations where only one set of scales is operational, both days were spent measuring both directions together. In general, all trucks passing through are required to go through the weigh station. However, when truck traffic backed up on the exit lane to the ramp, some trucks were allowed to bypass the data collection team. Therefore, it was not possible to measure all trucks that went by. Table 1 shows the type of station and the percentage of trucks measured out of the total number passing through the station.

Table 1
TRUCKS MEASURED AT EACH STATION

Route	Station	Number of Scales	Volume Passing	Number Measured	Percentage Measured
11	Hollins	1	496	408	82.3
11	Middletown	1	277	202	72.9
13	New Church	2	757	582	76.9
17	Portable	1	270	244	90.4
20	Portable	1	32	25	78.1
50	Aldie	1	288	229	79.5
58	Suffolk	2	1,934	1,116	57.7
301	Dahlgren	2	738	545	73.8

More than 70 percent of the trucks passing each station were measured except at Route 58, where about 58 percent were measured. The reason was the relatively high volume of truck traffic on that route, which resulted in many moretrucks being allowed to bypass the data collection team. The trucks were categorized as single-unit trucks or tractor-trailers, and the percentile distribution by width and length for each of these categories was determined.

Accidents by Truck Type and Size

Data on accidents in Virginia are obtained from police accident report forms, which are completed for every accident involving a fatality, an injury, or property damage of $500 or more. These reports are coded and stored in a computer system, also known as crash files. Accident data were extracted from the state's central computer accident data system and categorized with respect to truck type, truck size, and lane width for each location.

Analysis

Computation of Accident Rates

Distributions of truck by size were determined along each route according to truck width and trailer length. First, the VMT for single-unit trucks and tractor-trailers were calculated separately for each segment of roadway having a different lane width.

$$VMT_{sci} = LENGTH_s \times P_{sci} \times TAADT_{si} \times 365$$

where:

VMT_{sci} = vehicle miles of travel on segment *s* for truck category *c* (width or length) and truck type *i* (single-unit trucks or tractor-trailers)
$LENGTH_s$ = length of segment *s*
P_{sci} = the proportion on segment *s* of trucks in category *c* and truck type *i*
$TAADT_{si}$ = average annual daily traffic of truck type *i* on segment *s*.

The distributions (percentages) were then used to determine the VMT for each category of truck size. The VMTs, calculated for each part of the roadway having a different lane width, were used to calculate truck accident rates per 100 million VMT for the different segments, or:

$$ACR_{sci} = \frac{NOA_{sci}}{VMT_{sci}} \times 100{,}000{,}000$$

where:

ACR_{sci} = accident rate on segment *s* of trucks in category *c* and truck type *i*

NOA_{sci} = number of accidents on segment *s* involving trucks in category *c* and type *i.*

In addition, accident rates were calculated according to trailer length and truck width. To determine the effect of lane width on the accident rates, the rates were grouped according to the width of the lane at the site of the accidents. Three groups were established: 3.05 m (10.0 ft) and 3.20 m (10.5 ft); 3.35 m (11.0 ft) and 3.51 m (11.5 ft), and ≥3.66 m (12.0 ft).

Accident rates were also calculated for passenger cars along the routes that were studied. These rates were also categorized according to lane width in order to correspond to the truck accident rates and allow for significance testing between the two types.

Significance Testing

The *t* test and one-way analysis of variance (ANOVA) were used to test for significance at $\alpha = 0.05$. The *t* test was used in significance testing involving lane width, truck width, and truck length. The following null hypotheses were tested using the *t* test:

1. Large-truck accident rates on lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) are equal to those on lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft).
2. Large-truck accident rates on lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) are equal to those on lane widths ≥3.66 m (12 ft).
3. Large-truck accident rates on lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft) are equal to those on lane widths ≥3.66 m (12 ft).
4. Accident rates for all large trucks 2.44 m (8 ft) and >2.44 m (8 ft) wide are equal.
5. Accident rates for large trucks 2.44 m (8 ft) and >2.44 m (8 ft) wide on lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) are equal.
6. Accident rates for large trucks 2.44 m (8 ft) and >2.44 m (8 ft) wide on lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft) are equal.
7. Accident rates for large trucks 2.44 m (8 ft) and >2.44 m (8 ft) wide on lane widths ≥3.66 m (12 ft) are equal.
8. Accident rates for all trailers <14.63 m (48 ft) and 14.63 m (48 ft) long are equal.
9. Accident rates for trailers <14.63 m (48 ft) and 14.63 m (48 ft) long on lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) are equal.

10. Accident rates for trailers <14.63 m (48 ft) and 14.63 m (48 ft) long on lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft) are equal.

11. Accident rates for trailers <14.63 m (48 ft) and 14.63 m (48 ft) long on lane widths ≥3.66 m (12 ft) are equal.

The accident rates used for the *t* tests are shown in Tables A-1 through A-3 of the appendix. ANOVA was used to determine whether there were significant differences in accident rates between single-unit trucks and tractor-trailers, single-unit trucks and passenger cars, and tractor-trailers and passenger cars. The following null hypotheses were tested using ANOVA:

12. Accident rates for tractor-trailers and passenger cars are equal.

13. Accident rates for single-unit trucks and passenger cars are equal.

14. Accident rates for tractor-trailers and single-unit trucks are equal.

The accident rates used for the ANOVA test are shown in Table A-4 of the appendix.

RESULTS

Tables 2 and 3 show the percentile distributions by width and length for each truck category at each station. These tables show that the dominant trailer width is 2.44 m (8 ft) for both tractor-trailers and single-unit trucks, most trailers of tractor-trailers are ≤14.63 m (48 ft) in length, and single-unit trucks are mostly ≤9.14 m (30.0 ft) in length.

Table 2
PERCENTAGE DISTRIBUTION OF TRUCKS ACCORDING TO WIDTH

	Single-Unit Trucks Trailer Width (m)				Tractor-Trailers Trailer Width (m)	
Route	1.89-2.29 (6.2-7.5 ft)	2.32-2.41 (7.6-7.9 ft)	2.44 (8.0 ft)	>2.44 (>8.0 ft)	2.44 (8.0 ft)	2.59 (8.5 ft)
11 (HOL)	0	3.0	95.5	1.5	68.6	31.4
11 (MID)	0.9	1.8	95.5	1.8	82.6	17.4
13	9.5	29.0	58.2	3.3	75.3	24.7
17	0	8.2	67.8	24.0	76.7	23.3
20	7.7	7.7	61.5	23.1	83.3	16.7
50	7.0	2.4	68.2	22.4	69.0	31.0
58	0.8	0.2	96.8	2.2	52.8	47.2
301	1.0	1.5	95.5	2.0	70.0	30.0
Average	3.4	6.7	79.9	10.0	72.3	27.7

Table 3
PERCENTAGE DISTRIBUTION OF TRUCKS ACCORDING TO LENGTH

	Single-Unit Trucks Total Length (m)				Tractor-Trailers Trailer Length (m)			
Route	6.10 (<20.0 ft)	6.10-7.59 (20.0-24.9 ft)	7.62-9.14 (25.0-30.0 ft)	>9.14 (>30.0 ft)	<14.63 (<48.0 ft)	14.63 (48.0 ft)	14.66-16.12 (48.1-52.9 ft)	16.15 (53.0 ft)
11 (HOL)	16.2	37.1	21.8	24.9	79.0	19.5	0.5	1.0
11 (MID)	22.7	34.5	35.5	7.3	82.6	17.4	0	0
13		No lengths recorded				No lengths recorded		
17	22.2	29.6	29.6	18.6	83.9	14.5	1.6	0
20	15.4	30.8	30.8	23.0	83.3	16.7	0	0
50	23.5	34.1	25.3	17.1	84.5	12.1	3.4	0
58	8.1	20.2	59.5	12.2	69.5	26.9	0.7	2.9
301	9.1	34.4	23.4	33.1	69.6	29.7	0.5	0.2
Average	16.7	31.5	32.3	19.4	78.9	19.5	0.96	0.59

Figure 1 shows the overall accident rates for passenger cars, single-unit trucks, and tractor-trailers for 1987 through 1989, indicating a reduction between 1988 and 1989 for tractor-trailers. The fatal accident rates are shown in Figure 2, which indicates an increasing trend for single-unit trucks and a reduction between 1988 and 1989 for tractor-trailers.

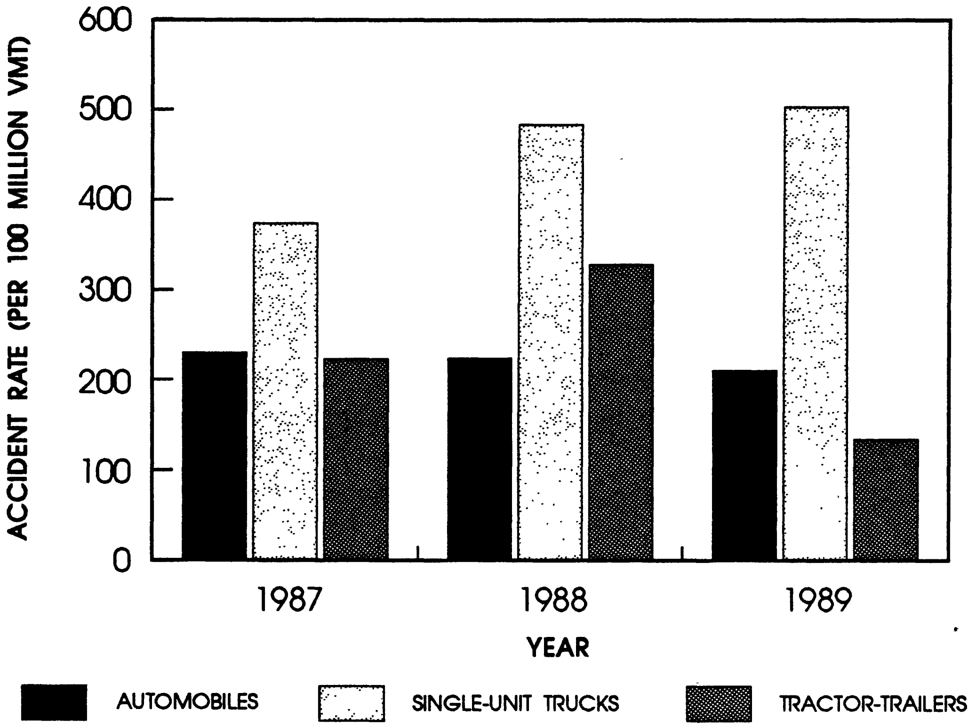

Figure 1. Average total accident rates for single-unit trucks, tractor-trailers, and passenger cars: 1987-1989.

91

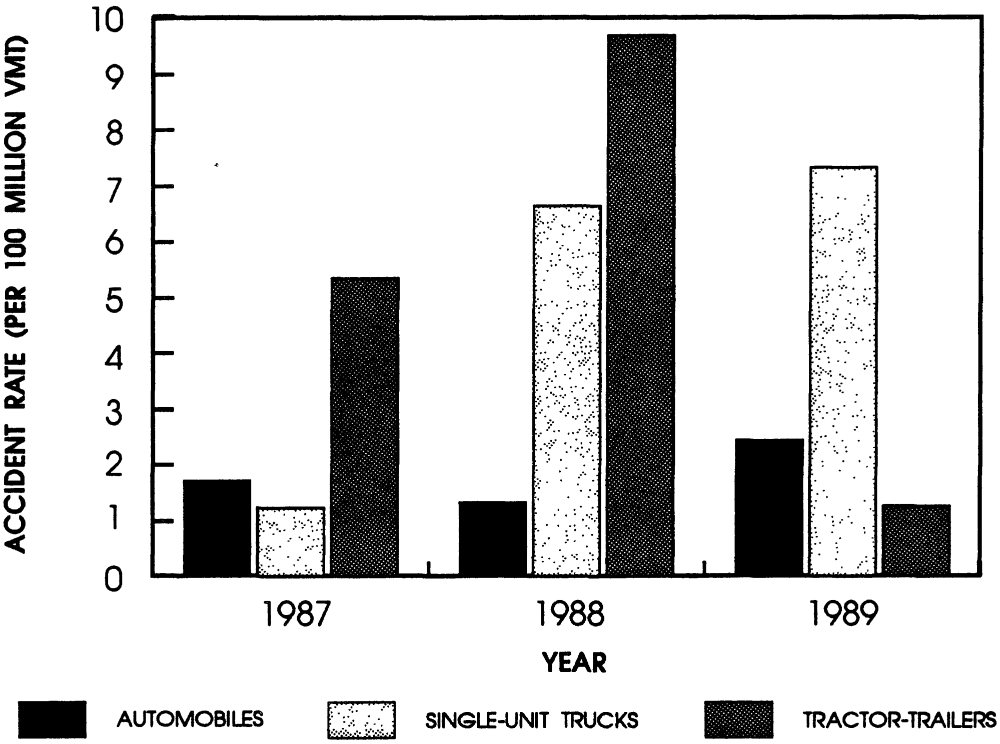

Figure 2. Average fatal accident rates for single-unit trucks, tractor-trailers, and passenger cars: 1987-1989.

Figure 3 shows the distributions for accidents by collision type for single-unit trucks and tractor-trailers. The predominant collision types are rear end, angle, and sideswipe same direction, which represent about 76 percent and 65 percent of all accidents for single-unit trucks and tractor-trailers, respectively.

The results of the *t* test shown in Table 4 indicate that the accident rates of large trucks (tractor-trailers and single-unit trucks) are significantly higher on sections of roads having lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) than on roads having lane widths of 3.35 m (11 ft), 3.51 m (11.5 ft), or ≥3.66 m (12 ft). However, there is no significant difference between the accident rates on road sections having lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft) and those having lane widths ≥3.66 m (12.0 ft). Null hypotheses 1 and 2 were therefore rejected, and null hypothesis 3 was not rejected.

Results of the *t* test shown in Table 5 indicate that although wider trucks (>2.44 m, or 8 ft) tend to have higher accident rates than trucks 2.44 m (8 ft) wide or less, particularly on road sections with lane widths of 3.05 m (10.0 ft) and 3.20 m (10.5 ft), as shown in Figures 4 and 5, this difference is not significant at $\alpha = .05$ even on road sections with lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft). Therefore, null hypotheses 4 through 7 were not rejected.

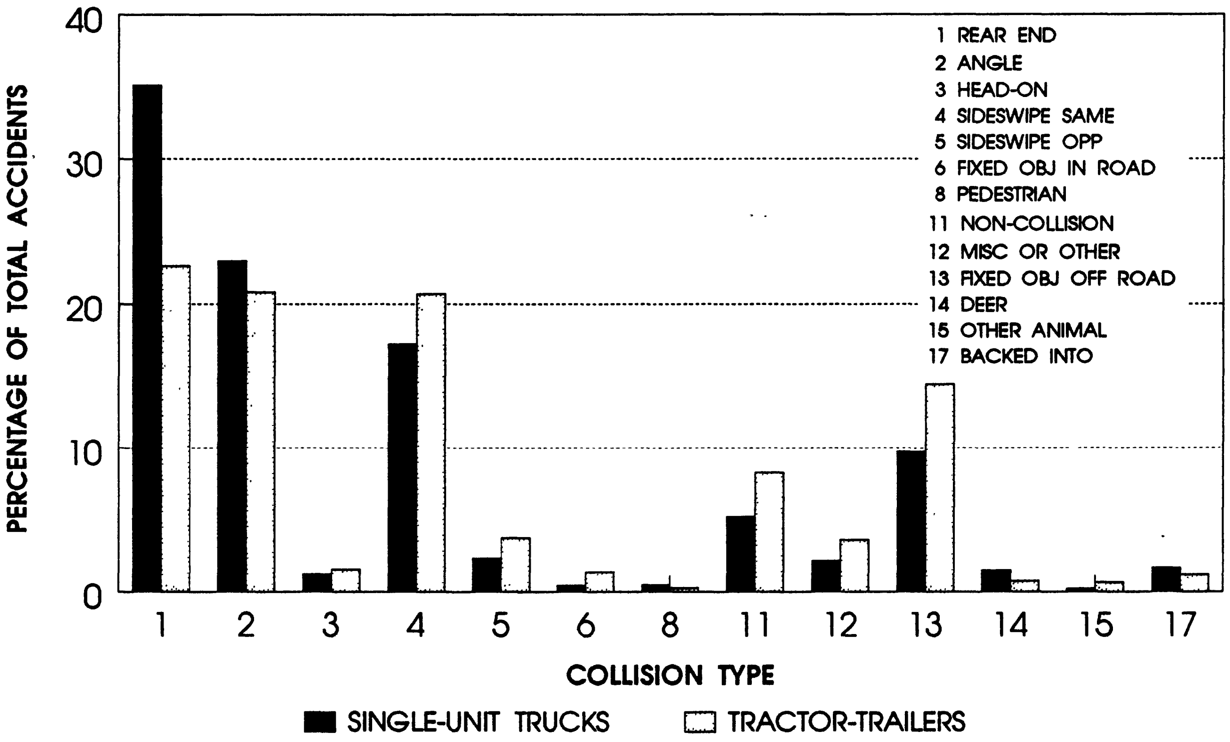

Figure 3. Percentage distribution of accidents by collision type.

Table 4
LANE WIDTH *t* TEST RESULTS

Assume the smaller lane is u_1.
Null hypothesis, H_o: $u_1 = u_2$ Alternate hypothesis, H_1: $u_1 > u_2$

Comparison	Calculated *t*	Critical *t* at 5% significance level
3.05 and 3.20 m vs 3.35 and 3.51 m lane width (10.0 and 10.5 ft vs 11 and 11.5 ft lane width)	4.4222800*	1.708
3.05 and 3.20 m vs ≥3.66 m lane width (10.0 and 10.5 ft vs ≥12.0 ft lane width)	3.8765600*	1.678
3.35 and 3.51 m vs ≥3.66 m lane width (11 and 11.5 m vs ≥12.0 ft lane width)	–.8434491	1.670

***Significance at 5% significance level.**

Table 5
TRUCK WIDTH t TEST RESULTS

Assume the 2.44 m (8.0 ft) truck is u_1.
Null hypothesis, H_0: $u_1 = u_2$ Alternate hypothesis, H_1: $u_1 < u_2$

Comparison	Calculated t	Critical t at 5% significance level
All 2.44 m vs >2.44 m (All 8.0 ft vs >8.0 ft)	–.5024734	1.671
3.05 and 3.20 m lanes: 2.44 m vs >2.44 m (10.0 and 10.5 ft lanes: 8.0 ft vs >8.0 ft)	–.6550574	2.015
3.35 and 3.51 m lanes: 2.44 m vs >2.44 m (11 and 11.5 ft lanes: 8.0 ft vs >8.0 ft)	–1.4990980	1.734
≥3.66 m lane: 2.44 m vs >2.44 m (≥12.0 ft lane: 8.0 ft vs >8.0 ft)	.4061606	1.694

Figure 6 shows the accident rates for tractor-trailers by trailer length and lane width. Figure 7 shows that tractor-trailers with trailer lengths >14.63 m (48 ft) have the highest accident rates, and tractor-trailers with trailer lengths <14.63 m (48 ft) have the minimum accident rates. The t tests conducted using the accident rates computed for all tractor-trailers with lengths <14.63 m (48 ft) and

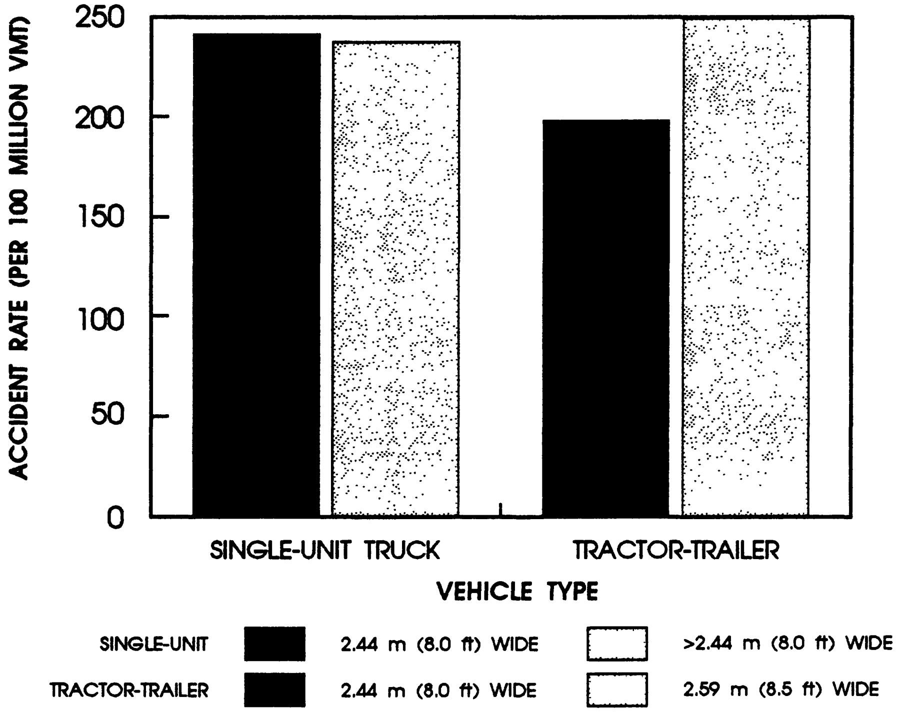

Figure 4. Average accident rates according to width for single-unit trucks and tractor-trailers: 1987-1989.

917

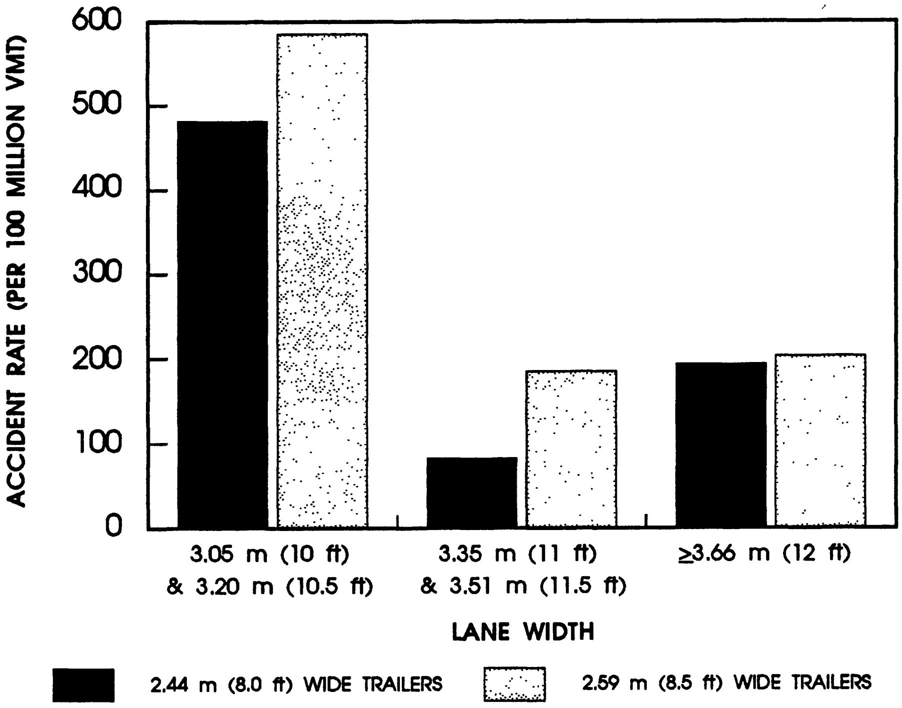

Figure 5. Average accident rates according to width and lane width for tractor-trailers: 1987-1989.

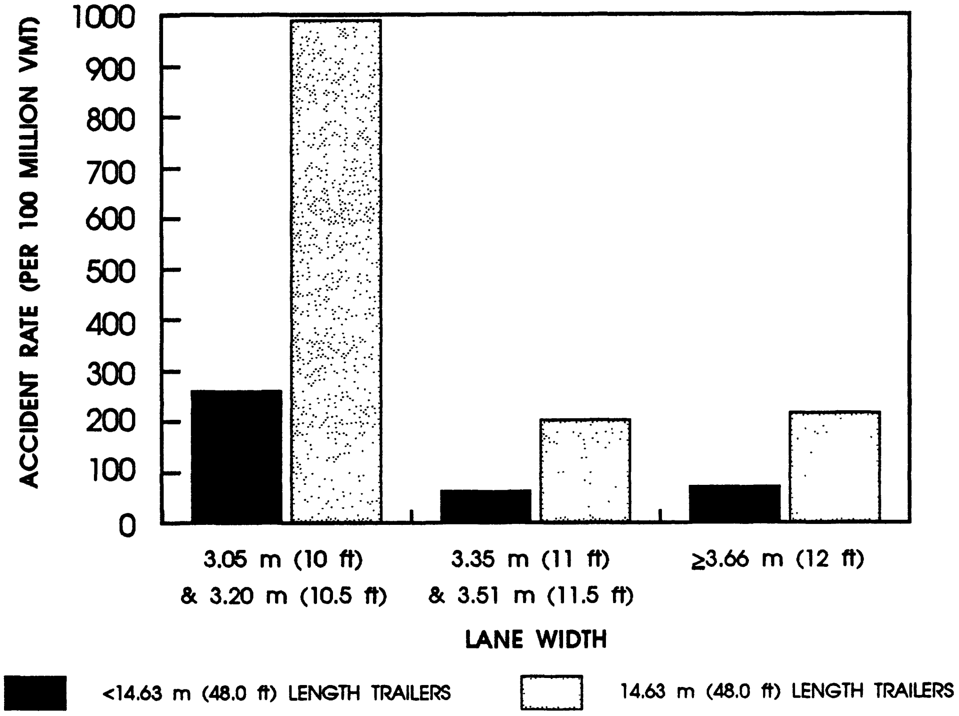

Figure 6. Average accident rates according to length and lane width for tractor-trailers: 1987-1989.

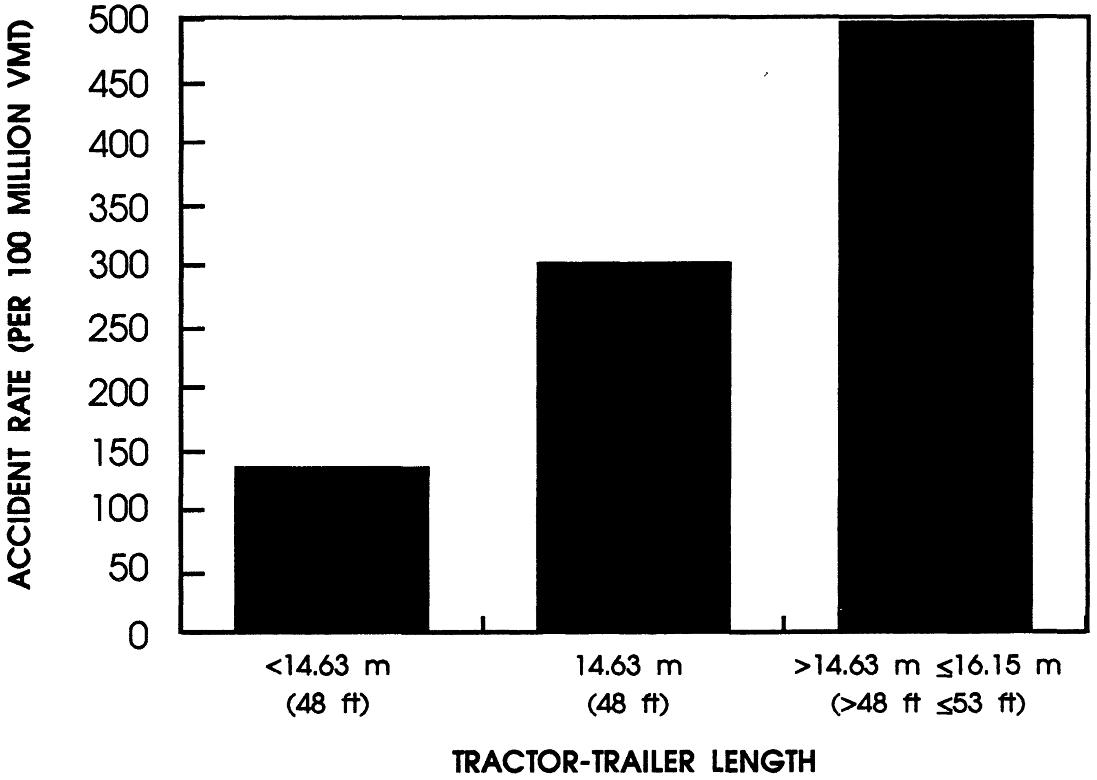

Figure 7. Average accident rates according to length for tractor-trailers: 1987-1989.

those with trailer lengths of 14.63 m (48 ft) showed that there was a significant increase in accidents for the longer trailers. These results are presented in Table 6. When the accident rates were compared for each lane width individually, there was a significant difference on the 3.35 m (11 ft) and 3.51 m (11.5 ft) lane widths, but not on the ≥3.66 m (12 ft) lane widths. There were insufficient data to test the 3.05 m (10 ft) and 3.20 m (10.5 ft) lane widths. Thus, null hypotheses 8 and 10 were rejected, null hypothesis 11 was not rejected, and null hypothesis 9 was indeterminable.

The results from ANOVA used for comparing rates computed for single-unit trucks, tractor-trailers, and passenger cars are shown in Table 7. The accident rates for tractor-trailers were found to be higher than those for passenger cars; however, this difference was not significant. On the other hand, there was a significantly higher accident rate for single-unit trucks when compared to passenger cars. Single-unit trucks were also found to have a significantly higher accident rate than tractor-trailers. Thus, null hypothesis 12 was not rejected, but null hypotheses 13 and 14 were rejected.

Table 6
TRACTOR-TRAILER LENGTH *t* TEST RESULTS

Assume the <14.63 m (48.0 ft) truck is u_1.
Null hypothesis, H_o: $u_1 = u_2$ Alternate hypothesis, H_1: $u_1 < u_2$

Comparison	Calculate *t*	Critical *t* at 5% significance level
All <14.63 m vs 14.63 m (All <48.0 ft vs 48.0 ft)	–1.8304330*	1.693
3.05 and 3.20 m lanes: <14.63 m vs 14.63 m (10 and 10.5 ft lanes: <48.0 ft vs 48.0 ft)	Not enough data available	
3.35 and 3.51 m lanes: <14.63 m vs 14.63 m (11 and 11.5 ft lanes: <48.0 ft vs 48.0 ft)	–2.3478700*	1.796
≥3.66 m lane: <14.63 m vs 14.63 m (≥12.0 ft lane: <48.0 ft vs 48.0 ft)	–1.6659630	1.761

*Significance at 5% significance level.

Table 7
RESULTS OF ANALYSIS OF VARIANCE

Comparison	Average Accident Rates	*F*	Significance of *F*
Tractor-trailer vs. passenger cars	317.83 vs 257.64	.533	.468
Single-unit truck vs. passenger cars	636.47 vs 257.64	11.239	.001
Tractor-trailer vs. single-unit truck	317.83 vs 636.47	4.571	.037

The following is a summary of the results:

- The predominant trailer width for all large trucks (tractor-trailer and single-unit trucks) on primary highways was 2.44 m (8.0 ft).
- Single-unit trucks with a 2.44 m (8.0 ft) trailer width were about 79.9 percent of the fleet of single-unit trucks on primary highways.
- The percentage of single-unit trucks on primary highways that had trailer widths greater than 2.44 m (8.0 ft) varied from 1.5 to 24, with an average of 10.0 percent.
- The percentage of tractor-trailers with a trailer width of 2.44 m (8 ft) was about 72.3.
- The percentage of tractor-trailers on primary highways having widths of 2.59 m (8.5 ft) varies from about 16.7 to 47.2, with the average being 27.7 percent.
- On primary highways, accident rates for large trucks increased between 1987 and 1989, although there was a decrease in the accident rate for tractor-trailers between 1988 and 1989.

9-31

- On primary highways, accident rates for single-unit trucks were significantly higher than those for passenger cars.
- Accident rates for large trucks (tractor-trailers and single-unit trucks) were significantly higher on primary road sections with lanes 3.05 m (10.0 ft) and 3.20 m (10.5 ft) wide than on primary road sections with lanes >3.20 m (10.5 ft) wide.
- Although on primary highways accident rates of large trucks with wider trailers (>2.44 m, or 8.0 ft) were higher than those for trucks with trailer widths ≤2.44 m (8.0 ft), this difference was not significant.
- Accident rates of tractor-trailers increased with increased trailer length from <14.63 m (48.0 ft) to 14.63 m (48.0 ft). However, this increase was not significant on road sections with ≥3.66 m (12.0 ft) wide lanes but was significant on road sections with 3.35 m (11.0 ft) and 3.51 m (11.5 ft) wide lanes.

CONCLUSIONS

- Accident rates of large trucks are higher on primary roads with lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) than on those with lane widths of 3.35 m (11 ft) and 3.51 m (11.5 ft). Also, accident rates of large trucks are higher on primary roads with lane widths of 3.05 m (10 ft) and 3.20 m (10.5 ft) than on roads with lane widths ≥3.66 m (12 ft).
- Lane width and trailer length seem to have a greater effect on large-truck accidents than the width of the truck.
- The critical lane width for large-truck accidents is between 3.05 m (10 ft) and 3.20 m (10.5 ft), i.e., large-truck accidents significantly increase on road sections with lane widths ≤3.20 m (10.5 ft).
- The accident rates of wider (trailer width >2.44 m, or 8 ft) trucks are higher than those for other trucks; however, the difference is not significant.
- The accident rates of longer (trailer length 14.63 m, or 48 ft) tractor-trailers are higher than those for other tractor-trailers, and the difference is significant.

RECOMMENDATIONS

- The results of this study should not be considered independently of a recent study by Garber and Sarath on large-truck safety.[3, 4] Although that study did not investigate the effect of truck size on truck safety because data on truck width were not available, it indicated that the probability of a large truck being involved in an accident depends on the geometric characteristics of the road in terms of the number and curvature of horizontal curves and the number of vertical curves and the grades of the tangents forming them. The development of guidelines for the selection of primary routes suitable for large-truck operations should, therefore, include some considerations of the geometric characteristics of the road.

- A special effort should be made to improve the data base for large trucks in Virginia, particularly the distribution of truck traffic with respect to width and length. In view of this, a statistically based sampling procedure should be developed that can be used to obtain statewide data annually on the size distributions of large trucks on the different classes of roads. This type of data would facilitate the successful completion of projects of this type on a statewide basis rather than on a limited number of road conditions.

- Traffic police officers should be informed that it is imperative that the width and length of each large truck involved in an accident be recorded. This will provide a good data base from which trend lines on the involvement of the different sizes of trucks can be determined.

- In order to substantiate the results obtained in this study, a similar study using data from all primary highways should be repeated as soon as the necessary data are available. In the meantime, the following guidelines are suggested for determining primary roads that can be used for large-truck operations:

  — When lane widths are ≥3.66 m (12.0 ft), no restrictions should be placed on large trucks.

  — When lane widths are >3.20 m (10.5 ft) but <3.66 m (12.0 ft), no restrictions should be imposed on single-unit trucks and tractor-trailers with trailer lengths ≤14.63 m (48.0 ft). However, road sections with restrictive geometric characteristics, such as sharp curves and/or inadequate sight distances, must be identified and warning signs placed to instruct large-truck drivers of these restrictions. In addition, the normal operating speeds of the highway should be reduced to an advisory level that allows for the safe operation of large trucks. These advisory speeds must be based on large-truck characteristics and not on those for passenger cars. Tractor-trailers with trailer lengths >14.63 m (48.0 ft) should, however, be restricted to these roads unless, in the opinion of the engineer, the geometric characteristics in terms of curvature and sight distance are superior to the minimum required for trucks traveling at the expected operating speeds.

  — When lane widths are ≤3.20 m (10.5 ft), all trucks with a trailer length >14.63 m (48 ft) should be restricted unless, in the opinion of the engineer, the geometric characteristics in terms of curvature and sight distance are superior to the minimum required for trucks traveling at the expected operating speed.

922

REFERENCES

1. Transportation Research Board. 1989. *Providing Access for Large Trucks*. Special Report 223. Washington, D.C.

2. Transportation Research Board. 1986. *Twin-Trailer Trucks.* Special Report 211. Washington, D.C.

3. Joshua, Sarath C., and Garber, N.J. 1990. Estimating Truck Accident Rates and Involvements Using Linear and Poisson Regression Models. *Transportation Planning and Technology*, 15: 41-58.

4. Garber, Nicholas J., and Joshua, Sarath C. 1991. *Traffic and Geometric Characteristics Affecting the Involvement of Large Trucks in Accidents: Part II.* VTRC Report No. 91-R18. Charlottesville: Virginia Transportation Research Council.

5. Zeeger C.V., and Deacon, John A. 1987. *Effect of Lane Width, Shoulder Width and Shoulder Type on Highway Safety.* State of the Art Report 6. Washington, D.C.: Transportation Research Board.

6. Zeeger, C.V., and Perkins, D.D. 1980. *Effect of Shoulder and Condition on Safety: A Critique of Current State of the Art*. Transportation Research Record 757, TRB. Washington, D.C.: Transportation Research Board.

7. Rinde, E.A. 1977. *Accident Rates vs. Shoulder Width*. Sacramento: California Department of Transportation.

8. Turner, D.S.; Fambro, D.B.; and Rogness, R.O. 1981. *Effects of Paved Shoulders on Accident Rates for Rural Texas Highways.* Transportation Research Record 819. Washington, D.C.: Transportation Research Board.

9. Rogness, R.O.; Fambro, D.B.; and Turner, D.S. 1982. *Before-After Accident Analysis for Two Shoulder Upgrading Alternatives*. Transportation Research Record 855. Washington, D.C.: Transportation Research Board.

10. Zeeger, C.V.; Mayes, J.G.; and Dean, R.C. 1981. *Cost-Effectiveness of Lane and Shoulder Widening of Rural Two Lane Roads in Kentucky.* Transportation Research Record 806. Washington, D.C.: Transportation Research Board.

11. Transportation Research Board. 1987. *Designing Safer Roads.* Special Report 214. Washington, D.C.

923

APPENDIX A

All accident rates are calculated per 100 million VMT.

Table A-1
AVERAGE ACCIDENT RATES FOR ALL TRUCK TYPES BY LANE WIDTH

Lane Width	Rate
3.05 and 3.20 m (10 and 10.5 ft)	496.6
3.35 and 3.51 m (11 and 11.5 ft)	150.6
≥3.66 m (≥12 ft)	214.1

Table A-2
AVERAGE ACCIDENT RATES BY TRUCK SIZE AND LANE WIDTH

	Single-Unit Trucks		Tractor-Trailers	
Lane Width	2.44 m (8 ft) Wide	>2.44 m (8 ft) Wide	2.44 m (8 ft) Wide	2.59 m (8.5 ft) Wide
3.05 and 3.20 m (10 and 10.5 ft)	381.5	—	481.6	584.1
3.35 and 3.51 m (11 and 11.5 ft)	175.3	479.0	82.4	185.1
≥3.66 m (≥12 ft)	269.8	176.9	193.0	203.2
All	241.3	237.3	199.4	249.2

Table A-3
AVERAGE ACCIDENT RATES BY TRAILER LENGTH AND LANE WIDTH

Lane Width	<14.63 m (48 ft) Trailer Length	14.63 m (48 ft) Trailer Length
3.05 and 3.20 m (10 and 10.5 ft)	369.9	—
3.35 and 3.51 m (11 and 11.5 ft)	69.7	219.3
≥3.66 m (≥12 ft)	77.2	215.2
All	138.2	217.1

92½

Table A-4
AVERAGE ACCIDENT RATES OF PASSENGER CARS, SINGLE-UNIT TRUCKS, AND TRACTOR-TRAILERS

Route	Passenger Car	Tractor-Trailer	Single-Unit Truck
11 (HOL)	253.7	502.5	585.6
11 (MID)	96.2	146.4	301.1
13	165.2	223.0	293.2
17	457.0	433.0	594.0
20	514.7	112.4	1,243.6
50	216.3	1,140.6	1,182.0
58	120.7	94.0	252.1
301	62.7	48.6	190.6