Operational Impacts of Wider Trucks on Narrow Roadways

David L. Harkey, Charles V. Zegeer, J. Richard Stewart, and Donald W. Reinfurt

A study was conducted to determine the differences in performance between 102-in.-wide and 96-in.-wide trucks and the impact that these trucks have on other traffic. Trucks that were studied primarily included random trucks in the traffic stream, although some control truck data were also collected to account for driver differences. Truck data were collected on rural two-lane and multilane roads that included curve and tangent sections and a variety of roadway widths and traffic conditions. The data collection effort resulted in approximately 100 hr of videotape and 9,000 slides from which various measures of effectiveness (MOEs) were extracted. Several MOEs were used to test for the operational effects of differential truck widths, lengths, and configurations. Such measures included (a) lateral placement of the truck and the opposing or passing vehicle, (b) lane encroachments by the truck or opposing vehicle, and (c) edgeline encroachments by the truck or opposing vehicle. Analysis of variance and regression analysis techniques were used to determine the significance of and the relationship among the variables used. The results revealed that the wider trucks had significantly higher rates of edgeline encroachments and tended to drive closer to the centerline than the narrower trucks. The wide ranges for a number of the operational measures for a given route and truck type also revealed the importance of driver influence on truck operations.

The Surface Transportation Assistance Act (STAA) of 1982 (P.L. 97-424) was enacted January 6, 1983. This piece of legislation contained provisions that have had a major impact on the nation's trucking industry. Among the changes included in the STAA of 1982 were requirements for states to allow the following:

- Trailers with lengths up to 48 ft, previously 45 ft, and widths up to 102 in., previously 96 in., on the Interstate system and designated federal-aid primary (FAP) highways.
- Vehicles weighing up to the maximum permissive weight limit of 80,000 lb on the Interstate system.
- Twin trailers (two 28-ft trailers) on the Interstate system and designated FAP highways.

With these changes came an increase in the use of longer and wider trucks. In fact, 70 percent of the van trailers purchased in 1984 were 102 in. wide instead of the older 96 in. (*1*). This increase in the use of wider trucks has stimulated concern as to whether the operation of wider trucks in the traffic stream affects the safety of other vehicles on the roadway.

D. L. Harkey, Scientex Corp., Charlotte, N.C. 28202. C. V. Zegeer, J. R. Stewart, and D. W. Reinfurt, Highway Safety Research Center, University of North Carolina, Chapel Hill, N.C. 27599.

The lack of information about the safety of wider trucks makes the decisions about which routes are adequate for such operation difficult to justify. This leads to considerable controversy over the decisions made about route designation. For example, the *Motor Carriers' Road Atlas* clearly shows that some states—such as Arkansas, Ohio, and Indiana—have extensive truck networks whereas few routes in New York and Arizona allow large trucks (*2*). This study was designed to examine the safety effects of wider trucks on narrow roadways so that future decisions on operational impacts can be based on sound transportation engineering research.

STUDY OBJECTIVE AND GENERAL RESEARCH APPROACH

The purpose of this study was to determine the effects of truck width (102 versus 96 in.) on traffic operations and safety under various roadway and traffic conditions. Several truck lengths and configurations and their relative performance were also investigated. The primary focus was on random trucks in the traffic stream, although some control truck data were also collected to account for driver differences.

Many measures were used to test for the operational effects of differential truck widths, lengths, and configurations. Such measures included

- Lateral placement of the truck and the opposing or passing vehicle (distance from the centerline and distance from the edge of pavement, i.e., distance from the outside edge of the paved shoulder if a paved shoulder exists);
- Centerline encroachments by the truck or opposing vehicle (a centerline encroachment is defined as occurring when the outside edge of the left rear tire for the vehicle being followed or the left front tire of the opposing vehicle crosses into the adjacent lane); and
- Edgeline encroachments by the truck or opposing vehicle (an edgeline encroachment is defined as occurring when the right rear tire of the vehicle being followed or the right front tire of the opposing vehicle crosses the outside edge of the edgeline).

Truck data were collected on two-lane and multilane rural roads that included curve and tangent sections, a range of lane and shoulder widths (see Table 1), and a variety of traffic conditions. Although the ranges of pavement width are large, the majority of the segments had lane widths of 11 to 12 ft.

TABLE 1 Comparisons of Cars and Trucks

Effects	Percentage of Edgeline Encroachments (%)	Mean Distance from the Centerline (ft)	Mean Distance from the Edge of Pavement (ft)	Percent Within 1 ft of the Edge of Pavement (CLOSE)
DESCRIPTIVE STATISTIC				
Vehicle Type:				
Cars	4.9	3.96	7.76	1.5
96-in Semis	11.8	2.81	5.92	8.2
102-in Semis	22.7	2.60	5.95	9.6
Curvature:				
Tangent	10.2	2.94	5.78	8.4
Curve	24.3	3.39	8.55	1.7
ANALYSIS OF VARIANCE	p-value	p-value	p-value	p-value
Effects:				
Vehicle Width	<.001	<.001	<.001	.025
Curves	<.001	<.001	<.001	<.001
Width x Curves	.13	.24	.83	.15
Contrasts:				
Cars vs 96-in Semis	<.001	<.001	<.001	.035
Cars vs 102-in Semis	<.001	<.001	<.001	.009

The shoulder widths on US-71 were predominantly 4 to 8 ft; on US-1 and US-220, most shoulder widths were 0 to 4 ft.

In another phase of the study, existing truck fleet data bases were examined to assess the feasibility of quantifying the safety impacts of wider trucks. The results of this investigation led to recommendations on the most feasible manner to conduct an accident analysis of various truck sizes. A discussion of the work conducted in this phase of the study as well as more detail on these results can be found in the research report prepared for FHWA by Harkey et al. (*3*).

Several caveats should be made relative to the results that will be discussed. First, all of the traffic stream and control truck data were collected during daylight hours under good weather conditions (e.g., no rain, ice, or snow on the pavement). Truck operations may differ under nighttime and adverse weather conditions. Second, the results pertain to rural two-lane highway conditions including sections on tangents and curves and are not intended for extrapolation to urban roadway sections. Likewise, the results of this study cannot be extended to longer and wider trailers than those examined here.

LITERATURE REVIEW

Many studies have been conducted in recent years related to large-truck safety and operations, but only a few have specifically investigated the effects of truck width. For example, Seguin et al. studied the effects of truck size on vehicles performing same-direction passing maneuvers around trucks on two-lane roads, as well as the impact of truck size at freeway entrances and on narrow bridges (*4*). Lateral separation between the control truck and passing or opposing vehicles decreased as the width of the truck increased, but the frequency of shoulder encroachments was not affected by truck width. The authors concluded that drivers were sensitive to truck width but that the added width did not create a safety hazard. A 1986 study by Zegeer et al. examined the effects of various truck configurations (semis and doubles), lengths (40, 45, and 48 ft), and widths (96 and 102 in.) at intersections and on two-lane roads with respect to traffic operations and safety. Longer and wider trucks (102-in.-wide, 28-ft doubles, and 102-in.-wide, 48-ft semis) were found to have greater operational problems (e.g., increased change in lateral placement by opposing vehicles) for some restrictive geometrics than shorter, narrower trucks (*5*). A 1977 study by Parker in Virginia used traffic conflicts and evasive maneuvers as measures to assess the safety problems associated with housing units 12 to 14 ft wide. The author concluded that narrow pavements on mainly two-lane roads should be avoided when transporting these oversized loads (*6*).

The offtracking effects of buses 102 in. wide were studied by Kakaley et al. The wider bus was found to offtrack beyond 12-ft lanes on curves of 27 degrees, whereas it took curves of 31 degrees or more before the narrow (96-in.) bus exceeded the 12-ft lane width. No significant differences were found between the two widths with respect to lateral placement of passing or opposing vehicles (*7*). A 1972 study by Weir and Sihilling also found no differences in the lane placement of passing vehicles between buses of 96 and 102-in. widths (*8*).

Gericke and Walton examined effects of increased limits for legal truck size on elements of highway geometric design. Truck configuration and length were identified as the primary factors in AASHTO's formula for pavement width. The authors recommended widening lanes to at least 12 ft to ensure safe operation of 102-in.-wide trucks. Strict adherence to AASHTO shoulder-width standards was also recommended to handle the larger trucks (*9*).

Limited research is available on isolated effects of truck width, but there is some evidence that it can adversely affect traffic operations, particularly on roadways with restrictive geometrics.

DATA COLLECTION AND REDUCTION

Data for this study were collected on four roadway sections in North Carolina, Arkansas, and Virginia that included a range of traffic conditions and geometric features and a sufficient volume of trucks for which data could be collected. This sample included about 47 mi of two-lane segments, 21 mi of multilane segments, and 10 mi of two-lane segments with a truck-climbing lane. Two basic types of data collection were used for comparing these operational truck effects on rural roadway sections. First, traffic-stream trucks of different widths and lengths, and a smaller sample of cars and pickups, were inconspicuously followed through the entire length of a selected site by a data collection van, and 35-mm slides were randomly taken of opposing vehicles as they were alongside the followed vehicle. From these slides, lane placement and encroachment data of the followed and opposing vehicles, called lane placement data, were recorded. The width of the truck or car being followed was also determined from a slide taken as the vehicle passed over a set of marks in the roadway that had been carefully placed and scaled for this purpose. Second, a video system inside the van was used to film the path of the followed vehicle through the entire roadway section.

Data on all encroachments of the followed vehicle through the selected routes, called encroachment data, were recorded from the videotape, A second video system at a roadside location along the route was used to obtain the length of any truck being followed. These data were then added to the two data files. Roadway geometric data (e.g., lane width, shoulder width, and length and degree of curve) were collected in the field, supplemented with data from aerial photographs, and later merged with the lane placement and encroachment data files to develop the final files used in the analysis. From the four routes selected, data were collected for 174 trucks and 55 cars in the traffic stream. This resulted in about 7,400 slides and 3,600 encroachments over 3,900 mi of travel.

In addition, a separate data collection effort was performed using four control trucks. These were trucks loaned to the research team by a trucking company along with an experienced driver. The collection of control truck data served to enhance the study by controlling for driver effects that may vary by truck size or type. Assume, for example, that the larger trucks (i.e., 102-in.-wide trucks with 48-ft-long trailers) are generally being driven by more-experienced drivers than the smaller trucks (i.e., 96-in.-wide trucks with 45-ft-long trailers). This could happen if trucking companies were to assign better drivers to handle the larger trucks, assuming that they are more difficult to operate than smaller trucks. If this were so, a comparison of operational effects between the two trucks would result in not only a comparison of truck size effects, but a comparison of 102-in.-wide trucks with more-experienced drivers and 96-in.-wide trucks with less-experienced drivers. Thus, having data for traffic-stream trucks alone would not allow for determining whether an operational difference were due to the difference in truck size alone, the differing driver characteristics between the truck groups, or both.

The same driver made multiple runs with different control trucks on a preselected route with severe curvature. Runs were made using a double with two trailers 102 in. wide and 28 ft long; a semi with a trailer 102 in. wide and 48 ft long; a semi with a trailer 96 in. wide and 45 ft long; and a semi with a trailer 96 in. wide and 48 ft long. In all data runs using control trucks, the same tractor was used and the trailers were empty—in contrast to the traffic-stream trucks, which had a variety of tractor rigs and unknown trailer weights. The rear axles on the control truck trailer were also pulled back to achieve the worst possible offtracking patterns. Ninety-nine runs were made following the four configurations of control trucks. This resulted in 1,586 slides and only 29 encroachments over 1,800 mi of travel.

DATA ANALYSIS AND RESULTS

The data collection and analyses were structured to address the question, What are the operational effects of 102-in.-wide trucks compared with 96-in.-wide trucks while accounting for other truck and driver characteristics?

To answer, five specific secondary issues were addressed for the rural roadway scenario, since truck width could interact with truck configuration, trailer length, roadway geometrics, driver differences, and other factors in affecting operations. Following is a listing of these subissues along with a summary of the analysis results as related to each issue.

Subissue 1

How do the various truck configurations (e.g., semitrailers versus doubles) compare with each other with respect to operational practices?

There is some evidence in the data that doubles are operated slightly farther from the centerline and slightly nearer to the pavement edge than semis. For example, from average values of traffic-stream trucks, doubles were driven 2.93 ft from the centerline and 4.39 ft from the edge of pavement, and semis (both widths and lengths of 45 to 48 ft) were driven 2.37 to 2.82 ft from the centerline and 4.84 to 6.61 ft from the edge of pavement.

The control truck data revealed that the 102-in. double had a slightly higher encroachment rate of 0.056 encroachments per mile based on five encroachments in 10 runs covering 90 mi, which compares with an encroachment rate of 0.037 encroachments per mile for 96-in. and 102-in. semis based on runs covering 108 mi and 59 mi, respectively.

In addition to the lane placement of the truck itself, opposing vehicles on two-lane roads were found to be driven farther from the centerline when meeting doubles than when meeting cars or other truck types. This may be caused by the simple perception that doubles are indeed larger trucks.

Subissue 2

What are the effects on operational practices of truck trailer length (e.g., 45-ft versus 48-ft trailers), kingpin–to–rear axle (KRA) distance, and trailer width (e.g., 96-in. versus 102-in.)?

Four operational MOEs were used in addressing this issue, as well as others, and included

- Distance from the centerline (previously defined).
- Percentage of edgeline encroachments (proportion of slides taken in which the vehicle being followed is encroaching the edgeline).
- Distance from the edge of pavement (previously defined).
- CLOSE, a variable that indicates the proportion of slides taken in which the vehicle being followed is within 1 ft of the edge of pavement.

Shown in Figures 1 through 4 are the values for each of these MOEs for each truck width, length, and KRA distance used in the analyses, which primarily consisted of two-way analyses of variance (ANOVA).

The lane placement data of traffic stream trucks showed no consistently significant effect of trailer length or KRA distance on edgeline encroachments or distance to the centerline, nor on tangents or curves, for a given trailer width. However, trailer width was associated with significant differences in truck operations in many situations. Depending on trailer length and KRA distance, the percentage of edgeline encroachments for 96-in. trucks ranged from 10.7 to 16.4 percent and for 102-in. trucks, from 20.2 to 25.2 percent. The distance of the trucks from the centerline ranged from 2.63 to 2.82 for 96-in. wide trucks and from 2.37 to 2.69 feet for 102-in. trucks.

No significant effects due to trailer length or KRA were found with respect to either average distance to the edge of pavement (i.e., distance to the outside edge of the paved shoulder if a paved shoulder exists) or the percentage of times the truck was CLOSE (1 ft or less) to the edge of pavement. This finding may seem somewhat surprising, because offtracking for longer trailers and KRA distances is expected to be greater and thus to result in more encroachments. However, one must consider the characteristics of low-speed and high-speed offtracking of vehicles with longer trailers, and particularly longer KRA distances (greater than 36 ft in this study). For example, when making turns under speeds of 35 to 40 mph, trucks with longer KRA distances will have their rear trailer tires track to the inside of the path of the front tractor tires. On sharp curves this can result in severe encroachments over the centerline (on curves to the left) or the edgeline (on curves to the right). However, high-speed offtracking can cause the trailer to swing outward so the rear trailer tires more closely track the path of the front tractor tires. For example, on a curve with a 1,200-ft radius, a semi with a 48-ft trailer traveling at 55 mph will offtrack about 0.24 ft to the outside of the curve. The fact that the majority of the data were collected under high-speed conditions may be the primary reason that the lane placement data for the traffic-stream trucks resulted in no consistently significant effect of trailer length or KRA distance on edgeline encroachments or distance to the edge of pavement.

Two other possible explanations for the lack of effect of trailer length and KRA distance in the analysis should also be mentioned. First, on tangent sections, the trailer length and KRA distance have little or no effect on swept path since the swept path is basically the truck width. Many of the observations were made on tangent sections. Another possible explanation is related to the characteristics (including skill) of the drivers. For example, if drivers of longer (i.e., 48-ft) trucks were more skilled at handling their trucks than drivers

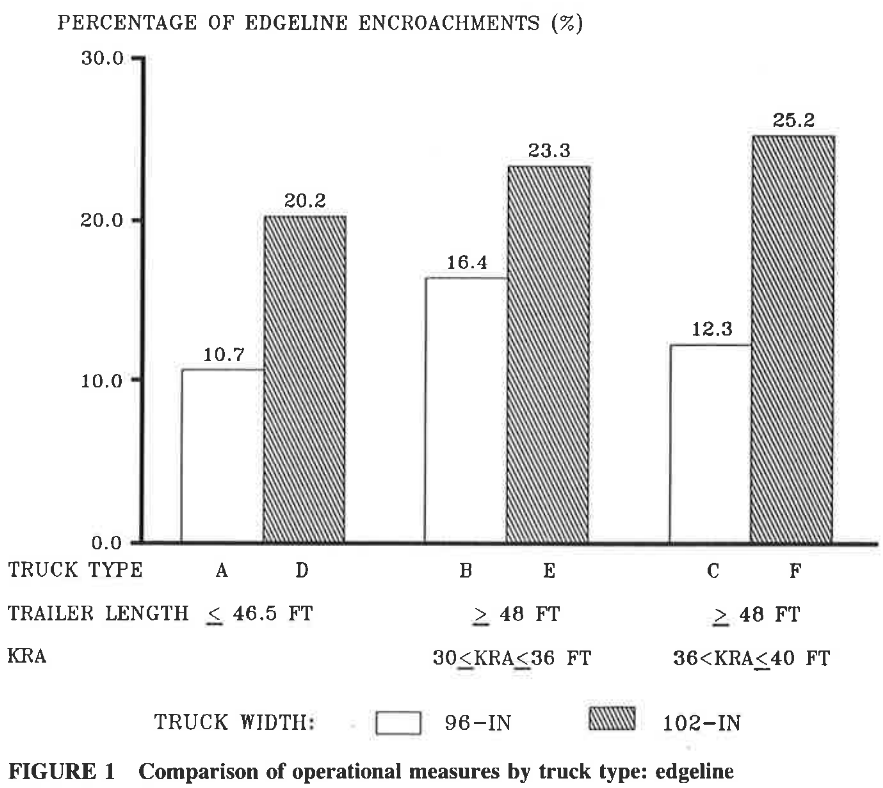

FIGURE 1 Comparison of operational measures by truck type: edgeline encroachments.

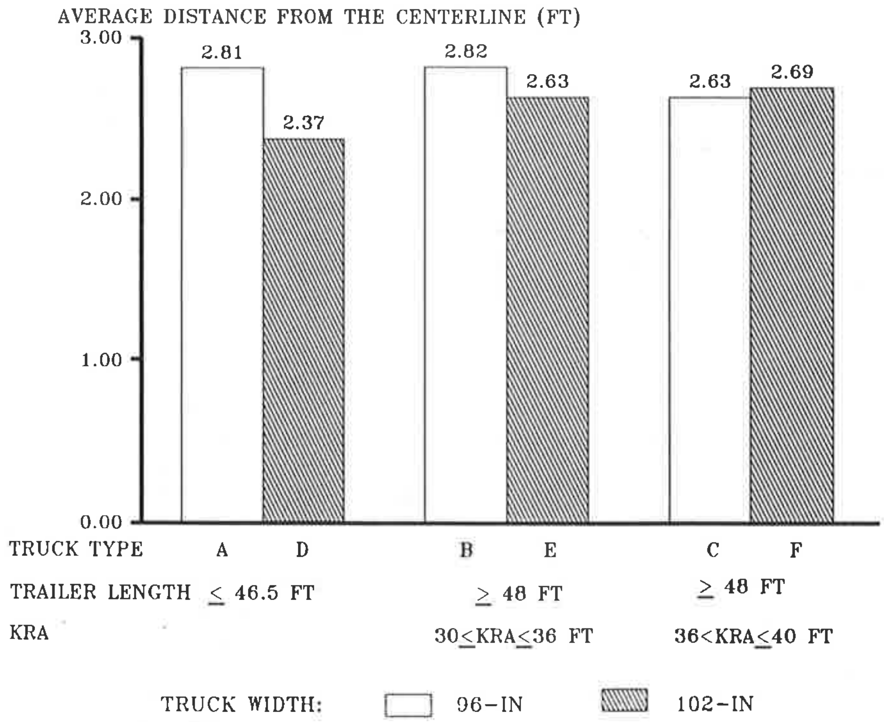

FIGURE 2 **Comparison of operational measures by truck type: average distance from centerline.**

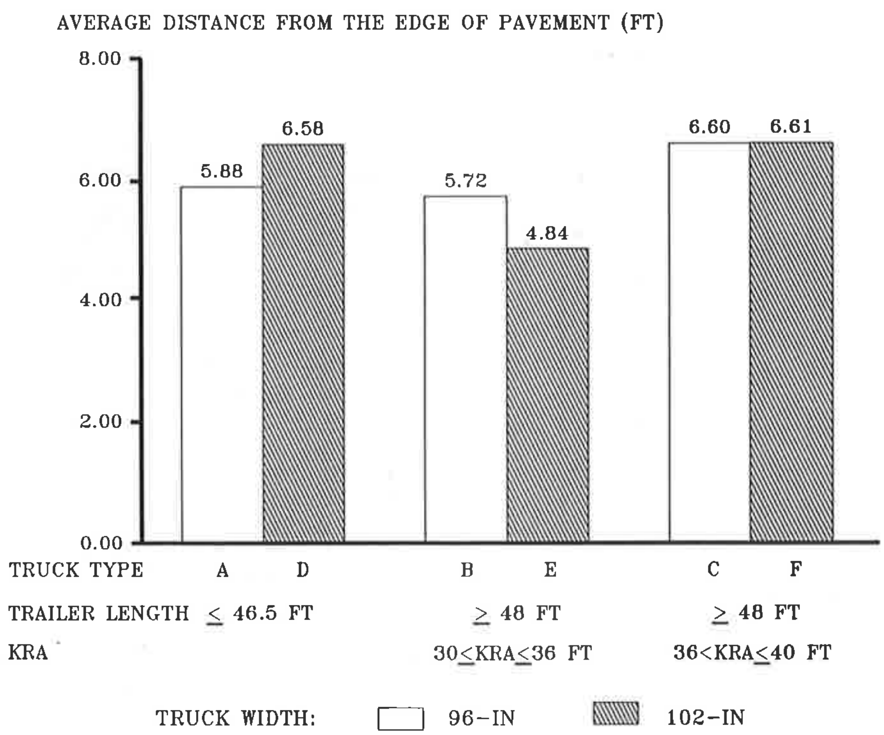

FIGURE 3 **Comparison of operational measures by truck type: average distance from edge of pavement.**

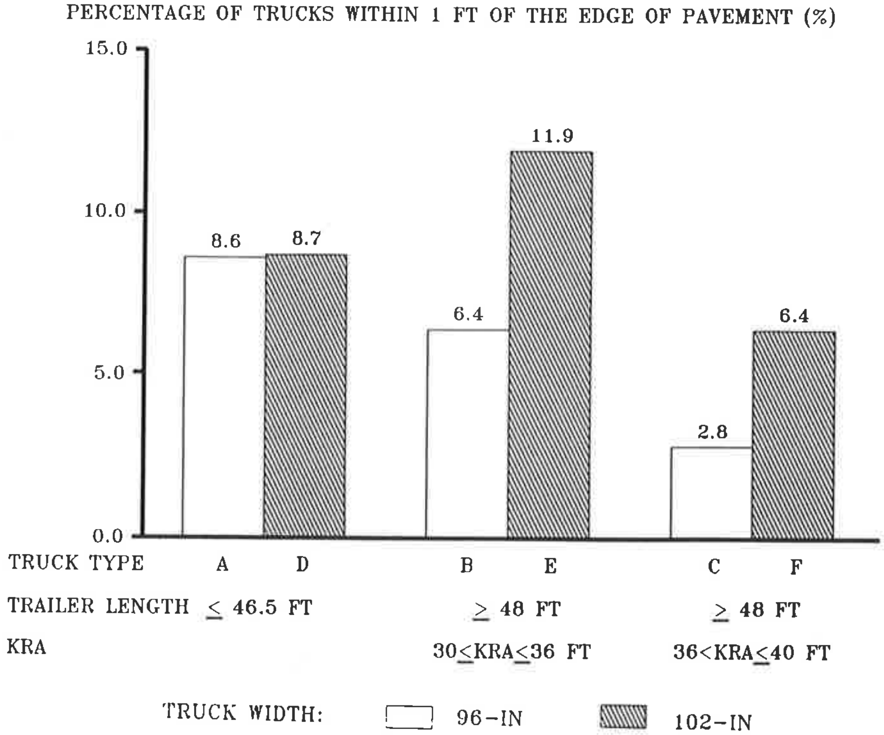

FIGURE 4 Comparison of operational measures by truck type: trucks within 1 ft of edge of pavement.

of shorter (i.e., 45-ft) trucks, this improved truck handling could help compensate for the added operational impacts of the increased trailer length or KRA distance.

The encroachment data collected in this study were analyzed separately for 96-in. and 102-in. semis to determine the degree to which trucks encroach beyond the edgeline. Such information was considered useful in determining the width of paved shoulders needed to accommodate large trucks that encroach beyond the edgeline. Distributions of edgeline encroachments were produced for the two-lane portions of the four sample segments because different roadway widths, curvature, and paved shoulder widths exist for each segment and such features were believed to affect truck placement (and amount of edgeline encroachment). A tire width was found to correspond to approximately 7 in. for purposes of translating tire widths to feet of encroachment.

The smoothed distribution of the total number of edgeline encroachments by tire width is shown in Figure 5 for both widths of truck on US-71A. This segment consists of moderate to severe curvature and grades and mostly paved shoulders of 6 to 10 ft. As one might expect, the greater width of paved shoulder allows more opportunity for encroachments beyond the edgeline, and the greater curvature may result in more of a tendency for drivers to "straighten out the curves," which

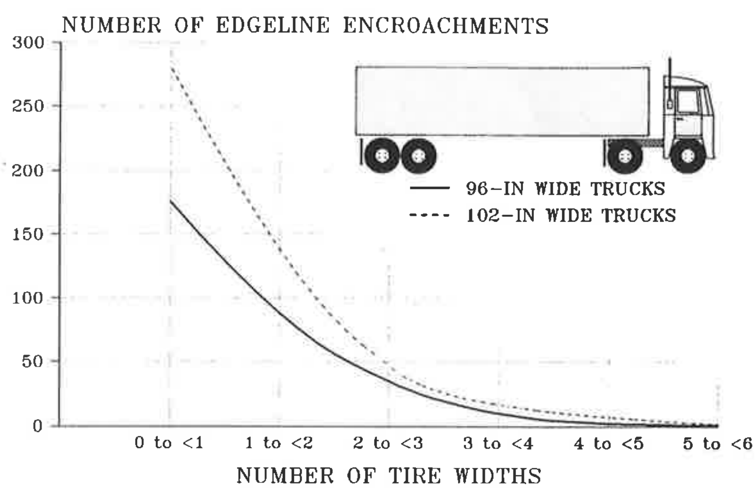

FIGURE 5 Distributions of edgeline encroachments on US-71A.

can result in shoulder encroachments. A greater number of edgeline encroachments existed for the 102-in. truck than for the 96-in. truck for encroachments of less than two tire widths (1.2 ft). Encroachment frequencies between two and six tire widths (1.2 to 3.5 ft) were quite similar for the two widths of truck and leveled off to near zero. Thus, even on this route with mostly moderate and some severe curvature and 6- to 10-ft shoulders, few trucks encroached beyond 3 ft. Similar distributions were produced for each of the other roadway segments at which data were collected.

Subissue 3

How do the operational characteristics of various truck types and sizes compare with cars? In other words, to what degree are large trucks, relative to cars, causing operational problems?

The lane placement data showed that cars have fewer edgeline encroachments and greater mean distances from the centerline and that they are driven farther from the edge of pavement than either the 96-in. or the 102-in. trucks (see Table 1). In fact, cars encroached the edgeline in only 4.9 percent of the cases when meeting opposing vehicles, compared with 11.8 percent for 96-in. trucks and 22.7 percent for 102-in. trucks. Mean distance from the centerline was 3.96 ft for cars, 2.81 ft for 96-in. trucks, and 3.60 ft for 102-in. trucks.

Cars, of course, may be expected to be driven farther from the edgeline and farther from the centerline than trucks because they are smaller. The mean distance of cars from the edge of pavement was 7.76 ft, compared with 5.92 and 5.95 ft for 96-in. and 102-in. trucks, respectively. These values indicate that all three vehicle types maintained a substantial distance from the edge of pavement.

In addition, a much smaller percentage of the cars than the trucks were CLOSE to the edge of pavement. This is again because cars are smaller. Only 1.5 percent of the cars were CLOSE to the edge of pavement as opposed to 8.2 and 9.6 percent of the 96-in. and 102-in. trucks, respectively. These values indicate a higher potential for running off the road for the 102-in. trucks than for passenger cars or 96-in. trucks.

Subissue 4

For a given truck type and size (e.g., 102-in. 48-ft semi), how much variation in operational measures is due to driver differences? In other words, do all drivers handle a given truck type in relatively the same manner or in different manners?

A wide range of vehicle behavior was found for a given route and truck type based on vehicle placement (see Table 2). For example, on US-1 in North Carolina, slides of the lane placements of 102-in. trucks revealed that an overall average of 20.2 percent of the trucks had edgeline encroachments. Of the 21 runs, the minimum and maximum percentages of edgeline encroachments were 6.5 and 58.6 percent, respectively. As another example, the 24 runs of 96-in. trucks on US- 220 had an overall average distance from the centerline of 2.89 ft, although the range of averages among the 24 trucks included a minimum of 2.09 ft and a maximum of 5.27 ft. Because this variation exists within a given route and for a given truck size, different driving behavior may be assumed to be important in explaining these results. This difference in driver behavior is further supported by the control truck data, which indicated that a given truck type can be operated consistently by the same driver in repeated runs and that different

TABLE 2 Variation Due to Driver and Vehicle for Distance from Centerline and Percentage of Edgeline Encroachments

			Distance From Centerline (ft)				Edgeline Encroachments (%)			
Location	Width (in)	No. of Runs	Mean	Min.	Max.	Sig.[a]	Mean	Min.	Max.	Sig.
US 1	102	21	2.22	1.72	2.92	yes	20.2	6.5	58.6	yes
	96	26	2.49	1.82	3.75	yes	8.5	0	25.7	yes
US 220	102	16	2.63	1.94	3.59	yes	14.7	0	40.6	yes
	96	24	2.89	2.09	5.27	yes	7.0	0	28.6	yes
US 71A	102	17	2.75	1.98	3.43	yes	31.8	7.7	66.7	yes
	96	21	2.90	1.89	3.39	yes	20.7	0	48.4	yes
US 71B	102	21	2.98	1.57	4.36	yes	23.7	0	61.1	yes
	96	24	3.11	2.21	3.97	yes	13.7	0	36.4	yes
	<96[b]	27	4.39	2.42	6.58	yes	5.1	0	66.7	yes

[a] Significant at .05 level using Analysis of Variance (ANOVA).

[b] <96 denotes cars and pickups.

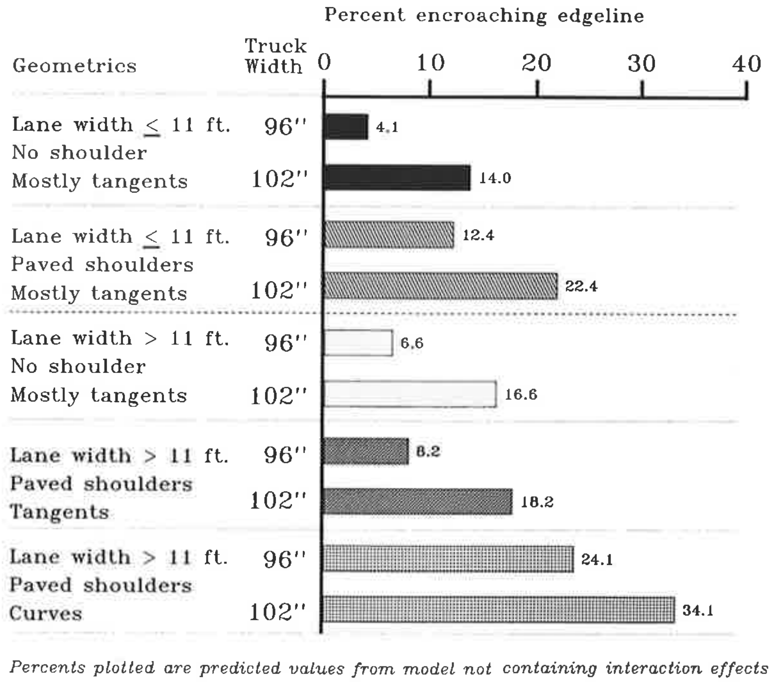

FIGURE 6 Percentage of trucks encroaching edgeline as result of road geometrics and truck width.

truck types can also be operated in a relatively similar fashion by the same driver.

Subissue 5

For a given truck type, how much operational variation occurs for various roadway geometrics?

Results from the initial ANOVAs indicated that both 102-in. and 96-in. trucks tended to be driven farther from the centerline and to have higher rates of edgeline encroachments on curves than on tangents. The percentage of edgeline encroachments was more than twice as high on curves (28.7 percent) as it was on tangents (12.8 percent). The average distance from the centerline was slightly higher on curves (3.04 ft) than on tangents (2.61 ft). This finding is, perhaps, the result of truck drivers' driving through curves cautiously: that is, where the pavement is wide enough on curves, drivers tend to move to the right (onto a paved shoulder, in some cases), thus increasing their clearance distance to opposing traffic.

Distance from the edge of pavement was considerably greater on curves (8.17 ft) than on tangents (5.38 ft), even though vehicles on curves were also farther from the centerline than vehicles on tangents. Trucks were also less likely to travel within 1 ft of the edge of pavement on curves (1.7 percent) than on tangents (10.0 percent). Again, these results are indicative of the wider paved shoulders on curves than on tangents.

A more-detailed analysis of geometrics and truck width examined the four dependent variables discussed previously along with two additional variables: (a) percentage of trucks within 1.75 ft of the centerline, and (b) percentage of trucks within 3.5 ft of an opposing vehicle. Of the variables examined, only the percentage encroaching the edgeline produced consistently significant results across all geometric categories (see Figure 6 and Table 3).

TABLE 3 ANOVA Results for Figure 6

Effect	Degrees of Freedom	Mean Square	p
Truck size	1	3.92	<.001
Geometrics	4	5.06	<.001
Interaction	4	.08	.85

CONCLUSIONS

Operational Differences

After these findings were examined, the following conclusions were drawn about the operational effects of the wider truck compared with the narrower truck:

- Wider trucks had significantly higher rates of edgeline encroachments than did narrower trucks.

This is reasonable because 102-in trucks require greater swept path widths than 96-in. trucks, all else being equal. Also, some drivers of the 102-in. trucks (particularly those with 48-ft trailers) were more likely to hug the edgeline on curves to the left, probably to avoid having the rear of their trailer encroach over the centerline.

- On average, wider trucks tended to be closer to the centerline than the narrower trucks were. For all four sites combined, the 102- in. trucks had higher centerline encroachment rates than the 96-in. trucks, although this result was not significant for any specific route because of the small samples of centerline encroachments.

This closeness to the centerline may be the result of two factors. First, the additional 6 in. of width for the 102-in. trucks could result in more of them being driven closer to the centerline than the 96-in. trucks because of their increased swept path. Thus, on winding, two-lane roads, this could translate into 102-in. trucks having a greater proportion of edgeline encroachments as well as being closer to the centerline.

The second factor relates to differential driving behavior for the two width categories when combined with the geometry of the test sites. If, for example, drivers of 102-in. trucks tend to hug the right edgeline on curved roads, one would expect a greater proportion of edgeline encroachments on roads with wide paved shoulders. However, on narrow curved roads with no paved shoulders, drivers of the 102-in. trucks would be limited in their ability to drive farther from the centerline (unless they encroach beyond the paved roadway). Thus, because of their greater swept path on curved roads, the 102-in. trucks would be expected to be closer to the centerline than the 96-in. trucks on narrow roadways.

Roadway Width Implications

The results of this study provided some insights on the width of paved shoulders needed to accommodate edgeline encroachments of large trucks. The study found that trucks encroach over the edgeline more frequently and to a greater degree where wide paved shoulders exist (i.e., the drivers use the paved shoulders as additional lane width). However, some trucks encroach over the edgeline even when little or no paved shoulder exists, which suggests an undesirable situation from a safety—as well as an operational—perspective. The data also showed that although 102-in. trucks encroach over the edgeline more often than 96-in. trucks, encroachments more than 3 ft beyond the edgeline were rare for both truck sizes for most roadway situations. There is also some evidence that trucks encroach more often on curves than on tangents, although this trend could not be clearly established from the available data.

On roadway sections having severe horizontal or vertical alignment, wider paved shoulders may be needed to provide adequately for large trucks. The use of 12-ft lanes and a minimum of 3-ft paved shoulders should be considered on rural roadways carrying truck traffic consisting of both 96-in. and 102-in. semis and doubles. In addition, the increased travel on such shoulders could result in a shorter pavement life. To minimize shoulder damage and maintenance problems and help ensure a stable shoulder for encroaching trucks, consideration should also be given to increasing the pavement thickness of the shoulder.

Providing paved shoulders of 3 ft or more will significantly increase construction costs on many roadway sections. In addition, rebuilding shoulders or adding shoulders that are designed to travel lane standards (i.e., to accommodate frequent truck encroachments) can also correspond to substantial costs for such improvements. Ideally, a benefit/cost analysis is needed to determine the economic feasibility of such shoulder construction projects. Such an analysis requires information on the accident effects of such improvements related to trucks and other vehicles, and such effects could not be quantified in this study.

It should also be remembered that the suggestion for a minimum of 3-ft paved shoulders applies only to truck sizes on the sample roadway sections in this study. The sample studied did not include semis with 53-ft trailers, triples (three 28-ft trailers), Rocky Mountain doubles (48- and 28-ft trailer combination), or the longer turnpike doubles (two 48-ft trailers). The offtracking characteristics of these longer trucks may require more paved surface than is suggested here. The reader should also remember that the analyses in this study were for rural two-lane and some multilane roadways and did not include any urban situations.

Safety Implications of Wider Trucks

The study results indicated that there are some operational differences associated with wider trucks that result from various restrictive geometric features. Some of these measures may be indicative of potential run-off-road events as a result of vehicles' traveling too close to the edge of pavement and potential opposite-direction accidents as a result of small clearance distances between the truck and an opposing vehicle. However, as is always the case with operational studies, it is difficult to translate differences in operational measures, such as truck placement within the travel lane and edgeline encroachments, directly into some predicted change in accident potential. This occurs because the link between these operational measures and subsequent accident experience has not been clearly established. But, as noted, the operational performance data do provide some clues as to the potential safety implications of wider trucks.

RECOMMENDATIONS

To relate the truck behaviors observed in this study directly to accidents requires that a comprehensive study be conducted of truck crashes and corresponding truck exposure for various truck sizes and geometric conditions. A study plan, as originally proposed by McGee and Morganstein (*10*), for accomplishing this effort is discussed in the FHWA report by Harkey et al. (*3*). The study should be performed to further identify any potential safety problems with wider and longer trucks. This effort is needed because previous truck studies have indicated that large trucks of all widths and lengths have trouble with certain types of roadway geometry such as sharp curves, narrow lanes, and steep grades.

The high toll of truck crashes on some roadways also dictates that each state should carefully review the truck crash frequency, rate, and severity of all routes in the national network for trucks. Such a statewide review has been conducted of high-crash sites in North Carolina by Council and Hall; it yielded a listing of roadway segments with high concentrations of crashes involving large trucks (*11*). Roadway sections identified as having an abnormally high incidence of truck accidents should be investigated to determine the probable cause of these crashes. From this detailed review of truck crashes, as well as the traffic and roadway characteristics of these sites, consideration should be given to improving the section through geometric or other roadway improvements. Examples of such improvements include widening the lanes or paved shoulders, reconstructing one or more sharp curves or upgrading the superelevation on curves, resurfacing the road to provide better pavement skid properties, and using improved signs, signals, and markings.

If roadway improvements cannot be economically justified, consideration then should be made to prohibit the larger trucks (102-in. doubles and semis longer than 45 ft) on selected roadways with inadequate geometry. If the roadway in question is part of the national network for trucks, the Code of Federal Regulations should be consulted (*12*): it contains procedures and factors that need to be addressed for deleting a section of highway from the national network for trucks. Alternative routes should also be considered for providing reasonable access to the prohibited trucks. A TRB Special Report provides some general guidance for providing truck access (*13*); this guidance includes a discussion of current access policies, accident risk as related to highway design, traffic operations and safety, and the impact on the highway infrastructure.

The results of this study clearly show a wide range of driving behavior by traffic-stream truck drivers for a given truck size on selected routes. This suggests the importance of driver performance as a critical factor in the operation of trucks in addition to roadway and truck characteristics. Thus, measures to improve truck driver performance (e.g., driver training programs) should also be considered and further studied as another potential method to improve truck operations and safety.

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Publication of this paper sponsored by Committee on Methodology for Evaluating Highway Improvements.