Transport of Manufactured Housing Units: Differential Effects of 4.27-m (14-ft)-Wide and 4.88-m (16-ft)-Wide Units on Traffic

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The results of a study on the impact of transporting 4.27-m (14-ft)-wide versus 4.88-m (16-ft)-wide manufactured housing units on traffic operations in Michigan are reported. Observations of the home unit and other vehicles passing the home unit were made by observers traveling in a specially equipped vehicle and by observers subsequently reviewing videotapes recorded in the equipped chase vehicle. Measures of home unit encroachment onto the right shoulder and the passing lane or left shoulder were made in addition to estimates of home unit speed. Measures of use of the shoulder by vehicles passing the units were also made. In general more excursions from the normal travel lane were seen for the 4.88-m (16-ft)-wide units, and on average both 4.27-m (14-ft) and 4.88-m (16-ft) units traveled over the speed limit prescribed by the travel permits.

There has been growing concern about the increasing widths of manufactured housing units transported on U.S. roads and the impacts of these wider loads on the safety of other road users. In Michigan the transport of manufactured housing units was restricted to units less than approximately 4.27 m (14 ft) in width before 1991. In 1991 Michigan Senate Bill 142 authorized the transport of units up to 4.88 m (16 ft) in width for a period of 1 year, during which time the effects of the wider units on mobility and traffic operations were to be evaluated [the units being compared were 4.27 or 4.88 m (14 or 16 ft) wide and between 21.35 and 24.4 m (70 and 80 ft) long]. This paper reports findings from that evaluation conducted by the University of Michigan Transportation Research Institute (UMTRI).

Previous studies on the safety effects of transporting manufactured housing units have been scarce and have focused exclusively on widths of less than 4.88 m (16 ft). Parker et al. (*1*) reviewed the literature on 4.27-m (14-ft)-wide manufactured housing units and concluded that findings on the movement of such units were generally inconclusive because of small sample sizes or study methods used. Results from the authors' own evaluation of 3.66-m (12-ft)-wide and 4.27-m (14-ft)-wide units indicated no major differential effects on the safety and convenience of other road users. The authors found no statistically significant differences between unit widths in average speed, delay to traffic, vehicle passing time, or crash potential (as measured by a traffic conflicts technique). They did, however, find statistically significant differences in vehicle displacement and encroachment because of narrow structures and narrow pavements.

More recently Stoke (*2*) analyzed centerline and edgeline encroachment of standard 4.27-m (14-ft)-wide manufactured housing units and 4.27-m (14-ft)-wide experiment units with different 0.3-m (1-ft) roof-eave configurations. Stoke concluded that 4.27-m (14-ft)-wide manufactured housing units with eaves of up to an additional 0.3 m (1 ft) posed minimal additional safety risks to traffic on roads with four or more lanes but had the potential to pose additional safety risks to traffic on roads with two or three lanes.

Harkey et al. (*3*) also examined the differential effects of width on traffic operations and safety, but their focus was heavy trucks rather than manufactured housing units. The authors compared 2.59-m (102-in.)-wide and 2.44-m (96-in.)-wide trucks using videotape and slides. They found significantly higher rates of edgeline encroachment among the wider trucks than the narrower trucks. The wider trucks also tended to drive closer to the centerline than the narrower trucks. The authors cautioned, however, against generalizing their findings beyond rural two-lane highways and to trucks longer and wider than those in the study.

The study reported here focused on the differential effects of 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide [21.35 to 24.4 m (70 to 80 ft) long] manufactured housing units on maneuverability and adjoining traffic. Field data were collected in October and November 1991 to evaluate driver behavior in the presence of manufactured housing units in Michigan. Computer analysis was used to evaluate the low-speed maneuverability of the units as well as their highway-speed dynamic characteristics. Findings from the field study are summarized here. Readers interested in more detail on the field study as well as findings from the computer analyses are referred to the full report by MacAdam et al. (*4*).

METHODS

The field study was designed to gather data on both manufactured housing units and the vehicles passing them. Of interest were the differential effects of 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units on the behavior of the units themselves as well as the behavior of passing vehicles. Because manufactured housing units of both 4.27-m (14-ft) and 4.88-m (16-ft) widths require a towing tractor during transport, the unit of interest in the field study was the entire tractor-home unit rather than just the home unit. Therefore the term *tractor-home unit* (or in some cases just *unit*) is used throughout the remainder of the paper to describe the manufactured housing unit and towing tractor being observed.

General Data Collection Protocols

In brief a vehicle equipped with a videotape unit followed behind the escort vehicle following the tractor-home unit. The videotape

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equipment in the observation vehicle generated a complete video record of each home delivery observed. In addition to the videotape record observers in the observation vehicle recorded behaviors of the tractor-home unit (i.e., lane encroachment) and vehicles passing the tractor-home unit (i.e. shoulder use) during the portion of the trip on multilane divided highways. Videotape and observation data were collected for a total of six deliveries of 4.27-m (14-ft)-wide units and seven 4.88-m (16-ft)-wide units.

Two identically configured vehicles were used for observations. Each data collection trip began with the observation vehicle traveling to the same rest area (located north of the Michigan-Indiana border). Observers waited there until a tractor-home unit of appropriate size [i.e., 4.27 or 4.88 m (14-ft or 16-ft) in width and 21.35 to 24.4 m (70 to 80 ft) in length] was seen approaching from the south. Once the tractor-home unit was observed approaching, the observers positioned their vehicle behind the escort vehicle following the tractor-home unit, started the video camera recording unit, and began recording background data about the route and the tractor-home unit.

The video camera was positioned in the camera mount so the view in the video monitor was filled by the road and the rear of the tractor-home unit. The field of view extended from the outside of the left shoulder to the outside of the right shoulder, with the camera lens focused at infinity. In addition to the view of the road and the tractor-home unit, the videotape was coded with the time the observation was made (hour, minute, and second of real time). This time stamp allowed linkages between the data recorded on the observation data sheets and the videotape record of the trip.

Analysis of tractor-home unit and passing vehicle behavior were conducted in two stages in the field study. First-stage analyses were based primarily on data recorded directly in the field, whereas second-stage analyses were based solely on review of the videotape logs made during field observations. In some cases the same behavior was analyzed in both stages (e.g., tractor-home unit encroachment into passing lane). In these cases the first-stage and second-stage analyses differed in terms of how the behavior was measured, the conditions under which it was measured, or the extent to which potentially confounding variables were examined. To enable readers to more easily compare results for similar behaviors, this paper is organized by topical area rather than sequential order of the analyses. Specific data collection protocols for each behavior observed are described briefly.

Encroachment by Tractor-Home Units

The primary goal of this portion of the study was to determine whether 4.88-m (16-ft)-wide tractor-home units encroached into the passing lanes of roads more than 4.27-m (14-ft)-wide units did. Passing lane refers to the lane to the left of the lane occupied by the tractor-home unit (i.e., the left adjoining lane). This lane is described as the passing lane throughout the paper, regardless of whether lane encroachment by the tractor-home unit occurred in the presence of a passing vehicle (overtaking the unit from the same direction) or an oncoming vehicle (overtaking the unit from the opposite direction).

Encroachment on Multilane Divided Highways

Encroachment of tractor-home units into the passing lane on multilane divided highways was examined in both first-stage and second-stage analyses by using different methods. During the first stage of the analyses, the encroachment time of the tractor-home unit was measured directly by observers in the field by using a timing apparatus mounted on the dashboard of the observation vehicle. Encroachment of the tractor-home unit was recorded only when a vehicle or platoon of vehicles began to pass the unit. This procedure was used because tractor-home unit encroachment is of little safety consequence unless vehicles are attempting to pass. Encroachment was measured in discrete events. An event was considered to be the period of time a vehicle or platoon of vehicles traveled from the front of the observation vehicle (passing maneuver initiation) to the front of the towing tractor (passing maneuver end).

During the second stage of the analyses the encroachment time of the tractor-home unit into the passing lane was based on review of the videotape logs made during the field observations. Data from the videotape logs were studied for each passing event. The encroachment time of the tractor-home unit into the passing lane was measured by using a computer program written especially for observers reviewing the videotape logs. The program was designed to measure two separate dimensions of encroachment behavior: tractor-home unit encroachment into the passing lane and tractor-home unit use of the shoulder.

Encroachment on Multilane Divided Highways and Two-Lane Roads by Lane Width, Shoulder Condition, and Road Type

Tractor-home unit encroachment was examined by lane width, shoulder condition (of the shoulder adjacent to the unit), and road type to determine whether factors other than unit width were related to encroachment. Both encroachment into the passing lane and use of the shoulder by the unit were examined because each represents a dimension of encroachment behavior. Encroachment time was calculated for both multilane divided highways and two-lane undivided roads on the basis of a review of the videotape logs in conjunction with the computer program discussed previously. Encroachment on two-lane undivided roads was limited to passing events by oncoming vehicles (although there were a few cases in which a vehicle overtook the unit while traveling in the same direction). Lane width, shoulder condition, and road type were determined on the basis of the observed road characteristics and information provided by the 1990 *Sufficiency Rating, Michigan State Trunkline Highways* (*5*).

Shoulder Use by Passing Vehicles

The goal of this portion of the study was to determine whether vehicles passing 4.88-m (16-ft)-wide tractor-home units used the shoulder of the road during the passing maneuver more often than vehicles passing 4.27-m (14-ft)-wide units. Data were collected for passing vehicles on multilane divided highways and for oncoming vehicles on two-lane undivided roads. Passing events on multilane divided highways included those in which vehicles were traveling in the same direction as the tractor-home unit and in the process of overtaking the unit. Passing events on two-lane undivided roads included those in which vehicles were passing the tractor-home unit in the oncoming direction. There were a few cases in which a vehicle traveling in the same direction as the tractor-home unit on a two-lane undivided road attempted to overtake the unit—these cases were also recorded and are discussed separately in the results.

Shoulder Use on Multilane Divided Highways and Two-Lane Undivided Roads

Shoulder use of passing vehicles on multilane divided highways was measured directly by observers in the field. Observations were made by the driver or observer seated in the front passenger seat of the observation vehicle. A vehicle was targeted for observation when it pulled even (in the passing lane) with the front of the observation vehicle. For each vehicle (or the first vehicle in a platoon of passing vehicles), the observer recorded the time from the video camera monitor.

Shoulder use of vehicles approaching the tractor-home unit in the oncoming lane on two-lane undivided roads was measured by observers reviewing the videotape logs of the trips. A vehicle was targeted for observation when it pulled even (in the oncoming lane) with the front of the tractor-home unit.

Shoulder Use on Multilane Divided Highways and Two-Lane Undivided Roads by Lane Width, Shoulder Condition, and Road Type

Shoulder use by passing and oncoming vehicles was examined by lane width, shoulder condition (of the shoulder adjacent to the passing vehicle), and road type to determine whether factors other than unit width were related to shoulder use. Shoulder use was observed for both passenger cars and heavy trucks (tractor semitrailers and doubles). Shoulder use was calculated for both multilane divided highways and two-lane undivided roads on the basis of a review of the videotape logs. Lane width, shoulder condition, and road type were determined on the basis of the observed road characteristics and information provided by the 1990 *Sufficiency Rating, Michigan State Trunkline Highways* (*5*).

Speed of Tractor-Home Units

The goal of this portion of the study was to examine the speeds of each of the tractor-home units during the trip. Once the observation vehicle caught up with the tractor-home unit and achieved a steady speed, the passenger seat observer queried the observation vehicle driver to determine the speed at which the vehicle was traveling. The driver reported the speed from the observation vehicle speedometer to the nearest 5-mph level. The passenger seat observer then held a prepared flash card up in front of the video camera to record the speed. This query and record system was repeated every 5 min throughout the trip. The speed data were transcribed from the videotape later by another observer who recorded speed of travel (from the flash card) and road type.

RESULTS

Encroachment of Tractor-Home Units

Encroachment on Multilane Divided Highways

Tractor-home unit encroachment into the passing lane on multilane divided highways was calculated by using two approaches. First the average of the proportion of time the units encroached into the passing lane during each passing event was calculated. That is, on the basis of the data recorded in the field, the total event time (from the stopwatch) was divided by the encroachment time from the timer, yielding a calculation of the proportion of time the tractor-home unit encroached during each event. This calculation resulted in events of different duration receiving an equal weight in the average encroachment time (e.g., a given event of 130 sec in duration in which the tractor-home unit encroached into the passing lane 40 percent of the time was given the same weight in the encroachment average as an event of only 30 sec in duration).

Because of concerns that differences in encroachment behavior that were potentially moderated by event duration would be overlooked by using the event-based encroachment average, a second approach was devised to estimate tractor-home unit encroachment into the passing lane that allowed all passing events to be given equal weight in proportion to their durations. On the basis of a review of the videotape logs, the second approach involved calculating the proportion of time the tractor-home units were observed to be encroaching into the passing lane by taking the total time that a specific unit encroached into the passing lane during all passing events and dividing this sum by the total time of all passing events for that unit.

Calculation 1 Results from the first calculation (the event-based encroachment average) indicated that, on average, 4.88-m (16-ft)-wide tractor-home units encroached into the passing lane during passing events on multilane divided highways more than 4.27-m (14-ft)-wide units. Specifically, 4.88-m (16-ft)-wide units were observed encroaching an average of 40.3 percent of the time for each passing event (168 total passing events), whereas 4.27-m (14-ft)-wide units were observed encroaching an average of 20.5 percent of the time for each passing event (128 total passing events).

There was a good deal of variation, however, between the encroachment behaviors of individual tractor-home units. That is, some tractor-home unit drivers encroached into the passing lane significantly less than other drivers. Average encroachment (over an entire delivery trip when adjoining traffic was present) for 4.88-m (16-ft)-wide units ranged from 3.4 to 60.9 percent. Average encroachment (over an entire delivery trip) for 4.27-m (14-ft)-wide units ranged from 2.3 to 54.3 percent.

When the entire range of encroachment time proportions was examined, it was found that 4.27-m (14-ft)-wide units did not encroach into the passing lane in 40 percent of all passing events, but 4.88-m (16-ft)-wide units did not encroach into the passing lane in only 10 percent of all passing events (Figure 1). This reinforces the finding that 4.88-m (16-ft)-wide units encroached into the passing lane more than 4.27-m (14-ft)-wide units.

Calculation 2 Results from the second calculation (based on the total encroachment time divided by the total event time over all events for each home) indicated that 4.88-m (16-ft)-wide units encroached into the passing lane on multilane divided highways more often than 4.27-m (14-ft)-wide units (43.9 versus 31.0 percent, respectively; Figure 1). These results are consistent with results from the first calculation of encroachment, although the absolute proportions differ.

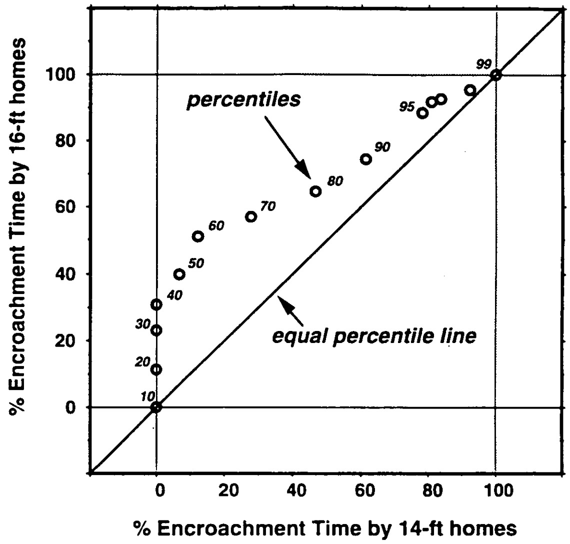

FIGURE 1 Percentile comparison of encroachment times for 4.88-m (16-ft) versus 4.27-m (14-ft) tractor-home units

Encroachment on Multilane Divided Highways and Two-Lane Undivided Roads by Lane Width, Shoulder Condition, and Road Type

Analyses of tractor-home unit encroachment on multilane divided highways and two-lane undivided roads by lane width, shoulder condition (of the shoulder adjacent to the unit), and road type were based on review of the videotape logs by using the second calculation of encroachment. Included were both tractor-home unit encroachment into the passing lane and tractor-home unit use of the shoulder. Because of the relatively small number of units observed, inferential statistics were not applied to the data. Instead a case study approach was used so that relationships could be examined as a whole, without having to interpret statistical values based on tests without sufficient statistical power to be meaningful because of small sample sizes. Readers should exercise caution in interpreting results; apparent differences may be the result of case-specific factors unrelated to the larger, more general population of vehicles.

Results for encroachment of tractor-home units by lane width, shoulder condition, and road type are presented in Table 1. Units of both widths were more likely to encroach into the passing lane on roads with 3.35-m (11-ft) lanes that on roads with 3.66-m (12-ft) lanes. However lane width appeared to have little effect on shoulder use for all units combined. On roads with 3.35-m (11-ft)-wide lanes, encroachment of 4.27-m (14-ft)-wide units into the passing lane was greater than that of 4.88-m (16-ft)-wide units. The reverse was true on roads with 3.66-m (12-ft)-wide lanes. Shoulder use, however, was greater among 4.88-m (16-ft)-wide units than 4.27-m (14-ft)-wide units on all roads, regardless of lane width.

Tractor-home units of both widths were more likely to encroach into the passing lane on road segments with no appreciable shoulder (e.g., no paved or improved shoulder) than on road segments with the shoulder in good condition. The reverse pattern was found for shoulder use. That is, units of both widths were more likely to use the shoulder when it was in good condition than when there was no appreciable shoulder. On road segments with a good shoulder, 4.88-m (16-ft)-wide units were more likely than 4.27-m (14-ft)-wide units to encroach into the passing lane. On road segments with no appreciable shoulder, the reverse was true. Shoulder use was greater among 4.88-m (16-ft)-wide units than 4.27-m (14-ft)-wide units both on roads with a good shoulder and on roads with no appreciable shoulder.

Tractor-home units of both widths were more likely to encroach into the passing lane on two-lane roads than on multilane divided highways. Although this may be due in part to the characteristics of the shoulder, this hypothesis could not be adequately explored because of the lack of sufficient data on the various shoulder characteristics for the different roads. There was essentially no difference in the overall use of the shoulder between two-lane and multilane roads. Although 4.88-m (16-ft)-wide units were more likely than 4.27-m (14-ft)-wide units to encroach into the passing lane on multilane divided highways, there appeared to be little difference between the two types of units on two-lane roads. On both multilane divided and two-lane roads, 4.88-m (16-ft)-wide units were more likely than 4.27-m (14-ft)-wide units to use the shoulder.

Shoulder Use by Passing Vehicles

Shoulder Use on Multilane Divided Highways and Two-Lane Undivided Roads

Figure 2 gives shoulder use by passing vehicles on multilane divided highways and oncoming vehicles on two-lane undivided

TABLE 1 Tractor-Home Unit Encroachment into Passing Lane and Use of Shoulder by Lane Width, Shoulder Condition, and Road Type

	4.26-Meter Wide[2]		4.88-Meter Wide		Both Widths	
	Encroachment % (N)	Shoulder Use % (N)	Encroachment % (N)	Shoulder Use % (N)	Encroachment % (N)	Shoulder Use % (N)
Lane Width						
3.35-Meter	46.8 (3)	27.3 (3)	29.5 (5)	91.2 (5)	36.2 (8)	67.2 (8)
3.66-Meter	4.9 (6)	54.8 (6)	15.5 (7)	79.8 (7)	10.7 (13)	68.3 (13)
Shoulder Condition						
Good	4.8 (6)	55.3 (6)	16.8 (7)	80.8 (7)	11.3 (13)	69.0 (13)
No Appreciable	50.0 (2)	20.4 (2)	40.7 (3)	58.0 (3)	44.4 (5)	43.0 (5)
Road Type						
Multilane Divided	5.3 (6)	75.8 (6)	15.2 (7)	80.7 (7)	10.7 (13)	70.2 (13)
Two-Lane	36.3 (2)	37.1 (2)	30.3 (5)	81.5 (5)	32.0 (7)	68.8 (7)

[2]1 meter = 3.28 feet

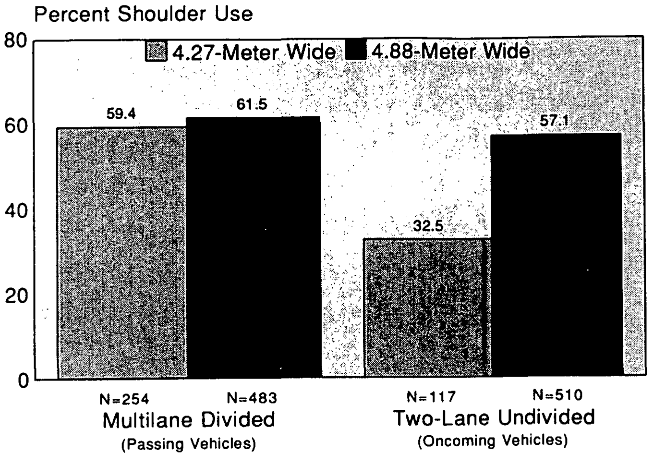

FIGURE 2 Shoulder use on multilane divided highways and two-lane undivided roads (1 m = 3.28 ft).

roads. On multilane divided highways a majority of passing vehicles used the shoulder when passing both 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units. However few apparent differences between 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units in the shoulder use of passing vehicles were found. On two-lane undivided roads a majority of passing vehicles used the shoulder only when passing 4.88-m (16-ft)-wide units.

Shoulder Use on Multilane Divided Highways and Two-Lane Undivided Roads by Lane Width, Shoulder Condition, and Road Type

Analyses of shoulder use by lane width, shoulder condition (of the shoulder adjacent to passing vehicle), and road type were based on review of the videotape logs and included shoulder use of both passenger vehicles and heavy trucks. As in the case of the supplemental analyses of tractor-home unit encroachment, a case study approach was used because of limited sample sizes. Readers should exercise caution in interpreting results; apparent differences may be the result of case-specific factors unrelated to the larger, more general population of vehicles.

Overall both cars and trucks were more likely to use the shoulder when passing 4.88-m (16-ft)-wide units than when passing 4.27-m (14-ft)-wide units, and trucks were more likely than cars to use the shoulder [15.6 percent (n = 960) of cars versus 35.7 percent (n = 140) of trucks used the shoulder when passing 4.27-m (14-ft)-wide units; 28.0 percent (n = 1,462) of cars versus 62.6 percent (n = 131) of trucks used the shoulder when passing 4.88-m (16/ft)-wide units]. Results for shoulder use of passenger cars and heavy trucks by lane width, shoulder condition, and road type are presented in Table 2.

Shoulder use by cars was greater on roads with 3.35-m (11-ft)-wide lanes than 3.66-m (12-ft)-wide lanes when passing both 4.88-m (16-ft)-wide and 4.27-m (14-ft)-wide units. On roads with 3.66-m (12-ft)-wide lanes, cars were more likely to use the shoulder when passing 4.88-m (16-ft)-wide units than when passing 4.27-m (14-ft)-wide units, whereas on roads with 3.35-m (11-ft)-wide lanes, there was little difference in shoulder use between cars passing 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units. Analyses of truck shoulder use were limited to roads with 3.66-m (12-ft)-wide lanes because of insufficient cases of trucks passing on roads with other lane widths. On roads with 3.66-m (12-ft)-wide lanes, trucks used the shoulder more often when passing 4.88-m (16-ft)-wide units than when passing 4.27-m (14-ft)-wide units.

Cars were more likely to use the shoulder when passing on roads with a good shoulder and less likely to use the shoulder when passing on roads with no shoulder. Analyses of truck shoulder use were limited to roads with a shoulder classified as "OK" because of insufficient cases of trucks passing on roads with other shoulder classifications. Regardless of shoulder condition, both cars and trucks were more likely to use the shoulder when passing 4.88-m (16-ft)-wide units than when passing 4.27-m (14-ft)-wide units, except in the case of cars passing on roads with a good shoulder (note, however, the small sample size).

Both cars and trucks were more likely to use the shoulder when approaching tractor-home units in the oncoming direction on two-lane roads than when passing on multilane divided highways. As was the case in the analyses of tractor-home unit encroachment, these findings may be due in part to characteristics of the shoulder. This hypothesis could not be adequately explored because of the lack of sufficient data on the various shoulder characteristics for the different roads. Cars were more likely to use the shoulder when approaching 4.88-m (16-ft)-wide units in the oncoming direction on two-lane roads, but their shoulder use was nearly the same as that of trucks when passing units of different widths on multilane divided highways. Trucks on the other hand were more likely to use the shoulder when passing 4.88-m (16-ft)-wide units than when passing 4.27-m (14-ft)-wide units, regardless of whether they were traveling on two-lane undivided roads or multilane divided highways.

On rare occasions vehicles traveling in the same direction as the tractor-home unit on two-lane undivided roads passed the unit. In such cases when an oncoming vehicle was also present, the oncoming vehicle was forced completely onto the shoulder of the road to avoid a collision with the passing vehicle.

Speed of Tractor-Home Units

Results from the speed observations are given in Figure 3. The speed limit for such vehicles is 72.5 km/hr (45 mph) on highways

TABLE 2 Shoulder Use by Passing Passenger Cars and Heavy Trucks by Lane Width, Shoulder Condition, and Road Type

	4.27-Meter Wide		4.88-Meter Wide		Both Widths	
	Passenger Cars % (N)	Heavy Trucks % (N)	Passenger Cars % (N)	Heavy Trucks % (N)	Passenger Cars % (N)	Heavy Trucks % (N)
Lane Width						
3.35-Meter	51.2 (41)	----	49.3 (322)	----	49.6 (363)	----
3.66-Meter	14.0 (919)	35.7 (140)	22.2 (1127)	57.0 (107)	18.5 (2046)	44.9 (247)
Shoulder Condition						
None	1.6 (124)	----	9.0 (166)	----	5.9 (290)	----
OK	15.5 (802)	38.6 (127)	30.0 (1261)	63.9 (122)	24.3 (2063)	51.0 (249)
Good	70.6 (34)	----	45.7 (35)		58.0 (69)	
Road Type						
Multilane Divided	17.2 (692)	37.7 (114)	18.5 (905)	54.8 (93)	17.9 (1597)	45.4 (207)
Two-Lane	23.3 (120)	55.6 (9)	50.9 (458)	88.2 (34)	45.2 (578)	81.4 (43)

with four or more lanes and 56.4 km/hr (35 mph) on highways with fewer than four lanes. As shown in Figure 3, vehicles of both widths consistently drove in excess of the speed limit prescribed on their travel permits. There was no difference between the average speeds of 4.27-m (14-ft)-wide units and 4.88-m (16-ft)-wide units.

SUMMARY AND CONCLUSIONS

Overall results of the field study are summarized. With regard to encroachment of tractor-home units, it was found that 4.88-m (16-ft)-wide units were more likely than 4.27-m (14-ft)-wide units to encroach into the passing lane while they were being passed by other vehicles on multilane divided highways. Although these encroachments degrade the level of safety on these roads, the level and effect of this degradation are unclear. To assess the significance of the effect of these encroachments on safety, the behavior of drivers attempting to pass the tractor-home units was examined.

One might expect that passing vehicles would be forced onto the shoulder of the road more often by the 4.88-m (16-ft)-wide units because these units were more likely to encroach into the passing lane. However no relationship was found between the shoulder use behavior of passing vehicles on multilane divided highways and the width of the tractor-home unit being passed. This finding complicates the question of the safety impact of 4.88-m (16-ft)-wide units. That is, although intuitively it would seem that if tractor-home units encroached more into other lanes, there would be a detrimental effect on the ability (or desire) of passing vehicles to remain in their lanes, this was not found to be the case. In fact passing vehicles on multilane divided highways were found to use the shoulder nearly two-thirds of the time, regardless of the width of the tractor-home unit being passed. This finding does not support the contention that 4.88-m (16-ft)-wide units degrade the safety of drivers traveling around those units more than 4.27-m (14-ft)-wide units. However these findings do suggest that both 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units degrade the safety of vehicles trying to pass those units. This degradation of safety is based on the fact that vehicle drivers used the shoulder rather than the travel lanes to complete passing maneuvers. Use of the shoulder decreased the margin of error for road departure available to vehicles passing the units. In addition the conditions of shoulder surfaces are often much poorer than those of normal travel lanes, thereby increasing the chances of vehicle control problems for vehicles that use the shoulder.

The shoulder use behavior of oncoming vehicles on two-lane undivided roads differed somewhat from that of passing vehicles on multilane divided highways. That is, no difference in shoulder use was found for vehicles passing 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units on multilane divided highways [although a majority of drivers passing both 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units used the shoulder], but a noticeable difference in shoulder use was found between vehicles approaching 4.27-m (14-ft)-wide and 4.88-m (16-ft)-wide units in the oncoming lane on two-lane undivided roads. Drivers passing an oncoming 4.88-m (16 ft)-wide unit were more likely than drivers passing an oncoming 4.27-m (14-ft)-wide unit to use the shoulder. In fact although 57 percent of drivers used the shoulder when passing an oncoming 4.88-m (16-ft)-wide unit, only 32 percent of drivers used the shoulder when passing an oncoming 4.27-m (14-ft)-wide unit.

What is clear is that the shoulder use of vehicles on two-lane undivided roads represents a reduction in safety. In many of the shoulder use events on two-lane undivided roads the observed drivers chose to move off of the paved road surface onto an unpaved shoulder area. The drop-off from and return to a paved road surface is a potentially hazardous vehicle maneuver that should generally be avoided because it can lead to loss of control. In addition driving on an unpaved surface is generally more hazardous than driving on a paved surface because of reduced tire friction and the uneven surface. This type of behavior by passing drivers was far less frequent on multilane divided highways.

With regard to tractor-home unit speeds, it was found that tractor-home units of both widths regularly traveled in excess of the maximum speed specified on their travel permits. Units of 4.88 m (16 ft) in width traveled at almost the same average speeds as units of 4.27 m (14 ft) in width; however, the effects of this speeding behavior on safety may differ between the units. The specific effects of this speeding behavior on the safety of the tractor-home units and on the traffic that must interact with the units are unclear. Some may argue that the higher tractor-home unit speeds simply act to reduce the speed variance on the road and thus actually improve safety. On the other hand these units are in clear violation of the lawfully permitted speed. In addition the dynamics of tractor-home unit stability is affected negatively by the higher observed, travel speeds, and the stopping distance requirements are

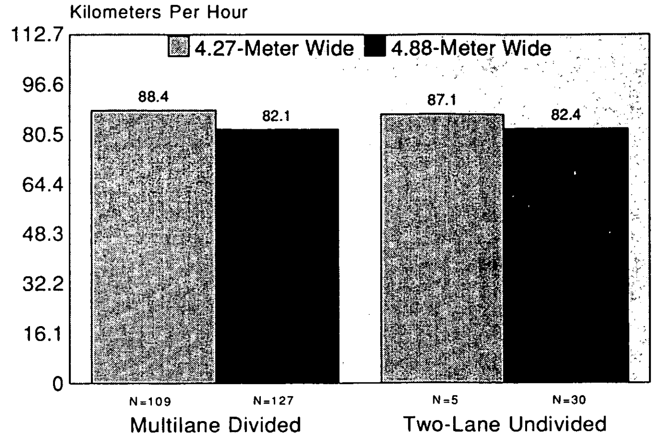

FIGURE 3 Speed of tractor-home units (kph = mph × 1.61; 1 m = 3.28 ft).

significantly increased because of the poor braking performance of tractor-home units.

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