Evaluation of the On-Road Behavior of Sixteen-Foot Wide Mobile Homes in North Carolina

FINAL REPORT

November 14, 1997

Submitted to:
The North Carolina
Department of Transportation
Division of Highways

By:
The University of North Carolina
Highway Safety Research Center

EVALUATION OF THE ON-ROAD BEHAVIOR OF 16-FOOT WIDE MOBILE HOMES IN NORTH CAROLINA

FINAL REPORT

Submitted to
The North Carolina Department of Transportation
Division of Highways

by:
The University of North Carolina
Highway Safety Research Center

William L. Hall
Steven R. Luxenberg
David L. Harkey
J. Richard Stewart
Charles W. Hamlett

November 14, 1997

This report was funded by the North Carolina Department of Transportation Division of Highways as part of a project titled "Evaluation of the On-Road Behavior of 16-ft. Mobile Homes." The findings and opinions contained in this report are those of the authors and not necessarily those of the sponsor.

Table of Contents

List of Tables

List of Figures

List of Appendices

Acknowledgments

The Highway Safety Research Center would like extend its gratitude to those organizations whose assistance made this evaluation of mobile home transportation safety in North Carolina possible.

First, we would like to acknowledge the extensive contributions made by the North Carolina Department of Transportation to this project, namely by the Office of the Administrator for the Division of Highways, and the Oversize/Overweight Permit Office. The staff of both DOT divisions provided us with information necessary for many areas of our research, and were available to answer our questions from the beginning.

We would also like to take this opportunity to express our appreciation to the North Carolina Manufactured Housing Institute for their support of this project. Without their assistance, and the cooperation of their members, this project would not have been possible. Our thanks also go out to the manufacturers participating in the 16-foot pilot program. The plant managers and marketing and transportation directors were of great assistance to the HSRC staff in schedule coordination and routing. We would also like to acknowledge the contributions of the mobile home transport companies, their terminal managers and the drivers of the mobile home transport units and escort vehicles, whose good nature and cooperation made this project possible.

And finally, the project team would like to thank Take One Productions for sharing their knowledge and some equipment, both of which provided a great deal of assistance with the videotaping.

Executive Summary

On January 10, 1997, the North Carolina Board of Transportation approved a pilot project to allow limited production and shipment of 16-foot wide mobile homes in North Carolina. Selected manufacturing facilities were allowed to manufacture these larger units and ship them out-of- state using specific routes established by the NC Department of Transportation. The Board decided to allow this pilot project only after careful assessment of safety data, and particularly the positive experiences of our neighboring states which have allowed these units to be transported successfully for the past two to four years. The Board concluded that restricted movements of 16-foot mobile homes could be made safely and with a minimal inconvenience to the motoring public.

The pilot project in North Carolina allows 16-foot mobile homes to be transported only from thirteen manufacturing sites to the closest interstate highway and then to the nearest state line following designated routes. Each mobile home must receive an individual permit and must have front and rear escorts. Movements are allowed only between 9:00 a.m. and 2:30 p.m., Monday through Thursday, and are restricted to speeds 10 miles per hour below posted speeds.

The North Carolina Department of Transportation Division of Highways contracted with the University of North Carolina Highway Safety Research Center (HSRC) to evaluate the on-road behavior of 16-foot mobile homes and their impact on surrounding traffic as compared to currently allowed 14-foot units. This evaluation was accomplished by following a sample of 16-foot and 14-foot units from their respective manufacturing plants to the state line. The routes covered consisted of interstate and other four-lane divided highways and secondary roads used to access these major routes from the manufacturing plants.

The mobile home units were followed in a van equipped with video cameras and timing devices. Videos made during the trips were reviewed and data was drawn from the video images to determine the positioning of the mobile home unit relative to the center lane line, outside edge line, and to oncoming vehicles on two-lane roads as well as vehicles overtaking the mobile homes on four-lane roads. Information was also derived from the tapes on the positioning of the oncoming or overtaking vehicles relative to the shoulder of the roadway. Data on traveling speed and counts of traffic directly behind and impeded by the mobile home were also collected in three-minute intervals during the duration of each data run.

To the degree that the parameters of this study have allowed, North Carolina regulations governing the movement of 14- and 16-foot mobile homes (Appendix A) have been evaluated to determine their appropriateness for safe movement of mobile homes.

This report includes a discussion of the results of these analyses, an evaluation of the regulations governing the movement of 14- and 16-foot units, and recommendations for regulations pertaining to the shipment of mobile homes in North Carolina. A summary of the results of this study follows.

Summary of Methodology

The sample of units to be observed was selected using the information provided to HSRC by the manufacturers participating in the pilot program and the NC Department of Transportation Oversize/Overweight Permit Office related to shipments of 14- and 16-foot units. Thirteen manufacturing plants were authorized to participate in the pilot program but not all thirteen were available to be included in the study. Some of the authorized plants decided not to participate in the program at all, and other plants produced only a few 16-foot mobile homes during the duration of the data collection period.

Based on the location, level of production, and shipping schedules of plants participating in the program, a sample of six 16-foot and five 14-foot mobile homes were included in the study. The overall intent of the data collection process was to collect information on the differences, if any, in the impact of 16-foot mobile homes on surrounding traffic as compared to the 14-foot units. More specifically, the questions of interest involved (1) the positioning of the 16- and 14-foot mobile homes on the roadway in the presence of another vehicle, and (2) the position of the other vehicle in the presence of the 16- and 14-foot mobile homes. Thus, of interest are the instances or "events" where another vehicle is the lane to the immediate left of the mobile home.

Five data runs (following the mobile home for the entire route to the state line) were made and analyzed for both 16-foot homes and 14-foot homes. A sixth run for a 16-foot home was made, but dropped from the study prior to analysis to make the samples more directly comparable. Every tape was fully reviewed and information was extracted for most instances, or “events”, where there was another vehicle in the lane to the immediate left of the mobile home. While the entire runs were videotaped, the times when there was no vehicle to the left of the mobile home were not analyzed since there would be no measureable effect on safety during these times. These other vehicles were either coming from the opposite direction on two-lane roads or were overtaking the mobile home while traveling in the same direction on a four-lane road.

Data was generated for 2937 events in this part of the data reduction process. Approximately 50 percent of the events observed occurred on two-lane roadways, 40 percent were recorded on four-lane interstates, and ten percent were on other four-lane divided roadways. Twenty-eight events occurred on four-lane roadways with a center turn lane. Due to the low number of events on this type of roadway, they were also excluded from further analyses. The final analysis file contains information on 2909 events (another vehicle to the immediate left of a mobile home) with 1293 events recorded for the 16-foot homes and 1616 events recorded for the 14-foot units. The number of runs that were made and the variety of roadways that were covered were not as high as initially planned or desired. However, the number of events on different roadway types in the final data set is large enough to produce valid and statistically significant results.

In the first phase of the analysis, each of the 2909 events was visually analyzed to determine (1) the placement of the mobile home relative to the center line and shoulder of its lane, and (2) the placement of the meeting/passing vehicle relative to the edge line for its lane. In a second phase of the analysis, a random sample of the images on the tapes for each data run was selected for image analysis. The image analysis was able to extract more detailed measurement data for the placement of both the mobile home and the other vehicle such as the distance between the mobile home and the other meeting/passing vehicle. Only those events occurring on two-lane roads and four-lane median divided roads with no shoulder obstructions (e.g., narrow bridges or work zones) were included in the image analysis since these are the predominate types of roadways used by the mobile homes and represent unimpeded operations of the mobile homes. A list of selected event images was generated and selected images were captured as a digitized file using video image capture hardware and software. Once images were captured, specified measurements were made for each image using image analysis software that allows the use of an object of known size on the image for calibration of measurements on the image. A total of 444 images were selected, captured and measured. Of this total, 232 14-foot mobile home event images and 212 16-foot mobile home event images were analyzed.

Summary of the On-road Behavior of 16-foot Mobile Homes Compared to 14-foot Homes

Encroachments of the Mobile Home Across the Lane Line

The overall lane encroachments for the 16-foot units are almost identical to those of the 14-foot homes with the mobile home definitely encroaching over the center or lane line slightly over five percent of the time when another vehicle was present to the left of the mobile home. Lane encroachments do, however, show significant differences between the different sizes when road type, lane widths, and shoulder widths are examined.

With respect to road class, on the two-lane roads used to access major four-lane highways and the interstates, the left (toward the center of the roadway) edge of the 16-foot units definitely did encroach over the center line or came very close to encroaching 38 percent of the time compared to a significantly lower 28 percent for the 14-foot units (Table 1).

The width of the travel lanes and paved shoulders also play a role in the ability of both sizes of mobile home units to stay within their lanes. On narrow lanes (less than twelve feet), the 16-foot units definitely encroached into the other lane 25 percent of the time compared to 10 percent for the 14-foot units. Where the paved shoulders were the narrowest, both sizes of mobile homes encroached into the other lane or were right on the lane line 70 percent of the time. In general, as the paved shoulder width becomes greater, both sizes encroach into the other lane less often.

Table 1 Encroachment of the Mobile Home Across the Lane/Center Line with Another Vehicle in the Lane to the Left.

	16-foot Mobile Home Lane Encroachment			14-foot Mobile Home Lane Encroachment		
	Yes	Close	Total	Yes	Close	Total
Interstate roads	0%	2%	2%	5%	1%	6%
Other four-lane divided roads	0%	4%	4%	1%	1%	1%
Two-lane roads	13%	25%	38%	8%	20%	28%

Instances of Mobile Homes Dropping off of the Paved Surface

Tires of any vehicle dropping off of the pavement are of concern due to the possibility of loss of control as the positioning of the vehicle is corrected to get back on the pavement. The right tire of the mobile home dropping off the pavement did occur during 65 events. Almost 16 percent of the events for 16-foot mobile homes on lanes less than twelve feet involved the right tire dropping off the pavement, significantly greater than the 2.7 percent drop-offs for the 14-foot events. There were no statistical differences for lanes twelve feet or more.

Encroachments of Other Vehicles onto the Shoulder

Of particular interest to the issue of the safety of wider mobile homes is the positioning of the other vehicles on the road that encounter the mobile homes and if the wider loads presented by the 16-foot mobile homes have an adverse effect on these other vehicles. The other vehicles next to a 16-foot unit did encroach onto the shoulder to some degree 34 percent of the time on two-lane roads, 26 percent of the time on four-lane interstates, and 23 percent of the time on four-lane non-interstate roads with medians (Table 2). In comparison, the 14-foot percentages were always lower -- 16 percent of the time on two lane roads, 18 percent of the time on four-lane interstates, and eight percent of the time on four-lane median non-interstate roads. In addition, 2.1 percent of the other vehicles next to the 16-foot units dropped at least one of their tires off of the pavement compared to 0.3 percent for the vehicles next to 14-foot units with all but one of the other vehicle drop-offs occurring on two lane roads.

Table 2 Encroachment onto Shoulders for Vehicles Meeting/passing Mobile Homes.

	Vehicles Meeting or Passing 16-foot Mobile Homes	**Vehicles Meeting or Passing 14-foot Mobile Homes**
Interstate roads	26%	18%
Other four-lane divided roads	23%	8%
Two-lane roads	34%	16%

Separation Distance

Based on the image analysis of the sample of events, an examination of the separation distance between the mobile home unit and oncoming vehicles on two-lane roads showed that, on average, the 16-foot units are significantly closer to opposing traffic than the 14-foot units. The adjusted mean separation distance for the 16-foot units across all paved surface widths is 6.4 feet, while for the 14-foot units, the mean separation distance is 6.7 feet. For every one-foot increase in paved surface width, the separation distance increased by 0.43 feet for both sizes of homes.

Lateral Positioning

Mean lateral positioning values for the left edge of the mobile home units during these events were computed from the mid-point of the center line on two-lane roads or the lane line on multi-lane roads. On two-lane roads, the 16-foot units were, on average, 0.5 feet inside the mid-point of the center line. In comparison, the 14-foot units were 1.2 feet inside the center line. This difference between the two width units was statistically significant. The distance of the mobile home inside the center line significantly increased as the width of the paved surface increased. For each one-foot increase in paved shoulder or lane width, both sizes of mobile home units moved 0.32 feet further inside the center line. The distance of the mobile home units inside the lane line on multi-lane roads also significantly increased as the width of the paved lane or shoulder surface increased. For each one-foot increase in the width of the paved lane or shoulder surface, the units moved 0.22 feet and 0.32 feet further inside the lane line for interstates and other multi-lane roads, respectively.

Encroachment over the Edge Line

Adjusted mean positioning values of the right edge of the mobile home were measured and computed from the outside of the edge line toward the edge of the paved shoulder or beyond to provide an indication of the magnitude of encroachment over the edge line by the mobile home

units during these events. For all roadway types, the magnitude of the encroachment was significantly greater for the 16-foot units when compared to the 14-foot units. On two lane roadways, the 16-foot units, on average, encroached beyond the edge line 4.0 feet compared to 2.8 feet for the 14-foot units. On interstates, the mean magnitude of the encroachment was similar for the 16-foot and 14-foot units at 4.3 feet and 2.9 feet, respectively. The largest difference between the two width units was observed on other multi-lane roadways with the 16-foot units encroaching over the edge line, on average, 5.2 feet while the 14-foot units encroached 3.3 feet.

Combining all analyzed measures of effectiveness, it appears that the drivers of the mobile home units took advantage of the paved shoulders to increase their distance from the center line or lane line and the separation distance from vehicles in the adjacent lane. For each one-foot increase in shoulder width on two-lane roadways, interstates, and multi-lane roadways, the amount of edge line encroachment increased by 0.33 feet, 0.32 feet, and 0.44 feet, respectively for both sizes of mobile homes.

Pavement Widths Required to Eliminate 95 Percent of the Lane Encroachments

To provide information needed to minimize the number of encroachments, and thus the potential for collisions with other vehicles, an analysis was undertaken to determine the amount of total paved surface (travel lane plus paved shoulder) required to eliminate 95 percent of the lane or center line encroachments by the mobile homes. For 14-foot units, the amount of paved surface required is 16 feet while for 16-foot units, the required amount of paved surface is 17 feet.

Impact of 16-foot Mobile Homes on Traffic Congestion

Counts of traffic backed up behind the mobile homes were made in three-minute intervals during the data runs in an attempt to determine if the larger 16-foot mobile homes impeded other traffic and created more congestion than the 14-foot units. On average, 5.3 vehicles were behind and impeded by the 14-foot units and 5.0 vehicles were behind the 16-foot units. In effect, there appeared to be no large difference overall between the two sizes in terms of congestion. Traffic counts behind both sizes of mobile homes are greatest in the urban areas. For both sizes, the urban counts are more than double the rural counts. For the 16-foot mobile homes, the average rear traffic count in urban areas was 8.7 vehicles compared to 4.0 for the rural areas. For the 14-foot homes, these counts were 8.1 urban and 3.9 rural areas. Traffic counts for mobile homes in the areas of transition between urban and rural were 4.3 for 16-foot and 5.4 for 14-foot mobile homes.

Summary of the Suitability of Designated Routes and Compliance with Permit Requirements

Designated Routes

The pilot program allowing limited manufacture and transport of 16-foot mobile homes requires that the 16-foot units be issued a single-trip permit that designates a specific route for the unit to follow. Four of the six 16-foot homes followed traveled off of their designated routes for at least some portion of their trips.

In general, the route is designed to take the 16-foot home in the most direct manner to the nearest multi-lane highway and then to an interstate highway for shipment out of the state. Designated routes were based on legal height which gives more flexibility in choosing routes. Over-height units (higher than 13' 6") allow less flexibility and, in some cases, less direct routes to avoid low clearances. Assessments of the designated routes indicate that in most cases the routes chosen serve to meet the goals of shipping the wider units on the most direct route and on the operationally safer wider and multi-lane roadways. It is apparent that routing of the wide loads on the overall safest route possible involves the need to weigh the availability the most direct routes against the availability of wider multi-lane roads with their potential for greater exposure of other vehicles to the wide loads over longer routes.

Speed of Mobile Homes

For both the 14-foot and 16-foot mobile homes, the maximum speed of travel is limited to 10 miles per hour less than the posted speed limit. Data on traveling speed were collected in three-minute intervals during the duration of each data run to determine the compliance of the units with speed limits and regulations. A total of 339 speed counts were made with 77 percent of the counts being made when the mobile home was unimpeded by traffic or traffic controls. Analyses of the speed data was restricted to the free-flowing units to present a clearer picture of unimpeded speed compliance.

Overall, the 14-foot units traveled an average speed eight miles per hour lower than the posted speed limit and the 16-foot units averaged six miles per hour below the speed limit. While the average speeds for these mobile homes are under the posted limits, they do not average at least 10 miles per hour under the limit as required. The 14-foot units were in compliance with the speed regulations 36 percent of the time and the 16-foot units were in compliance 17 percent of the time.

Escort Vehicles

Under the current set of regulations pertaining to the transport of mobile homes in North Carolina, 16-foot wide homes must have both a front and rear escort at all times. The 14-foot units transporting homes from the manufacturers to dealer lots must have a front escort on two-

lane roads and are not required to have any escorts while on multi-lane highways. All mobile homes followed during the course of this study complied with escort regulations.

It was apparent that the drivers of the 16-foot mobile homes benefitted from the information and assistance provided by the two escorts. The drivers of the 14-foot mobile homes driving without escorts were able to maneuver through potentially dangerous situations, but this was accomplished without the input or influence of escort drivers and vehicles and was solely the responsibility of the drivers of the other vehicles and the mobile home to recognize adverse situations and react to them. When escort vehicles were present, it appeared that the drivers of the mobile homes were able to concentrate more on the maneuvering of the wide load. It also appeared that although traffic may have still tried to get around the 16-foot mobile homes with their two escorts, the other vehicles tended to move more slowly and cautiously around them.

Recommendations

This evaluation of the on-road behavior of 16-foot mobile homes as compared to currently allowed 14-foot homes has shown that the 16-foot mobile homes are different in terms of their positioning on the roadway with other traffic present and that the other vehicles do react to the added width. In general, the differences indicate that the added width has significant potential for adversely affecting the safety of the other vehicles they may encounter. The decision of whether or not to expand the current 16-foot mobile home pilot program in North Carolina, and if so how to implement it in the safest manner possible, must take these differences into consideration.

If the decision is made to expand this program to allow more widespread transportation of 16-foot mobile homes within and through North Carolina, the following recommendations are made to assure that it can be accomplished in the safest manner possible:

Designated Routes

1. Routes used to transport 16-foot mobile homes should be multi-lane roadways where the total paved width of the travel lane and paved shoulders is at least 17 feet whenever possible. This same total paved width should be the target for two-lane roadways as well.

2. Modification of the existing system for determining acceptable routes should be considered. Alternative routes from a given shipping location should be identified where possible, such that the permitted route depends on both roadway geometries, current traffic conditions, and other factors (e.g., work zones). Determination of both the original definition of routes and the route actually permitted for a given shipment should be done with the input of all concerned parties -- the local DOT Division of Highways staff, the DOT Oversize/Overweight Permit Office staff, the manufacturer, and the transporter--

with the final route for any given trip determined as close to the actual shipment as possible.

3. Serious consideration of the impact of allowing shipment of over-height (over 13' 6") 16-foot wide mobile homes must be made. Over-height 14-foot mobile homes must already be routed differently than those of legal height. Routes that were designated by North Carolina Department of Transportation staff for pilot program 16-foot homes were based on legal heights which give some flexibility in choosing routes. Over-height units allow less flexibility in routing due to the need to avoid low clearances.

Escort Vehicles

4. The requirement for front and rear escorts for the 16-foot homes on all roadways should be continued. The escorts enhance the safety of the mobile home itself as well as that of the other vehicles sharing the road by providing information to the mobile home driver about road and traffic conditions and by positioning their vehicles as needed to block traffic when shifting or turning maneuvers are necessary on any roadway. In addition, finding routes with 17 feet of total paved surface width will be difficult if not impossible. The escorts are needed where narrow paved widths require the mobile homes to shift to the left and encroach across the lane or center line.

   While additional data collection, or further analysis of existing data, and a cost-benefit analysis would be required for a definite and strong recommendation, consideration should be given to requiring at least one escort vehicle for 14-foot mobile homes on all roadways. The 14-foot homes do not encroach across the center or lane line as often nor do other drivers encroach onto the shoulder as much when next to a 14-foot unit as for a 16-foot home. The mobile home center/lane line encroachments and shoulder encroachments for the other vehicles meeting or passing the 14-foot units that do exist are a concern and may be of sufficient frequency and magnitude to justify at least one escort on all roadways.

Allowable Times of Travel

5. All 16-foot homes began their runs after 9:00 am and were out-of-state by 2:30 pm as required. Furthermore, all of the wider homes were shipped on the days of the week allowed by the permits (Monday through Thursday). The parameters of this study did not allow for an evaluation of the impact on traffic congestion if the wider units were allowed to travel at other times of the day or days of the week, but common sense indicates that congestion would be worse and more vehicles would be exposed to the presence of the wider vehicles if the 16-foot homes were allowed to be on the road during weekday rush hours or on weekends. For this reason, it is recommended that the allowable times of

travel remain the same. If the allowable time for shipment is expanded, the additional time should be added to the Monday through Thursday early afternoon time but only to the extent that the time of day that travel is allowed does not extend into rush hour.

Speed Limits

6. Observations of the speed that the mobile homes traveled as well as their interaction with other vehicles provide no reason to recommend that allowable speeds be increased. Speeds for the mobile homes unimpeded by other traffic or traffic controls averaged less than the posted speed limit. The mobile homes did not, however, comply with the permitted speed of 10 miles per hour less than the posted speed limit the large majority of the time. It is felt that increasing allowable speed for the mobile homes would have an adverse effect on overall safety.

Permitting Process

7. The single trip permits for shipment of all 16-foot mobile homes should be continued to maintain maximum control and flexibility of routes as well as to enhance the possibility of enforcing permit violations. The annual permits issued for shipment of 14-foot homes from the manufacturer to dealer lots are actually issued to the transport vehicles rather than to the manufacturers or to the homes themselves. The transporter may have several permits listing up to 30 specific routes. Trying to determine if a mobile home is off-route on any given trip can therefore be problematic. Single trip permits would mean additional work for the DOT Oversize/Overweight Permit Office, the manufacturers and the transporters, but it should also enhance (1) the flexibility of assigning a final route for any given trip as close to the actual shipment as possible, and (2) the ability of enforcement officers to readily determine the specific requirements of a permit and whether the transporter is in compliance.

Enforcement of Violations

8. There are very complex issues involved in compliance with regulations, their enforcement, and sanctions for non-compliance. Enforcement officers are limited in their ability to pull over the mobile homes in a safe location to check for or enforce violations due to their size. Vehicles caught violating their permits must be parked in a safe location until the situation is resolved, and it can be difficult to find such a location. In addition, since the current sanctions are relatively small (especially when compared to possible sanctions for weight violations, which affect pavement wear rather than safety), they are probably not a sufficient deterrent to violations. Given that a sound system is in place to choose the safest routes (see Recommendation 2 above), then stronger sanctions for permit violators need

to be considered. Given the enforcement problems, the sanction itself should be the deterrent.

Driver Selection and Training

9. Conversations with manufacturer and transport company personnel revealed that the most experienced and better drivers are being used for shipment of 16-foot mobile homes. It is reasonable to assume that if the pilot program is expanded and the production and shipment of the wider homes increases significantly, the shipment of the 16-foot homes will increasingly be handled by drivers with less experience and who are not at the top of the driver group. Even with the better drivers, the 16-foot homes encroached over the lane or center line and dropped off of the paved surface significantly more often than the 14-foot homes under most conditions. For these reasons, the manufacturers and transporters should implement or modify driver selection procedures and driver training and monitoring programs to assure that the wider units are transported by the best drivers in terms of qualifications, experience, and safety records.

Data Collection Methodology

The basic method of data collection for this study was review and analysis of videotapes made of a sample of 14-foot and 16-foot mobile home units operating on North Carolina roadways. The field data collection consisted of following a representative sample of 14-foot units and 16-foot units from their manufacturing plants to the North Carolina border. The routes covered consisted of interstate and other four-lane divided highways as well as secondary roads used to access these major routes from the manufacturing plants. Methods used in this evaluation were based on and similar in many ways to previous studies evaluating the behavior and operational characteristics of 16-foot mobile homes and wider trucks.

Review of Studies Relevant to the Evaluation

There has been a great deal of research conducted on truck width as it relates to highway safety, but little has been done regarding the width of mobile homes being transported on highways. Most of the body of literature has to do with semis- and double-trailers, studies which examined width, length, and configuration of these trucks. One study conducted in North Carolina (Harkey et al., 1991) examined the operational effects of 102-inch-wide trucks compared to 96-inch-wide trucks, while accounting for other truck and driver characteristics. Lane placement and encroachment data were collected from slides taken of random trucks in the traffic stream. Truck width was determined from the slides as well, to prevent bias in reporting. Data was also collected from four control trucks on the same route with the same driver, to control for driver behavior. It was found that 102-inch-wide trucks have 1.5 to 2 times the number of edge line encroachments as 96-inch trucks, and operate about 2.5 inches closer to the center line overall. Although 102-inch trucks operated closer to the edge line, they did not operate any closer to the pavement edge than 96-inch trucks, since the majority of their encroachments were onto paved shoulders. Opposing vehicles were found to encroach on their edge lines more when meeting trucks closer to the center line, but only marginally more for 102-inch trucks than for 96-inch trucks (a 1% difference). Driver behavior was also found to have a significant effect on lane placement and edge line encroachments. In the random sample, similar trucks were operated differently by different drivers. In the control trucks, the same truck type was operated consistently by the same driver, and different truck types were operated similarly by the same driver.

There has been some work done, however, that deals specifically with mobile home width, and how traffic safety is affected by homes of different widths. One study conducted in Michigan specifically regarding mobile homes (MacAdam et al., 1992) evaluated the differential effects of mobile home width (14-feet versus 16-feet) on adjoining traffic and maneuverability. Data was collected using in-field measurements of 13 mobile homes chosen at random, and analysis of video logs of those vehicles. Encroachment time and oncoming vehicle behavior were the two principle areas of analysis. The authors found that trucks transporting 16-foot homes encroach into the adjacent lane twice as much as those hauling 14-foot wide homes (40.3%

versus 20.5%), but cause passing cars to encroach their shoulder in roughly equal numbers (66%). Oncoming vehicles were found to encroach their own shoulders 57 percent of the time when approaching a 16-foot home, and only 32% for a 14-foot home, but these numbers are tempered by the fact that most encroachments made when facing a 16-foot home were onto paved shoulders. A formula was derived for determining what roads should be approved for mobile home transport, which said that the cleared width of the right-of-way should be equal to or exceed the width of the mobile home plus 4.25 feet.

In all, these studies conclude that although width does play a role in the operation of wider trucks and mobile home transport units, it is uncertain whether the noted effects present any safety hazards that would require mitigation. In addition to affecting the operation of the trucks themselves, these wider trucks affect the behavior of drivers of other vehicles that encounter them. The Harkey et al. study recommends limiting the use of wider trucks to highways with sufficient paved shoulder width and cleared area, and the MacAdam et al. study recommends the continued practice of requiring escort vehicles for mobile home transport. According to the authors, both of these measures would increase the operational safety of wider trucks.

These studies were used as a basis for the methodology used in this evaluation if the on-road behavior of 16-foot mobile homes in North Carolina. Following is a description of the methodology used and information gathered for this study.

Inventory of Routes Designated for Transporting 16-foot Mobile Homes

Before videotaping runs were initiated, Highway Safety Research Center (HSRC) data collection staff took an inventory of the designated routes for each manufacturer. Each route was divided into route segments, identified by a 2-digit segment number, and detailed measurements were recorded on "Designated Route Roadway Inventory" forms for each segment. Each form included information regarding road number and name, length, number of lanes, speed limit, measurements of lane and shoulder widths and presence of curbing (see Appendix B). In addition, each contained a diagram of the segment as well as other comments. Later, these segment numbers were converted into unique 6-digit segment identification numbers. This information was used during videotape analysis to correlate tape times with actual locations, thereby providing specific roadway information at most points during the data collection run.

Sample Selection

Initial plans were to videotape a sample of eight 16-foot mobile homes from their manufacturing plants to the state line and to tape a comparable sample of eight 14-foot mobile homes traveling the same routes.

Ideally, mobile homes units included in the study would have been selected randomly and followed without the knowledge of the manufacturers or transporters. Due to the relatively low number of 16-foot homes being produced and shipped out of state under the pilot program, and in order to select the most appropriate transport routes for inclusion in the sample, it was necessary to enlist the help of individuals with close connection to the manufactured housing transport industry. The North Carolina DOT was very helpful in keeping the project team up-to-date on permits issued for transport, as well as in helping to clarify the specific regulations governing mobile home transport. Members of DOT Oversize/Overweight Permit Office staff worked with HSRC to devise an efficient system for monitoring the issuance of permits to each of the various manufacturers. These manufacturers, in turn, were contacted individually to allow the project team to determine their shipment schedules.

The shipping coordinators for each manufacturer were contacted at least weekly for scheduling updates and routing information regarding the transport of their 16- and 14-foot homes as well as any supplementary information that might be useful. Although some of the manufacturers handled mobile home shipments in-house, most used hired contractors to transport their homes from the plants to dealer lots. These transport companies were also contacted regularly for shipping information, and their drivers and managers were most cooperative in aiding our field team in their research.

The sample of units actually observed was selected using the information provided to HSRC by the participating manufacturers and the DOT Oversize/Overweight Permit Office related to shipments of 14- and 16-foot units. Thirteen manufacturing plants were authorized to participate in the pilot program but not all thirteen were available to be included in the study. Some of the authorized plants decided not to participate in the program at all and other plants produced only a few 16-foot units during the duration of the data collection period. Of the manufacturers that were actively participating, some were located so close to an interstate that their authorized route would not include significant non-interstate mileage. A further difficulty in locating appropriate units to include in the study was that the 14-foot homes are authorized to travel a wide variety of routes from the manufacturing plant to their final destination which may or may not be out-of-state.

Based on the location, level of production, and shipping schedules of plants participating in the pilot program, a sample of six 16-foot mobile homes were included in the study and five 14-foot units traveling similar, but not necessarily the same, routes were included in the study. A summary of the data runs made, including routes used, is included in Appendix D.

The overall intent of the data collection process was to collect information on the differences, if any, in the impact of 16-foot mobile homes on surrounding traffic as compared to the 14-foot units. Of particular interest are the instances or "events" where another vehicle is the lane to the immediate left of the mobile home. As shown in Table 3, a total of over 3100 vehicles were recorded while to the immediate left of the mobile homes followed with a similar

Table 3 Number of Events* Recorded per Data Run.

16' Units		14' Units		
Data Run	No. of Events*	Data Run	No. of Events*	
16.1	99	14.1	98	
16.2	334	14.2	318	
16.3	203	14.3	437	
16.4	240	14.4	483	
16.5	413	14.5	293	
16.6	222			
Total	1629		1511	3140

* Event defined as another vehicle present in the lane to the immediate left of the mobile home unit while:

- Meeting the mobile home from the opposite direction on a 2-lane road.
- Passing from the same direction on a 2-lane road,
- Overtaking the unit from the same direction on a 4-lane road, or

number of events recorded for the two sizes of mobile homes even though there was one less run for the 14-foot units.

Video Data Collection Methodology

HSRC data collection staff videotaped the mobile home units from the plant exits to the state line. Each videotape was stamped electronically with date and time information. The videotape in the front camera was also stamped with a stopwatch reading. The size of the mobile home being followed and the date of the data run were used to create unique a tape identification number. Each tape was also assigned a unique two-digit tape number. Individual images on the videotape from the front camera were assigned eight-digit image identification numbers by combining the two-digit tape number with the hour, minute, seconds, and tenths-of-a-second readings from the stamped stopwatch. A second video camera, mounted at the rear of the observation vehicle and pointed out the back window, was used to observe and record queuing behavior of vehicles preparing to overtake both 14- and 16-foot mobile homes. The set up of equipment and positioning of the cameras are illustrated in Figures 1 and 2.

The trained observers monitored the video to ensure quality and recorded roadway information (number, type, condition, intersections, speed limit and speed of unit) onto a form

Figure 1 Setup and Positioning of the Front Camera and Monitors.

Figure 2 Setup and Positioning of the Rear Camera.

associated with the video. The observation vehicle was also equipped with a CB radio to monitor communications between tractor, escort drivers and other vehicles surrounding the unit.

The protocol for data collection can be subdivided into four steps: pre-trip, on-site setup, final procedures immediately prior to exiting the plant, and the actual data collection run. Each of these steps involved distinct elements of preparation for the collection and assimilation of data used in this study.

During the pre-trip preparation stage, both the driver and data recorder used a pre-trip checklist to ensure that necessary supplies were sufficient and that the equipment was in proper condition. Once on site, and prior to the data run, data collectors went through a setup checklist to be sure that all equipment was set up and ready for the data run. First the video tapes to be used that day labeled with a 9-digit formatted identification number. The first two digits of the tape ID number were either 14 or 16, depending upon the size of the unit. The second two digits were the month, followed by two digits signifying the day, and then two digits identifying the sequence of tapes for that day (e.g., 01 or 02). The last digit was a letter, either "F" for the front view camera or "R" for the rear view camera. Next, the data collectors set up all video equipment, ensuring proper connections and settings. The date/time stamp was set to the current date and time and synchronized between the front and rear cameras. The character generator/stopwatch for the front camera was also reset to zero prior to departure. In addition, flashing lights and a CB antenna were mounted on the van roof, and all front and rear window glass was cleaned.

Immediately prior to the exit of the mobile home unit from the plant, data collectors informed the drivers of the transport vehicle and escort(s) that they would be following the unit. If the unit to be followed was a 16-foot unit with the required rear escort, the drivers were reminded that the van would be positioned between the unit and the rear escort for the duration of data collection. The physical measurements of the mobile home unit were made at this time, and the information entered on the “Mobile Home Unit Information” form (Appendix B). Data collectors then verified the CB channel that the drivers would be using so they would be able to establish or maintain contact if it became necessary and to monitor the conversations of the mobile home and escort drivers. As the mobile home unit left the plant, data collectors began recording tapes on both video cameras and started the character generator stopwatch and the digital timer.

During the data runs for the 16-foot units, the data collection van was positioned between the mobile home and the rear escort vehicle. This positioning was necessary to record the unobstructed view of the rear of the mobile home needed for detailed image analyses and other data reduction. The van was equipped with flashing yellow lights on top to indicate that the vehicle was a part of the mobile home convoy, not just some vehicle that had passed the escort to try to pass the mobile home. Fourteen-foot units had no rear escorts, so the data collection van was the only vehicle positioned directly behind the mobile home. The flashing yellow lights were placed on the van when behind 14-foot units as well to indicate that the van was traveling with the mobile home. The van may have looked like an escort vehicle to other

drivers coming up from behind, but the data collection van displayed no escort vehicle signs and did not position itself as an escort would during mobile home maneuvers.

During the data run, the responsibilities of the data collection team were divided between the driver and the recorder in such a way that each task could be accomplished most efficiently and effectively. The driver's responsibilities included first and foremost the safe operation of the data collection vehicle. The driver also maintained a relatively constant distance behind the mobile home unit, to the degree that was possible, and positioned the van as far as possible to the left of, but still within, the travel lane. The driver's other responsibilities included calling out the speed of the vehicle (read from the speedometer) when requested, and making audible comments regarding roadway features (in order to help determine roadway identification numbers when reviewing the tapes).

The recorder had the primary responsibilities of monitoring the data collection equipment and ensuring that the proper views of the road and the target mobile home unit were being captured. Other responsibilities of the recorder included the observation of the on-board video monitor to determine necessary zoom adjustments and camera positioning and the operation of the digital timer for speed and traffic counts.

The recorder also had the responsibility of updating the Mobile Home Speed/Traffic Log form (Appendix B). At 3-minute intervals, signaled by the digital timer, the recorder entered current data including stopwatch time, stabilized speed, rear traffic count, and roadway identification number. The recorder then reset the timer. If the mobile home unit traveled on roads not designated as part of its route, blank inventory sheets were used to quickly record the road name, number and location. Physical characteristics would be obtained later from the tape or from return trips if necessary.

These procedures were continued until the mobile home unit and data collection vehicle reached the state line. At that point, the driver left the interstate at the first available exit and pulled off the road at a safe and convenient location.. The driver and recorder then shut down and packed up the video equipment and returned to HSRC to review the tapes and record the information contained therein.

Reduction of Data from the Videotapes

Measures collected from review of the video were used to determine the positioning of the 16- and 14-foot mobile home units relative to the center or lane line and the positioning of vehicles to the left of 16-foot units as compared to 14-foot units. Comparisons were made for oncoming vehicles on two-lane undivided highways and for vehicles overtaking the mobile homes on four-lane median divided NC or US routes and interstates. Research assistants reviewed all tapes and recorded pertinent data for most vehicles (not including motorcycles) in a lane to the immediate left of the mobile home on two-lane and four-lane divided roadways. Vehicles were not included if the event occurred in an intersection or at a point where the

roadway was in transition from one lane configuration to another, such as when the pavement widens to add a center turn lane. Multi-lane roads with more than two travel lanes for the mobile home's direction of travel were also excluded. Data recorded for each event included:

- Event identifying information (e.g., image number, date, and time)
- Unit size
- Lane width (from initial roadway measurements or image analysis)
- Shoulder width) in categories of <1 foot, 1 ft - <2ft, 2 ft - <3ft, 3 ft - <4ft, 4+ ft, or presence of obstructions to reduce shoulder width)
- Left edge of mobile home encroachment across the center lane line (based on the view from the tape and categorized as
    - Definite yes: Left edge of unit appears to extend beyond left edge of lane line
    - Definite no: Left edge of unit appears to be on or inside left edge of lane line
    - Close: Very close to lane line and unable to definitely determine yes or no
    - Unable to determine for any other reason)
- Encroachment of the other vehicle categorized as
    - None: Left tire of opposite vehicle on or inside left edge of left fog or lane line
    - Minor: Left tire of opposite vehicle extends beyond left edge of left fog or lane line and appears to be within a foot of the line - On pavement
    - Moderate: Left tire of opposite vehicle extends beyond left edge of left fog or lane line and vehicle appears to be more than a foot over the line - On pavement
    - Off Pavement: Any tire of vehicle off of pavement to any degree
    - Unable to determine: For any reason
- Whether or not the right tire(s) of the mobile home dropped off of the edge of the pavement and categorized as
    - No - No tire of the mobile home appears to drop off of the pavement to the right.
    - Yes - Any tire of the mobile home appears to drop off of the pavement to the right.
    - Unable to determine - Very close to dropping off of the pavement to the right but unable to definitely determine yes or no.

A full list of variables derived through this process is included as Appendix E. The data reduction procedures produced information on 3140 events where there was another vehicle to the left of the mobile home. As will be discussed in more detail in the results of analyses, events from one of the 16-foot data runs were excluded from the analyses. With this exclusion, a total of 2937 events are available for analysis.

Sampling for Image Analysis

Samples of the images on the tapes for each data run were randomly selected for image analysis. Only those events occurring on two-lane and four-lane interstates or median divided roadways with no physical obstructions (e.g., narrow bridges or work zones) were included in the image analysis since these conditions include the predominate types of roadways used by the

mobile homes and portray the positioning of the mobile homes under normal shoulder conditions. The target sample size for each data run was 20 event images on two-lane roadways and 20 event images on four-lane roadways (interstates and other four-lane median divided roadways combined). A list of selected event images was generated and selected images were captured as a digitized file using “Snappy” video image capture hardware and software.

Once images were captured, specified measurements were made for each image using “Sigma Scan Pro” image analysis software. “Sigma Scan Pro” allows the user to employ an object of known size on the image to calibrate all other measurements made on the image. Calibrations were made using objects on the rear of the mobile home, such as the wide load signs or trailer width itself, measured by the research assistants prior to the start of the run. A vertical "plumb-line" was then drawn down toward the pavement from the mid-point of bottom edge of trailer. The plumb line was drawn to be the same distance as was measured from the bottom of the mobile home to the ground prior to the data run. The end-point of this line identified a point on the pavement directly beneath the rear edge of the mobile home on the image. Using the bottom point of the plumb-line defined above, a baseline across the width of the image was drawn as close as possible to be perpendicular to the lane lines. Vertical lines were then drawn from the outside and inside edges of the unit down to a point intersecting the baseline. Using these lines as guides, measurements were made of:

- Lane width = midpoint of lane line (or midpoint between double lane lines) to the outside of edge line
- Right shoulder width = outside of edge line to the edge of paved shoulder or curb
- Shoulder encroachment distance = outside edge of edge line to intersection of the right edge vertical line and the baseline (negative number if right edge of unit is inside the edge line)
- Centerline encroachment distance = intersection of left edge vertical line with the baseline to the midpoint of the lane line or midpoint between double lane lines (negative number if left edge of unit is inside the lane line), and
- Separation distance = intersection of left edge vertical line for mobile home with the baseline to the intersection of the baseline with the line defining alignment of opposing vehicle's tires

One concern with making measurements in this manner was the possible effects of parallax (increasing distortion in measurements as the distance from the center of the image increases) on the accuracy of the measurements to the right and left of the mobile home. To address this concern, tests were conducted to determine the presence and degree of measurement errors due to parallax using this method. Traffic cones were set up in a parking lot 16 feet apart to represent the edges of a 16-foot mobile home, with other cones placed in increments of five feet to either side. A videotape was made from the data collection van positioned just inside the left-hand edge-cone representing the width of the mobile home. This positioning was similar to the position taken behind the mobile homes during data runs. Measurements made from video images recorded from a distance of 50 feet from the cones resulted in a measurement of 9.5 feet to the cone placed 10 feet to the right of the right edge-cone. To the left, 10.1 feet was measured on the image to the cone placed 10 feet to the left of

the left edge-cone. The measurement error was greater to the right of the image since this was farther from the center of the image. This degree of accuracy, especially to the left of the image where the other vehicles would be, is considered to be close enough to produce consistently valid measurements.

Data derived in this manner as well as other information drawn from the event images was entered into a database for analysis (Appendix E). This process produced a total of 444 images that were captured, measurements were made and analyzed. Of this total, 232 of the measured images were for 14-foot homes and 212 were for 16-foot homes. Figures 3, 4, 5 and 6 provide examples of the measurements made from the images for the two sizes of mobile homes on two- and four-lane roads.

Table 4 Final Event Image Analysis Sample

Road Type	Mobile Home Size		
	14	16	Total
2 Lane	113	96	209
4 Lane Interstate	47	72	119
4 Lane Median Non-Interstate	72	44	116
Total	232	212	444

Speed of Mobile Home Units and Measures of Congestion Data Collection

The speed at which mobile home units are allowed to travel are addressed in the regulations covering the movement both the 14-foot and 16-foot mobile homes and is the same for both sizes. In both cases, the “Maximum speed of travel shall at no time exceed 10 mph less than the posted speed limit. For example, if the posted speed is 55 mph the mobile home is not to exceed 45 mph and if the posted speed is 65 mph, 55 mph is the maximum allowable speed.

Data on traveling speed and counts of traffic directly behind and impeded by the mobile home were collected in three-minute intervals during the duration of each data run. To assure that an accurate speed reading could be obtained, the speedometer on the data collection van was tested on a Clayton Dynamomet and found to accurate to one mph at speeds of 50 and 60 mph. At 3-minute intervals, signaled by a digital timer, driver stabilized the speed of the van to match that of the mobile home and called out the speed from the speedometer. The three-minute signal also prompted the recorder to look to the rear to count the number of vehicles impeded by and backed up behind the mobile home, escort vehicle (for 16-foot units) and the data collection van. The data recorder riding in the van entered this speed and traffic count information on a form along with the stopwatch time from the on-board video monitor. During the course of the runs, a total of 339 speed and traffic counts were made.

After the data run was completed and tapes were being processed for data reduction, one of the tasks was to review the tapes in combination with review of the roadway inventory logs to determine and/or verify the posted speed limit for each stopwatch reading where speed readings were made. Additional information determined and coded was the mobile home size, the date and day of week, time of day, roadway type, categorization of the setting as urban, rural or mixed, and whether the mobile home was traveling unimpeded or of it was impeded by other traffic or traffic controls. The data was then entered and processed for analysis (Appendix F).

References

Harkey, DL, Zegeer, CV, Stewart, JR, and Reinfurt, DW. **Operational Impacts of Wider Trucks on Narrow Roadways**. Chapel Hill, NC: University of North Carolina Highway Safety Research Center, 1991. 35 pp. UNC/HSRC--91/8/2.

MacAdam, C, Streff, F, Christoff, C, and Karamihas, S. **Executive Summary Report to the Michigan State Legislature and Steering Committee Regarding the 16-ft Wide Mobile Home Study**. Ann Arbor, MI: The University of Michigan Transportation Research Institute, 1992. 25 pp. UMTRI-92-18-1 (Volume 1).

MacAdam, C, Streff, F, Christoff, C, and Karamihas, S. **Final Report to the Michigan State Legislature and Steering Committee Regarding the 16-ft Wide Mobile Home Study**. Ann Arbor, MI: The University of Michigan Transportation Research Institute, 1992. 140 pp. UMTRI-92-18-2 (Volume 2).

Figure 3 14-foot Mobile Home on a Two-Lane Road

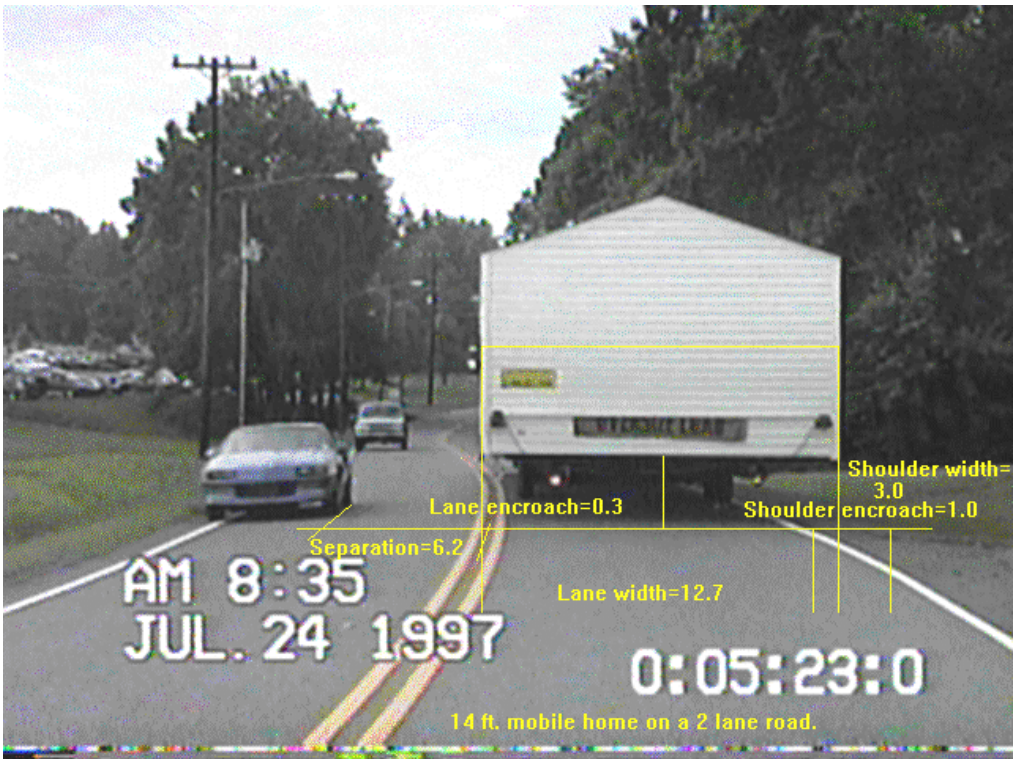


Figure 4 14-foot Mobile Home on a Four-Lane Road

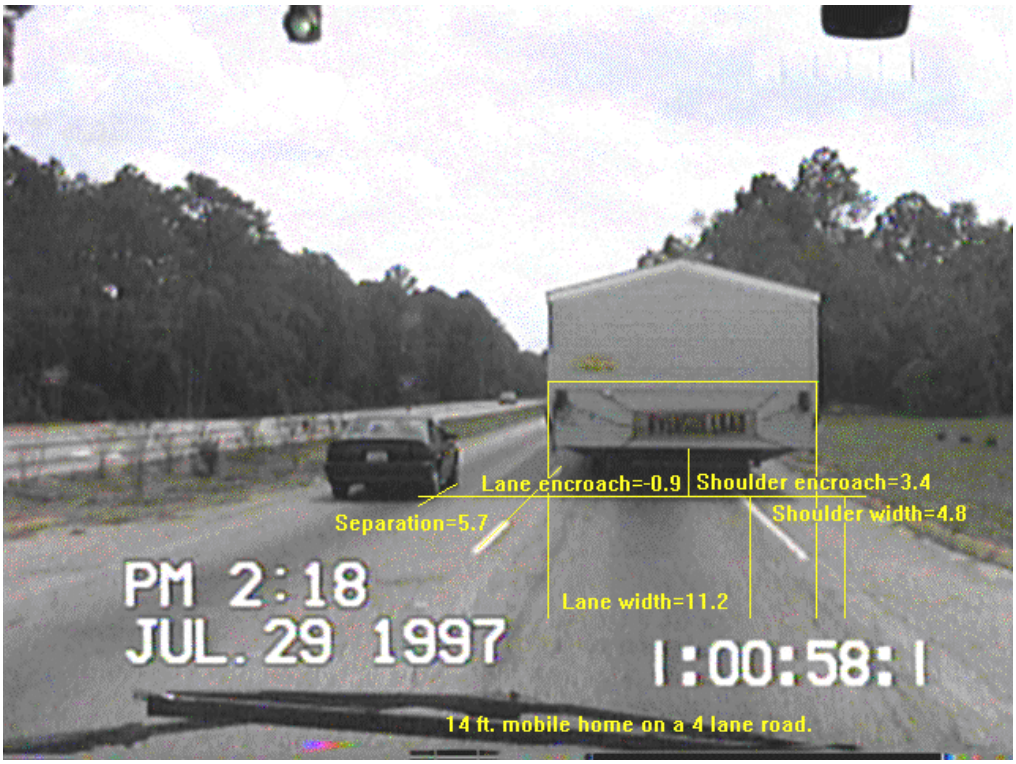


Figure 5 16-foot Mobile Home on a Two-Lane Road

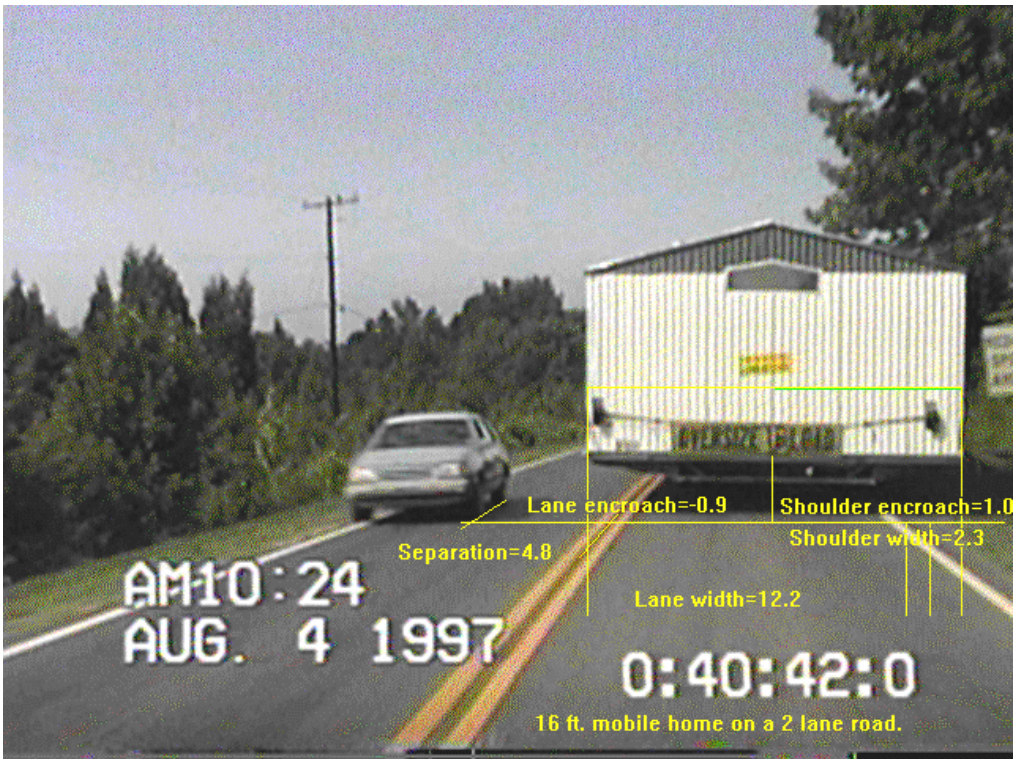


Figure 6 16-foot Mobile Home on a Four-Lane Road

Results

The basic method of data collection for this study was videotape review and analysis of data derived from the videotapes for a sample of 14-foot and 16-foot mobile home units operating on North Carolina roadways. The overall intent of the data collection process was to collect information on the differences, if any, in the positioning of the 16-foot mobile home itself on the roadway and in the impact of 16-foot mobile homes on surrounding traffic as compared to the 14-foot units. Every tape was fully reviewed and information was gathered for most instances, or “events”, where there was another vehicle in the lane to the immediate left of the mobile home. These other vehicles were either coming from the opposite direction on two-lane roads or were overtaking the mobile home while traveling in the same direction on a four-lane road. Data was gathered for over 3100 events in this part of the data reduction process. Of these 3100 events, a sample of over 400 events were randomly selected for further analyses. These images were captured as a digitized image and pertinent measurements were made to establish the position of the mobile home on the roadway and in relation to the right edge line, the center lane line, and to the other vehicle.

Results of Full Tape Analysis

As was indicated in Table 3 on page 16 above, six data runs were made for the 16-foot units and five runs were made for the 14-foot homes, resulting in 3140 events. The missing comparable run for the 14-foot units is one where the route taken is NC 49 south from US 52 to Charlotte. Two runs were made along this route for 16-foot units including one where two 16-wides traveled in tandem one behind the other. The one 14-foot data run on NC 49 was also two 14-wides traveling in tandem. A comparable single 14-foot unit following this same route was not located and followed during the data collection period. To better assure that the comparisons being made between the different sizes of mobile homes were as sound as possible, the data derived from run 16.3 (the run where a single 16-foot wide unit traveled NC 49 south from US 52 to Charlotte) has been excluded from analyses unless otherwise noted. A total of 2937 events are available for analysis with the 203 events from run 16.3 excluded.

The main categories of comparison between units of different sizes were mobile home and other vehicle overtaking behaviors on four-lane divided roadways, and their behavior on two-lane undivided highways used to access primary routes. As shown in Table 5, approximately 50 percent of the 14-foot and 40 percent of the 16-foot events observed occurred on two-lane roadways. The next highest proportion (39% of the 14's and 16's) were observed on four-lane interstates with four-lane median (but non-interstate) roadways following at 10 percent for the 14-foot units and 19 percent for the 16-foot units. Overall, about one percent of the events were observed on four-lane roadways with the travel lanes separated by a center turn lane. Due to the low number of events on this type of roadway, the twenty-eight four-lane with center turn lane events were also excluded from further analyses. The final analysis file contains information on 2909 events which is more than sufficient to produce valid and statistically significant results.

Table 5 Number of Events recorded by Road Type and Mobile Home Size (Excluding Run 16.3)

Road Type		Size 14'	16'	Total
2 Lane	N	820	534	1354
	Col%	50.3%	40.8%	52.4%
4 Lane Interstate	N	639	513	1152
	Col%	39.2%	39.2%	39.2%
4 Lane median	N	157	246	246
	Col%	9.6%	18.8%	14.0%
4 Lane + center turn lane	N	13	15	28
	Col%	0.8%	1.2%	1.3%
Total	N	1629	1308	2937
	Row%	55.5%	45.5%	100%

Chi-square tests of significance were computed to determine if the differences in the distributions between the different sizes of mobile homes are statistically significant. In the tables that follow, the chi-square (χ^2) distributions are presented where statistically significant differences exist. Differences that are not statistically significant are noted as "ns."

Encroachment of Mobile Homes Across the Lane Line

One variable of interest in this study is the degree to which the mobile homes encroach across the center lane line into the other lane. During review of the tapes from the data runs, careful examination was made to determine if the left edge of the mobile home was clearly over the lane line to the left of the mobile home. Categories assigned to lane encroachments and analyzed are as follow:

- Definitely yes - Left edge of mobile home definitely appears to extend beyond the left edge of the lane line.
- Definitely no - Left edge of mobile home definitely appears to be inside the left edge of the lane line.
- Close - Very close to left edge of lane line and unable to definitely determine yes or no.

Table 6 presents the percent of the time where the mobile home unit either definitely did or did not encroach across the lane line or if the positioning relative to the lane line was so close that no definitive judgement could be made. As indicated, the overall lane encroachments for the 16-foot units are almost identical to those of the 14-foot units when run 16.3 is excluded. For both sizes overall, the mobile home definitely did encroach over the lane line slightly over five percent of the time when another vehicle was present to the left of the mobile home. The mobile

Table 6 Encroachment of Mobile Home Across Lane Line by Size of Mobile Home

MH Lane Encroachment		Size		
		14	16	Total
Definite Yes	N	83	68	151
	Col%	5.2%	5.3%	5.2%
Close	N	167	149	316
	Col%	10.4%	11.6%	10.9%
Definite No	N	1359	1070	2429
	Col%	84.5%	83.1%	83.9%
Total	N	1609	1287	2896
	Row%	55.6%	44.4%	100%

Missing values = 12

Statistical significance: Not Significant (ns) $\chi^2_{(2)} = 2.3$, p =.31

homes did not encroach over the line about 84 percent of the time, and the positioning was too close to call about 10 percent of the time. The differences in the distribution of different types of encroachments between the two sizes of mobile homes are not statistically significant.

Analyses of lane encroachments, however, do show significant differences between the different sizes when road type, lane widths, and shoulder widths are examined. Table 7 presents encroachments of mobile homes across lane line by size of mobile homes and road type. Differences in lane encroachments are present and statistically significant on the two-lane roads. On the two-lane roads used to access major four-lane highways and the interstates, the left (toward the center of the roadway) edge of the 14-foot units definitely did encroach over the lane line 8.4 percent of the time with the left edge of the 16-foot units definitely encroaching at a higher rate of 12.8 percent. The events classified as “close” were those where the edge of the mobile home was very close to the lane line but not definitely over the line. When the “definite yes” and “close” categories are combined, the 14-foot units encroach or come close 28 percent of the time and the 16-foot units do so 38 percent of the time. This difference is also statistically significant ($\chi^2_{(1)} = 13.0$, p =.001). Figure 7 graphically presents the proportions of units definitely encroaching for the different roadways.

The width of the travel lanes plays a role in the ability of both sizes of mobile home units to stay within their lanes. Table 8 presents the lane encroachments of the 14- and 16-foot units when lane widths are taken into consideration. The proportion of units definitely encroaching are shown in Figure 8. Lane encroachments for the 16-foot units are much higher than for the 14-foot units where the lanes are less than 12 feet wide. On these narrow lanes, the 16-foot units definitely encroached into the other lane 25 percent of the time compared to 10 percent for the

Table 7 Encroachment of Mobile Home Across Lane Line by Size of Mobile Home and Road Type

MH Lane Encroachment		Road Type							
		2 Lane		4 Lane Interstate		4 Lane Non-Interstate		Total	
		14'	16'	14'	16'	14'	16'	14'	16'
Definite Yes	N	68	68	3	2	7	0	78	70
	Col%	8.4%	12.8%	0.5%	0.4%	4.5%	--	4.9%	5.4%
Close	N	162	132	6	20	2	4	170	156
	Col%	20.0%	24.9%	0.9%	3.9%	1.3%	1.6%	10.6%	9.7%
Definite No	N	582	330	630	491	148	242	1360	1063
	Col%	71.7%	62.3%	98.6%	95.7%	94.3%	98.4%	84.6%	66.1%
Total	N	812	530	639	513	157	246	1608	1289
	Row%	50.5%	41.1%	39.7%	39.8%	9.8%	19.1%	100%	100%
Significance:		$\chi^2_{(2)}$=14.1, p=.001		$\chi^2_{(2)}$=11.3, p=.003		$\chi^2_{(2)}$=11.2, p=.004		ns	
Missing values = 12								Total N = 2897	

Figure 7 Encroachment of Mobile Home Across Lane Line by Size of Mobile Home and Road Type

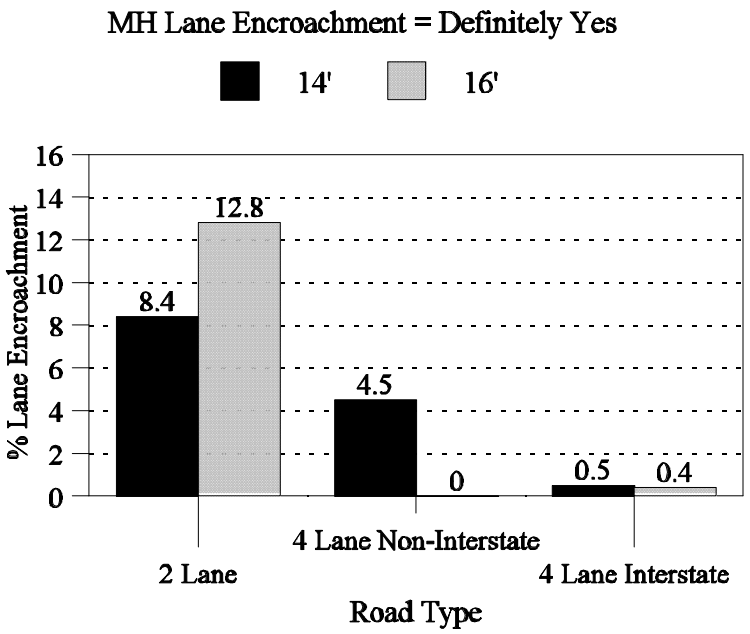
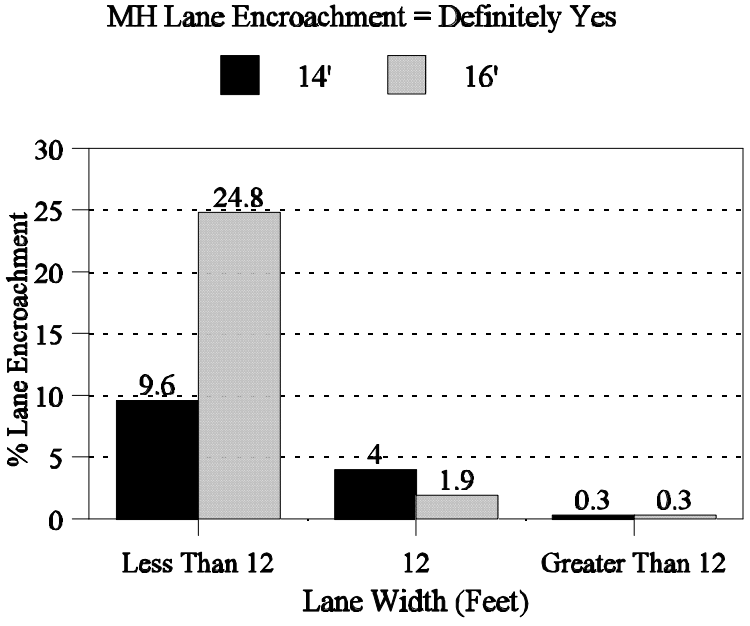


Table 8 Encroachment of Mobile Home Across Lane Line by Size of Mobile Home and Lane Width

MH Lane Encroachment		Lane Width							
		Less than 12'		12'		Greater than 12'		Total	
		14'	16'	14'	16'	14'	16'	14'	16'
Definite Yes	N	46	61	31	7	1	2	78	70
	Col%	9.6%	24.8%	4.0%	1.9%	0.3%	0.3%	4.9%	5.4%
Close	N	107	98	58	39	5	19	170	156
	Col%	22.4%	39.8%	7.5%	10.3%	1.4%	2.9%	10.6%	12.1%
Definite No	N	325	87	687	333	348	643	1360	1063
	Col%	68.0%	35.4%	88.5%	87.9%	98.3%	96.8%	84.6%	82.5%
Total	N	478	246	776	379	354	664	1608	1289
	Row%	29.7%	19.1%	48.3%	29.4%	22.0%	51.5%	100%	100%
Significance:		$\chi^2_{(2)}$=73.2, p=.001		$\chi^2_{(2)}$=6.0, p=.05		ns			
Missing values = 12								Total N = 2897	

Figure 8 Encroachment of Mobile Home Across Lane Line by Size of Mobile Home and Lane Width



14-foot units. This difference is highly significant. Interestingly, on the 12-foot lanes, the percentage of 14-foot units definitely encroaching was higher than for the wider units (4.0% vs. 1.9%) with the difference being statistically significant. When the "yes" and "close" categories are combined, however, the proportions are nearly identical (11.5% for the 14's and 12.1% for the 16's) and the difference is not significant ($\chi^2_{(1)} = 0.1$, p =.74).

Table 9 examines mobile home lane encroachments while controlling for shoulder width. Shoulder width is divided into categories of less than one foot, one to two feet, two to three feet, three to four feet, and four feet or more. As expected, the proportions of lane encroachments are highest where the shoulders are narrower. On the roads where there were in effect no paved shoulders (less than one foot of paved shoulder width), the 14-foot mobile homes encroached across the lane line 15 percent of the time and the 16-foot units encroached 23 percent of the time. The differences between the 14- and 16-foot units where the paved shoulders are less than one foot are not statistically significant. Without paved shoulders available for the units to shift onto when other vehicles were present, both sizes of mobile homes either definitely encroached or were very close to encroaching nearly 70 percent of the time. In general, as the paved shoulder width becomes greater, both sizes encroach into the other lane less often. The 16-foot units, however, definitely encroached more often where the shoulders were from one to two feet than they did with shoulders of less than one foot, and the differences between the 14- and 16-foot units are statistically significant for shoulder width of less than one foot.

Table 9 Encroachment of Mobile Home Across Lane Line by Size of Mobile Home and Shoulder Width

MH Lane Encroachment		Shoulder Width											
		<1 foot		1-2ft		2-3ft		3-4ft		4+ft		Total	
		14'	16'	14'	16'	14'	16'	14'	16'	14'	16'	14'	16'
Definite Yes	N	28	33	25	16	1	9	0	0	4	5	58	63
	C%	14.8%	22.6%	11.2%	34.8%	0.4%	6.6%	--	--	0.1%	0.6%	3.7%	4.9%
Close	N	99	63	42	15	8	36	1	11	9	31	159	156
	C%	52.4%	43.2%	18.8%	32.6%	2.8%	26.5%	0.7%	7.1%	1.2%	3.9%	10.1%	12.2%
Definite No	N	62	50	156	15	275	91	145	143	714	763	1352	1062
	C%	32.8%	34.3%	70.0%	32.6%	96.8%	66.9%	99.3%	92.9%	98.2%	95.5%	86.2%	82.9%
Total	N	189	146	223	46	284	136	146	154	727	799	1569	1281
	R%	12.0%	11.4%	14.2%	3.6%	18.1%	10.6%	9.3%	12.0%	46.3%	62.4%	100%	100%
Significance:		ns		$\chi^2_{(2)}$=25.7, p=.001		$\chi^2_{(2)}$=73.7, p=.001		*		$\chi^2_{(2)}$=10.4, p=.005			
Missing values = 47												Total N = 2850	

*Not computed due to row or column sum = 0. When categorized as "Yes/Close" vs. "No", $\chi^2_{(1)}$= 8.1, p=.004

Table 10 presents mobile home lane encroachments where the shoulders were obstructed by some object, such as a parked car, or where the shoulders narrowed due to bridges (or for any other reason). There were a total of 35 events recorded while the shoulder was obstructed. Both sizes of units definitely encroached or were close to encroaching nearly 90 percent of the time, with the 14-

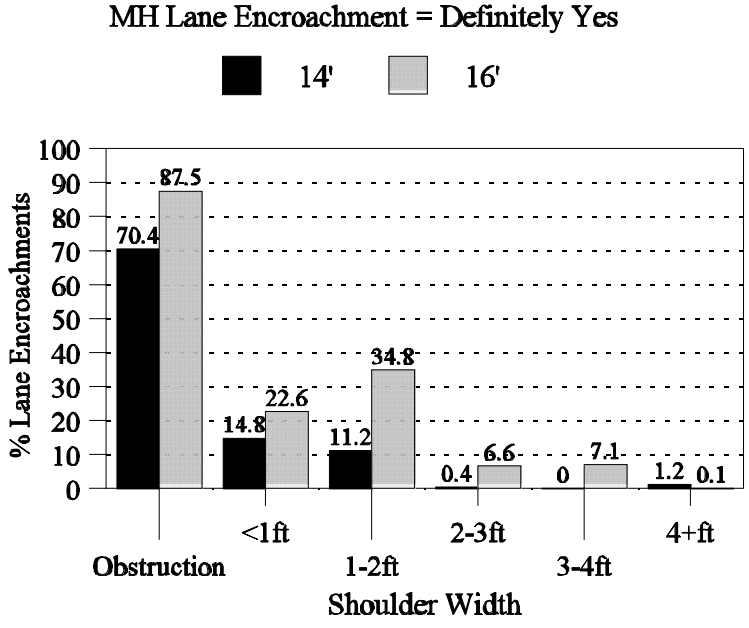
foot units definitely encroaching in 19 out of 27 cases (70%). Seven out of the 8 (88%) 16-foot units definitely encroached, and one definitely did not. Figure 9 presents the definite lane encroachments for different paved shoulder widths, including the obstructed shoulders.

Table 10 Encroachment of Mobile Home Across Lane Line When Shoulder is Obstructed by Size of Mobile Home.

MH Lane Encroachment		Size		
		14	16	Total
Definite Yes	N	19	7	26
	Col%	70.4%	87.5%	74.3%
Close	N	5	0	5
	Col%	18.5%	--	14.3%
Definite No	N	3	1	4
	Col%	11.1%	12.5%	11.4%
Total	N	27	8	35
	Row%	77.1%	22.9%	100%

Significance: ns ($\chi^2_{(2)} = 1.73$, $p = .42$)

Figure 9 Encroachment of Mobile Home Across Lane Line by Size and Shoulder Width



Instances of Right Tires of Mobile Homes Dropping Off of the Pavement

Also of interest to this evaluation of the on-road behavior of mobile homes, and relevant to the routes chosen for the transport of wide loads, are those instances where the right tire(s) of the mobile homes being studied dropped completely off of the pavement. Tires dropping off of the pavement are of concern due to the increased possibility of loss of control as the positioning of the unit is corrected to get back on the pavement. Fortunately, no instances of loss of control due to this situation were witnessed during the data collection runs. During review of the tapes and the data reduction process, careful examination again noted the instances where the right tires of the mobile homes dropped off the pavement. Categories assigned to pavement drop-offs and analyzed are as follow:

- No - No tire of the mobile home appears to drop off of the pavement to the right.
- Yes - Any tire of the mobile home appears to drop off of the pavement to the right.
- Unable to determine - Very close to dropping off of the pavement to the right but unable to definitely determine yes or no.

Table 11 contains information on the cases where the right tire of the mobile home did drop off of the pavement and as can be seen this did occur 65 times (2.2%) out of the 2909 total events. The right tire dropped off the pavement in 1.3 percent of the 14-foot events and 2.2 percent of the 16-foot events.

Tables 12 and 13 present pavement drop-offs with lane and shoulder widths taken into consideration. As shown in Table 12 and Figure 10, the majority of drop-offs do occur for both sizes (86% for the 14's and 83% for the 16's) where the lanes are less than twelve feet wide. Almost 16 percent of the events for 16-foot units on lanes less than 12 feet wide involved the right tire dropping off of the pavement, significantly greater than the 2.7 percent drop-offs for the 14-foot events. There were no statistical differences for lanes 12 feet wide or more.

As would be expected, pavement drop-offs occur most often where the paved shoulders are narrow, as shown in Table 13 and Figure 11. Where the shoulders were less than a foot in width, 29 percent of the 16-foot events involved pavement drop-off compared to the smaller, and significantly different, four percent for the 14-foot units.

Table 11 Instances of Right Tire of Mobile Home Dropping Off of the Pavement by Size of Mobile Home

MH Drop off Pavement		Size		
		14'	16'	Total
Yes	N	19	46	65
	Col%	1.2%	3.6%	2.2%
No	N	1538	1183	2721
	Col%	95.2%	91.5%	93.5%
Unknown	N	59	64	123
	Col%	3.7%	5.0%	4.2%
Total	N	1616	1293	2909
	Row%	55.6%	44.4%	100%

Significance: $\chi^2_{(2)} = 22.1$, p =.001

Table 12 Instances of Right Tire of Mobile Home Dropping Off of the Pavement by Size of Mobile Home and Lane Width

MH Drop off Pavement		Lane Width							
		Less than 12'		12'		Greater than 12'		Total	
		14'	16'	14'	16'	14'	16'	14'	16'
Yes	N	13	36	5	7	1	0	19	43
	Col%	2.7%	15.6%	0.6%	1.9%	0.3%	--	1.2%	3.3%
No	N	461	170	724	349	353	664	1538	1183
	Col%	95.5%	68.0%	92.9%	92.1%	99.7%	100%	95.2%	91.5%
Unknown	N	9	41	50	23	0	0	59	64
	Col%	1.9%	16.4%	6.4%	6.1%	--	--	3.7%	5.0%
Total	N	483	250	779	379	354	664	1616	1293
	Row%	29.9%	19.3%	48.2%	29.3%	21.9%	51.4%	100%	100%
Significance:		$\chi^2_{(2)}$=104, p=.001		ns		*			
Total N = 2909									

*Not computed due to row or column sum = 0.

Figure 10 Instances of Right Tire of Mobile Home Dropping Off of the Pavement by Size of Mobile Home and Lane Width

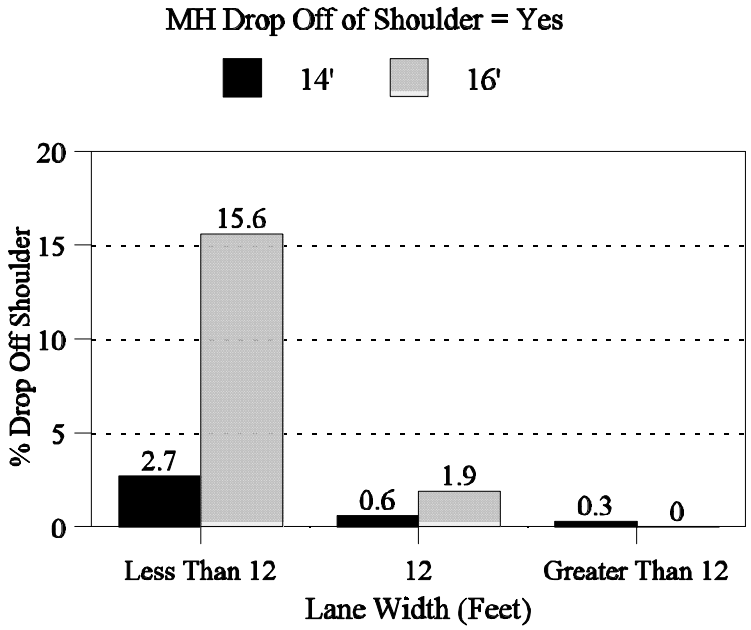
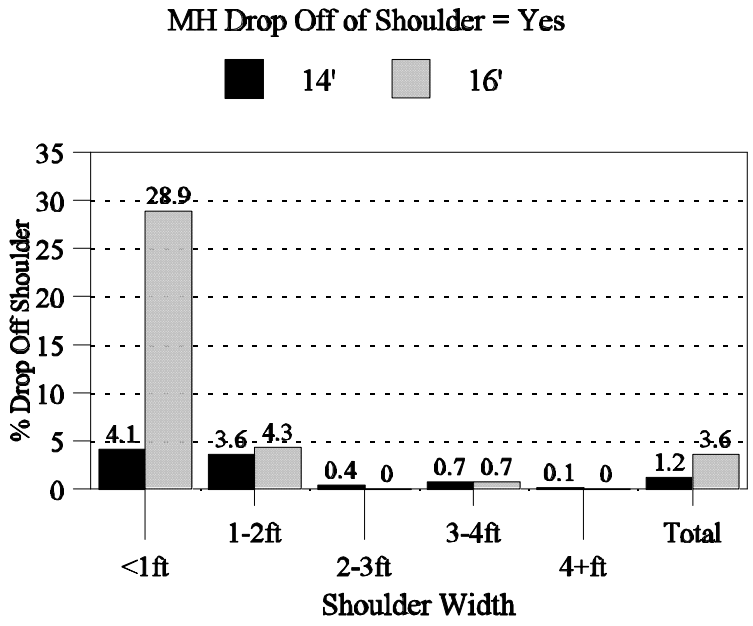


Table 13 Instances of Right Tire of Mobile Home Dropping Off of the Pavement by Size of Mobile Home and Shoulder Width

MH Drop off Pavement		Shoulder Width											
		<1 foot		1-2ft		2-3ft		3-4ft		4+ft		Total	
		14'	16'	14'	16'	14'	16'	14'	16'	14'	16'	14'	16'
Yes	N	8	43	8	2	1	0	1	1	1	0	19	46
	C%	4.1%	28.9%	3.6%	4.3%	0.4%	--	0.7%	0.7%	0.1%	--	1.2%	3.6%
No	N	177	67	186	35	275	123	144	151	725	799	1507	1175
	C%	90.3%	45.0%	83.4%	74.5%	96.5%	90.4%	98.6%	98.1%	99.7%	100%	95.6%	91.4%
Un-known	N	11	39	29	10	9	13	1	2	1	0	51	64
	C%	5.6%	26.2%	13.0%	21.3%	3.2%	9.6%	0.7%	1.3%	0.1%	--	3.2%	5.0%
Total	N	196	149	223	47	285	136	146	154	727	799	1577	1285
	R%	12.4%	11.6%	14.1%	3.7%	18.1%	10.6%	9.3%	12.0%	46.1%	62.2%	100%	100%
Significance:		$\chi^2_{(2)}$=84.5, p=.001		ns		$\chi^2_{(2)}$=8.1, p=.02		ns		ns			
Total N = 2862*													

*35 cases where shoulder was obstructed and no drop-offs occurred excluded from table.

Figure 11 Instances of Right Tire of Mobile Home Dropping Off of the Pavement by Size of Mobile Home and Shoulder Width



Encroachment of Other Vehicles Onto the Shoulder

Of particular interest concerning the safety of wider mobile homes is the positioning of other vehicles on the road that encounter the mobile homes and whether the wider loads presented by the 16-foot units adversely affect these other vehicles. During review of the tapes and reduction of the data from the runs, observations were made to determine if the outside tires of the other vehicle crossed completely over the edge line and onto the shoulder, and if so, to what degree. Categories defined and analyzed for other vehicle shoulder encroachment are as follow:

- None: Any tire of the other vehicle is on or inside outside edge of left edge line
- Yes <1ft: Any tire of the other vehicle is completely beyond outside edge of left edge line and appears to be within a foot of the line and still on pavement
- Yes >1ft: Any tire of the other vehicle extends beyond outside edge of left edge line and vehicle appears to be more than a foot over the line and still on pavement
- Yes Off Pavement: Any tire of the other vehicle is completely off of the pavement to any degree

Table 14 presents the encroachment of other vehicles onto the shoulder while controlling for the size of mobile home. The other vehicles did encroach onto the shoulder when next to a 16-foot unit 29 percent of the time overall, compared to 16 percent for vehicles next to a 14-foot unit. The

Table 14 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home

Other Vehicle Encroachment		Size		
		14'	16'	Total
Yes: <1ft	N	200	272	472
	Col%	13.0%	21.7%	16.3%
Yes: >1ft	N	44	62	106
	Col%	2.9%	4.9%	3.7%
Yes: Off Pavement	N	5	26	31
	Col%	0.3%	2.1%	1.1%
None	N	1288	894	2182
	Col%	83.8	71.3	75.1%
Total	N	1615	1289	2904
	Row%	55.6%	44.4%	100%
Missing values = 12				

Significance: $\chi^2_{(3)}=71.47$, p=.001

differences in the distribution of other vehicle encroachments between the two sizes are statistically significant.

Table 15 presents other vehicle shoulder encroachments controlling for road type and indicates that other vehicles next to 16-foot units did encroach onto the shoulder to some degree 34 percent of the time on two-lane roads, 26 percent of the time on four-lane interstates, and 23 percent of the time on 4 lane median non-interstate roads. These shoulder encroachments for the 16-foot units are higher than for the 14-foot units on all types of roads where the other vehicles encroached onto the shoulder 16 percent of the time on two-lane roads, 18 percent of the time on four-lane interstates, and 8 percent of the time on four-lane median non-interstate roads. Figure 12 presents other vehicle shoulder encroachments dichotomized into “yes, the other vehicle encroached onto the shoulder” and “no, the other vehicle did not encroach” while controlling for road type.

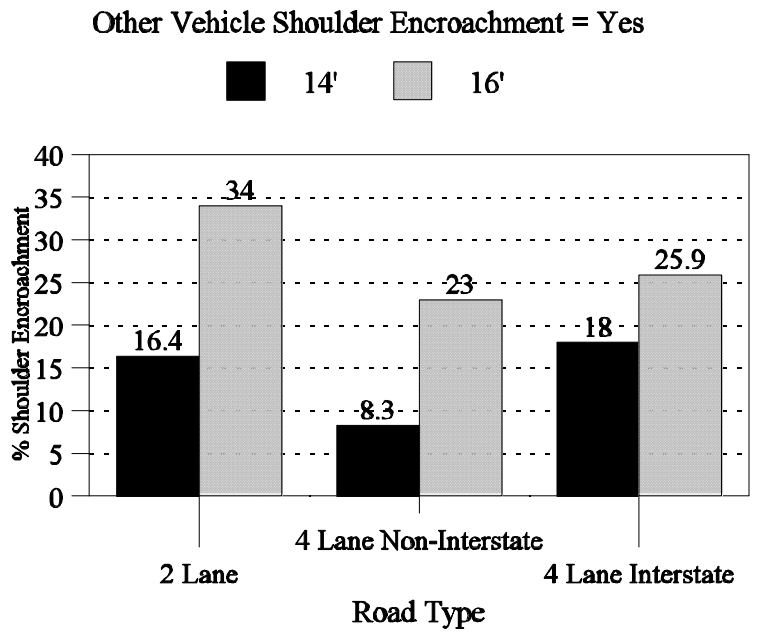
Of particular interest and concern are the cases where the other vehicles encroached onto the shoulder and at least one of their tires dropped completely off of the pavement. Dropping off of the pavement is of great concern since this can increase the chance of loss of control of a vehicle. Table 14 indicates that overall, 2.1 percent of the other vehicles next to the 16-foot units dropped at least one of their tires off of the pavement compared to 0.3 percent for vehicles next to 14-foot wide units. Table 15 shows that all but one of the 31 other vehicle pavement drop-offs occurred on two-lane roads.

Table 15 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home and Road Type

Other Vehicle Encroachment		Road Type							
		2 Lane		4 Lane Interstate		4 Lane Non-Interstate		Total	
		14'	16'	14'	16'	14'	16'	14'	16'
Yes: <1ft	N	111	128	81	105	8	39	200	272
	Col%	14.3%	24.9%	13.4%	21.0%	5.1%	16.3%	13.0%	21.7%
Yes: >1ft	N	11	22	28	25	5	15	44	62
	Col%	1.4%	4.3%	4.6%	5.0%	3.2%	6.3%	2.9%	4.9%
Yes: Off Pavement	N	5	25	0	0	0	1	5	26
	Col%	0.7%	4.9%	--	--	--	0.4%	0.3%	2.1%
None	N	648	339	496	371	144	184	1288	894
	Col%	83.6%	66.0%	82.0%	74.1%	91.7%	77.0%	83.8%	71.3%
Total	N	775	514	605	501	157	239	1537	1254
	Row%	50.4%	41.0%	39.4%	40.0%	10.2%	19.1%	100%	100%
Significance:		$\chi^2_{(3)}$=64.8, p=.001		*		$\chi^2_{(3)}$=15.0, p=.002			
Missing values = 118								Total N = 2791	

*Not computed due to row or column sum = 0. When categorized as "Yes" vs. "No", $\chi^2_{(1)}$=10.2, p=.001

Figure 12 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home and Road Type



Other vehicle shoulder encroachment categories while controlling for lane widths are presented in Table 16 with dichotomized shoulder encroachments presented in Figure 13. As indicated by Table 16, 33 percent of the vehicles next to a 16-foot wide mobile home on two-lane roads encroached onto the shoulder, with nearly nine percent dropping off of the pavement. This compares to an overall shoulder encroachment rate of 17 percent for the vehicles next to 14-foot units with only one percent going off of the pavement. Twenty six percent of the vehicles next to the 16- foot mobile homes, compared to 12 percent for the 14-foot units, encroached onto the shoulder where the lanes were 12 feet wide, but the off-pavement shoulder encroachments were reduced to one percent for vehicles next to 16-foot units and zero for 14-foot units.

Other vehicle shoulder encroachments are not as affected by shoulder width as might be expected. Table 17 presents information on the encroachment of other vehicles onto the shoulder while controlling for mobile home size and the width of the shoulder. Instances where the shoulder for the mobile home unit was obstructed are presented in Table 18. Dichotomized shoulder encroachments are presented in Figure 14. Statistically significant differences between the distributions of shoulder encroachments for the different sizes are found for shoulder widths of less than one foot and where the shoulders are 3-4 feet or greater. Where shoulder widths are narrow, it appears that other vehicles are either forced to (or choose to) use the shoulder to get around the 16-foot units more often than when encountering the 14-foot units. Ten percent of the vehicles next to the 16's, compared to one percent for the 14's, went off of the pavement where the shoulder for the mobile home was less than a foot. All of the five off-pavement shoulder encroachments for vehicles next to 14-foot units and 22 of the 26 (85%) of the off-pavement shoulder encroachments vehicles next to the 16-foot units occurred where the shoulder width was not obstructed but was less than three feet.

Where the shoulders were obstructed, the other vehicles encroached onto the shoulder when next to a 16-foot unit 63 percent of the time compared to 40 percent for vehicles next to 14-foot units (Table 18 and Figure 14). This difference is not statistically significant.

Interestingly, 40 percent of the vehicles encountering 16-foot units where the shoulders for the mobile home lanes were three to four feet, and 25 percent where the shoulder was four feet or greater, encroached onto the shoulder to some degree. This compares to significantly smaller proportions for vehicles encountering the 14's, of which about 18 percent encroached in the presence of the wider shoulders. Assuming that wide shoulders for the mobile home travel lane means that the shoulders for the other lane will also be wider, it appears that drivers of vehicles encountering the 16-foot units recognize the wider load and use all available paved surface to safely get around the mobile home.

Table 16 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home and Lane Width

Other Vehicle Encroachment		Lane Width							
		Less than 12'		12'		Greater than 12'		Total	
		14'	16'	14'	16'	14'	16'	14'	16'
Yes: <1ft	N	62	53	93	95	45	124	200	272
	Col%	13.5%	22.0%	12.4%	26.1%	13.8%	9.1%	13.0%	21.7%
Yes: >1ft	N	10	6	14	19	20	37	44	62
	Col%	2.2%	2.5%	1.9%	5.2%	6.1%	5.7%	2.9%	4.9%
Yes: Off Pavement	N	5	21	0	4	0	1	5	26
	Col%	1.1%	8.7%	--	1.1%	--	0.2%	0.4%	2.9%
None	N	384	161	643	246	261	487	1288	894
	Col%	83.3%	66.8%	85.7%	67.6%	80.1%	75.0%	83.8%	71.3%
Total	N	461	241	750	364	326	649	1537	1254
	Row%	30.0%	19.2%	48.8%	29.0%	21.2%	51.8%	100%	100%
Significance:		$\chi^2_{(2)}$= 37.5, p=.001		$\chi^2_{(2)}$= 54.9, p=.001		ns			
Missing values = 118								Total N = 2791	

Figure 13 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home and Lane Width

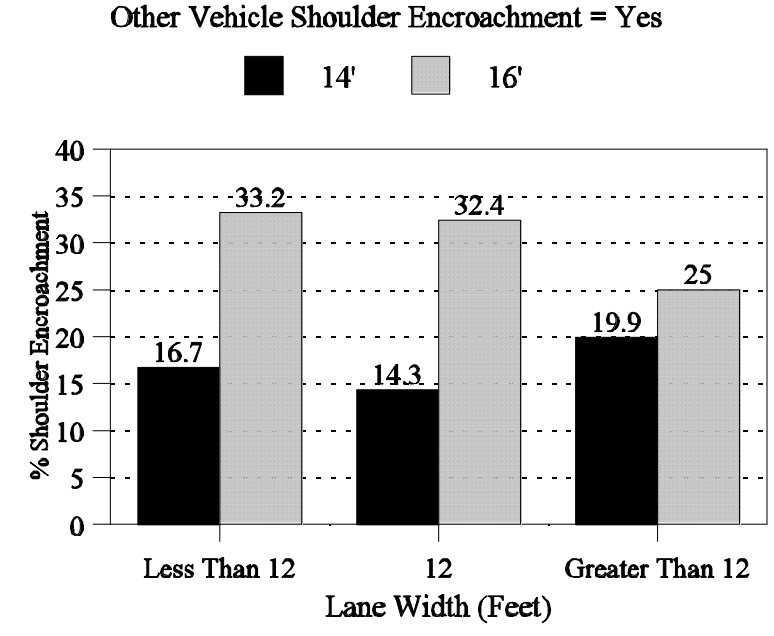


Table 17 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home and Shoulder Width

MH Lane Encroachment		Shoulder Width											
		<1 foot		1-2ft		2-3ft		3-4ft		4+ft		Total	
		14'	16'	14'	16'	14'	16'	14'	16'	14'	16'	14'	16'
Yes:<1ft	N	14	27	21	12	46	25	20	48	91	158	192	270
	C%	7.7%	17.6%	10.1%	27.3%	16.8%	19.1%	14.0%	32.9%	13.1%	20.3%	12.8%	21.7%
Yes:>1ft	N	2	2	0	0	3	4	4	11	28	43	37	60
	C%	1.1%	1.4%	--	--	1.1%	3.1%	2.8%	7.5%	4.0%	5.5%	2.5%	4.8%
Yes: Off Pvmnt	N	3	15	2	5	0	1	0	2	0	2	5	25
	C%	1.7%	10.3%	1.0%	11.4%	--	0.8%	--	1.4%	--	0.3%	0.4%	2.8%
None	N	162	101	185	27	225	101	119	85	575	577	1266	891
	C%	89.5%	69.7%	88.9%	61.4%	82.1%	77.1%	83.2%	58.2%	82.9%	74.0%	84.4%	71.5%
Total	N	181	145	208	44	274	131	143	146	694	780	1500	1246
	R%	12.1%	11.6%	13.9%	3.5%	18.3%	10.5%	9.5%	11.7%	46.3%	62.6%	100%	100%
Significance:		$\chi^2_{(2)}$=22.6, p=.001		*		ns		$\chi^2_{(2)}$=22.4, p=.001		$\chi^2_{(2)}$=18.2, p=.001			
Missing Values = 87												Total N = 2850	

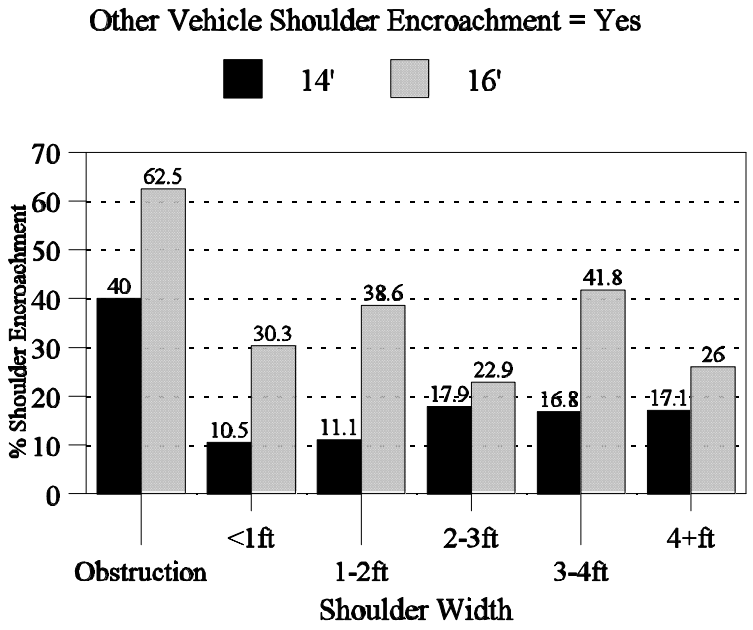
*Not computed due to row or column sum = 0. When categorized as "Yes" vs. "No", $\chi^2_{(1)}$= 20.7, p=.001

Table 18 Encroachment of Other Vehicles Onto the Shoulder When Shoulder is Obstructed by Size of Mobile Home

MH Lane Encroachment		Size		
		14	16	Total
Yes: <1ft	N	4	2	6
	Col%	16.0%	25.0%	18.2%
Yes: >1ft	N	6	2	8
	Col%	24.0%	25.0%	24.2%
Yes: Off Pavement	N	0	1	1
	Col%	--	12.5%	3.0%
None	N	15	3	18
	Col%	60.0%	37.5%	54.5%
Total	N	25	8	33
	Row%	75.8%	24.2%	100%

Significance: ns

Figure 14 Encroachment of Other Vehicles Onto the Shoulder by Size of Mobile Home and Shoulder Width



Results of Detailed Image Analyses

As previously described, video image analysis methods were developed to measure and capture information on the following variables:

- Lane width = midpoint of lane line (or midpoint between double lane lines) to outside of travel lane edge line
- Right shoulder width = outside of edge line to edge of paved shoulder or curb
- Shoulder encroachment distance = distance right edge of mobile home extends beyond outside edge of edge line (negative number if right edge of unit is inside the edge line)
- Centerline encroachment distance = distance left edge of mobile home extends to the left of the midpoint of center or lane line or midpoint between double lane lines (negative number if left edge of unit is inside the lane line), and
- Separation distance = distance between the left edge of mobile home and tires of the other vehicle to the left of the mobile home

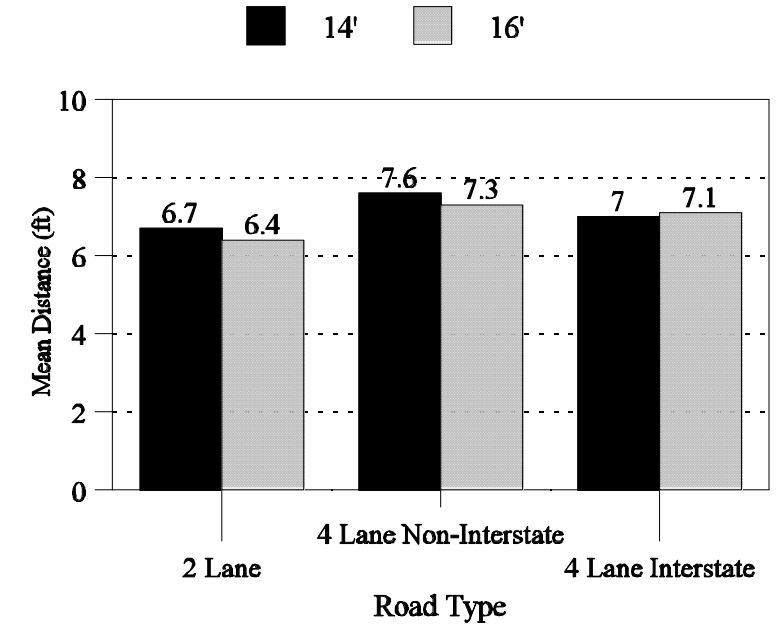
As previously indicated in Table 4 on page 22, a total of 444 images were selected, captured and analyzed using these procedures when images for data run 16.3 are excluded. Of this total, 232 14-foot mobile home event images and 212 16-foot mobile home event images were analyzed.

The analysis of the still images extracted from the video tapes focused on three specific variables: 1) position of the mobile home units with respect to the center line or lane line, 2) encroachment of the mobile home units onto or beyond the right shoulder, and 3) separation distance between the mobile home units and oncoming or passing vehicles. Since all of these measures of effectiveness (MOE's) are impacted by the amount of available paved surface, the analysis was conducted to assess the differences between 14- and 16-foot units as a function of total paved surface width, which includes the travel lane width and the paved shoulder width. The analysis was also performed separately for each of the three roadway classifications included in this study: 1) two-lane roads, 2) interstates, and 3) other divided multi-lane roads. The significant differences between the 14- and the 16-foot units are based on a confidence level of 95 percent. The mean values provided in the figures are adjusted means across all sites, and subsequently all lane and shoulder widths, which correct for any differences in the significant variables between sites. These adjusted means provide a much more adequate picture of the differences and the magnitude of any effects. Finally, an analysis was conducted to determine the amount of space and paved surface required for these vehicles to safely operate.

Separation Distance

An examination of the separation distance between the mobile home unit and oncoming vehicles on two-lane roads showed that, on average, 16-foot units are significantly closer to opposing traffic than 14-foot units. As shown in Figure 15, the adjusted mean separation distance for the 16-foot units across all paved surface widths is 6.4 feet, while for the 14-foot units, the mean separation distance is 6.7 feet.

Figure 15 Mean Separation Distance by Size of Mobile Home and Roadway Type Across All Pavement Widths.



Further examination of this variable showed that as the width of the travel lane or paved shoulder increased, the separation distance between oncoming vehicles and either size mobile home unit also significantly increased. For every one-foot increase in paved surface width, the separation distance increased by 0.43 feet. These results indicate that the mobile homes and/or the oncoming traffic take advantage of the increased surface area and use it to provide increased separation distance.

The adjusted mean separation distances between the 14- and 16-foot units and passing vehicles on both interstates and other divided multi-lane roadways are also shown in Figure 15. On interstates, the separation distance was nearly the same for the 16- and 14-foot units (7.1 vs 7.0 feet, respectively). On other types of multi-lane roadways, the 16-foot units were closer to the passing vehicles when compared to the 14-foot units (7.3 vs. 7.6 feet, respectively). However, in contrast to the two-lane results, the differences between the two different width units on either type of multi-lane facility were not significant. When separation distance was evaluated as a function of paved surface width, the results were the same as previously noted from the two-lane road analysis. As the width increased, the separation distance between the mobile home units (irrespective of unit width) and passing vehicles significantly increased. For each one-foot increase in the paved surface width, the separation distance increased by 0.26 feet on interstates and 0.29 feet on other multi-lane roadways.

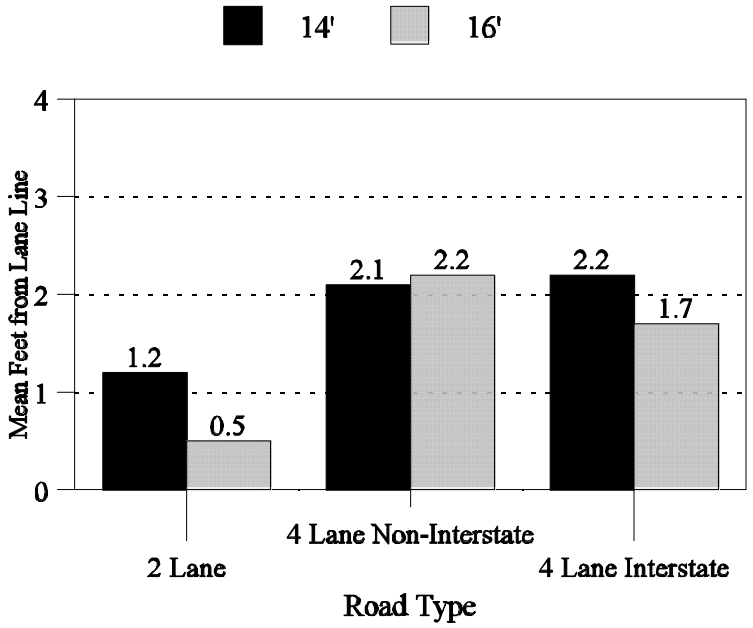
Further examination of the separation distance variable showed that this distance significantly decreased when the opposing or passing vehicle was a large truck, irrespective of the width of the mobile home unit. On two-lane roads, the separation distance was reduced by 0.45 feet. On interstates, the magnitude of the reduction was 0.64 feet while on other types of multi-lane roadways, the reduction was 1.01 feet. These results simply reflect the increased width of the large trucks and the fact that drivers of these vehicles are probably less intimidated by these large units on the roadway and thus less likely to move away from the units. It may also reflect the fact that, in some cases, the increased width of these vehicles does not allow them to move further from the unit if the width of the paved surface is already being fully utilized by the interacting vehicles.

Lateral Positioning

Shown in Figure 16 are the mean lateral positioning values for the left edge of the mobile home unit as measured from the center line on two-lane roads or the lane line on multi-lane roads. On two-lane roads, the 16-foot units were, on average, 0.5 feet from the center line. In comparison, the 14-foot units were 1.2 feet from the center line. This difference between the units of different sizes was statistically significant. As with the separation distance variable, the distance of the mobile home unit from the center line significantly increased as the width of the paved surface increased. For each one-foot increase in paved shoulder or lane width, the mobile home units moved 0.32 feet further from the center line.

On interstates, the 16-foot units were also, on average, closer to the lane line that the 14-foot units (1.7 feet vs. 2.2 feet, respectively). This difference of 0.5 feet was also statistically significant. On other types of multi-lane roadways however, there was virtually no difference in the adjusted mean values with the 16-foot units being, on average, 2.2 feet from the lane line and the 14-foot units

Figure 16 Mean Distance From the Center or Lane Line by Size of Mobile Home and Roadway Type Across All Pavement Widths.



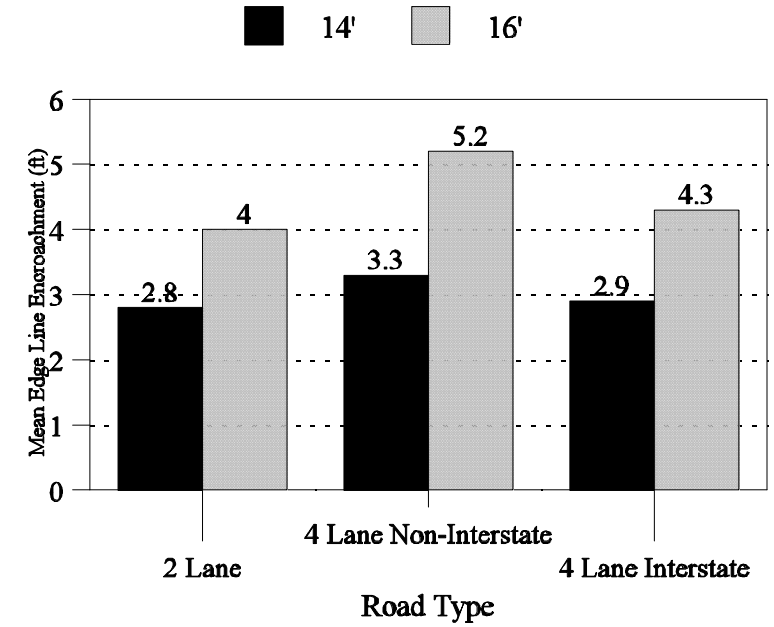
being 2.1 feet from the lane line. As with the two-lane road analysis, the distance of the mobile home units from the lane line also significantly increased as the width of the paved surface increased. For each one-foot increase in the width of the paved surface, the units moved 0.22 feet and 0.32 feet further from the lane line for interstates and other multi-lane roads, respectively.

Encroachment Over the Edge Line

Shown in Figure 17 are the adjusted mean positioning values of the right edge of the mobile home as measured from the outside of the edge line toward the paved shoulder or beyond. In other words, these values provide an indication of the magnitude of encroachment over the edge line by the mobile home units. For all roadway types, the magnitude of the encroachment was significantly greater for the 16-foot units when compared to the 14-foot units. On two-lane roadways, the 16-foot units, on average, encroached beyond the edge line 4.0 feet compared to 2.8 feet for the 14-foot units. On interstates, the mean magnitude of the encroachment was similar for the 16- and 14-foot units at 4.3 feet and 2.9 feet, respectively. The largest difference between the two sizes of units was observed on other multi-lane roadways with the 16-foot units encroaching over the edge line, on average, 5.2 feet while the 14-foot units encroached 3.3 feet.

As with the other measures of effectiveness, the degree of encroachment on all three roadway types was significantly related to paved surface width. As lane width increased, the amount of encroachment significantly decreased. This would be expected since a greater portion of the mobile home unit could travel within the lane as it became wider. For each one-foot increase in lane width on

Figure 17 Mean Edge Line Encroachment by Roadway Type Across All Pavement Widths.



two-lane roadways, interstates, and other multi-lane roadways, the amount of encroachment decreased by 0.66 feet, 0.65 feet, and 0.54 feet, respectively. The opposite effect was found for shoulder width. As the width of the shoulder increased, the amount of encroachment also significantly increased. Combining these results with those of the other measures of effectiveness, it is noted that the drivers of all mobile home units took advantage of paved shoulders to increase their distance from the center line or lane line, and to increase their separation distance from vehicles in the adjacent lane. For each one-foot increase in shoulder width on two-lane roadways, interstates, and multi-lane roadways, the amount of encroachment increased by 0.33 feet, 0.32 feet, and 0.44 feet, respectively.

Pavement Widths Required to Eliminate 95 Percent of the Lane Encroachments

Encroachments into the adjacent lane to the left can be a serious problem if these events occur in the presence of another vehicle in that lane. On a two-lane road, such an event could potentially result in a head-on or sideswipe collision or possibly in one or both vehicles running off the road. On multi-lane roadways, such events may result in sideswipe or run-off-road type crashes. As previously discussed, the 16-foot units exhibited significantly more encroachments over the center line or lane line, and over the edge line, when compared to the 14-foot units. It was also found that the 16-foot units ran off the paved surface significantly more often than the 14-foot units. To provide information needed to minimize the number of encroachments, and thus the potential for collisions with other vehicles, an analysis was undertaken to determine the amount of paved surface required to eliminate 95 percent of the lane encroachments.

Logistic models were fit to the observations to determine the probabilities of (1) encroachments over the center line or lane line, (2) encroachments beyond the right paved surface, and (3) encroachments over either of these locations. Models were fit to the observations on all three roadway types for each type of encroachment. The results are shown in Table 19 and indicate the paved width required to eliminate 95 percent of each type of encroachment. For 14-foot units, a width of 16.3 feet would be required to eliminate encroachments over the centerline or lane line, while a width of 17.3 feet would be required to eliminate encroachments beyond the right edge of the paved surface. In order to eliminate both types of encroachments for 14-foot unit, a width of 17.8 feet would be required. For 16-foot units, these values increase to 19.0 feet for left encroachments, 19.0 feet for right encroachments, and 19.5 feet for both.

Table 19 Desired "Clear-Zone Widths" Required to Eliminate 95 Percent of All Encroachments.

Mobile Home Width	Type of Encroachment		
	Center line or lane line	Right Paved Surface	Both
14 ft	16.3 ft	17.3 ft	17.8 ft
16 ft	19.0 ft	19.0 ft	19.5 ft

In reality, the values produced by the models represent the "clear zone" width required, since by definition the widths produced by the models eliminate encroachments of the entire width of the mobile home units, as opposed to encroachment of the tires of the units. Assuming that the "clear zone" values produced can be achieved, the amount of paved surface required can be determined by subtracting the amount of overhang on the right side of the unit. Mobile home unit's axles are typically 9.5 feet in width. Thus for a 14-foot unit, the amount of overhang on one side is 2.25 feet [(14-9.5)/2]. For a 16-foot unit, the amount is 3.25 feet.

Since the ultimate goal is to eliminate encroachments both to the left and right, the paved surface calculations were only made for this condition. For 14-foot units, the amount of paved surface required becomes 15.50 feet (17.75 - 2.25) while for 16-foot units, the required amount of paved surface becomes 16.25 feet (19.5 - 3.25). Since it is unlikely that an incremental width would be paved in the real-world, these values have been adjusted up to 16 feet for 14-foot units and 17 feet for 16-foot units. The recommended clear widths and paved surface widths for the two sizes of mobile home units are shown in Table 20.

Table 20 Recommended Paved Surface Widths and Clear Zone Widths for the Safe Operation of 14-foot Wide and 16-foot Wide Mobile Home Units.

Mobile Home Width	Recommended Widths (ft)	
	Clear Zone	Paved Surface
14 ft	18	16
16 ft	20	17

Assessment of Mobile Homes' Compliance With Speed Regulations and Impact on Traffic Congestion

The speed at which mobile home units are allowed to travel is addressed in the regulations covering the movement both the 14- and 16-foot units, and is the same for both sizes. In both cases, the "Maximum speed of travel shall at no time exceed 10 mph less than the posted speed limit." For example, if the posted speed is 55 mph, the mobile home is not to exceed 45 mph, and if the posted speed is 65 mph, 55 mph is the maximum allowable speed (Appendix A). Data on traveling speed and counts of traffic directly behind and impeded by the mobile home were collected in three-minute intervals during each data run to determine the compliance of the units with speed limits and regulations.

During the course of the data runs, a total of 339 speed and traffic counts were made. As indicated in Table 21, 186 counts were made for 16-foot units and 153 were made for 14-foot units. Most of the counts (77% overall) were made when the mobile home was unimpeded by traffic or traffic controls, that is the mobile home was "free-flowing." Further analyses of the speed data will be restricted to the free-flowing units to present a clearer picture of unimpeded speed compliance.

Analysis of Mobile Home Speed

Table 22 presents the average speed for the two sizes of mobile homes on different types of roads. Overall, the 14-foot units traveled an average speed eight miles per hour lower than the posted speed limit, and the 16-foot units averaged six miles per hour below the speed limit. For both sizes, the average speeds were higher on four-lane median roads than on either two-lane or interstate roads but were still under the posted limit.

Table 21 Number of Instances of Speed Measurements by Speed Impediments and Mobile Home Size

		Mobile Home Size		
		14'	16'	Total
None- Free Flow	N	112	149	261
	Col%	73.2%	80.1%	77.0%
Slow Traffic	N	1	1	2
	Col%	0.7%	0.5%	0.6%
Stop light/sign	N	16	14	30
	Col%	10.5%	7.5%	8.8%
Other	N	24	22	46
	Col%	15.7%	11.8%	13.6%
Total	N	153	186	339
	Row%	45.1%	54.9%	100%

Table 22 Average Speed of Mobile Homes Compared to Posted Speed Limit by Road Type and Mobile Home Size

Roadway		Mobile Home Size		
		14'	16'	Total
2 Lane	N	28	32	60
	Col%	31.1%	28.8%	29.9%
	Avg*	-8.1	-6.0	-7.0
4 Lane Median	N	12	10	22
	Col%	13.3%	9.0%	10.9%
	Avg*	-5.8	-4.1	-5.0
4 Lane Interstate	N	50	69	119
	Col%	55.6%	62.2%	59.2%
	Avg*	-8.5	-6.5	-7.3
Total	N	90	111	201
	Row%	44.8%	55.2%	100%
	Avg*	-8.0	-6.1	-7.0
Other road types or impeded MH units = 138				

* Average speed in relation to posted speed limit

As noted above, the regulations covering the movement of these units require them to travel at least ten miles per hour below the speed limit. While the average speeds for these units are under the posted limits, they do not average at least 10 miles per hour under the limit. For each unit, the traveling speed was compared to the posted limit and a determination was made relative to compliance with the speed regulations. Table 23 indicates the levels of compliance with the regulatory speed limits for mobile homes unimpeded by other traffic or traffic controls. As can be seen, the 14-foot units were in compliance with the speed regulations 36 percent of the time, and the 16-foot units were in compliance 17 percent of the time. Levels of compliance were lowest for both sizes on the four-lane median roadways (Table 24).

Table 23 Compliance with Regulatory Speed Limits* for Unimpeded Mobile Homes by Size

Speed Regulatory Compliance		Mobile Home Size		
		14'	16'	Total
No	N	72	124	196
	Col%	64.3%	83.2%	75.1%
Yes	N	40	25	65
	Col%	35.7%	16.8%	24.9%
Total	N	112	149	261
	Col%	100%	100%	100%
Impeded MH units = 78				

* Both 14' and 16' units are limited to traveling at a speed no greater than 10 mph less than the posted speed limit.

Analysis of Traffic Counts

Counts of traffic backed up behind the mobile homes were made in an attempt to determine if the 16-foot units caused greater congestion. These counts were made in three-minute intervals along with the speed checks. Table 25 presents 153 traffic counts for the 14-foot units and 186 counts for the 16-foot units. On average 5.3 vehicles were behind and impeded by the 14-foot units, and 5.0 vehicles were behind the 16-foot units. In effect, there appeared to be no large difference overall between the two sizes in terms of congestion.

The level of urbanization of the area that each unit was passing through at the time of each count was classified as being either urban (well inside city limits and developed), rural (outside city limits with little development), or mixed (transition between urban and rural). Table 26 compares the traffic counts for the different sizes within each of the urban/rural categories. As would be expected, traffic counts behind the mobile homes are greatest in the urban areas. For both sizes, the urban counts are more than double the rural counts, with the mixed area counts in between.

Table 24 Compliance with Regulatory Speed Limits* for Unimpeded Mobile Homes by Size and Road Type

Speed Regulatory Compliance		Road Type and Mobile Home Size									
		2 Lane			4 Lane Median			4 Lane Interstate			Total
		14'	16'	Total	14'	16'	Total	14'	16'	Total	
No	N	16	24	40	9	10	19	28	56	84	143
	Col%	57.1%	75.0%	66.7%	75.0%	100.0%	86.4%	56.0%	81.2%	70.6%	71.1%
Yes	N	12	8	20	3	0	3	22	13	35	58
	Col%	42.9%	25.0%	33.3%	25.0%	0.0%	13.6%	44.0%	18.8%	29.4%	28.9%
Total	N	28	32	60	12	10	22	50	69	119	201
	Row%	46.7%	53.3%	29.9%	54.5%	45.5%	10.9%	42.0%	58.0%	59.2%	100%
Other road types or impeded MH units = 138											

* Both 14' and 16' units are limited to traveling at a speed no greater than 10 mph less than the posted speed limit.

Table 25 Number of Traffic Counts and Average Counts by Mobile Home Size

Size		Total
14'	N	153
	Col%	45.1%
	Avg. Count	5.3
16'	N	186
	Col%	54.9%
	Avg. Count	5.0
Total	N	339
	Col%	100%
	Avg. Count	5.1

Table 26 Average Traffic Counts by Mobile Home Size and Urban/Rural Classification

Urban/Rural		Mobile Home Size		
		14'	16'	Total
Rural	N	81	106	187
	Col%	52.9%	57.0%	55.2%
	Avg. Count	3.9	4.0	4.0
Urban	N	38	36	74
	Col%	24.8%	19.4%	21.8%
	Avg. Count	8.1	8.7	8.4
Mix	N	34	44	78
	Col%	22.2%	23.7%	23.0%
	Avg. Count	5.4	4.3	4.8
Total	N	153	186	339
	Row%	45.1%	54.9%	100%
	Avg. Count	5.3	5.0	5.1

Observations on the Function and Benefits of Escort Vehicles

Under the current set of regulations pertaining to the transport of mobile homes in North Carolina, 16-foot units must have both a front and rear escort at all times. The 14-foot units transporting homes from the manufacturers to dealer lots operate under annual permits that require a front escort on two-lane roads, while allowing the homes to have no escorts while on multi-lane highways. Fourteen-foot units being transported from dealer lots to their home sites are issued single-trip permits with at least one escort required on two-lane roads. All other types of oversize vehicles (those over eight feet in width) operating in North Carolina operate under single-trip permits and must have at least one escort vehicle.

The escort vehicles used to accompany mobile home transport units serve several safety-related purposes. Escort vehicles used in front of the transport unit provide an advance information collection service which can relay road and traffic conditions to the driver of the mobile home unit. Front escorts can also attempt to prevent oncoming traffic from trying to pass the unit when the driver is forced to shift toward the middle of the road (when shoulder obstructions are encountered on two-lane roads). When used behind the mobile home unit, the rear escorts serve to warn the driver of vehicles overtaking from the rear on multi-lane roadways and can attempt to block this traffic from passing the unit when the driver is forced to shift the unit toward the middle of the road for any reason.

A full analysis of all of the instances on the tapes where the mobile homes were forced to shift to the left and the role the escorts may have played in blocking other vehicles from getting beside the

mobile homes was not included in the data reduction and analysis completed for this study. Instances where the mobile home was forced to shift to the left for any reason, with or without other vehicles present, were noted during review of the tapes.

There were 124 instances where the mobile home shifted to the left due to shoulder obstructions or traffic merging from the right (Table 27). For the 14-foot homes, there were 54 instances in all where the mobile home shifted to the left and there were 27 instances where another vehicle was present to the left of the mobile home (events) with the shoulder obstructed. For the 14-foot homes the ratio of events (other vehicle present to the left of the mobile home) per number of left shifts is 2.0 or one event occurring every two times the 14-foot home shifted to the left. For the 16-foot homes this ratio is 8.8, or one event every 8.8 times the 16-foot units shifted to the left. These ratios and the percents of left shifts where another vehicle was next to the mobile homes (50% for the 14-foot and 11% for the 16-foot homes) indicate that the benefits related to the presence of the escort vehicles warrants further study.

Table 27 Ratio of Other Vehicles Being to the Left of the Mobile Home to Total Number of Instances When Mobile Homes Shift to the Left.

	14’	16’	Total
Total left shifts for any reason	54	70	124
Events (other vehicle beside MH) while shoulder obstructed	27	8	35
Ratio: 1 Event per # of shifts to the left	2.0	8.8	3.5
Percent of shifts involving an event	50.0%	11.4%	28.2%

The function and behavior of the escort vehicles, and the behavior of other vehicles encountering both sizes of mobile home units, was observed on a more subjective level throughout the course of data collection and review of the tapes. The project staff was impressed by the level of communication and coordination of vehicle placements that took place between the drivers of the mobile homes and the escort drivers. During the movement of the 16-foot units on two-lane roads, the front escorts would warn the mobile home driver of obstacles or adverse conditions ahead giving the driver time to adjust speed or otherwise maneuver safely past or through the situation. On multi-lane roads, the front escorts would again warn the mobile home driver of shoulder obstacles or traffic merging from the right. Upon hearing the warning, the rear escort would position the escort vehicle in the left lane to block traffic from overtaking the mobile home unit until the driver could safely maneuver back over to the right.

On data collection runs for 14-foot units, potentially dangerous maneuvers made by drivers who may have been unaware of road and traffic conditions ahead of them appeared to be more likely to occur when no rear escort vehicle was present. Review of the tapes during situations where the

mobile home driver had to shift to the left showed cars (and less often trucks) that would attempt to pass the mobile home while it was negotiating a curve or maneuvering around a roadside obstruction.

In some cases when no escort vehicle was present and the mobile home shifted to the left, the drivers of the other vehicles responded by waiting for the mobile home unit to pass an obstruction before continuing past the unit. In other cases, the mobile home unit awaited the passage of oncoming traffic before passing an obstruction. And in some cases, the driver of the mobile home unit, in anticipation of an obstruction, shifted into the middle of a two-lane road in order to prevent traffic from overtaking the unit while passing an obstruction. Although these actions prevented any dangerous situations from arising, it was accomplished without the input or influence of escort drivers and vehicles. Recognizing adverse situations and reacting to them was solely the responsibility of the drivers of the other vehicles and the mobile home unit. When escort vehicles were present, and utilized in the manner described above, it appeared that the drivers of the mobile homes were able to concentrate more on the maneuvering of the wide load. It also appeared that although traffic may have still tried to get around the 16-foot mobile homes, it tended to move more slowly and cautiously around them. During the transport of 16-foot units, the escort vehicles definitely appeared to reduce the instances in which hurried or impatient drivers compromised the safety of the situation by performing ill-advised passing maneuvers around mobile home units. This leads to the conclusion that escort vehicles are a simple method for reducing the possibility of crashes occurring in situations where the shoulders are obstructed or merging traffic forces any size of mobile home to shift to the left.

Assessment of the Designated Routes Used by 16-foot Mobile Homes

The pilot program allowing limited manufacture and transport of 16-foot mobile homes requires that they be issued a single-trip permit. The permit designates a specific route for the unit to follow. The routes are designed to send the 16-foot unit in the most direct manner to the nearest multi-lane highway, and then to an interstate highway for shipment out of the state. Routes that were designated by North Carolina Department of Transportation staff were based on legal heights which give more flexibility in choosing routes. Over-height units (over 13' 6") allow less flexibility and, in some cases, less direct routes to avoid low clearances. Assessments of the designated routes made by the project staff indicates that in most cases the routes chosen serve to meet the goals of shipping the wider units on the most direct route and on the widest possible roadways.

There were routes, however, that were insufficient in terms of total paved surface width. The insufficient paved width resulted in a great deal of difficulty for the drivers of the 16-foot units to keep the units from encroaching into the opposing lane without dropping off of the paved surface. Sixteen-foot units shipped from Stanley County to South Carolina were routed south on NC 49 from US 52 to Charlotte. This is a two-lane highway where the lanes are 12 feet wide, but there is little or no shoulder for much of the distance that it covers. All mobile homes, and in particular the 16-foot units, had a tendency to encroach into the opposite lane or drop off of the pavement to the right. Over-height units, in contrast, are routed along US 52 to Interstate 85 at Salisbury and then south to Charlotte. This route does cover more distance but it may be that the total paved surface is wider and

more conducive to safer operation of the 16-foot units. Safer operation, however, needs to be weighed against the potential for more exposure of other vehicles to the wider loads over longer routes.

Routing of the wider mobile homes also appears to result in some conflicts between more exposure to other vehicles by routing them on wider roads that run through urban areas when more direct routes with less traffic, but on less desirable roads, are available. This situation was seen with the routes assigned for at least two manufacturers, and presents cases where the safer operation of the wide loads on more desirable roadways, but along a greater distance with more congestion, needs to be weighed against the potential for less exposure of other vehicles to the wider loads over more direct but less desirable routes.

Conclusions and Recommendations

The North Carolina Department of Transportation Division of Highways contracted with the University of North Carolina Highway Safety Research Center to evaluate the on-road behavior of 16-foot mobile homes and their impact on surrounding traffic as compared to currently allowed 14-foot homes. The evaluation was conducted in response to the approval of a pilot program to allow limited production and shipment of 16-foot mobile homes in North Carolina by the North Carolina Board of Transportation and was accomplished by following a sample of 16- and 14-foot mobile homes from their respective manufacturing plants to the state line. The routes covered consisted of interstate and other four-lane divided highways and two-lane secondary roads used to access these major routes from the manufacturing plants.

The mobile home units were followed in a van equipped with video cameras and timing devices. Videos made during the trips were reviewed and data was drawn from the video images to determine the positioning of the mobile home unit relative to the center lane line, outside edge line, and to oncoming vehicles on two-lane roads as well as vehicles overtaking the mobile homes on four-lane roads. Information was also derived from the tapes on the positioning of the oncoming or overtaking vehicles relative to the shoulder of the roadway. Data on traveling speed and traffic directly behind and impeded by the mobile home were also collected in three-minute intervals during each data run.

The data collection methodology and data analyses have resulted in a number of conclusions and have allowed the research staff to evaluate the on-road behavior of 16-foot mobile homes relative to the behavior of the currently allowed 14-foot homes. This evaluation had in turn led to recommendations relevant to assuring the safest transportation of the wider 16-foot units should the North Carolina Board of Transportation decide to expand the pilot program and allow more widespread manufacture and movement of the 16-foot mobile homes in North Carolina.

The number of runs that were made and the variety of roadways that were covered were not as high as initially planned or desired. Only a few manufacturers are producing and transporting 16-foot homes under the pilot program and of those, only two are shipping them on a regular basis along routes appropriate for this study. Even with these limitations, however, the number of events in the final data set is large enough to produce valid and statistically significant results.

Conclusions Reached Based on the Results of this Study

On-road Behavior of 16-foot Mobile Homes Compared to 14-foot Mobile Homes

- Encroachments of the mobile homes do show significant differences between the different sizes when road type, lane widths, and shoulder widths are examined. The 16-units encroached over the lane or center line significantly more often than the 14-foot homes under most conditions. The proportions of lane encroachments by the both sizes of mobile homes are greater on two-lane roads, and on roads where lane and shoulder widths are narrower.

- Instances of the right tires of mobile homes dropping off of the paved surface occurred during 65 events and is a concern relevant to selecting the safest routes for mobile homes to use. The large majority of pavement drop-offs occurred on two-lane roads and where paved shoulder widths of less than two feet.

- Encroachments of other vehicles onto the shoulder while meeting or overtaking mobile homes do show significant differences between the two sizes. Shoulder encroachments of the other vehicles were higher when next to a 16-foot home on all types of roads (two-lane roads, four-lane interstates, and four-lane median non-interstate roads). Other vehicles encroaching onto the shoulder far enough to drop off the paved surface is a concern. Overall, 2.1 percent of the other vehicles meeting or overtaking the 16-foot units dropped at least one of their tires off of the pavement compared to 0.3 percent for the vehicles next to 14-foot units.

- Where shoulder widths are narrow, the other vehicles are either forced to or choose to use to shoulder to get by or around the 16-foot units more often than when encountering the 14-foot units. It also appears that drivers of vehicles encountering the 16-foot units recognize the wider load and use all available paved surface to safely pass by or get around the mobile home.

- On average, the 16-foot units are significantly closer to opposing traffic than the 14-foot units. The adjusted mean separation distance for the 16-foot units across all paved surface widths is 6.4 feet, while for the 14-foot units, the mean separation distance is 6.7 feet. For every one-foot increase in paved surface width, the separation distance increased by 0.43 feet for both sizes of mobile homes. These results indicate that the mobile homes and/or the oncoming traffic take advantage of the increased surface area and use it to provide increased separation distance.

- On two-lane roads, the 16-foot units were, on average, 0.5 feet inside the center line. In comparison, the 14-foot units were 1.2 feet inside the center line. This difference between the two sizes of units was statistically significant. For each one-foot increase in paved shoulder or lane width, both sizes of mobile homes moved 0.32 feet further inside the center line. The distance of the mobile home units inside the lane line on multi-lane roads also significantly increased as the width of the paved surface increased. For each one-foot increase in the width

of the paved surface, both sizes moved 0.22 feet and 0.32 feet further inside the lane line for interstates and other multi-lane roads, respectively.

- It appears that the drivers of both the 14- and 16-foot mobile homes took full advantage of the paved shoulders to increase their distance from the center line or lane line and the separation distance from vehicles in the adjacent lane. For each one-foot increase in shoulder width on two-lane roadways, interstates, and multi-lane roadways, the amount of encroachment over the edge line increased by 0.33 feet, 0.32 feet, and 0.44 feet, respectively, indicating that the drivers tend to move as far to the right as possible to avoid center or lane line encroachments.

- Calculations were made to determine the total paved surface width (travel lane plus paved shoulder) needed to eliminate 95 percent of the center or lane line encroachments of mobile homes. For 14-foot units, the amount of paved surface required is 16 feet. For 16-foot wide units, the required amount of paved surface is 17 feet.

- Routes designated by the North Carolina Department of Transportation for the 16-foot mobile homes are designed to route them in the most direct manner to the nearest multi-lane highway and then to an interstate highway for shipment out of the state. With some exceptions, the designated routes followed during this study serve to meet the goals of shipping the wider units on the most direct route and on the operationally safer wider and multi-lane roadways. Routes that were designated by DOT were based on legal heights which give more flexibility in choosing routes. Over-height units (over 13' 6") allow less flexibility and, in some cases, less direct routes to avoid low clearances. The use of some routes that were less than desirable, in terms of number of lanes and paved surface width, made it difficult for the drivers of the mobile homes to keep the unit from encroaching into the opposing lane without dropping off the paved surface. It is apparent that routing of the wide loads on the safest routes possible overall should involve the consideration of the availability of the most direct routes against the availability of wider multi-lane roads with their potential for greater exposure of other vehicles to the wide loads over longer routes. Results of this study should provide much of the information needed to assist in this planning in the event the pilot program is expanded to allow more 16-foot mobile homes to be transported within North Carolina.

- There appeared to be no large difference overall between the two sizes of mobile homes in terms of congestion. On average 5.3 vehicles were behind and impeded by the 14-foot units and 5.0 vehicles were behind the 16-foot units. Traffic counts behind both sizes of mobile homes were highest in the urban areas and lowest in the rural areas. The concern that greater congestion would be created with 16-foot mobile homes was not confirmed in the course of this study. Other studies with different methodologies designed specifically for examining this issue may be of some benefit.

Compliance with Regulations

- Overall, the 14-foot units traveled an average speed eight miles per hour lower than the posted speed limit and the 16-foot units averaged six miles per hour below the speed limit. While the average speeds for these mobile homes are under the posted limits, they do not average at least 10 miles per hour under the limit as required by their permits. The 14-foot units were in compliance with the speed regulations 36 percent of the time and the 16-foot units were in compliance 17 percent of the time.

- During the course of this study, four of the six 16-foot mobile homes followed chose to use non-designated roads rather than following the routes specified by their permits for at least some portion of their trip. In these cases, the mobile home units traveled on routes from the manufacturers' lots to a designated highway that were shorter, more direct, and involved less travel through congested urban roads than the designated routes. In two cases, the chosen routes avoided construction on urban streets, where maneuver room would be even more restricted. It appears that the chosen routes may have in some ways been better routes, at least with respect to congestion, and perhaps to safety. However, they were used in violation of the requirements of the permits. The need for strong enforcement and sanctions is noted later (Recommendation 8). The need for accurate determination of the safest route is a necessary companion to strong enforcement.

  This leads to the conclusion that the existing system for determining the safest route probably should be modified in some manner. The "safest route" can not be determined solely as a function of pavement width and roadway geometrics. The best and safest route must be based on a combination of factors including existing roadway and traffic conditions for the day of the permitted shipment. Thus, it is recommended that the initial selection of permitted routes be determined by combining the inputs of the local Division of Highways staff, the DOT Oversize/Overweight Permits Office staff, and the manufacturers and the transporters. In some cases this may involve upgrading roads that the manufacturers and transporters would like to use, and perhaps should use, on a routine basis. The final selection of which alternative route to use would then be based on conditions on or close to the day of the move, and could again be determined through discussions among the concerned parties.

- All mobile homes followed during this study were accompanied by escort vehicles as required under current regulations pertaining to the transport of mobile homes in North Carolina. It was apparent that the drivers of the 16-foot mobile homes benefitted from the information and assistance provided by the two escorts. Observations of 16-foot mobile homes and other vehicles in their vicinity when the mobile home shifted to the left (due to merging traffic or shoulder obstructions) supports the need for two escort vehicles accompanying and assisting the mobile home driver during these maneuvers. The observed behaviors of the 14-foot mobile homes and other vehicles in their vicinity when the 14-foot homes shifted to the left indicate that they, and the other vehicles they encounter, would also benefit from rear escorts on all types of roadways. The greatest benefit may be gained from two escorts since the front escort is able to give advance warning of hazardous situations to the mobile home driver. Given the relatively small number of cases in which the shifted 14-foot unit was passed by a following

vehicle, and given the size of the 14-foot fleet, it is not possible to conclude that requiring such a trailing escort would be economically justified without a more detailed analysis. However, the mobile home center/lane line encroachments and shoulder encroachments for the other vehicles meeting or passing the 14-foot units that do exist are a concern and it does appear clear that in some cases, safety would be enhanced by a trailing escort.

- Based on the extent of the failure of the mobile homes to comply with the permitted speed and route requirements while in transport, it can be concluded that enforcement of regulations imposed can be problematic. Enforcement officers are limited in their ability to pull the mobile homes over in a safe location to check for or enforce violations due to the size of the units. Vehicles caught violating their permits must be parked in a safe location until the situation is resolved and it could be difficult to find such a location to do so. It is apparent that issues relating to compliance with regulations, their enforcement, as well as effective sanctions for non-compliance need to be discussed and agreed to by all interested parties.

- Finally, it can be concluded that while the 16-foot mobile home units do behave differently than the 14-foot units, this does not mean that shipment of the 14-foot mobile homes is not without problems also. The 14-foot units encroach to the left over the center or lane line and drop off the shoulder to the right, but not to the same degree as do the wider homes. The other vehicles on the road that encounter the 14-foot units encroach onto the shoulder when meeting or overtaking them, but again not to the same degree as with the 16-foot mobile homes. The 14-foot mobile homes require a paved surface width of 16 feet to eliminate most of their center or lane line encroachments compared to the 17 feet needed by the 16-foot units. It is apparent that issues and concepts relating to the safe transportation of the 16-foot homes need to be applied to the 14-foot wide mobile homes as well.

Recommendations

This evaluation of the on-road behavior of 16-foot mobile homes as compared to currently allowed 14-foot homes has shown that the 16-foot mobile homes are different in terms of their positioning on the roadway with other traffic present and that the other vehicles do react to the added width. In general, the differences indicate that the added width has significant potential for adversely affecting the safety of the other vehicles they may encounter. The decision of whether or not to expand the current 16-foot mobile home pilot program in North Carolina, and if so how to implement it in the safest manner possible, must take these differences into consideration.

If the decision is made to expand this program to allow more widespread transportation of 16-foot mobile homes within and through North Carolina, the following recommendations are made to assure that it can be accomplished in the safest manner possible:

Designated Routes

1. Routes used to transport 16-foot mobile homes should be multi-lane roadways where the total paved width of the travel lane and paved shoulders is at least 17 feet whenever possible. This same total paved width should be the target for two-lane roadways as well.

2. Modification of the existing system for determining acceptable routes should be considered. Alternative routes from a given shipping location should be identified where possible, such that the permitted route depends on both roadway geometries, current traffic conditions, and other factors (e.g., work zones). Determination of both the original definition of routes and the route actually permitted for a given shipment should be done with the input of all concerned parties -- the local DOT Division of Highways staff, the DOT Oversize/Overweight Permit Office staff, the manufacturer, and the transporter-- with the final route for any given trip determined as close to the actual shipment as possible.

3. Serious consideration of the impact of allowing shipment of over-height (over 13' 6") 16-foot wide mobile homes must be made. Over-height 14-foot mobile homes must already be routed differently than those of legal height. Routes that were designated by North Carolina Department of Transportation staff for pilot program 16-foot homes were based on legal heights which give some flexibility in choosing routes. Over-height units allow less flexibility in routing due to the need to avoid low clearances.

Escort Vehicles

4. The requirement for front and rear escorts for the 16-foot homes on all roadways should be continued. The escorts enhance the safety of the mobile home itself as well as that of the other vehicles sharing the road by providing information to the mobile home driver about road and traffic conditions and by positioning their vehicles as needed to block traffic when shifting or turning maneuvers are necessary on any roadway. In addition, finding routes with 17 feet of total paved surface width will be difficult if not impossible. The escorts are needed where narrow paved widths require the mobile homes to shift to the left and encroach across the lane or center line.

   While additional data collection, or further analysis of existing data, and a cost-benefit analysis would be required for a definite and strong recommendation, consideration should be given to requiring at least one escort vehicle for 14-foot mobile homes on all roadways. The 14-foot homes do not encroach across the center or lane line as often nor do other drivers encroach onto the shoulder as much when next to a 14-foot unit as for a 16-foot home. The mobile home center/lane line encroachments and shoulder encroachments for the other vehicles meeting or passing the 14-foot units that do exist are a concern and may be of sufficient frequency and magnitude to justify at least one escort on all roadways.

Allowable Times of Travel

5. All 16-foot homes began their runs after 9:00 am and were out-of-state by 2:30 pm as required. Furthermore, all of the wider homes were shipped on the days of the week allowed by the permits (Monday through Thursday). The parameters of this study did not allow for an evaluation of the impact on traffic congestion if the wider units were allowed to travel at other times of the day or days of the week, but common sense indicates that congestion would be worse and more vehicles would be exposed to the presence of the wider vehicles if the 16-foot homes were allowed to be on the road during weekday rush hours or on weekends. For this reason, it is recommended that the allowable times of travel remain the same. If the allowable time for shipment is expanded, the additional time should be added to the Monday through Thursday early afternoon time but only to the extent that the time of day that travel is allowed does not extend into rush hour.

Speed Limits

6. Observations of the speed that the mobile homes traveled as well as their interaction with other vehicles provide no reason to recommend that allowable speeds be increased. Speeds for the mobile homes unimpeded by other traffic or traffic controls averaged less than the posted speed limit. The mobile homes did not, however, comply with the permitted speed of 10 miles per hour less than the posted speed limit the large majority of the time. It is felt that increasing allowable speed for the mobile homes would have an adverse effect on overall safety.

Permitting Process

7. The single trip permits for shipment of all 16-foot mobile homes should be continued to maintain maximum control and flexibility of routes as well as to enhance the possibility of enforcing permit violations. The annual permits issued for shipment of 14-foot homes from the manufacturer to dealer lots are actually issued to the transport vehicles rather than to the manufacturers or to the homes themselves. The transporter may have several permits listing up to 30 specific routes. Trying to determine if a mobile home is off-route on any given trip can therefore be problematic. Single trip permits would mean additional work for the DOT Oversize/Overweight Permit Office, the manufacturers and the transporters, but it should also enhance (1) the flexibility of assigning a final route for any given trip as close to the actual shipment as possible, and (2) the ability of enforcement officers to readily determine the specific requirements of a permit and whether the transporter is in compliance.

Enforcement of Violations

8. There are very complex issues involved in compliance with regulations, their enforcement, and sanctions for non-compliance. Enforcement officers are limited in their ability to pull over the mobile homes in a safe location to check for or enforce violations due to their size. Vehicles caught violating their permits must be parked in a safe location until the situation is resolved, and it can be difficult to find such a location. In addition, since the current sanctions are relatively small (especially when compared to possible sanctions for weight violations, which affect pavement wear rather than safety), they are probably not a sufficient deterrent to violations. Given that a sound system is in place to choose the safest routes (see Recommendation 2 above), then stronger sanctions for permit violators need to be considered. Given the enforcement problems, the sanction itself should be the deterrent.

Driver Selection and Training

9. Conversations with manufacturer and transport company personnel revealed that the most experienced and better drivers are being used for shipment of 16-foot mobile homes. It is reasonable to assume that if the pilot program is expanded and the production and shipment of the wider homes increases significantly, the shipment of the 16-foot homes will increasingly be handled by drivers with less experience and who are not at the top of the driver group. Even with the better drivers, the 16-foot homes encroached over the lane or center line and dropped off of the paved surface significantly more often than the 14-foot homes under most conditions. For these reasons, the manufacturers and transporters should implement or modify driver selection procedures and driver training and monitoring programs to assure that the wider units are transported by the best drivers in terms of qualifications, experience, and safety records.

APPENDIX A

Regulations Covering Transport of 12' and 14' Wide Mobile Homes in North Carolina

Regulations Covering Transport of 16' Wide Mobile Homes in North Carolina

REGULATIONS FOR EXPORT MOVEMENT
OF 16 FOOT WIDE MOBILE/MODULAR HOMES
(TEST PILOT PROGRAM)

TYPE OF PERMIT - Single trip permit only. Specific routes to be authorized by the Department of Transportation Permit Office from point of manufacture to the nearest state line.

MOBILE HOME

WIDTH - Maximum width shall be a 16 foot unit with no overhang. Overhang is to be defined as bay windows, roof overhang, porch extensions, room extensions, etc.

LENGTH - Of mobile/modular home 76' unit and 4' tongue = 80' maximum length.

LENGTH OF COMBINATION - 80' unit/tongue and 20' power unit = 100' maximum.

AXLES - For mobile/modular unit one axle required for each 6,000 lbs. of mobile/modular unit weight.

BRAKES - Mobile/modular unit shall be equipped with adequate brakes controlled and operated from inside the towing unit.

FLASHING AMBER LIGHTS - (5' diameter. CP35 60 flashes per minute) to be displayed on all corners (4) of the mobile/modular unit 72 inches from the road surface.

POWER UNIT (TOTER)

POWER UNIT - Shall be rated no less than 2 tons and minimum requirement of 4 speed transmission.

- Maximum length - 20'

AUTHORIZED TIME OF MOVEMENT

- Monday through Thursday - 9:00 a.m. to 2:30 p.m.

REQUIREMENTS/RESTRICTIONS

ESCORTS - Front and rear escort vehicles required for 16' wide mobile/modular movements on all highways in North Carolina. Escort vehicles are to display banners in full length on vehicle (front or rear) as appropriate; 5" flashing amber light on top of escort vehicles; two-way radio contact with permitted vehicle; and to burn head lamps.

- On two-lane highways, leading escort vehicle shall be a minimum distance of approximately 300 yards in front of towing vehicle in order to allow an approaching vehicle and the towing vehicle to take any action necessary for safe passage.

SPEED - Maximum speed of travel shall at no time exceed 10 mph less than the posted speed limit.

Example: Posted 55 mph - 45 mph
Posted 65 mph - 55 mph

ADDITIONAL REQUIREMENTS AND REGULATIONS - Movements will comply with all other requirements and regulations applicable to single-trip permits for mobile/manufactured homes (i.e.. flags. banners. burning headlights. two-way radio contact with towing unit. etc.) Other restrictions may be included as necessary.

TRAFFIC BUILD-UP - Escort vehicle/transporters shall monitor trailing traffic build-up and pull to the roadside periodically as the opportunity arises to allow lines of traffic to clear.

SUGGESTED ADDITION - Permit not valid when visibility is less than 500'; highway covered with ice or snow; wind gusts exceed 25 mph or travel conditions are considered unsafe by the Division of Highways or law enforcement having jurisdiction.

MOBILE/MANUFACTURED HOME PERMIT REGULATIONS
12 FOOT AND 14 FOOT WIDE

TYPE OF PERMIT

12 Ft - **Annual permits** authorize travel on all roads in North Carolina with the exception of specific restricted routes located in the western regions of the state.

Single trip permits are required for all mobile/modular homes in excess of legal height (13' 6").

14 Ft - **Annual permits** with **30** specific routes of travel to authorize travel from a specified manufacturer to a specific state licensed mobile home dealership (in-state and out-of-state).

Single trip permits are required for movement of mobile/modular homes from a retailer/dealership to a specific destination, movement from a point of manufacture that is not authorized on an annual (blanket) permit, movement from one location to another and all mobile/modular homes in excess of legal height (13' 6").

AUTHORIZED TIME OF MOVEMENT - unless otherwise restricted in the via route section of permit.

Monday through Friday - sunrise to sunset
Saturday - sunrise to 12:00 noon

SPEED

12 Ft - May travel posted speed limit unless otherwise restricted on permit.

14 Ft - Maximum speed of travel shall at no time exceed 10 mph less than the posted speed limit.

Example : Posted - 55 mph - 45 mph
Posted - 65 mph - 55 mph

LENGTH OF COMBINATION - **100'** maximum = **76'** mobile/modular home/**4'** tongue and power unit (minimum **15'**).

ESCORT REQUIREMENT -

12 Ft - No escort required unless specified on permit after consideration by issuing agent for route of travel, geographical location, height, etc.

14 Ft - No escort required on multi-lane highways.
Front escort vehicle required for movement on all 2 lane highways.

All overheight mobile/modular homes exceeding 14' 5" in height require a front pole car escort entire route of travel on North Carolina highways - escort may be required for any over height as determined by issuing agent.

Failure to have required escort(s) or correct placement of escort(s) may cause the permit to be invalidated.

MOBILE/MODULAR HOME

WIDTH **12 Ft -** 12' maximum unit width with **no** roof overhang. If mobile/modular home is a 12' unit with any overhang will be permitted as a 14' mobile home.
14 Ft - 14' maximum unit width with up to a total of 1' roof overhang.

*** An even width exposure must be presented to the general motoring public at all times unless otherwise stated on the permit.**

HEIGHT 13' 6" maximum (annual permit)
At this time, there is not a maximum height restriction, however; height in excess of 14' 5" requires a front escort.

LENGTH mobile/modular home 76' unit and 4' tongue = 80' maximum length

AXLES **14 Ft -** minimum of 3 axles required for units greater than 52' in length (to include tongue measurement). Two of which must be braking axles operated and controlled from inside the towing unit.

SAFETY DEVICES

BRAKES - mobile/modular unit shall be equipped with a minimum of 2 braking axles in good working condition controlled and operated from inside the towing unit. All wheels on the braking axle shall be equipped with operable brakes.

TIRES - 7 x 14.5 , 8 ply, 10 ply or 12 ply rated tires - tread depth not less than 2/32 inch.

FLASHING AMBER LIGHTS - rotating sealed beam or strobe, minimum 5" diameter base/minimum 4" lens height are required to be displayed 72" from the road surface on all 4 corners of the mobile home with the option of mounting the required front lights on the mirror bar no less than the extreme width of the power unit.

BANNERS - measuring 7' x 18", yellow or orange in color, bearing the legend: "**WIDE LOAD"** or **"OVERSIZE LOAD"** in black 10" x 1 1/2" brush stroke lettering to be displayed on front and rear of mobile/modular home combination.

FLAGS - red in color 18" square to be displayed on all four (4) corners of the mobile/modular unit 50" from the road surface.

TAIL LIGHTS/TURN SIGNALS - in good working condition installed on the rear of the mobile/modular unit.

HEIGHT - Pole indicator required for front escort vehicle for overheight moves in excess of 14' 5".

POWER UNIT (TOTER)

DESIGN - shall be a vehicle designed and equipped to specifically transport mobile/modular homes.

SIZE - shall be rated (GVWR) no less than 2 tons and minimum requirement of 4 speed transmission.

LENGTH - minimum length - 15'

SHIPPING DOCUMENTS - shall have in its possession a Freight Bill and Straight Bill of Lading for specific mobile/modular home being transported (serial number specific).

IDENTIFICATION - shall display name and address of mobile home mover on the right and left side of the power unit.

REGISTERED LICENSE WEIGHT - shall equal the gross weight of the toter/power unit and tongue weight of the mobile/modular home.

SAFETY DEVICES

RADIO - two way radio contact with the escort vehicle.

HEADLAMPS - must be burning during movement.

BANNERS - measuring 7' x 18", yellow or orange in color, bearing the legend: **"WIDE LOAD"** or **"OVERSIZE LOAD"** in black 10" x 1 1/2" brush stroke lettering to be displayed on front and rear of mobile/modular home combination.

ESCORT VEHICLE(S)

PLACEMENT OF ESCORT(S) - A front pole car escort is required the entire route for all overheight mobile/manufactured homes exceeding 14' 5" or as otherwise required by the issuing agent.

Escort required for overwidth on shall provide support as a rear escort on multi-lane highways and as a front escort on two lane/two way traffic highway.

SIZE - weight - a truck of not less than a one-quarter (1/4) ton rated local capacity but not more than 10,000 pounds GVWR or a passenger vehicle of not less than 2,000 pounds gross weight.

IDENTIFICATION - shall display placards or identification signs measuring at least 8" x 12" providing name, address and telephone number of the registered owner of the power unit (company or individual) shall be displayed on the right and left side of the power unit.

SAFETY DEVICES

RADIO two way radio contact with power unit of mobile/modular combination.

BANNERS - yellow or orange in color to be mounted on bumper or roof bearing the legend: **"WIDE LOAD"** or **"OVERSIZE LOAD"** in black 10" x 1 1/2" brush stoke lettering visible from the front or rear as required by location of the escort vehicle.

FLASHING AMBER LIGHTS - rotating sealed beam or strobe, minimum 5" diameter base/minimum 4" lens height to be mounted on top of escort vehicle.

HEADLAMPS - must be burning during movement.

ADDITIONAL REQUIREMENTS AND REGULATIONS

Movements will comply with all requirements and regulations applicable to annual/single trip permits for mobile/manufactured homes for both the mobile home combination and escort(s). Other restrictions may be included as necessary.

TRAFFIC BUILD UP

Escort vehicle/transporters shall monitor trailing traffic build-up and pull to the road side periodically as the opportunity arises to allow lines of traffic to clear.

PERMIT INVALID

Permit may not be honored if the permitted vehicle is operating in violation of the correct placement or the required number of escorts stated on the permit regardless of actual dimensions of load in transport.

APPENDIX B

Data Collection Forms

Designated Route Roadway Inventory Form

Mobile Home Unit Information Form

Video Data Collection Log Form

Designated Route Roadway Inventory Inventory Date: _____/_____/_____

Manufacturer: _____ Page: ____ of ____

Roadway ID#: _____

Road Class: ❑ Interstate ❑ US Route ❑ NC Route

❑ Secondary Route ❑ Other:_____

Road Number: _____ ❑N ❑S ❑E ❑W Road Name: _____

Route Segment #: ___ ___ ___ County: _____

From: _____ to _____

Odometer From: _____ to _____ = Miles _____ . ___

❑ ***Same as Previous Segment***

Total Lanes: _____ ❑ Divided-Median ❑ Divided-Barrier ❑ Undivided

#Route Lanes: _____

Speed Limit: _____

Lane Measurements(diagram and label)

Shoulder Measurements

Left Shoulder			**Right Shoulder**		
Type:	❑ None		Type:	❑ None	
	❑ Paved	Width: _____		❑ Paved	Width: _____
	❑ Gravel	Width: _____		❑ Gravel	Width: _____
	❑ Dirt/Grass	Width: _____		❑ Dirt/Grass	Width: _____
Curb:	❑ Yes ❑No		Curb:	❑ Yes ❑No	
Gutter Pan:	❑ Yes ❑No	Width: _____	Gutter Pan:	❑ Yes ❑No	Width: _____

Comments: _____

_____

_____

The NC DOT Permits Section has identified specific routes that each manufacturer may use to move 16' units. The purpose of this roadway inventory is to compile detailed information on these

routes being used to transport 16' wide mobile homes in a fashion that can be linked to the videotapes that will be made. To complete this inventory locate the manufacturing plant and drive the complete route to the state line. Record the following information:

1. Roadway ID# - Each route will be made up of several different streets and highways. Each different street or highway will be considered a separate roadway. Sequentially number each different roadway in the space provided.

    A. Road Class - Check the appropriate road classification. If “Other” is checked, write in the appropriate road class. An example would be a city street that is neither a US or NC route.

    B. Road number and direction of travel - Write in the route number for the roadway such as 95 (for I-95) or 64 (for US 64). Check the direction of travel for the mobile home. Note that the direction for the roadway may differ from the actual compass direction. For instance, I-85 South actually goes west between Durham and Greensboro.

    C. Road Name - Write in the name of the roadway if it also has a name that can be determined from a map or street sign.

2. Segment # - Each roadway and the entire route will be made up of smaller route segments defined as being portions of the route that are: in the same county, on the same roadway, and have similar characteristics such as number of lanes and lane width.

    A. Sequentially number each segment with three digits such that the first one (at or near the manufacturing plant, is “001."

    B. Start a new segment when you come to and pass by:

        (a) A city limit or county line

        (b) A turn onto a different roadway and/or route number

        (c) A turn at an intersection even if the route number stays the same

        (d) A change in the speed limit

        (e) A change in the roadway configuration such as:

            (1) Number of lanes for either the roadway or for the travel lanes for the designated route

            (2) Lane width

            (3) Type and or width of the shoulders

        (f) Any other change that may effect wide load movements

    C. Write in which county the segment is in

    D. In the blanks for “From” and “to” indicate the starting and end points for the segment Such as “from plant entrance to US 70" from “SR1529 to NC 42"

E. At the start of each segment, note the odometer reading and enter in the "Odometer From" blank. Record the odometer reading (in the "to" blank) at the end of the segment also and compute the distance to the nearest .1 mile.

3. The remaining information needs to be filled in for the first segment of any roadway. If the next segment is identical in all respects, the "Same as Previous Segment" box may be checked without filling in the remaining information. If any features change, record all information.

   A. # Total Lanes - Enter the total number of lanes for both directions of travel. Center left turn lanes should be counted, but short right or left turn lanes should not be counted.

   B. Check the appropriate box for the lane configuration. To be divided, lanes for opposing directions of travel must be separated by either a median or physical barrier. If a segment is one-way (most likely inside city limits) indicate this in the "comments" section.

   C. Speed Limit - Fill in the speed limit for this segment.

   D. # Route lanes - Indicate the number of lanes designated for traffic traveling in the direction of travel that the mobile home unit will be taking.

   E. Lane width - Measure the width of the "travel lanes" taking all possible precautions for personal safety. Measure the lanes from the outside of the edge line to the midpoint of the lane line or midway between double solid lines. Make measurements for the curb lane and inside travel lanes as well.

   F. Right Shoulder - Assess the type and measure the width of the shoulder to the right of the travel lanes. No shoulder would be in the case of a physical barrier such as a curb or guardrail preventing use of the shoulder. Indicate presence of a curb (Yes/No) and measure the width of any associated gutter pan.

   G. Left Shoulder - Perform the same assessment and measurement for the type and width of the shoulder to the left of the travel lanes or the shoulder for opposing lane for a two lane road.

4. Use the "Comments" section for any comments about the road segment that may impact the movement of wide loads such a road construction, narrow bridges, presence and width of bike lanes, etc.

MH Unit Information

Tape ID# ___ ___ ___ ___ ___ ___ ___ ___

Manufacturer: _____ Date: _____/_____/_____

Approximate Begin Time: ____ ____ : ____ ____

Unit Type: ❑ 14ft ❑ 16ft ❑ Other: _____

Unit Measurements: Measure and record on the diagram the following dimensions:

(A) Total width of the rear of the mobile home unit

(B) Outside edge of left tire to outside edge of right tire

(C) Outside edge of left rear tire to left outside edge of mobile home

(D) Outside edge of right rear tire to right outside edge of mobile home

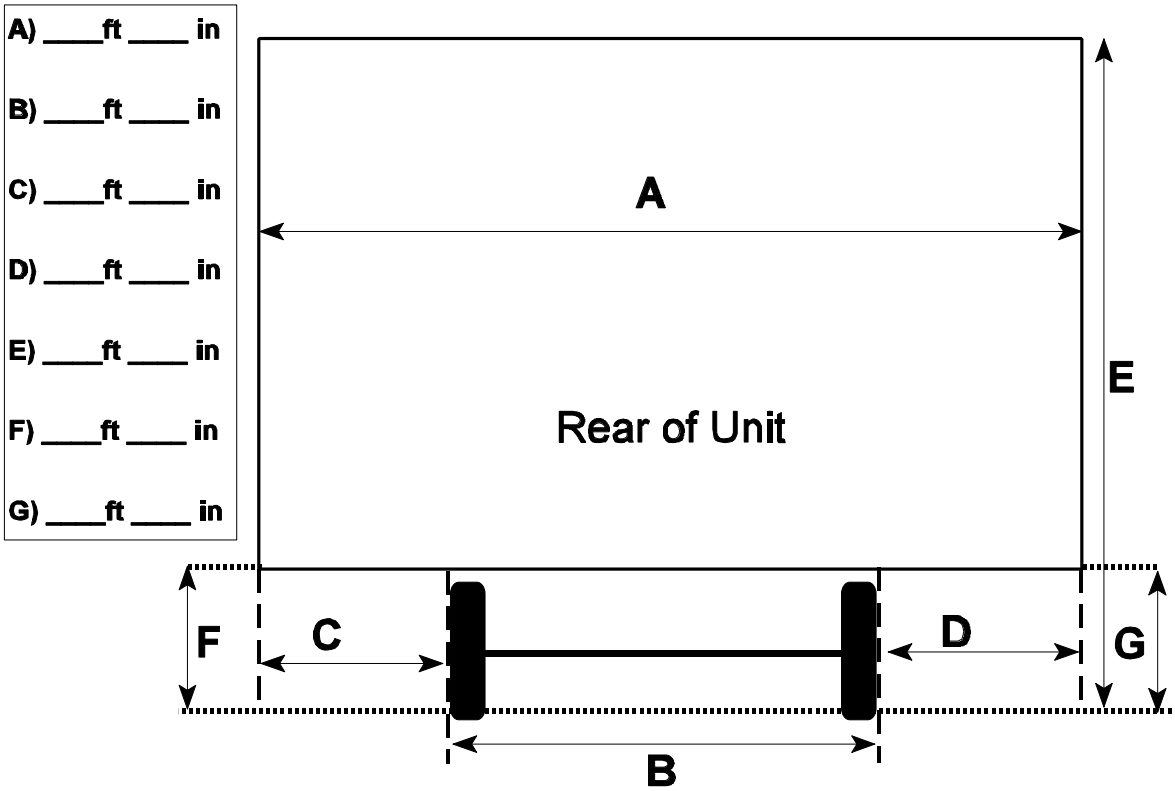
(E) Total height of unit from highest point of roof to ground

(F) Distance from bottom left corner of unit to ground

(G) Distance from bottom right corner of unit to ground

Draw in and note measurements of any other features that affect the width of the unit

Draw in and note measurements of features that can be used as an object size reference point (e.g. windows, banners, etc.)



Video Data Collection Log

Tape ID# ___ ___ ___ ___ ___ ___ ___ ___

Manufacturer: ___________________________

Date: _____/_____/_____

Begin Time[1]: ____ ____ : ____ ____

End Time[1]: ____ ____ : ____ ____

Roadway ID#:	**Stopwatch[2]** **h : m m : s s**	**Speed[3]**	**Rear Traffic[4]**
____________________	____ **:** ____ ____ **:** ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________
____________________	____ : ____ ____ : ____ ____	_______mph	_____________

[1]Clock time in hh:mm format

[2]Stopwatch time in h:mm:ss format

[3]Speedometer reading every 3 minutes

[4]Count of vehicles behind unit every 3 minutes

APPENDIX C

Protocol for Videotape Data Collection

Mobile Home Data Collection Protocol

The purpose of this project is to evaluate the behavior and impact of 16' modular home units on North Carolina roadways as compared to 14' units currently allowed in North Carolina. This evaluation will be based on the review and analysis of videotapes made of a sample of 14' and 16' modular home units operating on NC roadways. In order for this analysis to achieve validity and reliability the following protocols must be followed for each data run.

Pre-Trip

Use PRE-TRIP CHECK LIST to check supply and condition of supplies, equipment and forms.

On-Site Pre Data Run

5. Determine Tape ID number(s)
    A. Nine digit number where places
        1) 1&2 = Size of unit (14 or 16)
        2) 3&4 = Month
        3) 5&6 = Day
        4) 7&8 = Tape number (e.g., 01 or 02)
        5) 9 = "F" (front view camera) or "R" (rear view camera)
        6) Sample: 16071601F = 16ft unit taped on July 16, tape 1 of front view camera
6. Go through pre-run checklist to be sure all supplies and equipment are set up and ready for the data run. Check installation and security of video equipment
7. Check to see that day/time stamp on camcorders are set to current date and time and that time is synchronized between the cameras
8. Set character generator stopwatch for front camera to zero

Immediately prior to exit of mobile home unit from the plant,

1. Inform driver and escort(s) that you will be following the unit
2. If unit to be followed is a 16ft unit with required rear escort, remind driver and escorts that the van will be positioned between the unit and the rear escort
3. Make required measurements of the MH Unit and enter information on "MH Unit Information" form
4. Verify CB channel driver and escort(s) will be using

As MH unit is getting ready to exit plant

1. Turn power to camcorders on and verify
2. Set camcorder to record and verify
3. Set date/time stamps for both camcorders to record and verify in monitor
4. Turn character generator stopwatch on, be sure characters are positioned in bottom right corner of frame, and verify in monitor.

Data Run

1. Responsibilities
    A. Driver
        1) Safety
        2) Maintain constant distance behind unit (to degree possible)
        3) Maintain position of van to the left of the lane as far as possible
        4) Monitor camera zoom setting as needed
        5) Help monitor route roadway segment currently on, the beginning of another segment and informing recorder of changes
        6) Call out speed from speedometer when requested
    B. Recorder
        1) Operate cameras and check monitors to assure correct views are being obtained.
        2) Track roadway segments and roadway ID numbers from copy of "Designated Route Roadway Inventory" sheets,giving feedback to driver. As unit comes to or turns onto another segment, driver will call out this information to recorder. Recorder then enters on log sheet:
            a) Roadway ID# and
            b) Stopwatch reading (h:mm:ss) for start of segment
        3) Operate digital timer for speed and traffic counts

Protocol

1. As MH unit leaves plant entrance
    A. Verify cameras are on and set on predetermined zoom
    B. Start all counters
        1) Character generator stopwatch
        2) Digital timer for speed/traffic counts
    C. Establish predetermined distance behind MH unit

2. Verify route segment and roadway ID# and

   A. Record Roadway ID# and stopwatch reading on Video Data Collection Log

   B. If the MH unit goes off route,

      1) Use blank Inventory sheets to quickly record road name, number and location. Physical characteristics will be obtained later off of the tape or return trips

      2) Sequentially number the segments starting at 01 and enter this number and stopwatch setting on Video Data Collection Log

3. Verify and record Roadway ID# and stopwatch reading on Video Data Collection Log for each subsequent route segment.

4. When timer signals 3 minutes

   A. Recorder asks driver for speedometer reading

   B. Driver stabilizes speed and gives reading to recorder

   C. Recorder enters speed in appropriate column on next available row on logsheet

   D. Recorder looks to rear of vehicle to count number of vehicles backed up behind MH unit.

   E. Recorder resets timer for 3 minutes

5. Continue above procedures to the state line

6. At first available exit, pull off the road and shut down and pack up video equipment.

APPENDIX D

Summary of Video Data Runs

Video Data Run Summary

16" Units

Run #	Date	Tape Numbers: ID's	Start Time	End Time
16.1	7/17/97	05: 16071701F 06: 16071701R	09:20	09:54
Route:	From a point on Robeson Co. SR 1564 to SR 1571 to NC 711 East to I-95 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
16.2	7/22/97	09: 16072201F 10: 16072201R 11: 16072202F 12: 16072202R	09:40	11:49
Route:	From a point on Lee Co. SR 1529 to US 421 South to Dunn to I-95 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
16.3	8/4/97	19: 16080401F 20: 16080401R	09:43	11:17
Route:	From a point on Stanley Co. SR 1816 to SR 1783 to NC 24/27 West to US 52 North to NC 49 South to US 29/NC 49 South to Mecklenburg Co. SR 2772 to I-85 South to I-77 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
16.4	8/13/97	21: 16081201F 22: 16081201R	10:02	11:36
Route:	From a point on Stanley Co. SR 1816 to SR 1783 to NC 24/27 West to US 52 North to NC 49 South to US 29/NC 49 South to Mecklenburg Co. SR 2772 to I-85 South to I-77 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
16.5	8/14/97	23: 16081401F 24: 16081401R 25: 16081402F 26: 16081402R	09:48	12:06
Route:	From a point on Lee Co. SR 1529 to NC 42 West to US 421 South to Dunn to I-95 South to South Carolina Line			

Video Data Run Summary

Run #	Date	Tape ID's	Start Time	End Time
16.6	8/18/97	27: 16081801F 28: 16081801R	09:29	11:18
Route:	From a point on Davie Co. SR 1601 to SR 1602 to US 64 West to US 601 North to I-40 West to I-77 South to South Carolina Line			

14" Units

Run #	Date	Tape ID's	Start Time	End Time
14.1	7/21/97	07: 14072101F 08: 14072101R	08:22	09:09
Route:	From a point on Robeson Co. SR 1564 to SR 1571 to NC 711 East to SR 1003 US 74 East to I-95 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
14.2	7/24/97	13: 14072401F 14: 14072401R	08:30	10:07
Route:	From a point on Davie Co. SR 1601 to SR 1602 to US 64 West to US 601 North to I-40 West to I-77 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
14.3	7/29/97	15: 14072901F 16: 14072901R 17: 14072902F 18: 14072902R	13:17	15:31
Route:	From a point on Lee Co. SR 1529 to NC 42 West to US 421 South to NC 87 South to Fayetteville to Santa Fe Dr. to All-American Highway South to Owen Dr. to US 301 South to I-95 South to South Carolina Line			

Run #	Date	Tape ID's	Start Time	End Time
14.4	8/19/97	29: 14081901F 30: 14081901R 31: 14081902F 32: 14081902R	09:30	11:38
Route:	From a point on Lee Co. SR 1529 to NC 42 West to US 421 South to NC 87 South to Fayetteville to Santa Fe Dr. to All-American Highway South to Owen Dr. to US 301 South to I-95 South to South Carolina Line			

Video Data Run Summary

Run #	Date	Tape ID's	Start Time	End Time
14.5	09/22/97	33: 14092201F 34: 14092201R	08:12	09:59
Route:	From a point on US 52 North in Stanley Co. to NC 49 South to US 29/NC 49 South to Mecklenburg Co. SR 2772 to I-85 South to South Carolina Line			

APPENDIX E

Variable List and Codes for Encroachment Analysis

Encroachment Analysis Variables

Variable **VAR NAME**	**CODES**	**VALUE**	**COMMENT**
ID Number SEQID#	##### 	Sequentially numbered vehicles	
Tape# TAPENUM	##	Tape number	
Unit size MHSIZE	16 _____ 14 _____	16 feet 14 feet	
Stopwatch STOPWTCH	h m m s s t	h = Hour reading from stopwatch m m = Minutes reading from stopwatch s s = Seconds reading from stopwatch t = 1/10 second reading from stopwatch	
Time TIME	h h : m m	Time of day 24 hour clock	
Segment ID SEGID	From list or Dummy		
Road Type RDTYPE	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____	2 Lane 3 Lane _____ 4 Lane undivided 4 Lane + center turn 4 Lane divided by median 4 Lane Interstate	 Where 3rd lane is center turn
Curb Present CURB	1 _____ 2 _____ 3 _____	Yes No Undetermined	
Event Type EVTYPE	1 _____ 2 _____ 3 _____	Passing _____ Overtaking _____ Oncoming _____	Passing unit on 2-lane road Overtaking unit on 4-lane road Meeting unit from opposite direction

Encroachment Analysis Variables

Variable VAR NAME	CODES	VALUE	COMMENT
Lane width LANEWIDE	nn.n	# feet to nearest foot	Travel lane width measured from outside of fog line to outside of centerline. From roadway inventory forms or image analysis.
Shdr width* SHDRWIDE *Any time 6, 7, or 8 used, fill out left shift data form*	0 _____ 1 _____ 2 _____ 3 _____ 4 _____ 6 _____ 7 _____ 8 _____ 99 _____	<1 foot ≥1 ft and <2ft ≥2 ft and <3ft ≥3 ft and <4ft ≥4 ft Narrow bridge _____ Work zone Any other obstruction Unable to determine	Right shoulder width measured from outside of fog line to outside edge of paved shoulder or curb. From roadway inventory forms or image analysis. Additional codes where obstruction to right prevents full use of shoulder
MH Encroach (into lane to immediate left) MH_ENCR	1 _____ 2 _____ 3 _____ 9 _____	Definite Yes _____ Definite No _____ Too close to call _____ Unable to determine _____	Left edge of unit appears to extend beyond left edge of lane line Left edge of unit appears to be on or inside left edge of lane line Very close to lane line - unable to definitely determine Unable to determine for any other reason
MH Drop (off pavemnt) MH_DROP	1 _____ 2 _____ 9 _____	No _____ Yes _____ Unable to determine	Mobile home does not drop off pavement/right shoulder Yes, mobile home <u>does</u> drop off pavement/right shoulder

Encroachment Analysis Variables

Variable VAR NAME	CODES	VALUE	COMMENT
OV Flow	1 _____	Free flowing _____	Single vehicle or lead vehicle in string
OV_FLOW	2 _____	Trailing _____	Trailing another vehicle within 5-6 car lengths
OV Type	1 _____	Car, minivan, utility, pickup, full van	Type of vehicle to the left of mobile home
	2 _____	Tractor trailer	
OV_TYPE	3 _____	Other large truck	
	4 _____	Mobile home	
	5 _____	Other	
OV Encroach	1 _____	None _____	Left tire of opposite vehicle on or inside left edge of left fog or lane line
OV_ENCR	2 _____	Moderate _____	Left tire of opposite vehicle extends beyond left edge of left fog or lane line and appears to be within a foot of the line - On pavement
	3 _____	Severe _____	Left tire of opposite vehicle extends beyond left edge of left fog or lane line and vehicle appears to be more than a foot over the line - On pavement
	4 _____	Off Pavement _____	Any tire of vehicle off of pavement to any degree
	9 _____	Unable to determine	

APPENDIX F

Variable List and Codes for Speed and Rear-Traffic Analysis

Speed and Rear-Traffic Analysis Variables

Variable VAR NAME	CODES	VALUE	COMMENT
IDNUM	nnn	Sequential ID number	
Size of MH SIZE	14 _____ 16 _____	14' mobile home 16' mobile home	
Date DATE	mm/dd/yy	Date of run	
Day of week DAYWEEK	1 _____ 2 _____ 3 _____ 4 _____ 9 _____	Monday Tuesday Wednesday Thursday DK	
Start Time STRTTIME	h h : m m	Time of day 24 hour clock	
Stopwatch STOPWTCH	h m m s s t	h = Hour reading from stopwatch m m = Minutes reading from stopwatch s s = Seconds reading from stopwatch t = 1/10 second reading from stopwatch	
Roadway RDTYPE	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 9 _____	2 Lane 3 Lane _____ 4 Lane undivided 4 Lane + center turn 4 Lane divided by median 4 Lane Interstate Greater than 4 Lanes UNK	Where 3rd lane is center turn

Speed and Rear-Traffic Analysis Variables

Variable VAR NAME	CODES	VALUE	COMMENT
Urban/Rural URBRUR	1 _____ 2 _____ 3 _____ 9 _____	Urban Rural Mix DK	
Cruise CRUISE	1 _____ 2 _____ 3 _____ 9 _____	Cruise _____ Slow Traffic _____ Stop light/sign _____ Other UNK	Unimpeded by other traffic or controls MH behind other traffic Slowing for or starting up from light or sign
Speed Limit SPLIMIT	nn	Speed limit for roadway	
Speed of MH MHSPEED	nn	Speed of mobile home taken from van speedometer	
Rear Traffic Count TRCOUNT	nn	Number of vehicles behind mobile home unit	
Count Time CNTTIME	h m m s s	Time between speed/traffic counts	
Total Time TOTTIME	h m m s s	Time between start time and current speed/traffic count	
Time of Day TIMEDAY	h h : m m	Time of day (24 hour clock) when count was made	

Speed and Rear-Traffic Analysis Variables

Variable **VAR NAME**	**CODES**	**VALUE**	**COMMENT**
Speed Differential SPEEDDIF	nn	Difference between traveling speed of MH and speed limit (MHSPEED - SPLIMIT). Negative # indicates MH slower than speed limit.	
Does MH comply with Speed Regs. CMPLYSPD	1 _____ 2 _____ 9 _____	Yes, MH is at least 10mph below posted speed limit No, MH is not at least 10mph below posted speed limit Unknown	
Time of day-hour TIMDAY2	nn am or pm	Time of day to the hour, am or pm	

APPENDIX G

Variable List and Codes for Image Analysis

Image Analysis Variables

VARIABLE	CODES	VALUE	COMMENT
RUN INFORMATION			
Tape ID Number TapeID	########	Full tape identification number	
Tape Number TapeNum	##	Two digit tape number	
Run Number RunNum	nn.n	Where nn is unit size and .n is sequential number	
Run Begin Time BgnTime	h h : m m	24 hour clock	
Run End Time EndTime	h h : m m	24 hour clock	
Day of Week Day	1 _____ 2 _____ 3 _____ 4 _____	Monday Tuesday Wednesday Thursday	
MH UNIT INFORMATION			
Size of Unit MHSize	14 _____ 16 _____	14 wide 16 wide	
Width of Unit RearWide	nn..n	Measured width of unit at the rear in feet to the nearest tenth	
Unit Axle Width AxleWide	nn..n	Measured width from outside of tire to outside tire in feet to the nearest tenth	

Image Analysis Variables

VARIABLE	CODES	VALUE	COMMENT
Leftedge	nn..n	Distance of bottom left rear corner of unit to the ground in feet to the nearest tenth	
Rigtedge	nn..n	Distance of bottom right rear corner of unit to the ground in feet to the nearest tenth	
EVENT INFORMATION			
Event # EventNum	# # h m m s s t	Eight digit code where # # = Tape number h = Hour reading from stopwatch m m = Minutes reading from stopwatch s s = Seconds reading from stopwatch t = 1/10 second reading from stopwatch	
Event Time of Day EvntTime	h h : m m	24 hour clock	
Road Type RdType	1 _____ 2 _____ 3 _____	2 Lane 4 Lane median, non-Inter. 4 Lane Interstate	
Road feature RdFture	1 _____ 2 _____ 3 _____	Straight Right curve Left curve	
Curb present Curb	1 _____ 2 _____ 3 _____	Yes No UNK	

Image Analysis Variables

VARIABLE	CODES	VALUE	COMMENT
OTHER VEHICLE			
Vehicle Type OVType	1 _____ 2 _____ 3 _____ 4 _____ 5 _____	Car, minivan, utility, pickup, full van Tractor trailer Other large truck Mobile home Other	Type of vehicle to the left of mobile home
Event type EvntType	1 _____ 2 _____ 3 _____	Passing _____ Overtaking _____ Oncoming _____	Passing unit on 2-lane road Overtaking unit on 4-lane road Meeting unit from opposite direction
POSITIONING AND MEASUREMENTS			
Travel lane width LaneWide	nn.n	# feet to nearest 1/10	Measured from outside of fog line to midpoint of lane line or midway between double lines
Paved shoulder width ShldWide	nn.n	# feet to nearest 1/10	Measured from outside of fog line to outside edge of paved shoulder
MH shoulder encroachment (onto shoulder) MHShenc	1 _____ 2 _____ 9 _____	Yes _____ No _____ UNK _____	Right edge of unit extends beyond outside edge of fog line Right edge of unit on or inside fog line Unable to determine
MH shoulder encroachment distance RigtTire	nn.n	+/- # feet to nearest 1/10	Distance edge of unit extends beyond outside edge of fog line (Negative number denotes distance inside edge of fog line)

Image Analysis Variables

VARIABLE	CODES	VALUE	COMMENT
MH lane encroachment (into lane to immediate left) MHLnEnc	1 _____ 2 _____ 9 _____	Yes _____ No _____ UNK _____	Left edge of unit extends beyond midpoint of lane line or midway between double lines Left edge of unit on or inside left edge of lane line Unable to determine
MH lane encroachment distance LeftTire	nn.n	+/- # feet to nearest 1/10	Distance left edge of unit extends beyond midpoint of lane line or midway between double lines (Negative number denotes distance inside left edge of lane line)
Separation distance SepDist	nn.n	+/- # feet to nearest 1/10	Distance between the left edge of the unit and vehicle to immediate left
OV Shoulder encroachment (onto shoulder or into lane to immediate left) OVEncr	1 _____ 2 _____ 9 _____	Yes _____ No _____ UNK _____	Left tire of vehicle extends beyond left edge of left fog or lane line Left tire of vehicle on or inside left edge of left fog or lane line Unable to determine