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OMIC EVALUATION OF MOBILE AND MODULAR NG SHIPMENTS BY HIGHWAY

Vol. I Research Report

W. D. Glauz, B. M. Hutchinson, and D. R. Kobett

April 1974
Final Report

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U.S. DEPARTMENT OF TRANSPORTATION
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16. Abstract

The objective was to obtain data needed to reach rational decisions regarding state regulations so that wide-load movements can be made as safely as possible, without undue economic burdens to the purchasers of such homes, to the states, or to other users of the highways. The project included extensive photographic and visual observations of vehicular traffic in the vicinity of 12- and 14-ft wide mobile and modular homes in 20 states, with about 12,000 miles being logged on 63 trips. Nearly 3,000 motorists were stopped on the highways of six states and interviewed. These interview and associated mail-back questionnaires were analyzed to determine public opinions concerning many vehicles including mobile homes. Extensive costs and operational data were obtained from carriers of wide loads. Additionally, cost and regulation information were gathered from officials of most states.

After assembling and combining all of these data, a number of subjects were addressed, including: (1) the need for permits; (2) the advisability of multiple-trip permits; (3) permit costs; (4) permit reciprocity; (5) the advisability of divisible loads; (6) the use of divided vs two-lane roads; (7) reasonable speeds for wide loads; (8) rear lighting needs; (9) the advisability of escort vehicles; (10) differences between 12- and 14-wides; (11) differences between mobiles and modulars; (12) specific safety hazards noted; and (13) regulatory questions such as signing, flagging, etc.

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UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

DATE:

In reply refer to: HRS-41

SUBJECT: Transmittal of Research Report: "Economic Evaluation of Mobile and Modular Housing Shipments by Highway"

FROM : Director, Office of Research
Washington, D.C. 20590

TO : Regional Federal Highway Administrators
Regions 1, 3 - 10

This report will be of interest to personnel responsible for traffic operations, traffic safety, highway systems planning and highway administration. The results of this study identify and evaluate various aspects of traffic safety and costs associated with shipment of mobile and modular housing by highway, and describe public attitudes regarding such shipments. Recommendations are made regarding the conditions under which such shipments should be permitted, and various regulatory and administrative measures which might be taken to increase their safety and acceptability.

Sufficient copies of this report are being distributed to provide four copies for each regional office, one copy for each division, and additional copies for each State highway or transportation department in amounts corresponding to their estimated need and interest. Copies of this report for the division offices and State highway and transportation departments are being sent directly to the division offices for distribution.

A limited number of additional copies of the report are available for official use from the Environmental Design and Control Division, Office of Research. Copies for the public are available from the National Technical Information Service (NTIS), Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22151. A small charge is imposed for each copy ordered from NTIS.

T. Solomon
for Charles F. Scheffey

ERRATA
in

HIGHWAY TRANSPORTATION OF MOBILE AND MODULAR HOMES
Volume I: Research Report

Page	Location	Comment
ii	First paragraph, last line	Add "(Building Technology Division)" at end of line
6	Third paragraph, fourth line	Change "operations" to "observations"
6	Third paragraph, seventh line	Change "63" to "62"
32	Figure legend	Add "Each plotted symbol (number or letter) represents a data point for a specific driver-vehicle-roadway combination. Dashed lines connect data points involving the same driver-vehicle combination."
68	Equation 5, left side	Change "$10^3{}_{p.u.}$" to "$10^3 f_{p.u.}$"
68	Last paragraph, last line	Delete all after "prices" and add "in 1969."
103	Itemized list, third line	Insert a comma after "routing"
111	Second paragraph, seventh line	Change "presumable" to "presumeably"
134	Last paragraph, sixth line	Change "then" to "than"
143	Second paragraph, third line	Change "is" to "are"
148	First paragraph, first line	Change "accure" to "accrue"
152	Footnote a	Footnote should read: "The summed total of overdimension charges associated with the individual states is $65 while $45 is the trip charge. This reflects an inconsistency in Tariff MC-I.C.C. No. 23."

ERRATA (Concluded)

Page	Location	Comment
161	Fifth paragraph, last line	"Mirrow" should read "mirror"
178	Third paragraph, second line	Change "align" to "by the"
186	Third paragraph, third line	Change "align" to "perhaps"
190	Second paragraph, sixth line	Change "set" to "sets"
190	Second paragraph, eighth line	Add "high" at end of line
193	Footnote, line 4-5	Change "transport" to "transporting"
206	Third paragraph, third line	Change the period at end of line to a comma
223	Entry three	Delete "Director of Transportation" and insert "Office of Policy Development and Research"

PREFACE

This report was prepared under Contract No. DOT-FH-11-7989 for the Department of Transportation, Federal Highway Administration. The authors acknowledge the assistance and helpful suggestions of Messrs. David Dickens, Burt Stephens, David Solomon, C. A. Steele, and Earl Newman with the Federal Highway Administration and Mr. James McCollom with the Department of Housing and Urban Development.

Dr. William Glauz was the principal investigator and participated in all phases of the research, but with special attention to the motorist interviews, formulation of cost models for motorists, and traffic data collection. Barrie Hutchinson was responsible for the work regarding costs to shippers and to states. Donald Kobett concentrated on the traffic data collection and the analysis of costs to motorists.

MRI personnel who contributed significantly to this research include William Jellison (photographic techniques); James Azzeh, Bernard Brown, Hugh Hass, Walter Hodge, Robert Kutchko, Mel Lavik, and Gregory Muleski (traffic data collection); Gordon Gross, Kenneth Doll, and Phillip Tyrrell (equipment design); Dorothy Beattie, Rosemary Moran, Ahmed Morsi, and Cathy Wilton (data reduction and analysis); Duncan Sommerville (computer programming and analysis); Michael Sharp (statistical analysis); George Beitel, Bernard Brown, Mel Lavik, Bruce McDonald, Gregory Muleski, and Barry Sanders (motorist interviews); Robert Fleisher, Richard Salmon, and Barry Sanders (costs to shippers and to states); and Robert Blackburn, John Glennon, and Andrew St. John (general consulting, especially with regard to traffic data analysis).

The various data collection activities were made possible through the cooperation of members of the mobile home and modular housing industries. The following are gratefully acknowledged: Morgan Drive Away, Inc., Barrett Mobile Home Transport, Inc., Fleetwood Enterprises, Inc., The Wickes Corporation, New England Homes, Inc., Marlette Homes, Inc., Active Homes Corporation, Redman Industries, Inc., Ord Corporation, AVCO Corporation, National Homes Corporation, and Transit Homes, Inc.

We are also deeply indebted to the many state highway departments who assisted us. Nearly all of the adjacent 48 states provided us with data, and many of them worked with us closely in one or more phases of the research. They also provided indirect assistance through the NCHRP, which they support. A forerunner to this contract was NCHRP Project 3-19. As a task of that project, preliminary work was done regarding movements of wide loads by highway. The experience gained there was invaluable as it pointed out the many pitfalls and difficulties in obtaining the types of data necessary for this contract.

Despite pressures of deadlines, the typists worked uncomplainingly on the many drafts of this report. We particularly wish to thank Audene Cook, Cheryl Fowler, Candace McGrew, Carol Shaw, Debbie Hurlock, and Theresa Lamb.

The work reported here was conducted during the period 15 February to 15 October 1973. The report is in two volumes. Volume I contains an introduction, a presentation of the methodology, results, conclusions, and recommendations. Volume II is a compendium of appendices which provide backup material for the discussions of Volume I.

Approved for:

MIDWEST RESEARCH INSTITUTE

Michael C. Noland, Director
Engineering Sciences Division

15 April 1974

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I. INTRODUCTION

A. History

A major change has been occurring over the past two decades in the housing habits of Americans. Today, over one-fifth of all new housing units, and 75% of all units priced under $20,000, are mobile homes.* In addition, factory-produced modular homes and buildings are finding a niche in the housing industry. Cost is the prime factor in this change. A large number of Americans find that these types of housing better suit their needs and budgets.

Prior to 1955, mobile homes were mostly limited to 8 ft widths (hereafter called 8-wides). They could be transported over the highways with no special consideration required--they were "legal." But they were not highly sought after for housing due to their narrowness. Annual production stabilized at under 100,000 units. However, in 1955-1957 a new concept appeared--the 10-wide mobile home. Within a few years, these units almost completely supplanted the 8-wides in production. At the same time, another situation developed. These homes were wider than the legal limits for highway use. Therefore, they had to move under special permit as extra-legal loads. The trend to extra-legal loads has continued to the point where, now, almost all mobile homes are 12 ft or more in width.

In 1961, 12-wides began to be produced and transported on the highways. Most of these were complete homes; others were half-houses or "double wides," wherein two units could be joined on-site to produce a 24 ft wide house. With the introduction of 12-wides, the demand for mobile homes increased rapidly, from 100,000 in 1961 to 250,000 in 1967 and over 450,000 12-wides in 1972. During this period 14-wides were introduced. Beginning about 1969, their production has increased, but at a lesser rate than 12-wides, to about 104,000 in 1972. They now consist of approximately 18% of the total volume. Even wider units (16-wides) appeared on the market in 1969-1970 but they have not proven popular (only 0.1% of the market), probably because their highway transportation is banned in most states.

The Mobile Home Manufacturers Association estimates continued growth of the mobile home market to 580,000 units in 1974.

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* Statistical data on the mobile home industry are taken from 1973 reports of the Mobile Home Manufacturers Association and from Elrick and Lavidge, Inc., consultants to MHMA.

The growth of the modular industry has been less spectacular. Unlike a mobile home, which has its own wheels and can thus be pulled about, a modular unit is a box which is loaded on a flatbed trailer for transporting. It is usually much heavier, at a given size, than a mobile home, and more expensive. Often, two or more units are joined in the field to construct a house. Also, apartment complexes, motels, and other buildings have been built in this way. This industry received a major boost through the federally-financed "Operation Breakthrough."2/ Although now defunct, "Operation Breakthrough" resulted in many new concepts and techniques for factory production of housing.

B. Permit Operations

Mobile and modular housing are here to stay. And to the dismay of many highway engineers, traffic safety experts, and public interest groups, so is their usage of the highways. Although rail transportation is possible in special cases,3/ the demand of moving only one or two units at a time from a given origin to a given destination usually makes highway transportation the only reasonable alternative.

To enable this transportation, the states use permit systems. As with other shippers of extra-legal cargo (oversize, overweight, or both), the shipper or the carrier applies for and obtains a special permit. The permit, and the regulations relevant thereto, define the conditions under which the move may be made. This procedure is, in theory, a reasonable approach for the states to follow. They have the responsibility to provide and maintain the highway systems and to insure the reasonable safety of their users.

However, the states are variant in their policies, creating numerous real and imagined problems. If the regulations are to help provide for the safety and convenience of the motoring public, why do they vary so much from state to state? Why does one state set very low speed limits for wide loads while another has none? Why do some states ban them from divided highways while others almost insist on such usage? Often, escort or pilot vehicles are required, front and/or rear; under similar conditions they are not necessary in other states.

C. Accident Records

Safety to the highway user is a foremost consideration of the states. But, what is known about wide load accidents? Not much, and even less concerning how accidents might be affected by regulatory parameters. However, certain data are available. Table I displays information obtained from

TABLE I

COMPARATIVE ACCIDENT DATA

Vehicle Type	Accidents Per 100 Million Vehicle Miles	Injuries Per 100 Million Vehicle Miles	Fatalities Per 100 Million Vehicle Miles	Source
All Motor Vehicles	1,435	179	4.91	National Safety Council (1970)[4/]
Trucks	1,242[a/]	563[a/]	44.6[a/]	" " "
Buses (Intercity)	661	---	---	" " "
Motorcycles	3,000	---	23	" " "
Mobile Homes	1,390	115	9	Bureau of Motor Carrier Safety (1970)[b/]
Mobile Homes[c/]	2,000-5,000	---	---	Carrier Data (1970-1972)[5/]
Mobile Homes[c/]	4,900	100	---	1971 Data of Morgan Drive Away, Inc.

a/ Fleet accident rate data reported by National Safety Coucil were combined with Bureau of Motor Carrier Safety data on number of injuries and fatalities, to determine injury and fatality rates.

b/ Assumes 400,000 shipments (a conservative estimate based on Mobile Home Manufacturers Association data on initial moves) at 250 miles each.

c/ Industry data; these accidents were not necessarily all reported or reportable.

several sources, some of it from official accident reports and some from company files.*

In summary, although it is possible that wide loads may experience a higher total accident rate than other vehicles, reported accident, injury and fatality rates are similar. Industry records show higher accident rates than BMCS data, probably reflecting the minor nature of many of these mobile home accidents. In fact, Morgan Drive Away, the nations's largest carrier, reports that over 60% of their accidents are "fixed object" accidents resulting only in property damage, and only involving the wide load. Based on Table I, injury and fatality rates for wide load accidents appear to be comparable to those for other vehicles, in general, and lower than for some vehicle classes such as trucks and motorcycles. Due to the small numbers (there were only nine fatalities for the country in 1970), fatality rates involving wide loads cannot be compared accurately. Also, truck and motorcycle data are not known as precisely as would be desired.

These data provide few clues as to how wide-load movements can be made with fewer accidents. The data of Solomon[6/] suggest that mobile homes may have a higher-than-average accident involvement because they travel at lower-than-average speeds. However, because most of their accidents involve fixed objects, it is unlikely that raising their speeds would decrease their total accident rate. On the other hand, their involvement in, or contribution to, multiple-vehicle accidents could be changed. The data are not robust enough to say.

A second clue concerns time-of-day effects. All studies of accidents other than those involving wide loads clearly show that accident rates and accident severities are significantly higher at night than during daylight hours, for a variety of reasons. No substantial nighttime data concerning wide-load movements exist because, except under conditions relating to national defense or emergency relief, such movements are not allowed

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* Ideally, it would be desirable to examine only rural, daytime accidents since most wide load traffic is of that type. But, such data are not readily available. It is known[4/] that fatality rates are higher in rural areas, and lower in the daytime, so that the rural, daytime fatality rate for all vehicles is about 4.7/100 million vehicle miles, compared with the value, 4.91, shown in the table. Total accident rates are lower in rural areas, but do not differ appreciably from day to night.

after dark.* Nevertheless, it appears prudent to assume wide load accident rates would be higher if nighttime operations become routine.

D. Need for Data

The data just discussed leave the question of wide load safety unresolved. There appears to be a problem, but its magnitude and causes are unclear. Certainly, there are accidents and safety hazards associated with this industry. On the other hand, it appears unlikely that the demand for wide-load movements on the highways will diminish. Therefore, it is important that all reasonable steps be taken to ensure a high degree of safety at reasonable cost.

Although accident studies might shed further light on the problems, such studies would suffer for the same reason that many accident studies suffer, that is, the relative rarity of accidents and the generally inadequate quality of the data pertaining thereto. Moreover, wide load accidents per se may not tell the full story. Accident studies would not bring to light the frequency of accidents in which a wide load may have played a causative role, but not been physically involved. Neither would accident studies answer questions concerning incidents which, although not developing into accidents, create motorist inconvenience and discomfort. Likewise, wide load movements could also lead to changes in operating costs on the part of other motorists, and the imposition of delays, neither of which can be determined from accident studies.

Presumably, these phenomenon can be affected by the regulations regarding movements of wide loads. It is important, therefore, that studies be performed to determine the impact of these movements on society and how this impact can be minimized by varying operating procedures and regulations. This research project was designed to satisfy that need.

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* HUD has had some experience with nighttime movements relative to providing emergency relief. Recently they moved 18,000 mobile homes into the Pennsylvania area following Hurricane Agnes. Some of this travel was at night. There were no reported injuries or fatalities associated with this move.

E. Objectives

The ultimate mutual objective of the parties involved in the transportation of mobile and modular homes--that is, the U.S. Government, the state governments, mobile and modular builders and shippers, and the general public--is to establish acceptable regulations regarding shipment over the highways of these homes. These regulations should ensure safe transportation at reasonable costs. To this end, the objective of this research project was to obtain the data needed to reach rational decisions regarding such regulations, to analyze these data, and to make recommendations based upon the analyses, all in a timely fashion.

F. Scope

Our intent in the project was to identify factors in the highway movement of mobile and modular housing concerned with safety, inconvenience and cost. To do this, we first obtained data in four distinct ways. Then, after analysis of these data, conclusions were reached and recommendations made addressing specific questions which deal with increasing the safety, minimizing the inconvenience, and imposing only reasonable costs upon the purchasing and motoring publics.

The major data collection effort was associated with obtaining traffic data--data concerning movements of other traffic in the vicinity of wide loads (12- and 14-wide mobile homes and 12-wide modular homes). The data were collected photographically, supplemented by visual operations and manual counts of such things as queue lengths and passes. Our crews rode with wide loads, photographing from the cab, from the rear of the house, or from an escort vehicle. About 12,000 miles were logged on 63 trips in most parts of the country, on all kinds of highways and terrain, and under a variety of controlling state regulations. The films were then reduced by image measuring techniques. Over 25,000 frames of film were thus analyzed and the data were coded for computer processing. Speed-distance profiles were obtained, as well as other features of the vehicle maneuvers.

Two types of analyses were made of these data. One type concerned safety-related measures. Included here were considerations of relative speeds between vehicles, the time remaining before overtaking at which a motorist saw and responded to the wide load (by changing lanes or decelerating), usage of the shoulder by oncoming traffic, etc. The other type of analysis determined the costs imposed on the motoring public. These costs included incremental operating costs associated with fuel and tire consumption, delay, and added air pollution. Delay measurements also provided a measure of inconvenience to the motoring public. In addition to these data, we also recorded a number of incidents observed during these trips.

A second data collection effort was the conducting of motorist interviews. Almost 3,000 drivers were stopped on the highways, both divided and two-lane, of six states and a short interview conducted. The procedure was designed to optimize the chances that the motorists had recently passed a wide load. They were asked questions concerning delays and safety hazards, with wide loads not being specifically mentioned until the end of the interview. Then, the motorists were asked to complete and return a questionnaire in which they could compare wide loads with other classes of vehicles on the highways.

Thirdly, we obtained extensive cost and related data from common and private carriers of mobile and modular homes. This was done by on-site interviews at about two dozen locations around the country. Also, hard data were obtained on such factors as circuitous routing, costs of permit acquisition, delays enroute, etc.

Fourth, we obtained data from the states. This effort involved three steps--first by mail, second by telephone interview, and third (in a few states) by personal interview. Information was sought of state officials concerning permit office operations; costs to the states of issuing permits, enforcing regulations, etc.; permit and regulation policies and philosphies; and particular regulation problems within the state.

After assembling and combining all of these data, a number of questions regarding movements of wide loads were addressed. Among the topics were the following:

(1) The need for permits;

(2) The use of multiple-trip permits;

(3) Permit costs;

(4) Permit reciprocity;

(5) Advisability of divisible loads;

(6) The use of divided highways vs two-lane highways;

(7) Reasonable speeds for wide loads;

(8) Rear lighting;

(9) Advisability of escorts, front or rear;

(10) 12-Wides vs 14-wides on (a) divided highways, (b) two-lane highways with good sight distance and wide lanes, and (c) two-lane highways with marginal sight distance and narrow lanes;

(11) Mobile vs modular movements;

(12) Particular safety hazards such as frequent tire failures, and improperly equipped or operated escort vehicles; and

(13) Other regulatory questions such as signing, flagging, etc.

G. Project Limitations

The research project covered a large number of facets of the cost and safety implications of wide load transportation. However, it is important to clarify certain areas which were outside the scope of the contract and of the study.

Aside from activities associated with the literature survey, the project did not encompass accident studies. We did not review accident statistics nor were accident investigations conducted. Accidents are too rare to provide reasonable samples, and most accident reports are not adequate to answer questions concerning causation.

It was not the intent of this project to examine wide loads in comparison to normal size loads or other types of vehicles. The only comparisons made in this regard were associated with the motorist surveys. From the beginning, it was implicitly assumed that wide loads are, and will continue to be, using the highways. Therefore, the intent of the project was to compare various alternatives and examine the parameters involved in their movement.

Likewise, certain costs involved in the transportation of wide loads were not examined in depth in this project. The study did not concern itself with cost elements common to all trucking, or even those costs which apply uniformly to mobile and modular home transportation. The present study was confined to incremental costs which arise within and between states as a result of complying with the particular regulations of the states.

Finally, there were many vehicle characteristics which were not examined in detail. The scope of the project did not include such items as the aerodynamic characteristics of mobile homes, stability considerations concerning their movements, the mechanical and other properties of the towing vehicle and how they relate to handling properties, or analyses of construction practices of mobile homes as they might relate to transportation.

H. Report Organization

This volume of the report contains the details of the research methodology, results, and discussion. These are arranged in sections, generally following the manner in which the project was divided into major tasks.

Section II covers the traffic data collection task. The techniques used, the types of data obtained, and the methods of analysis are briefly described. Then the results of the analysis as they pertain to measures of risk and traffic safety are presented.

Section III is concerned with the motorist opinion and attitude surveys. The methodology is described and the major results presented. Also included are the findings of a number of cross-comparisons made between respondent characteristics and other measurable parameters.

Section IV of this report considers the cost implications to the motoring public of wide load movements. The methodology used is developed in this section in some detail. Then this methodology is applied to the data obtained during the traffic data collection activities discussed in Section II to obtain cost measures. These include incremental operating costs, delay costs, and changes in the emission of air pollutants.

Section V contains a detailed analysis and discussion of the costs borne by mobile and modular home manufacturers, carriers, and purchasers, as well as costs to the states of providing permit services. This section includes a number of tables which detail the various regulations of the states and serve as basic reference material for other portions of the report. Also included in this section are several illustrative examples of the types and magnitudes of incremental costs associated with complying with the various state regulations.

Section VI departs somewhat from the organization of the rest of the report in that it is only indirectly related to the original research plan. In the conduct of the traffic data collection activities, a number of unusual incidents occurred. Taken singly these incidents would not be too meaningful for research purposes. But, because there were so many, and because several of them had common characteristics, we believe that they do have importance as indicators of problem areas, although their significance cannot be surmised from these few observations. Because of their importance as indicators, they are discussed separately in Section VI.

Sections VII and VIII are devoted to discussions concerning the basic questions itemized on page 7. Questions concerning permit operations and policies are covered in Section VII; questions of a regulatory nature are covered in Section VIII. Each of these discussions contains conclusions and recommendations on the particular question.

Section IX consists of a recapitulation of the conclusions stated and discussed throughout the report. And Section X lists our recommendations, based on the analysis and study of all information obtained during the project.

A great deal of back-up material is also included in this report, as Volume II. This volume contains the Appendices which present detailed information and results from the motorist's surveys; tabulations of regulations, by state, including their cost implications; tabulations of regulation variations between adjacent states, and their cost implications when a wide load crosses state lines; selected comments on a variety of subjects submitted by motorists encountered in the survey activities; details concerning the traffic data collection and analysis procedures; specific formulas applied to the traffic data to obtain cost and pollution measures; and an annotated bibliography covering the major references used in the project.

II. COLLECTION AND ANALYSIS OF TRAFFIC DATA

It would be unrealistic to expect that a mobile home or modular house in shipment on the highways does not alter the normal traffic flow pattern. Regulations are therefore imposed on the shipments by the various states to minimize the hazards and inconveniences induced by these wide loads. Establishment of the regulations is hampered because currently available information is largely subjective. An important and logical part of the present research was to identify and measure the effect on other traffic of the highway shipment of 12- and 14-wide mobile homes and modular houses. Collection and analysis of these data was the objective of the task discussed in this section.

Two kinds of data were gathered. In a major effort, time-lapse photographs were obtained of traffic in the vicinity of the wide loads. The photographing was alternately conducted from inside the load, from the cab of the towing tractor and from escort vehicles. The photographic data were used to determine the speed, lateral placement and lane occupancy characteristics of traffic encountering the load.

The second kind of data collected was counts of traffic events over timed intervals. Attention was concentrated on queuing and passing; occasional events such as intrusions into an adjacent lane were also recorded. The count data provide the basis for determining the temporal characteristics of queuing, overtaking and passing frequencies, etc.

The necessity to obtain cooperation from manufacturers and carriers, and state laws related to riding inside of trailers imposed some constraints on the scope of the data collection activity. It was possible, however, to cover a comprehensive range of experimental conditions. The field teams made 62 trips totalling approximately 12,000 miles. Shipment configurations included 12- and 14-wide mobile homes (some double-wide) and modular houses. Two trips were made with 12-wide divisible modular loads. The complete variety of current escort vehicle usage was sampled, and the data collection activity touched all major geographical regions of the country except the Southwest (Figure 1). Descriptive details of the data collection trips are summarized in Table II.

The photographic and count data were reduced separately. The major effort concerned obtaining measurements from the film, then processing these by computer to obtain speed-distance profiles.

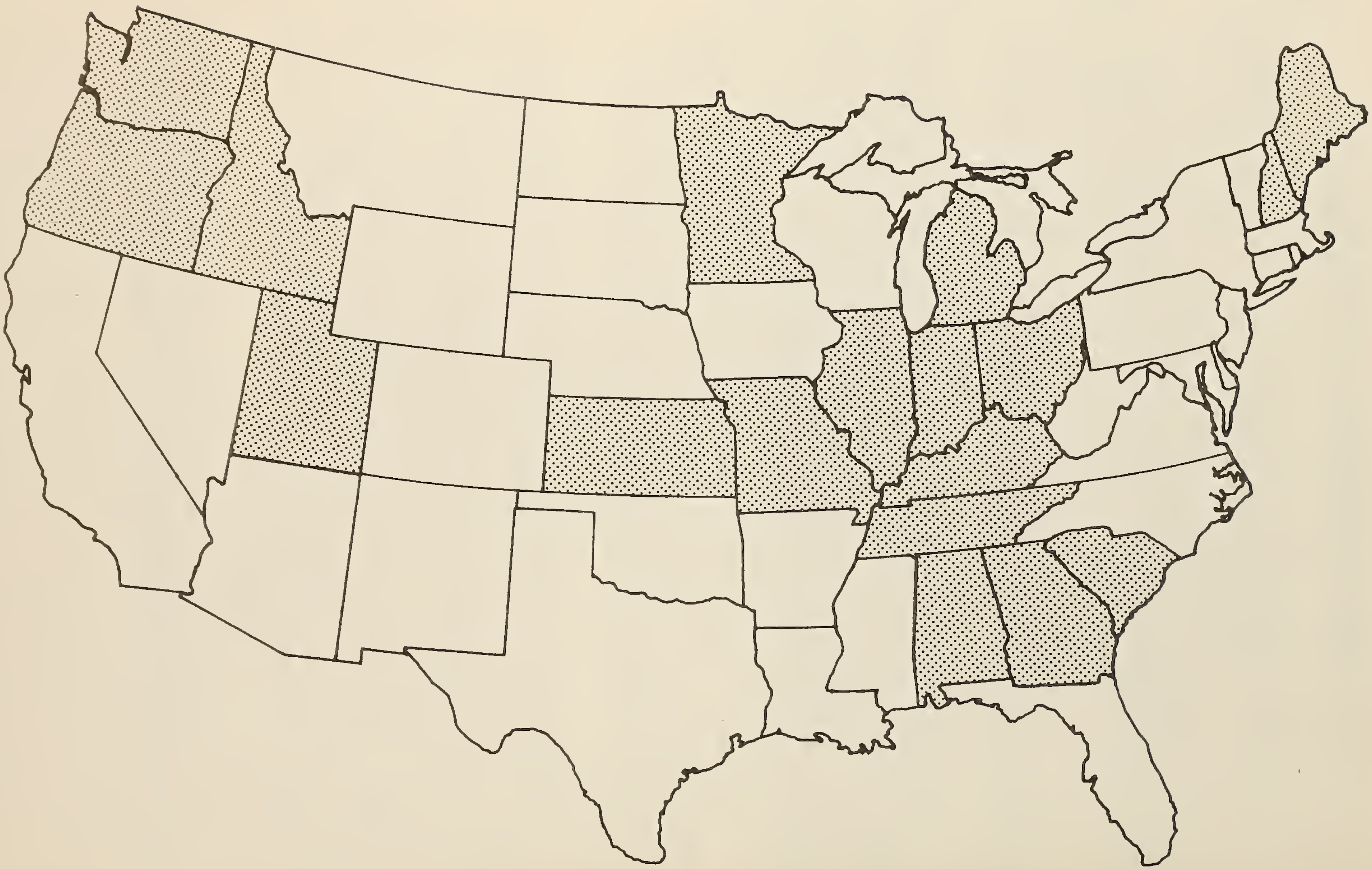

Figure 1 - Geographical Distribution of Data Collection Trips

TABLE II

DATA COLLECTION TRIPS

MRI Trip Designation	Date	House		Camera Location	Escort	State	Highway Type
		Size	Type				
1-1	4-26-73	12x64	Mobile	Load	None	Kansas/Missouri	Multilane
1-2	5-4-73	12x64	Mobile	Load	None/Front	Missouri	Two-Lane/Multilane
1-3	5-22-73	12x60	Mobile	Load	None	Georgia/S. Carolina	Two-Lane/Multilane
1-4	5-24-73	12x60	a/	Load	None	Georgia	Two-Lane
1-5	5-31-73	12x60	Mobile	Load	None	Georgia	Two-Lane
1-6	6-1-73	12x64	Mobile	Load	None	Georgia/Alabama	Two-Lane/Multilane
1-7	6-7-73	12x50	Mobile	Load	None	Georgia/Tennessee	Two-Lane/Multilane
1-8	6-19-73	14x68	Mobile	Rear/Front Escort	Front & Rear	Idaho	Two-Lane/Multilane
1-9	6-21-73	12x44	Mobile	Load	None	Idaho/Oregon	Two-Lane/Multilane
1-10	6-25-73	12x50	Mobile	Load	None	Idaho/Oregon	Multilane
1-11	6-27-73	14x60	Mobile	Rear/Front Escort	Front & Rear/Rear	Idaho/Utah	Two-Lane/Multilane
1-12	7-2-73	14x68	Mobile	Rear Escort	Rear	Washington/Oregon	Multilane
1-12	7-2-73	12x32	Mobile	Rear Escort	Rear	Oregon	Multilane
1-13	7-5-73	14x64	Mobile	Rear Escort	Rear	Oregon/Washington	Multilane
1-14	7-17-73	14x70	Mobile	Load	None	Minnesota	Two-Lane
1-15	7-20-73	14x70	Mobile	Load	None	Minnesota	Two-Lane
1-16	7-23-73	14x60	Mobile	Cab	None	Minnesota	Two-Lane
1-17	7-24-73	14x70	Mobile	Load	None	Minnesota	Two-Lane/Multilane
1-18	7-26-73	14x70	Mobile	Load	None	Minnesota	Two-Lane
1-19	7-30-73	12x50	Mobile	Load	None/Front & Rear	Idaho/Washington	Two-Lane/Multilane
1-20	8-1-73	14x64	Mobile	Cab	Front	Idaho	Two-Lane
1-21	8-1-73	None	b/	Car	None	Idaho	Two-Lane
1-22	8-2-73	12x60	a/	Cab	Front	Idaho	Two-Lane
1-23	8-3-73	14x70	Mobile	Load	None/Rear/Front & Rear	Idaho/Oregon	Two-Lane/Multilane
1-24	8-6-73	14x64	Mobile	Load/Cab	None/Front/Front & Rear	Idaho/Montana	Two-Lane/Multilane
1-25	8-22-73	12x71	c/	Load	None	Indiana/Ohio	Two-Lane/Multilane
1-26	8-23-73	None	a/	Car	None	Indiana	Two-Lane/Multilane
1-27	8-24-73	12x71	c/	Load	None	Indiana/Ohio	Two-Lane/Multilane

TABLE II (Concluded)

MRI Trip Designation	Date	House Size	House Type	Camera Location	Escort	State	Highway Type
2-1	5-22-73	14x70	Mobile	Load	Front/Rear	Ohio	Two-Lane/Multilane
2-2	5-24-73	14x64	Mobile	Load	Front	Ohio	Two-Lane/Multilane
2-3	6-4-73	14x70	Mobile	Load	Front	Ohio	Two-Lane/Multilane
2-4	6-7-73	12x44	a/	Cab	None	Ohio/Indiana/Illinois	Two-Lane
2-5	6-14-73	12x65	Mobile	Cab	Front/None	Tennessee	Two-Lane
2-6	6-14-73	12x52	Mobile	Cab	Front/None	Kentucky/Tennessee	Two-Lane
2-7	6-19-73	10x40	Mobile	Cab	None	Tennessee	Two-Lane
2-8	6-20-73	12x60	Mobile	Load	None	Tennessee/Missouri	Two-Lane/Multilane
2-9	6-22-73	12x52	Mobile	Front Escort	Front	Tennessee	Two-Lane
2-10	6-26-73	12x65	Modular	Load	Front	Maine	Two-Lane
2-11	6-26-73	12x48	Modular	Load	Front/Rear	Maine	Two-Lane/Multilane
2-12	6-28-73	14x48	Modular	Load	Front & Rear	Maine/New Hampshire	Two-Lane/Multilane
2-13	6-29-73	12x65	Modular	Front Escort	Front	Maine	Two-Lane
2-14	7-2-73	12x40	Modular	Load	Front/Rear	Maine	Two-Lane/Multilane
2-15	7-5-73	12x40	Modular	Load	Front	Maine	Two-Lane
2-16	7-11-73	12x65	Mobile	Load	None	Tennessee/Kentucky	Two-Lane/Multilane
2-17	7-12-73	12x65	Mobile	Load	None	Tennessee	Two-Lane/Multilane
2-19	7-17-73	12x52	Mobile	Load	None	Tennessee/Kentucky	Two-Lane/Multilane
2-20	7-18-73	12x60	Mobile	Load	None	Tennessee/Kentucky	Two-Lane/Multilane
2-21	7-18-73	12x65	Mobile	Load	Front/None	Kentucky/Tennessee	Two-Lane/Multilane
2-22	7-19-73	12x60	Mobile	Load	None	Tennessee	Two-Lane/Multilane
2-23	7-20-73	12x65	Mobile	Load	None	Tennessee/Kentucky	Two-Lane/Multilane
2-24	7-25-73	12x65	Mobile	Cab	None	Michigan	Two-Lane
2-25	7-25-73	None	b/	Car	None	Michigan	Two-Lane
2-26	7-26-73	14x70	Mobile	Load	Rear	Michigan	Two-Lane/Multilane
2-27	7-27-73	12x60	a/	Cab	None	Michigan	Two-Lane
2-28	7-30-73	12x60	Modular	Cab	None	Michigan	Two-Lane
2-29	7-31-73	12x60	Modular	Load	Rear	Michigan	Two-Lane/Multilane
2-30	8-1-73	12x60	a/	Load	None	Michigan/Ohio	Two-Lane/Multilane
2-31	8-3-73	14x70	Mobile	Cab	Rear	Michigan	Two-Lane
2-32	8-6-73	12x54	Modular	Load	None	Michigan	Two-Lane/Multilane
2-33	8-7-73	14x70	Mobile	Rear Escort	Rear	Michigan	Two-Lane/Multilane
2-34	8-8-73	12x55	Modular	Load	None	Michigan	Two-Lane
2-35	8-9-73	12x54	Modular	Load	None	Michigan	Two-Lane/Multilane
2-36	8-10-73	14x70	Mobile	Cab	Rear	Michigan	Two-Lane

a/ Double-wide mobile
b/ Comparative data collected from automobile
c/ Divisible modular--71 ft in overall length (load plus trailer)

The reduced data were then analyzed. Measures relating to risk, traffic safety, and inconvenience were developed. Values of these measures obtained under various traffic conditions corresponding to a number of differing state regulations were compared. These comparisons are presented and discussed in this section.

Cost implications were also deduced from the data collected in this task. Section IV contains these analyses and results.

The data collection and reduction activities are summarized below and described in detail in Appendix D.

A. Data Collection

Two kinds of data were collected--time lapse photographs of traffic in the vicinity of the wide loads and counts of traffic events over timed intervals.

The photographic data collection was made possible through the cooperation of manufacturers and contract carriers. MRI 16 mm cameras were used, modified for this special application. Photographing was alternately conducted from inside the wide load, from the tractor cab and from escort vehicles. Generally, one mode was employed throughout a complete trip. A log of filmed sequences was kept for correlation with the developed film.

The second category of data was obtained by counting and recording occurrences of passing and queuing. These data were collected alternately with the photographic data when the photographer was riding inside the wide load. The counts were made over 1-min intervals and recorded on specially prepared data forms.

B. Data Reduction

The reduction of the photographic data was structured around the fact that the basic information sought from the film was the speed-distance profiles of vehicles approaching and passing the wide load from behind (overtakers) and from the front (oncomers). Distance and speed can be determined from the image size (or change in size from frame to frame) of known vehicle dimensions such as headlight spacing, tread width (tire spacing, center-to-center), etc. Data reduction therefore consisted primarily in the measurement of projected image dimensions and the recording of supplemental identifiers required for the calculation of distance and speed.

Measurements were also made which enabled estimation of lane width and lateral placement of oncomers. The data taken from the film were keypunched to facilitate computation.

Speed-distance profiles were calculated using formulas derived from basic optical relationships. Knowledge was required of vehicle dimensional data such as tread width, etc. A table of dimensions was assembled from information in several publications, unpublished data from manufacturers and field measurements.

The manually recorded data on passing and queuing were reduced by summarizing on special forms, coding and keypunching for computer processing.

C. Measures Related to Traffic Safety

The photographic and manual observations performed in this task served two purposes. One purpose was to provide basic data from which costs to the motorists in terms of incremental operating expense and delay could be determined. The results of these determinations are discussed in Section IV. The other purpose was to determine what other motorists did in the vicinity of wide loads which might have safety implications. The latter is the subject of this portion of the report.

When a motorist comes into proximity with another vehicle he must generally perform some manuever as a result of the other vehicle's presence. This means that some work load, with some degree of discomfort, is imposed on the driver. In addition, the parameters describing the manuever may be used as measures of its relative safety. This technique has been followed in this study to compare the relative safety of a number of situations, such as 12-wide vs 14-wide movements, movements with or without escorts or flashing lights, the speed of movements of the load, etc. Additional information relating to safety is given in Section VI of this report, concerning obviously hazardous situations or incidents encountered.

This discussion is divided into three parts, based upon the three most commonly encountered manuevers of other drivers. These are: (a) overtaking the wide load on a multilane highway followed by a lane change and flying pass; (b) overtaking on a two-lane road, including a deceleration prior to forming a queue; and (c) coming upon a wide load movement from the front, slowing, and possibly giving way to the right. Additionally, a separate presentation is given of queuing on two-lane highways.

1. Overtaking on multilane highways: As a driver approaches a slower one in the same lane on a multilane highway he will make a decision whether to slow and follow that vehicle or to change lanes and pass it. At a given relative speed, the closer the overtaking vehicle approaches before making that decision, the more hazardous the situation. This was our philosophy in analyzing such manuevers.

The film sequences gathered from the rear of a wide load on multilane highways from 13 trips were reviewed. The vast majority of all motorists approaching from the rear made a lane change with relatively small speed adjustments rather than forming a queue. For purposes of the ensuing calculations we dropped from further consideration certain situations. These included vehicles which slowed and then exited, vehicles which were obviously constrained from making a lane change by traffic in the adjacent lane, and situations where the wide load itself made a lane change. Because of the smaller sample sizes, and the differences in driving techniques they display, trucks were not considered for these analyses.*

Of course, it is not possible to ascertain by observation when a motorist first becomes aware of a wide load. However, it is possible to tell when he reacts to its presence. Because it was the common reaction, lane changing was selected as the indicator of reaction on multilane highways. From the filmed data the position, relative speed, and absolute speed of the lane-changing vehicle were determined as its right front tire crossed the center line.

From these quantities two measures of relative criticality of the situation at that instant were calculated. The first of these was the time remaining before the overtaking vehicle would collide with the wide load if it maintained its present speed and did not change lanes. This closure time, T, is given by:

$$T = 0.682x/\Delta v \tag{1}$$

where x is the separation in feet and Δv is the speed differential in miles/hr. The numerical factor provides that T will have units of seconds.

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* Overtaking trucks tend to stay right longer than passenger vehicles and are also slower to reduce speed. Therefore, it was considered inappropriate to mix trucks with passenger vehicles in an analysis of the safety aspects of overtaking.

The second measure is the deceleration which would be required of the overtaker if a certain critical event were to occur. That critical event would be a sudden maximum deceleration by the wide load. Because of its size, the wide load would prevent the overtaking motorist from observing hazardous situations ahead. Hence, it is reasonable to assume that such a sudden deceleration would probably occur without warning to the overtaker. Assuming the wide load deceleration capability is 20 ft/sec^2, the critical event deceleration required of the overtaker to avoid impact is given by:

$$D = \frac{20 v_c^2}{v_L^2 + 18.595\, x} \qquad (2)$$

where v_c and v_L are the speeds of the car and wide load, respectively (miles per hour), and x is the separation between the two in feet. The numerical factors contain the wide load deceleration value and corrections for mixed units. No allowance was included in this formulation for driver perception and reaction time.*

In assessing the numerical results, the smaller values of closure time imply a higher criticality. On the other hand, large values of the critical event deceleration, D , are more hazardous. In fact, if D exceeds 20 ft/sec^2 the driver could not avoid collision unless he swerved to an adjacent lane or off the road.

Table III illustrates the results from a typical trip. This trip involved a 12 x 65 ft mobile home with an average speed of approximately 60 mph. The average time to overtake for these 17 vehicles was 12.3 sec with a standard deviation of 9.5. The most conservative manuever was performed by one of the drivers in film sequence 8, who changed lanes nearly 40 sec before overtaking. At the opposite extreme was one of the drivers in film sequence 16 who, at a relative speed of 12 mph closed to within 46 ft and 2.6 sec before vacating the lane. Approximately the same time remained for the driver in film sequence 10.

The average deceleration which would be required by these vehicles in the event of the emergency situation previously described was 15.2 ft/sec^2.

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* A third measure, the Time Sum, was also calculated. This measure, first used by St. John,[7/] is the time remaining for a driver to perceive, decide, and react by applying maximum (20 ft/sec^2) deceleration when faced with the critical event described here. The Time Sum displayed the same information as D, so is not discussed further.

TABLE III

SAMPLE CONFLICT DATA, MULTILANE HIGHWAY

TRIP 2 - 21 | 12 x 65 Mobile Home | Average Speed 60 mph

Film Sequence	Distance at Lane Change (ft)	Speed of Wide Load (mph)	Speed of Overtaker (mph)	Relative Speed (mph)	Time to Overtake (sec)	Emergency Deceleration (ft/sec^2)
5	630	57	89	32	13.4	10.6
6	585	65	86	21	19.0	9.8
8	580	65	75	10	39.5	7.5
10	92	60	83	23	2.7	25.9
11	155	58	74	16	6.6	17.5
13	150	66	71	5	20.5	14.1
15	515	53	79	26	13.5	10.1
16	473	62	76	14	23.0	9.1
17	200	55	78	23	5.9	18.0
18	140	57	69	12	8.0	16.3
19	145	55	76	21	4.7	20.2
19	300	55	79	24	8.5	14.5
8	110	62	74	12	6.2	18.6
21	260	48	70	22	8.1	13.7
7	180	53	71	18	6.8	16.4
12	170	63	69	6	19.3	13.4
16	46	60	72	12	2.6	23.3
			AVERAGE		12.3	15.2
			S. DEV.		9.5	5.1
17 SAMPLES			SUM SQUARES		4010.8	4359.7

Several of the vehicles would have had to swerve to avoid collision. There is a general tendency for the vehicles with low overtaking times to have high required decelerations, although the correlation is not perfect.

The results of all 13 trips are summarized in Table IV. In addition to parameters descriptive of the trip, the number of samples and the average times and decelerations are given. Also, the number of vehicles which would require decelerations in excess of 15 ft/sec^2 and the number of vehicles which would require decelerations in excess of 20 ft/sec^2 are given. Clearly, there are differences from trip to trip in the tabulated results. Statistical tests are applied to assess the significance of the differences.

A one-way analysis of variance of the 13 trips was applied. An F statistic, F(12,156) of 1.20 was obtained from the T-data, and the D-data yielded 1.28. Neither of these are significant. Therefore, a series of Student t tests were used to compare the mean times and decelerations, to obtain maximum discrimination. To examine the fraction of vehicles needing large decelerations, Chi-square analyses were performed when the sample size warranted. Otherwise, the Fisher exact probability test was used.

First, trips 1-1 and 2-30 were compared to determine if the two, presumably similar trips, gave the same results. No significant differences between the two could be found. Then other comparisons were made, attempting to distinguish certain effects. The potential effects examined included the speed of the wide load, the width of the wide load, the effect of amber warning flashers on 12-wides and on 14-wides, the escort vehicle compared to a wide load, and a divisible load compared to similar but nondivisible loads. In summary, trends were found but none were statistically significant, even at the 0.10 level. The trends were intuitively meaningful, however, and therefore deserve mention.

There was a trend, which was not pronounced, for the closure times to be slightly larger at the point of lane change when the wide load was moving faster. This is to be expected because the closure speeds would be less when the wide load is moving faster.

There was a slight indication, based on the six observations of trip 1-10, that the use of special amber warning flashers resulted in larger (safer) closure times. This trend was not borne out by the trips involving 14-wides.

No trends could be observed between 14-wide and 12-wide movements.

There were two trips which yielded results that were almost significantly different from the others. These two trips deserve further discussion. One of these was trip 1-25 involving a 12-wide divisible load.

TABLE IV

SUMMARY OF CONFLICT DATA FOR MULTILANE HIGHWAYS

Trip	Load Width	Average Load Speed	Signing[a]	Sample Size, N	$\overline{T}$ Sec[c]	$\overline{D}$ ft/sec^2 [c]	N_{15} [c]	N_{20} [c]
1-1	12	47	Plain	26	9.8	13.7	10	1
1-9	12	52	Plain	3	5.1	20.5	2	2
1-10	12	58	Special	6	16.4	14.4	2	1
1-12	Escort	45	Special	24	12.5	14.8	11	6
1-24	14	54	Special	26	8.4	15.9	15	6
1-25	12[b]	43	Plain	17	7.8	14.9	9	2
2-1	14	45	Special	10	11.1	11.6	1	0
2-3	14	47	Special	6	9.8	13.0	2	0
2-20	12	61	Plain	6	10.2	15.1	3	0
2-21	12	60	Plain	17	12.3	15.2	8	3
2-30	12	47	Plain	21	11.4	13.0	7	1
2-32	12	44	Plain	2	12.6	8.6	0	0
2-33	14	46	Plain	5	9.6	12.4	0	0

a/ "Plain" signifies that only a sign and flags were displayed; "Special" indicates that amber warning flashers were also used.

b/ Divisible load.

c/ $\overline{T}$ = Sample average time to overtake.

$\overline{D}$ = Sample average emergency deceleration.

N_{15} = Number of emergency decelerations larger than 15 ft/sec^2.

N_{20} = Number of emergency decelerations larger than 20 ft/sec^2.

The average closure time for this trip was less than for other trips involving 12-wide loads. The t value was 1.62, not quite as great as the value, 1.67, required for significance at $\alpha = 0.10$. This trend was unexpected so further analysis was performed.

It was noted that the average speed for trip 1-25 was 43 mph, several miles per hour less than other trips for which substantial data were obtained. Believing this speed differential might be influencing the results, a second analysis was performed including only those filmed sequences from other comparable trips in which the wide load speed was under 50 mph. The resulting t value was 1.02, indicating that, indeed, the wide load speed had played a role.

Despite the lack of statistical significance, we were still intrigued as to why the average overtaker seemed to allow himself a slightly smaller time margin when approaching the divisible load as compared to other loads. Upon reexamining the conditions surrounding the divisible load trip, it was apparent that the overtaking motorists were confronted with an additional problem--the sun. This trip started at 7:30 in the morning and was headed due east. There were no clouds until midmorning when scattered light cloud cover was encountered. The trip ended prior to noon. The film clearly shows that nearly all overtaking motorists were driving with their sun visors down to block out the sun.

In summary, then, we are convinced that the apparent but not sigfificant difference in the closure times for motorists behind the divisible load was due to the slightly lower average speed of the load and the secondary influence of the morning sun, and was not due to inherent characteristics of the divisible load.

The other apparently different set of data could not be so easily explained. This set was from trip 1-12 in which the camera was located in a rear escort vehicle, not in the wide load. Since the escort vehicle was carrying amber flashing lights, we compared data for this trip with data from wide load trips where the wide load used amber flashing lights. The mean closure time behind the escort vehicle was over 3 sec greater than the average time behind 14-wide mobile homes, indicating that motorists reacted to the escort vehicle more quickly than to the wide loads. The value of t for this analysis was 1.65, again not quite as large as the value, 1.67, required for significance at $\alpha = 0.10$.

The variances in the two distributions of the overtaking times were determined to be significantly different, using an F test (the standard deviation for the escort was 11.5, compared to 4.3 for the comparable 14-wide loads). Under such conditions the t test is not appropriate.

Therefore, the data were analyzed using the Mann-Whitney test. The results again showed that there was no significant difference in the mean overtaking times.

Nevertheless, the trend indicates that there might have been a difference. We believe such a difference can be rationalized. The rationale concerns the use of flashing amber lights. As discussed in Section VIII, the special lights used on wide loads have relatively low visibility under daylight conditions. They are rated, generally, at 50 candlepower and are not highly effective.

On the other hand, the revolving beacons on escort vehicles apparently are effective (the escort vehicle on trip 1-12 carried such a high intensity unit, typically rated at 35,000 candlepower or more, flanked by two of the standard 50 candlepower flashers). Since the escort vehicle, an automobile, is inherently less conspicuous than a 12- or 14-wide load, we must attribute the motorists' early reaction not to the escort vehicle, but to the light it carried.

2. Overtaking on two-lane roads: Safety-related measures used for overtaking on two-lane roads were very similar to those used for multilane roads. Again, we observed motorists overtaking from the rear, to determine at what point they took some action in response to the wide load.

Contrary to their behavior on multilane highways, however, driver response on two-lane roads is generally a deceleration preparatory to forming or joining a queue. A far rarer action is a lane change preparatory to making a flying pass. Therefore, for this analysis we selected the point in the vehicle trajectory at which a speed reduction was obvious. This usually meant a speed change of approximately 3-4 mph from the vehicle's earlier, free speed.

Again, we dropped trucks from further consideration in this analysis. We included only those vehicles which slowed, apparently in response solely to the wide load. That is, we discarded sequences in which a vehicle slowed and then turned off the highway, vehicles which may have slowed because of intervening vehicles in queue behind the wide load* or vehicles which did not display a stable free speed because, for example, they had just entered the highway or just passed another vehicle.

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* Vehicles which slowed to join a queue were not included because our purpose was to examine the direct interaction of vehicles with the wide load and its attributes. The temporal growth of queues is of course, safety-related but it is a common traffic phenomenon, not uniquely associated with wide load movements, and should be independently studied.

The number of usable samples was not as large as would be desired. The overwhelming reason for this shortage is that the event in question is a relatively rare event. The frequency with which one vehicle overtakes another isolated vehicle is not as common as one might first expect. If the wide load is able to travel at a moderate speed of, say, 45-50 mph and traffic densities are light, then the time between overtakings of vehicles traveling at 60-65 mph is quite large (it was not uncommon that we would observe 20-30 oncoming vehicles between overtakings). At the other extreme, if traffic densities are heavy or if the wide load speed is slow, then there is almost always a queue behind the wide load. (In fact, there was, on the average, a queue of one or more vehicles behind the wide load over half the time, as discussed later.) Our observations suggest that most wide load drivers reacted to long queues by pulling over when possible to allow the queue to pass by. But, we often observed a single vehicle or two which would choose to follow at a distance behind the wide load rather than pass it, although other motorists would, after assessing the situation, pass both the wide load and its followers. We commonly observed isolated drivers content to follow for 1/4 hr or more.

Despite the problems we did have enough usable data to perform some analyses. In the analyses we computed, as before, the closure time at constant speed and the deceleration required to avoid collision in the afore-described critical situation. However, the results from the multi-lane cases and the two-lane cases are not comparable because the manuevers involved are different.

Table V displays typical results from these analyses. As was often done, we grouped data from several like trips to acquire larger sample sizes. In this instance data from five trips were aggregated, all of which involved a 12 x 60 ft mobile home with plain signing* and an average speed in the mid-upper 40's. For these vehicles the average closure time at point of speed change was 10 sec, while the average critical event deceleration was 13.1 ft/sec^2. There is no misprint concerning the vehicle in sequence 6 of trip 1-04. The data clearly show it was traveling at 106 mph on the two-lane road.

The findings are summarized in Table VI. There are apparently several differences in overtaking times between groups. Due to the small sample sizes and the high variances, however, most of these differences were not significant. Nonetheless, the trends were all in the directions that logic would dictate and deserve further discussion.

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* No flashing lights.

TABLE V

SAMPLE CONFLICT DATA, TWO-LANE HIGHWAY

12 x 60 Mobile Home — Plain Signing — Average Speed 47 mph

Trip	Film Sequence	Distance at Speed Change (ft)	Speed of Wide Load (mph)	Speed of Overtaker (mph)	Relative Speed (mph)	Time to Overtake (sec)	Emergency Deceleration (ft/sec^2)
1-02	17	200	47	66	19	7.2	14.7
1-02	21	220	49	65	16	9.4	13.0
1-02	28	330	48	63	15	15.0	9.4
1-02	29	150	50	64	14	7.3	15.5
1-02	23	200	45	64	19	7.2	14.3
1-04	1	320	50	68	18	12.1	10.9
1-04	6	400	45	106	61	4.5	23.7
2-08	14	390	56	79	23	11.6	12.0
2-08	16	350	42	63	21	11.4	9.6
2-19	5	200	45	60	15	9.1	12.5
2-20	2	287	40	53	13	15.1	8.1
				AVERAGE		10.0	13.1
				S. DEV.		3.4	4.2
	11 SAMPLES			SUM SQUARES		1208.1	2060.0

TABLE VI

SUMMARY OF CONFLICT DATA FOR TWO-LANE HIGHWAYS

Group	Load Size	Load Type	Average Load Speed	Signing a/	Sample Size N	$\bar{\bar{T}}$ b/ sec	$\bar{\bar{D}}$ b/ ft/sec^2	N_{15} b/	N_{20} b/
1	12x54	Modular	44	Plain	13	11.4	10.7	0	0
2	12x60	Mobile	47	Plain	11	10.0	13.1	1	1
3	12x44	Mobile	50	Special	13	13.2	12.3	3	0
4	14x70	Mobile	58	Special	4	17.7	12.1	1	1
5	--	Car	50	None	6	11.9	13.3	1	1
6	--	Escort	37	Special	5	16.8	9.4	0	0
7	14x64	Mobile	45	Special	3	14.2	11.4	0	0
8	12x65	Mobile	58	Plain	2	25.2	10.6	0	0

a/ "Plain" signifies that only a sign and flags were displayed; "Special" indicates that amber warning flashers were also used.

b/ $\bar{\bar{T}}$ = Sample average time to overtake.

$\bar{\bar{D}}$ = Sample average emergency deceleration.

N_{15}= Number of emergency decelerations larger than 15 ft/sec^2.

N_{20}= Number of emergency decelerations larger than 20 ft/sec^2.

The trips in Group 3 were compared with the trips of Groups 1 and 2, which were combined because the differences in their overtaking times were small and insignificant. (That is, we could detect no difference in the closure times behind modular homes compared with mobile homes.) The overtaking times for Group 3 were somewhat larger. This could have occurred because of the special signing (flashing lights) or the somewhat higher speeds. Either factor could logically result in this trend although, as discussed previously, we tend to discount any large effects due to the flashers. The trips of Group 4 were compared with a subset of Group 3, comprised of the higher load speed sequences. This was done to attempt to remove any speed effect and concentrate on a mobile home width effect. No significant effect was observed although, on the average, overtaking vehicles tended to react with a greater time margin to the 14-wide home than to the 12-wide home.

Group 5 was comprised of observations made from an unmarked automobile. Apparently, overtaking motorists reacted to it no sooner nor later than they would a wide load. The situation was different with Group 6, however. In this instance the automobile was an escort vehicle carrying a high intensity rotating beacon. Despite its low speed, which in itself would lead one to expect low closure times, the escort vehicle caused overtakers to react sooner, resulting in high closure times compared to a wide load. Unfortunately, no data are available for a wide load with a high intensity rotating beacon mounted to the rear.

Finally, two observations of overtaking times were made from a relatively high speed 12-wide mobile home with no special lights. The two observations were nearly identical. The lack of variance and the high average combined to indicate that these sequences were significantly different at the 0.01 confidence level. Examination of the data showed that the overtaking vehicles in this group did not react at unusually large distances from the mobile home--the large closure times resulted from the low relative velocities.

In general, the critical event decelerations differed less from one another than did the closure times. The two exceptions were Group 2 and Group 6. In fact, the difference between Groups 1 and 2, as measured by the average critical event deceleration, was marginally significant ($\alpha = 0.10$). However, this significance is lost if the "outlier" in Group 2 is removed. It is the vehicle with the 106 mph speed.

The low decelerations in Group 6, although not significant, may be real. Low decelerations would be expected if, indeed, overtaking drivers saw and reacted to the high intensity flashing beacon on the escort vehicle.

3. Oncoming traffic on two-lane highways: Approaching and passing a wide load from the front by oncoming traffic constitutes a potentially hazardous situation. To analyze these maneuvers, we used as measures of criticality the speed of the oncomer at meeting, the lateral placement of the oncomer, and usage of the shoulder. It is implicitly assumed that increased hazard accompanies higher meeting speeds, smaller lateral displacement relative to the highway center, and sustained use of the shoulder. In addition, use of the shoulder could have meaning regarding highway maintenance expenses.

The photographic data include a variety of configurations. The configurations and the results are summarized in Table VII for passenger/pickup class vehicles and in Table VIII for trucks. The following definitions apply to the items in the tables:

- Load speed - average speed of wide load or other vehicle from which data were collected;
- Final speed - average speed of oncomers at meeting;
- Lateral displacement - average distance from highway center line to outside edge of left front tire of oncoming vehicle, if a car or a pickup, and to outside edge of left rear tire if a truck;* and
- Pavement margin - average remaining lane width available to oncoming vehicles, the distance from outside edge of oncomer lane to outside edge of right front tire of oncomer (right rear tire for trucks).

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* Lateral displacement was measured in the photographic frame of closest approach, i.e., when the oncomer was near the tractor cab or other vehicle housing the camera. It would also have been interesting to determine lateral displacement as a function of approach distance to determine when the oncomer moved laterally and his rate of displacement. This was not done for several reasons: the safety implications of the former are not known; no extreme rates of lateral displacement were observed; the necessary requirements to make such determinations (entire vehicle, road, and centerline must be clearly visible in the photographic frame) often were not met due to intervening vehicles, curvature; indistinct striping; etc.; and fund and time constraints dictated that efforts be expended in more productive activity.

TABLE VII

SPEED AND LANE POSITION OF ONCOMING TRAFFIC
(Passenger and Pickup)

Trip[a]	House	Escort	Camera Location	Load Speed (mph)	Final Speed (mph)	Lane Width (ft)	Lateral Displacement (ft)	Pavement Margin (ft)	Percent Encroachment[c]
1-11 (15)	14x60	Both	Front Escort	60	53	12	6.02	0.48	40
(9)	Mobile			60	66	12[b]	5.17	1.01	11
1-20 (31)	14x64 Mobile	Front	Cab	47	43	12	5.33	0.77	26
1-21 (7)	None	None	Car	52	64	14	3.59	4.63	0
(15)				52	64	10	2.44	1.80	0
1-22 (4)	12x60	Front	Cab	46	51	10	3.95	0.11	75
(10)	Double Wide			46	50	12	4.09	2.17	0
(13)				56	66	14	5.11	3.17	0
2-5 (13)	12x65 Mobile	Front and None	Cab	47	52	10	4.05	0.44	31
2-6 (7)	12x52 Mobile	Front and None	Cab	38	52	10	4.09	0.00	57
2-9 (10)	12x52	Front	Front Escort	53	46	10	2.96	0.99	10
(20)	Mobile			53	55	11	2.94	2.24	0
(12)				58	57	12	3.36	2.77	0
2-13 (7)	12x50	Front	Front Escort	47	44	10	4.34	0.11	29
(2)	Modular			49	48	12	4.65	1.33	0
(2)				47	38	14	5.20	3.23	0
2-24 (6)	12x65	None	Cab	47	53	10	3.47	0.53	16
(19)	Mobile			47	60	11	3.81	1.34	5
2-25 (2)	None	None	Car	51	56	10	3.45	0.74	50
(8)				51	65	11	4.03	1.36	12
(5)				51	57	12	4.20	2.12	0
2-27 (29)	12x60 Double Wide	None	Cab	46	55	12	4.28	1.98	0
2-36 (23)	14x70 Mobile	Rear	Cab	46	63	10	4.48	-0.29	65

a/ Number in parenthesis is sample size.
b/ Poorer quality of shoulder for this sample.
c/ Percent of vehicles in sample which encroached on the shoulder.

TABLE VIII

SPEED AND LANE POSITION OF ONCOMING TRAFFIC
(Trucks)

Trip[a]	House	Escort	Camera Location	Load Speed (mph)	Final Speed (mph)	Lane Width (ft)	Lateral Displacement (ft)	Pavement Margin (ft)	Percent Encroachment[b]
1-11 (1)	14x60 Mobile	Both	Front Escort	59	66	12	1.37	2.63	0
1-20 (6)	14x64 Mobile	Front	Cab	45	44	12	3.97	0.03	33
1-21 (2)	None	None	Car	53	52	14	2.70	3.30	0
1-22 (4)	12x60	Front	Cab	44	52	12	3.66	0.34	25
(2)	Double Wide			44	52	14	5.10	0.90	50
2-5 (3)	12x65 Mobile	Front and None	Cab	52	53	10	2.27	-0.27	67
2-6 (2)	12x52 Mobile	Front and None	Cab	50	58	10	2.28	-0.28	50
2-9 (9)	12x52	Front	Front Escort	52	37	11	1.65	1.35	0
(1)	Mobile			57	66	12	1.97	2.03	0
2-13 (0)	--	--	--	--	--	--	--	--	--
2-24 (2)	12x65 Mobile	None	Cab	43	54	11	1.79	1.21	0
2-25 (2)	None	None	Car	53	52	11	3.44	-0.44	50
2-27 (3)	12x60 Double Wide	None	Cab	45	52	12	3.16	0.64	33
2-36 (13)	14x70 Mobile	Rear	Cab	47	55	10	3.26	-1.26	100

a/ Number in parenthesis is sample size.
b/ Percent of vehicles in sample which encroached on shoulder.

The lateral displacement of a passenger or pickup vehicle was obtained directly from the films; the pavement margin was calculated by subtracting the lateral displacement, the tread width and the tire width from the lane width.* For trucks the lateral displacement and pavement margin were calculated in a similar fashion by measuring, from film, the right front tire location and knowing the lane width, the front tire tread width, the tire width* and the truck width (8 ft). Note that if the pavement margin is zero in Tables VII and VIII, the outside tire is on the highway but immediately adjacent to the shoulder.

The data summarized in the tables show that, among other things, there is a large amount of variation between similar trips. That is, the speeds and displacements can be quite different even though the load width and lane width are the same. There could be many causes for this, such as geographical differences between drivers, differences in the quality of the shoulders, or differences in the way that the wide load is being driven.

To assist in the interpretation of the data, Figure 2 was prepared. This figure shows the lateral displacement data from Table VII. Also included in the figure are two reference values (U and B). The first of these is the lateral displacement for passenger vehicles unimpeded or uninfluenced by any other traffic.[8/] These unimpeded vehicles tended to position themselves, on the average, 5 in. to the left of the center of their 12-1/2 ft lane. The standard deviation of these measurements was also about 5 in. The other reference data are from Weir and Sihilling.[9/] These data pertain to passenger vehicles passing intercity buses that are 8 ft and 8-1/2 ft in width. The buses were traveling at highway speeds in the center of their lane. (Other data, not shown, were obtained when the bus traveled on the right side of its lane.)

The data in Tables VII and VIII and in Figure 2 indicate several informative trends. The results were analyzed for statistically significant characteristics. All features discussed were significant at the 0.05 level or better.

a. <u>Lateral displacement and speed</u>: As noted earlier, we view reduction of lateral displacement and/or increase in oncomer speed as implications of increased hazard. The data for oncoming traffic were therefore examined for the effects of load width and lane width on speed and lateral displacement. Distinction is made between passenger vehicles (which includes pickups) and large trucks.

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* Average tire widths of 8 in. and 10 in., respectively, were assumed for passenger (or pickup) vehicles and trucks.

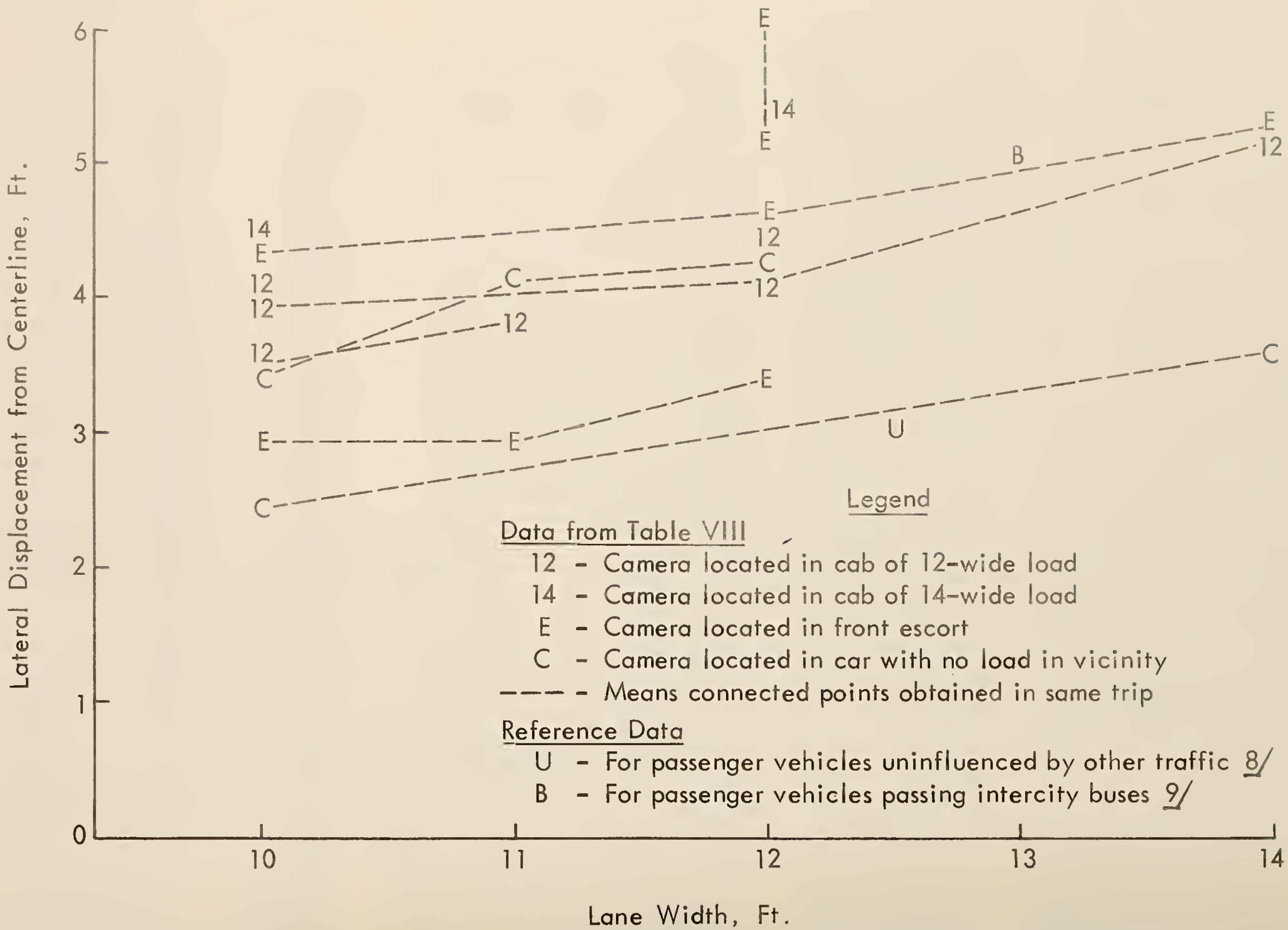

Figure 2 - Oncoming Vehicle Placements When Passing Other Vehicles

For 12-wide loads the lateral displacement of passenger vehicles did not vary significantly on lanes 12 ft wide and less but was larger on 14-ft lanes. For 14-wide loads lateral displacement was smaller on 10-ft lanes than on 12-ft lanes (there are no data for 14-ft lanes). The relative insensitivity to lane width in the case of the 12-wide loads is probably explained by the fact that oncomer speeds were lower on the narrower lanes. Apparently, the reduced lateral clearance available on narrow lanes and proximity to the shoulder leads to reduced speeds.

The association between speed and available lateral clearance indicated in the data for varied lane width is also seen in the data obtained for varied load widths on 10-ft lanes. The lateral displacement of oncomers was largest when meeting 14-wide loads, next largest for 12-wide loads and smallest for oncomers meeting other passenger vehicles. At the same time, oncomer speeds were smaller at meeting with 12-wide loads than with passenger vehicles. Inexplicably, oncomer speeds were highest on trip 2-36 involving a 14-wide.

In agreement with the above results for 10-ft lanes, on 12-ft lanes lateral displacement was greater for vehicles meeting 14-wides than for vehicles meeting 12-wides.

The presence of a front escort did not significantly affect lateral displacement and speed for passenger vehicles meeting 12-wide loads on 10-ft lanes. These findings were derived from trips in which sight distances were moderate to above average and the escort was 800 to 1,000 ft in front of the wide load. Under these conditions, drivers have plenty of time, even in the absence of an alerting escort, to adjust their lane position and speed to accommodate the wide load. Therefore, it appears that in these circumstances the front escorts produce no measurable benefits. Insufficient data exist concerning 14-wides without escorts, so the effects of escorts in this instance cannot be obtained.

Comparison was made between passenger vehicles and trucks. For 14-wides on a 10-ft lane, passenger and pickup oncomers met the wide load with higher speeds and larger lateral displacements than did trucks. Similar findings were obtained for 12-wides on 11-ft lanes. Sample sizes for the truck were too small to permit findings of significance for other load width-lane width combinations. But, for the two cases mentioned, the observed behavior is probably, again, the result of a compromise between speed, lateral clearance, and shoulder proximity.

Surprisingly, aside from the 14-wides, some of the largest displacements were observed for oncomers passing an escort vehicle. The displacements were exceptionally large on trip 1-11, involving an escort ahead of a 14-wide, but were nearly as large on trip 2-13 in which the escort was leading a 12-wide load. The displacements were also quite large for the bus data reported in the literature.[9/]

In summary, it appears that drivers of vehicles approaching a wide load from the front choose a compromise between speed, clearance with the wide load and proximity to the shoulder. The amount of accommodation is greater for narrow lanes and wider loads, but for both 12- and 14-wide loads lane displacement and speed adjustments were made for the complete range of lane widths observed.

b. Use of shoulder: The pavement margins generally had more variance than did the lateral displacements, perhaps because of the added effect of variance in vehicle widths. Therefore, there were fewer findings with statistical significance concerning this measure.

For 12- and 14-wide loads on 10-ft lanes, oncoming trucks often pass with their rear wheels running partly on the shoulder. In fact, in trip 2-36, every one of the 13 trucks observed used some portion of the shoulder. There were also occasions when trucks used a portion of the shoulder passing cars or escort vehicles on 11- and 12-ft lanes.

On 10-ft lanes, passenger and pickup oncomers passing a 14-wide (trip 2-36) often had part or all of their right wheels on the shoulder (the pavement margin was -0.29 ft, indicating that perhaps 2-3 in. of the tire, on the average, were on the shoulder). Passenger oncomers frequently use the shoulder in passing 14-wide loads on 12-ft lanes or 12-wide loads on 10-ft lanes. An extreme instance was a vehicle in trip 1-11 which, at a speed of 60 mph, and when still 1,000 ft from the front escort, and despite the poorly paved and broken up shoulder, was running with the right edge of the vehicle 2 to 3 ft off the pavement.

No significant effect of the presence of front escort vehicles could be found on the usage of the shoulder by oncoming traffic.

4. Queuing observations: Although the time delay associated with queuing is included in the cost calculations in Section IV, the queue data are summarized separately here because queuing is of inherent interest. It is perhaps the most visible effect of wide loads on other traffic, particularly on two-lane highways. Also, queuing is probably the most annoying aspect of their movements, as far as motorists are concerned.

The queue data are summarized in Figure 3 in a normalized form, vehicle minutes/minute of travel of the wide load. These data were obtained by summing the observed times in queue for each trip and grouping them according to the average flow rate during the trip. Although the data are presented in terms of traffic flow rate, implications of the effect of flow rate must be viewed with reservation because there may be hidden effects of other significant parameters such as lane width, sight distance, wide load speed, etc. It does appear that queuing was more or less random on multilane highways and tended to increase with traffic flow on two-lane highways for the range of flow rates observed. Figure 3 conclusively shows that there was much more queuing on two-lane roads than on multilane, as one would expect.

On multilane highways multiple vehicle queuing was rarely observed and the histogram in Figure 3 therefore implies that on the average there was a vehicle in queue 4-5% of the time. On two-lane roads multiple vehicle queuing was common, but Figure 3 does not indicate how the queue lengths varied with time. The temporal character of queuing on two-lane highways is therefore presented in Table IX. The entries in the table are the percent of time the indicated number of vehicles were in queue. Table IX shows that on the average there was at least one vehicle in queue more than one-half the time (100% - 43%) and nearly one-quarter of the time there were three or more in queue (9% + 6% + 4% + 5%).

TABLE IX

QUEUE SIZE ON TWO-LANE ROADS AS A PERCENT OF TRAVEL TIME

Vehicle Type	Number of Vehicles in Queue[a/]						
	0	1	2	3	4	5	>5
Passenger	54	18	12	8	4	3	1
Pickup	80	15	5	0	0	0	0
Truck	83	15	2	0	0	0	0
All	43	16	17	9	6	4	5

a/ The interpretation is as follows: 54% of the time there were no passenger vehicles in queue, 18% of the time there was one, 12% of the time there were two. Also, 5% of the time there were more than five vehicles in a queue, but the mix is not defined. There could be five passenger vehicles and one or more pickups or trucks, four passenger vehicles and two or more pickups or trucks, etc.

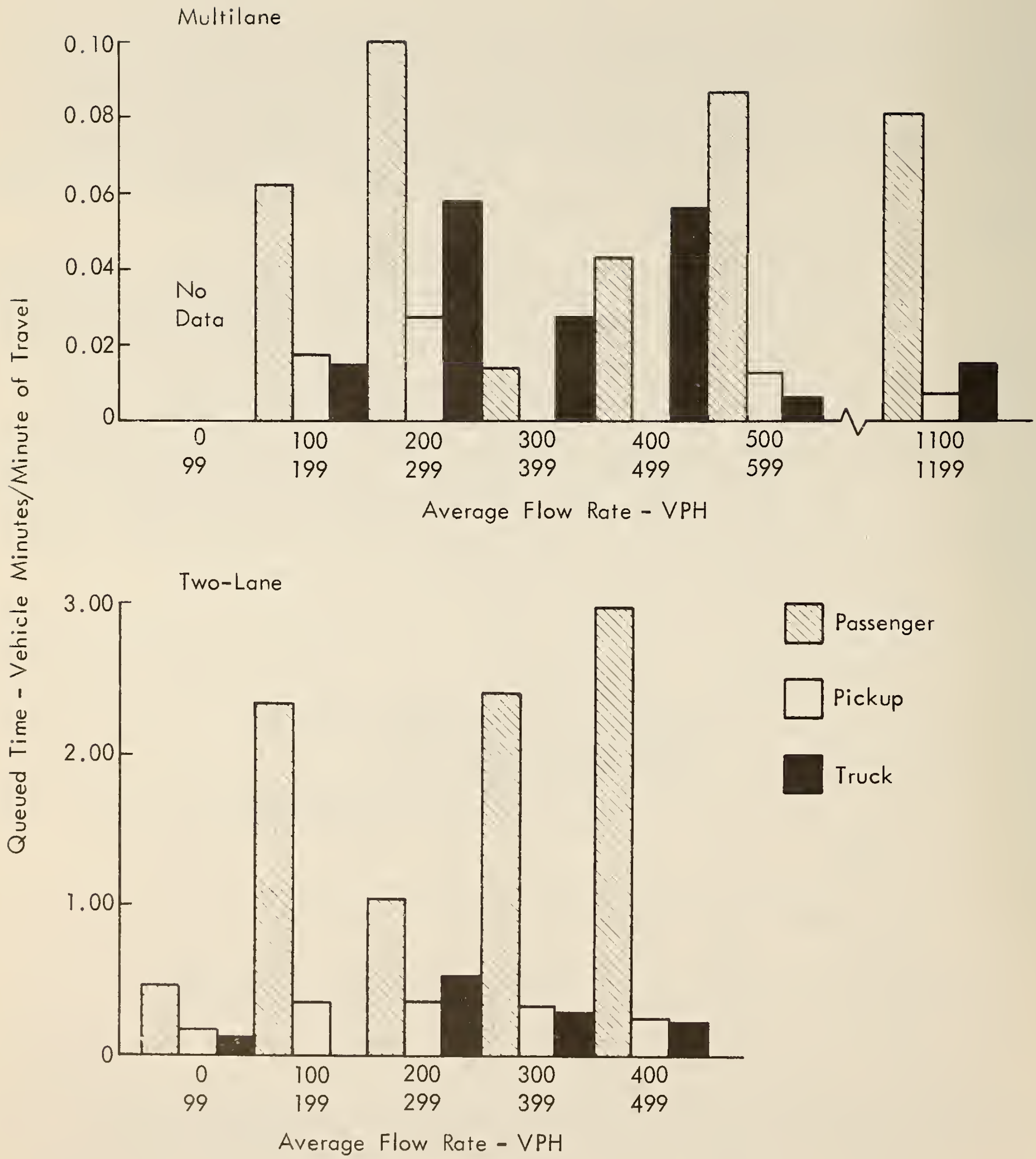

Figure 3 - Queuing on Multilane and Two-Lane Highways

The two-lane queuing data are displayed in another way in Table X. The data shown are for eight trips in which observations were made for at least three-fourths of an hour. Mean queue length is tabulated for comparison with speed, flow rate, load size, lane width and escort configuration. Speed was nearly the same for all trips and lane width did not vary, so the effect of these two parameters cannot be assessed. Mean queue length appears to increase with flow rate (first noted in Figure 3) and with load width. There is no obvious effect of load length or the presence of a front escort. Trip 2-26 suggests that a rear escort may have substantially increased the mean queue length. (In the field we sometimes observed fairly long queues behind rear escorts when they followed close to the wide load, forcing traffic to wait and pass the escort and load in one maneuver.)

The time spent in queue by individual vehicles is not directly available from the data. Some clues can be obtained by observing the continuity of the queue size and composition in conjunction with the record of passes made by queued vehicles. Indications are that for some trips is was not uncommon for a vehicle(s) to trail the wide load during the entire 15 min period of manual data recording. In one instance the photographer noted that the same car had been following for more than one-half hour.

D. Summary

After the filmed data were reduced and analyzed, a number of measures were defined and examined which are measures of relative risk or hazard. Despite the rather large amount of filmed data, the samples' sizes for individual combinations of parameters such as load width, speed, escort and signing configurations were not exceedingly large. Also, the habits of individual drivers vary greatly, so the variances in the measures on individual trips were large. Because of these two factors we were generally unable to establish with statistical confidence, differences in driver behavior as affected by various load parameters. However, there were a number of consistent trends observed which are both reasonable and important.

Overtakers on divided highways tended to react in a less hazardous manner if the wide load had a speed closer to their own. Overtaking motorists reacted most cautiously, not to a wide load, but to a rear escort vehicle carrying a very high intensity flashing beacon. The relatively low intensity flashers used on the rear of some wide loads were generally ineffective. No differences whatsoever could be noted with 14-wides carrying such flashers and only a slight tendency towards safer behavior with 12-wides carrying flashers. No trends could be observed between the approaches of motorists to 12-wide loads vs 14-wide loads.

TABLE X

MEAN QUEUE LENGTH ON TWO-LANE HIGHWAYS

Trip	Mean Queue Length* (veh)	Flow Rate (vph)	Average Speed (mph)	Load Size	Lane Width (ft)	Escorts Used
1-9	0.33	84	48	12 x 44	12	None
1-18	1.00	97	53	14 x 70	12	None
1-23	0.89	62	45	14 x 70	12	Front and Rear
1-24	1.24	95	45	14 x 64	12	None
2-14	3.76	352	43	12 x 40	12	Front
2-26	4.02	151	42	14 x 70	12	Rear
2-30	1.94	207	45	12 x 60	12	None
2-32	2.00	225	44	12 x 54	12	None

* Mean Queue length is equal to total vehicle-minutes of queuing divided by minutes of observation.

Overtaking traffic on two-lane highways demonstrated the same general trends as that on divided highways. The measures of risk indicated that the safer approaches were made when the wide load had a higher speed. Motorists also approached 14-wide loads more cautiously than 12-wide loads. They also tended to approach escort vehicles with high intensity beacons very cautiously. However, no difference could be found in motorists' approaches to wide loads as opposed to their approaches to a normal automobile traveling at wide load speeds. Neither could any trends be found between modular and mobile movements. One finding did have statistical significance. Although the sample size was small, a load traveling at 58 mph elicited responses from overtakers which yielded the highest margin of safety.

As opposed to the trends concerning overtakers, the findings regarding oncoming traffic were generally statistically significant. It was determined that the lateral displacement from the centerline of oncoming vehicles tends to increase as the lane width increases. Vehicles also tend to move further to the right for 14-wides than they do for 12-wides or for automobiles. No significant effect could be observed on motorists' lateral displacements passing a wide load that could be related to the presence or absence of a leading escort. However, motorists often tended to move to the right as they passed an escort vehicle, perhaps as much or more than in passing a wide load. Automobiles tend to move to the right further than trucks and to decrease their speed more than do trucks.

On 10-ft lanes, all trucks observed used some of the shoulder in approaching a 14-wide load. To a lesser extent trucks had a tendency to edge onto the shoulder in passing 12-wide loads on 10-ft lanes or 14-wide loads on 12-ft lanes. Putting this in proper prospective, however, trucks were also noticed to occasionally edge onto the shoulder in passing cars and escort vehicles on 11-ft lanes. They generally did not use the shoulder in passing 12-wide loads or escort vehicles on 12-ft lanes or greater. Passenger vehicles also tended to use part of the shoulder in passing a 14-wide load on a 10-ft lane, but not to do so otherwise. No effect could be found concerning shoulder usage which was related to the presence or absence of a leading escort.

Queuing behind a wide load on two-lane highways is a common phenomena, with one or more vehicles in queue over half the time. The queue length is dependent on traffic volume. Available data do not allow clear assessment of other variables on queue length, although the presence of a rear escort appears to enhance queuing.

III. MOTORIST OPINION AND ATTITUDE SURVEYS

A. Procedure

The intent of this task was to determine, in an unbiased fashion, the attitudes and opinions of the motoring public toward mobile homes. A carefully structured survey instrument was prepared and procedures developed to determine how the motorists compared mobile homes with other types of highway vehicles.

Interviews were conducted in six states--Oregon, Idaho, Nebraska, Indiana, New Hampshire, and Florida. In each state the interviewing was carried out in coordination with the appropriate state officials. In most states, the State Highway Department provided personnel, procedures, and materials for setting up the appropriate traffic control operations. A typical survey site is shown in Figure 4. In all cases the procedures recommended by the individual state were adhered to. Generally speaking, motorists were randomly selected from the traffic stream and flagged to an interview station. All types of vehicles were eligible for selection, including semis, motorcycles, etc.

The sites were selected in cooperation with the traffic engineers and permit officers of the states. The intent was to select highways which carried relatively high mobile home traffic. In that way we could maximize the possibility that the motorists being interviewed had recently passed a wide load. The selection of routes, therefore, was greatly enhanced by the knowledge of the state permit directors. The state traffic engineers assisted in locating sites on these routes where surveys could be carried out with a miminum of traffic interference and at maximum safety to the interviewing personnel and to the other traffic.

Interviews were conducted both on divided highways and on two-lane roads. Of the six states, divided highway interviews were carried out in all but Nebraska. And two-lane highway interviews were conducted in all of these states except Florida. The procedures for the interviews were modified in Florida to abide by their normal survey practices. In Florida, motorists were interviewed at Welcome Stations along the northern border. Thus, the motorists generally were heading into Florida from Georgia and Alabama. With the exception of Indiana, interviewing was carried out for 3 or 4 days in each state, with one site being used each day. In Indiana, the interviewing was limited to 2 days because of inclement weather on one day and a mobile home travel curfew on another day because of an impending holiday. Interviews were carried out, typically, from 9:00 a.m. until 3:00 p.m. over the period 7 August 1973 through 20 September 1973.

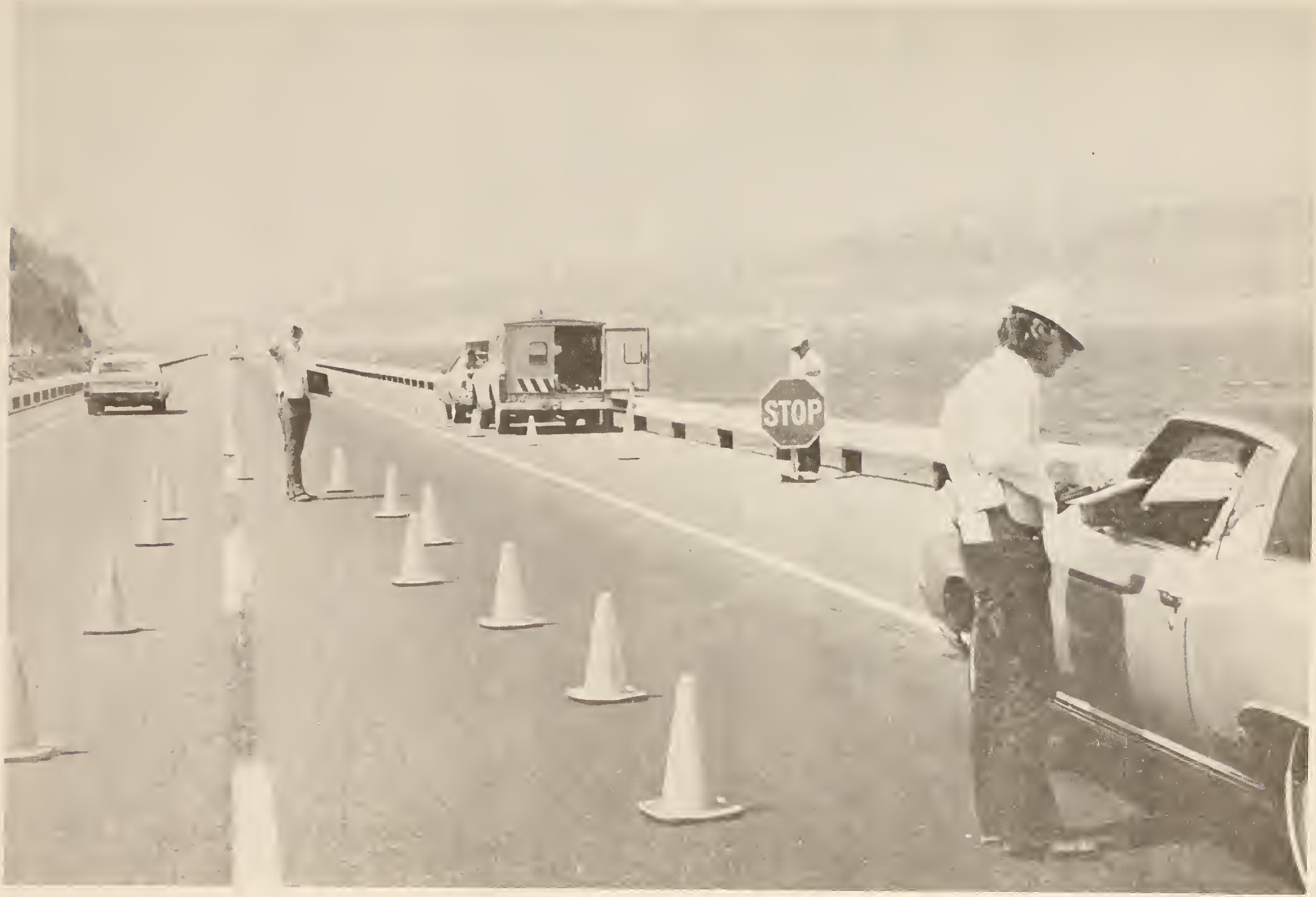

Figure 15 - Motorist Interview Station in Oregon

The survey instrument was developed in coordination with the Federal Highway Administration. A two-step interview technique was planned. Part A was a personal interview of the driver carried out on site. This interview typically required about 2 min to complete. Part B consisted of a mail-back questionnaire which the drivers were asked to complete and mail using a furnished, post-paid envelope. Figure 5 contains the questions asked in Part A. Figure 6 is the coding form used in the field while Figure 7 is a copy of the mail-back questionnaire. Appendix F contains a copy of the set of printed instructions given to the interviewers. These instructions contain most of the interview details and coding definitions. The survey teams also recorded the passage of wide loads on a "wide load log."

It is important in interpreting the results of the survey, to keep in mind the order in which the questions were asked. To begin with, the subject of mobile homes or wide loads is not mentioned. The driver does not know that this is the real interest in the survey. The first few questions simply establish information concerning the driver's experience. Then, Question 6 asks him if he has experienced delays on this trip and, if so, additional information concerning the delay is obtained. Similarly, Question 7 addresses the possibility of recently experienced safety hazards. In summary, then, Questions 6 and 7 relate to the actual experiences of the driver on the present trip.

Question 8 asks the motorist to generalize his driving experience and to name the type of vehicle which he considers a problem. Again, the interviewer has not yet mentioned the subject of wide loads or mobile homes. Finally, Question 9 of Part A of the survey is the one question specifically relating to wide loads. People are asked if they recall passing a wide load. Those who did are then asked pointedly whether it caused them any difficulty and, if so, why.

The mail-back portion of the survey was completed, of course, after the personal interview took place. Therefore, the responses to the mail-back survey could have been contaminated by the asking of Question 9. This type of contamination was unavoidable. The mail-back questionnaire, however, did not emphasize mobile homes.* It simply asked the respondent to select, from a series of choices, answers for a group of questions. One of the choices was "large mobile homes transported by trucks."

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* Others, such as the American Automobile Association, have conducted mail surveys and polls of opinions about mobile homes. Their results could be quite different than ours, depending on the survey instrument's emphasis on mobile homes, use of leading questions, etc.

3744-E(3) PERSONAL INTERVIEW

Good Morning! We are conducting a brief traffic survey for the Federal Highway Administration. Could you tell me--

1. Is this a business or non-business trip?
   (Possible answers--Business, Non-business)

2. About how long have you been driving today?
   (Less than an hour, 1 to 3 hours, More than 3 hours)

3. About how many miles per year do you drive?
   (Under 1,000, 1-3,000, 3-10,000, 10-20,000, more than 20,000)

4. Is most of your driving for business or non-business reasons?
   (Business, Non-business)

5. What kinds of roads do you drive most often? (Read answers!)
   (Local streets, Two-lane rural highways, High-speed freeways)

6. Have you encountered anything along the road today that has caused you any delay, even if only briefly?
   (Yes, No)
   a. (If yes) What was it?
   (Accident, Traffic congestion, Slow moving vehicle, Construction, Other (specify)
   b. (If slow vehicle) What type of vehicle was it?
   (Truck, Mobile home, Bus, Car, Other)

7. Have you encountered anything along the road today that you felt was a safety hazard?
   (Yes, No)
   a. (If yes) What was it?
   (Accident, Traffic congestion, Slow moving vehicle, Construction, Other (specify)
   b. (If slow vehicle) What type of vehicle was it?
   (Truck, Mobile home, Bus, Car, Other)

8. In general--not just on this trip--is there any particular type of vehicle which causes you problems in terms of delay or safety?
   (Truck, Mobile home, Bus, Car, Other)

9. Did you notice any wide loads such as mobile homes being transported on this trip?
   (Yes, No)
   a. (If yes) Was it moving in your direction?
   (Yes, No)
   b. (If yes) Did it (they) cause you any problems?
   (Yes, No)
   c. (If yes) Why did it cause you a problem?
   (Hard to see around, Moving too slow, Couldn't pass, Taking two lanes, Other (specify)

Thank you very much for helping us in this traffic safety survey. We would certainly appreciate your opinions on the traffic questions on this form. Please fill it out at your convenience and drop it in the mail. No postage is needed.

Figure 5 - Motorist Survey--Part A

Mo. - Day - Page

PERSONAL INTERVIEW - PART A

State__________ Route__________ Approx. Location______________ Type--2 Lane ☐ , 4-Lane ☐ , Unlim. Access Divided ☐ , Lim. Access Divided ☐

Lane Width__________ Shoulders--Paved ☐ , Unpaved ☐ , None ☐ ; Speed Limit__________ ; VPH, 1-Way__________ Interviewer ______________________

Number	Is This Trip		How Long Driving			Miles Per Year Drive					Most Driving		Kinds of Roads Driven Most Often (Read)						Any Delay Today		If No, → (If Yes) What					If Slow Veh., What Type					Safety Hazard Today		If No, → (If Yes) What					If Slow Veh., What Type					Gen'l, V. Type Causes Prob. Delay/Safety				
	Bus.	Nonbus.	< 1 Hr	1-3 Hr	> 3 Hr	< 1 K	1-3 K	3-10 K	10-20 K	> 20 K	Bus.	Nonbus.	Local	Streets	2 Lane	Rural	H. Spd.	F'wys	Yes	No	Acc't	Cong.	Slow Veh.	Const.	Other	Truck	M. Home	Bus	Car	Other	Yes	No	Acc't	Cong.	Slow Veh.	Const.	Other	Truck	M. Home	Bus	Car	Other	Truck	M. Home	Bus	Car	Other
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Number	Wide Load This Trip		If No, → (If Yes) Your Dir.?		(If Yes) Cause Prob.		(If Yes) Why					Observe: Sex		Observe: Age						Observe: Veh. Type					Time, Mil.	Estimate Later When Passed W.L.					Remarks
	Yes	No	Yes	No	Yes	No	Visib.	Slow	Pass	2 Lane	Other	M	F	1	2	3	4	5	6	Car	VW	PU	Truck	Semi		30 M	1 Hr	3 Hr	> 3 Hr	No	
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1																															
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															

Figure 6 - Coding Form--Part A

_____-_____-_____-_____
Site Code

MIDWEST RESEARCH INSTITUTE
Highway and Traffic Systems Engineering
425 Volker Boulevard
Kansas City, Missouri 64110

Form Approved
O.M.B. No. 04-S73020

PART B - MAIL-BACK QUESTIONNAIRE

PLEASE CHOOSE YOUR ANSWERS FROM THIS LIST
(See back of page for examples)

A. Passenger sedans
B. Sports cars
C. Self-contained motorized campers (such as motor homes, Winnebagos)
D. Large single-unit trucks (such as dump trucks)
E. Large mobile homes transported by truck
F. Large multi-unit trucks (such as semis or tractor-trailers)
G. Passenger buses
H. Cars towing trailers (such as tent trailers and small boats)
I. Other (please describe)
J. None

PLEASE ANSWER THE FOLLOWING QUESTIONS

1. a. Which vehicles do you feel are a safety hazard on the Interstate Highway System? ________
   b. Which vehicles do you feel are a safety hazard on two-lane highways? ________

2. a. Which vehicles most often cause you delay on the Interstate Highway System? ________
   b. Which vehicles most often cause you delay on two-lane highways? ________

3. a. Which vehicles do you think should be limited in their use of the Interstate Highway System to restricted hours, weather conditions, etc.? ________
   b. Which vehicles do you think should be limited in their use of two-lane highways to restricted hours, weather conditions, etc.? ________

4. a. Which vehicles do you think should not ever be allowed to use the Interstate Highway System? ________
   b. Which vehicles do you think should not ever be allowed to use two-lane highways? ________

5. Which vehicles do you now own? ________

6. Which vehicles have you ever driven often? ________

7. In general, which vehicles cause the most problems for other drivers? Please list them with those causing the most problems first, and those causing the least problems last. ________

THANK YOU.

Please use back of page if you wish to make any additional comments.

Figure 7 - Motorist Survey--Part B

Thank you for agreeing to participate in the Federal Highway Administration's survey about vehicles using the highways. In order to help us improve the safety and convenience of our highway system, we would appreciate it if you would take a few moments to answer the questions on the other side of this page.

We want to know how you feel about different types of motor vehicles that use our roads. On the other side is a list of vehicles and several questions about them. For each question, study the list and select the letter or letters of those vehicles which you think answer the question. Write the letters in the space next to each question. If you feel that a vehicle that is not on the list best answers the question, use the letter "I" (Other) and fill in the name of the vehicle. If no vehicle answers the question, use the letter "J" (None). You may have more than one answer to a question. You may also want to use the same letter to answer several questions. Please feel free to do so.

As an example, Question 1a asks: "Which of the above vehicles do you feel is a safety hazard on the Interstate Highway System?" If you think passenger buses and self-contained campers are safety hazards on the Interstate Highway System, you would answer by placing the letters "G" and "C" in the space provided. If, however, you think motorcycles are a hazard on the Interstate Highway System, you would fill in the letter "I" and write the word "motorcycles." If you think that no vehicles are a particular hazard on the Interstate Highway System, answer with the letter "J."

Remember, we want to know how you feel, so please answer the questions carefully. If you have any comments, please write them in the space provided. When you have finished, please insert the form in the envelope, and put it in the mail. You do not need a stamp. Since your name is not asked for, nobody will know how you answered the questions.

Thank you for taking the time to respond to this survey. Your answers and comments will help us to improve the safety and traffic movement on our nation's roads.

Comments:

Figure 7 (Concluded)

Following the interviewing an estimate was made as to whether the motorists did, indeed, pass a mobile home and if so, how long ago. This estimate, although crude, was made on the basis of the motorist's comments, his response to Question 2 (About how long have you been driving today?) and data from the wide load log. We observed that motorists often passed a wide load but did not recall it when asked. (On several occasions where sight distance was excellent we actually saw motorists leading, passing, or following wide loads. Two, when asked "Did you notice any wide loads such as mobile homes being transported on this trip?" said no.)

After completion of the field interviewing the coding forms were reviewed, and it was found that recoding would be necessary for several of the questions. For example, in Question 7a the most common safety hazard that motorists mentioned was a highway-related problem or hazard. A separate code was, therefore, assigned for that response. Several different categories were added for answers to Questions 6b and 7b. A number of people mentioned farm equipment, campers, vehicles pulling trailers, and, in response to Question 8, motorcycles or bicycles. (The category, bus, was seldom used. Of the nearly 3,000 people interviewed only one mentioned a bus as a slow vehicle and only one mentioned a bus as a safety hazard.) After recoding the interview responses they were keypunched for subsequent computer processing.

The mail-back questionnaires were similarily reviewed. By means of the "site code" it was possible to match the mail-back questionnaires with the on-site interviews. Therefore, all data from the same motorist were keypunched on the same card. Prior to keypunching the mail-back data, the responses were reviewed and recoded because so many people used the category, I, for "other" vehicle types. The common "other" vehicles were pickup campers, motorcycles, bicycles, farm equipment, and "slow vehicles."

A number of motorists took advantage of the space offered to make additional comments. These comments were all reviewed and a number of them compiled, categorized, and included in this report as Appendix H.

B. Results

1. Summary information: A total of 2,952 motorists were interviewed, 1,097 on divided highways and 1,855 on two-lane highways. These two groups were analyzed and are discussed separately in the remainder of the report. Summaries of their responses are tabulated as Tables G-1 and G-2 in Appendix G.

About 80% of the motorists were males. The respondents had a nearly uniform age distribution from the 20's through the 50's. Seventy-seven percent of the motorists on divided highways and 67% on two-lane highways were driving passenger vehicles. Ten percent on divided highways and 13% on two-lane highways were driving single-unit trucks or semis. The remainder of the vehicles were pickup trucks, including pickup campers.

Of the motorists stopped on divided highways, 57% recalled seeing a wide load; of those nearly two-thirds said it was going their way, the remainder said it was going in the other direction. Thus, 383 motorists on divided highways recalled overtaking and passing a wide load. Our estimates indicate that substantially more than this number passed a wide load, perhaps as many as 591. On two-lane roads 425 persons (23%) remembered passing a wide load; our estimate is slightly higher--529.

On divided highways approximately one-third of the motorists were traveling for business purposes; 54% of the motorists on two-lane highways were making a business trip. On both types of roads the drivers tended to be persons who did a lot of driving, with over three-fourths of the drivers logging over 10,000 miles per year. The majority of drivers stopped on two-lane highways use such roads most of the time; similarily, the divided highway drivers claimed to use that type of facility most often.

The motorists were asked whether they had experienced any delays on this trip. Twenty-eight percent of the motorists on divided highways, and 16% of those on two-lane highways said they had done so. As shown in Tables G-1 and G-2 the reasons for the delays were diverse, with highway construction being the major cause. Slow vehicles caused some delays, the most common slow vehicle being a truck. Mobile homes were mentioned by only nine drivers on divided highways and eight drivers on two-lane roads.

About the same number of drivers on two-lane roads said they had encountered a safety hazard as had experienced delays, although perceived safety hazards were less common among divided highway drivers than were delays. The most commonly experienced safety hazard related to the road or the roadside, with slow moving vehicles being mentioned with the second highest frequency. Over one-half the slow moving vehicles mentioned were trucks. Only one driver on a divided highway and only four on two-lane highways considered that a mobile home had been a slow moving safety hazard.

The drivers were then asked "in general--not just on this trip--is there any particular type of vehicle which causes you problems in terms of delay or safety." Again, the most commonly mentioned type of vehicle was a truck. On divided highways drivers also mentioned campers and various types of cars (fast moving, slow moving, erratically driven, etc.) quite frequently. Mobile homes were the fourth ranked problem vehicles, being named by about 10% of the drivers. On two-lane highways a similar situation was encountered. Again, mobile homes were the fourth most frequently mentioned vehicle type (13.6%) with trucks, campers, and farm vehicles being named more often.

These latter responses are summarized in Figure 8 along with answers to a similar question given on the mail-back portion of the survey. The answers on the mail-back portion are obviously quite different. There, mobile homes were the most frequently mentioned problem vehicles. There are several reasons why this difference in expressed opinion could have occurred. As discussed in Section III-B2, there could be differences between the respondents and nonrespondents to the mail-back questionnaire. But more importantly, during the on-site interview, no mention of mobile homes or wide loads had yet been made by the interviewer when the question was asked. Therefore, the motorist responses at that time should have been unbiased, representing their first impression. Subsequent to that question, however, motorists were asked specifically if they had seen any wide loads. This could have placed some bias in their subsequent answers. Moreover, on the mail-back form, a list of vehicle types was given, including "large mobile homes transported by truck." It is likely that many motorists would not be thinking about mobile homes (or, for that matter, other specific vehicle types) during the roadside interview. But, bringing it to their attention could result in a different set of answers than would be obtained spontaneously.

The final question during the on-site interview concerned the motorist's recent experience in passing a wide load. Of those passing a wide load on a divided highway less than 9% said that it caused them a problem, compared with 18% of drivers passing a wide load on two-lane highways.

As of 15 October 1973, mail-back responses had been received from 25.7% of the motorists interviewed. This date was selected as a cut-off point for analysis purposes, although a number of additional responses have been received since that date. The highest percent of responses came from Indiana (33.7%) with the Midwest and Far West states all yielding approximately 30% response. The percentage of returns from the two Eastern states, New Hamsphire and Florida, was about 19%. The overall response rate is typical of, or somewhat better than, most mail-back survey response rates.

The motorists' answers to the mail-back survey are given in Tables G-1 and G-2 of Appendix G and are summarized in Figures 9 through 12.* Clearly, drivers tend to view mobile homes and trucks as being the most troublesome vehicles with "other" being the third most troublesome.

* Some persons gave multiple answers.

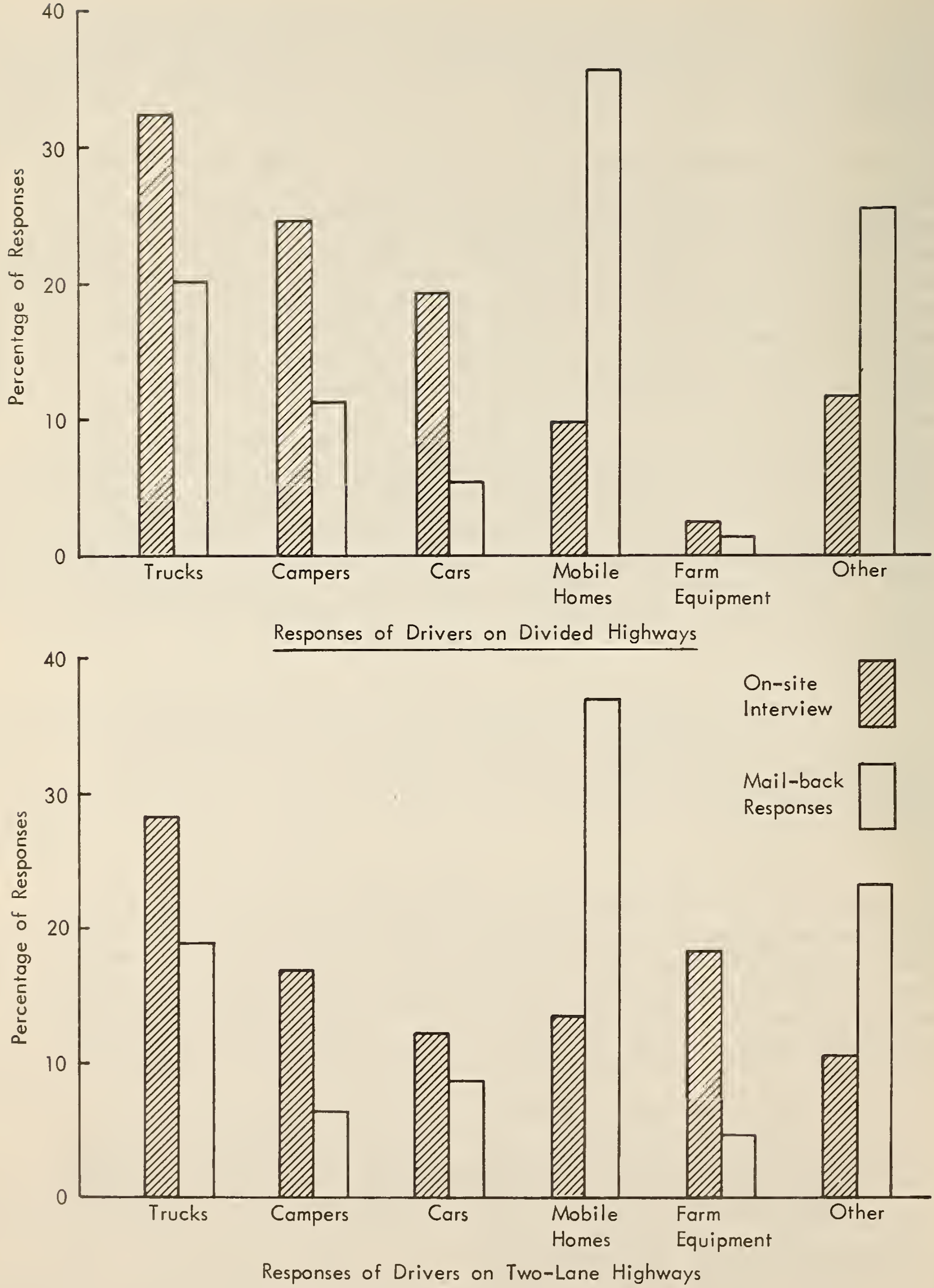


Figure 8 - Type of Vehicle Which Causes the Most Problems

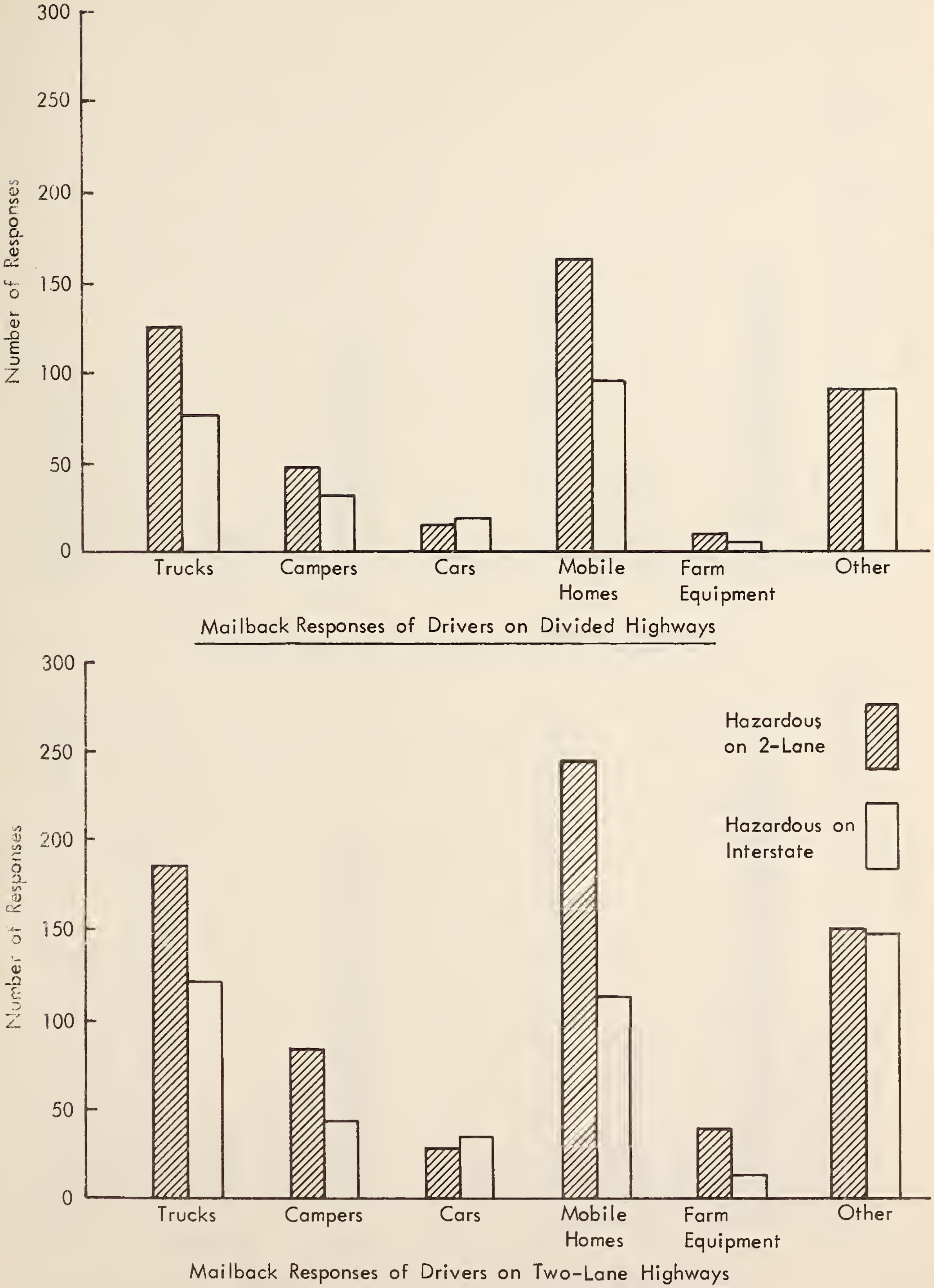


Figure 9 - Type of Vehicle Causing Most Hazards

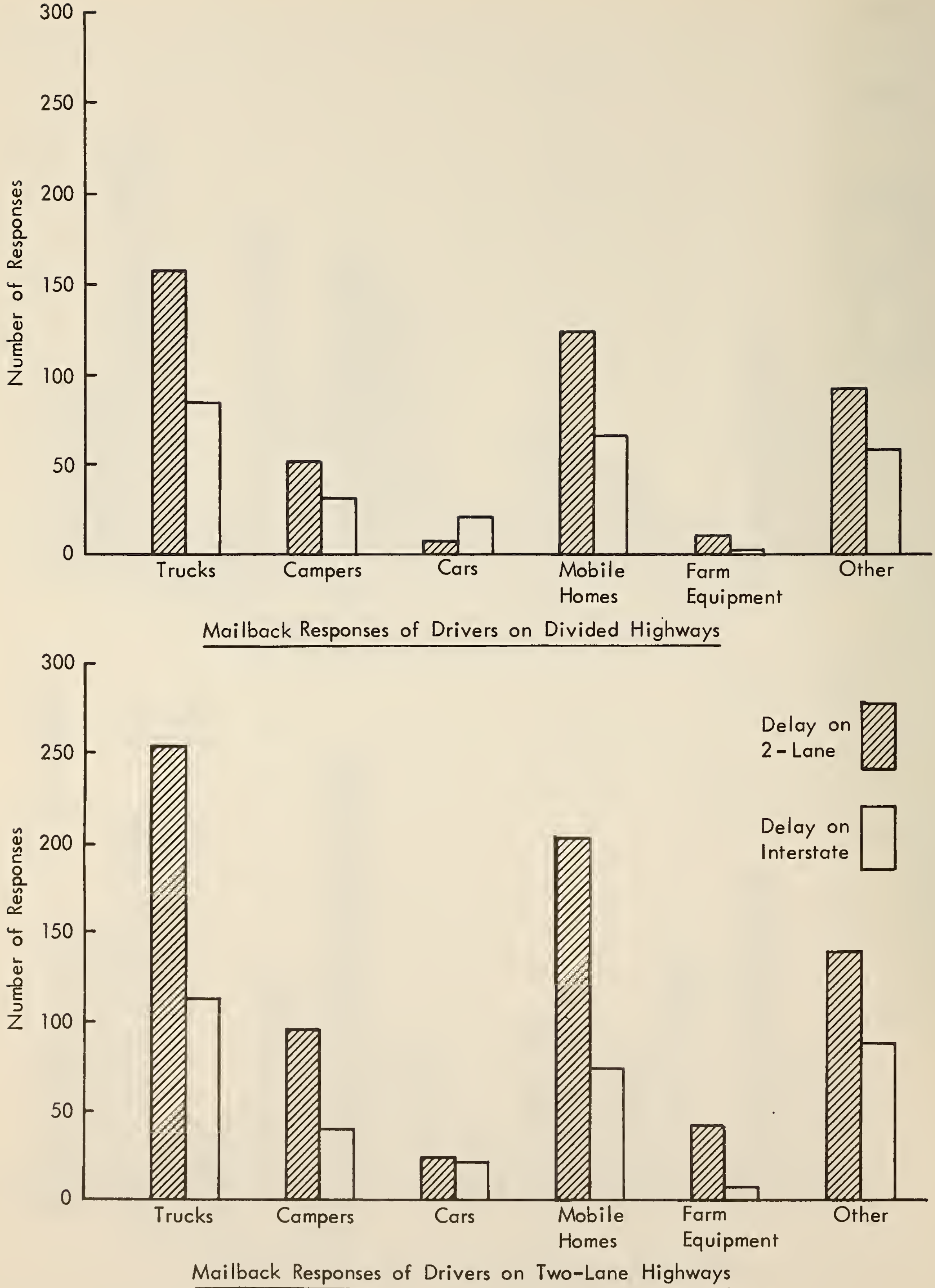


Figure 10 - Type of Vehicle Causing Most Delays

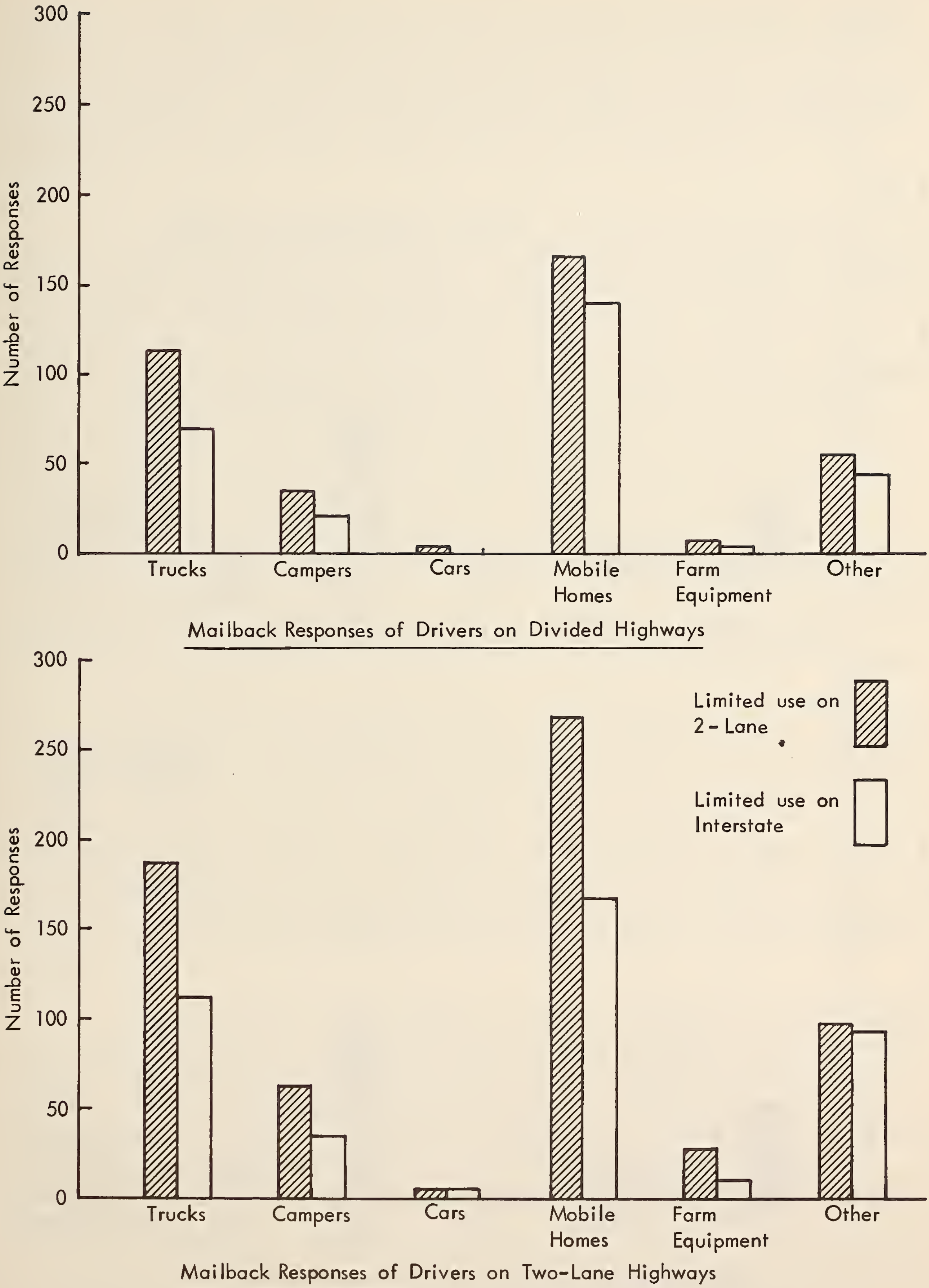
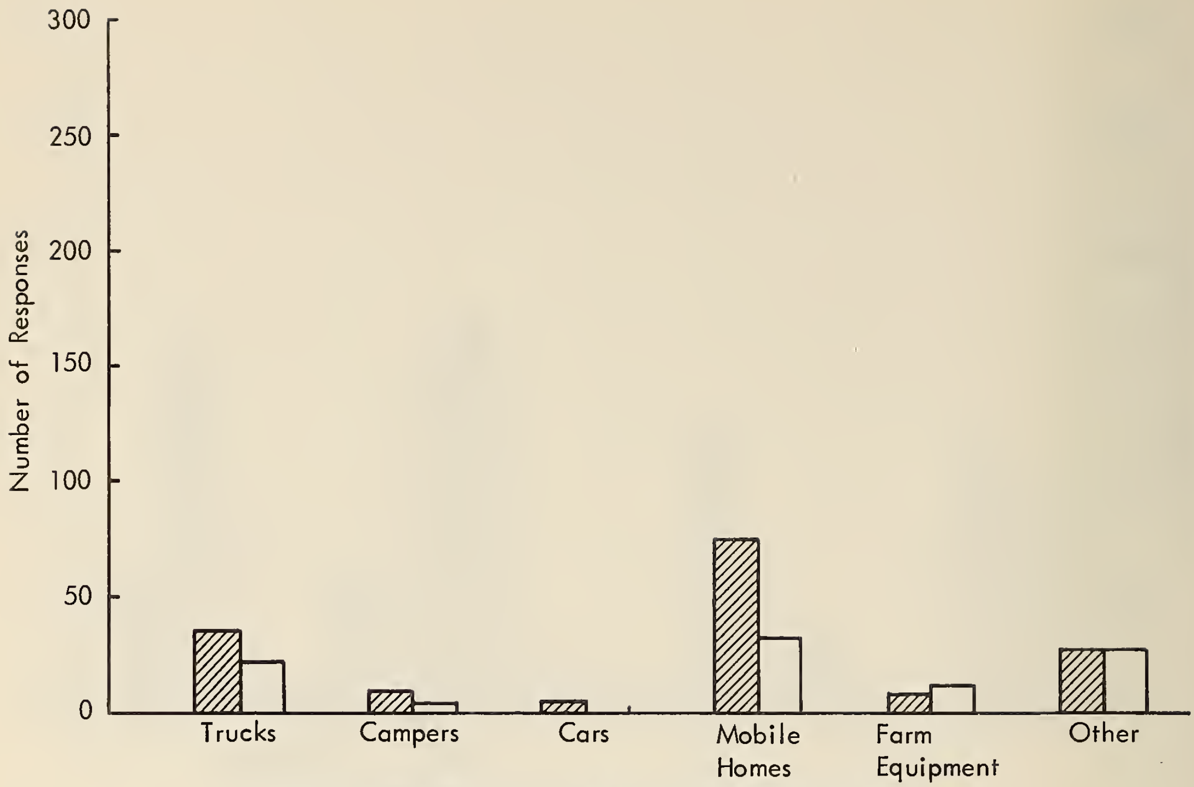
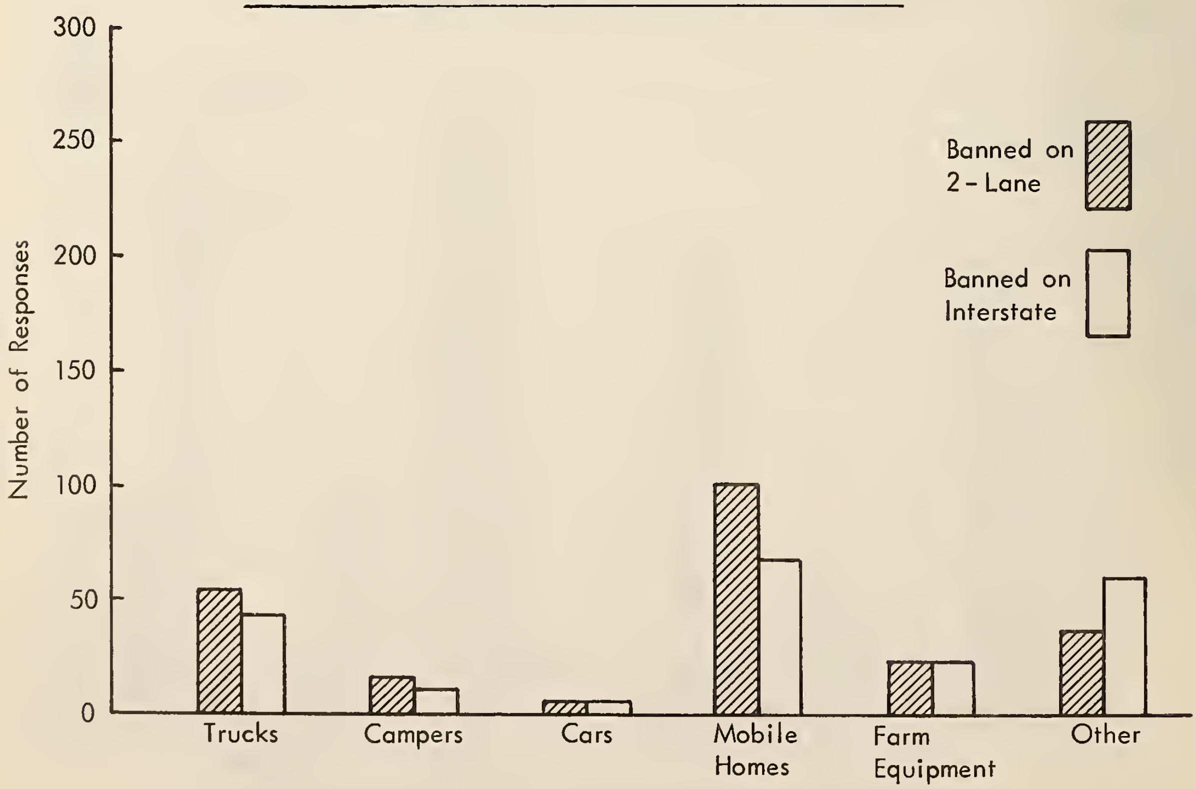


Figure 11 - Type of Vehicle Which Should be Allowed Only Limited Use of Highways



Mailback Responses of Drivers on Divided Highways



Mailback Responses of Drivers on Two-Lane Highways

Figure 12 - Type of Vehicle Which Should be Banned from the Highways

("Other" includes several vehicle types, of which "cars towing trailers" was the most commonly mentioned.) The figures also show that mobile homes are considered particularly troublesome on two-lane roads as compared to divided highways. Not shown in any of these figures are the numbers of persons who gave the answer, "none," which can be found in the tables in Appendix G.

2. Mail-back respondent biases: An analysis was performed to determine what differences, if any, could be found between those persons who did respond and those who did not. The parameters considered included trip purpose, annual mileage, type of roads used, sex, age, type of vehicle, and whether or not the motorists had recently passed a wide load. The analyses were done separately for two-lane and divided highway respondents. In all of these comparisons there was only one in which the respondents were statistically different (0.10 level of significance or better) than the nonrespondents. It concerned the type of vehicle driven by drivers interviewed on two-lane highways. Truck drivers were found to be less likely to respond than passenger vehicle drivers (0.005 level of significance). The same trend was observed among divided highway drivers but it was not statistically significant. Even on the two-lane highways, however, the numerical differences were not large. A change in attitude concerning responding to the survey by 3% of the passenger vehicle drivers and 10% of the truck drivers would have made their response rates identical.

Further analysis was performed to determine if motorists who were "critical" of wide loads during the on-site interview were more likely to have responded to the mail-back questionnaire and, if so, if their responses biased the results. In determining which motorists were "critical," several alternate criteria were applied. These involved their answers to Questions 6b, 7b, 8, and 9b. The first two of these seek unsolicited criticisms resulting from the present trip, while the third would identify persons who, without prompting, named mobile homes as a problem vehicle in general. Question 9b explicitly solicits information concerning wide loads.

Analysis showed that persons who were "critical" of wide loads only after prompting (Question 9b) were not statistically different from others in their mail-back response rate, but that motorists who spontaneously criticized wide loads were more likely to answer the mail-back questionnaire. The response rates are summarized in Table XI. Chi-square analysis showed the difference to be significant at the 0.05 level of significance for divided highway drivers, and at the 0.005 level for two-lane drivers.

TABLE XI

RESPONSE RATES OF CRITICAL AND NONCRITICAL MOTORISTS

	Divided Highway			Two-Lane Highway		
	Respondents	Nonrespondents	Total	Respondents	Nonrespondents	Total
Critical Without Prompting[a/]	25	40	65	55	95	150
Critical Only After Prompting[b/]	9	22	31	12	24	36
All Others	245	756	1,001	415	1,254	1,669

a/ Answered "mobile home" or equivalent to Questions 6b, 7b, or 8.
b/ Answered "yes" to Question 9b but not included in first row.

Given, then, that there is a bias in the response rates, it is of interest to determine the effect of this bias on the total responses. To do this we compared the answers to the mail-back questions given by the "biased" group (those who were critical of wide loads without prompting) with those of the others. Selected crucial questions and the answers are displayed in Tables XII, XIII, and XIV. From these data, it is clear that the biased motorists not only were more likely to respond, but were two or three times as likely to be critical of mobile homes in their responses.

The net effect of this bias is negligible, however. The last line in each table is a corrected set of numbers. The correction consists of using the responses of the biased and other responders, but in the ratio that they were encountered (randomly) on the highway rather than in the ratio that they answered the questionnaire. It is seen that the changes are small. The reason, of course, is that there were few "biased" motorists to begin with (less than 10%), and that all of them were not critical of mobile homes on the mail-back portion of the survey.

Therefore, the original (uncorrected) data are referred to elsewhere in the report.

3. Detailed analyses of respondents and responses: Many cross tabulations of the response data were prepared and analyzed. The analysis generally consisted of Chi-square calculations to locate significant differences between groups of respondents and their responses. These analyses are detailed in Appendix G and summarized at the end of Section III.

The major categories of analysis were:

- Divided vs two-lane highway drivers;
- State-to-state variations; and
- Demographic and other response characteristics.

4. Banning of mobile homes: Because a number of people suggested banning mobile homes,* a separate analysis was made of the motorists' answers to Questions 1, 2, and 4 on the mail-back survey. As with the other analyses, the responses were separated according to whether the initial interview occurred on a two lane road or a divided highway.

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* As shown in Figure 12, drivers also suggested banning trucks and other vehicles quite frequently. However, this discussion is limited to those responses concerning mobile homes.

TABLE XII

WHICH VEHICLES SHOULD BE BANNED FROM THE INTERSTATE SYSTEM

	Divided Highway Drivers				Two-Lane Highway Drivers			
	Mobile Homes	None	Other	Total	Mobile Homes	None	Other	Total
Biased	9	13	3	25	16	31	8	55
Others	19	179	50	248	44	276	94	414
Total	28	192	53	273	60	307	102	469
Corrected Total[a]	25	194	54	273	57	309	103	469

a/ Obtaining by weighting the first two rows to correct for the different response rates.

TABLE XIII

WHICH VEHICLES SHOULD BE BANNED FROM TWO-LANE ROADS

	Divided Highway Drivers				Two-Lane Highway Drivers			
	Mobile Homes	None	Other	Total	Mobile Homes	None	Other	Total
Biased	12	10	3	25	26	26	3	55
Others	53	151	47	251	65	262	86	413
Total	65	161	50	276	91	288	89	468
Corrected Total[a/]	63	163	51	277[b/]	86	291	92	469[b/]

a/ Obtaining by weighting the first two rows to correct for the different response rates.

b/ Slight difference in totals due to rounding.

TABLE XIV

WHICH VEHICLES CAUSE THE MOST PROBLEMS, IN GENERAL

	Divided Highway Drivers					Two Lane Highway Drivers				
	Mobile Homes	Semis	None	Other	Total	Mobile Homes	Semis	None	Other	Total
Biased	13	5	0	7	25	38	1	3	13	55
Others	72	36	38	104	250	121	61	48	185	415
Total	85	41	38	111	275	159	62	51	198	470
Corrected Total[a/]	83	40	39	112	274[b/]	152	64	52	202	470

a/ Obtaining by weighting first two rows to correct for the different response rates.
b/ Slight difference in total due to rounding.

As discussed previously, the drivers interviewed on two-lane roads tended to do most of their driving on two-lane roads whereas those interviewed on divided highways tended to use them more.

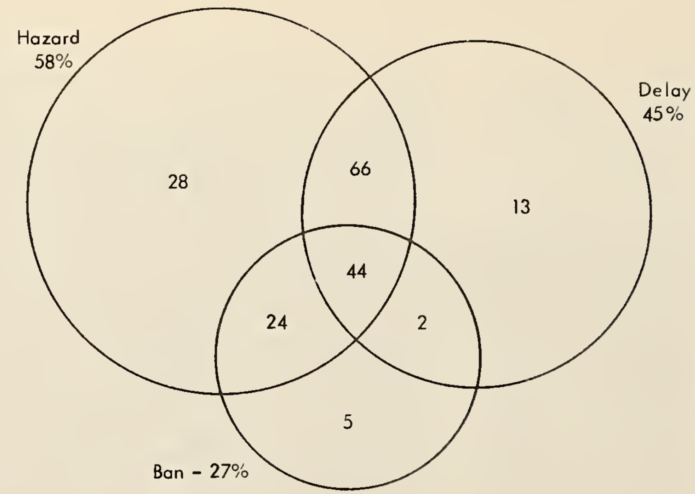
In response to Question 4, a fairly large number felt that mobile homes should be banned from the highways. Twenty-one percent of the two-lane drivers stated that they should be prohibited from use of two-lane highways and a larger fraction of Interstate drivers, 27%, held that view. Fourteen percent of two-lane drivers said they should be banned from Interstate highways, compared to 11.5% of Interstate drivers so stating.

It would be of interest to know why a significant, although small, number of drivers would like mobile homes banned from the highways. Within the confines of the questionnaire it is not possible to completely answer that question. However, some indications of their concerns can be obtained by comparing their responses to the three questions under discussion. The results of these comparisons are displayed in Figure 13. In these diagrams the sizes of the circles are proportional to the percentage of respondents. Within the circles are the actual numbers of persons giving the answers indicated. For example, in Part a of the Figure, 63 persons said that mobile homes were a hazard, caused delay, and should be banned. Ninety-nine said that they were a hazard and caused delay, but did not say they should be banned. Likewise, 22 felt that they were a hazard and should be banned but did not consider they caused delays. And finally, 58 said they were a hazard but did not cause delays and should not be banned.

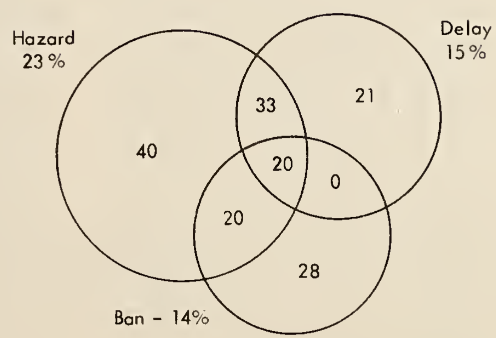
Despite some notable exceptions, the data indicate several general trends. For example, in all four breakdowns given, almost no one who said mobile homes should be banned said that they caused delay but were not a hazard. In other words, people do not believe mobile homes should be banned solely because they cause delays. In fact, generally over half of the people suggesting a ban consider mobile homes to be both a hazard and a delay. Except for one identifiable group, 80 to 90% of the motorists suggesting the ban also stated they were a hazard. The exceptional group was the two-lane drivers voicing opinions concerning mobile homes on Interstate highways. Among this group 28, or 41%, of those suggesting a ban apparently said so without strong reasons, since they mentioned neither hazards nor delays.

The data can be viewed in another way--to gain an indication as to why the motorists believed the mobile homes are a hazard. Concerning the use of two-lane roads by mobile homes, over two-thirds of the drivers who said they were a hazard also said they caused delays. About half of the motorists had the same opinion concerning Interstate highways. One wonders if the public's major impression of hazard is something which causes delay.

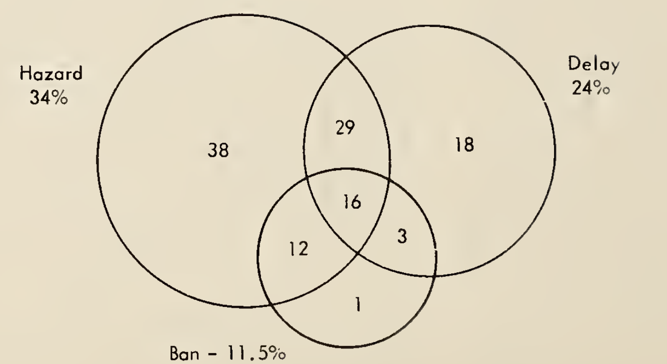
a. Two-Lane Highways, 482 Two-Lane Drivers



b. Two-Lane Highways, 279 Interstate Drivers



c. Interstate Highways, 482 Two-Lane Drivers



d. Interstate Highways. 279 Interstate Drivers

Figure 13 - Summary of Negative Opinions Regarding Mobile Homes

If so they are at least partly correct, as can be shown, for example, by studies relating accidents to relative speeds.[6/] The same general ratios are true also among drivers who believe mobile homes are a hazard and should be banned. That is, the majority of these drivers additionally stated that the mobile home causes delays. Finally, looking at it the third way, about three-fourths of the drivers who said mobile homes caused delays also said that they were a hazard.

C. Conclusions

Only rarely did a motorist who had recently passed a wide load suggest, without prompting, that he had encountered delay or a safety hazard at that time. Again, without prompting, motorists did not rank mobile homes extremely high as problem vehicles--trucks, campers, other cars, and farm equipment were more commonly mentioned.

When drivers who recalled recently passing a wide load were specifically queried about that experience, less than one in 10 on divided highways, and less than one in five on two-lane highways, recalled any problems.

When motorists were pointedly asked to rate mobile homes against other types of vehicles, they tended to place them at the top of the list in terms of hazards, impedances, and problems in general. Also ranking nearly as high on the list were trucks, campers, farm vehicles, and cars pulling trailers. These responses were slightly, but negligibly, affected by the self-selection bias present in the group of motorists choosing to respond to this question.

Motorists who normally drive on two-lane highways tended to be more tolerant of their driving environment, when compared to persons who normally drive on divided highways, except for mobile homes.

There were many geographic differences among the drivers and their opinions, relating directly or indirectly to mobile homes. Drivers in Florida tended to be older than others. Trucks and pickup trucks were more common in Idaho and Oregon, and, on two-lane highways, single unit and semi trucks were most common in Nebraska. Drivers from Indiana were most vocal concerning delays, hazards and mobile homes. New Hampshire drivers were least likely to express concerns. Drivers in the Northwest were most likely to complain about campers and cars pulling trailers. Nebraska drivers were troubled by farm equipment and, along with Indiana drivers, by mobile homes on two-lane highways. Trucks were a particular concern on divided highways to drivers in Indiana and Florida and, on two-lane highways, to New Hampshire drivers. The latter were also bothered by small passenger vehicles on divided highways.

Young drivers were more likely to express concerns about delays and hazards than were older drivers. And people driving for business purposes were particularly concerned about problem vehicles on two-lane highways. Truck drivers were most bothered by campers and cars pulling trailers, whereas automobile drivers were more likely to express concern about trucks and mobile homes. Female drivers were particularly annoyed by, or fearful of, motorcycles.

Finally, and overwhelmingly, drivers on divided highways were far less concerned about mobile homes than were drivers on two-lane highways. Throughout all of the responses and the detailed analyses thereof, the trend remained--motorists perceive mobile homes to be about twice as troublesome on two-lane highways as on divided highways.

IV. ANALYSIS OF COSTS TO HIGHWAY USERS

A. Introduction

Any vehicle, by its presence on the highway, has the potential of influencing the progress of other vehicles. That is, its presence could cause other drivers to change speeds, change lanes, be delayed etc. These influences could be especially pronounced if the vehicle in question is extraordinarily large, or moving slower than other traffic, or both.

In Section II the disturbances to traffic flow induced by the transport of 12- and 14-wide mobile and modular homes were identified and measured. In this Section the cost implications of these disturbances are determined, as measured by changes in operating costs and other objective measures.

There are several traffic flow effects induced by other vehicles, which are quantifiable in terms of ultimate costs. One of the most obvious is a speed change. When a driver changes speed for a period of time, two phenomena occur which give rise to incremental costs. First, by driving at a constant speed which is different from the unimpeded or free speed, the motorist incurs incremental fuel, oil and tire costs, a change in the emission of air pollutants, and a change in travel time. Any of these quantities could be positive or negative depending on whether the affected speed is lower or higher than the unimpeded speed. The affected speed would be lower than the unimpeded speed if, for example, the motorist becomes a part of a queue; but it could become higher while, for example, the motorist is passing the impeding vehicle. The second phenomena is the speed change cycle per se. That is, decelerating and later accelerating (or vice versa) results in additional consumption of fuel, oil, and tires and increases the emission of air pollutants.

The other common maneuver with which costs can be associated is a lane change. The major cost incurred in this maneuver is increased tire wear.

Seven cost elements were identified and evaluated in this study. These are:

1. Changes in fuel consumption;

2. Modified tire wear;

3. Increased oil consumption;

4. Accelerated depreciation;

5. Added maintenance expense (aside from fuel, tires, and oil);

6. Delay time; and

7. Air pollution.

It was determined that of these seven, the consumption of oil and modified depreciation and maintenance expenses were either insignificant or inappropriate for inclusion in this analysis. Therefore, the final results are based on consumption of fuel and tires, delay time, and air pollution.

As is commonly done in highway economic analyses, all of the observed vehicles were placed into one of a few vehicle-type categories for final analysis. The three types used here are a composite passenger car, a composite pickup truck, and a composite heavy truck (semi). The composite passenger car corresponds to the 4,000 lb passenger car used by Winfrey[10/] and the composite car used by Claffey.[11/] The composite pickup truck is that used by Winfrey and Claffey; it weighs about 5,000 lb. The composite truck is similar to that used by Claffey except in the type of fuel consumed. Our composite truck was made up of 50% 2-S2 tractor semi-trailer combinations at 40,000 lb and 50% 3-S2 tractor semi-trailer combinations at 50,000 lb. Moreover, 35% of the composite trucks are diesel powered and 65% use gasoline as a fuel.

Aside from vehicle type and, of course, speed, the other important consideration in determining costs is the roadway configuration. The roadway configuration is important primarily in ascertaining tire wear costs. Here, again, three categories* were selected as covering the range of roadways encountered without unnecessarily complicating the analysis. These were:

1. Divided highway, implying modern construction, concrete roadways in good condition with small-to-moderate curvature and excellent sight distance;

2. Two-lane roads with good sight distance, concrete surface, and low-to-moderate curvature;

* The two factors, curvature and surface material, play a role in costs, particularly tire wear costs, with curvature the more important. The three composite categories cover the range of interest.

3. Asphalt two-lane roads with poor-to-moderate sight distances and generally more frequent curves of larger curvature than the Type 2 roadway.

The placing of final dollar values on costs is always open to question, in part because the analysis must then be dated. Unfortunately, if one stops short of assigning dollar values, one has no way of balancing, for example, excess gasoline consumption against delays incurred. Therefore, we have reduced all elements (except air pollutant emissions) to monetary values. Specifically, the year 1969 was selected for this purpose because the majority of the data reported in the literature utilized this as a base year. One could convert these costs to other years, with varying degrees of sophistication, by referring to the appropriate economic trend data.

B. Methodology

1. Changes in Fuel Consumption

a. Cost due to traveling at different speed: Fuel consumption for a given vehicle is dependent primarily on vehicle speed. Therefore, if the driver operates the vehicle at a speed other than his desired speed, the fuel consumption will change. The cost difference to the driver will be the product of the difference in fuel consumption rates (usually expressed as gallons per mile), the distance traveled at the differing speed, and the per gallon cost of the fuel.

Suppose a driver desires to travel at speed V , miles per hour. However, because of the presence of the wide load, he travels instead at speed v , miles per hour. The distance traveled at the different speed is the product of v and the time, t , during which the altered speed is in effect. If the time is measured in hours then the product, vt , is in miles.

Let the fuel consumption rate be denoted by f , gallons per mile, and the fuel cost by c , dollars per gallon. Then, because f varies with speed, the incremental fuel cost to the driver when he is traveling at a different speed is given by:

$$\text{Cost} = \int_0^t (f_v - f_V) v(t)\, c\, dt$$

or, approximately, (3)

$$\text{Cost} = (f_v - f_V) t v c.$$

Equation 3 is an approximation which assumes, in effect, that the driver instantaneously shifts from speed V to speed v , maintains that speed for a time t , and then instantaneously shifts back to speed V . A review of typical speed histories observed in the field data indicates that the difference between the actual speed history and this assumed speed history results only in second order corrections, so the approximation is adequate for our purposes. The fuel consumption rate is commonly (and correctly) thought to increase as the speed increases. Therefore, it should be noted that the driver's fuel consumption will actually decrease and he will incur negative costs from this source if he drives slower because of the wide load.

There have been many studies of fuel consumption rates. Winfrey[10] and Claffey[11] both give rather extensive data in this regard for a variety of vehicles. However, Winfrey's fuel consumption data are about 10 years older than those given by Claffey. They are not in wide disagreement, but the more recent information indicates somewhat better fuel consumption rates at higher speeds than the earlier data and poorer consumption at low-to-moderate speeds. Unfortunately, a complete compilation of data similar to that of Winfrey or Claffey is not available for recent model years for which fuel consumption is reportedly substantially poorer due to the advent of a variety of anti-pollution devices. Therefore, for this project the basic data of Claffey were utilized.

Fuel consumption rate can be very accurately represented as a quadratic function of the speed. Regression analyses of the Claffey data resulted in the following expressions for the fuel consumption rates of the composite car, pickup and truck, respectively:

$$10^3 f_{car} = 47.4 - 0.42v + 0.01v^2 \quad (4)$$

$$10^3{}_{p.u.} = 49.0 - 0.68v + 0.02v^2 \quad (5)$$

$$10^3 f_{truck} = 283.9 - 9.59v + 0.13v^2 \quad (6)$$

Many authors,[10,12] in discussing traffic cost analyses, suggest that highway planners and engineers include only the base cost of the fuel and not the cost of the state and federal taxes. This approach, they point out, is necessary to avoid duplicate accounting when the cost analysis is for the purpose of highway construction or reconstruction. In the present case, however, the interest is focused instead on the total cost <u>to the driver</u>. This cost is assumed to be the result of the wide load and not the result of state highway improvements. Therefore, it is appropriate to include the total fuel price paid by the driver. In the subsequent calculations the value of c was taken as 40¢ per gallon for cars and pickups and 34¢ per gallon for the composite truck, representative of prices the first half of 1973.

b. Speed changing costs: The fuel consumption during a speed change cycle was taken from Claffey.[11/] His data were found to be represented extremely well by a multiple linear regression with variables V and v. In performing the regressions, the very low speed data and the very large speed changes were ignored as not being of interest to the present situation. The resultant fuel consumption, g (gallons) in excess of the constant speed consumption brought about by the deceleration-acceleration cycle is given below.

$$10^3 g_{car} = -2.573 + 0.435V - 0.379v \quad (7)$$

$$10^3 g_{p.u.} = 3.320 + 0.208V - 0.274v \quad (8)$$

$$10^3 g_{truck} = -42.60 + 5.820V - 4.631v \quad (9)$$

We found that all of these regressions had multiple correlation coefficients of 0.999+ except for the truck data. In Claffey's Table 18[11/] the entry corresponding to an initial speed of 40 miles an hour and a speed change of 20 miles an hour was determined to be out of line with the other entries in the table and in probable disagreement with his Appendix A data. By deleting this data point, the correlation coefficient of that regression (Eq. 9) was also greater than 0.999.

The fuel consumed, given by Equations 7, 8, and 9 must be multiplied by the fuel cost to arrive at the cost to the driver.

c. Lane changing costs: Changing from one lane to another at constant speed requires lateral acceleration, that is, the path of the vehicle is curved in relationship to the centerline of the highway. Procedures similar to that outlined subsequently in connection with tire wear were used to estimate the added fuel consumption caused by this maneuver. In this regard, correction factors for curvature given by Claffey[11/] were employed. The results from making these calculations indicated that these costs amount to only a percent or two of the other types of incremental costs. Therefore, this cost element was neglected in subsequent calculations.

2. Modified Tire Wear

a. Cost due to traveling at different speed: The differential cost due to traveling a time, t (hours), at a speed, v (miles per hour), which is different than the desired or free speed V (miles per hour) is:

$$\text{Cost} = (W_v - W_V)vt \quad (10)$$

where W_v and W_V are the tire wear costs (dollars per mile) at speeds v and V , respectively. These depend primarily on the vehicle type, speed, and road characteristics.

Most authors,[10-12] when considering tire wear, evaluate the wear on tangent roadway and curves separately. Moreover, tire wear tests show that the wear rate, even on moderate curves, can be several times that on tangent roadway. Thus, it would be a gross underestimate to use wear rate values appropriate to tangent roadway. However, detailed horizontal curvature data were not collected in conjunction with the project. Even if such data had been collected, its usage would have been far too cumbersome to be practical. Therefore, it was decided to use representative curvature distribution data.

The lateral acceleration of a vehicle is related to the curvature by the expression:

$$a = v^2/r \tag{11}$$

where v is the speed of the vehicle and r is the radius of curvature. Smith and Smith[13] determined the lateral acceleration distribution using a number of different drivers traversing several types of roads. Using their lateral acceleration data, it is thus possible to determine the distribution of curvature on the roadway. Figure 14 shows the resultant distributions for three types of roadway. The interpretation of these curves is that, for example, the curvatures experienced are less than one degree: 83% of the time on Type 1 roadways, 60% of the time on Type 2, and 47% on Type 3 roadways.

The speeds observed and other descriptive information recorded by Smith and Smith[13] indicate that the Type 1 roadway can be considered representative of much of our Interstate system. Likewise, the Type 2 road is comparable to our better two-lane roads having, for the most part, good sight distance. The Type 3 roadway, on the other hand, involves lower speeds and, quite frequently, rather sharp curves. This we will associate with two-lane roads with poor-to-moderate sight distance. During our data collection activities reported in Section II, we made continuous observations of the general quality of the road as typified by sight distance. This representation was used to select the appropriate curve from Figure 14.

The cost data from Claffey[11] were used in association with Figure 14 to arrive at the tire wear cost, W , for normal highway driving at constant speed. For the composite passenger vehicle, Claffey uses a base price of $119 for a set of four new, medium quality tires. Claffey

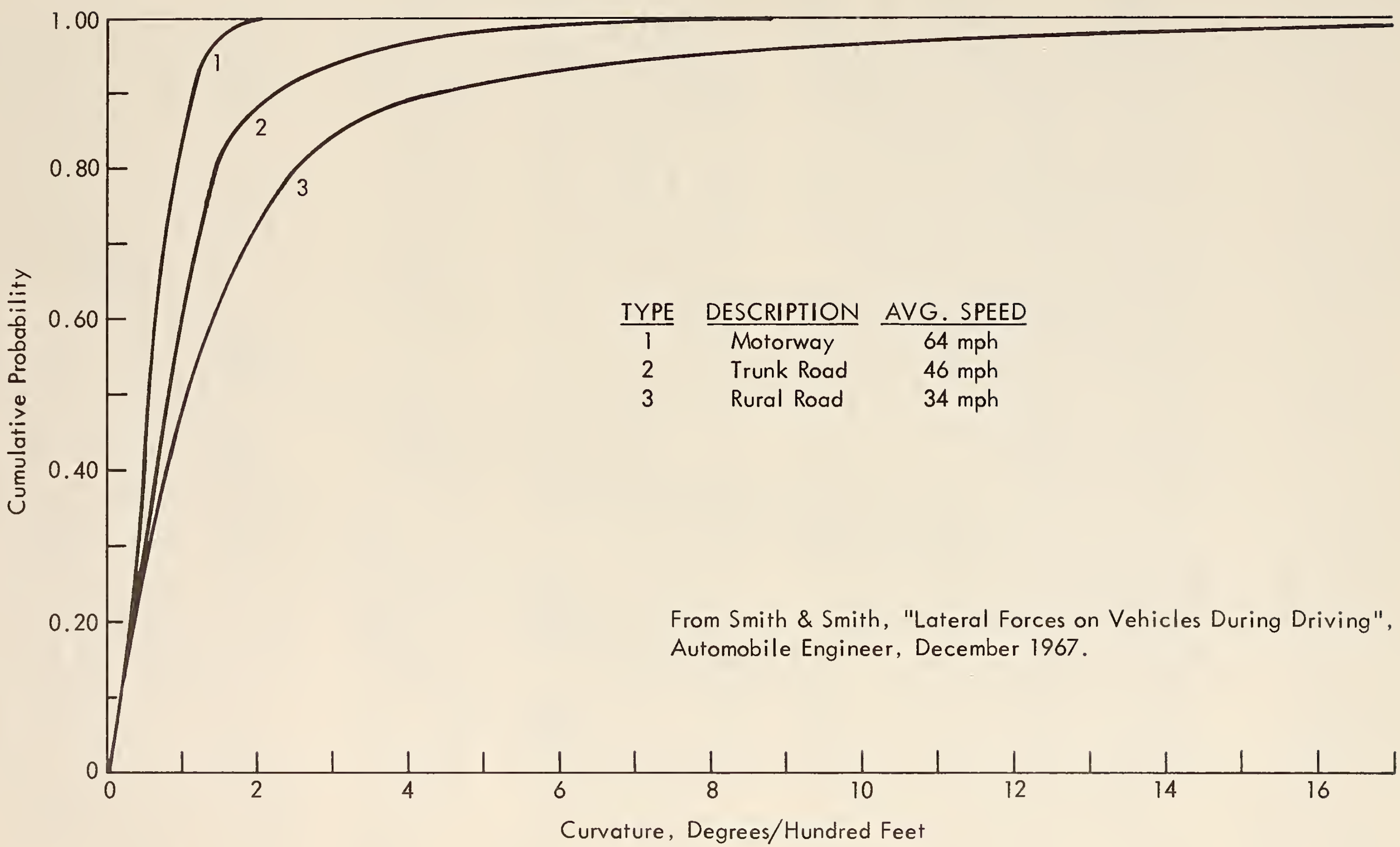


Figure 14 - Representative Curvature Distributions

also gives, in his Table 19, the tire wear costs at constant speed on tangent roadway and, in Table 19A, multiplying factors to account for curvature. We used his data for "high type concrete" as representative of our road Types 1 and 2 and "high type asphalt" for road Type 3. Thus the curves given in Figure 15 were obtained by combining the curvature distribution data and the cost data.*

Data for the composite pickup truck were obtained in the same fashion. Claffey[11/] gives wear rate data for speeds up to 50 miles an hour, on the assumption that the wear rate is the same as that for passenger vehicles. He gives no data for speeds over 50 miles an hour but suggests that pickup truck tire wear should be more rapid than passenger car tire wear because of differences in the aerodynamic shapes of the vehicles. Winfrey's data,[10/] on the other hand, imply that the tire wear rates for the two types of vehicles are essentially the same up to 70 miles an hour. Lacking data to the contrary, therefore, we assumed the wear rates to be the same. Tire costs are higher for pickup trucks than for passenger tires, based on usable tread, so the wear costs will be different. Winfrey's data imply pickup costs to be 20% higher than passenger cars whereas Claffey shows an 18.6% difference. In this study we used 20%. Figure 16 shows the results of the calculations for pickup trucks.

The data are more sparse for trucks, particularly semis. Claffey has no data at all for semis and a few example costs for single unit trucks. Winfrey,[10/] on the other hand, does give dollar costs for tangent roadway but no correction factors for curvature. We used Winfrey's basic cost data on tangent roadway (which showed truck tire costs to be 6 to 8 times those of passenger car tire costs, depending on speed) and the curvature correction factors which Claffey[11/] suggests and uses for passenger cars and pickup trucks. The curves of Figure 17 result.

In summary, the incremental tire wear costs incurred by driving at a speed other than the desired or free speed are given by Equation 10 where the wear rate costs are obtained from Figures 15, 16, and 17 for the appropriate composite vehicle and road type.

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* Figure 15 suggests a somewhat shorter tire life than should be expected. Yet, this indication is consistent with Claffey's data,[11/] which show much higher wear rates than Winfrey's theoretical estimates.[10/] We suspect that the difficulty lies in distinguishing between the highway curvature and the (different) curvature of the drivers path.[14/] The Claffey correction factors for curvature are probably too great, considering that the driver path has curvature even on tangent roadway. Therefore, a higher than expected wear rate results when using driver path data such as derived from Smith and Smith.[13/] Additional research is needed in this area.

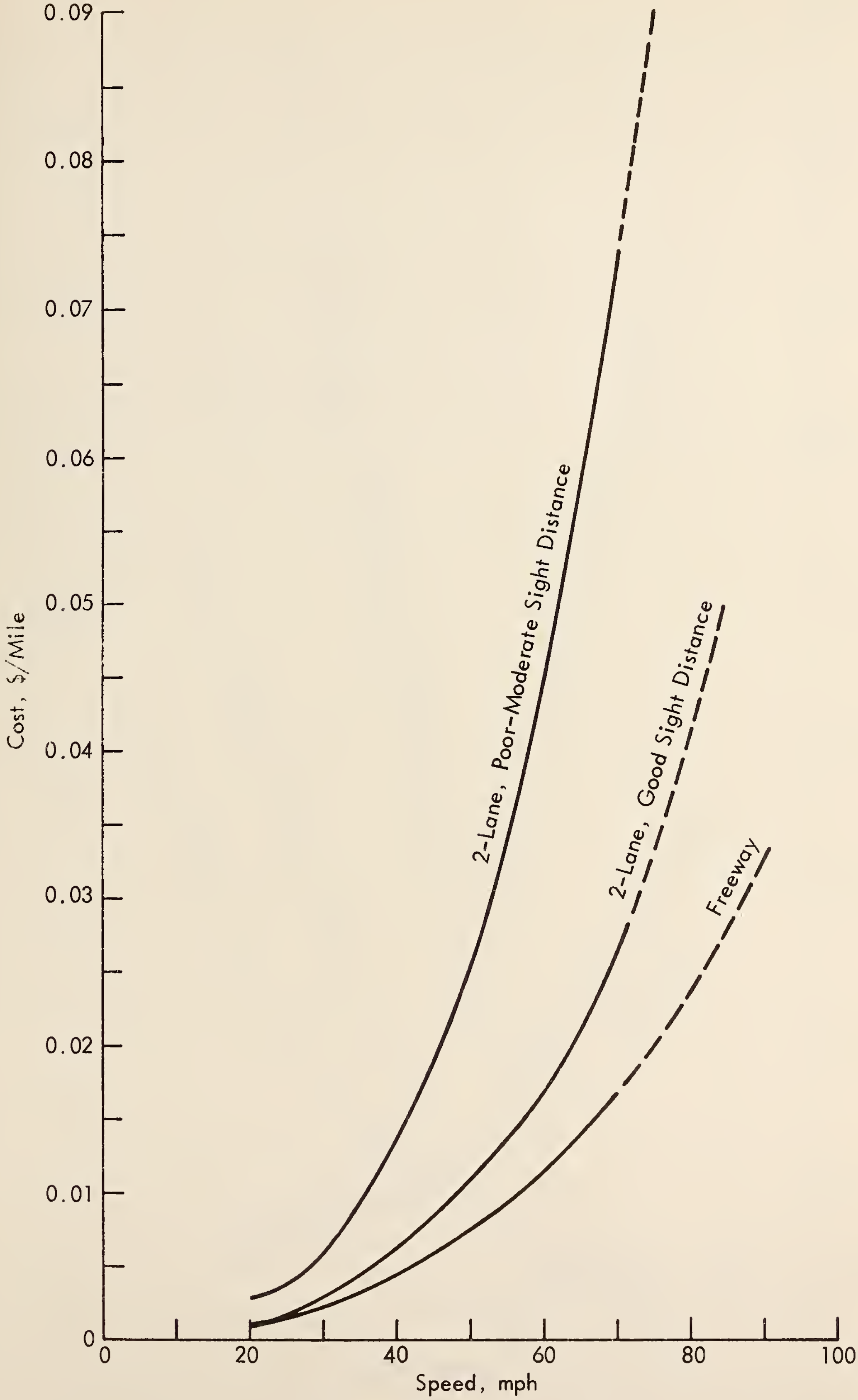

Figure 15 - Composite Automobile Tire Wear Cost at Uniform Speed

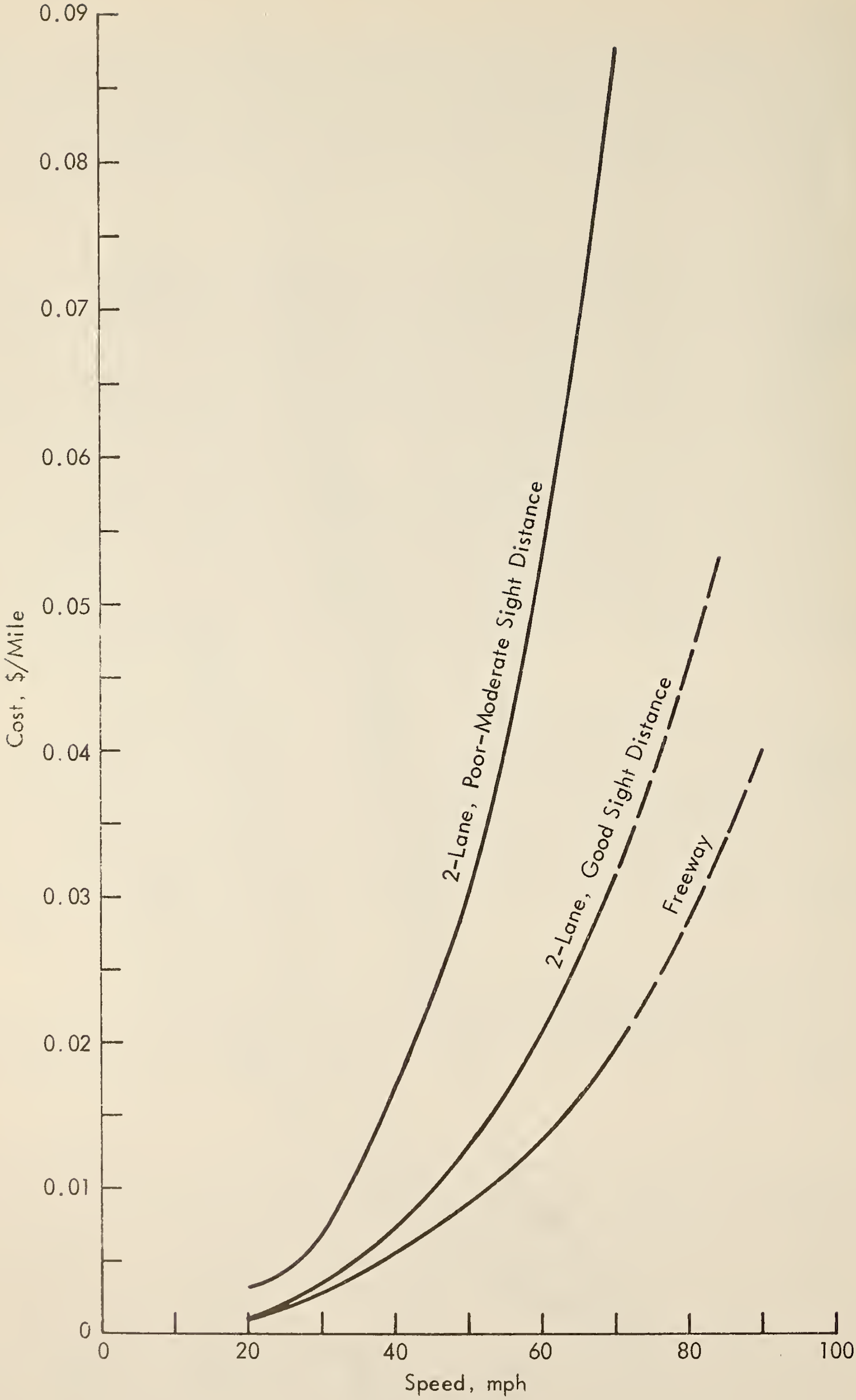

Figure 16 - Composite Pickup Tire Wear Cost at Uniform Speed

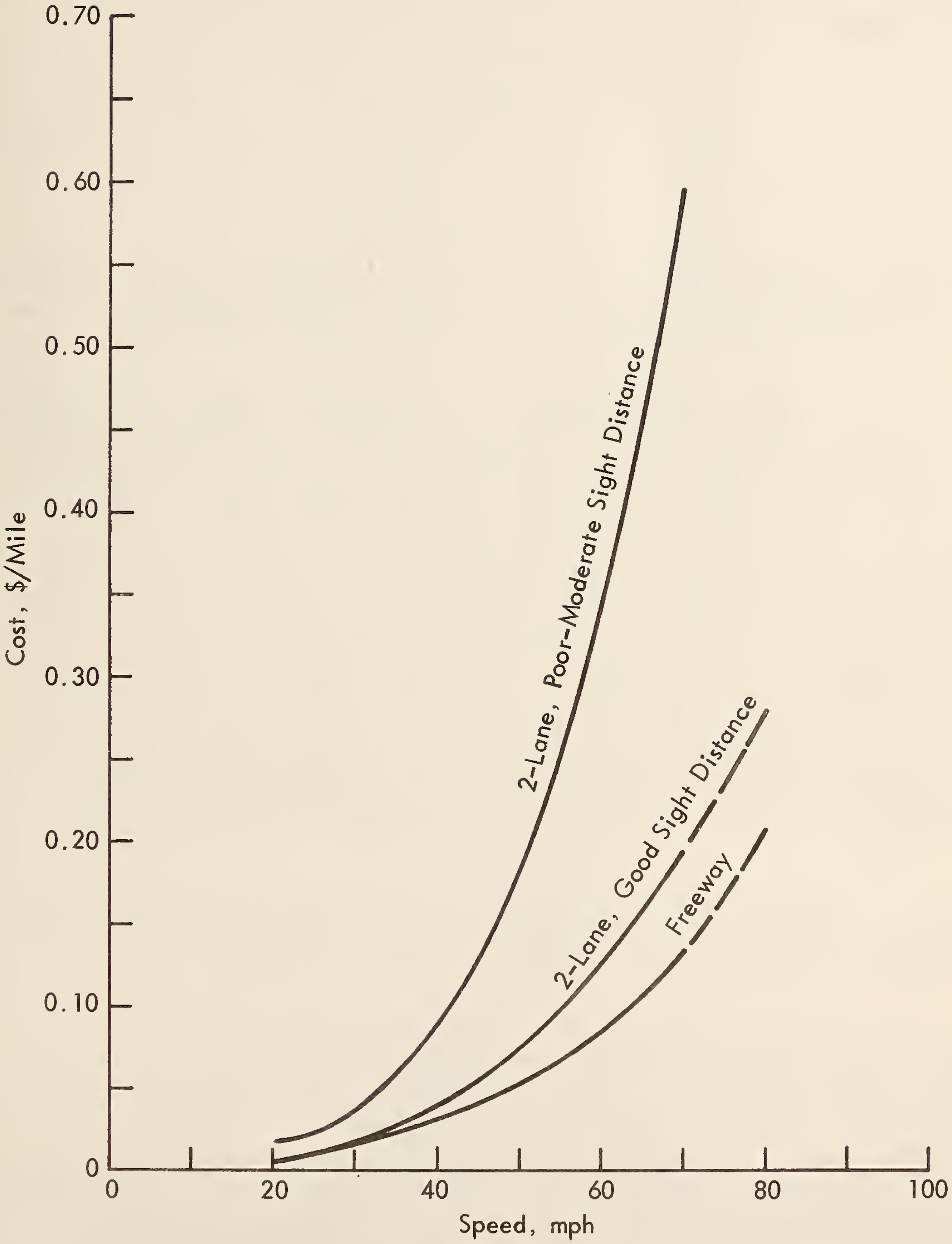

Figure 17 - Composite Truck Tire Wear Cost at Uniform Speed

b. Speed changing costs: These costs are given by:

$$\text{Cost} = W_{\Delta}(|V-v|) \tag{12}$$

where W_{Δ} is given by

$$W_{\Delta}\ (\text{car}) = \$0.00011/\text{mph}$$

$$W_{\Delta}\ (\text{p.u.}) = \$0.00013/\text{mph} \tag{13}$$

$$W_{\Delta}\ (\text{truck}) = \$0.0008/\text{mph}$$

The passenger car value was determined to be a sufficiently accurate approximation of Claffey's Table 20. We increased that value 20% for pickup trucks and sevenfold for the composite semi, in keeping with other tire wear costs.

c. Lane changing costs: We defined lane change as beginning with the vehicle traveling straight ahead in one lane and ending with the vehicle traveling straight ahead in an adjacent lane. The path traversed during a lane change can be thought of as composed of two arcs. Although any number of curve shapes could be used to describe the path, one with constant curvature with a mid-point inflection is a reasonable description and is easy to deal with analytically. St. John and Glauz[15/] analyzed lane changing data from the literature, particularly as regards the time required to make lane changes. The shorter the time, the larger the curvature and, hence, the higher the tire wear costs. They found that 4.0 sec is representative of the time required to complete a lane change. Under hurried conditions, such as passing on a two-lane road it is possible to change lanes as quickly as 2.5 sec, but most lane changes take longer than this. For the present study we used 4 sec as being typical of the types of lane changes observed.

Figure 18 shows the incremental cost of a lane change for the composite car and pickup. It is dependent on the speed and the road surface type. Figure 19 shows similar data for the composite truck.

3. Increased oil consumption: Oil costs may be divided into two categories. One category is the cost associated with oil changes which should be performed when the oil is contaminated. The oil change frequency is recommended by the vehicle manufacturer and is relatively independent of vehicle speed, stop and go cycles, etc. Instead, it is a function of mileage driven and environmental conditions (for example, the oil should be changed more frequently when the vehicle is driven in a dusty environment).

The other category is the cost of adding oil between changes to replace that consumed. This oil consumption does depend on vehicle speed

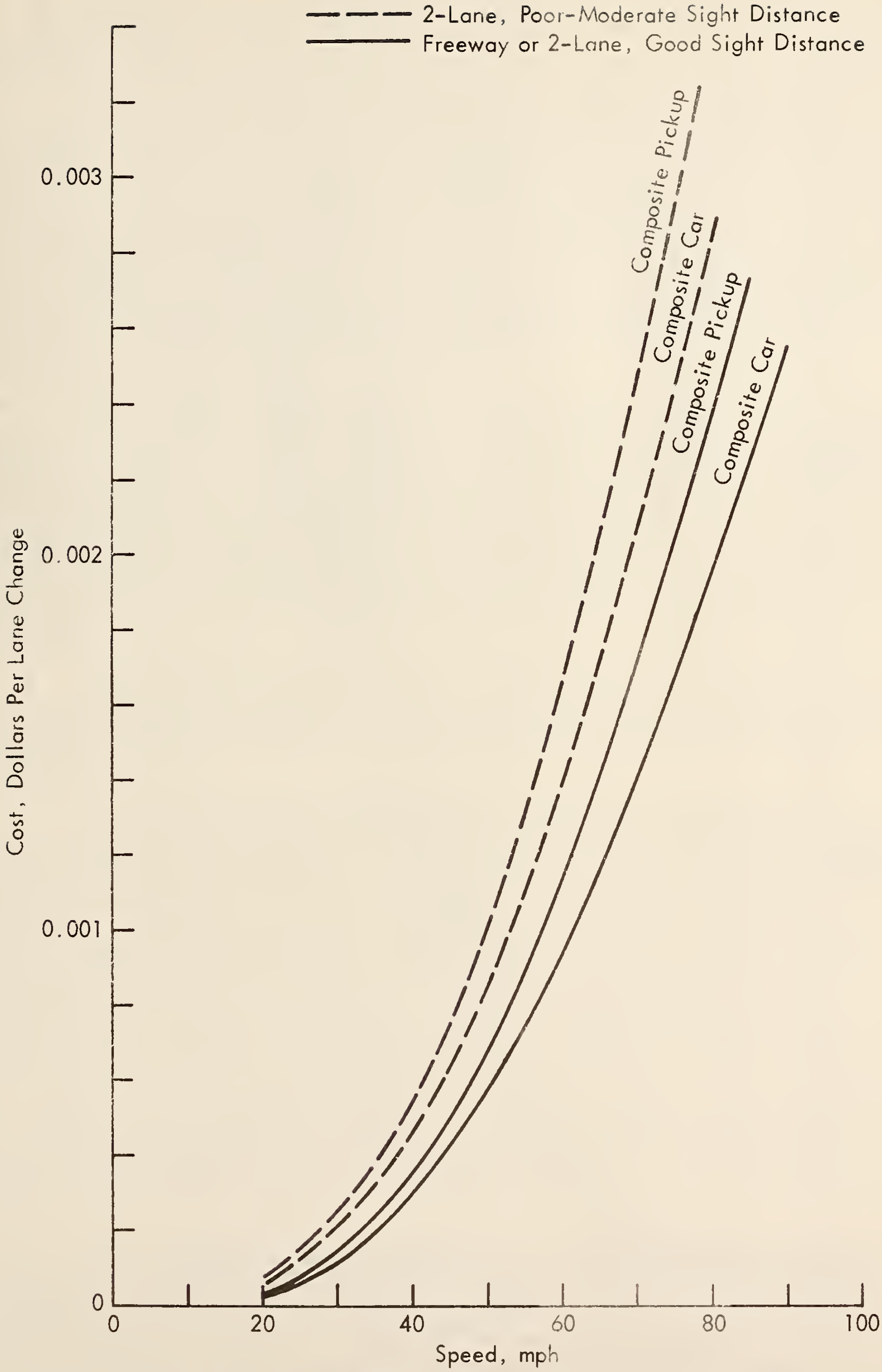

Figure 18 - Tire Wear Cost for a 4.0-Sec Lane Change
(Composite Pickup and Car)

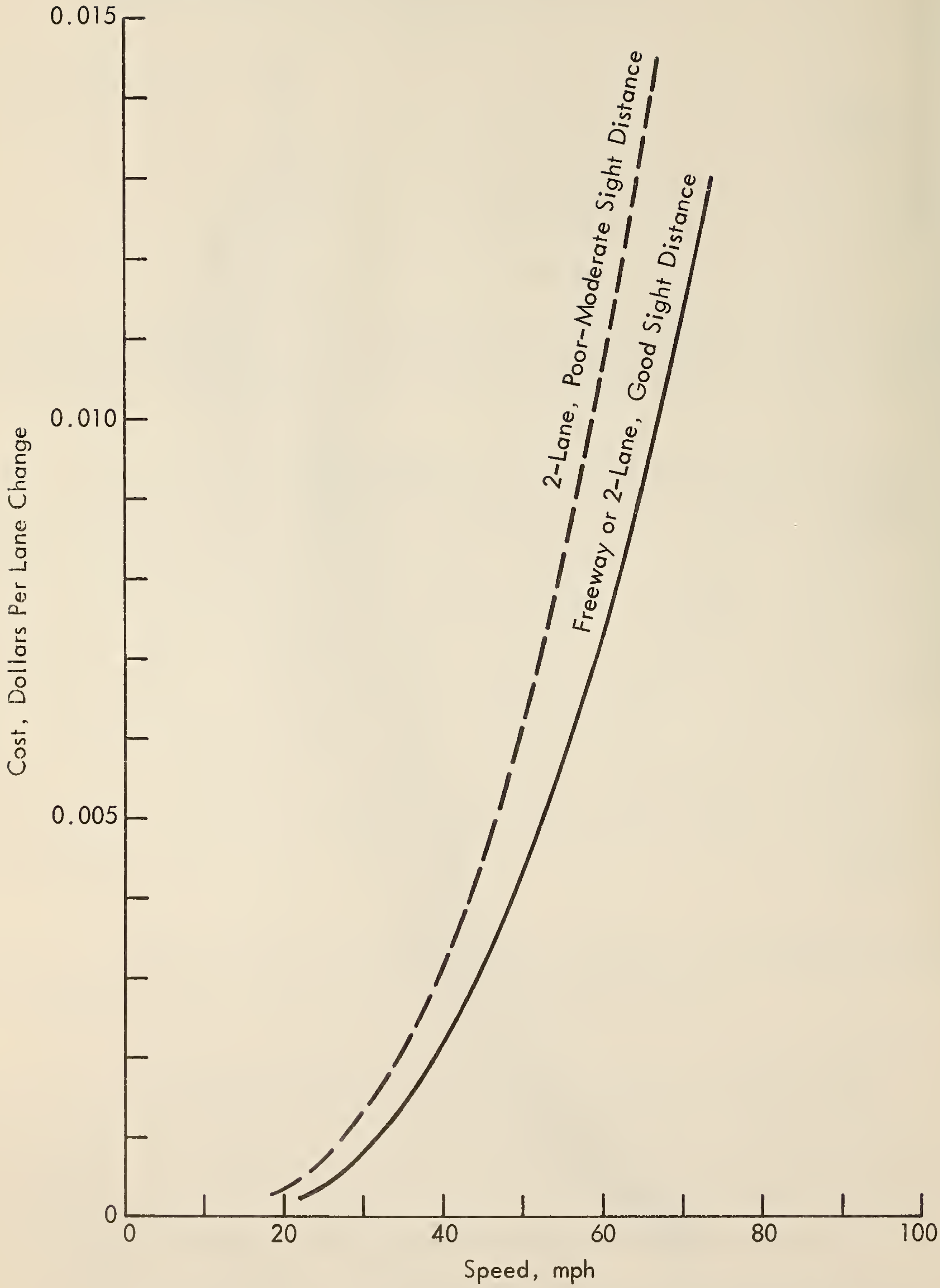

Figure 19 - Tire Wear Cost for a 4.0-Sec Lane Change
(Composite Truck)

and speed changes, so it should be examined as a possible source of costs to drivers in the vicinity of wide loads.

Both Winfrey[10/] and Claffey[11] give data pertaining to oil consumption. Both imply that, for a passenger vehicle, a consumption rate in the neighborhood of one quart of oil per 1,000 miles at 60 miles an hour is reasonable. The consumption rate, moreover, increases as the speed increases. Using Claffey's data, which require less judgment and assumptions, yields oil consumption costs associated with driving a car at a speed other than the free or desired speed which are less than 3% of the corresponding fuel costs. This ratio for pickup trucks and the composite trucks is even less. Therefore, this cost element can be neglected.

To estimate oil consumption during speed change cycles, Winfrey[10/] suggests a correction to the constant speed oil consumption rate. The correction amounts to using the (higher) oil consumption rate at the initial speed throughout the time period of the speed change cycle. Applying this technique to the passenger vehicle yields incremental costs in the neighborhood of 1% of the corresponding incremental fuel cost, and even less for pickup trucks and the composite trucks. Therefore, these costs also can be neglected.

In summary, because of their comparatively small contribution, the incremental costs of engine oil consumption were neglected compared to other incremental costs.

4. Accelerated depreciation: Winfrey[10/] discusses the effect of speed on vehicle depreciation. From other data he shows that the total lifetime mileage of a vehicle is higher if the average speed of the vehicle is higher. Therefore, the per mile depreciation cost is assumed to decrease as the average speed increases. This appears to be a generally valid argument which would be useful to the highway engineer or planner in considering highway design or redesign. We consider it inappropriate for the present study, however, to assume that if a vehicle is slowed down briefly by other traffic that its depreciation cost changes. It is unlikely that such a period of depressed speed will change the total mileage traveled by the driver--it will merely affect the time required to travel the distance. Because depreciation should be based on mileage, it is inappropriate to assign an incremental cost for depreciation.

5. Added maintenance expense: This cost element includes repair and replacement of vehicle components excluding fuel, tires, and oil. Claffey[11/] assumes that, with the exception of brake systems, vehicle maintenance depends primarily on mileage. Winfrey[10/] implies the same thing although he also allocates maintenance expense to vehicle speed. It is not clear how he performed this latter step, which resulted in somewhat higher

per mile maintenance costs at higher speeds. He does say that he used "considerable personal judgment" and that the results were "not substantiated by test data."

For this study we chose to follow Claffey[11/] and, therefore, by the same argument as used in the discussion of depreciation, incremental maintenance costs are inappropriate for the present study.

Maintenance of the braking system would be appropriate if, in fact, much evidence of braking were observed during the speed change cycles of traffic in the vicinity of a wide load. In fact, however, nearly all observed decelerations were of relatively low magnitude so that braking was not required.

6. Delay time: The incremental costs of the time lost because of traffic impedances is simply the product of the amount of time lost and the dollar value associated with lost time. The amount of time lost is relatively easy to calculate. However, it is important to note that, for example, if a motorist spends 5 min following a slow moving vehicle he may, in fact, have been delayed for 5 min but he was not delayed by 5 min. The time that he lost is the difference between the 5 min he was in queue and the time he could have covered that same distance at his unimpeded speed. Therefore, the time lost is given by:

$$\text{Time Lost} = t(1-v/V) \quad (14)$$

where, as before, t is the time during which the vehicle traveled at speed v instead of the desired or free speed V. In what follows it is convenient to express the speeds in miles per hour and the time in hours.

The more difficult problem is the assigning of a value to time. Probably the best study done in that regard is that of Thomas and Thompson.[16/] Their work involved examining the habits of motorists who had a choice between taking a toll-free road or, by paying a toll, taking an alternate route which would require less time. Their surveys yielded information relative to the trip purposes, income level, amount of time saved, and many other parameters. Their findings were that the value of time depended primarily on the trip purpose, the income level, and the amount of time saved. More to the point, the value of time saved was not linearly related to the amount of time saved. The implied value per minute or per hour depended on the number of minutes or hours involved. The authors point out that the user of this information, when comparing two alternatives, must therefore know the difference between the cumulative travel times for the entire trip using both alternatives; the time savings or losses over a portion of the trip are not sufficient to describe the situation.

Of course we have no information from this project as to the distribution of the income levels of the motorists who were actually delayed by wide loads. Neither, of course, do we have information on the motorists' trip purposes, or on the total amount of delay (due to all causes) that the motorists incurred on their trips, the length distributions of which we know nothing about either. So, to meet the challenge laid down by Thomas and Thompson, we made several assumptions.

The per minute saving certainly does depend upon the total time saved, as discussed by Thomas and Thompson. Mathematically, the cost incurred is a nonlinear function of the time saved. However, if one examines their results he finds that the nonlinearity is most pronounced when the total time saved is relatively short. If the total time is, say, over 20 min the function does not depart significantly from linearity--at least for most trip purposes and income levels. Therefore, we used the hourly savings based on 20 min total savings on the assumption that most of the trips we observed on the highway were of relatively long duration and that there would be time delays incurred from multiple causes. This assumption, if incorrect, tends to overestimate the value of time.

To estimate the distribution of income levels and trip purposes we used the results obtained by Thomas and Thompson.[16/] That is, we weighted the individual tabular entries in their work by the frequencies with which they observed motorists of those characteristics.

Because of the method which they used to collect the data, there is some question concerning the relative importance attached to the value of time for the various trip purposes. It is important to note that the costs compiled most nearly represent the value that the individual driver places on his time, not the value of his time to society. Specifically, the cost data imply that the value of time is highest for personal business and vacation trips and lowest for school and work trips. These rankings seem intuitively incorrect, but can be rationalized in terms of the data collection technique.

It seems reasonable that many drivers would cherish their personal time more than their work time, and therefore, reflect this personal attitude in the cost rankings. It is even conceivable that drivers making work trips, if being paid on a salary or hourly rate, might prefer to take the long route over the short route if driving were more pleasant than the work to be done at the end of the trip. This could lead to an implication of a zero or negative "value of time" for some motorists.*

Regardless of these problems, the data of Thomas and Thompson are probably the best in existence for passenger car trips and so were used in this study. We did convert the cost figures for work and school trips to a per car basis rather than the per person basis as given by the authors. Doing so and determining a composite cost over all income levels and trip purposes, as discussed previously, yielded an average of $4.285/hr/car as the value of time saved.

Pickup truck trips were handled in a slightly different fashion. From our own surveys discussed in Section III, we determined that approximately half of the pickup truck trips were for business purposes as compared to about one-fourth of the passenger vehicle trips. If we had used this fact with the Thomas and Thompson[16/] data and modified the trip purpose distributions accordingly, the value of time for a pickup truck trip would have been less than that for a passenger car trip. Such a conclusion would be at odds with all of the other studies of which we are aware. Therefore, a hybrid technique was developed.

Winfrey[10/] quotes results of a rather complete study of the cost of travel time for commercial vehicles. His data indicate that a nationwide average of $3.91/hr was the value of travel time for pickup trucks in 1965. This was corrected to $4.69/hr for the year 1969 using gross hourly earnings data from the Department of Labor, Bureau of Labor Statistics for their category "transportation and public utilities." These data yield an "inflation" factor of 1.198 between the years 1965 and 1969.

The value of time for a composite pickup truck trip was taken as the average of the Winfrey work trip cost and the Thomas and Thompson nonwork trip cost. The composite value thus determined was $4.62/hr.

The cost of time for trucks was determined solely on the basis of Winfrey's[10/] data. It averaged $5.94/hr in 1965 and $7.12/hr when corrected to 1969, for the composite truck in this project.

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* This, in fact, happened. Apparently Thomas and Thompson did encounter negative results with which they had to deal. First they eliminated data wherein the time required to make the free trip was less than the time required to take the toll road. Secondly, in estimating the expected benefits for the average (50th percentile) motorist with a given income level, trip purpose and time saving, they integrated over all motorists satisfying those criteria except they replaced any negative benefits by the value, zero.

In summary then, the incremental cost of time is given by multiplying the time lost as given by Equation 14 with the average hourly cost, H , given by Equation 15.

$$\left.\begin{aligned} H_{car} &= \$4.29/hr \\ H_{p.u.} &= \$4.62/hr \\ H_{truck} &= \$7.12/hr \end{aligned}\right\} \quad (15)$$

7. Air pollution

a. Carbon monoxide: There are two phenomena contributing to changes in carbon monoxide emissions. These are the difference in emission rate with speed and the emissions resulting from deceleration/acceleration cycles. Curry and Anderson[12/] give representative emission rate data for a composite 4,000 lb car. Their data for carbon monoxide are reproduced here as Figure 20a.

Curry and Anderson[12/] also present data on the incremental emissions occurring from stop cycles as a function of initial speed. These data were derived on the assumption that the vehicle used a constant deceleration (and acceleration) during the maneuver. Therefore, differing techniques are appropriate for estimating emissions during speed changing. That is, the emissions resulting from cycling from 70 mph to 60 mph and back, for example, are equal to the emission differences between a stop cycle from 70 mph and a stop cycle from 60 mph.

The total amount of carbon monoxide emissions, in pounds, can thus be given by:

$$E_{co} = (2.1)\{[e_{co}(v)-e_{co}(V)]vt + 19.5 \times 10^{-6}(v+V)(|V-v|)\}. \quad (16)$$

The factors, e_{co}, are from Figure 20a where v is the speed (miles per hour) at which the vehicle travels when different from V, the desired or free speed, for a time, t (hours). The numerical factor, 2.1, is applicable for the composite passenger vehicle on the highway in 1973. This factor should decline rapidly in future years as the more sophisticated emission controls become more common. Data are not readily available for the year 1969, but backward extrapolation from the information given by Curry and Anderson[12/] would indicate that a factor of approximately 2.6 would be appropriate.

Equation 16 is appropriate for the composite passenger car. Lacking data to the contrary, it was also used for the composite pickup truck. For the composite truck, however, Equation 16 should be multiplied by an additional factor, 1.63. This factor was deduced based on the assumption[12/] that trucks with gasoline engines have emissions 2.5 times those of the reference automobile but that the emissions of diesel engines, other than smoke, are negligible.

b. Hydrocarbons: Hydrocarbon emissions are determined in the same way as carbon monoxide emissions except that Equation 17 is used.

$$E_{HC} = (2.1)\{[e_{HC}(v)-e_{HC}(V)]vt + 0.2 \times 10^{-6}(v+V-40)(|V-v|)\}. \quad (17)$$

The value of e_{HC} is given by Figure 20b. The second half of Equation 17 should be set equal to zero if the sum, $v + V$, is less than 40 miles an hour. Again, a multiplying factor of 1.63 should be used for the composite trucks.

c. Other emissions: The procedures of Curry and Anderson[12/] imply that emissions of oxides of nitrogen depend primarily on distance traveled, and not on speed. Therefore, the influence of other traffic on these emissions is unclear and, at this stage, its calculation is inappropriate.

There are also apparently insufficient data to evaluate the effects on emissions of smoke, particulate matter, and lead as well as smog which is chemically produced in the atmosphere by reaction of vehicle emissions in the presence of sunlight.

d. Air pollution costs: Dollar costs resulting from air pollution depend strongly on a variety of environmental conditions, and even under controlled conditions only a small amount is known. In addition to the amount of pollutants, damage done will depend on atmospheric conditions which will affect the dispersal of pollutants, the types of vegetation nearby, the types of structures, building materials, etc., in the vicinity, and, as regards animals and humans, their population density and other factors. In view of these many unknowns, only the amount of the basic pollutants, carbon monoxide and hydrocarbons, were determined--no dollar values were associated with them.

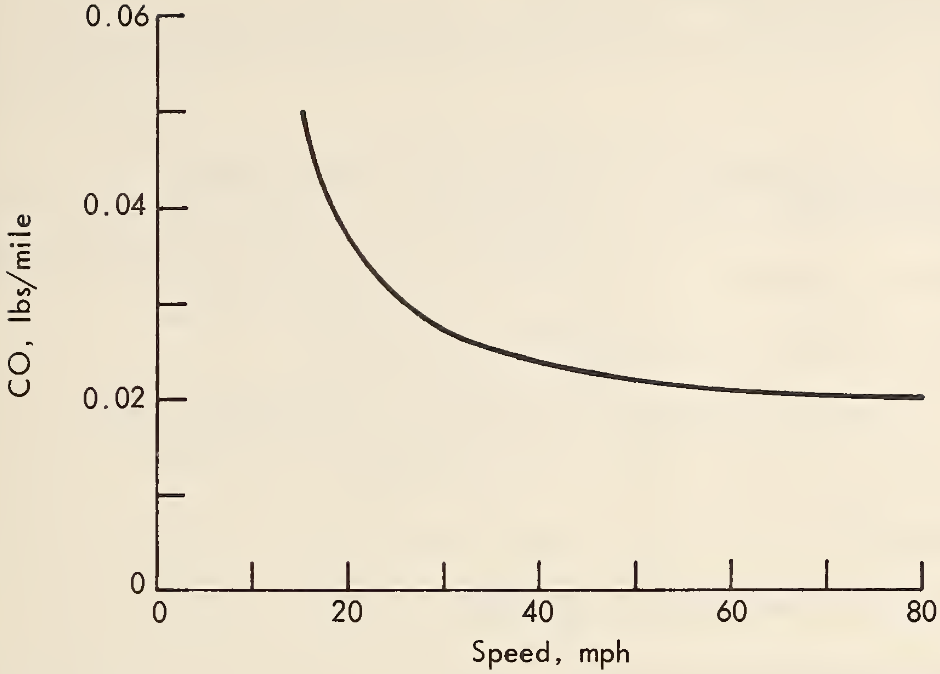

Figure 20a -- Carbon Monoxide Emissions at Uniform Speed

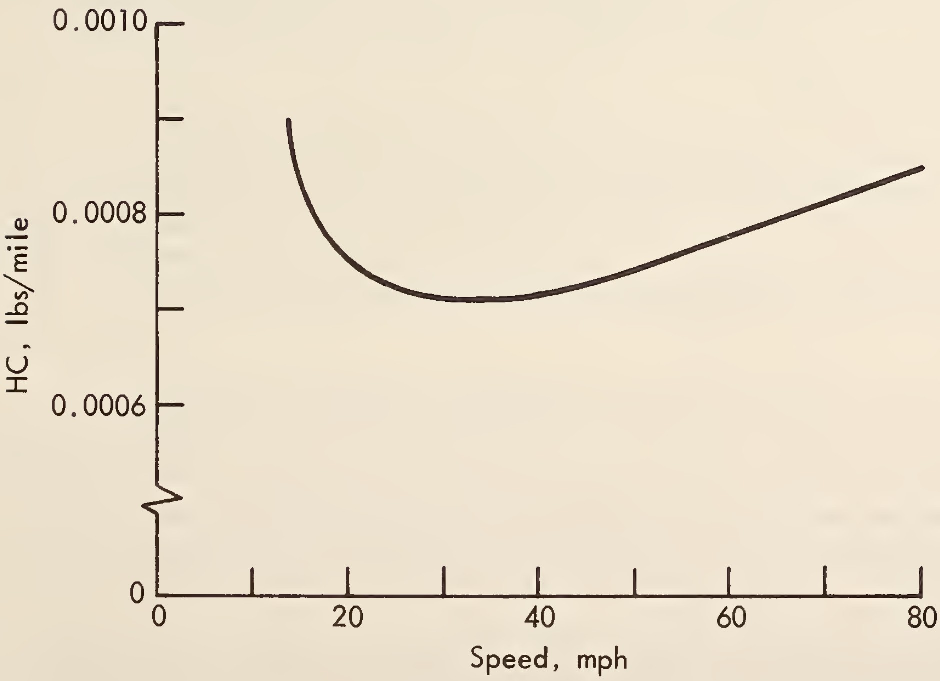

Figure 20b - Hydrocarbon Emissions at Uniform Speed

C. Calculation of Costs to Other Traffic

The costs incurred by traffic encountering the wide loads were calculated using:

- The passing and queuing counts obtained in the field data collection;
- Maneuver characterisrics deduced from the photographic data; and
- Results of the cost analysis just discussed.

Four cost-incurring traffic situations are included. These are:

- Traveling in queue;
- Unimpeded overtaking and passing;
- Passing from queue; and
- Meeting from the front (oncomers).

The cost calculations were programmed for computer processing. In the following the calculation procedure is briefly discussed, input and output are described and the results of statistical analysis of the cost results are presented.

1. Procedure: Initially we considered calculating costs separately for each minute of observation. However, this would result in sporadic results which would be difficult to interpret. We decided, therefore, to calculate total costs for the contiguous observation periods employed in the data collection. The length of these periods vary from about 5 to 30 min, but most are about 15 min.

The vehicle population was subdivided into the three general classes--passenger, pickup, and truck. Average desired free speeds, passing speeds, and passing distances for each class were determined from the photographic data samples and used with the results from Section B to quantify the cost of maneuvers executed by traffic in response to the wide load.*

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* It may appear that a more precise approach would be to use individual measured speeds and passing distances rather than averages. However, this would require photographing all of the traffic--an impractical and unnecessary filming and data reduction task.

Total costs were obtained using the unit costs and the maneuver counts from the field data. (The formulations used are presented in Appendix E.) The calculated costs were normalized by dividing by the distance traveled by the wide load during the observation period, to put them on a comparable per mile basis.

2. Input to cost calculations: Two kinds of input are required for the cost calculations. One involves the frequency of queuing and passing events and specifically includes:

- Average speed of wide load;
- Minutes queued by each class of vehicle;
- Number of unimpeded passes by each class of vehicle;
- Number of passes from queue by each class of vehicle; and
- Number of oncoming vehicles of each class.

All of these quantities were directly observed and recorded during data collection and were readily available for subsequent computations.

The second type of data involves parameters which specify details of the maneuvers performed by the other traffic. Included are:

- Desired speed of each class of vehicle;
- Average speed during unimpeded pass by each class of vehicle;
- Distance traveled (relative to the wide load) at adjusted speed by unimpeded passer;
- Average speed of each class of oncomer under influence of wide load; and
- Distance traveled (relative to the wide load) at adjusted speed by oncomers.

These quantities were obtained from the analyses of the photographic data. In some cases data were available from the same trips in which the queuing and passing counts were obtained. Otherwise photographic data from other trips were used to guide the selection of input parameters. In the latter case, particular attention was paid to matching the photographic data and the queuing/passing data on the bases of geographical location, roadway type, and quality.

3. <u>Computer program output</u>: A sample of the computer program output is shown in Figure 21. Dollar costs are printed in considerable detail as well as in summary. The notation in the output is largely consistent with that used in the formulations (Appendix E), and the output format is nearly self-explanatory. The first line is a descriptive comment. The second line contains the maneuver parameter input. Subscript 1 refers to passenger class, 2 to pickup, and 3 to truck. The general definitions are:

Output	Description
VF(I)	Desired speeds
VFP(I)	Unimpeded pass speeds
VO(I)	Oncomer speeds
LFP(I)	Unimpeded pass distances
LO(I)	Oncomer distances
F1(I)	Fraction of unimpeded passes made out of right-hand lane

Traffic volume (vehicles per hour) refers to flow past a fixed point in the same direction as the wide load. This volume was estimated from the observed count and average speed of overtakers under the assumption that the cumulative distribution of speeds has the characteristic <u>shape</u> exhibited by Curve D, Figure 3.24 of the Highway Capacity Manual.*

The remainder of the output contains computed dollar costs and air pollutant emissions in a self-explanatory format.

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* A simpler approach is to assume that all overtaking traffic travels at the measured average speed. Flow rate past a fixed point is then equal to flow rate past the wide load times the factor 1/(1 - speed of load/average speed of overtakers). For oncoming traffic it was found that the more sophisticated method using the speed distribution gives results which are very similar to those obtained with the simpler method. Accordingly, the simpler approach was used for estimating oncomer flow rate from oncomer counts (two-lane traffic).

TRIP 1-I 12X64-MOBILE INTERSTATE PLAIN-SIGNING NO-ESCORTS MISSOURI

VF(1)	VF(2)	VF(3)	VFP(1)	VFP(2)	VFP(3)	LFP(1)	LFP(2)	LFP(3)	F1(1)	F1(2)	F1(3)	VO(1)	VO(2)	VO(3)	LO(1)	LO(2)	LO(3)
75	71	61	72	75	63	400	400	280	.50	.90	1.00	-0	-0	-0	0	0	0

MINUTES		5	13	12	9	9
HOUSE SPEED		45	44	43	47	50
MILES		3.7	9.5	9.6	7.0	7.5
TRAFFIC-VPH		416	255	416	140	140
	PASS	0.0000	-.0007	0.0000	0.0000	0.0000
GQ	PU	0.0000	0.0000	-.0075	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
	PASS	0.0000	-.0010	0.0000	0.0000	0.0000
TQ	PU	0.0000	0.0000	-.0058	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
	PASS	0.0000	.0031	0.0000	0.0000	0.0000
DQ	PU	0.0000	0.0000	.0177	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL Q		0.0000	.0013	.0044	0.0000	0.0000
	PASS	.0020	.0018	.0021	.0006	.0005
GFP	PU	0.0000	0.0000	-.0000	0.0000	-.0000
	TRUCK	.0021	0.0000	.0009	.0034	.0011
	PASS	.0043	.0038	.0044	.0013	.0011
TFP	PU	0.0000	0.0000	.0005	0.0000	.0012
	TRUCK	.0053	0.0000	.0023	.0085	.0027
	PASS	.0012	.0010	.0011	.0004	.0004
DFP	PU	0.0000	0.0000	-.0001	0.0000	-.0002
	TRUCK	-.0002	0.0000	-.0001	-.0003	-.0001
TOTAL FP		.0147	.0066	.0111	.0137	.0066
	PASS	0.0000	.0006	0.0000	0.0000	0.0000
GQP	PU	0.0000	0.0000	.0003	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
	PASS	0.0000	.0006	0.0000	0.0000	0.0000
TQP	PU	0.0000	0.0000	.0006	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL QP		0.0000	.0011	.0009	0.0000	0.0000
	PASS	0.0000	0.0000	0.0000	0.0000	0.0000
GON	PU	0.0000	0.0000	0.0000	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
	PASS	0.0000	0.0000	0.0000	0.0000	0.0000
TON	PU	0.0000	0.0000	0.0000	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
	PASS	0.0000	0.0000	0.0000	0.0000	0.0000
OON	PU	0.0000	0.0000	0.0000	0.0000	0.0000
	TRUCK	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL ON		0.0000	0.0000	0.0000	0.0000	0.0000
DELAY $/MI		.0010	.0041	.0186	.0000	.0001
OTHER $/MI		.0137	.0049	-.0021	.0137	.0066
TOTAL $/MI		.0147	.0090	.0165	.0137	.0066
	PASS	.0434	.0543	.0442	.0126	.0121
ECO	PU	0.0000	0.0000	.0208	0.0000	.0064
	TRUCK	.0021	0.0000	.0009	.0033	.0010
CO (LB/MI)		.0455	.0543	.0659	.0162	.0195
	PASS	.0003	.0004	.0003	.0001	.0001
FHC	PU	0.0000	0.0000	.0000	0.0000	.0000
	TRUCK	.0000	0.0000	.0000	.0000	.0000
HC (LB/MI)		.0003	.0004	.0004	.0001	.0001

Figure 21 - Sample of Cost Program Output

D. Results of Cost Calculations

Dollar costs to other traffic and incremental air pollutant emission induced by wide loads were calculated as described earlier. A statistical analysis of the costs was conducted to determine the influence of load type, width and speed, escort usage, and variations in signing and warning configurations. The results are presented here. For clarity of presentation, we consider the total dollar costs on multilane highways first, next examine the two-lane highway results, and finally look at time delay costs separately from other costs.

1. Multilane highways: Multilane highway data were collected during 19 trips; a total of slightly over 1,300 min of data were obtained which were suitable for use in the cost calculations. The load configurations are summarized in Table XV, where a configuration is completely defined by four parameters, namely, width, signing, escort and load type. In two instances a trip appears twice in the tabulation because one of the parameters changed enroute. The two levels of speed for 12-wide loads were obtained by grouping speeds of 52 mph and less under "slow" and the remainder under "fast." This breakpoint was selected because one group of wide load speeds clustered about 60 mph and the second group, except for Trip 1-9 at 52 mph, fell below 50 mph.

A gross picture of the results is provided by Figure 22 which shows the average dollar costs and incremental carbon monoxide emissions plotted against average traffic volume for each configuration identified in Table XV. The data are widely scattered, reflecting the effects of variables other than flow rate. However, the purpose of Figure 30 is to show the range of results and not to infer any correlations; flow rate was chosen as the abscissa because it might be anticipated to be the major factor affecting costs.

Figure 30 shows that the dollar cost incurred by other traffic due to the wide load is very small. It was almost always less than $0.02 per wide-load mile which is obviously small considering it is the total for all traffic encountering the load. The cost is almost entirely due to unimpeded passing by overtakers. (There is very little queuing and, of course, no oncomers.) Tire wear costs from lane changing are generally largest; fuel consumption costs and time delay costs are sporadic.

Carbon monoxide emissions induced by the wide load are also small as illustrated by comparing the emissions in Figure 30 with 2 lb/100 miles which is the approximate emission rate for a single vehicle traveling at a uniform speed of 60 mph (Figure 28a). Hydrocarbon emissions were also calculated. They have the general character of the CO emissions, but reduced by a factor of about 200. For both CO and the hydrocarbons, the incremental

TABLE XV

MULTILANE HIGHWAY TRIPS INCLUDED IN COST CALCULATIONS

Trip	Minutes of Data	Average speed mph	House Width: 12-wide (fast)	House Width: 12-wide (slow)	House Width: 14-wide	Signing[a/]: Plain	Signing[a/]: Special	Escort: None	Escort: Rear	Type of Load: Mobile	Type of Load: Double Wide	Type of Load: Modular	Type of Load: Divisible Modular
1-1	48	46		x		x		x		x			
1-9	21	52		x		x		x		x			
1-10	155	58	x				x	x		x			
1-12	74	48			x		x		x	x			
1-12	132	48		x			x		x	x			
1-13	137	43			x		x		x	x			
1-23	15	57			x		x	x		x			
1-23	27	55			x		x		x	x			
1-24	119	50			x		x	x		x			
1-25	73	44		x		x		x					x
1-27	59	44		x		x		x					x
2-1	59	47			x		x		x	x			
2-3	79	46			x		x		x	x			
2-14	34	50		x		x			x			x	
2-19	38	60	x			x		x		x			
2-20	39	62	x			x		x		x			
2-21	78	59	x			x		x		x			
2-26	10	40			x	x			x	x			
2-30	89	50		x		x		x			x		
2-32	32	47		x		x		x				x	
2-35	9	42		x		x		x				x	

a/ "Plain" signifies that only a sign and flags were displayed; "Special" indicates that amber warning flashers were mounted on the rear of the load.

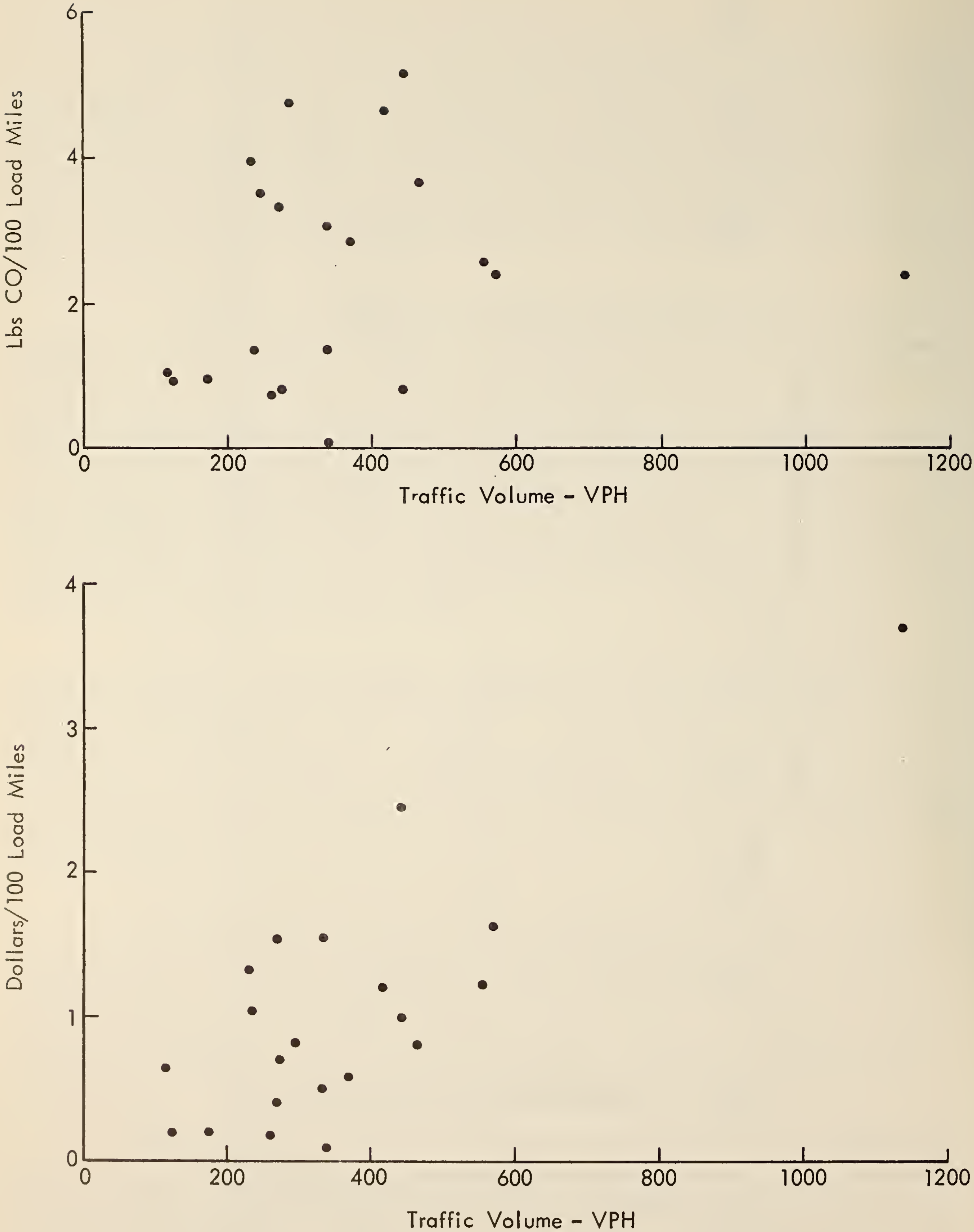

Figure 22 - Incremental Costs and Pollutant Emission--Multilane Highway
(Each plotted point represents a wide load trip)

emissions are due entirely to the speed change cycles executed by the other traffic. The change in emissions resulting from temporarily traveling at speeds different from the desired speeds is negligible.

A statistical analysis of the costs and pollutant emissions was conducted to compare the effect of configuration parameters. The initial analysis consisted of a sequence of one-way analyses of variance supplemented, where applicable, by comparisons of means (Fisher method). In certain cases variables are badly confounded, e.g., almost all two-lane trips with special signing (flashing lights) are on 12-wide loads. Therefore, several comparisons of this type were made using a general (unbalanced) analysis of variance approach.

The following configuration parameters were considered:

Speed - 12-wide slow vs 12-wide fast

Size - 12-wide vs 14-wide

Signing - plain vs special

Escort - none vs rear

Type - mobile vs modular vs divisible modular

The analyses of dollar costs produced the following results at 0.01 significance:

- The slow 12-wides induced larger costs than the fast (approximately 2:1).

- 14-wides induced larger costs than 12-wides (approximately 1.5:1).

- A rear escort induced larger costs than no escort (approximately 1.5:1).

It was also indicated at 0.05 significance that the divisible modular induced larger costs than the regular modular. This effect is not intuitive and is judged to be unreal on the basis of credibility, lower confidence level and small sample size. As discussed earlier (Section II-C.1), the abnormally low speed and the low, bright sun associated with the divisible load trips were probably the cause of the finding--not the divisible load per se.

The analysis of CO emissions indicated no significant differences between the configuration parameters.

2. Two-lane highways: Two-lane highway data were collected during 22 trips. Just under 1,000 min of data were obtained which were suitable for use in the cost calculations. The load configurations are summarized in Table XVI. In this case the breakpoint between "slow" and "fast" is 42 mph, in contrast with 52 mph for multilane trips.

A gross picture of the overall results is shown in Figure 23. Dollar costs are again seen to be generally small, but two important differences between these and the multilane costs are notable. First, many of the costs here are negative and, secondly, some of the negative cost magnitudes are quite large. The negative costs arise when the operating cost savings from reduced fuel consumption and tire wear at reduced speed overbalance the costs of speed changing and time delay in queue. This occurs when the time spent in queue increases; the largest negative costs were from samples with especially large queue times. Dollar costs on two-lane highways arise principally from queuing and from speed changes of oncomers. There is very little unimpeded passing.

Incremental CO emissions increase by a factor of 10 between multilane and two-lane highways. This is not surprising. It has already been observed that the incremental emissions are caused by speed changing. Furthermore, the emission magnitudes are proportional to the speed change magnitudes. On two-lane highways speed reductions by overtakers are much larger than on multilane facilities, and there is the added effect of moderate speed reduction by oncomers.

A statistical analysis of the two-lane results was conducted, similar to the multilane case. The same configuration parameters were considered except that now there are four escort options instead of just two (none, front only, rear only, and both front and rear).

The analysis of dollar costs produced no differences detectable at $\alpha \leq 0.05$. The failure to detect parametric influences must be due to the rather widespread variation in costs between trips (Figure 31) and to the high variance during the trips (not shown).

The analysis of CO emission produced the following results at 0.01 significance:

- The slow 12-wide loads induced larger incremental emissions than the fast (approximately 1.5:1).

TABLE XVI

TWO-LANE HIGHWAY TRIPS INCLUDED IN THE COST CALCULATIONS

Trip	Minutes Of Data	Average Speed mph	House Width: 12-wide (fast)	12-wide (slow)	14-wide	Signing[a/]: Plain	Special	Escort: None	Front	Rear	Both	Type of Load: Mobile	Double Wide	Modular	Divisible Modular
1-2	24	46	x			x			x			x			
1-9	216	48	x			x		x				x			
1-10	16	49	x				x	x				x			
1-14	32	50			x		x	x				x			
1-18	86	53			x		x	x				x			
1-23	112	45			x		x				x	x			
1-24	50	45			x		x	x				x			
1-24	29	46			x		x				x	x			
1-25	16	42		x		x		x							x
1-27	9	45	x			x		x							x
2-10	21	40		x		x			x					x	
2-11	28	39		x		x			x					x	
2-14	45	43	x			x			x					x	
2-15	18	40		x		x			x					x	
2-19	19	42		x		x		x				x			
2-20	22	47	x			x		x				x			
2-20	6	39		x		x			x			x			
2-21	19	33		x		x			x			x			
2-26	44	42			x	x				x		x			
2-29	22	37		x		x				x				x	
2-30	64	45	x			x		x					x		
2-32	44	44	x			x		x						x	
2-34	20	44	x			x		x						x	
2-35	21	36		x		x		x						x	

a/ "Plain signifies that only a sign and flags were displayed; "Special" indicates that amber warning flashers were mounted on the rear of the load.

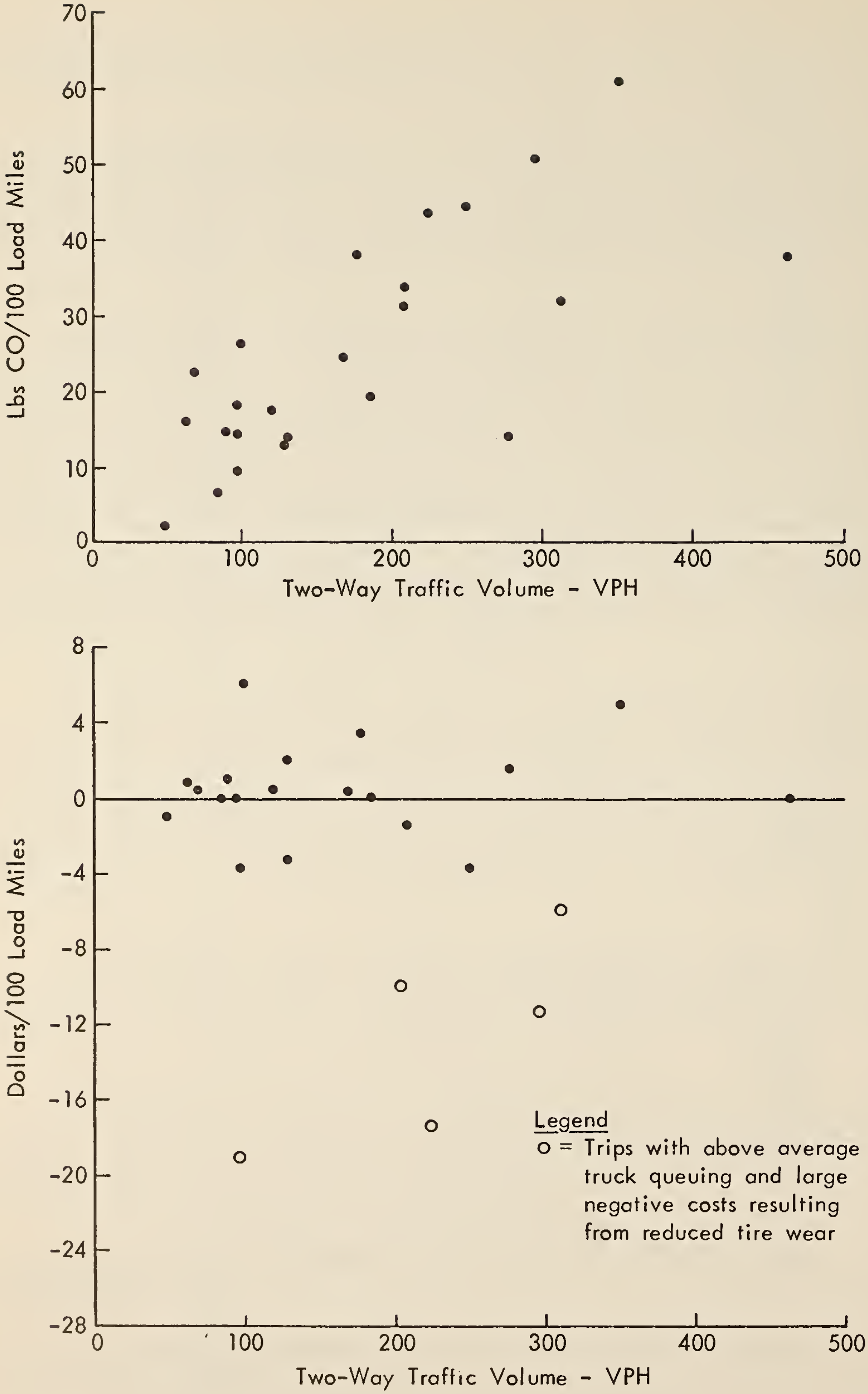

Figure 23 - Incremental Costs and Pollutant Emission--Two-Lane Highway
(Each plotted point represents a wide load trip)

- The 14-wide loads induced larger incremental emissions than the 12-wide (approximately 1.5:1).

- Of the escort options the use of a front escort or two escorts induced the largest emissions. The no-escort case was next in severity and the rear-escort case was least severe.

The larger effect of slow loads agrees with the previously discussed fact that incremental emissions are proportional to speed change magnitude. The larger effect of the 14- over the 12-wide loads may be partly a speed effect. Review of the trip data reveals that the 14-wide trips were made in regions where the free speed of other traffic was high. Larger speed decrements experienced by queuing traffic, not necessarily related to load size, may explain some of the increased pollutant emission.

The increased emissions accompanying use of a front escort or two escorts can be explained on the basis that many overtakers are forced into queue behind the load or rear escort, and subsequently into a second queue behind the front escort, thus increasing the number of speed change cycles. The apparent lack of effect of a rear escort may be due to the fact that rear escorts travel close to the load so overtakers seldom queue between the rear escort and the load. Conceptually, the addition of a rear escort displaces the queue from behind the wide load to behind the escort, and possibly increases queue lengths by adding to the effective length of the vehicle to be passed.

3. Time delay costs: Following the analysis of total costs, the cost of time delay was singled out and analyzed separately. A gross picture of time delay costs is shown in Figure 24 where average time delay costs are plotted vs average traffic volume for multilane and two-lane highways. For multilane highways the costs are seen to be very small, as expected. For two-lane highways, however, the costs for some trips are large, reaching an extreme in one case of $0.25 per mile.*

The following results were obtained from the statistical analyses:

- On multilane highways at 0.05 significance no differences were detectable among the configuration parameters.

- On two-lane highways at 0.05 significance time delay costs induced by slow 12-wide loads were larger than those induced by fast loads (approximately 2.5:1).

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* This cost was obtained for Trip 2-21 where there was an above average amount of queuing. It should be viewed with some reservation since only 19 min of data were obtained during this trip. The two values near $0.20 per mile in Figure 24 also were obtained from short time samples.

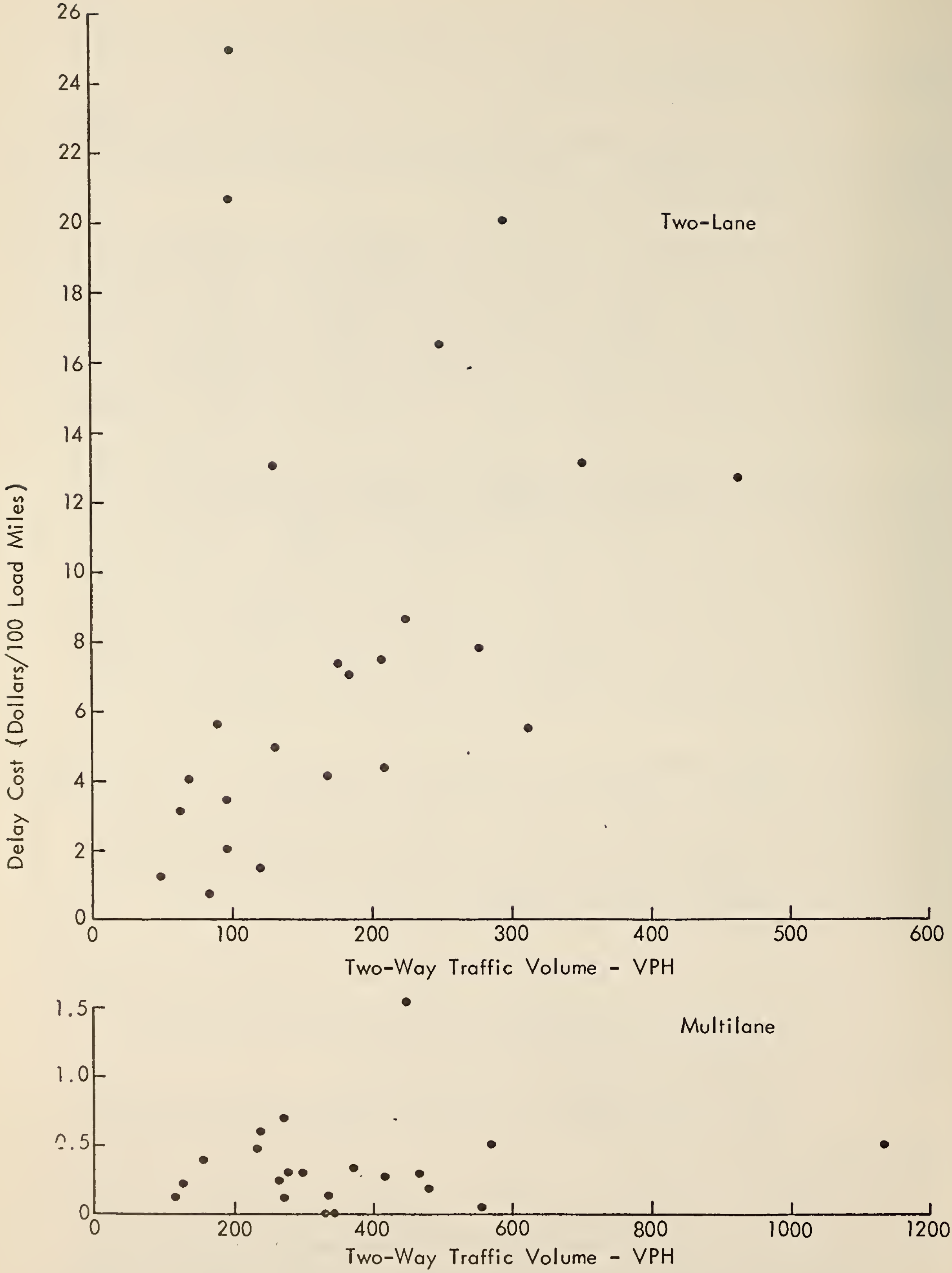

Figure 24 - Time Delay Costs (Each plotted point represents a wide load trip)

The failure to detect differences for multilane highways could be anticipated because the costs are very small and parametric influences are unimportant. It might be possible to detect differences from larger samples but not worth the effort.

For two-lane highways the higher delay costs precipitated by slow loads is understandable and in agreement with similar findings concerning slow loads.

E. Summary of Cost Analyses

The following general comparisons were observed between multilane and two-lane trips:

- On two-lane highways the net dollar costs imposed on other traffic were both positive and negative. (Negative cost implies a saving; lower fuel consumption at reduced speed, for example.) On multilane highways, imposed costs were always positive.

- The magnitudes of imposed dollar costs--either positive or negative--were much larger on two-lane than on multilane highways.

- Incremental pollutant emissions precipitated by the wide loads were an order of magnitude larger on two-lane than on multilane highways.

- Time delay costs were much higher on two-lane than on multilane highways.

The following effects of configuration parameters were detected at 0.01 significance:

On Multilane Highways

- The slow 12-wides induced larger total costs than the fast 12-wides.

- The 14-wides induced larger total costs than the 12-wides.

- A rear escort induced larger total costs than no escort.

On Two-Lane Highways

- Time delay costs induced by slow 12-wides were larger than those induced by fast 12-wides.

- The slow 12-wides induced larger incremental air pollutant emissions than the fast 12-wides.

- The 14-wides induced larger incremental pollutant emissions than the 12-wides.

- Of the escort options, a front escort or two escorts induced the largest incremental emissions. The no-escort case was next in severity and the rear-escort case was least severe.

V. EXAMINATION OF COSTS TO SHIPPERS AND/OR CARRIERS AND STATES

A. Introduction

Every state has regulations or policies pertaining to the movement of overdimensional cargoes such as mobile homes. Compliance with oversize regulations contributes to the carrier's costs. Also, regulations vary from state to state and, as a result of variance, give rise to further incremental costs to carriers and shippers. This study examines these costs. Assessing the cost of compliance calls for analyzing each state's regulations, determining differences in regulations between states, and assigning costs of complying with the regulations and variances.

Additionally, the existence of state overdimension or permit regulations brings about a cost burden to the states. States must provide for issuance of oversize permits and enforcement of attendant regulations. Therefore, examination of the costs to the states of providing for and enforcing carrier compliance is also in order.

A four-element approach was developed to fulfill the requirements of this task. The elements are: (1) a detailed analysis of existing state regulations which affect the transportation of overdimensional mobile and modular homes, (2) the determination of variances in regulations between adjacent states, (3) the development and application of cost data which relate to regulations and variances in regulations, and (4) the determination of costs to the states of issuing permits and enforcing pertinent regulations. The approach is discussed further in Section V-B.

The findings of the cost analyses are presented in two distinct parts. One part contains a narrative discussion of the various elements considered in the studies and includes the following topics:

- Permit Regulations;
- Cost Burden to the States; and
- State Transportation Regulations (including):

    1. Signs,
    2. Flags,
    3. Warning lights,
    4. Escorts,
    5. Time of operations,
    6. Towing vehicles,
    7. Dimensions,

8. Coach equipment,
9. Speed limits,
10. Insurance, and
11. Routing.

Appendices B and C comprise the second part of the presentation. They contain the details of regulatory application and impact. Appendix B presents regulations applying in each state (as of 1 July 1973) and the cost to carriers and shippers of compliance. Differences in regulations between adjacent states are identified in Appendix C, and cost impacts of the variances are quantified.

Descriptions of six hypothetical interstate shipments conclude the narrative and tie together various parts of the narrative and appendices. Examples of how and when regulations apply, blended with the cost impact of compliance with those regulations, and variances between states, offer an approximation of the costs borne by shippers and carriers.

B. Methodology

Execution of the four-element approach involved many information sources, but principal among them were compendia of regulations, carrier and shipper representatives, state officials, actual trip experience, and Mobile Housing Carriers Conference tariffs.

Several compilations of regulatory abstracts have been assembled and are in use throughout the mobile housing carrier industry. These are necessary because it is difficult for an individual to keep current with regulations and policies in more than a few states. Generally, the compilations contain a description not only of existing regulations, but also policies which affect mobile home transportation on state highways. Contracted drivers of several large carriers are issued a volume at the beginning of their service, which they sometimes refer to as their "bible." We made use of three such books in defining and categorizing regulatory parameters and listing regulations by state. Using three volumes, however, led to many difficulties. There is disagreement among the three, and determining existing regulations and policies proved to be more complex than imagined. The experiences of shipper and carrier representatives as well as state officials supplied information to resolve the discrepancies and provided other information.

Seven pilot interviews with shippers and carriers were conducted to familiarize the researchers with the industry and its regulatory constraints, and to assess available information sources. The pilot interviews included discussions with three common carriers and four manufacturers. Of the manufacturers interviewed one produces mobile homes only, two make mobiles and modules, and one manufactures modules only. The manufacturers employed various distribution methods--one used only private carriage, two combined private and common carriage, and one used common carriers exclusively. Thus, the cross section of shipper/carrier pilot interviews was comprehensive.

The pilot interviews acquainted the researchers with the extreme variability regarding when and how various regulations apply and their consequent impact. It was found that some regulations tend to apply regionally, and many are conditional on factors such as dimensions or highway type.

We discovered that aggregate averages or composite trips are not meaningful in most instances. Instead, each trip occasions various regulatory situations dependent on a number of combined variables.

In order to provide more complete understanding of the various states' regulatory interpretations, applications, and impacts, additional interviews with shippers and carriers were conducted. It was felt that shipper/carrier nationwide experience with thousands of trips provides the best basis for comprehensive appreciation unconstrained by geographic limits. A total of 26 interviews of this type were conducted in all parts of the country. Interviews included 21 common carrier and five private carrier representatives. The subjects related their experience regarding interpretation, application, and impact of regulations and policies in the following categories:

- Permits (type, acquisition, costs);
- Accessories (signs, flags, lights);
- Operating constraints (time, routing speeds);
- Vehicle configuration (special power, dimensions, coach equipment); and
- Escort requirements.

This information enabled the researcher to supplement the determination of existing state regulations, understand the incidence and significance of variances of regulations between states, and assess the incremental cost impact of regulations and their variances to mobile home shippers and carriers.

State officials played an important role in several facets of this task. Permit directors in 48 states were informed by letter of the research study and asked to provide copies of regulations pertinent to wide load transportation in their respective states. Additionally, they were asked to identify individuals who might be able to answer specific questions regarding permit operations. Telephone interviews were subsequently conducted with respondent officials in 34 states, and questions were asked concerning the following:

- Wide load transportation policy and philosophy;
- Permit type and issuance;
- Cost of issuance;
- Enforcement of permit regulations; and
- Cost of enforcement.

Where further benefits from personal contact seemed likely, visits were made. In conjunction with Section V specifically, personal interviews with officials of two states were conducted to further develop data relating to issuance costs. Officials of five other states were personally contacted in conjunction with the motorist surveys; however, cost inputs were also obtained. Contributions of state officials enabled completion of the determination of state regulations and policies and provided permit issuance and cost data.

Actual trip experience was useful in quantifying circuitous routing and qualifying causes of trip delay. Circuity was determined in five geographic locations selected as centers of mobile or modular home manufacturing. At each location 100 trip records were analyzed to determine actual trip miles to destination with an extra-legal load in tow, and return miles when the vehicle was legal. The mileage difference represented circuitous routing occasioned because of the wide load. Regulation-related delay of trips made in conjunction with the traffic data collection (Section II) was noted along with the causes of delay. Analysis of escort costs by trip experience proved futile due to varying escort requirements and the unavailability of a large smaple of trip records.

Tariffs filed with the Interstate Commerce Commission provided additional cost information. Pertinent tariffs include MF-I.C.C. No. 23, MF-I.C.C. No. 24, and MF-I.C.C. No. 25, relating to initial mobile home moves, modular moves, and secondary mobile home moves, respectively. The tariffs set forth specific charges and rates which must be applied by common carriers. All charges and rates have been approved by the Interstate Commerce Commission as justified for the services performed. Where questions arose, resolution was sought from a representative of the Mobile Housing Carriers Conference, Inc., who acts as agent for member carriers before the Interstate Commerce Commission.

C. <u>Study Scope and Limitations</u>

Investigations conducted in conjunction with this cost study concerned interstate transportation of overdimensional mobile and modular homes, primarily 12- and 14-ft wide. The effect of each regulation is examined and expressed as a function of each act of compliance. Because such acts are so highly trip (and state) dependent, no attempt has been made to assess the aggregate (e.g., summed or integrated) impact of various state regulations.

The study focuses only on highway transportation of mobile (and modular) homes, as distinguished from all other types of cargo. For this reason no consideration is given to the general requirements for truck licensing, fuel tax payment, and P. S. C. compliance. Also, the study was limited to investigation of state regulations and excluded probes into regulations set forth by other government bodies.

Each regulation is considered independently except where compliance with two or more regulations in conjunction clearly imposes an additional economic burden on the carrier or shipper. This may cause some cost totals to be conservative.

Delay of shipments due to regulations is not uncommon. Where regulation-related delays can be accurately predicted in keeping with the specific trip orientation of the study, those delays have been taken into account. Some delays, however, cannot be specifically predicted. Examples include delay due to weather and untimely permit receipt. More precisely, some states prohibit wide-load movement while certain inclement weather conditions prevail. Also, for various reasons, valid permits may not be in the hands of carriers at the intended departure time. In neither instance are sufficient data available to substantiate the frequency of these occurrances and duration of delay making even the application of gross averages impossible. Therefore, these delays have not been accounted for in the study, but the reader should be aware of the possibility of their occurrence, their direct impact of $7.50/hr (based on tariff rates for driver wait time), and potential indirect impact on shippers, carriers, and consignees.

Opportunity costs are not reflected. While time-of-operation restrictions, particularly, limit a carrier which tows overdimensional mobile and modular homes, many drivers choose to operate only part-time, and depend on other sources for additional income. Further, depreciation of their specialized towing vehicles is mostly a function of use, and nonuse costs little.

Throughout this section the term mobile home is used to include modular sections unless otherwise indicated. With few exceptions overdimension regulations affect both cargoes equally. However, occasionally, a heavier truck is required to tow modular sections. Other differences which exist for modular home transportation are largely operational considerations not directly related to overdimension regulations. For example, few Friday moves are made because of the economic penalty of installing modular sections during the weekend. Also, lowboy loading and unloading charges are usually not assessed because the shipper (not the carrier) performs both steps.

D. Permit Regulations

In all states except one, 12- and 14-wides exceed legal width limits and can only move under special permit. The one exception is the State of Alabama in which a 12-wide combination up to 75 ft long is legal, but permits are required for all 14-wides and for those 12-wides which, in combination with a tractor, exceed 75 ft in length.

Separate permits are required in each state. If an overdimensional home moves in more than one state, it must meet the permit requirements of each state in which it moves. The typical shipment requires one to three permits, and some moves require more.

Basically, two types of overdimension permits exist. One allows a specific shipment to move; the other allows numerous like shipments to move. Specific (single) trip permits (STP) are issued by all states. Multiple-trip permits (MTP), are issued by at least 20 states, and are usually valid for a specified period and, once received by the carrier, generally allow an unlimited number of moves in the state of issuance until expiration of the permit. Single-trip procedures, because of greater volume, bring about greater administrative and overhead burden both for the applicant and the issuing agency, but they assure the state a greater ability to control overdimensional moves. Conversely, multiple-trip procedures require less administrative effort per trip, but the states forfeit some ability to control shipments. Qualities of both specific and multiple-trip permits are combined in at least eight states by issuance of single-trip permits in bulk quantities.

Securing any overdimension permit involves application to the appropriate state agency, issuance by that agency, and receipt by the carrier. This must be accomplished before the move can begin. In most states the agency responsible for issuing such permits is a division of the state highway department. In several others, state police issue permits. In about 10 states overdimension permits are issued only from a central office, while in others permits are issued at various fixed or roving locations. Methods of payment of state fees (which most states require) vary also. Typical arrangements include prepayment, charge account backed by a surety bond, and payment attendant to each application.

Permit application and receipt can be accomplished by numerous methods including: in-person, mail, telephone, teletype, and facsimile transmission. Permits can be applied for and issued in all states either in-person or by mail. Multiple-trip permits, for which time is not a critical factor, are usually obtained by mail. However, for single-trip permits, competition within the carrier industry dictates that speed override economy, and electronic transmissions are preferred. Telephone applications are accepted by many states, although generally a permit cannot be issued by telephone. Often teletype or facsimile transmission is employed by the state permit agency to send an approved permit to an applicant. If a driver requires an additional permit to cross into an adjacent state, he frequently can obtain the permit in-person at a port of entry or by electronic transmission at a truck stop. Occasionally, it may be necessary to have a permit hand delivered from the issuing office to the carrier.

Once received, a specific trip permit is usually nontransferrable; it is valid only for a specific trip, coach and truck for a period from 1 day to 2 weeks, depending on the limits in the state of issuance. If delays should arise, a permit can expire. While some states are willing to extent the period of validity, others are not, in which case the permit process must begin anew.

Obtaining permits is costly. The applicant pays state fees and transmission costs out of pocket and is burdened with administration and overhead. State fees range from no charge to $20, as depicted in Table XVII. Only West Virginia assesses a greater fee for a 14-wide permit than a 12-wide permit, and only Kentucky charges more for issuance of a permit to transport a module than for a permit to move a mobile home.

Transmission costs can vary tremendously depending on the methods employed. If time were not a consideration, 25 cents worth of envelopes and postage would suffice. At the other extremes, costs of $10 and more for single permit transmission are not unknown. Generally, telegram charges range from $4 to $6, while charges for more rapid facsimile services are about 50% higher. Not all states offer the carriers electronic transmission as an alternative, however, and in some states carriers routinely employ a permit acquisition service to obtain and deliver required permits. The carrier pays the state fee, the transmission cost, and an additional $1 to $3 to the permit service for each permit thus recieved. Occasionally, taxi or bus delivery is necessary at an added cost of several dollars.

TABLE XVII

SINGLE TRIP PERMIT FEES AND TARIFF-DERIVED OVERDIMENSION CHARGES

State	Single Trip Permit Fee ($)	Charge Derived from Tariff: Mobile Homes 12-Wide ($)	Charge Derived from Tariff: Mobile Homes 14-Wide ($)	Charge Derived from Tariff: Modules All ($)
Alabama	N/C	0	0	10
Arizona	5	5	5	15
Arkansas	5	10	10	20
California	3	15	N/A	25
Colorado	5	10	10	20
Connecticut	N/C	10	10	20
Delaware	5	15	15	25
Florida	5	10	N/A	20
Georgia	10	7	N/A	15
Idaho	5	10	10	20
Illinois	17	25	N/A	35
Indiana	10	10	25	20
Iowa	5	15	15	25
Kansas	10	15	15	25
Kentucky	10[a]	20	20	25
Louisiana	6	15	15	20
Maine	10	15	15	25
Maryland	10	20	20	30
Massachusetts	N/C	10	10	20
Michigan	N/C	5	25	15
Minnesota	5	10	10	15
Mississippi	N/C	0	N/A	16
Missouri	5	10	N/A	20
Montana	6	15	15	25
Nebraska	10	20	20	30
Nevada	N/C	15	15	25
New Hampshire	5	15	15	25
New Jersey	10	20	N/A	25
New Mexico	5	10	10	20
New York	7	15	15	25
North Carolina	N/C	0	N/A	15
North Dakota	5	5	5	15
Ohio	2	15	15	25
Oklahoma	5	15	15	25
Oregon	N/C	5	5	15
Pennsylvania	10	10	N/A	20
Rhode Island	N/C	5	5	5
South Carolina	5	10	N/A	20
South Dakota	5	5	5	15
Tennessee	N/C	0	N/A	30
Texas	5	10	10	20
Utah	3	5	5	15
Vermont	10	20	20	30
Virginia	6	25	N/A	35
Washington	3	5	5	15
West Virginia	15/20[b]	25	30	25
Wisconsin	N/C	0	10	10
Wyoming	5	15	15	25

a/ Kentucky charges $15.00 for a permit to move a module.

b/ West Virginia charges $15.00 for a 12-wide permit and $20.00 for a 14-wide permit.

N/C = No charge.

N/A = Not applicable.

Administrative and overhead burdens are not as significant as state fees and transmission costs. An experienced clerk can complete application and receipt procedures in 10 to 15 min total time. This includes gathering the necessary information, and applying for and receiving the permit. Information required on a typical single-trip permit application includes the following:

- Name and address of applicant;
- Coach serial number and size description;
- Truck serial and license numbers;
- Combination dimensions and weight;
- Origin, destination, and desired routing; and
- Date of move.

After a shipper supplies coach and delivery information, the clerk assembles and formats the remaining information. Normally, the clerk telephones the application information to the issuing agency. Delay may arise at the issuing office, but a permit approved by an efficient issuing office is often received by the applicant in 1 or 2 hr, and sometimes as quickly as 20 min. Meanwhile, the application clerk can attend to other work. One supervisor interviewed stated that in a day, one clerk could process permits for 10 shipments involving four states--a total of 40 permits. If a clerk receives $3 an hour or $24 a day, the cost of the clerk's time per permit is $0.60. Direct overhead associated with the clerk's work is estimated at $6 a day or $0.15 per permit. Administrative and overhead burden, then, approximates $0.75 per permit assuming the clerk is working full capacity.

Use of multiple-trip permits may save a carrier money. Much of the expense of obtaining a permit is fixed or semi-fixed. Spread over more than one trip, the fixed expense per trip becomes less. Moreover, transmission costs for a multiple-trip permit are likely to be less than for a single-trip permit because of the differences in urgency of acquisition. Fees for multiple-trip permits, however, often are substantially greater than for single-trip permits in those states which assess fees. In some states the fee for a multiple-trip permit is 10 times as much as that of a single-trip permit. If used only a few times, a multiple-trip permit can be more expensive on a per trip basis. In general, however, savings accrue because of repetitive usage.

The following analysis demonstrates the possible savings in acquisition costs (exclusive of state fees) to carriers using multiple-trip permits. Electronic transmission is assumed for single-trip permit acquisitions, while for multiple-trip permit acquisition, transmission by mail of application and permit is assumed because the time factor is less urgent. Jorgensen[1] estimates there are an average of 35 trips per multiple-trip permit in the mobile home transportation industry, so that 35 single-trip permits would have to be obtianed to achieve equal utility. Adding the costs of administration, overhead, and transmission yields the acquisition cost of one permit. Multiplying the single-trip permit acquisition cost by 35 supplies the total cost of acquiring 35 single-trip permits. The difference between that amount and the cost of acquiring one multiple-trip permit is the estimated savings to carriers employing such permits. The calculations are as follows:

	Single-Trip Permit	Multiple-Trip Permit
Administration cost	$0.60	$0.60
Overhead	0.15	0.15
Transmission	6.00	0.20
Permit acquisition cost	$6.75	$0.95
x number of acquisitions	35	1
Total Cost of acquisitions	$236.25	$0.95

Savings by using multiple-trip permit $235.30

The approximate cost of permit acquisition, including fees, is passed on to the shipper, as shown in Table XVII. As expected, the charges are not insignificant and often range from 10 to 25% of the basic transportation costs for a shipment. Common carriers are regulated with respect to specific amounts which are charged to shippers for obtaining permits. Standard "overdimensional charges" are set forth in the tariffs which regulate common carriers, and indicate the amount a shipper pays a common carrier for permit acquisition. The charges were developed as a result of "actual experience of carrier members of the [Mobile Housing Carriers] Conference and reflect actual out-of-pocket expense in securing permits in operating between any two named states."[17] The charges are designed to recover state fees and transmission costs, but they are not intended to reflect nor include administrative or overhead costs.

The cost information discussed above tends to substantiate the claim that "overdimensional charges" reflect actual out-of-pocket cost, on the average, for securing single-trip permits. However, large volume carriers should, in many cases, experience lower per trip costs than reflected in Section 1-A of the tariffs by using multiple-trip permits, and as the use of multiple-trip permits gain more widespread use, the Section 1-A overdimension charges should be reviewed so that carrier savings are passed on to shippers and permit charges continue to reflect actual costs.

It is noted that tariff-specified overdimension charges for modular sections are $10 more than for 12-wide mobile homes in the case of most states. When a modular shipment travels in several states, however, the $10 "surcharge" applies only once for each trip. The researchers are unable to document any justification* for these higher charges. In fact, acquisition of permits for modular movements is often simplified because a large number of units may be moving at about the same time from a common origin to a common destination. Therefore, the movements can be planned well in advance, and permits can be obtained in a more economical fashion.

Occasionally, other than state-issued permits are required for movements on roads and highways under different jurisdictions. Many toll road and turnpike authorities maintain their own regulations relating to overdimensional loads, and some require special permits in addition to tolls. Examples include the Northern Illinois Tollway--$10; New York Thruway-$15; and Ohio Turnpike--variable size-distance formula. Many larger municipalities issue permits at a nominal charge, presumable to control the movement of wide loads within city limits. Some smaller communities also have adopted permit requirements, perhaps as much to raise revenues as to control overdimensional moves. In some areas, counties, too, have established permit regulations pertaining to the use of county-maintained roads. It is almost impossible for the transporter who hauls a mobile home only occasionally in a given area to keep abreast of local permit requirements.

E. Cost Burden to the States

Issuance of overdimension permits and enforcement of related regulations give rise to expense borne by the states. People are employed to process permits and enforce regulations, working space is provided, and materials are supplied.

Despite the large size of some permit issuing agencies, accurate cost information is difficult to obtain. In most states, issuance of oversize and overweight permits is a function of a division of the state highway department. While cost records of the highway department are available, interviews with state officials indicate that few states maintain an accounting system which treats permit processing as an independent cost center.

At least one state, California, is an exception. The accounting system used in California relates permit revenues to expenses on a cost recovery basis. In 1971, the State of California issued 109,921 transportation permits. Typical among these issuances in terms of procedures and

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* Except for Kentucky--see Table XVII.

issuance costs were overdimension permits for mobile homes. During the same period, the California permit issuing facilities incurred $330,761 labor expense, $78,987 operating expense, and $161,393 overhead expense. On a per issue basis, costs are:

Labor	$3.01
Operating Expense	0.72
Overhead	1.47
Total	$5.20

California recovers most costs associated with permit issuance through a system of fees. The fee for most single-trip permits for mobile homes is $3, while for multiple-trip permit fees are $30.

Connecticut does not charge a fee for overdimension permits and, therefore, cannot relate revenue to expense. However, in December 1971, a cost study of the oversize permit issuing activity was conducted by the state. Results show the average cost of permit issuance was $3.54. Again, mobile home permit issuances are typical in terms of procedures and costs. The permit director stated that if Connecticut were to charge a fee for permits, an accounting system would be required at an estimated additional cost of $1.50 per issue, raising the total to $5.04.

Despite a lack of hard evidence, 15 other state permit directors were willing to estimate the cost of issuing a permit. Their approximation ranged from $2 to "more than $10." Of those, 12 were in the range of $3 to $5.

Enforcing regulations relating to overdimension shipments is usually (if not always) part of a larger activity. Most often, responsibility for enforcing overdimension regulations is assigned to the agency responsible for enforcing weight laws of the state. According to a 1969 Highway Research Board project,[1/] "In at least 19 states, weight enforcement is just one of the many functions of the state police." Thus, enforcement costs are often buried within the budget of the larger agency. Interviews with numerous state police officials yielded no estimates regarding what fraction of a trooper's workday might be devoted to these particular enforcement activities. Two permit officials (who were also charged with enforcement responsibility) both estimated $1.50 as the cost to their states of enforcing overdimension regulations.

F. State Transportation Regulations

1. Sign regulations: The single thread of continuity among the states' signing regulations is a requirement by most states for front and rear signs identifying the cargo as on overdimensional load. Signs are required in 39 states, but as a matter of practice are employed almost universally. Each state's sign regulations apply uniformly to both 12- and 14-wides.

State regulations specify as many as nine individual characteristics, as portrayed in Table XVIII. Of the nine, sign location, wording, and color scheme are the most rigidly enforced. Any of these characteristics might necessitate a sign change upon crossing a border into another state with differing regulations. These characteristics, therefore, serve as our criteria in determining when sign changes may be required.

Most states require the front sign to be on the bumper of the towing vehicle; however, three states require the front sign to be over the cab of the towing vehicle. Many states require the rear sign to be a specified minimum height from the roadway.

At least 14 different wordings are recognized by the states as preferred or required for signing purposes. "Wide Load" is accepted or required as the preferred wording by 20 states. Second most common is "Oversize Load," required or accepted in 12 states. One interesting note is, that of two particular adjoining states, one requires "Oversize Load" and the "Over Size Load."

Yellow signs with black letters are required or preferred by 27 states. Second in popularity (when specified) is red with white letters, called for in three states. Four states do not specify a color scheme, and the remaining five states require combinations of red, white, and black.

Other characteristics include: (1) length of sign, (2) height of sign, (3) height of rear sign above roadway, (4) letter height, and (5) letter stroke. These characteristics all involve dimensions and, generally, state regulations specify a minimum dimension but allow a greater value.

Experience gained in traffic data collection activities indicates that there are few states which rigorously enforce their own state signing regulations. Most states are willing to accept the signs required by neighboring states. Consequently, carriers use, within a geographical region, the signs of the state(s) which enforces its regulation strictly. Therefore, few sign changes are made at boundaries between states, in practice.

TABLE XVIII

SIGN REGULATIONS FOR 12- AND 14-WIDES

State	Location a/	Wording b/	Sign Characteristics: Length (ft)	Width (in.)	Height Above Road Surface (ft)	Back-ground Color	Color of Letters	Letter Height (in.)	Letter Stroke (in.)
Alabama	--	--	--	--	--	--	--	--	--
Arizona	1,3	1	6	--	--	Yel	Blk	--	1-1/2
Arkansas	1	1	--	--	--	Yel	Blk	10	2
	3	1	--	--	6	Yel	Blk	10	2
California	1,3	1	6	--	--	Yel	Blk	5	1-1/2
Colorado	1,3	1	--	--	--	--	--	12	2
Connecticut	1,3	3,4 or 5	3	36	--	Yel/Org	Blk	6	3/4
Delaware	--	--	--	--	--	--	--	--	--
Florida	1,3	1	--	--	--	Yel/Wht	Blk	--	--
Georgia	1,3	1	6	12	--	Blk	Org/Red	8	1-1/8
Idaho	1	1	4	12	--	Yel	Blk	--	--
	3	1	4	12	8	Yel	Blk	--	--
Illinois	1,3	2	--	--	--	Yel	Blk	12	--
Indiana	1,3	2	6-8	18	--	Wht	Red	12	--
Iowa	1	2	5	14	--	Yel	Blk	10	--
	3	2	5	14	7	Yel	Blk	10	--
Kansas	2	9	4	22	--	Red	Wht	6	--
	3	9	4	22	6	Red	Wht	6	--
Kentucky	--	--	--	--	--	--	--	--	--
Louisiana	1,3	1 or 2	5	12	--	Yel	Blk	9	--
Maine	1	2	--	--	--	Yel	Blk	6	1-5/8
	3	7	5	18	--	Yel	Blk	6	1-5/8
Maryland	1,3	1	--	--	--	Yel	Blk	--	--
Massachusetts	--	--	--	--	--	--	--	--	--
Michigan	1	14	6	16	--	Yel	Blk	12	--
	3	14	8	18	7	Yel	Blk	16	--
Minnesota	1 or 2	1	5	12	--	Yel	Blk	8	1-1/2
	3	1	5	12	6	Yel	Blk	8	1-1/2
Mississippi	--	--	--	--	--	--	--	--	--
Missouri	1,3	2	7	18	--	Yel	Blk	10	1-5/8
Montana	1	--	--	--	--	Wht	Blk	8	--
	3	--	--	--	6	Wht	Blk	8	--
Nebraska	1,3	6	--	--	--	Red	Wht	6	1-1/8
Nevada	4	11	5-1/2	18	--	Red	Blk	5	1
	3	10	7	24	7	Red	Blk	8	1-5/8
New Hampshire	1	8	--	--	--	Yel/Org	Blk	10	1
	3	7	--	--	--	Yel/Org	Blk	10	1
New Jersey	1,3	1	6	12	--	Yel	Blk	10	--
New Mexico	1,3	1	6	--	6	Yel	Blk	8	1-1/4
New York	1	1 or 2	--	--	--	Yel	Blk	8	1-9/16
	3	1 or 2	--	--	2-5	Yel	Blk	8	1-9/16
North Carolina	1,3	2	--	--	--	Yel	Blk	10	--
North Dakota	1,3	2	7	18	--	Yel	Blk	12	2
Ohio	1	14	6	14	--	Yel	Blk	10	--
	3	14	8	18	7	Yel	Blk	12	--
Oklahoma	2,3	1	5	18	--	Red	Wht	10	--
Oregon	2	1	--	--	--	Yel	Blk	8	1-1/2
	3	12	--	--	8	Yel	Blk	8	1-1/2
Pennsylvania	1,3	2	6	12	--	Yel	Blk	10	--
Rhode Island	1,3	1	--	--	--	--	--	--	--
South Carolina	1,3	1	--	--	--	--	--	12	1-1/2
South Dakota	1,3	1	--	--	--	--	--	12	--
Tennessee	1,3	1	9	18	--	Blk	Org/Red	10	2
Texas	--	--	--	--	--	--	--	--	--
Utah	1	1	6	18	--	Yel	Blk	10	1-9/16
	3	1	6	18	7	Yel	Blk	10	1-9/16
Vermont	3	5 or 13	3	36	--	Yel	Blk	6	--
Virginia	--	--	--	--	--	--	--	--	--
Washington	2	2	--	--	--	Yel	Blk	--	--
	3	2	--	--	8	Yel	Blk	--	--
West Virginia	1	2	6	14	--	Yel	Blk	12	--
	3	2	6	14	6	Yel	Blk	12	--
Wisconsin	--	--	--	--	--	--	--	--	--
Wyoming	--	--	--	--	--	--	--	--	--

a/ Location of Sign
1. Front bumper
2. Top of cab
3. Rear of load
4. Front of load, vertical

b/ Word Configuration
1. Wide Load
2. Oversize Load
3. Caution
   Wide Load
4. Caution
   Oversize
5. Caution
   Overwidth
6. Caution Wide Load
7. Danger Oversize Load Ahead
8. Danger Oversize Load Following
9. Caution Wide and Long Load
10. Caution While Passing
11. Pass With Caution
12. Long Wide Load
13. Danger Oversize
14. Over Size Load (three words)

The need for any sign changing at state boundaries seems illogical to drivers. The operation is considered an inconvenience, although it is relatively simple and inexpensive. The front sign is generally a reversible accessary to the towing vehicle, so changes can easily be effected. The per trip equipment cost of the front sign is negligible. The rear sign is usually cloth or vinyl and subject to loss or damage. Replacement averages about every fourth trip, yielding a per trip cost of $3 based on a purchase cost of $12. The time required to install signs at a trip origin or to change signs at border crossings is typically 1/10 hr, yielding a cost of $0.75 using the tariff base of $7.50/hr. Consequently, the total cost of signing at trip origin, and again at each state border crossing where a sign change is necessary, approximates $3.75, which is absorbed in the mileage rate and is not passed on directly to the shipper.

2. Flag regulations: Nearly every state requires warning flags on all oversize shipments. Red flags are accepted by all states requiring flags. Size requirements vary somewhat, but do not present a problem. Of the 42 states which require warning flags, most specify 12 in. sq as the minimum size, although flags up to 24 in. minimum are required by some. Since states will accept flags in excess of minimum requirements, carriers usually install flags large enough to avoid size problems.

State regulations vary most in flag location requirements as indicated in Table XIX. Twenty different flag locations are required in the aggregate. The six locations most freuqently required consist of two flags (one on each side) at the bottom rear of the coach (36 states), the bottom front of the coach (26 states), and the front bumper of the tractor (19 states). Most often the flags are attached by one corner to the coach or truck bumper.

Drivers indicate that a constant renewal of lost and torn flags is necessary. This renewal is estimated to average one flag per trip, or about $0.50. The time required to equip a vehicle with flags at trip origin, or change location of flags at border crossings, is estimated at 1/10 man-hour ($0.75 absorbed cost). Equipment cost and time combine to equal $1.25, which is absorbed in the carriers' mileage rate.

3. Warning light regulations: Of the three categories of accessories--signs, flags, and lights--special warning lights* are least commonly required. For 14-wides, 13 states require special lights, while only eight states require 12-wides to display them (see Tables XXa and b).

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* Special warning lights, as used in this context, are those required over and above all other lights and reflectors specified in DOT regulations (FHWA Regulation Part 393 and Standard 108, as amended by Part 571).

TABLE XIX

FLAG REGULATIONS FOR OVERWIDTH COACHES

State	Flag Characteristics Location[e]	Size (in. sq)	Color	State	Flag Characteristics Location[e]	Size (in. sq)	Color
Alabama	--	--	--	Nebraska	3-6	16	Red
Arizona	3-6	--	Red	Nevada	1-4	--	Red
Arkansas	1,2,7,8	18	Red	New Hampshire	3-6	12	Red
California	3-6	12	Red	New Jersey	1-4	18	Red
Colorado	--	--	--	New Mexico	1-6	12	Red
Connecticut	3-6	12	Red	New York	1,3,4	24	Red
Delaware	1-4,11,12	12	Red	North Carolina	1-6	--	Red
Florida	--	--	--	North Dakota	13,15,17,18	18	Red[b]
Georgia	3-6	18	Red	Ohio	1-6[c]	16	Red
Idaho	1-4,19,20	16	Red	Oklahoma	3-6	16	Red
Illinois	1-6	12	Red	Oregon	3-6	12	Red
Indiana	3-6,11,12	16	Red	Pennsylvania	3-6	12	Red
Iowa	1-4,7,8	18	Red	Rhode Island	--	--	--
Kansas	1-6	16	Red	South Carolina	3-6	--	Red
Kentucky	3-12	12	Red	South Dakota	1-6	16	Red
Louisiana	3-6	24	Red	Tennessee	3-10	--	Red
Maine	3-6	24	Red	Texas	--	--	--
Maryland	--	--	--	Utah	3-6[a]	12	Red
Massachusetts	1-4	--	Red	Vermont	3-6	16	Red
Michigan	1-6	16	Red	Virginia	1-4	12	Red
Minnesota	3-6	16	Red[b]	Washington	3-6	12	Red
Mississippi	7-10	18	Red	West Virginia	1,2,7-10	16	Red
Missouri	1-4	18	Red	Wisconsin	1-3,5	16	Red
Montana	1-4	12	Red	Wyoming	13-16[d]	12	Red

Notes:
a/ At least 7 ft above the road surface.
b/ Orange is acceptable.
c/ Staff at 45 degree angle on front bumper.
d/ Flags also required on all projections extending from body.
e/ See drawing.

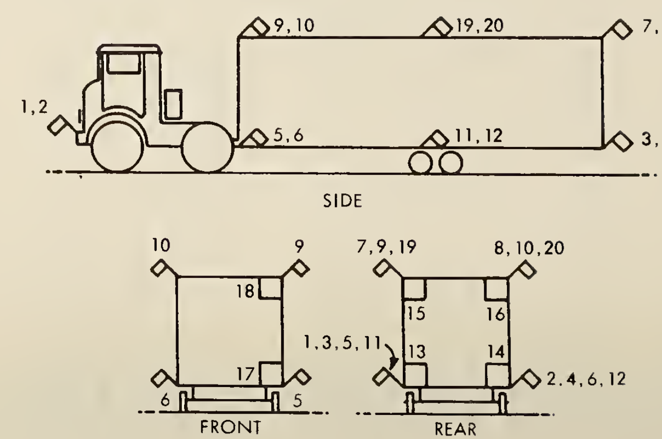

TABLE XXa

WARNING LIGHT REGULATIONS FOR 12-WIDES

State	Warning Light Characteristics							
	Location*	Size (in.)	Color	Height Above Surface (ft)	Candle Power	Operating Mode	Separation (ft)	Horizontal Visibility (ft)
Alabama	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--
Arkansas	--	--	--	--	--	--	--	--
California	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	--	--
Connecticut	--	--	--	--	--	--	--	--
Delaware	--	--	--	--	--	--	--	--
Florida	--	--	--	--	--	--	--	--
Georgia	--	--	--	--	--	--	--	--
Idaho	Front, rear	6 to 9	Amber	--	50	Flash	--	--
Illinois	--	--	--	--	--	--	--	--
Indiana	--	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	--	--
Kansas	--	--	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	--	--
Louisiana	--	--	--	--	--	--	--	--
Maine	--	--	--	--	--	--	--	--
Maryland	--	--	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	--	--	--
Michigan	Rear	--	Amber	--	--	Flash	--	--
Minnesota	--	--	--	--	--	--	--	--
Mississippi	--	--	--	--	--	--	--	--
Missouri	--	--	--	--	--	--	--	--
Montana	Front,	5	Amber	--	50	Flash	--	--
	Top rear	5	Amber	7	--	Flash	--	500
Nebraska	--	--	--	--	--	--	--	--
Nevada	Top rear	5	Amber	--	50	Flash	--	--
New Hampshire	--	--	--	--	--	--	--	--
New Jersey	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	--	--
New York	Top rear		Yellow	2-5	50	Steady	6	500
North Carolina	--	--	--	--	--	--	--	--
North Dakota	--	--	--	--	--	--	--	--
Ohio	--	--	--	--	--	--	--	--
Oklahoma	--	--	--	--	--	--	--	--
Oregon	Front, rear	6	Amber	--	32	Flash	--	--
Pennsylvania	--	--	--	--	--	--	--	--
Rhode Island	--	--	--	--	--	--	--	--
South Carolina	Rear,	--	Red	--	--	--	--	--
	Front	--	Amber	--	--	--	--	--
South Dakota	--	--	--	--	--	--	--	--
Tennessee	--	--	--	--	--	--	--	--
Texas	--	--	--	--	--	--	--	--
Utah	Top rear	5-1/2	Amber	--	50	Flash	--	--
Vermont	--	--	--	--	--	--	--	--
Virginia	--	--	--	--	--	--	--	--
Washington	Front, Top rear	6	Amber	--	32	Flash	--	--
West Virginia	--	--	--	--	--	--	--	--
Wisconsin	--	--	--	--	--	--	--	--
Wyoming	--	--	--	--	--	--	--	--

* Warning lights appear in horizontal pairs at locations noted.

TABLE XXb

WARNING LIGHT REGULATIONS FOR 14-WIDES

		Warning Light Characteristics						
State	Location*	Size (in.)	Color	Height Above Surface (ft)	Candle Power	Operating Mode	Separation (ft)	Horizontal Visibility (ft)
Alabama	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--
Arkansas	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	--	--
Connecticut	--	--	--	--	--	--	--	--
Delaware	--	--	--	--	--	--	--	--
Idaho	Front, rear	6-9	Amber	--	50	Flash	--	--
Indiana	--	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	--	--
Kansas	--	--	--	--	--	--	--	--
Kentucky	Top rear	--	Amber	6	--	Flash	--	--
Louisiana	--	--	--	--	--	--	--	--
Maine	--	--	--	--	--	--	--	--
Maryland	--	--	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	--	--	--
Michigan	Top rear	--	Amber	--	--	Flash	--	--
Minnesota	Front, rear	--	Amber/yellow	5	--	Flash	--	--
Montana	Front	5	Amber	--	50	Flash	--	--
	Top rear	5	Amber	6	--	Flash	--	500
Nebraska	Front	--	Amber	--	--	--	--	--
	Top rear	--	Red	--	--	--	--	--
Nevada	Top rear	5	Amber	--	50	Flash	--	--
New Hampshire	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	--	--
New York	Top rear	6-9	Yellow	2-5	50	Steady	6	500
North Dakota	--	--	--	--	--	--	--	--
Ohio	Top rear	--	Amber	6	--	Flash	--	--
Oklahoma	--	--	--	--	--	--	--	--
Oregon	Front, rear	6	Amber	--	32	Flash	--	--
Rhode Island	--	--	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--	--	--
Texas	--	--	--	--	--	--	--	--
Utah	Top rear	5-1/2	Amber	7	50	Flash	--	--
Vermont	--	--	--	--	--	--	--	--
Washington	Front, Top rear	6	Amber	--	32	Flash	--	--
West Virginia	--	--	--	--	--	--	--	--
Wisconsin	Top rear	6	Amber	--	--	Flash	--	--
Wyoming	--	--	--	--	--	--	--	--

* Warning lights appear in horizontal pairs at locations noted.

Warning lights most often consist of a pair of amber flashing lamps installed on the rear (and, in some states, the front) of a coach for the purpose of alerting approaching motorists. Regulations, other than location, generally vary little. All but one state require the lights to be amber or yellow. Lens diameter requirements are all fulfilled by 6 in. lenses. Other characteristics regulated by one or more states include: (1) height above the roadway, (2) candle power, (3) frequency of flash, (4) minimum separation of the two lights, and (5) minimum range of visibility.

When installation of a temporary warning light rig is required, considerable time is needed to attach, wire, make operable, and (later) remove such a rig. Thus, for common carriers the Interstate Commerce Commission has approved charges of $15 (which are passed on to the shipper) to defray the cost of materials and time to perform such actions. This amount is judged reasonable and also probably approximates the cost to private carriers when a temporary light rig is used.

4. Escort regulations: Escorts or pilot cars can be helpful, both to the driver of the towing vehicle and to motorists approaching from the front or rear. Their purpose is to guide the truck driver away from situations which may be hazardous and to caution motorists in the vicinity of a wide load. All but three states require escorts with wide loads on at least some routes, and all states, including the three with no specific regulations, reserve the right to designate escort requirements as they deem necessary. Also, some states may require a flagman who rides the truck but who can disembark and flag (direct) traffic as necessary (see Tables XXIa and b).

Although a few states specify police, truck regulatory, or state certified escorts, most escorts are private contractors--not certified nor regulated. Frequently, they are housewives, retirees, or students working on a part-time basis. This is possible because there are only very limited barriers to entry into the escort business. Few states require more of the driver than a driver's license, while private escorts are expected to provide a suitable vehicle when contracted by a carrier, and almost any automobile can be rigged with required accessories (which may include warning signs, flags, and lights similar to those required on truck-coach combinations).

Many states also require two-way radio communication between escort and truck driver. Comments by drivers, dispatchers, and state officials (as well as our field observations) indicate that a two-way radio can make an escort more effective. This applies particularly to a front escort on two-lane highways and a rear escort on four-lane routes where, because of the radio, escorts can alert the towing vehicle driver to road and traffic hazards.

TABLE XXIa

ESCORT REGULATIONS FOR 12-WIDES

		Conditional Escort Requirements							
		Escort Designation by Highway Characteristics				Escort Designation by Dimensions			
State	Required Always	2-Lane	4-Lane or Divided	Interstate	Lane Width	Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Alabama	--	--	--	--	--	--	--	--	--
Arizona	--	Front and Rear	Front and Rear	--	--	--	--	--	--
Arkansas	--	--	--	--	Front if < 11 ft	--	--	Front on 2-lane if combination > 75 ft	--
California	--	--	--	--	--	--	--	State map designates where front escorts are required	c/
Colorado	--	--	--	--	--	--	--	State map designates where front escorts are required	--
Connecticut	Front	--	--	--	--	--	--	--	c/
Delaware	--	--	--	--	--	Front if > 75 ft	--	Rear also on 2-lane if combination > 85 ft	--
Florida	--	--	--	--	--	--	--	--	--
Georgia	--	--	--	--	--	Rear if > 75 ft	--	--	--
Idaho	--	Front	Front	--	Front, Rear if < 10 ft	--	--	--	a
Illinois	Flagman	--	--	--	Front if < 11 ft	--	--	--	--
Indiana	--	--	--	--	--	--	--	Front, rear if load exceeds 1/2 of roadway	--
Iowa	--	--	--	NA	--	Front if > 70 ft	--	--	--
Kansas	--	Front	--	--	--	--	--	--	--
Kentucky	--	Front	--	--	--	--	--	--	--
Louisiana	--	--	--	--	Front if < 10 ft	--	--	--	--

TABLE XXIa (Continued)

State	Required Always	Conditional Escort Requirements: Escort Designation by Highway Characteristics: 2-Lane	4-Lane or Divided	Interstate	Lane Width	Escort Designation by Dimensions: Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Maine	--	Front	Rear	Rear	--	--	--	--	c/
Maryland	Front	--	--	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	Front if > 70 ft	--	--	--
Michigan	--	--	--	--	--	Rear if > 80 ft	--	--	--
Minnesota	--	--	--	--	--	--	--	--	--
Mississippi	--	--	--	--	--	--	--	--	--
Missouri	--	Front	Rear	--	--	--	--	--	--
Montana	Front	--	--	--	--	--	--	--	--
Nebraska	--	--	--	Rear	--	--	--	Front in metropolitan areas on 2-lane	--
Nevada	--	--	--	--	--	--	--	--	--
New Hampshire	--	Front	Rear	Rear	--	--	--	--	c/
New Jersey	--	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	Front if < 10 ft	Front if > 90 ft	Front if > 70 ft	--	--
New York	--	Front	--	--	--	--	--	--	--
North Carolina	--	Front	--	--	--	--	--	--	--
North Dakota	--	--	--	--	--	--	Front if > 75 ft	--	--
Ohio	--	--	Rear	Rear	--	Front if > 80 ft	--	State map designates where front escorts are required	--
Oklahoma	--	Front	--	--	--	--	--	--	--
Oregon	--	Front	--	--	--	--	--	--	a

TABLE XXIa (Concluded)

State	Required Always	Conditional Escort Requirements: Escort Designation by Highway Characteristics: 2-Lane	4-Lane or Divided	Interstate	Lane Width	Escort Designation by Dimensions: Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Pennsylvania	--	--	--	--	--	--	--	Front on 4-lane or divided; front, rear on 2-lane if combination > 85 ft	--
Rhode Island	--	--	--	--	--	Front if > 80 ft	--	--	--
South Carolina	--	--	--	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--	--	--	--
Tennessee	--	--	--	--	--	Rear if > 75 ft	--	State map designates where front escorts are required	--
Texas	--	--	--	--	--	--	--	Front, rear if load exceeds 1/2 of roadway	--
Utah	--	--	--	--	--	Rear if > 90 ft	--	--	b/
Vermont	--	Front	Rear	Rear	--	--	--	--	--
Virginia	--	Front and Rear	--	--	--	--	--	--	--
Washington	--	Front and Rear	--	--	--	--	--	--	c/
West Virginia	--	Front	Rear	--	--	--	--	--	--
Wisconsin	--	--	--	--	--	--	--	State map designates escort requirements	--
Wyoming	--	--	--	--	--	--	--	Front, rear on 2-lane, rear only on 4-lane, divided if combination > 90 ft	--

Notes: a/ State map available summarizes specific escort requirements.
b/ Escort must be state certified.
c/ Two-way radio required.

TABLE XXIb

ESCORT REGULATIONS FOR 14-WIDES

		Conditional Escort Requirements							
		Escort Designation by Highway Characteristics				Escort Designation by Dimensions			
State	Required Always	2-Lane	4-Lane or Divided	Interstate	Lane Width	Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Alabama	Front, Rear	--	--	--	--	--	--	--	--
Arizona	Front, Rear	--	--	--	--	--	--	--	--
Arkansas	--	Front, Rear	--	--	--	--	--	--	d/
Colorado	--	Front, Rear	--	--	--	--	--	--	f/
Connecticut	Front, Rear	--	--	--	--	--	--	--	f/
Delaware	--	Front, Rear	Front	--	--	Front, Rear if > 85 ft	--	--	--
Idaho	--	Front, Rear	Front, Rear	Rear	--	--	--	--	f/
Indiana	Front, Rear	--	--	NA	--	--	--	--	f/
Iowa	--	Front	Front	NA	--	--	--	--	--
Kansas	Front, Rear	--	--	--	--	--	--	--	--
Kentucky	--	Front, Rear	Front	Front	--	--	--	--	--
Louisiana	Front	--	--	--	--	--	--	--	e/
Maine	Front, Rear	--	--	--	--	--	--	--	f/
Maryland	Front	--	--	--	--	--	--	--	a/
Massachusetts	Rear	--	--	--	--	--	--	--	--
Michigan	Front	--	--	--	--	--	--	--	--
Minnesota	--	--	--	--	--	--	--	--	--
Montana	--	Front	Front	--	--	--	--	--	f/
Nebraska	Front	--	--	NA	--	--	--	--	--
Nevada	Front, Rear	--	--	--	--	--	--	--	f/
New Hampshire	Front, Rear	--	--	--	--	--	--	--	f/

TABLE XXIb (Concluded)

State	Required Always	Conditional Escort Requirements: Escort Designation by Highway Characteristics: 2-Lane	4-Lane or Divided	Interstate	Lane Width	Escort Designation by Dimensions: Combination Length	Coach Length	Other Escort Designations	Additional Requirements
New Mexico	Front, Rear	--	--	--	--	--	--	--	--
New York	--	Front	Rear	Rear	--	--	--	--	--
North Dakota	--	--	--	--	--	--	Front if > 70 ft	--	c/
Ohio	Rear	--	--	--	--	--	--	--	--
Oklahoma	--	Front, Rear	Rear	Rear	--	--	--	--	--
Oregon	--	Front, Rear	Rear	Rear	--	--	--	--	f/
Rhode Island	Front	--	--	--	--	--	--	--	--
South Dakota	--	--	--	--	Front if < 12 ft	--	--	--	--
Texas	--	--	--	NA	--	--	--	--	--
Utah	--	Front	Rear	Rear	--	--	--	--	b/
Vermont	--	Front	Rear	Rear	--	--	--	--	a/
Washington	--	Front, Rear	Rear	Rear	--	--	--	--	f/
West Virginia	Front, Rear	--	--	--	--	--	--	--	--
Wisconsin	--	--	--	--	--	--	--	State map designates escort requirements	--
Wyoming	--	Front, Rear	Rear	--	--	--	--	--	--

Notes: a/ Police escort required.
b/ Escort must be state certified.
c/ Truck regulatory escort required.
d/ Permit required for escort.
e/ "Wide Load" sign and warning lights may replace escort requirements.
f/ Two-way radio required.

The states specify escort requirements in various ways. The most straightforward approach is simply a requirement that all 12- or 14-wides be accompanied by one or more escorts. More commonly, the requirements are conditional. Many escort requirements for 12- or 14-wides are contingent on the number of lanes or highway type. Escorts, for example, may be required to follow the wide load on four-lane divided highways and lead on two-lane highways. Less common are systems which relate to the dimensions of the vehicle or highway. Some states require escorts on highways where the lane width or pavement width is less than a specified amount. Others require escorts where coach width exceeds one-half of the pavement width, and some employ coach or combination length as a determinant of escort necessity. A few states combine conditions in designating escort requirements. For example, some states require an escort if the route is two-lane and the combination length exceeds 75 ft. Other states require an escort on two-lane routes if the lane width is 10 ft or less.

A few states have established escort requirements by specific highway. Often a state route map (e.g., Figure 25) designates appropriate requirements and is available to carriers or supplied with permits. This method is both effective and popular.

The variation in methods of designating escorts is a cue that complying with escort requirements may sometimes be difficult. Where a state has a universal requirement for escorts there is seldom a problem in obtaining escort services, but where conditional regulations exist it frequently happens that no escort is available at a point where one is required. This situation can cause delay. Sometimes, to avoid the situation, a carrier will secure the services of an escort in an area where an escort is available but not required in order to be assured of complying with an escort requirement further along the route.

Contracting escorts is very costly. Tariffs provide that carriers can charge shippers a <u>minimum</u> of $0.25/mile for escort services. Usually the charge is greater. Escorts are not regulated so the individuals are able to set their own prices for their services. Rates vary somewhat, but generally range from $0.30-$0.35/mile for each escort. Normally, a 100-mile minimum charge applies, so $30 to $35 per escort is a conservative estimate of minimum actual escort charges for each incidence. A requirement for <u>both front and rear</u> escorts doubles the $30 estimate. When required, riding flagmen (who do not provide a vehicle but ride in the truck cab) can be contracted for a mileage rate of about $0.25/mile, 100-mile minimum. All such costs are passed on directly to the shipper.

(This figure appears on pp. 225-226 as a foldout map.)

Figure 25 - Sample Route Map Including Escort Requirements

5. Time of operation restrictions: Regulations in all states limit movements of mobile and modular homes to daylight hours (see Table XXIIa and b). Most states also prohibit wide-load movements on weekends, and many curtail operations during rush hours on state roads in metropolitan areas. Movement of 12-wides is limited to Monday through Friday in 31 of 48 states. Sixteen states allow some Saturday travel, and three allow travel 7 days per week.

Regulations for 14-wides are often more restrictive. Of the 36 states allowing 14-wides, five states allow travel only Tuesday through Thursday, two states allow travel Monday through Thursday, 25 states allow travel Monday through Friday, two states allow travel Monday through Saturday morning, and two states allow travel every day. Regulations are also more limiting with respect to hours of operation. Only 23 of these 36 states allow travel during all daylight hours, while six states allow only six driving hours per day, 9:00 a.m. to 3:00 p.m. The other seven states compromise between these extremes.

Curtailment of operations during holiday periods varies significantly. Texas allows movements any day of the year, but 41 states observe at least six standard holidays (Christmas, New Year's Day, Memorial Day, Independence Day, Labor Day, and Thanksgiving Day). And 23 other holidays are observed variously by one or more states. Compounding the situation is the length of holiday travel curfew. Twenty-eight states observe only the holiday or the nearest work day to the holiday. Nine states prohibit movements of oversized loads for 3 days, the day preceding the holiday, the holiday itself, and the day following the holiday. Regulations of the other 14 states vary between 1 and 3 days.

Finally, seasonal restrictions come into play in at least seven states which maintain seasonal differences with respect to hours of operation. In five of the seven states additional restrictions during the summer months prohibit wide load movement before or during weekends. Idaho, Minnesota, and Washington prohibt both 12- and 14-wide moves after 2 p.m. in the summer and Vermont curtails 12-wides moves after noon on Fridays. Additionally, Oregon eliminates Saturday morning as an allowable travel time for 12-wides. The remaining two states have less restrictive travel requirements during summer months. Arkansas drops its 14-wide rush hour curfew on two-lane highways when school is not in session, and Maryland allows 12-wides to move during daylight before and after rush hour periods (i.e., sunrise to 7 a.m. and 6 p.m. to dusk).

In costing the time-of-operation restrictions we have been conservative by costing only those restrictions around which a normal schedule cannot be maintained. Regulations allowing operations 4 or 3 days a week do not in themselves prohibit normal operations of the drivers on those

TABLE XXIIa

TIME OF OPERATIONS RESTRICTIONS FOR 12-WIDES

State	Allowable Operating Hours: Monday	Tuesday - Thursday	Friday	Saturday	Sunday	Holiday Restrictions: Number of Observed Holidays	Normal Holiday Period
Alabama	D	D	D	D f/	D f/	6	H
Arizona	D	D	D	--	--	7	H
Arkansas	D	D	D	--	--	9	H
California	D	D	D	--	--	12	H
Colorado	D	D	D	M	--	11	H
Connecticut b/	D	D	D	--	--	11	DB-DA
Delaware b/	D	D	D	--	--	7	H
Florida	D	D	D	--	--	7	H
Georgia	D	D	D	D	--	7	H
Idaho	D	D	D h/	--	--	6	H
Illinois a,d/	D	D	D	M	--	6	NDB-H
Indiana	D	D	D	--	--	6	NDB-NDA
Iowa	D	D	D	--	--	7	DB-DA
Kansas	D	D	D	M	--	10	H
Kentucky	D	D	D	M	--	6	NDB-H
Louisiana	D	D	D	D	--	13	H
Maine	D	D	D	--	--	9	H
Maryland e/	9-3:30	9-3:30	9-3:30	9-12	--	8	H
Massachusetts	D	D	D	M	--	12	H
Michigan i/	D	D	D	--	--	6	NDB-DA
Minnesota d/	D	D	D h/	--	--	6	NDB-NDA
Mississippi	D	D	D	M	--	6	DB-DA
Missouri d/	D	D	D	--	--	9	NDB-H
Montana	D	D	D	--	--	6	H
Nebraska	D	D	D	--	--	7	H
Nevada	D	D	D	--	--	8	H
New Hampshire	D	D	D	--	--	10	H
New Jersey	D	D	D	--	--	7	H
New Mexico	D	D	D	--	--	6	NDB-H
New York	D	D	D	--	--	6	DB-DA
North Carolina	D	D	D	--	--	8	H
North Dakota	D	D	D	--	--	6	NDB-H
Ohio c/	D	D	D	--	--	6	NDB-H
Oklahoma d/	D	D	D	M	--	7	NDB-H
Oregon d/	D	D	D	M h/	--	6	H
Pennsylvania d/	D	D	D	--	--	6	DB-DA
Rhode Island d/	D	D	D	--	--	10	H
South Carolina	D	D	D	--	--	9	H
South Dakota	D	D	D	M	--	9	H
Tennessee	D	D	D	--	--	9	H
Texas d/	D	D	D	D	D	0 g/	--
Utah d/	D	D	D	--	--	7	NDB-H
Vermont	D	D	D h/	--	--	8	H
Virginia	D	D	M	SR-11 a.m.	--	7	NDB-H
Washington	D	D	D h/	--	--	6	NDB-H
West Virginia	D	D	D	--	--	8	H
Wisconsin d/	D	D	SR-4	--	--	6	NDB-H
Wyoming	D	D	D	D	D	10	H

ABBREVIATIONS

D --Daylight Hours	H --Observed Holiday
SR--Sunrise	DB --Day Before
SS--Sunset	DA --Day After
M --Morning Hours	NDB--Noon Day Before
	NDA--Noon Day After

Notes:
a/ Operations permitted from 1 hr after sunrise until 1 hr before sunset.
b/ Only mid-day hours allowed on certain routes.
c/ Only 8 a.m. - 4 p.m. operations allowed on Interstates.
d/ Rush hour curfew observed in metropolitan areas.
e/ Also allowed sunrise - 7 a.m. and 6 p.m. - sunset weekdays during summer months.
f/ No Interstate travel allowed on Saturday or Sunday.
g/ Travel on holidays is allowed if permit has been previously acquired.
h/ Additional restrictions apply during summer months.
i/ Operations allowed 9 a.m. - 3 p.m. if coach length exceeds 64 ft.

TABLE XXIIb

TIME OF OPERATIONS RESTRICTIONS FOR 14-WIDES

State	Allowable Operationg Hours: Monday	Tuesday-Thursday	Friday	Saturday	Sunday	Holiday Restrictions: Number of Observed Holidays	Normal Holiday Period
Alabama	D	D	D	D f/	D f/	6	H
Arizona	D	D	D	--	--	7	H
Arkansas c/	D	D	D	--	--	9	H
Colorado	D	D	--	--	--	11	H
Connecticut	--	9-4	--	--	--	11	DB-DA
Delaware	9-3	9-3	--	--	--	7	H
Idaho	D	D	D h/	--	--	6	H
Indiana	8:30-3:30	8:30-3:30	8:30-3:30	--	--	6	NDB-NDA
Iowa	D	D	D	--	--	7	DB-DA
Kansas d/	D	D	D	--	--	10	H
Kentucky	9-3	9-3	9-3	--	--	6	NDB-H
Louisiana	D	D	D	--	--	13	H
Maine	--	9-3	--	--	--	9	H
Maryland	9-3:30	9-3:30	9-3:30	--	--	8	H
Massachusetts	--	9-3:30	--	--	--	12	H
Michigan	9-3	9-3	9-3	--	--	6	NDB-DA
Minnesota d/	D	D	D h/	--	--	6	NDB-NDA
Montana	D	D	D	--	--	6	H
Nebraska	D	D	D	--	--	7	H
Nevada	D	D	D	--	--	8	H
New Hampshire	--	9-3:30	--	--	--	10	H
New Mexico	D	D	D	--	--	6	NDB-H
New York	D	D	D	--	--	6	DB-DA
North Dakota	D	D	D	--	--	6	NDB-H
Ohio	9-3	9-3	9-3	--	--	6	NDB-H
Oklahoma d/	9-SS	9-SS	9-SS	M	--	7	NDB-H
Oregon d/	D	D	D	--	--	6	H
Rhode Island d/	D	D	D	--	--	10	H
South Dakota	D	D	D	M	--	9	H
Texas d/	D	D	D	--	--	0 g/	--
Utah d/	D	D	D	--	--	7	NDB-H
Vermont	--	9-3:30	--	--	--	8	H
Washington	D	D	D h/	--	--	6	NDB-H
West Virginia	9-3	9-3	9-3	--	--	8	H
Wisconsin d/	D	D	SR-4	--	--	6	NDB-H
Wyoming	D	D	D	D	D	10	H

ABBREVIATIONS

D --Daylight Hours
SR--Sunrise
SS--Sunset
M --Morning Hours

H --Observed Holiday
DB --Day Before
DA --Day After
NDB--Noon Day Before
NDA--Noon Day After

Notes:
a/ Operations permitted from 1 hr after sunrise until 1 hr before sunset.
b/ Only mid-day hours allowed on certain routes.
c/ Only 8 a.m. - 4 p.m. operations allowed on Interstates.
d/ Rush hour curfew observed in metropolitan areas.
e/ Rush hour curfew observed on 2-lane highways except during summer months.
f/ No Interstate travel allowed on Saturday or Sunday.
g/ Travel on holidays is allowed if permit has been previously acquired.
h/ Additional restrictions apply during summer months.
i/ Operations allowed 9 a.m. - 3 p.m. if coach length exceeds 64 ft.

days,* but do require care in scheduling so that all deliveries can be completed during those days. Curfews during holiday periods are similar. However, regulations which limit driving time to less than the 10 hr a day allowed by DOT do interfere with normal operations, and can give rise to unavoidable delay. The cost due to restricted hours of operations has been computed as a function of lost driving time, which is the difference between the 10-hr maximum and the state-imposed limit. Thus, a state allowing only 9:00 a.m. to 3:00 p.m. operations (6-hr driving time) could cause as much as a 4-hr loss of driving time. The value of this lost time has been estimated at $7.50/hr, the same as set forth in the tariffs for driver wait time. Up to $30 (4 hr x $7.50/hr) could be the cost of lost time due to the limiting regulation. Since not every shipment is so burdened, we have described the cost in Appendices B and C as conditional, ranging from $0 to $30. This cost is an absorbed cost.

6. Towing vehicle regulations: Most state regulations include certain specifications relating to the trucks used to tow mobile and modular homes. Many regulations involve the capacity of the towing vehicle. Also, wheelbase requirements, when specified, may be important when considered in conjunction with overall length dimensions.

Truck size requirements are difficult to compare because of the different measures employed. Manufacturer's rated capacity is most common, but other measures used by one or more states include curb weight, gross vehicle weight (G.V.W.), and gross combination weight (G.C.W.). Table XXIII relates the four measures by indicating typical values for each. Since only two values of G.C.W. appear in state regulations, those values are the only entries in the G.C.W. column. The values (except rated capacity) are expressed in pounds.

TABLE XXIII

COMPARISON OF TYPICAL VALUES OF TRUCK CAPACITY MEASURES

Rated Capacity	Curb Weight	G.V.W.	G.C.W.
3/4 tons	4,000	7,000	--
1 ton	5,000	10,000	--
1-1/2 tons	7,500	15,000	22,000
2 tons	10,000	19,000	35,000

* The drivers often have second jobs they pursue on other days.

State regulations regarding towing vehicles, summarized in Tables XXIVa and b, incicate that the majority of states which stipulate vehicle size, require a 1-1/2 ton rated capacity truck (or equivalent) for 12-wides and a 2-ton rated capacity truck (or equivalent) for 14-wides. However, size regulations vary widely by state from "no regulations" to 2-ton requirements. Even within a state, size requirements sometimes vary depending on the dimensions of the coach or the highway type to be traveled. Manufacturers, drivers, and dispatchers suggest that at least a 1-ton truck is needed to adequately pull mobile homes despite some lesser state requirements. In costing the effects of various size regulations, therefore, we have adopted a 1-ton truck size as a zero base. When state regulations require use of a larger vehicle (either conditionally or unconditionally) the appropriate incremental cost is reflected in Appendices B and C.

In determining the cost increments associated with vehicle size requirements greater than 1-ton, we have assumed that carriers could, if they chose, have sufficient vehicle flexibility to comply exactly with various state size regulations.* The regulations, then, serve as the sole determinant of vehicle size above a 1-ton minimum. Adhering to this scheme, the carrier would always use the appropriately sized vehicle according to regulation.

Costing the effect of various size regulations was accomplished on the basis of differential truck purchase price--operating cost and depreciation differentials were not considered because they tend to be offsetting as size varies. The average life of a towing vehicle is estimated to be 250,000 miles. An average trip is roughly 250 miles one-way or 500 miles round trip. Therefore, the average towing vehicle makes 500 trips. The price difference between two different sized trucks was distributed evenly to produce a per trip cost attributable to a state's towing vehicle size regulations.

Truck sales offices provided the purchase price differences in Table XXV that typically accompany the stated capacity increases.

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* In practice large carriers do not choose to operate in this manner. Typically, they contract only heavy trucks (1-1/2 tons and more) so minimum size requirements are seldom a problem.

TABLE XXIVa

TOWING VEHICLE REGULATIONS FOR 12-WIDES

	Weight Specifications					
State	Manufacturer's Rated Capacity (tons)	Curb Weight (lb)	Gross Vehicle Weight (lb)	Gross Combination Weight (lb)	Minimum Wheelbase (in.)	Other Pertinent Regulations Specified[c/]
Alabama	--	--	--	--	--	--
Arizona	2	--	--	--	90	--
Arkansas	1	--	--	--	--	--
California	1-1/2	6,500	--	--	--	--
Colorado	1/2	--	--	--	--	Brakes
Connecticut	--	--	10,000	--	--	Brakes
Delaware	--	--	--	--	--	--
Florida	1	--	--	--	--	--
Georgia	--	--	--	--	--	--
Idaho	--	7,500	14,000	--	--	Tires, Brakes
Illinois	1	--	--	--	--	--
Indiana	--	--	--	--	120	Length
Iowa	1-1/2	6,000	--	--	120	--
Kansas	2	--	--	--	--	Brakes
Kentucky	1-1/2	--	--	22,000	99	--
Louisiana	1-1/2	--	--	--	--	--
Maine	2	--	--	--	--	--
Maryland	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	--
Michigan	1-1/2	--	--	--	--	Brakes, Cabtop Light
Minnesota	2	--	--	--	100	Brakes
Mississippi	3/4	--	--	--	--	--
Missouri	1-1/2	--	--	--	--	Brakes
Montana	2	--	--	--	--	--
Nebraska	1-1/2	--	12,000	--	120	Hitch, Brakes
Nevada	3/4	--	--	--	--	Cabtop Light
New Hampshire	2	--	--	--	--	--
New Jersey	1-1/2	--	--	--	--	--
New Mexico	1-1/2	--	--	--	99	Length
New York	3/4	--	--	--	--	--
North Carolina	1-1/2	--	--	--	--	--
North Dakota	2	--	--	--	--	--
Ohio	2	4,600	--	--	120	--
Oklahoma	2	--	--	--	118	--
Oregon	--	7,000	--	--	--	Engine, Brakes
Pennsylvania	1-1/2	--	--	--	--	--
Rhode Island	--	--	--	--	--	--
South Carolina	1-1/2	--	--	--	--	--
South Dakota	1-1/2	--	--	--	--	--
Tennessee	--	--	--	--	--	--
Texas	3/4	--	--	--	--	--
Utah	1-1/2	--	--	--	--	--
Vermont	2	--	--	--	--	Cabtop Light
Virginia	1-1/2	--	--	--	--	--
Washington	--	8,000	15,000	35,000	120	Tires
West Virginis	1	--	--	--	90	Csbtop Light
Wisconsin	1-1/2	--	11,000	--	--	Cabtop Light
Wyoming	--	--	--	--	--	--

Notes: a/ Rated capacity requirements vary with coach length and highway type, and the greatest required capacity is entered.

b/ Wheelbase requirements vary with truck type (longnose or cabover), and the longest is entered.

c/ Cabtop light is normally a single-amber rotating beacon.

TABLE XXIVb

TOWING VEHICLE REGULATIONS FOR 14-WIDES

State	Weight Specifications: Manufacturer's Rated Capacity (tons)	Curb Weight (lb)	Gross Vehicle Weight (lb)	Gross Combination Weight (lb)	Minimum Wheelbase (in.)	Other Pertinent Regulations Specified
Alabama	--	--	--	--	--	--
Arizona	2	--	--	--	90[b]	--
Arkansas	1	--	--	--	--	--
Colorado	2	--	19,000	--	--	Brakes
Connecticut	--	--	10,000	--	--	Brakes
Delaware	--	--	--	--	--	--
Idaho	--	9,000	19,000	--	100	Tires, Brakes
Indiana	2	--	--	--	120	Length
Iowa	1-1/2	6,000	--	--	120	--
Kansas	2	--	--	--	99	Brakes
Kentucky	2	--	--	--	--	--
Louisiana	1-1/2	--	--	--	--	--
Maine	2	--	--	--	--	--
Maryland	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	--
Michigan	1-1/2	--	--	--	--	Brakes, Cabtop Light
Minnesota	2	--	--	--	100	Brakes
Montana	2	--	--	--	--	--
Nebraska	1-1/2[a]	--	12,000	--	120	Hitch, Brakes
Nevada	2	--	--	--	--	Cabtop Light
New Hampshire	2	--	--	--	--	--
New Mexico	1-1/2	--	--	--	99	Cabtop Light, Length
New York	3/4	--	--	--	--	--
North Dakota	2	--	--	--	--	--
Ohio	2	4,600	--	--	120	Cabtop Light
Oklahoma	2	--	--	--	118[b]	--
Oregon	--	9,000	--	35,000	120[b]	Engine, Tires, Brakes
Rhode Island	--	--	--	--	--	--
South Dakota	2	--	--	--	--	Cabtop Light
Texas	3/4	--	--	--	--	--
Utah	1-1/2	9,000	19,000	--	100	Tires
Vermont	2	--	--	--	--	Cabtop Light
Washington	--	9,000	--	35,000	120[b]	Tires
West Virginia	2	--	--	--	120	Cabtop Light
Wisconsin	1-1/2	--	11,000	--	--	Cabtop Light
Wyoming	--	--	--	--	--	--

Notes: a/ Rated capacity requirements vary with coach length and highway type, and the greatest required capacity is entered.

b/ Wheelbase requirements vary with truck type (longnose or cabover), and the longest is entered.

c/ Cabtop light is normally a single-amber rotating beacon.

TABLE XXV

PRICE DIFFERENTIALS FOR INCREASED TRUCK CAPACITY

Capacity Increase From To	Total Price Difference* ($)	Per Trip Price Difference* ($)
1 ton to 1-1/2 tons	625	1.25
1-1/2 tons to 2 tons	1,000	2.00
2 tons to 2-1/2 tons	1,000	2.00

* These entries may be summed to obtain cumulative effects.

Many states include a minimum wheelbase requirement in their towing vehicle regulations. The reason for such requirements presumably is to provide truck stability. Where wheelbase requirements are not stipulated, standard trucks are sometimes shortened to enable them to pull longer coaches while complying with overall length limits. Normally, however, minimum wheelbase requirements do not pose a problem since standard trucks usually have a wheelbase in excess of the largest minimum requirement of 120 in. More discussion of nonstandard trucks is included in the next subsection, which deals with dimension restrictions.

Other categories of towing vehicle regulations involve tires, brakes, hitches, and cabtop lights. We have included these regulations in the tables and in the appendices but have added no costs because they are negligible on a per trip bases.

7. Dimension restrictions: Dimension limits allowed under permit regulations vary considerably from state to state. The four dimensions regulated by the states are: (1) width; (2) height; (3) load length; and (4) combination length, as indicated in Table XXVI. All 48 contiguous states allow 12-wides to move under permit while only 36 allow 14-wides. Several states' regulations would allow coaches wider then 14 ft to move, but only in Texas are permits routinely issued for moving coaches as wide as 16 ft. Interpretation of width limits varies somewhat, with most states allowing about 6 in. additional for appurtenances such as door handles and roof overhang. A few states, however, employ a strict interpretation--coaches, including accessories and overhang, are not permitted to exceed the limits. Experience has taught most drivers which states adhere to such strict interpretation.

State	Maximum Dimension Limits Allowed Under Permit			
	Width	Height	Coach Length	Combination Length
Alabama	14 ft	--	--	85 ft
Arizona	14 ft[a]	--	65 ft	--
Arkansas	14 ft	--	--	--
California	12 ft	13 ft 6 in.	70 ft	85 ft
Colorado	14 ft	13 ft 6 in.	--	--
Connecticut	14 ft	13 ft 6 in.	60 ft	75 ft
Delaware	14 ft	--	--	--
Florida	12 ft	13 ft 6 in.	70 ft	85 ft
Georgia	12 ft[b]	13 ft 6 in.	--	83 ft
Idaho	14 ft 6 in.	14 ft	--	85 ft
Illinois	12 ft	--	--	70 ft
Indiana	14 ft	13 ft 6 in.	--	80 ft
Iowa	14 ft	13 ft 10 in.	68 ft	80 ft
Kansas	14 ft	--	--	85 ft
Kentucky	14 ft	--	70 ft[c]	80 ft
Louisiana	14 ft	13 ft 6 in.	--	85 ft
Maine	--	--	--	--
Maryland	14 ft[a]	14 ft	--	--
Massachusetts	14 ft[a]	--	--	--
Michigan	14 ft	15 ft	70 ft	85 ft
Minnesota	14 ft 6 in.	13 ft 6 in.	70 ft	85 ft
Mississippi	12 ft	--	--	80 ft
Missouri	12 ft 4 in.	14 ft	70 ft	85 ft
Montana	15 ft	--	70 ft	--
Nebraska	14 ft	13 ft 6 in.	65 ft	85 ft
Nevada	14 ft	--	--	85 ft
New Hampshire	14 ft	--	--	--
New Jersey	12 ft	--	--	--
New Mexico	14 ft	13 ft 6 in.	80 ft	95 ft
New York	14 ft	13 ft 6 in.	--	--
North Carolina	12 ft	13 ft 6 in.	--	80 ft
North Dakota	14 ft	13 ft 6 in.	--	--
Ohio	14 ft	13 ft 6 in.	70 ft	85 ft
Oklahoma	14 ft	--	--	--
Oregon	14 ft	--	--	85 ft
Pennaylvania	12 ft	--	--	85 ft
Rhode Island	14 ft	13 ft 6 in.	--	79 ft
South Carolina	12 ft	-- --	70 ft	80 ft
South Dakota	14 ft	--	--	--
Tennesaee	12 ft	13 ft 10 in.	--	85 ft
Texas	--	--	--	--
Utah	14 ft	--	--	85 ft
Vermont	14 ft	--	--	--
Virginia	12 ft	--	70 ft	80 ft
Washington	14 ft	--	--	85 ft
West Virginia	14 ft	12 ft 6 in.	--	75 ft
Wisconsin	16 ft	14 ft	70 ft	85 ft
Wyoming	--	--	--	--

Notes: a/ 14-Wides allowed only on lowboy trailer.
b/ 12 Ft 4 in. width permitted for modules.
c/ 65 Ft coach length limit for 14-wides.

A few states, although their regulations allow 14-wides, require that they be transportatd on lowboy trailers. Prohibitive costs discourage most 14-wide moves under these circumstances. Some states, prior to full acceptance of 14-wides, have allowed them on lowboys as an interim measure. The tariffs provide for loading and unloading charges totaling $50 and an additional mileage rate of $0.40 for mobile homes with a mileage minimum of $50.

Height restrictions are not generally a problem with mobile homes. In 1966 only about 1-1/4% of overwidth mobile home shipments exceeded 13 ft 6 in.,[1/] and all but one state allows heights up to 13 ft 6 in. West Virginia allows only up to 12 ft 6 in., even with a permit. Modules, however, which are transported on lowboy trailers and which are often constructed with a sloping roofline, more frequently do exceed 13 ft 6 in. It has been necessary for some manufacturers to include design modifications (notably hinged roofs) in order to comply with height restrictions. A significant point related to height restrictions is that physical features on many routes limit the height of moves regardless of the state regulation limitations.

There is considerable nonuniformity among the states' regulations pertaining to allowable length. Fifteen states have no maximum length regulations. Many states stipulate maximum overall (combination) length. Other states limit coach length. Some states restrict both. Specifically, 31 states regulate the combination length, 16 regulate the load length, and 14 regulate both. The most common combination maximum is 85 ft and the usual coach maximum is 70 ft. These maximums allow 15 ft for the towing vehicle. A standard truck length is 12 to 15 ft.

Other length limits may require use of nonstandard (short) trucks. They are often used in the seven states which have combination maximums of less than 85 ft but have no coach length restriction, and in the three states where the difference between coach length and combination length is less than 12 ft. If a state limits combination length to 80 ft, a 70-ft coach cannot be moved with a standard 12-ft truck, so a nonstandard "slide frame" or "10-ft" truck must be used.

Slide frame trucks (sometimes called 10-ft trucks) provide the capability to tow a coach which measures only 10 ft shorter than the combination length limit. To create a slide-frame truck, the frame of a standard truck is telescoped such that the hitch is only 10 ft behind the front bumper, as illustrated in Figure 26. The wheelbase is, thus, shortened to 6 or 7 ft. The frame can be extended to standard length in order to meet the longer wheelbase requirements of other states.

Another special unit is the 5-ft truck, a normal cabover truck fitted with a sliding hitch. (See Figure 27.) The hitch can be positioned

Figure 26 - "Slide Frame" Truck Shown in its Extended Position (left) and its Shortened Position (right)

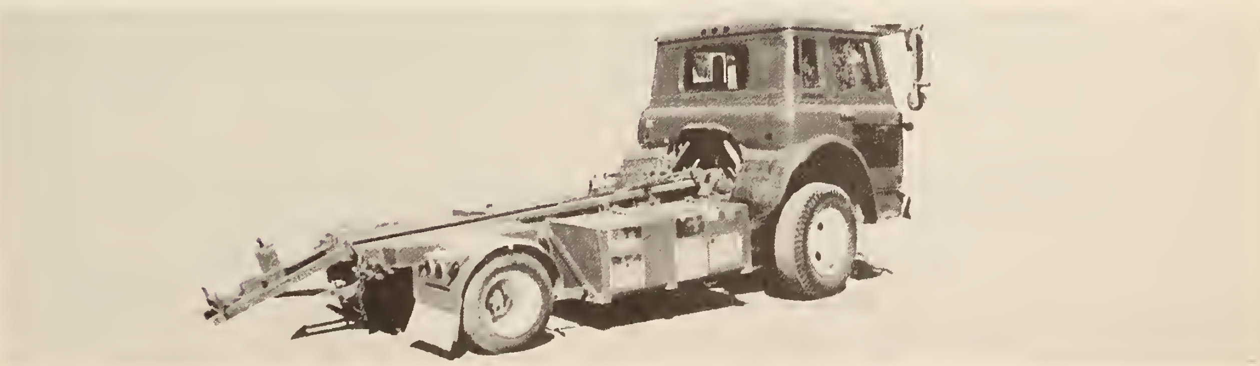

Figure 27 - "Five-Foot" Truck Shown with Ball Hitch at Rear of Slide

as near as 5 ft from the front bumper so that a coach only 5 ft shorter than combination length limits can be legally towed. Normally, the wheelbase is not altered. A disadvantage of the 5-ft truck is that the slide to which the hitch is attached must clear the running gear and, therefore, it slopes upward from rear to front. Consequently, in the 5-ft configuration the forward end of the coach is abnormally high and, with the trailer wheels serving as a fulcrum, the rear is abnormally low.

A study of the safety differences between a standard towing vehicle and one of the "special power" units is beyond the scope of this study. However, discussions with drivers and dispatchers indicate that, in their opinion, use of these variations is less safe than use of normal towing units.

A dimension restriction causes an incremental cost to shippers whenever it causes a special towing vehicle to be used. The standard tariff charge for use of "special power" is $25. The charge is due to the cost of altering a special towing vehicle and the time involved in adjusting the hitch or frame. We adopted the $25 charge and used it in the appendices.

8. <u>Coach equipment regulations</u>: Two types of coach equipment requirements are mentioned by many states. These are the number of axles and the number of braking axles. These regulations apply only to mobile homes and are summarized in Tables XXVIIa and b.

There have been no studies to determine the safest or optimum number of axles or braking axles on a 12- or 14-wide mobile home. However, evaluation of various state regulations concerning this subject and information gathered in discussions with manufacturers and carriers of mobile homes suggests that minimum installations include two axles, one of them equipped with brakes.

Many states have additional requirements. For 12-wides, eight states require a third axle if the coach exceeds a specified length--variously 60 or 65 ft. Brakes described as "adequate" are required by 15 states. Eleven states require brakes on at least two axles, and, of those, four require brakes on all axles.

Of the 36 states allowing 14-wides, five require at least two axles, five conditionally require three axles (based on length as above), six require a minimum of three axles (independent of length of coach), and one state requires four axles. "Adequate" brakes on 14-wides are required by nine states, whereas six states require brakes on at least two axles, and six require them on all axles.

TABLE XXVIIa

COACH EQUIPMENT REGULATIONS
FOR 12-WIDES

State	No. of Axles	Brakes	Other
Alabama	--	--	--
Arizona	--	Adequate	--
Arkansas	2	Adequate	--
California	2[a,c]	2 axles	--
Colorado	--	All axles	--
Connecticut	--	All axles	--
Delaware	--	Front	--
Florida	--	Adequate	--
Georgia	--	--	--
Idaho	--	Adequate	--
Illinois	--	All axles	--
Indiana	--	--	--
Iowa	--	--	--
Kansas	2[a]	--	e,f/
Kentucky	--	--	--
Louisiana	--	2 axles[d]	--
Maine	--	Adequate	e/
Maryland	--	--	--
Massachusetts	--	--	--
Michigan	--	Adequate	--
Minnesota	2[b]	Adequate	--
Mississippi	--	--	--
Missouri	2	Adequate	--
Montana	--	Adequate	--
Nebraska	2[a]	2 axles	e/
Nevada	--	Adequate	--
New Hampshire	--	Adequate	e/
New Jersey	--	--	--
New Mexico	--	--	--
New York	--	--	--
North Carolina	--	Adequate	--
North Dakota	c/	--	--
Ohio	2[a]	Adequate	f/
Oklahoma	2[b]	--	--
Oregon	2[a]	2 axles	--
Pennsylvania	--	All axles	--
Rhode Island	--	--	--
South Carolina	--	--	e/
South Dakota	--	2 axles	--
Tennessee	--	--	--
Texas	--	Adequate	--
Utah	--	--	--
Vermont	--	--	--
Virginia	--	--	--
Washington	2[a]	2 axles	f/
West Virginia	--	--	--
Wisconsin	2[b]	2 axles	--
Wyoming	--	--	--

TABLE XXVIIb

COACH EQUIPMENT REGULATIONS
FOR 14-WIDES

State	No. of Axles	Brakes	Other
Alabama	--	--	--
Arizona	--	--	--
Arkansas	2	Adequate	--
Colorado	--	All axles	--
Connecticut	--	All axles	--
Delaware	--	Front	--
Idaho	2[a]	All axles	--
Indiana	3	All axles	--
Iowa	--	--	--
Kansas	3	Adequate	e,f/
Kentucky	--	All axles	--
Louisiana	--	2 axles[d]	--
Maine	--	Adequate	e/
Maryland	--	--	--
Massachusetts	--	--	--
Michigan	--	Adequate	--
Minnesota	--	Adequate	--
Montana	--	--	--
Nebraska	2[a]	2 axles	--
Nevada	3	--	f/
New Hampshire	--	Adequate	--
New Mexico	--	--	--
New York	--	--	--
North Dakota	--	--	--
Ohio	4	Adequate	f/
Oklahoma	2[b]	--	--
Oregon	3	2 axles	f/
Rhode Island	--	--	--
South Dakota	--	2 axles	--
Texas	--	Adequate	--
Utah	2[a]	2 axles	--
Vermont	--	--	--
Washington	2[a]	2 axles	f/
West Virginia	3	Adequate	f/
Wisconsin	3	All axles	--
Wyoming	--	--	--

Notes:
a/ Three axles required if coach is > 60 ft long.
b/ Three axles required if coach is > 65 ft long.
c/ Maximum weight per axle specified.
d/ Brakes required on 3 axles on 4-axle loads.
e/ Reflector required.
f/ Minimum tire specifications.

Additional brake and axle installations add significantly to the cost of a mobile home. Although installation of axles and brakes on a mobile home is usually completed during the manufacturing stage, variance between states' brake and axle regulations causes significant additional manufacturing expense attributable to the transportation phase. Using the minimum state requirement of two axles, one braking, as a base,* we attached costs to additional state requirements. Installation of one braking axle costs about $150; and an axle without brakes costs about $120 installed--$30 less. Thus, additional brakes on one axle is costed at $30. The costs are applied as add-on costs related to various states' requirements and may be conditional on coach size. Costs of the various brake and axle requirements can be a great deal higher if installations must be effected in transit, but on initial moves this can be avoided by proper planning.

Other miscellaneous coach regulations include requirements relating to tires, clearance and running lights, safety glass, and safety chains. Most of these regulations correspond to DOT regulations and none were costed.

9. Speed limit restrictions: Many states specify speed limits for mobile home combinations in their regulations regarding overdimensional moves. Both upper and lower limits are variously stipulated as included in Tables XXVIIIa and b. Specification includes establishment of:

- Statewide limits;
- Limits by highway type; and
- Limits dependent on posted speed.

The most commonly stipulated maximum speed for both 12- and 14-wides is 45 mph. Interestingly, composite maximums are slightly less stringent for 14-wides. This is not the result of more lenient regulations but, rather, because of the prohibition of 14-wides in several states where, for 12-wides, lower maximum speeds are enforced.

Experience in the traffic data collection activities indicates that carriers tend to travel somewhat faster than 45 mph where conditions and enforcement permit.

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* This is not meant to imply that the minimum requirement is necessarily adequate for safety for all configurations; further research is required to establish standards in this area.

TABLE XXVIIIa

SPEED LIMITS FOR 12-WIDES*

	Upper and Lower Speed Limits Under Various Conditions							
	2-Lane Highways				4-Lane, Divided, Interstate			
	60 MPH Zone		70 MPH Zone		60 MPH Zone		70 MPH Zone	
State	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Alabama	50	--	50	--	50	--	50	--
Arizona	45	--	45	--	45	--	45	--
Arkansas	35	--	35	--	35	--	35	--
California	55	--	55	--	55	--	55	--
Colorado	--	--	--	--	--	--	--	--
Connecticut	--	40	--	40	--	40	--	40
Delaware	45	--	45	--	45	--	45	--
Florida	35	--	35	--	35	--	35	--
Georgia	50	--	50	--	50	--	50	--
Idaho	--	--	--	--	--	--	--	--
Illinois	35	--	35	--	Min+5	--	Min+5	--
Indiana	--	--	--	--	--	--	--	--
Iowa	35[a/]	--	35[a/]	--	35[a/]	--	35[a/]	--
Kansas	50	35	50	35	50	35	50	35
Kentucky	--	--	--	--	--	--	--	--
Louisiana	45	--	45	--	45	--	45	--
Maine	45	--	45	--	45	--	45	--
Maryland	--	--	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	--	--	--
Michigan	45[b/]	--	45[b/]	--	45[b/]	--	45[b/]	--
Minnesota	--	--	--	--	--	--	--	--
Mississippi	30	--	30	--	30	--	30	--
Missouri	50	--	50	--	55	--	55	--
Montana	50	20	50	20	50	20	50	20
Nebraska	50	35	50	35	50	35	50	35
Nevada	55	--	55	--	55	--	55	--
New Hampshire	--	--	--	--	--	--	--	--
New Jersey	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	--	--
New York	--	--	--	--	--	--	--	--
North Carolina	30	--	30	--	45	--	45	--
North Dakota	50	--	50	--	50	--	50	--
Ohio	40	--	40	--	40[a/]	--	40[a/]	--
Oklahoma	50[a/]	--	50[a/]	--	50[a/]	40[a/]	50[a/]	40
Oregon	60	--	60	--	60	--	60	--
Pennsylvania	45	--	45	--	45	--	45	--
Rhode Island	--	--	--	--	--	--	--	--
South Carolina	45	--	45	--	45	--	45	--
South Dakota	40	--	50	--	45	45	50	45
Tennessee	--	--	--	--	--	--	--	--
Texas	45[a/]	--	45[a/]	--	45[a/]	--	45[a/]	--
Utah	--	--	--	--	--	45	--	45
Vermont	35	--	35	--	50	--	50	--
Virginia	35[c/]	--	35[c/]	--	45	--	45	--
Washington	40	35	45	35	40	35	45	35
West Virginia	40	--	40	--	45	--	45	--
Wisconsin	35	--	35	--	45	--	45	--
Wyoming	45[d/]	--	45[d/]	--	45[d/]	--	45[d/]	--

* Entries reflect regulations but are formatted to exemplify maximum and minimum speeds on various highways at speeds commonly posted.

Notes: a/ Posted truck speed limit supercedes entry.
b/ Speed limit reduced to 35 mph if combination length exceeds 80 ft.
c/ Speed limit reduced to 25 mph if pavement width is less than 24 ft.
d/ Entered speed applies only if escorted; otherwise no restriction.

TABLE XXVIIIb

SPEED LIMITS FOR 14-WIDES*

State	Upper and Lower Speed Limits Under Various Conditions							
	2-Lane Highways				4-Lane, Divided, Interstate			
	60 MPH Zone		70 MPH Zone		60 MPH Zone		70 MPH Zone	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Alabama	50	--	50	--	50	--	50	--
Arizona	45	--	45	--	45	--	45	--
Arkansas	35	--	35	--	35	--	35	--
Colorado	--	--	--	--	--	--	--	--
Connecticut	--	--	--	--	--	--	--	--
Delaware	45	--	45	--	45	--	45	--
Idaho	40	35	50	35	40	35	50	45
Indiana	45	35	45	35	--	--	--	--
Iowa	--	--	--	--	--	--	--	--
Kansas	50	35	50	35	50	35	50	35
Kentucky	35	--	35	--	45	--	45	--
Louisiana	45	--	45	--	45	--	45	--
Maine	45	--	45	--	45	--	45	--
Maryland	--	--	--	--	--	--	--	--
Massachusetts	--	--	--	--	--	--	--	--
Michigan	35	--	35	--	45	--	45	--
Minnesota	--	--	--	--	--	--	--	--
Montana	50	20	50	20	50	20	50	20
Nebraska	50	35	50	35	50	35	50	35
Nevada	55	--	55	--	55	--	55	--
New Hampshire	45	--	45	--	50	--	50	--
New Mexico	--	--	--	--	--	--	--	--
New York	55	--	55	--	55	--	55	--
North Dakota	50	--	50	--	50	--	50	--
Ohio	35	--	35	--	45	--	45	--
Oklahoma	50	--	50	--	50	40	50	40
Oregon	--	35	--	35	--	45	--	45
Rhode Island	--	--	--	--	--	--	--	--
South Dakota	40	--	50	--	40	40	50	45
Texas	45	--	45	--	45	--	45	--
Utah	60	30	60	30	60	30	60	30
Vermont	35	--	35	--	50	--	50	--
Washington	40	35	45	35	40	35	45	35
West Virginia	40	--	40	--	45	--	45	--
Wisconsin	35	--	35	--	45	--	45	--
Wyoming	45[d/]	--	45[d/]	--	45[d/]	--	45[d/]	--

* Entries reflect regulations but are formatted to exemplify maximum and minimum speeds on various highways at speeds commonly posted.

Notes: a/ Posted truck speed limit supercedes entry.
b/ Speed limit reduced to 35 mph if combination length exceeds 80 ft.
c/ Speed limit reduced to 25 mph if pavement width is less than 24 ft.
d/ Entered speed applies only if escorted; otherwise no restriction.

10. Insurance regulations: Most states require all types of motor carriers to be financially responsible in cases of claims of liability. This responsibility usually involves liability insurance, although some states will hold a posted bond to cover damage to government or private property. While in-depth study of all insurance requirements is beyond the scope of this research report, Table XXIX sets forth minimum liability insurance requirements for mobile home carriers. It can be seen that the most common minimums are 100/300/50. These minimums are variously higher or lower from state to state than those set for carriers of other commodities.

On a per trip basis, incremental premium payments for varying additional amounts of liability insurance coverage are insignificant. For this reason, the incremental costs of required liability coverage is not considered in this report.

11. Routing restrictions: A majority of overwidth mobile or modular home movements incur some extra mileage because drivers are unable to utilize the shortest route between origin and destination. Circuitous routing generally results from one or more of three factors: (1) vehicle dimensions (height, width, length) exceed the physical capacities of the shortest route; (2) the state or governing body will not allow the move on the shortest route; and (3) economics dictate that a longer altennative be used to effect other cost savings. State regulations play a significant role in the second and third factors.

States often prohibit the use of certain routes by wide loads to avoid potential hazards. Such hazards may include construction areas, narrow pavement, inadequate shoulders, limited sight distance, and heavy traffic in addition to absolute physical constraints such as low overpasses and narrow bridges.

Occasionally, shippers will elect to use a longer alternative to avoid incurring additional costs on the shorter route. Examples of additional costs include toll payments and escort costs. If such costs exceed the extra mileage cost, it is reasonable to choose the longer but less costly route.

Routing control by the states normally does not cause problems for moves under a single-trip permit. The states reserve the right to designate routing or approve requested routing. Under systems permitting multiple trips, however, problems can arise because of the possible loss of routing control by the states. In either case, up-to-date knowledge of authorized routes simplifies the route planning for both carriers and states.

TABLE XXIX

INSURANCE REGULATIONS FOR CARRIERS OF 12- AND 14-WIDES

	Minimum Coverage ($1,000's)				Minimum Coverage ($1,000's)		
	Liability		Personal Property		Liability		Personal Property
State	Individual	Per Accident	Per Accident	State	Individual	Per Accident	Per Accident
Alabama	--	--	--	Nebraska	25	100	10
Arizona	10 a/	20 a/	5 a/	Nevada	100	300	50
Arkansas	25	100	10	New Hampshire	--	--	--
California	--	--	--	New Jersey	100	300	50
Colorado	--	--	--	New Mexico	50	100	25
Connecticut	b/	b/	b/	New York	--	--	--
Delaware	b/	b/	b/	North Carolina	--	--	--
Florida	--	--	--	North Dakota	100	300	20/50 c/
Georgia	--	--	--	Ohio	100	300	50
Idaho	100	300	50	Oklahoma	5	10	5
Illinois	100	300	50	Oregon	10	20	10
Indiana	10 a/	20 a/	5 a/	Pennsylvania	100	300	100
Iowa	100	200	20	Rhode Island	--	--	--
Kansas	100	300	25	South Carolina	--	--	--
Kentucky	--	--	--	South Dakota	100	300	20
Louisiana	10 a/	20 a/	5 a/	Tennessee	100	300	100
Maine	20	40	5	Texas	--	--	--
Maryland	--	--	--	Utah	50	100	50
Massachusetts	--	--	--	Vermont	75	300	75
Michigan	100	300	100	Virginia	--	--	--
Minnesota	--	--	--	Washington	100	300	50
Mississippi	25	--	25	West Virginia	100	300	50
Missouri	25	100	25	Wisconsin	50/100 c/	100/300 c/	25/100 c/
Montana	100	300	50	Wyoming	--	--	--

* Notes: a/ States do not require insurance but recommend coverages indicated.
b/ Indicated states require insurance but do not specify minimum coverage.
c/ Different coverages required for 12-wides/14-wides.

States variously employ several methods of making known unauthorized routes. Some states limit wide load operations to certain categories of highways and disallow the use of others. Without the aid of the type of maps used by highway engineers, these restrictions can confuse a carrier. Other states designate certain specific routes to be "off limits" to wide loads. In these instances the carrier must be sure his list of prohibited routes is current. Increasingly, the publication of state maps clearly indicating authorized routes has gained popularity. This method avoids uncertainty by all concerned parties on routes to be employed. An example of a state route map is shown in Figure 25.

With few exceptions, persons interviewed about routing restrictions believe most states are making a sincere effort to allow travel on routes safe for wide loads and restrict wide load travel only where necessary.

To determine the extent of circuitous routing, records of 500 actual shipments were analyzed. One hundred observations were obtained from each of five geographic areas selected because of high levels of mobile home manufacturing (and, thus, transportation) and availability of source data. The methodology involved a comparison, on a trip-by-trip basis, of "out miles" (miles driven with a mobile home in tow), to "in miles" (miles returning from the destination in a vehicle which conformed to legal dimensions). The difference is assumed to reflect the effect of routing restrictions brought about by all causes.

Overall, 7.9% extra miles were traveled on the 500 trips. The analysis yielded 96,139 "out miles" to the 500 trip destinations (about 192 miles per trip) and 89,096 miles returning to the points of origin. Table XXX indicates percentages of excess of "out miles" over "in miles" at the five locations from which observations were obtained.

TABLE XXX

PERCENT CIRCUITOUS ROUTING

Origin	Circuitous Routing (%)
Lafayette, Indiana	13.1
Tempe, Arizona	8.9
Terryville, Connecticut	11.1
Thomson, Georgia	6.1
Tyler, Texas	3.4

It can be seen from the table that circuitous routing varied greatly from location to location. This might be expected in areas of differing topography, population density, and highway conditions.*

Costs associated with circuitous routing increase directly with the amount of additional mileage since transportation charges typically are based on mileage charges plus add-on items.

G. Regulatory Effect on Hypothetical Trips

Greater appreciation of the potential costs impact of certain regulations can be gained by assembling several hypothetical trips for which compliance with various regulations is required. This section evaluates the cost impact of regulatory circumstances for six trips. All are assumed to take place prior to 1 July 1973; subsequent to that date some state regulations may have been changed. Also, all trips are assumed to be initial moves and tariff MF-I.C.C. No. 23 applies. The evaluation takes into account coach and combination characteristics as well as regulations applying in the origin state, intermediate state(s) and the destination state. Both absorbed and add-on costs are considered. The first four examples involve mobile homes while the last two consider modules.

Table XVII supplies the cost of permit acquisition in each state. Appendix B provides the costs of intiating a move in the state of origin. Appendix C provides the costs associated with regulation changes from state to state. Escort costs are added, where appropriate, based on entries in Appendices B and C, and amount to $0.35/mile (100-mile minimum) for each escort. Circuitous routing is determined by comparing shortest routes on state highway maps with routes satisfying pertinent regulations and is charged at the per mile rate specified in the governing tariff.

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* Specific causes of circuity cannot be identified without detailed routing information, except in certain cases. In Texas, 14 wides are prohibited from traveling on the Interstate System. The 3.4% circuity from Tyler, Texas, represents the additional travel required by 14 wides to comply with that regulation. Varying state regulations can also play a role in generating circuitors routing. The 100 trips originating in Indiana incurred 13.1% circuity on the average, but five of these which originated in Indiana and were delivered in Missouri incurred 31.4% circuity. Of these five, one incurred 124% circuity because the driver was obligated to circumvent Illinois since his combination, although permissible in Indiana and Missouri, exceeded permit length limits in Illinois.

Trip 1 South Bend, Indiana, to Cedar Rapids, Iowa (310 miles)
Coach dimensions: 12 x 60
Mileage charge: $201.50

For this trip, the purchaser must pay $160 in add-on costs (in addition to line-haul charges), and the carrier absorbs $16.25. These costs, detailed in Tables XXXI and XXXII, arise from compliance with state regulations.

TABLE XXXI

ABSORBED DOLLAR COSTS FOR TRIP 1

State	Permit Admin.	Signing	Flagging	Stop for Flagman[a/]	Truck Capacity	Total Absorbed
Indiana	0.75	3.75	1.25			5.75
Illinois	0.75	3.75	1.25	1.50		7.25
Iowa	0.75	____	1.25	____	1.25	3.25
Total	2.25	7.50	3.75	1.50	1.25	$16.25

a/ Delay cost incurred to pick up flagman, assumed to be the same as the delay cost to pick up an escort.

TABLE XXXII

ADD-ON DOLLAR COSTS FOR TRIP 1

State	Permit Charge	Flagman Charge	Special Power	Circuitous Routing	Brakes on Coach	Total Add-On
Indiana	10.00					10.00
Illinois	25.00	42.00	25.00		30.00	122.00
Iowa	15.00	____	____	13.00	____	28.00
Total	50.00	42.00	25.00	13.00	30.00	$160.00

The absorbed costs outlined in Table XXXI accure in several ways. Permit administration is attendant to permit acquisition in every state in which the coach moves. At the trip origin, signing and flagging are required. Changes must be made at the Indiana/Illinois border to both signs and flags while a riding flagman must also be contracted. For operation in Iowa, the flags must again be changed and greater truck capacity is required.

Costs which are added to the transportation or coach costs and passed on to the consumer are shown in Table XXXII. The permit charges include the permit fees and out-of-pocket costs, as reflected in the tariff charges. In Illinois, a riding flagman is required for 168 miles at a cost of $0.25/mile. Special power is required--a standard towing vehicle would provide compliance with Indiana's wheelbase requirement of 10 ft, but a 12-15 ft truck in combination with the 60-ft coach would exceed Illinois' 70-ft maximum. Therefore, a nonstandard towing vehicle (special power) equipped with a sliding frame facilitates compliance with Indiana's wheelbase requirement in the extended position and Illinois' combination length restriction in the shortened mode (see Figure 26). Brakes are required on all axles in Illinois--at least one more than in Indiana where there is no regulation.

In Iowa, 12-wides are not allowed on the Interstate System. Mileage is increased due to circuitous routing, raising the line-haul charge.

All three states allow travel during daylight hours Monday through Friday (Illinois also on Saturday morning). Speed limits are somewhat restrictive in Illinois and Iowa, and Illinois restricts travel during rush hours in metropolitan areas. However, the move can be completed in one driving day if no significant problems arise. The Indiana Toll Road (I-80/90) is a shorter route and undoubtedly faster, but an additional $10 permit plus tolls would bring about expenses which exceed the mileage saving.

In total, add-on charges are 80% of the basic line-haul charges and absorbed costs are 8%. Final costs for transportation would include $201.50 basic line-haul charges (of which about $16.25 are brought about by regulatory compliance and absorbed) plus approximately $130 added on for permits, flagman, special power and circuitous routing. The $30 for required additional brakes is passed on to the shipper (dealer) who in turn includes it in the price of the home.

Trip 2 San Bernardino, California, to Phoenix, Arizona (310 miles)
Coach dimensions: 12 x 60
Mileage charge: $201.50

This trip would entail $50 in add-on charges and $9.75 in absorbed costs, as outlined in Tables XXXIII and XXXIV.

TABLE XXXIII

ABSORBED DOLLAR COSTS FOR TRIP 2

State	Permit Admin.	Signing	Flagging	Truck Capacity	Total Absorbed
California	0.75	3.75	1.25	1.25	7.00
Arizona	0.75	____	____	2.00	2.75
Total	1.50	3.75	1.25	3.25	$9.75

TABLE XXXIV

ADD-ON DOLLAR COSTS FOR TRIP 2

State	Permit Charge	Brakes on Coach	Total Add-On
California	15.00	30.00	45.00
Arizona	5.00	_____	5.00
Total	20.00	30.00	$50.00

The absorbed costs shown in Table XXXIII result from permit administration in both states, signing and flagging in the origin state, and truck capacity requirements of 1-1/2 tons in California and 2 tons in Arizona on the Interstate System.

Add-on costs depicted in Table XXXIV result from permit charges in both states and the California requirement for brakes on two axles.

No other requirements bring about incremental costs. There are no obvious conditions requiring escorts or circuitous routing. Both states allow travel during daylight hours Monday through Friday, and both allow speeds sufficient to complete the trip in one day.

Of the line-haul charge, about $9.75 or about 5% is brought about by state regulations and is absorbed. Added to the basic line-haul charge is $20 (about 10%) for permit acquisition; the $30 for additional brakes is included in the sales price of the home.

Trip 3 Atlanta, Georgia, to Meridian, Mississippi (310 miles)
Coach dimensions: 12 x 60
Mileage charge: $201.50

For this trip the costs of compliance are small, as indicated in Table XXXV. The absorbed costs total $16.75 and the add-on costs are $7.

TABLE XXXV

DOLLAR COSTS OF COMPLIANCE FOR TRIP 3

	Absorbed Costs					Add-On Costs
State	Permit Admin.	Other Permit	Signing	Flagging	Total	Permit Charge
Georgia	0.75	9.00	3.75	1.25	14.75	7.00
Alabama						
Mississippi	0.75	___	___	1.25	2.00	___
Total	1.50	9.00	3.75	2.50	16.75	$7.00

It is clear that Georgia's regulations bring about the greatest costs. Permit acquisition accounts for most of these. In Georgia, a $10 permit fee is charged by the state, but only a $7 tariff charge appears. When the tariffs were proposed, the fee was only $1. The $7 tariff charge at that time covered both the state permit fee and out-of-pocket expenses. Of course, now it does not. Some expense is absorbed. Estimated absorbed expenses are brought about by transmission costs and the unrecovered portion of the fee. They total about $9 and are reflected in the column headed "Other Permit" absorbed costs. Additionally, the permit administrative expense applies as indicated. Georgia also requires signing and flagging.

No compliance costs are incurred in Alabama. No permit is required in Alabama for a combination within the 12 x 75 ft overall limits. No circuitous routing is obvious, and no escorts would normally be required.

In Mississippi a permit is required. The state issues a multiple-trip permit free of charge and most trucks which might tow an oversize coach in Mississippi have such a permit. Postal service is usually used to obtain multiple-trip permits, and the out-of-pocket expense is slight. Because no fee is charged and out-of-pocket acquisition expense is negligible, no charge is reflected in the tariff for obtaining a Mississippi permit. Even so, some administrative expense is incurred. The $0.75 standard cost is shown but probably is overstated since it should be allocated equally over all trips made under the multiple-trip permit. In Mississippi flag location requirements differs from those in Georgia and a flag change is necessary.

Trip 4 Cleveland, Ohio, to Hagerstown, Maryland (290 miles)
Coach dimensions: 14 x 60
Mileage charge: $246.50

This trip involves a wide (14-ft) coach and represents an extreme case of compliance costs. As outlined in Tables XXXVI and XXXVII, absorbed costs would be approximately $52.25, and add-on costs would be about $731.40.

TABLE XXXVI

ABSORBED DOLLAR COSTS FOR TRIP 4

State	Permit Admin.	Signing	Flagging	Stop for Escort	Time of Day	Truck Capacity	Total Absorbed
Ohio	0.75	3.75	1.25		15.00	3.25	24.00
W. Va.	0.75	3.75	1.25	1.50	15.00		22.25
Maryland	0.75	3.75		1.50			6.00
Total	2.25	11.25	2.50	3.00	30.00	3.25	$52.25

TABLE XXXVII

ADD-ON DOLLAR COSTS FOR TRIP 4

State	Permit Charge	Warning Light	Escort Costs	Lowboy Charge	Circuitous Routing	Coach Axles	Total Add-On
Ohio	15.00	15.00	54.95			240.00	324.95
W. Va.	30.00[a/]		102.20				132.20
Maryland	20.00		45.15	101.60			166.75
Other (Pa.)	___	___	___	___	127.50	___	127.50
Total	45.00[a/]	15.00	202.30	101.60	127.50	240.00	$731.40

a/ Overdimension charges for a West Virginia permit have been increased while the cumulative charges for the three permits have not. Thus, the total does not equal the sum of the individual charges.

Routing accounts for a substantial additional burden on this hypothetical trip. Because Pennsylvania does not allow 14 wides, circuitous routing around Pennsylvania increases the trip distance from 290 to 432 miles. Additionally, a route through West Virginia which would shorten the trip by 12 miles, is not feasible since West Virginia does not allow travel of 14 wides on pavement less than 24-ft wide. State maps indicate that the shorter route does not meet that specification.

Other expenses for Trip 4 brought about by state regulations are many and varied. Absorbed costs amount to over 21% of line-haul and result from normal permit administration, signing, flagging, escorts, and truck capacity. Additionally, time of operations has a cost impact. In a normal driving day of 10 hr, chances are fair that a 432-mile trip could be completed. However, Ohio and West Virginia both allow operations of 14 wides only from 9:00 a.m. to 3:00 p.m. In Ohio and West Virginia, then only 6 hr per day are open to 14-wide operations. Observing the legal speed limit of 35 mph in Ohio, driving time to the West Virginia border is 4-1/2 hr. Only 1-1/2 hr driving time remains before the West Virginia curfew causes curtailment. An overnight stop somewhere in West Virginia is brought about by limited operating hours. While a driver can legally drive 10 hr a day under DOT regulations, he is limited to 6 hr under state regulations for 14 wides, leaving 4 hr of potential driving time unoccupied. The cost of those 4 hr is allocated equally to Ohio and West Virginia. About 4 hr of a second day is required to complete the delivery. Driving can begin at 9:00 a.m. in West Virginia so arrival can be anticipated about 1:00 p.m. No cost arises on the second day due to time of operations since the driver can complete delivery before 3:30 p.m. and return legally under normal DOT regulations. However, an additional overnight stop is necessary for which the carrier pays the driver's expenses. More important to the driver is the fact that the round trip, with no restrictions, could be completed in 2 days, while 2-1/2 days are required to comply with regulations. The driver is prevented from towing another coach on the third day, and, thus, prevented from earning additional income.

Add-on costs are also extreme. Special axle requirements in Ohio add $240 to the price of the home. Permits are required in all states. A special warning light is required in Ohio. Ohio also requires one escort, West Virginia requires two, and Maryland requires one police escort. Use of a lowboy trailer is required for the 129 miles of movement in Maryland causing a $50 loading and unloading charge and a mileage rate of $0.40, both specified in the governing tariff. As shown in Table XXXVII the add-on transportation charges equal about 200% of the $246.50 line-haul charge. In addition, the costs associated with axle requirements amount to almost 100% of basic line-haul charges, and combined with add-on charges, they approximate 300% of the mileage charge over the shortest route.

Conceivably, a net saving could be achieved by using a lowboy trailer for the entire trip. Ordering the coach with minimum brake and axle requirements would save $240. Increased mileage on the lowboy trailer would be 303 miles which would add $121.20. The net result would be a saving of $118.80. No other opportunities for savings are apparent.

Because of the high cost of this hypothetical trip, it is unlikely that it would be made commonly under existing regulatory conditions.

Trip 5 Muncie, Indiana, to Tompkinsville, Kentucky (295 miles)
Module dimensions: 12 x 50
Mileage charges: $165
Return undercarriage: $29.50

Transportation of overdimensional modular sections involves compliance identical to that observed for mobile homes for most regulation categories. Compliance costs, similarly, coincide with the exception of permit overdimension charges. Table XXXVIII summarized the routine absorbed costs which involve permit administration, signing, flagging, escorts acquisition, and truck capacity.

TABLE XXXVIII

ABSORBED DOLLAR COSTS FOR TRIP 5

State	Permit Admin.	Signing	Flagging	Stop for Escort	Truck Capacity	Total Absorbed
Indiana	0.75	3.75	1.25			5.75
Kentucky	0.75	____	1.25	1.50	1.25	4.75
Total	1.50	3.75	2.50	1.50	1.25	10.50

Add-on costs for the Muncie to Tompkinsville trip (see Table XXXIX) are brought about by permit requirements, the need for a front escort on two-lane highways in Kentucky, and a tariff charge for trailer return (an operational consideration). Conditional add-on charges not related to compliance have not been considered in this example.*

TABLE XXXIX

ADD-ON DOLLAR COSTS FOR TRIP 5

State	Permit Charge	Escort Costs	Total Add-On
Indiana	20.00		20.00
Kentucky	25.00	35.00	60.00
Total	35.00[a/]	35.00	70.00[a/]

a/ "Surcharge elimination" of $10 reduces total permit charges from $45 (summed total of charges associated with individual states as per Table XVII) to $35 reflected in Section I-A of Tariff MC-I.C.C. No. 24.

* Other tariff add-ons can arise conditionally and include additional mileage charges for "excess" weight, height, length or modular expandability, loading and unloading charges if the carrier is commissioned to perform these tasks, and rates for use of the carrier's lowboy trailer if the shipper does not provide his own trailer. While these charges can add substantially to the delivery cost of a modular section, they have not been considered in this example (nor the next) because they do not arise from regulatory compliance.

Overdimension charges for the acquisition of Indiana and Kentucky permits amount to $35--$5 higher than similar charges for mobile homes. The permit fee in Kentucky for transportation of modules is $5 greater than for transportation of mobile homes, however, so that the higher overdimension charge for modules may be thought of as "justified." No surcharge appears in the modular rate, on the other hand, and that is highly unusual.

Escort requirements in Kentucky call for a front escort on all two-lane roads for both mobile home and modular section moves. The trip from Muncie to Tompkinsville would necessitate an escort in Kentucky, and payment would be based on the 100-mile minimum--probably in the neighborhood of $35.

The lowboy trailer which serves as an undercarriage for a modular section must be returned after the module is off-loaded at its destination. The tariff provides a size-formula rate to be charged by common carriers which provide this service. Since most special trailers in use as modular undercarriages can be reduced to legal dimensions for the return trip, the minimum rate (incremental charge) of $0.10 per mile has been assumed. Based on a 295-mile return, the total for trailer return is $29.50.

The necessity for circuitous routing is not apparent. Indeed, the analysis of circuitous routing (described previously) indicated that of four trips originating in Indiana and delivered in Kentucky, circuity amounted to a total of only 0.1%.

Add-on charges, then, amount to roughly $100--$35 for permit acquisition, $35 for escort costs, and $29.50 for trailer return. Of these charges, only the first two arise because of compliance; the third comes about because of the nature of the modular operation.

Trip 6 Bethlehem, Pennsylvania, to Manchester, Vermont (230 miles)
Module dimension: 12 x 50
Mileage charge: $126.50
Return undercarriage: $23

Add-on charges (displayed in Table XL) for complying with requirements along the route from Bethlehem to Manchester exceed the simple transportation charges. Add-on charges related to regulatory compliance include permit, escort, and warning light charges. Overdimension charges for acquiring permits in Pennsylvania, New York, and Vermont total $55--$10 more than similar charges for like permits to transport a mobile home. Escort charges were calculated at $0.35/mile for 139 miles in New York, amounting to $48.65, and $35 in Vermont because of the 100-mile minimum. Together, these amounts total $83.67. A warning light installation to comply with

New York requirements gives rise to a charge of $15. Summing the add-on charges yields $153.65 exclusive of the $23 charge for return of the lowboy trailer to its origin (at $0.10/mile for 230 miles).

TABLE XL

ADD-ON DOLLAR COSTS FOR TRIP 6

State	Permit Charge	Escort Costs	Warning Light Charge	Total Add-On
Pennsylvania	20.00			20.00
New York	25.00	48.65	15.00	88.65
Vermont	30.00	35.00	___	65.00
Total	55.00 a/	83.65	15.00	153.65 a/

a/ "Surcharge" elimination of $20 reduces total permit charge from $75 (summed total of charges associated with individual states as per Table XVII) to $55 reflected in Section I-A of Tariff MC-I.C.C. No. 24.

Absorbed costs of complying with routine signing, flagging, and truck capacity regulations as well as stops for contracting escorts amount to $18.50 as shown in Table XLI.

TABLE XLI

ABSORBED DOLLAR COSTS FOR TRIP 6

State	Permit Admin.	Signing	Flagging	Stop for Escort	Truck Capacity	Total Absorbed
Pennsylvania	0.75	3.75	1.25		1.25	7.00
New York	0.75		1.25	1.50		3.50
Vermont	0.75	3.75	___	1.50	2.00	8.00
Total	2.25	7.50	2.50	3.00	3.25	18.50

In association with the absorbed costs, three items merit mention. First, in passing from New York to Vermont, flag change is needed. However, if the flags installed originally to comply with the Pennsylvania regulations remain in place, the Vermont flag regulation is fulfilled. Thus, no additional absorbed cost has been included. Second, although both New York and Vermont require only one escort to accompany an oversize combination of the description over the types of highways which constitute the appropriate route, one escort cannot serve in both states. This is due to Vermont's requirement for special licensing of the beacon on the escort vehicle. Therefore, two separate escorts must be employed, and two stops to contract escorts must be made--one on entering New York State and one on entering Vermont. Finally, regarding truck capacity, although passing from New York to Vermont calls for increasing truck size from minimum capacity to 2 tons, the increment considered for costing purposes is from 1-1/2 tons (required in Pennsylvania and costed accordingly) to 2 tons. Thus, the full increment from minimum size to 2 tons is considered in two separate parts which equal the whole as displayed in Table XLI.

H. Summary: Cost of Regulations to Shippers and Carriers

The most notable characteristic of costs to mobile home shippers and carriers brought about by permit and transportation regulations is their variability from trip to trip. The cost of regulations can range from a small fraction of basic line-haul charges to several times the cost of transportation only. However, for shipment of a 12-wide mobile home (excluding modules) an average distance, the cost of complying with regulations is typically $50 to $100. Compliance costs increase for modules primarily because of higher permit charges, and for 14-wides because of a combination of greater volumes of regulations and more stringent requirements for transportation.

Costs of compliance with regulations are ultimately paid by the consumer. Those costs are either added on to the price of the home or absorbed in the transportation costs. During the intermediate steps before final delivery to the consumer, compliance costs which are added on to the price of the home are borne by the shipper, and those costs absorbed in the transportation charges are borne by the carrier. For the most part, only minor costs (up to several dollars) are absorbed in transportation charges, while costs of greater than several dollars are added to the carrier invoice and paid by the shipper.

Highlights of Section V are presented below in the same sequence as the discussions appear in the body.

Permits are universally required for shipment of oversize homes and are universally nonstandard. Currently, no state will honor another's permit. Additionally, acquisition, particularly in terms of application and receipt procedures and state-permit fees, varies substantially from state to state. Dependent on fees and acquisition costs, obtaining permits for a shipment can add 10% to 25% to basic transportation charges. Over-dimension permit charges specified in the tariffs regulating common carrier rates are usually $10 higher for modules for each trip, than for mobile homes, although state fees do not reflect this. Multiple-trip permits reduce the burden to both the issuing agency and the applicant/user. Based on average use of an annual multiple-trip permit, states should save over $100 in labor and materials for each multiple-trip permit issued. Carriers should save over $200 in transmission and labor expenses, exclusive of state fees with each annual multiple-trip permit.

Accessories including signs, flags, and warning lights are subject to wide variance of regulations. Nearly all states require signing and flagging, but little uniformity exists in the requirements. This means that, by the letter of the law, many changes are necessary. While not costly, such changes cause nuisance and delay. In practice, far fewer sign and flag changes occur than may be warranted by regulation or policy. Warning lights are required by fewer states, but where they are, carriers comply with regulations at a cost to shippers of $15.

Escort vehicles are often conditionally required for 12- and 14-wides. Usually, escorts are private contractors who charge about $0.30 to $0.35 per mile of service with a 100-mile minimum for each escort.

Time of operations restrictions can usually be scheduled around. For example, curtailment of operations on weekends and holiday periods can be taken into account when a shipment is dispatched. Time of day restrictions for 14-wides do present unavoidable problems, however, by limiting allowable driving time. Unoccupied driving time was costed at $7.50/hr to a maximum of $30/day.

Towing vehicle regulations bring about incremental costs primarily in the realm of truck capacity. While not expensive on a per trip basis, additional required truck capacity causes a substantial increase in initial pruchase price of the towing vehicle. Other regulations relating to towing vehicles cause similar initial investments, the costs of which are negligible when allocated over the life of the truck. Wheelbase requirements, when coupled with overall length dimensions, can lead to problems in some states.

Dimension restrictions, because of their variety, prohibit certain shipments from moving in some states. Combined with other regulations dimension restrictions can cause circuitous routing and, sometimes, the use of special "short" trucks.

Coach equipment regulations pertain primarily to brakes and axles on the under carriage of a mobile home. Many states require brakes and axles in addition to absolute minimums, particularly on very long or wide mobile homes. Normally, installation is completed at the factory at a cost of $120 for an axle without brakes, and $150 for a braking axle. These costs are added to the price of a home.

Speed limit restrictions vary somewhat at both the upper and lower bounds. Commonly upper limits are set at 45 mph.

Insurance is required by most states. Most often minimum carrier liability requirements are 100/300/50 (dollars in thousands). The incremental costs are negligible on a per trip basis.

Routing restrictions exist to some extent in all states. They may be due to physical incapacity of the route, traffic or congestion considerations, hazards such as construction sites or limited sight distance, and legal problems such as no wide loads on the Interstate System. A survey made in conjunction with this study indicated an average of 7.9% circuity for trips made in five selected regions of the country. The cost impact is a direct increase of basic transportation charges which are size-distance based.

VI. SAFETY HAZARDS

A. Introduction

In the course of collecting traffic data, our engineers traveled on 59 trips with mobile or modular homes, logging approximately 12,000 miles. These trips included all types of highways, in most parts of the country. They involved approximately 40 drivers working for a number of private and common carriers, and the wide loads were manufactured by a score of companies. With one exception, the movements were all initial movements. Since, for the most part, the same drivers make both initial and secondary moves, we believe our experiences were typical of wide-load movements in general. For example, our experience with flat tires, discussed subsequently, was probably not unusual as evidenced by the fact that most drivers carry four or five spare tires with them.

In the course of our observations, we noted a number of hazardous situations. Some of these resulted in property damage, either to the load or to another vehicle. Some of the incidents were considered not related to the wide load, and others were related only in an indirect fashion. Nevertheless, these incidents are described here because, in our opinion, they indicate definite areas where the safety of wide-load movements can and should be improved.

Many of the problems relate to the manufacture of the home, as typified by our tire experience. Several others illustrate problems which can arise when escort vehicles are used ineffectively. Finally, some of the problems are inherent with the routing of oversize loads on highways with marginal capabilities of handling them. The incidents are described below in trip-number sequence.

B. Incident 1-2

This incident, in our opinion, in no way involved the wide load, but was observed by our photographer in the rear of the mobile home, and filmed by him. The home was a 12 x 64. At the scene of the incident, the two-lane highway was tangent with very wide gravel shoulders. Sight distance was very good.

To the rear of the wide load was a large, specially built single-unit truck, apparently used for construction. At the time of the incident, it was approximately 300 ft back of the wide load and closing gradually. A sedan pulled out from behind the truck and proceeded to pass it. Immediately behind the sedan was a pickup truck which simultaneously pulled out to pass the large truck. After the sedan cleared the truck, it pulled back into the right-hand lane. At this point, the pickup truck driver apparently realized that there was an oncoming vehicle. Being uncertain as to whether he could complete the pass in time, he swerved off the road and drove down the left-hand shoulder.

C. Incident 1-20

This incident involved minor property damage to another vehicle. It occurred at low speed in an urban area, and the driver of the other vehicle was unaware of the damage until it was pointed out to him.

The home was a 14 x 64 being driven on a two-lane road. At the point in question, the road curved gradually to the mobile home driver's left. Coming in the other direction was a passenger vehicle pulling an 8-ft wide travel trailer. Protruding from the left side of the travel trailer were two small plastic hoses from the air conditioner. As the vehicles came abreast, the left-hand rearview mirror of the truck contacted the protruding air conditioning hoses. The hoses were deformed and sheared off, causing a small amount of sheet metal damage to that portion of the travel trailer immediately to the rear of the hoses. Also, the mirror bracket on the mobile home truck was slightly bent.

The driver of the other vehicle was apparently unaware of the incident and continued down the road. A police officer, parked in a gas station adjacent to the impact scene, observed the incident and chased the other motorist. Fault was not established.

D. Incident 1-22

This incident occurred on private property and involved property damage to another vehicle. A 12 x 60 mobile home was being parked at a truck stop at lunch time. During the parking of this vehicle, it was inadvertently backed into the rear of a parked Winnebago motor home. Damage to the Winnebago included broken tail lights and one damaged sheet metal panel. Damage to the mobile home included broken tail lights, two damaged sheet metal panels, and a broken mirrow in the bedroom of the home.

The Winnebago was occupied at the time of the collision. Our driver and our observers could hear voices inside the motor home. However, all attempts to converse with the occupants were to no avail. They did not respond to our inquiries. After approximately 15 min of these futile attempts, our people walked over to the restaurant. At that point, they turned and saw the Winnebago driving off down the highway.

E. Incident 2-4

This incident was a three-vehicle collision not directly involving the wide load. However, our observer believes that the presence of the mobile home could have been a secondary contributing factor.

The load involved was a 12 x 44 mobile home. It was being driven on a four-lane highway in an urban area, within a few miles of its destination. There was relatively heavy traffic, estimated at level of service B or C. Typical traffic speeds were 40 mph. The wide load was moving in the right-hand lane at an estimated 30 to 35 mph. One of our staff was in the cab of the truck and did not witness the incident. Our other observer was driving a chase car behind the mobile home, in good position to witness the situation.

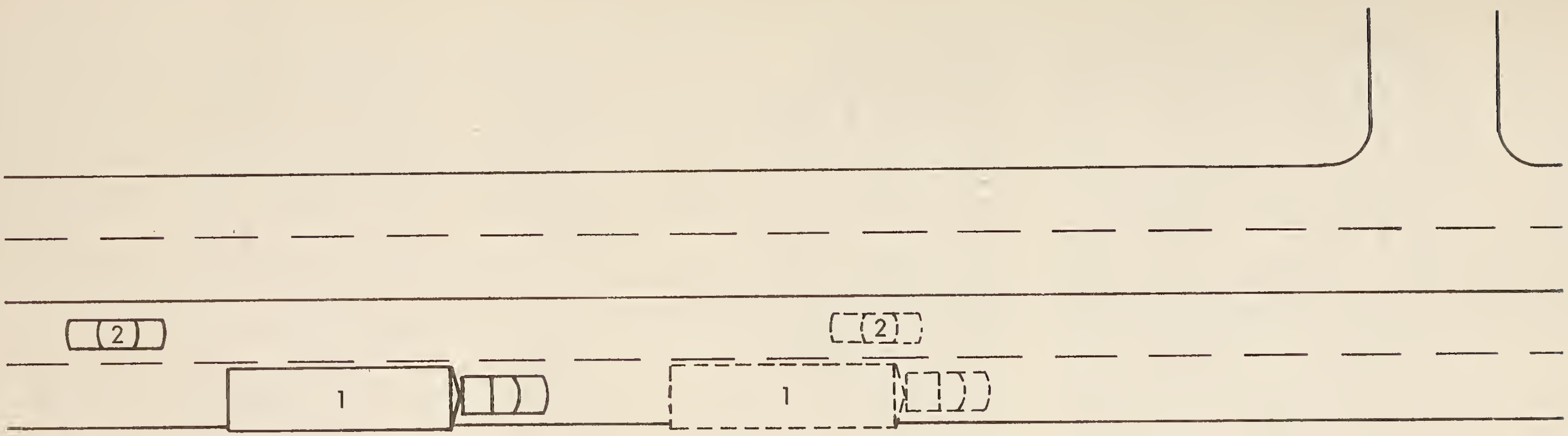
The incident is explained with the aid of Figure 28. Vehicle No. 2 overtook and essentially passed the wide load, Vehicle No. 1. However, Vehicle No. 2 then stopped in preparation for a left-hand turn when the traffic cleared. Vehicles Nos. 3 and 4, which had been following behind Vehicle No. 2 in the same lane, apparently did not realize soon enough that Vehicle No. 2 was stopping. Vehicle No.3 collided with Vehicle No. 2, and Vehicle No. 4 with Vehicle No. 3 as the wide load was continuing to proceed in the adjacent lane at its same speed. It is believed that no serious injuries resulted from this incident, although Vehicles Nos. 2 and 3 received substantial damage and Vehicle No. 4 a lesser amount of damage.

The wide load was not physically involved in the collision. Neither did its presence physically present any sight limitations for Vehicles Nos. 3 and 4. In our observer's opinion, however, the drivers of Vehicles Nos. 3 and 4 could have been distracted by the presence of the mobile home in the adjacent lane to the point where they neglected to observe Vehicle No. 2. Judging by the very small amount of braking by Vehicles Nos. 3 and 4, it is doubtful that the presence of the wide load prevented their swerving into an adjacent lane--there would not have been time.

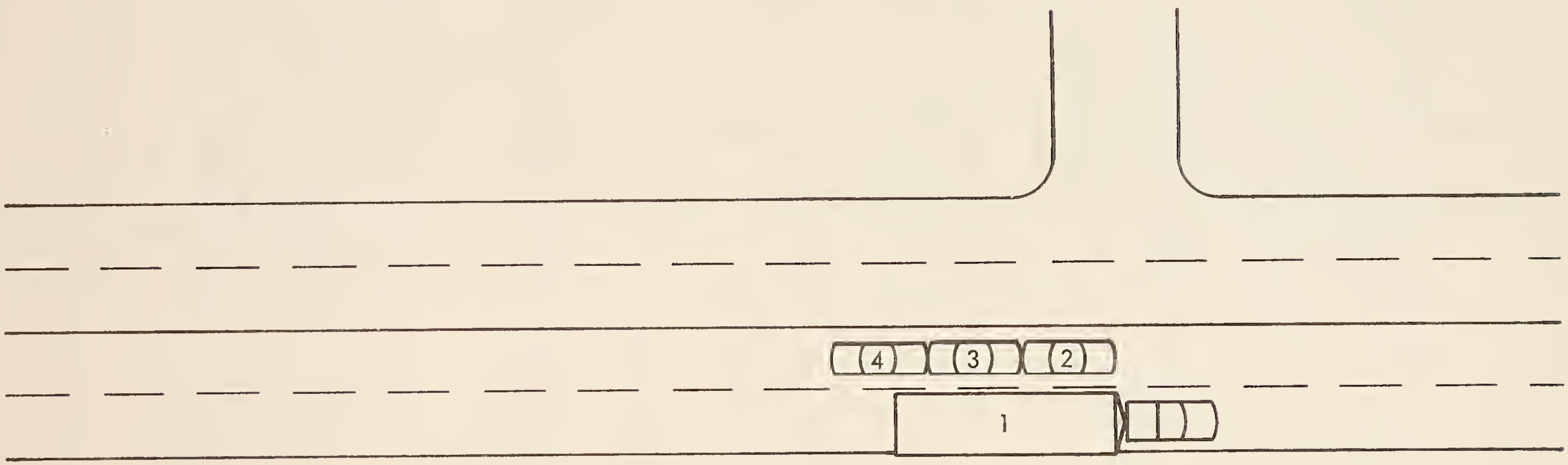
F. Incident 2-9

This incident, involving minor damage to the mobile home, occurred because of a lack of coordination between the wide load driver and the escort driver in a situation with limited sight distance.

The load was a 12 x 52 mobile home being moved on two-lane roads with a front escort. The incident occurred on a rather long, highly arched bridge. The arch in the bridge prevented visual observation of oncoming



a. Before Impact



b. At Time of Impact

Figure 28 - Incident 2-4

traffic on the other side. Also, the bridge was only about 20 ft wide, making it extremely difficult for oncoming traffic to pass the wide load on the bridge.

On approaching the bridge, the escort and wide load drivers pulled off on the shoulder to discuss the strategy for crossing the bridge. It was decided that the wide load would, at an appropriate opportunity, pull out onto the highway and block traffic from the rear. In the meantime, the escort vehicle would proceed across the bridge and flag the oncoming traffic. They proceeded with this plan. However, as the escort driver moved up onto the bridge, he noted that there was a highway crew doing repair work over the crown of the bridge, blocking one lane. By this time the wide load had already pulled out, stopping overtaking traffic. When apprised of the situation, the highway crew picked up their equipment and, within a few minutes, drove their vehicle off the bridge, leaving it clear for traffic. At this time the escort driver proceeded across the bridge and prepared to flag the oncoming traffic.

Not seeing any oncoming traffic, and being concerned about the long line of cars backed up behind him, the wide-load driver proceeded onto the bridge. However, it developed that he was premature in his decision. The oncoming traffic had not yet been stopped, as the wide-load driver learned as he progressed up over the crown. While edging by the oncoming traffic, the mobile home did contact a structural member of the bridge. Several hundred dollars damages occurred to the mobile home. No other vehicle was involved.

G. Incident 2-14

This incident involved a trailer-mounted 12 x 40 modular home with an estimated weight, including trailer, of 50,000 lb--the heaviest unit we encountered. The trailer ran on six bogey axles, carrying a total of 12 tires.

While traveling at about 40 mph, one of the interior wheels came off its axle. Our photographer, who was riding in the back of the house, heard the wheel and tire ricocheting between the pavement and the bottom of the trailer, as illustrated in Figure 29. When the wheel cleared the back of the trailer, it bounded into the air to a height estimated at 40 to 50 ft. Oncoming motorists were observed to undergo evasive maneuvers to avoid the bouncing wheel. Nobody collided with the wheel, and no damage was done to the wide load or trailer.

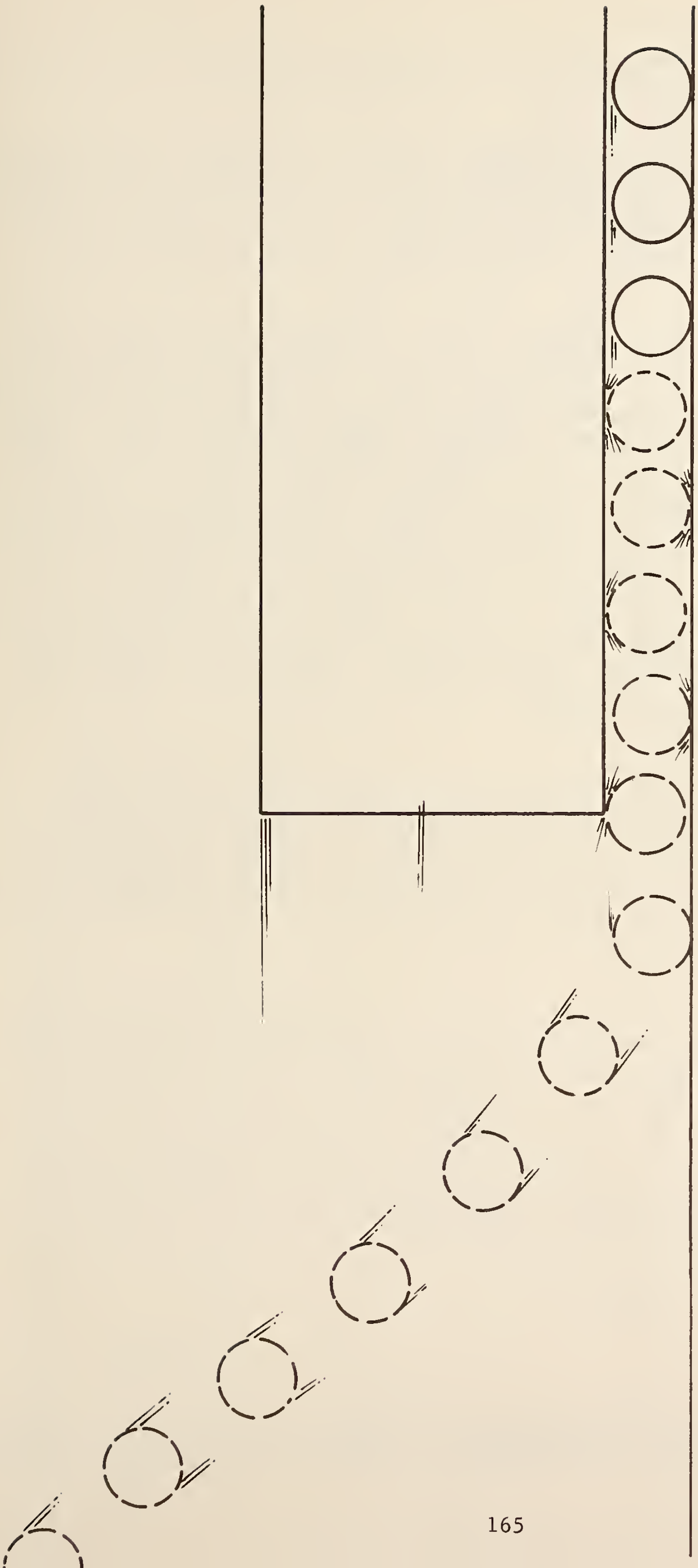


Figure 29 - Incident 2-14

H. Incident 2-16

This incident, which resulted in substantial damage to a mobile, home could have been avoided by proper escort operations.

The load was a 12 x 65 mobile home being delivered by a relatively inexperienced driver. The route included a section of two-lane road through a mountainous area. The pavement was 20 ft wide with only 1- to 2-ft shoulders. In places, the road went through rock cuts with basically vertical walls.

The location of the incident was a rather sharp right-hand curve with minimal side clearance, as shown in Figure 30. A front escort was used on this trip. The planned procedure was for the escort vehicle to slow the oncoming traffic and/or to warn the wide-load driver of such traffic. With this assistance, the driver then would swing wide so as to avoid the rock wall to the right. In so doing, a significant encroachment on the adjacent lane would be required. As they approached this curve at about 40 mph, the escort vehicle got too far ahead of the wide load and, unfortunately, lost contact with the driver. Thinking (or hoping) the way ahead was clear, the driver proceeded to swing wide and enter the curve. At this point, an oncoming tractor trailer suddenly appeared ahead. Its speed was estimated at 50 to 60 mph. The wide-load driver pulled back to the right, choosing the rock wall over the tractor trailer.

The 65-ft mobile home sideswiped a rock outcropping. The side paneling was damaged extensively from a point about 20 ft back from the front to a point about 50 ft back from the front. Some panels were torn off. The door was torn loose except at one hinge, from which the door hung dragging on the pavement. The rock outcropping penetrated the mobile home to a maximum depth of about 8 in.

Our photographer, who was riding in the back of the mobile home, was unaware of the incident at the time. The rear bedroom, in which he was located, was not penetrated by the rock outcropping. The jolt of the collision was apparently no more severe than the normal jolts and bouncing to which he was accustomed. His first knowledge of the problem was when he heard the door dragging on the pavement. There were, of course, no injuries; and, after stopping to inspect the damages, the unit was driven on to its destination. (It was subsequently returned to the manufacturer for major repairs.)

I. Incident 2-29

This incident involved two modular half-houses, which were over height as well as over length. Each half was a 12 x 60 mounted on a trailer.

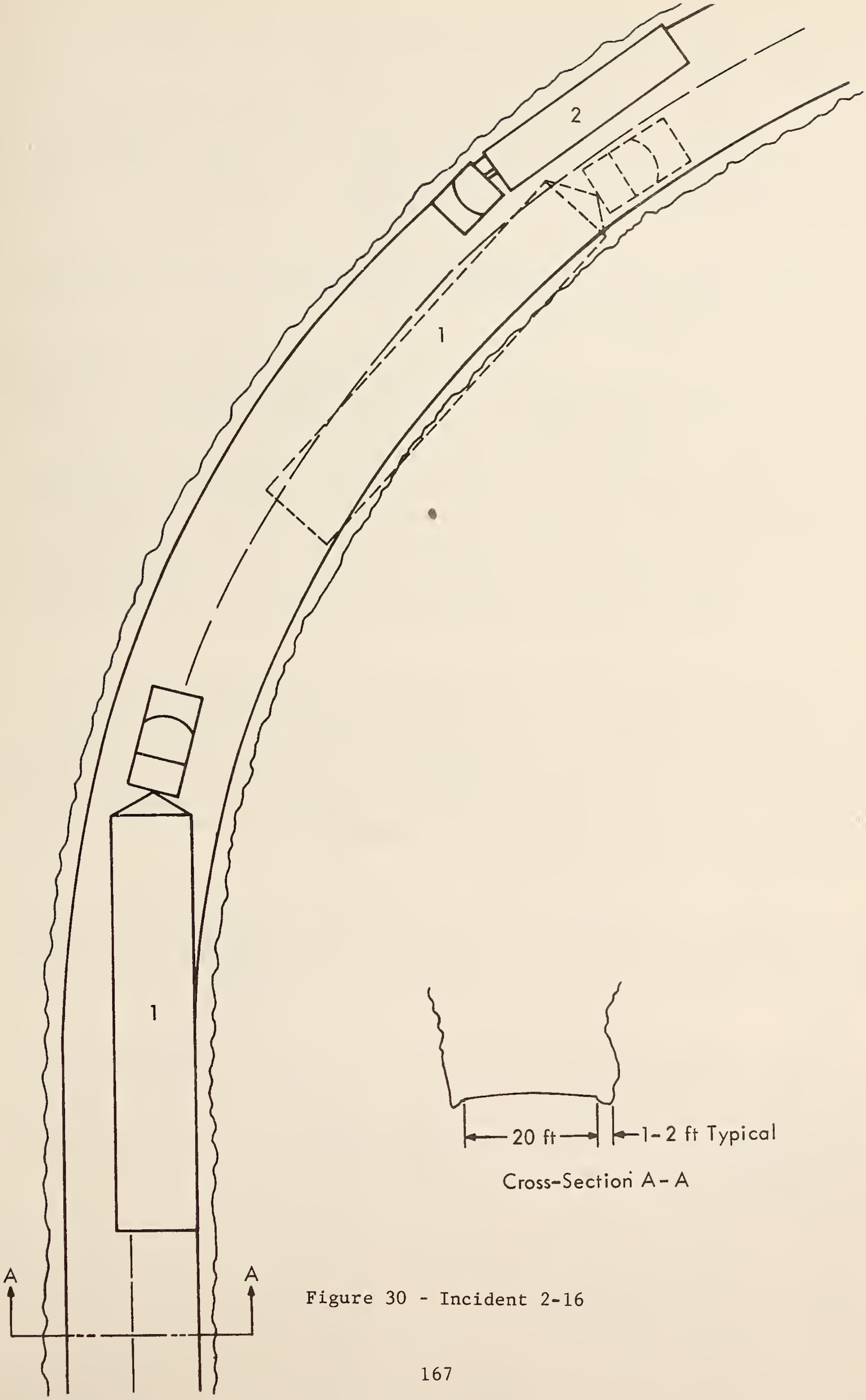


Figure 30 - Incident 2-16

These units had a peaked roof, as illustrated in Figure 31. The manufacturer stated the height at the peak to be 14 ft 5 in.

The trip was routed over highways with a minimum clearance of 14 ft 9 in. The road in question was a divided, limited access highway with a 70-mph speed limit, but was not part of the Interstate system. The pavement was wet from an earlier rain and traffic was very light.

The two wide loads traveled approximately 1/4 mile apart. Each had a rear escort. The escort behind the first wide load was a Volkswagen with a roof-mounted flashing beacon.

During the course of the trip, as the units went under an overpass, the second unit scraped slightly, doing only minor damage to the peak of the roof. At this time, however, the driver warned the driver of the lead vehicle of this potential danger and suggested he approach the next overpass very cautiously. When they came to the next overpass the vehicle, indicated as Vehicle No. 1 in Figure 31, stopped because the driver feared there was insufficient clearance. Shortly thereafter, the other unit, Vehicle No. 2, pulled up behind and stopped. At this point our photographer was in the rear of Vehicle No. 2 and our observer in the cab of Vehicle No. 2.

To get a better look at the clearance situation, the driver of the escort vehicle, Vehicle No. 3, pulled along side Vehicle No. 1 and stopped in lane two! The driver then got out of the car and walked forward to get a better look. At this time Vehicle No. 4, a panel truck, approached at high speed in lane two and recognized too late that his lane was blocked. He braked and swerved off into the median, stopping just short of the concrete pillars supporting the overpass.

Clearly, the driver of the VW escort vehicle was negligent in parking in lane two. Also, the attention of the other motorist was possibly diverted by the presence of the two large half-houses stopped in the adjacent lane.

There is an aftermath to this incident. It was determined that the two modular half-houses could not, in fact, clear the overpass. Therefore, they backed up approximately 1/2 mile to the previous exit. This they accomplished without any other problems. Subsequently, the half-houses were measured and found to be 15 ft 2 in. in height and not 14 ft 5 in. as the manufacturer had stated.

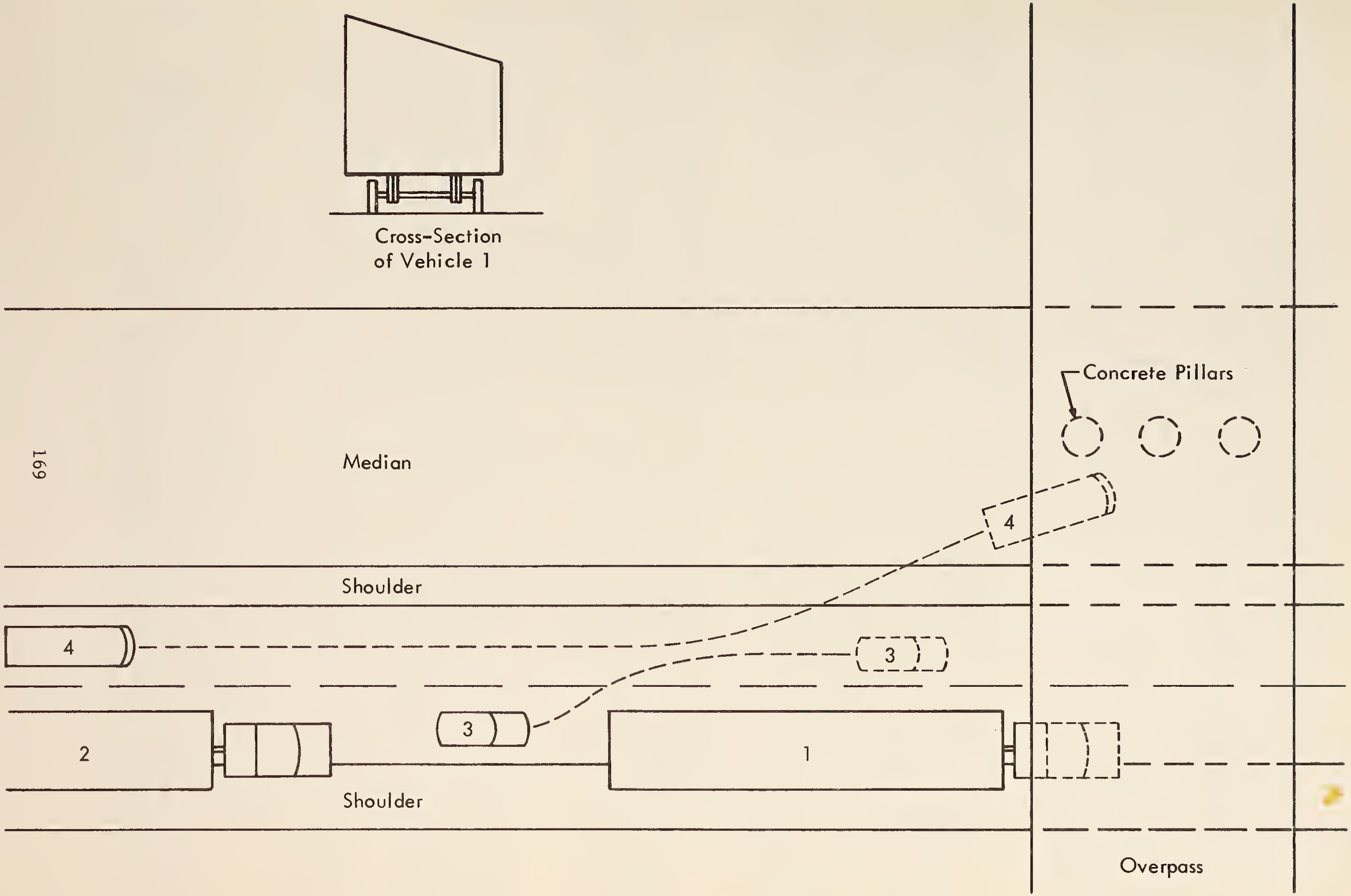


Figure 31 - Incident 2-29

J. Tires

Flat tires on mobile and modular shipments were experienced on 11 of the 59 trips made by our observers. Of these 11 trips, a single flat tire was observed on seven, two flat tires on three, and four flat tires on one. Although no untoward incidents occurred during any of the 17 times when a tire had to be changed, we consider each of these occasions a potential hazard. Moreover, we consider the frequency of these occurrences to be unreasonable. Seventeen flat tires in 12,000 miles indicates that a significant problem exists, especially since the mobile home tires were supposedly all new tires (the modular homes are carried on trailers whose tires are generally not new).

There are probably several reasons for the frequent occurrence of flat tires. Figure 32 illustrates what is probably the principal reason--overloading. Displayed in this figure are the approximate, average static wheel loadings on each trip for which data were available. In making this calculation, it was assumed that 10% of the wide-load weight was carried on the hitch and the remaining 90% was equally distributed over all tires. It is clear from the figure that, with a few exceptions, the more heavily loaded units were the ones which suffered tire loss. Unfortunately, we do not have detailed data on the tire characteristics for each trip--the magnitude of this problem was unexpected at the beginning of the project.

The two successful 14-wide mobile home trips with exceptionally high tire loading were identical units. Our observers were struck by the exceedingly heavy and careful construction of these two mobile homes as compared to all others they had observed. It is not unreasonable to believe that they also used far-better-than-average quality tires.

Another probable cause for flat tires relates to the mobile home construction process. Typically, they are built on an assembly line. The line begins by mounting the understructure on the wheels. The framework is then pulled, on its own wheels, along the assembly line as construction progresses. The construction line is often littered with staples, nails, and screws over which the tires roll. Our observers noted occasional flat tires on homes at the factory. These tires were sometimes patched and put into service as new tires. In one instance our observer discovered that a tubeless tire, which went flat during a trip, had had an innertube inserted in it.

Possibly related to the problem of flat tires is the manufacturing problem of axle and wheel assemblies. Many persons have reported witnessing a mobile home on the highway whose axles were not square with the home. This would result in "crabbing" of the home as it is pulled down the highway, giving it an effective width greater than its nominal width. It would, at the

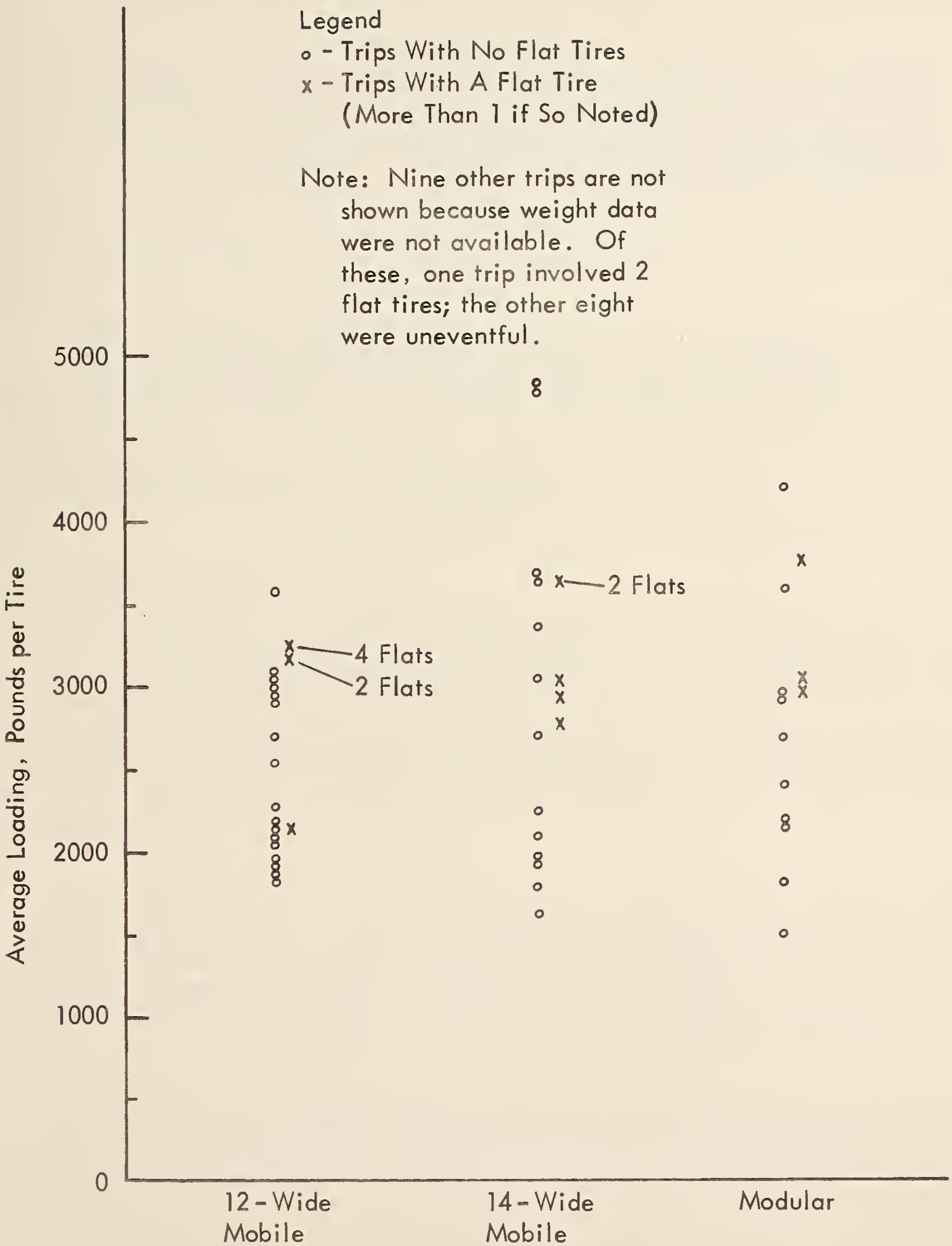


Figure 32 - Tire Loading of Wide Loads

same time, expose the tires to scrubbing by the pavement and premature wear of the tread. It could also lead to excessive fishtailing of the unit. This particular problem was not encountered by our observers during this project.

Another flaw witnessed at times is improper mounting of the wheels so that they are not square with the axle. Excessive tow-in or tow-out has been seen on mobile homes not part of this project. This would also lead to premature wear of the tire tread.

K. Brakes

No incidents occurred relating to faulty brakes. However, the subject was one of much concern to many of the wide-load drivers. They complained of often having pulled mobile homes with inoperative, inadequate, or unbalanced brakes.

Generally, the brakes on a mobile home are electrically actuated. They are installed as new units. The drivers felt that, often, the brakes were not installed properly or not inspected and tested.

We observed no incidents or heard no complaints concerning brakes on modular home trailers. This was not surprising because such trailers presumably have brakes comparable to other semi-trailers.

Again, we did not observe any problems of this nature and have no documentary evidence to substantiate driver complaints.

L. Wind

Winds, particularly gusty or crosswinds, are a real factor with which the drivers must contend. The effects of winds are particularly pronounced with the very light mobile homes and with the half-houses when the high side is exposed to the wind (but not as pronounced with heavier modular homes).

Most experienced drivers are constantly alert to wind conditions and, when noticeable wind is encountered, the driver often stops and either makes a wind measurement using his own equipment or calls the weather bureau for information.

Many states have regulations prohibiting mobile home movements when winds exceed certain limits. In addition, many of the major common carriers have established their own company policies concerning movement under windy conditions. Twenty-five miles per hour is the commonly selected maximum under which mobile home movement will continue.

Our observers did note windy conditions on several occasions. Some swaying of the house was noted during crosswinds estimated at 10 to 15 mph. This was particularly true in areas with uneven terrain where gusty conditions were encountered. During the summer, our data collecting activities were affected by winds on two occasions. On one occasion, no mobile home traffic moved at all in a several-state area because of high winds. On another occasion, our driver ceased operation for several hours during the middle of the day when winds approached 25 mph (we understand that another driver in the area was not so prudent that day, he lost the roof of the half-house he was towing).

A complete study of the wind effects on mobile and modular homes is obviously beyond the scope of this study. Our impression is that under some conditions, winds of 25 mph may produce hazardous conditions. This subject should be examined further with the intent of determining if, perhaps, 20 mph should be the wind speed limit.

M. Roadside Hazards

Most of the time a wide load can be transported on most roads without encroaching on adjacent lanes. When the width of the wide load exceeds that of the lane, the driver generally is able to position the load so that it overhangs the shoulder. He must abandon this practice, however, and encroach upon an adjacent lane when there is an obstacle on the shoulder. The frequency with which this happens was somewhat of a surprise to our observers.

Even on Interstate highways, where such roadside obstacles are not so frequent, they were still encountered with surprising frequency. The most common obstacles were parked or abandoned cars. Such vehicles are largely ignored by most motorists but can become a real problem to a 14-wide mobile home. One particularly notable instance of this was recorded on film. A motorist, perhaps with car troubles, had parked his vehicle close to the traveled way and was standing alongside his car, on the edge of the traveled way, staring at his vehicle and apparently oblivious to the oncoming 14-wide mobile home. Our driver had to change over to the other lane. In addition, there are bridges and other short segments with no shoulders on some portions of the Interstate system. We have also encountered sections where guardrail was installed flush with the edge of the traveled way, forcing the wide load (and probably all traffic) to move to the left slightly.

Such obstacles are more common on two-lane roads. A particularly bad situation was noticed on some roads where reflective markers were installed by the highway department continuously along the roadway and placed about 1 ft from the traveled way. This type of installation, in our opinion, is hazardous not just to mobile homes but to all traffic. Also, in many rural areas, mailboxes are placed 1 or 2 ft from the traveled way. Their presence also causes the wide-load driver to encroach upon the adjacent lane. Pedestrians can also occasionally be a problem. On one memorable occasion, on a two-lane road, a pedestrian was observed walking along the shoulder with his back to oncoming traffic. The driver sounded his horn but to no avail. He was forced to use the oncoming lane to avoid the pedestrian.

Finally, there are highway construction practices, now outdated, which create difficulties. There still exist many otherwise good quality two-lane highways, carrying heavy traffic, which have occasional 18 and 20 ft wide bridges. Also, in a few states, two-lane highways remain with curbs on the side. Again, these highways create hazards not just to the mobile home carriers but to all drivers.

N. Summary

The incidents described in this section, taken individually, would not be too meaningful for research purposes. But, because there were so many, and because several of them had common characteristics, we believe that they do have importance as indicators of problem areas.

In 12,000 miles of travel, we observed six incidents involving the wide-load movement and resulting in property damage. (Two other incidents were observed not directly involving the wide load.) Of the six, only two would be classified as "reportable," with the others either resulting in too little property damage or occurring on private property. To our knowledge, however, none of the six were reported.

Three of these six incidents were the direct result of improper escort operation. They would not have occurred if the escort driver had properly carried out his duties or if there had been no escort (although proper escorting would appear to have been generally beneficial on trips 2-9 and 2-16).

Tires were a recurring problem. We averaged a flat tire for every 706 miles of travel. In addition, we lost an entire wheel from the modular shipment of trip 2-14. It appears that the tires may be overloaded, considering their quality. This is a problem area worthy of additional study.

Strong or gusty winds are a particular problem with which mobile home drivers must contend. Despite the industry's concern with winds, numerous state regulations concerning wind limits, and driver caution (usually), many turn over or other wind-caused accidents occur yearly, according to BMCS officials. Further study is probably warranted here, also.

VII. DISCUSSION OF PERMIT OPERATIONS

Certain fundamental questions arise in any discussion of permits and regulations relating to the interstate highway transportation of mobile and modular homes. They center around the following subject areas:

- Conditions under which permits should be required;
- The use of multiple-trip vs single-trip permits;
- Permit reciprocity by states (and also within states where local and state requirements are in conflict);
- The cost, if any, which should be charged for permits;
- The advisability of legalizing the transportation of two modules on a single trailer; and
- The advisability of standardizing state regulations governing mobile and modular home shipments.

In part, these questions are philosophical in nature. They cannot be answered altogether on the basis of hard data which result from scientific research. Where possible we have tried to relate the various tasks of this study to the discussion of these subject areas, but discussion must sometimes be based on intuition or judgment.

The first four of these subject areas, all pertaining to permit operations, are discussed in this section, with specific recommendations given for each. The remainder, however, are treated in Section VIII, which deals with a number of regulatory questions.

A. Conditions Under Which Permits Should be Required

Traditionally, it has been necessary for governing authorities to limit legal vehicle size and weight parameters in order to preserve regular and safe highway operations and assure sound highway structure. The states, as governing authorities, have each established their own sets of limits, restrictions, regulations, and prohibitions relating to legal vehicles or loads.

Occasionally, the states have been petitioned to grant permission to a carrier to haul a load which by its nature could not be made to conform to legal specifications. The states have cooperated in the effort to allow reasonable, although extra-legal, loads to be transported. Generally, the states have each strictly defined to what limits a "reasonable" load may extend by establishing another set of regulations. Thus, motor carriers are faced with two sets of dimensions--one set legal for routine use and the other extra legal for extraordinary use.

Modern mobile homes usually exceed legal limits due to their overwidth and overlength dimensions. For mobile home combinations which exceed a state's legal dimension limits, an overdimension permit is required. Additionally, modular construction of homes and buildings is a developing industry which also frequently has need to transport overdimensional loads. Mobile and modular homes are light cargoes, considering their size, so weight limitations are not a problem and will not be considered.

We agree with and defend the states' reasonable approach to regulating the types of highway users. It is simply not good judgment to allow any and all sizes of vehicles on public highways. Limits must be set and enforced. It is beyond the scope of this study to determine what those limits should be, but experience gained suggests that 12- and 14-wide loads exceed normal capabilities of most highways, and place certain burdens on other users. We therefore conclude that the states must continue to have the ability to control the transportation of 12- and 14-wide mobile and modular homes under most highway conditions. The permit mechanism is one way to provide this ability.

Permits normally allow control over who transports a shipment, what is transported, where a shipment moves, and when it moves. A typical single-trip permit describes the following:

- Applicant;
- Truck, coach and combination;
- Approved routing; and
- Valid time frame.

The identification of the applicant provides an opportunity to screen potential carriers. Some states maintain lists of preferred applicants which are eligible for liberalized permit privileges or special accounting status. The opportunity to deny a permit because of improper licensing or an unsatisfactory driving record is also provided.

A description of the vehicle, coach, and combination allows the state to assess the feasibility of the proposed move based on size, weight, power, etc. It also provides a means to check stated statistics for conformity with existing regulations such as truck size, coach size and weight, overall size, and gross combination weight.

The routing proposed on the application can be checked, and unacceptable routing proposals can be modified to be acceptable to both the carrier and the state. A first check might cross-reference the size of the combination to insure sufficient physical capacity of the route. Other checks might relate to regulatory, traffic, or safety considerations, and special conditions. Some states prohibit oversize moves on certain types of highways or on specific routes for various reasons. Other states which do not maintain such general prohibitions may wish to limit the frequency of oversize moves in specific areas for reasons of traffic flow or safety. Also, special local conditions, such as construction sites, local celebrations, etc., might prevail which would induce a state to reroute overdimensional movements.

Finally, the proposed time frame of the move on the application offers further control align states. In the issuance decision temporal considerations may well interact with routing restrictions as in specific cases of local celebrations (e.g., state fairs) or construction sites, but timing considerations may also be more general. Most states, for example, do not allow oversize shipments to move during certain holiday periods. Even more general are seasonal restrictions which prevail in a few states, as discussed in Section V. The state can assure all time considerations by allowing the proposed time frame of the move or suggesting an alternative.

If these types of control can be provided by other means, specific notations on overdimension permits may not be necessary. Some aspects of these controls <u>can</u> be provided by other means, and <u>are</u> in many states. General policy pronouncements often serve to control parameters describing the mobile home combinations as well as routing and time frame. Regulations relating to towing vehicles, coach equipment, and coach dimensions are discussed in Section V. Because those specifications are explicit, few problems of judgment should arise regarding which combinations are to be allowed on public highways.

Routing is another realm where general statements can often suffice to control the transportation of wide loads. The most satisfactory system seems to be the use of route maps depicting allowable routing, conditional routing (with the use of escorts) and prohibited routing where applicable. Strong support for such a system stems from the fact that regional variances in topography, highway construction, and population density create dissimilar transportation conditions. The states are the appropriate authorities to assess and govern transport possibilities under these conditions. It is hoped that greater future use can be made of route maps, and that the states can arrive at a system which provides universal coverage and utmost continuity.

Time frame can be controlled by general policy to a lesser extent than routing. Most states now restrict movement of 12-wides to weekdays only during daylight hours. Transportation of 14-wides is further restricted in some states to 3- or 4-day midweek operations. This type of policy alone, however, cannot provide control over the number of oversize moves which use specific corridors at any one time.

While general policy statements can provide some control of overdimensional homes, both the states and carriers give up something by their use. General policies cannot provide the states the ability to individually assess each case and, therefore, such policies offer somewhat less specific control. Because less specific control is possible, general policies may be more limiting to carriers than specific judgments are likely to be. If they can substitute for permit regulations, however, general policies can mean a great deal less burden to the states as well as the carriers.

What are the disadvantages of permit operations? They require the states to establish and maintain an administrative apparatus and to provide for enforcement. To the carriers, present permit operations create a cost burden of permit acquisition and of regulatory compliance. As discussed elsewhere, the cost to the user of each acquisition typically includes the direct cost of state fees as well as transmission expenses and indirect costs associated with administration and overhead.

Often, several permits may be required for a single trip. This would happen, for example, if the trip is routed through several states, or if a permit should expire prior to completion of the trip. The inconvenience of delay also can add to the cost burden to carriers. The cost of compliance with permit conditions and variances in those conditions is substantial, as indicated in Section V.

Most of these disadvantages, however, can be overcome by altering and streamlining permit operations. This is the subject of Section VIIB.

We return briefly to a point alluded to earlier--"experience gained suggests that 12- and 14-wide loads exceed normal capabilities of <u>most</u> highways and place certain burdens on other users." (The underscoring has been added here for emphasis.) Experience also showed substantial differences in the problems encountered, burdens imposed, and potential safety hazards on two-lane roads as opposed to modern, divided highways such as the Interstate System. These differences are discussed further in Section VIII. They suggest that if there is an important circumstance under which permits could be dispensed with, that circumstance would be the movement of coaches not exceeding 12 ft in width confined to divided, limited-access highways.

Unfortunately, there is a major difficulty in implementing this change. Most divided, limited-access highways are part of the Interstate System, 90% funded by the Federal Government under provisions of the Federal-Aid Highway Act of 1956. Under conditions of the Act the states are limited in their powers to authorize certain uses of these highways. The law and its implications are discussed in Section VIII. It is our interpretation that it denies the states the authority to allow oversize loads on the Interstate System without permits, unless such movements could have occurred without permits on existing roads prior to 1956. The apparent solution requires that the Federal-Aid Highway Act be amended to allow larger vehicles without permits.

We do not feel that mobile home transportation should be considered as a special case. Mobile home carriers are part of a larger group comprising all motor carriers and should not be shown preferential treatment by legalizing their specific cargoes. Although under some circumstances mobile homes cause little or no interference to normal highway use, they do exceed legal limits, and they do interfere with regular highway operations in many cases. Therefore, to grant special exemption to mobile homes seems unwarranted. Certainly other carriers would bring much pressure to bear on the states if special exemptions were granted to oversize mobile homes.

In conclusion we recommend:

* In general, 12- and 14-wides move only under permit as presently required.

* General policies, as much as possible, replace specific judgments by permit issuing agencies regarding permissible combination size and configuration, routing, and travel times.

* To encourage wide loads to travel on the roads most capable of handling them, the Federal-Aid Highway Act be amended to allow loads as wide as 12 ft to move on the Interstate System without permits.

* All states compile a route system suitable for use by oversize homes and publish it in the form of a route map.

B. Use of Multiple-Trip Permits

Permit operations allow transportation of shipments which exceed legal limits. At the same time, control over individual shipments can be maintained. This is often necessary because of the variety and degree of exceptions to legal parameters. However, some applicants frequently transport shipments which routinely require the same kinds of permit considerations. Mobile home carriers fall into this category because shipments, while overdimensional, are for the most part uniform in width, shape, and weight.

Many states have acknowledged the similarity of mobile home shipments by issuing multiple-trip permits. They allow a carrier to transport numerous mobile homes under certain conditions without making application for a permit for each specific shipment. Various states have instituted several types of multiple-trip permits. Most commonly, a single permit is issued on which several shipment and trip characteristics are specified. Such a permit expires periodically and must be renewed. As long as it is valid, a carrier can use it repeatedly for hauling cargoes within the specified parameters. Another type of multiple-trip permit allows a carrier to deliver numerous similar shipments from a common origin to a common destination. This type of permit is well suited to delivering a series of modules from a factory to a construction site. Finally, bulk issuance has many of the characteristics of a multiple-trip permit. Permits pre-purchased in quantity allow the carrier to initiate trips without the delay of single-trip permit acquisition. A separate permit is used for each shipment. Except as an aid in accounting, we can see little advantage to the issuance of trip permits in bulk. Also, greater staff requirements at the issuing agency appear to be a disadvantage.

The use of multiple-trip permits provides most of the attributes of single-trip permits, benefits both the states and the carriers, and appears to have few drawbacks. As previously discussed, permits provide control capabilities in four areas: who, what, where, and when. Under single-trip authorization each of these areas may be judged separately. But under circumstances of repeated moves of similar shipments, such judgment often becomes perfunctory and unnecessary if other methods can suffice. In most cases other methods can suffice, as evidenced by the success of many states' multiple-trip permit operations.

Control of users of multiple-trip permits is possible, both at time of issuance and thereafter. Applicants can be screened, as under single-trip operations, but usually applicants for multiple-trip permits are acceptable. These applicants are generally carriers (private, contract, or common) which are frequent transporters of mobile homes. Frequent transporters are preferred by the issuing agencies because of their familiarity and compliance with state regulations or policies. Even so, if serious problems should arise, a multiple-trip permit previously issued could be suspended or revoked.

What is transported is usually controlled under multiple-trip permit operations by a stipulation on the permit itself. In order to exclude extraordinary shipments not intended by the issuing agency, the nature and maximum dimensions of the commodity or vehicle combination are generally specified. Often, the dimensions specified on the multiple-trip permit are as great as allowed under any type of permit, although in some states multiple-trip permits are more restrictive than single-trip permits. For example, some states issue multiple-trip permits allowing numerous 12-wide moves, while 14-wides can move only under single-trip permit. In addition to limits on commodities and dimensions, other regulations such as specified configurations of brakes, axles, and warning accessories can be maintained by regulation, as under single-trip permit operations.

Routing can be controlled, where necessary, under multiple-trip permit operations by use of a state route map system. If a carrier wished to use a route not on the system, a single-trip permit application could be filed and the alternative routing and other trip characteristics judged by the issuing agency on a trip-specific basis. This system, in use in some states, serves to route overdimensional traffic around areas where the likelihood of interference or hazard is greatest, yet still allows wide-load carriers a large degree of freedom in selecting routes. Maintenance of a list of users (recipients) of overdimension privileges can provide the basis for communicating route closings or construction delays for further control of a less permanent nature.

Control by the state of the time frame of a trip moved under a multiple-trip permit is not possible unless specific authorization is required before each shipment is transported. Statewide regulations limiting operating days or hours can be enforced, but controlling the number of coaches, for example, along a particular highway segment at any one time to prevent an overload is sacrificed. This does not seem to be a problem, however, to states which issue multiple-trip permits. Possible, the potential of such a problem is averted by use of adequate routing mechanisms.

Issuance of multiple-trip permits for similar shipments can substantially reduce the administrative workload (and, thus, the expense) for both applicants and issuing agencies. These savings arise from the single processing, by both the carrier and the state, of one permit which allows numerous shipments vis-a-vis separate permit processings for each coach transported.

The analysis in Section V-D indicates carriers can save over $200 in permit acquisition costs (exclusive of fees) through use of multiple-trip permits. The states also stand to cut costs of permit processing by issuing multiple-trip permits, as the following analysis demonstrates. Various state officials have estimated an equal cost of issuance for both single- and multiple-trip permits. We shall assume a $5 issuance cost here.

Because some of the issuance cost is fixed or semi-fixed, not all of the issuance cost can be saved when permit issuance is avoided. The California permit agency experiences about 30% fixed costs and 70% variable costs associated with both single- and multiple-trip permit issuance. Thus, in California, only about 70% of the total issuance costs could be saved. We assume this experience is typical. Achievable saving, then, amounts to $3.50 (0.70 x $5). Unfortunately, neither carriers nor state officials interviewed could provide data regarding how many trips are made under multiple-trip permits where available. However using Jorgensen's[1/] estimate of 35 trips per annual multiple-trip permit indicates sizable savings can occur. A state would have to issue either 35 single-trip permits or one multiple-trip permit to facilitate 35 trips. Therefore, the achievable savings must be multiplied by 34 (the difference in numbers of issuance between one multiple-trip permit and 35 single-trip permits), yielding $119 as the total cost savings to the state.

Additional benefits to the carriers arise because of the increased flexibility inherent with multiple-trip permits. Often, unexpected events disrupt the anticipated flow of a trip from origin to destination. Single-trip permits may prohibit adaptation to such circumstances while multiple-trip permits allow for certain substitutions. In a sample of trips actually observed during the project, over half were delayed at origin and about one-fourth were delayed enroute for various reasons. At origin the most common delay cause involved the coach, but in nearly one-fourth of the cases permit receipt was not timely (one trip moved without a permit), and about one-fifth of the scheduled trips were delayed because the towing vehicle specified on the face of the permit was not able to provide service.

The use of multiple-trip permits could have averted much of the delay. It may not have altered the incidence of delay due to unavailability of the cargo, but permit delays would have been avoided because permits would have been presupplied, and delays due to nonavailability of a specific towing vehicle could have been avoided in part by the substitution of another towing vehicle. Because single-trip permits usually identify the specific truck and coach, problems are created for the carrier. If either truck or coach is unable to move, the trip is delayed. Although multiple-trip permits usually identify the truck, they do not describe a specific coach. Therefore, in the case of a truck's inability to perform, another truck possessing a multiple-trip permit may be substituted. Similarly, if a coach is not sufficiently prepared, the truck originally dispatched could be used as power for another trip.

Delay of a trip under single trip operations usually means equipment and driver are tied up for some period of time. Sometimes, also, a single-trip permit expires before the delay cause can be rectified. Then another permit must be processed before the move can take place. This causes further delay. Multiple-trip permits eliminate most of these problems for the carriers. For this reason carriers applaud the use of multiple-trip permits.

In conclusion we recommend:

* Multiple-trip permits be issued by the states for frequent and standard movements of coaches of widths of up to and including 12 ft.

* Consideration be given, in those states where 14-wides are allowed, to granting multiple-trip permits for 14-wides on a limited system of routes.

* Issuance of bulk permits, where applicable, be superseded by conventional multiple-trip permit operations.

* Published route systems be disseminated by the states to aid in controlling routing under multiple-trip permit operations.

C. Permit Reciprocity

The concept of permit reciprocity has been around for many years. Those promoting mobile housing argue that permit reciprocity would enable more mobile housing to be provided with greater ease and at less expense. Mobile home carriers have long looked forward to the day when an oversize permit issued in one state would be honored in any others on the route to the destination.

Many carriers believe that permit reciprocity will end much of the inconvenience, cost, and delay presently experienced in obtaining required permits for the several states on the route. This may be partly true. However, these difficulties are associated primarily with single-trip permit operations. Little problem exists where multiple-trip permits are issued and used. Equipped with multiple-trip permits, a driver is able to depart on a trip with great flexibility--greater than would be possible under a reciprocal permit scheme in our opinion. Increased issuance of multiple-trip permits, then, could alleviate most of the acquisition problems now experienced by carriers.

Admittedly, multiple-trip permits do not serve the entire community of mobile home haulers, and this is one point in favor of permit reciprocity. The carrier who only occasionally delivers a mobile home shipment does not benefit from use of multiple-trip permits, and for interstate moves he still requires trip permits in each state. Permit reciprocity would provide a partial remedy for his permit acquisition problems. He would still, however, need to obtain a (single trip, reciprocal) permit for each specific trip.

While permit reciprocity may provide a worthwhile service in terms of easing some of the problems of permit acquisition, many intermediate problems must be solved before reciprocity can become a reality. The major challenge along the way is standardization of currently nonstandard institutions. While complete uniformity of regulations relating to extra-legal vehicles probably can never be achieved, much that remains to be done is in the realm of possibility, and the necessary standardization of state regulations may be the greatest benefit in the establishment of permit reciprocity.

In 1969, Roy Jorgensen and Associates[1/] described, in their discussion on the subject of permit reciprocity, eight nonuniform areas. These were:

1. Application format;
2. Method of issuance;
3. Fee schedules;
4. Vehicle configuration;
5. Legal size and weight limits;
6. Size and weight limits under permit;
7. Exceptions to legal limits and permit regulations; and
8. Granting of blanket or multiple-trip privileges.

All apply today to the transportation of 12- and 14-wide mobile homes.

Jorgensen suggested, and we agree, that, "possibly the biggest problem faced by haulers is the variance in permit size and weight limits and allowable vehicle configurations." As described in Section V, variances in permitted dimensions lead to prohibitions of some moves in certain areas, occasional routing difficulties of monstrous proportions, and the alteration of towing vehicles in order to comply with overall length regulations. Configuration variances can affect both coach and towing vehicle. They can necessitate the addition of brakes and/or axles to coaches, and lead to the alteration of towing vehicles, in some cases, to comply with wheelbase requirements. The states must resolve among themselves what size and type vehicles will be permitted on state highways before reciprocity can be achieved.

Other sets of problems standing in the way of permit reciprocity can be cited. One involves the states' permit operations and revenue collections. Current application formats, methods of issuance, fee schedules, and remittance schemes all lack uniformity. Finally, routing and regulations governing moves under permit are also subject to variance and, therefore, are sources of problems. These are areas requiring greater standardization.

Many groups have worked long and hard to solve these problems. The groups consist of experts who have listed and considered many alternatives. Align the Western Association of State Highway Officials (WASHO) has come closest to realizing its goal of uniformity by proposing a system of reciprocity.[18/] Awaiting approval by the member states is a substantial, 15-page proposal which suggests solutions to each problem area. It is organized into sections dealing with system administration, coach specifications, towing vehicles, escort vehicles, and highway movement and safety. Without detracting from other portions of the WASHO proposal, we point to standard specifications of coach and towing vehicle size and configuration as the most important contribution of the proposal. This is true simply because greater shipper/carrier problems are likely to be solved in that realm than any other. The exact specifications outlined in this and other sections of the proposal are not as important as their acceptance throughout the entire area of the WASHO conference. This, indeed, is a big step toward standardization.

The American Association of State Highway and Transportation Officials (AASHTO) has also studied the problem of standardization. As a result, AASHTO has not only recommended extra-legal size and weight limits for all loads, but has designated certain mobile and modular housing shipments as "routine" oversize loads.[19/] Although the AASHTO does not propose permit reciprocity, as such, the adoption of standardized recommendations by the various state legislatures or regulation bodies is a necessary first step in attaining that objective.

Permit discussions thus far have related to state operations. Additionally, some municipalities and counties issue permits. Large cities often require permits for transporting oversize loads, either to discourage or control oversize moves in the city. Some smaller cities also require permits. Typically the permits are issued by the local enforcement agency, and a fee may be charged. Sometimes special escorts are mandatory while moving in the city, but otherwise no changes to the shipment need be made. Some counties also view permit operations either as a means of controlling county highway use or of collecting revenues. Issuance of county permits is widespread in some regions of the country. Normally, however, county permits would only be required for local travel on county highways at the beginning or end of a trip since larger, more direct state highways are preferred as through routes. County enforcement agencies are usually responsible for county permit operations and revenue collections where they exist.

Perhaps the greatest problem to carriers traveling off state highways is that the driver is unaware of local permit requirements until apprehended and fined by the agency enforcing local permit regulations. A system under which municipal and county governments would honor a state-issued permit would be a boon to carriers. If a local government determines a particular need for additional control, perhaps petitioning the state for establishment of appropriate policy measures would suffice. In that way the state permit agency would serve as a clearinghouse for establishment of special conditions which could be made known to interested parties.

In conclusion we recommend that:

* Lacking permit reciprocity, multiple-trip permit operations be recognized as a major means of enabling more economic mobile housing movements, and be employed widely by the states.

* Standardization of state regulations, especially those concerning size, weight, and configuration limits, be an immediate objective of the states.

* Proposals of standardization, such as those of WASHO and others, be reviewed, discussed, and considered as possible models for adoption by other compact groups of states and by AASHTO.

* Permit reciprocity be a goal of the states in order to better serve the infrequent carrier and to encourage standardization of institutions and regulations among the states.

* Municipalities and counties universally honor state permits which include, if necessary, special city and county requirements thus eliminating city and county permits.

D. Recommendations Regarding State Permit Fees

The states have adopted various policies regarding fees for permits. All but nine states charge a fee for permits allowing transportation of overdimensional combinations,* ranging from $2 to $20 for single-trip permits with the most common being $5.

In the nine states which charge no fee, permit issuance is apparently considered a normal part of highway use control. More commonly, a nominal fee is charged to recover the cost of issuance, Some states, however, believe the fee should also cover special law enforcement or other costs, contending they should be assessed as user charges rather than be borne by a more general fund. Moreover, some states use the fee system to produce revenue.

These varying attitudes have evolved over many years and reflect commitment on the part of the states. Each is eager to defend its point of view and system. Undoubtedly, the states would be reluctant to suffer the burden of disruption of present conditions. Therefore, suggesting a single fee which should be charged by all states is difficult in light of varying philosophies and practices as to the costs to be recovered by permit fees.

There are several alternatives. One is that no fee should be charged. Then the state would have to absorb the costs associated with permitting movement of overdimensional shipments. Practice indicates that most states do not favor this alternative, because most charge a fee. Their justification is that carriers of oversize homes constitute a special group

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* Permit fees are additional to costs involving vehicle legalization. State licenses for truck and trailer, Public Service Commission (et al.) plates and cards, and Motor Fuel Cab Cards all may be required at considerable costs. Since the entire motor carrier industry is faced with truck legalization, however, compliance with these matters has not been considered related specifically to overdimensional vehicles or combinations.

of highway users which should accept responsibility for costs occasioned by their group. The cost of issuing a permit is one such cost. Since this cost and others are directly associated with extra legal shipments, most states believe these costs should be allocated to the shipments responsible.

Concluding that some charge should be assessed to offset incremental costs, it must be determined which costs to recover. The obvious and most direct economic impact on the states is the cost of the issuing function. As discussed in Section V, people, offices, and supplies must all be provided to carry on this activity. Although most state permit officers do not know the exact cost of permit issuance, many suggest that $5 is sufficient to cover issuance costs. Studies in California and Connecticut, however, show that fully allocated costs of issuance and accounting may be slightly above $5 in those states. In California (1971) issuance costs amounted to $5.20 per permit, while in Connecticut (1971) similar costs (including the estimated cost of providing an accounting function) totaled $5.04. Assuming 5% annual cost increases, these amounts increase to $5.73 and $5.56, repsectively, in the year 1973 and to $6.02 and $5.84, respectively, in 1974. Based on this analysis we conclude that a single permit fee of $6 is currently justified to cover issuance and accounting expenses in most states.

Contributions to enforcement overhead are included by some states in their permit fees. Generally, those states defend a direct relationship between special enforcement activities and certain classes of extra legal shipments (usually oversize-overweight combined). Although the existence of specific cost data related to enforcement of regulations pertaining to oversize homes was not uncovered in this study, state permit officials interviewed indicated enforcement costs are not high. In at least four states where a $5 fee is currently charged, the cost of enforcement is included and permit officials in those states estimate that revenues cover expenses for both issuance and enforcement. Officials from two other states related similar experiences; their fees are $6 and $10, respectively. Only one state permit director made a separate estimate of enforcement cost; his estimate was $1.50 per shipment.

Despite inclusion in some states, a strong argument can be made against including enforcement costs in overdimension permit fees. Common oversize vehicles such as mobile homes call for little enforcement activity above normal levels for all truck traffic. State officials, as well as manufacturer and carrier spokesmen, relate that while many states maintain weigh stations or scale operations for overweight control of motor carriers, few states, if any, have established or carry out elaborate, special procedures related to oversize mobile homes. Permits are routinely checked and sometimes measurements are made and weights recorded, but much the same thing is done for all trucks passing through a weigh station. In effect, oversize mobile homes are treated very much like legal vehicles when it comes to enforcement of regulations, and, thus, little incremental expense accrues. We conclude that unless a state incurs specific incremental enforcement costs brought about by oversize mobile homes, the cost of enforcement should not be levied through oversize permit fees. Rather, mechanisms should be utilized which allocate motor carrier enforcement costs among all motor carriers proportionally.

Other costs are included in permit fees by a few states. One is a charge for highway maintenance. Although overdimensional mobile and modular homes are seldom, if ever, overweight, such shipments ride on an undercarriage, the wheels of which often range in separation to 8 ft or more. Normally, drivers of mobile home combinations are able to keep all set of wheels on the highway pavement, but occasionally (particularly on narrow highways) the right wheels leave the pavement and travel on the highway shoulder. Soft shoulders cannot withstand frequent travel at speed and sometimes suffer deterioration due to the effects of wide loads and other vehicles.

More to the point is the use, occasioned by the wide load, of the shoulder by other traffic. Our data and observations indicate that usage is rare on divided highways, but is common on two-lane roads. However, certain situations, such as a 14-wide home on a 20-ft pavement, essentially force most oncoming traffic to use the shoulder. Damage to shoulders in such situations would not be surprising.

No attempt was made in this study to determine the extent of shoulder damage occasioned by wide loads or other vehicles. No doubt damage varies with highway construction and various restrictions placed on the transportation of wide loads by the states. Proper routing and speed restrictions probably can minimize such damage where the potential exists. When this is not feasible and where the incremental damage (and costs of maintenance) can be determined and associated with the wide load user, states may want to consider a system of recovering the incremental cost of additional shoulder maintenance based on the width of both the coach and the route to be followed coupled with distance traveled. Such a system would charge shipments responsible for causing incremental shoulder damage. Also, such a system might discourage the use of narrow highways by wide combinations.

Until a state can determine the damages caused by specific highway users, however, it is felt that maintenance costs should be shared, as now, by all users through existing revenue mechanisms. We adopt a similar view with respect to other costs which may be levied on carriers of overdimensional mobile and modular homes.

Even more disparity exists among the states regarding fees for multiple-trip permits than exists in the realm of single-trip fees. A small number of states charge no fee. The remaining states charge either a fixed permit fee regardless of the number of times the permit is used or a variable fee for permit privileges dependent on the number of shipments moved. Often the flat fee charged by a state for a multiple-trip permit vastly exceeds the fee of a single-trip permit issued by the same state. Under a variable fee schedule the per-trip charge is usually equal to the fee for a single-trip permit. These observations suggest that some states are basing multiple-trip permit fees on the value to the user rather than the cost to the state. Also, since costs to the states are usually at least as low under multiple-trip permit operations as single-trip permit operations, the fees described above suggest that some states conduct multiple-trip permit operations at least in part to collect greater net revenues. Nevertheless, the carriers sufficiently value multiple-trip privileges that they are willing to pay fees in excess of issuance cost to the state.

As with single-trip permit fees, we recommend that the states charge a fee for multiple-trip permit issuance for wide loads which is sufficient to recover the cost of issuance and any other costs which can be specifically allocated to wide-load movement. Issuance costs probably do not now exceed $6. Other incremental costs could be included either on a one-time or variable basis. If a one-time basis is selected the specific incremental cost per trip should be multiplied by the usage factor of the multiple-trip permit. If the incremental cost is to be recovered depending on actual usage, an additional accounting function (and attendant cost) must also be considered. A one-time recovery charge system tends to favor the carrier which makes use of a multiple-trip permit most often--usually a larger carrier, while the variable charge system does not discriminate against the infrequent user but probably would increase the cost to the state and, thus, to the users, because of additional accounting.

In conclusion we recommend that:

* Permit fees be charged for the right to transport extra-legal loads.

* Permit fees should reflect only incremental costs directly associated with the extra-legal vehicle.

* Six dollars, being sufficient at this time to cover issuance costs of single-trip permits in most states, be adopted as the permit fee for mobile and modular homes.

* If states can clearly demonstrate other incremental costs brought about specifically by the transportation of mobile and modular homes, those costs be considered for inclusion in the permit fee.

* The states charge a fee for multiple-trip permits designed to recover issuance costs plus any other specific incremental costs to the state brought about by wide-load movements on either a one-time or variable basis.

VIII. DISCUSSION OF REGULATIONS

A. Divisible Loads

Most states require a load, which is oversize or overweight but which can be disassembled or otherwise modified to bring it within legal limits, to be divided and carried on two trucks. In theory, this "divisible load" requirement is reasonable. But special problems arise when a load is extra-legal in two dimensions. Such a situation often occurs within the modular housing industry.

Modular units are commonly 12 ft wide and 25 to 35 ft in length. Often, two such modules are assembled in the field to form a complete unit. Therefore, the industry is naturally very interested in the possibility of putting two such units on the same trailer. This process would cut their transportation costs nearly in half. We believe that such a procedure would also result in overall increased safety, and reduced costs and inconvenience to the motoring public. But the majority of states, at this time, cannot permit this because of their divisible load policies.

If two modules are put on the same trailer it results in a load which is overwidth (12 ft) and overlength (70 to 80 ft, including the tractor). Therefore, because of the divisible load statute it must be divided and placed on two trucks. The result is two loads, each of which is of legal length but overwidth (12 ft). Therefore, two permits must be obtained, two truck drivers employed, perhaps two sets of escort vehicles hired, and two trips made over the same route.

Our data show that a wide load does create certain types of problems for motorists. Because of its width and its slower than average speed, motorists are faced with delays and the possibility of increased operating costs, increased air pollution, and increased risks. As discussed elsewhere, however, our data do not show any major incremental problems associated with an additional 20 or 30 ft of length for a movement which is already overwidth and moving at reduced speed.* Therefore, it is apparent that by requiring the carrier to make two movements instead of one, there will be essentially twice the total inconvenience, costs, and potential hazards imposed on other motorists.

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* An exception to this is the "tracking" problem which is more severe for longer loads. To some extent this problem could be minimized by using articulated trailers for the two modules. However, a means of transport, the articulated trailers within legal limits when empty would be required.

The rationale behind present divisible load statutes is so vague and illconceived, in the minds of many carriers, that they feel justified in adopting subterfuges to avoid strict compliance. It is not unheard of for a manufacturer or carrier to nail connective material between modules so that the load can then be considered indivisible. Another ploy which has been used is to cover the entire shipment securely with canvas so that its true contents are not apparent.

The states, collectively, have expressed the desire to ameliorate the divisible load quandry. The American Association of State Highway and Transportation Officials (AASHTO) has included a special provision in their document, "Recommended Policy on Maximum Dimensions and Weights of Motor Vehicles..."[19/] The special provision pertains to "routine" moves of mobile and modular units, and implicitly allows for divisible loads provided the overall combination dimensions do not exceed 12 x 85. Two difficulties remain, however. The special provision is not explicit in allowing "routine" divisible loads, which are otherwise explicitly disallowed. And, the states need not and, indeed, have not all accepted the recommended policy.

In conclusion, we recommend that:

* The states do not prohibit oversize divisible loads, which otherwise meet permit requirements, if such loads would remain overwidth even after subdivision.

B. Length Restrictions

The states differ in the length of load they will allow, as well as in their manner of specifying maximum length. These variations can lead to extreme difficulties within the mobile home industry. They can also lead to ingenious, although perhaps unnecessarily hazardous solutions.

One obvious effect of increasing the length of a load concerns passing maneuvers on two-lane roads. Clearly, the longer the load, the longer it will take another motorist to pass that load and the longer he will be exposed to a high risk situation by being in the wrong lane. Quantitative information depends, of course, on the many parameters which control a passing maneuver, such as the length of the load, the speed of the load, the speed of the passer, and the speed of the oncomer. For illustration, however, assume the following, relatively severe conditions. Assume that the load is traveling at 55 mph and the passer accelerates to 70 mph and maintains that speed for the remainder of the pass (alternatively, he could be making a flying pass at 70 mph). Assume, also, that oncoming traffic is at 70 mph. Under these conditions every 10 ft of additional length of the load will require the passer to spend an additional one-half second in the opposing lane, and will require an additional 100 ft of open road between the passer and the oncoming traffic. These considerations do not apply, of course, on multilane highways.

Another concern is the tracking ability, or lateral space requirement, of wide loads. As the length of a load increases, it requires more lateral space when negotiating horizontal curves. The lateral space "swept" by the load depends also on the axle spacings of load and tractor, and front and rear overhangs, as well as the basic length and width dimensions. Tracking studies have been carried out by the Federal Highway Administration[20/] to examine these effects. Although their results are not yet published, it is clear that there is an interplay between length and width. Based only on tracking consideration, 12-wides could be tolerated in longer lengths than 14-wides.

The data collected in this project concerning measures of risk and measures of cost to the motoring public did not display any length effect. We could not discern any difference in motorists' overtaking behavior or in the oncoming maneuvers of other traffic attributable to length. Therefore, it is difficult to support or refute the maximum length allowances of any particular state. We believe that the collective judgment of the states, as expressed through AASHTO, can select an equitable compromise.

Once agreement is reached on a length limit, a second problem must be faced. Because of state-to-state differences in methods of specifying lengths, the industry has developed special tractors to take advantage of loopholes. Most commonly, the states regulate the total or combination length, although some regulate the load length and a few regulate both. In addition, some states regulate certain tractor characteristics such as minimum wheelbase. As a result, the industry has developed "10-ft" trucks and "5-ft" trucks, as discussed in Section V, to get around these problems. The industry expresses serious concern about the safety and handling characteristics of these unusual vehicles. The problem could be avoided if the states would establish maximum load length regulations instead of, or in addition to, maximum combination length specifications.

In conclusion, we recommend that:

* The states adopt the maximum length recommendations of AASHTO.

* The states establish maximum <u>load</u> length limits as well as maximum combination length limits to discourage unusual, and possibly unsafe, tractor configurations.

C. <u>14- vs 12-Wide Loads</u>

The question of greatest concern presently to the states and to the mobile home industry pertains to allowing movement of 14-wide mobile homes by highway. A majority of the states do allow 14-wides, under permit, and usually with the imposition of more stringent regulations than are required for 12-wides. The industry hopes to have favorable legislation adopted by all of the states. On the other hand, some of the states have maintained opposition to such movements and, in fact, a few states are considering rescinding previous action allowing 14-wides.

The question is not a simple one and, unfortunately, the data obtained in this study do not clearly show that the states should, or should not, allow 14-wides. The data do show that movements of all oversized loads cause certain problems and, to some degree, impose on other motorists. The data also show that, generally, 14-wides cause more problems and greater impositions than 12-wides. But, these differences are usually not extreme, in our opinion. The states could allow 14-wides but keep the problems and impositions at an acceptable level through use of their regulatory powers.

The photographic and visual traffic data collected during the project were analyzed to ascertain whether trends could be found concerning the width of the load. On multilane highways, there were no trends which could be observed concerning the safety aspects of overtaking which could be attributed to the width of the load. Likewise, on two-lane highways, there were no significant effects although there was a nonsignificant tendency for motorists to react with a somewhat greater time margin to 14-wides than to 12-wides.

No significant effects on costs to the motoring public, due to width, could be found on two-lane highways, On multilane highways, 14-wides did induce approximately 50% higher costs on the public than did 12-wides, but in each case the costs were very small (on the order of 2 cents per wide-load mile). The emission of air pollutants by other traffic was somewhat greater on two-lane highways in the vicinity of 14-wides than in the vicinity of 12-wides. This could, however, be a reflection of the different average speed levels of other motorists in the regions of the country where the 14-wide data were collected.

There were some statistically significant width effects on oncomers on two-lane highways. When passing 14-wides, oncoming passenger vehicles tended to move further to the right and, on 10-ft lanes, many of them used part of the shoulder. This phenomena was less often observed with 12-wides. On 10-ft lanes all oncoming trucks used some of the shoulder in passing a 14-wide. The oncoming behavior is clearly a matter of simple geometry. Even by using some of the air space over the shoulder, a 14-wide load on a 10-ft lane does overhang part of the adjacent lane and forces oncoming traffic to move over.

A related problem concerning lane usage occurs on divided highways. Under normal circumstances, a 14-wide load can be, and usually is, positioned in the right-hand lane by the driver in such a way that it occupies 2 to 3 ft of air space above the shoulder and does not encroach into the adjacent lane. Even after allowing for meandering of the path[11/] a 14-wide load does not normally encroach onto adjacent lanes. However, encroachment does occur during abnormal situations. These include obstructions on the shoulder, or a temporary narrowing or disappearance of the shoulder such as might occur when crossing a narrow bridge.

When there are three or more lanes in one direction, on a limited-access highway, there is a tendency for the wide-load driver to want to stay out of the right-hand lane so as to avoid conflicts with entering and exiting traffic. If the load is a 12-wide, its normal meandering will cause it to encroach slightly outside of a normal 12-ft lane. A 14-wide load will, of course, tend to encroach 1 ft more on either side than a 12-wide.

An indirect, speed-related effect on traffic of 14-wide loads was observed in this project. Generally, 14-wides are longer and heavier than 12-wides. Seventy feet is a common length for 14-wides; we did not encounter any less than 60 ft. Because of their increased size in general, and perhaps because of their increased weight, 14-wides tend to be driven slower than 12-wides. The speed differential is 5 to 10 mph. We determined (Sections II and IV) that slower moving wide loads created more problems and more impositions on other motorists than did faster moving loads, regardless of the width of the load. Motorists' operating costs, air pollution emissions, delays, and measures of risk taking all tend to increase as the wide load speed decreases.

In conclusion, we recommend that:

* Certain restrictions, in addition to those imposed on 12-wides, be imposed on 14-wide movements. These restrictions should include:

    - Discouraging or prohibiting 14-wide movements on highways with less than 12-ft lane widths.

    - Discouraging 14-wide movements on two-lane highways with 12-ft lane widths if the highways have narrow or poor shoulders, or frequent constrictions of the roadway.

- Confining them to the right-hand lane in urban areas or other locations where more than two lanes are available, except under extenuating circumstances.

- Requiring installation of highly visible and effective warning beacons on the rear of the wide load because 14-wides tend to move slower than 12-wides.

- Discouraging 14-wides from using highways with poor sight distances or else requiring that they employ two-way-radio-equipped front escorts on such highways.

D. Speeds of Wide Loads

As discussed in Section V, most states regulate the speeds of wide-load movements. These regulated, or allowable, speeds vary greatly from state to state.

One of the data elements collected in the project was the speed of wide loads (see Section II). These data were collected on 41 trips in which: (a) the speedometer in the truck was in working condition and either reasonably accurate or had a known and correctable inaccuracy; and (b) an observer other than the photographer was riding in the cab of the truck or in an escort vehicle pacing the wide load. The data are summarized in Table XLII.

The averages in Table XLII were developed from the data recorded during the trip. Speed observations were recorded at either 15-sec or 1-min intervals, depending on the recorder's other functions at the time. To eliminate the effect of short-term fluctuations, 5-min averages were calculated. Then, the 50th percentile (average) speeds and the 85th percentile speeds of the wide loads were determined.* These are displayed in the table together with the highway speed limit and the speed allowed under the regulations of the particular state.

The data show that the drivers' speeds were influenced by the allowable speed. They tended to drive faster in those states which allowed higher speeds. However, the observed speeds did not differ as widely as the allowable speeds. For instance, on <u>all</u> trips witnessed in areas where

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* These are not to be confused with 50th and 85th percentile speeds of <u>all</u> traffic, which traffic engineers often utilize.

TABLE XLII

OBSERVED WIDE LOAD SPEEDS

State	Trip no.	Road	Coach Size	N	Highway Speed Limit	Regulation-Allowable Speed mph	Average Speed[a/] mph	85th Percentile Speed mph[a/]
Idaho	1-9	Multilane	12x44	6	70	70	52	53
	1-10	Multilane	12x50	9	70	70	62	63
	1-23	Multilane	14x70	11	70	50	55	57
Indiana	1-25	Multilane	12x71	3	70	70	43	43
	1-27	Multilane	12x71	2	70	70	40	40
Kansas	1-1	Multilane	12x64	9	75	50	45	47
Kentucky	2-19	Two-Lane	12x52	7	45	45	40	40
		Multilane	12x52	13	70	70	60	60
	2-20	Two-Lane	12x60	3	45	45	36	36
		Multilane	12x60	8	70	70	59	60
	2-21	Two-lane	12x65	8	45	45	30	32
		Multilane	12x65	7	70	70	58	60
Maine	2-10	Two-Lane	12x65	7	45	45	39	40
	2-11	Two-Lane	12x48	15	50	45	42	44
		Multilane	12x48	6	70	45	42	47
	2-14	Two-Lane	12x40	12	50	45	44	46
		Multilane	12x40	12	70	45	47	48
	2-15	Two-Lane	12x40	12	45	45	42	44
Michigan	2-26	Two-Lane	14x70	12	55	35	42	43
		Multilane	14x70	4	65	45	40	40
	2-29	Two-Lane	12x60	5	65	45	38	38
		Multilane	12x60	4	70	45	40	40
	2-30	Two-Lane	12x60	3	60	45	41	41
		Multilane	12x60	9	70	45	49	50
	2-32	Two-Lane	12x54	13	50	45	42	43
		Multilane	12x54	10	70	45	46	47
	2-34	Two-Lane	12x55	7	50	45	42	43
	2-35	Two-Lane	12x54	7	55	45	38	38
		Multilane	12x54	3	70	45	40	40
Minnesota	1-14	Two-Lane	14x70	10	60	60	52	53
	1-18	Two-Lane	14x70	27	65	65	51	53
Missouri	1-1	Multilane	12x64	19	70	55	45	46
	1-2	Two-Lane	12x64	26	65	50	42	47

TABLE XLII (continued)

State	Trip No.	Road	Coach Size	N	Highway Speed Limit	Regulation-Allowable Speed mph	Average Speed[a] mph	85th Percentile Speed mph[a]
Missouri (continued)		Multilane	12x64	8	70	55	48	49
Ohio	1-25	Multilane	12x71	19	65	40[b]	44	45
		Two-Lane	12x71	5	60	40[b]	41	42
	1-27	Two-Lane	12x71	5	60	40[b]	43	44
		Multilane	12x71	14	65	40[b]	45	45
	2-1	Two-Lane	14x70	9	50	35	38	40
		Multilane	14x70	38	70	45	45	46
	2-3	Two-Lane	14x70	3	60	35	41	41
		Multilane	14x70	33	70	45	46	47
	2-30	Two-Lane	12x60	20	60	40[b]	44	45
		Multilane	12x60	13	65	40[b]	50	51
Oregon	1-9	Two-Lane	12x44	47	65	60	46	49
	1-10	Multilane	12x50	52	75	60	57	59
	1-12	Multilane	14x68	36	70	60[c]	48	49
	1-13	Multilane	14x64	5	50	60[c]	39	40
	1-23	Two-Lane	14x70	36	70	60[c]	46	47
Tennessee	2-19	Two-Lane	12x52	5	40	40	40	43
		Multilane	12x52	4	75	75	50	50
	2-20	Two-Lane	12x60	6	55	55	50	52
		Multilane	12x60	6	70	70	55	58
	2-21	Multilane	12x65	15	75	75	58	60
Washington	1-12	Multilane	14x68	20	70	45	47	49
	1-13	Multilane	14x64	28	70	45	44	45

a/ Based on N 5-minute averages of the wide load speed.
b/ Or posted minimum, whichever is greater.
c/ State specifies maximum speed of 60 mph (statute) for 12 wides, and minimum speed of 35 (two-lane) and 45 (divided) for 14 wides. No other specifications are given.

the allowable speed was 35 or 40 mph, the drivers chose to drive above those limits. On the other hand, no case was observed where the average speed exceeded an allowable limit of 55 mph or more. Overall, speeds in the range of 45 to 50 mph were most common.

Table XLII also provides insight into the speeds preferred by the drivers when unhindered by allowable speed limits. Drivers of 12-wides averaged 57 mph on multilane highways on the 11 trips where the allowed speed was 60 mph or above. The data are more sparse for 14-wides, but, for the three trips of such loads on multilane highways with allowable speeds of 50 mph or more, the average speed driven was 48.6 mph. There are almost no comparable two-lane data; the small amount available suggests that, given an ideal two-lane road, the drivers would choose speeds of about 50 mph. Such a road, which would have 12-ft lanes, wide shoulders, low traffic, and unlimited sight distance, is rare, however. Drivers generally chose lower speeds on two-lane roads.

During the course of the trips many of the drivers were queried as to their speed preference. The general consensus among the drivers was that they would prefer to drive at a speed approaching that of other traffic--that is, they would prefer to "move with the traffic." It is unknown to us whether this preference is prompted by reasons of safety or of convenience. Our data and other studies indicate that both factors would suggest the same strategy.

In studies of accidents in general, Solomon[6/] examined the role of speed differentials in crashes. His data show that, in general, vehicles traveling at, or a few miles per hour above, the average speed have the lowest crash rate. The crash rate increases rapidly, however, for vehicles traveling well in excess of the average speed or for vehicles traveling at less than the average speed. A partial explanation for this phenomena is found in the results of studies of human perception ability. Researchers such as Michaels[21/] find that relative motion is seen as a perceived rate of change of the angle subtended by the object observed. Moreover, there is a threshold for this perception which is somewhere in the neighborhood of 6×10^{-4} radians/sec. However, research also shows that humans are relatively incapable of estimating the magnitude of a perceived speed. Employing the concept of a threshold of perception implies that the distance at which a motorist can discern the existence of relative motion between himself and a distant object is proportional to the square root of the relative speed. This means that measures of criticality, such as the time to overtake, decrease as the relative speed increases, implying a less safe situation. Specifically, the time to overtake is proportional to the reciprocal of the square root of the relative velocity.

There was too much variance in the observed traffic data to establish significance in the differences in the overtaking time as a function of relative speed. However, the trends observed were in the right direction. That is, drivers reacted with greater time margins when overtaking a faster moving (lower relative speed) wide load, both on multilane and two-lane highways.

Higher wide-load speeds also imposed less burden on other traffic. Our data show that the costs due to delay and vehicle operations borne by other drivers increase significantly on multilane highways as the wide-load speed decreases. The same trend is observed, but is not significant, in additional emissions of air pollutants.

Thus, all available data indicate that extremely low speed limits should not be placed on wide loads. When road, traffic, and weather conditions permit, such loads are easily capable of being driven at 45 to 50 mph. In fact, speeds substantially in excess of 50 mph were often observed but cannot be recommended without further study. Such studies should consider the aerodynamics and stability of the combination as well as the aerodynamics induced on passing motorists.

In conclusion, we recommend that:

* Regulated, statewide, maximum speeds of wide loads be not less than 45 mph on two-lane roads, and 50 mph on multilane highways.

E. Usage of Interstate Highways by Wide Loads

All of our data indicate that, to the greatest extent possible, 12- and 14-wide mobile and modular homes should be routed on Interstate or other divided highways in preference to two-lane roads. For a number of reasons, many of the states do not follow this policy. In as least two states, 12-wides are not allowed on Interstate roads, and in at least five states, 14-wides are allowed only on non-Interstate roads. At least one other state prohibits use of the Interstate System by slow moving vehicles which, by the state's policy, include 12- and 14-wide mobile and modular homes. Finally, there are a number of turnpikes and toll roads which prohibit such movements, often because toll facilities cannot physically accommodate them.

Some states have legal difficulties in permitting these loads on the Interstate System. This difficulty stems from the Federal-Aid Highway Act of 1956, authorizing the Interstate System. The pertinent section quoted from the U.S. Code, Title 23, Section 127, follows:

> No funds authorized to be appropriated for any fiscal year under Section 108(b) of the Federal-Aid Highway Act of 1956 shall be apportioned to any State within the boundaries of which the Interstate System may lawfully be used by vehicles with weight in excess of eighteen thousand pounds carried on any one axle, or with a tandem-axle weight in excess of thirty-two thousand pounds, or with an overall gross weight in excess of seventy-three thousand two hundred and eighty pounds, or with a width in excess of ninety-six inches, or the corresponding maximum weights or maximum widths permitted for vehicles using the public highways of such State under laws or regulations established by appropriate State authority in effect on July 1, 1956, whichever is the greater. Any amount which is withheld from apportionment to any State pursuant to the foregoing provisions shall lapse. This section shall not be construed to deny apportionment to any State allowing the operation within such State of any vehicles or combinations thereof that could be lawfully operated within such State on July 1, 1956. With respect to the State of Hawaii, laws or regulations in effect on February 1, 1960, shall be applicable for the purpose of this section in lieu of those in effect on July 1, 1956.

The basic difficulty is this: A state's present capability in utilizing the Interstate System for 12- and 14-wide mobile and modular homes is contingent upon that state's laws, and the wording thereof, at a time when such highways and such vehicles did not exist. It happens that the laws in the majority of the states were vague in this regard. In such states, the laws allowed for the possibility of oversized loads and set up general provisions for their regulation. Such provisions typically included the requirement of a permit and other regulatory requirements that might be established.

Other states, however, had very explicit laws with prohibitions against, for example, movement over any highway of a load exceeding certain dimensions. In such states extra-legal movements on the Interstate System could be made only under one of two conditions. One is that the state Attorney General render an opinion, based on that state's laws, that would, in fact, allow such movements. Approval would then be required from the Chief Counsel's Office of the U.S. Department of Transportation. The other possibility is to seek U.S. Congressional action regarding this section of the Highway Act.

It is worthwhile to review here our findings pertinent to the use of divided highways for oversized loads. All indications are that, as with other vehicles, divided highways are the safest place for these movements. There is, of course, no oncoming traffic on divided highways so there are no potential oncoming conflicts. There is essentially no queuing behind wide loads on divided highways; substantial queuing may occur on two-lane roads. Overtaking and passing on divided highways is done relatively casually by motorists; passing may be extremely difficult and lead to great driver discomfort, impatience, and, perhaps, accident-prone behavior on two-lane roads. Roadside hazards, although encountered on the divided highways, are far less frequent there than on two-lane roads. The necessary lateral displacement to avoid roadside hazards is generally less significant on divided highways, both because there is usually more lateral space and because relative velocities between vehicles are less.

The impact of wide loads on other motorists is much less pronounced on divided highways than on two-lane roads. As discussed in Section III, nearly 3,000 motorists were interviewed, some on divided highways and some on two-lane highways. When asked, "In general--not just on this trip--is there any particular type of vehicle which causes you problems in terms of delay or safety" 5.3% of the motorists on divided highways mentioned mobile homes compared to 7.8% on two-lane roads. A second part of the survey asked the driver which vehicles fell in certain categories, including:

1. A safety hazard on Interstate highways;

2. A safety hazard on two-lane highways;

3. Cause delays on Interstate highways;

4. Cause delays on two-lane highways;

5. Should not ever be allowed on Interstate highways; and

6. Should not ever be allowed on two-lane highways.

Mobile homes were consistently named twice as frequently relative to two-lane roads as to Interstate highways.

Costs due to delay imposed on other motorists are generally greater on two-lane roads than they are on divided highways. This occurs, in part, because the wide load on a divided highway interacts only with the same-directional stream of traffic, whereas opposing vehicles may also be delayed on two-lane roads. In addition, costs incurred by overtaking vehicles on multilane divided highways are generally less than those incurred on two-lane roads because of the low frequency of queuing in the former case. The same arguments hold true concerning emissions of pollutants.

The use of Interstates can result in substantial savings in transportation costs and, therefore, the cost of the housing to the purchaser. The biggest incremental cost incurred in transportation is generally the cost of escort vehicles. Such vehicles are not needed on divided highways, in our opinion. On the other hand, there are situations where proper escorts are desirable on two-lane roads, as discussed elsewhere in this section. The price differential due to escorts could be as high as 60 to 70 cents per mile. It hardly seems proper to ask the purchaser to pay these extra costs for transporting in a fashion which is more hazardous and more disruptive of traffic than would be the case using divided highways.

In conclusion, we recommend that:

* The states make every effort to encourage wide-load transportation on divided highways, in preference to two-lane roads.

* The Federal Government provide relief to the few states with outmoded laws by modifying Title 23, Section 127 of the United States Code relative to use of the Interstate System by overwidth loads.

F. Time of Day/Day of Week Restrictions

Most states regulate the hours of the day and days of the week on which wide loads may move. This is usually done to minimize such movements when they might cause more than normal congestion or hazards. Of the two types of restrictions, time of day or day of week, the former has more impact on these problems, as well as on cost considerations to the carriers involved.

Day of week restrictions usually are not a significant problem to the carriers because, with planning, difficulties can be avoided. Generally, the states allow wide-load movements Monday through Friday but not Saturday or Sunday. As a result, the carriers often will not initiate trips during the day Friday unless they are confident that the trip can be completed that day. Therefore, wide-load traffic is generally lower on Friday than it is on other days of the week.

Most states prohibit wide-load movements on holidays. This is reasonable and also does not prove to be a problem to the carriers except in those instances where individual states may celebrate relatively obscure holidays or have special regulations such as prohibiting traffic on the work day preceding or following a holiday. If, in fact, other traffic is observed to be abnormally heavy in certain areas on days preceding or following holidays, then such regulations are reasonable.

Weekend traffic volumes in many states are higher than weekday volumes. Therefore, because of the generally lower-than-average speeds of wide loads, it is reasonable to restrict them during these days because of the congestion which they could enhance. However, the states may wish to modify this policy should significant changes occur in future highway use patterns. The current energy crisis has several long-range implications in this regard. If vehicular traffic is limited to 55 mph speeds, then mobile homes, particularly 12-wides, should not be a cause of congestion because they are nearly capable of these speeds. Secondly, if recreational travel by motor vehicle is severely curtailed, then weekend traffic volumes should drop significantly and, in fact, might make weekends the best times for mobile home movements.

Under certain conditions, special regulations may be appropriate for 14-wides. With the exception of travel on two-lane highways with 10-ft lanes, few differences in traffic behavior are attributable to the width. per se, of the wide loads. However, 14-wides generally tend to travel slower than 12-wides. The difference in speed makes 14-wides more likely to affect congested traffic than 12-wides. Under these conditions, a state may wish to further limit 14-wide movements if, for example, traffic volumes are higher on Mondays and/or Fridays than they are on Tuesday, Wednesdays, or Thursdays.

As previously noted, time of day restrictions have greater consequences than day of week restrictions. Many states allow movements any time during daylight hours, or have regulations to that effect, but others severely restrict hours of operation. Such restrictions can have great economic impact on the carriers. We can find little justification for such restricted hours, particularly in rural areas. In urban areas, where morning and afternoon peak volumes lower the level of service substantially, it is reasonable to have wide-load curfews. Otherwise, carriers should be permitted a reasonable length workday.

No state normally allows nighttime movements of wide loads. Therefore, little data are available concerning the hazards involved in such operations, and it is necessary to rely on general knowledge and professional judgment. General knowledge concerning accidents establishes without doubt that nighttime driving is more hazardous than daytime driving. Accident rates are substantially higher at night and accidents tend to be more serious then. There are a number of reasons for this. An obvious reason is the radical difference in visibility. More subtly, but probably as importantly, drivers on the road at night are generally less fit for driving than are drivers on the road during the day. At night drivers are often tired and subject to dozing, hallucinations, or generally slow reactions. Nighttime driving is more likely to be for social purposes than daytime driving with an attendent decrease in attentiveness to the driving task. And, as shown by innumerable studies, the percentage of drunk driving increases drastically at night. Therefore, it is reasonable to assume that, in general, other drivers will react to wide loads with more risk at night than during the day. In summary, we agree with the states in prohibiting routine nighttime movements of wide loads.

Under special conditions, however, the states have allowed nighttime wide-load movements.* In times of national emergency or disaster relief, waivers of the normal regulations are often granted.** We believe that such permission should be granted only under extreme circumstances, and after all other alternatives have been exhausted. In times of national emergency, when a matter of a few hours can be important, such movements may be necessary. It would appear, however, that a delay of a few hours in providing housing for emergency relief might not be that crucial. Movements for these purposes should be restricted to daylight hours if at all possible. If the movements do not exceed about 400 miles there should be no problem in this regard.

For longer trips, however, other strategies could be employed. Instead of an individual driver running into or through the night to get his load to its destination, and then dead heading back on the succeeding day, a relay procedure could be used. Drop points could be established. Drivers could run one leg of the trip during the daylight hours, leave the house at a drop point, and use the nighttime hours for dead heading back to their origination. Another crew of drivers could then move the houses from the drop point to the destination or a second drop point during the next day. Although an individual house would take longer to complete the trip by this technique, an overall movement, involving perhaps thousands of mobile homes and requiring days or weeks to complete, would be accomplished in the same time as would be needed by the usual method.

A final point should be made concerning nighttime movements of wide loads. Most drivers of the common carriers are experienced and well qualified to move wide loads with minimal damage and hazard. However,

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* Some cities and locales allow wide-load movements only at night.

** Eighteen thousand units were moved, both day and night, in response to the recent Hurricane Agnes disaster. HUD reports that no injuries or fatalities were incurred relative to the movement.

their wide-load experience is gained entirely during daylight operations. They are not accustomed to moving 12- and 14-wide loads at night under conditions of limited visibility. Therefore, one should expect that either damage rates will be higher or that the drivers will cause more traffic impedances (for example, by using more of the road and less of the shoulder) at night than they would during the day.

In conclusion, we recommend that:

* Mobile and modular homes be allowed to move during daylight hours on weekdays, except on major holidays, or in congested areas during peak hours.

* Weekend movements be allowed if traffic volumes on such days do not exceed weekday volumes.

* Nighttime movements be prohibited except in times of national emergency or disaster relief, and even then only after all possibilities of daytime movements have been exhausted.

G. Special Lighting

As discussed in Section V, many of the states require oversized movements, particularly 14-wides, to carry flashing amber lights on the rear of the load. As shown in Table XIX, however, relatively few specifications exist concerning these lights. In states which have specifications, they typically require only a flashing light of 50 (or less) candlepower, or one which is visible at 500 ft.

A similar situation exists regarding lighting on escort vehicles. Of the contiguous 48 states, nine require flashing or revolving amber lights but with no further specifications, while 17 states give additional lighting specifications. Most are vague, such as "high intensity," "visible at 500 ft," "readily seen," or "plainly visible." Only three states, in our opinion, have adequate regulations in this regard. Washington requires the lights to meet SAE standard specification SAE J-5956, "Flashing Warning Lights for Authorized Emergency, Maintenance and Service Vehicles." Idaho has a similar regulation. Utah regulations require a "heavy duty, rotating, motor-driven emergency beacon for emergency equipment." Among other requirements it must have a minimum of three magnifying prismatic parabolic lenses that rotate 360 degrees and produce 10,000 candlepower.

The actual practices followed by escort vehicles are not exactly what one might expect from the regulations. Our observations indicate that, where an escort vehicle is used, and when it has any special light at all, it is usually of the high intensity variety designed for daylight use. Normally it is a rotating beacon unit, commonly used by emergency vehicles. Such units usually are rated at 35,000 candlepower or more (1,000,000 candlepower flashers are available). This should be contrasted with the type of lights used on a mobile home when special lighting is required. These lights are, at most, 50 candlepower flashers. Provided they are kept clean, which they are often not, they are visible at 500 ft but they are certainly not eye catching. Generally, under daylight conditions, a motorist should be able to see the wide load before he would see a 50 candlepower flasher.*

It would seem that such lights, if they have any value at all, would be useful only at night or under foggy conditions. These are not the conditions under which wide loads are moved. Our data seem to bear out this hypothesis, that the special lighting currently in use on wide loads does nothing for the motorist.

On the other hand, our data concerning escort vehicles tend to indicate that their high intensity beacons are effective. Motorists responded to them with caution and awareness, apparantly more so than they responded to wide loads.

In conclusion, we recommend that:

* Where special lighting is required, either on an escort vehicle or on a wide load, it be specified in accordance with SAE J-5956, or equivalent.

H. Use of Escorts

Most of the states (40 of the 48 contiguous states) require one or more escorts, at least under certain conditions, for 12-wides; all but two of the states require them for 14-wides.** Certainly, the states' escort requirements are well intentioned. Hopefully, escorts should provide an increased factor of safety to other motorists in the vicinity of the wide load. Secondarily, they should be of assistance to the wide-load driver.

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* Theoretically, a 14-wide mobile home would be detectable to the naked eye at 48,000 ft under ideal conditions!

** All states reserve the right to specify them.

In many respects, however, our findings are to the contrary. Our data show that escorts produce limited, if any, benefits; they are extremely expensive to the ultimate purchaser of the wide load; they create increased costs, delays, and air pollution on the part of other motorists; and they can create additional hazards. Therefore, we believe that the escort requirements should be re-examined.

First, we should ask what benefits are desired by the use of escort vehicles. It would be hoped that they would serve to warn overtaking motorists of a slow, wide vehicle ahead or to warn oncoming vehicles of the wide load they are about to meet. They can provide more diverse benefits to the wide-load driver. An escort vehicle can "flag" other traffic when the wide load needs additional room. And, if properly equipped with two-way communications, escorts can warn the wide-load driver of potential hazards of which the driver may be unaware.

To reap these benefits, certain costs are incurred. The going rate for escort vehicles is 30-35 cents per mile, with a 100 mile minimum often required. If two escort vehicles are needed the cost would be doubled. This cost is passed on directly to the shipper. If it is an initial move, the cost is generally included indirectly in the purchase price. Costs are also imposed on other motorists when escorts are used. In particular, increased emissions of air pollutants were significantly related to the use of a front escort on two-lane highways, and increased costs were significantly related to the use of a rear escort on multilane highways.

One should also consider the effects of increased or degraded safety occasioned by the use of escorts. In our analysis of the traffic data we found no statistically significant safety-related effect attributable to the use of escorts. There was a tendency for overtaking motorists to respond to escort vehicles earlier than to wide loads, but this tendency was attributed primarily to the high intensity beacon which these escorts carried. The speeds and lateral displacements of oncoming vehicles passing a wide load were not related to the presence or absence of a front escort. So, we conclude that these particular measures do not demonstrate escort effectiveness.

Let us consider some of the potential hazards involved with escort vehicles. We begin by accepting the postulate that a large, slow-moving vehicle (the wide load) can be a potential hazard to overtaking motorists. But, if so, then the placing of a small, slow-moving vehicle behind it (a rear escort) also constitutes a hazard. Overtaking motorists must now perceive and react to the slow-moving escort vehicle rather than the large, wide load. Fortunately, the majority of the states require the escort to have special lighting and, in practice, the special lighting is often a high intensity beacon such as used on emergency vehicles.* Generally speaking, oncoming motorists were found to react to a front escort with a flashing beacon. In fact, they often gave it as wide a berth as they gave the wide load. We do not believe this to be a desirable reaction, particularly if it requires oncoming motorists to encroach upon the shoulder in passing by the escort vehicles.

The addition of escort vehicles on two-lane highways increases the number of slow vehicles which overtaking motorists must pass. In particular, a front escort vehicle often creates its own queue while the wide load trails a second queue. A motorist who passes the load must then often follow the front escort until another suitable passing opportunity exists. Thus, the number of two-lane passes, one of the most hazardous of driving maneuvers, is essentially doubled with a front escort. This situation is generally not observed relative to rear escorts because they tend to drive close to the wide load when overtaking traffic appears. These overtakers, however, must then usually pass both vehicles at once.

It was mentioned that one function of an escort vehicle was to "flag" other traffic. In practice, such flagging ranges in activity from doing nothing except hoping that traffic will react to the mere presence of the escort (which we found was not the case), to waving a flag at oncoming motorists, to physically blocking or stopping other traffic. Often, a rear escort on a divided highway will straddle lanes to prevent overtaking traffic from passing the wide load if there is some constriction ahead. Also, a front escort on two-lane highways may proceed past a road restriction such as a narrow bridge or sharp curve, and attempt to stop oncoming traffic so that the wide load can clear the restriction.

When not absolutely needed, an escort vehicle can produce a false sense of security for the wide-load driver. Some drivers have admitted to us that they realize they tend to get lazy and more inattentive to their driving tasks because of their reliance on an escort vehicle. But, as some of the incidents discussed in Section VI indicate, reliance on escort vehicles can be dangerous if the escort vehicle does not or cannot provide

* One extremely inconspicuous vehicle was seen escorting a wide load not connected with this study. It was a sedan with no lights and no signing. Its markings consisted of one red oil rag pinched by, and protruding from, each corner of the hood.

the necessary services, such as warnings or flagging. It should be quite clear in this regard that an escort vehicle without two-way communication cannot produce warnings in any event so, in fact, can be of very little assistance to the driver aside from flagging.

Finally, we must look at the qualifications and capabilities of the escort drivers. In nearly all states the only requirement for being an escort driver is to have a valid driver's license. No special training in highway safety, traffic control, emergency situations, or the like is required. The drivers tend to be persons without particular skills, since the pay is not particularly high.* An escort driver's allegiance is usually to the wide-load driver who is paying him, and not to other traffic. This type of allegiance was particularly observed in some escort drivers who believed it was part of their job not to let any motorist get between them and "their" wide load. Motorists who passed such rear escorts were immediately repassed by the escort. Finally, as dramatized by the incident on Trip 2-29, discussed in Section VI, the sheer negligence of these drivers can create extreme hazards.

We believe that indiscriminate requirements for escort vehicles do more harm than good. There are, of course, situations where such vehicles can be very beneficial. In our opinion, these situations are limited to two-lane highways where there are short sight distances and/or constrictions such as narrow bridges. They are not needed on divided or Interstate highways nor on most two-lane highways. We believe that the states should publish road maps indicating where escort vehicles are required. Generally, restrictions based on combination length or lane width, although easy to specify, do not portray the true situations where escorts may be needed.

In general, a front escort should solve most escorting functions. There appears to be little use for rear escorts other than to slow down overtaking traffic. They can only do this safely if they are carrying a high intensity flashing beacon. We believe it would be advisable to eliminate the hazard of the additional slow vehicle by requiring this type beacon to be mounted on the rear of the wide load.

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* For example, a 100-mile trip at 30 cents per mile would pay the escort driver \$30. Assuming that his vehicle costs are 10 cents a mile, these costs would total \$20, considering the 100 miles while serving as escort and the unpaid 100-mile return trip. If the 200-mile round trip requires a total of 4 hr, then his net income is \$2.50 an hour.

Finally, an escort vehicle cannot be truly effective without two-way communication with the wide-load driver. Two-way communication should be mandatory where escort vehicles are used.

In conclusion, we recommend that:

* Escort vehicles not be used on divided highways.

* Front escorts be required where short sight distances, narrow clearances, etc., dictate the need for motorists and wide-load driver warnings.

* The states publish route maps showing locations requiring escort vehicles.

* High intensity rear lighting on the wide load be specified in lieu of a rear escort.

* All escort vehicles be required to have two-way radio communication with the wide-load driver.

IX. CONCLUSIONS

The collection, analysis, and evaluation of data from many sources has illuminated a number of problems relating to highway transportation of mobile and modular housing. These problems occur, in part, because of the inherent effects of moving such loads and, in part, because of the nonuniform regulations adopted by the several states concerning these movements.

Reviewing the problems encountered by the public, the carriers, and the states indicates that a number of conclusions can be drawn. These conclusions are summarized here. The interested reader is referred to the section of this report most appropriate for background information.

A. Traffic Safety (Section II)

* Reported accident rates and severities involving mobile and modular homes are similar to those involving other commercial vehicles (trucks).

* Slow moving wide loads create more traffic impedances and initiate driver responses of a more hazardous nature than do faster moving wide loads.

* Traffic disruptions and impedances caused by wide-load movements are more frequent and severe on two-lane highways than on divided highways.

* The use of escort vehicles does not measurably reduce hazardous reactions of other motorists to the wide-load movement; some situations, such as passing on two-lane roads, are worsened by the presence of escorts.

* On two-lane roads, motorists approach 14-wide loads with more caution than 12-wides. Motorists are also more likely to encroach upon the shoulder in passing such loads. No other differences could be found that were attributable to the load width, per se.

* Few vehicles encroach upon the shoulder when passing 12-wide loads on 12-ft lanes, but shoulder usage increases as the load width increases and as the lane width decreases.

* Queuing behind a wide load on two-lane pavements is rather common; queue length is highly dependent on traffic volume, but not measurably dependent on other variables except that the presence of a rear escort may intensify queuing.

* The low intensity, flashing, warning lights presently used on the rear of some wide loads have no effect on motorists' responses; evidence indicates that high intensity flashers on escort vehicles do elicit early driver responses.

B. Motorists' Opinions and Attitudes (Section III)

* Only rarely did a motorist who had recently passed a wide load suggest, without prompting, that he had encountered a delay or safety hazard at that time. Neither did he spontaneously rank mobile homes extremely high as problem vehicles--trucks, campers, other cars, and farm equipment were more commonly mentioned.

* When asked specifically to rank mobile homes against other types of vehicles, motorists tended to rank mobile homes as the most hazardous, most impeding, and most likely to cause problems in general. Ranking nearly as high on the list were trucks, campers, farm vehicles, and cars pulling trailers.

* Motorists perceive mobile homes to be about twice as troublesome on two-lane highways as on divided highways.

C. Costs Imposed on the Motoring Public (Section IV)

* On two-lane highways, the motoring public often saves money by following a wide load because the reduction in operating expenses is greater than the increase in delay costs, using generally accepted value-of-time figures.

* Dollar costs or savings to other traffic brought about by delays, modified fuel consumption, tire wear, etc., were much larger on two-lane than on multilane highways.

* Time delays and increased pollutant emissions were much higher on two-lane highways than on multilane highways.

* Where differences were noted, greater costs, delays, and incremental pollutant emissions were associated with slow moving rather than fast moving wide loads, with 14-wides rather than 12-wides, and with loads accompanied by escort vehicles rather than without.

* The total cost imposed on all traffic on multilane highways is generally less than 2 cents for each mile of travel of a wide load. On two-lane highways the cost is much more variable, is often negative, and seldom exceeds 5 cents for each mile of travel by the wide load.

D. Costs of Regulations to Shippers and Carriers (Section V)

* The most notable characteristic of costs to mobile home shippers and carriers brought about by permit and transportation regulations is their variability from trip to trip. The cost of regulations can range from a small fraction of basic line-haul charges to several times the cost of transportation only. However, for interstate shipment of a 12-wide mobile or modular home about 250 miles, the cost of complying with regulations is typically $50 to $100. Compliance costs increase for 14-wides.

* For the most part, the costs brought about by regulations are added to the manufacturer's or carrier's invoice and paid by the shipper; minor costs (up to several dollars), are absorbed by the carrier.

* Permits are required in every state, at least under some conditions, to transport a wide load, and one state's permit is not honored by another. The costs associated with permits can add 10-25% to the basic transportation charges, with the permit acquisition costs often equaling or exceeding the state permit fee.

* Where used, multiple-trip permits are a boon to the state and shipper alike.

* Escort vehicles, where required by regulation, are extremely costly, adding 30-35 cents per mile to the basic transportation charge for each escort vehicle.

* Circuitous routing induced by regulations is extremely variable, but can add appreciably to the transportation costs because the line-haul charges are based on mileage.

* Differences among the states in allowable length, and in the method of specification, have caused the carriers to resort to specially designed tractors to enable interstate moves.

* Regulations pertaining to signing, flagging, and warning lights are extremely variable from state to state. Contrary to common belief, however, these variations have relatively little cost impact.

* Organizations of states, such as AASHTO, WASHO, etc., are attempting to bring about more uniformity among the state regulations.

* Mobile and modular homes are usually treated under the same regulations which apply to other over sized vehicles, although, because of the high volume of such movements, steps have been taken to routinize mobile and modular home movements.

E. <u>Safety Hazards</u> (Section VI)

* Escorts, although presumably employed to make a wide load movement safer, often result in degraded safety. Lack of two-way radio communication, misunderstanding of the function of an escort vehicle, lack of training, and blatantly unsafe practices are all reasons for such degradation.

* Faulty or inadequate tires are a very common problem in the movement of mobile homes and modular homes.

* High winds continue to plague the movement of mobile homes on the highways, despite the concern and awareness of the states and the industry of this problem.

X. RECOMMENDATIONS

Many recommendations are dispersed throughout this report, particularly in Sections VII and VIII. They are repeated here for conciseness and for the convenience of the reader.

A. Conditions Under Which Permits Should be Required

* In general, 12- and 14-wides should move only under permit, as presently required.

* General policies, as much as possible, should replace specific judgments by permit-issuing agencies regarding permissible combinations, size and configuration, routing, and travel times.

* To encourage wide loads to travel on the roads most capable of handling them, the Federal-Aid Highway Act should be amended to allow loads as wide as 12 ft to move on the Interstate System without permits.

* All states should compile a route system suitable for use by oversize homes and publish it in the form of a route map.

B. Use of Multiple-Trip Permits

* Multiple-trip permits should be issued by the states for frequent and standard movements of coaches of widths up to and including 12 ft.

* Consideration should be given, in those states where 14-wides are allowed, to granting multiple-trip permits for 14-wides on a limited system of routes.

* When the use of multiple-trip permits becomes widespread, Section I-A of pertinent I.C.C. Tariffs should be reviewed to ensure that overdimension charges accurately reflect average costs to carriers.

* Issuance of bulk permits, where applicable, should be superseded by conventional multiple-trip permit operations.

* Published route systems should be disseminated by the states to aid in controlling routing under multiple-trip permit operations.

C. Permit Reciprocity

* Proposals of standardization such as those of WASHO and others should be reviewed, discussed, and considered as possible models for adoption by other compact groups of states and by AASHTO.

* Permit reciprocity should be a goal of the states in order to better serve the infrequent carrier and to encourage standardization of institutions and regulations among the states.

* Municipalities and counties should universally honor state permits which would include, if necessary, special city and county requirements--thus eliminating city and county permits.

D. State Permit Fees

* Permit fees should be charged for the right to transport extra-legal loads.

* Permit fees should reflect only incremental costs directly associated with the extra-legal vehicle.

* Six dollars, being sufficient at this time to cover issuance costs of single-trip permits in most states, should be adopted as the permit fee for mobile and modular homes.

* If states can clearly demonstrate other incremental costs brought about specifically by the transportation of mobile and modular homes, those costs should be considered for inclusion in the permit fee.

* The states should charge a fee for multiple-trip permits designed to recover issuance costs plus any other specific incremental costs to the state brought about by wide-load movements on either a one-time or variable basis.

E. Divisible Loads

* The states should not prohibit oversize divisible loads, which otherwise meet permit requirements, if such loads would remain overwidth even after subdivision.

F. Length Restrictions

* The states should adopt the maximum length recommendations of AASHTO.

* The states should establish maximum load length limits as well as maximum combination length limits to discourage unusual and possibly unsafe tractor configurations.

G. 14- vs 12-Wide Loads

* Certain restrictions, in addition to those imposed on 12-wides, should be imposed on 14-wide movements. These restrictions should include:

- Discouraging or prohibiting 14-wide movements on highways with less than 12-ft lane widths.
- Discouraging 14-wide movements on two-lane highways with 12-ft lane widths if the highways have narrow or poor shoulders, or frequent constrictions of the roadway.
- Confining 14-wides to the right-hand lane in urban areas or other locations where more than two lanes are available, except under extenuating circumstances.
- Requiring installation of highly visible and effective warning beacons on the rear of the wide load, because 14-wides tend to move slower than 12-wides.
- Discouraging 14-wides from using highways with poor sight distance, or else requiring that they employ two-way-radio-equipped front escorts on such highways.

H. Speed of Wide Load

* Regulated, statewide, maximum speeds of wide loads should be not less than 45 mph on two-lane roads and 50 mph on multilane highways.

I. Usage of Interstate Highways by Wide Loads

* The states should make every effort to encourage wide-load transportation on divided highways, in preference to two-lane roads.

* The Federal Government should provide relief to the few states with outmoded laws by modifying Title 23, Section 127 of the United States Code relative to usage of the Interstate System by overwidth loads.

J. <u>Time of Day/Day of Week Restrictions</u>

* Mobile and modular homes should be allowed to move during daylight hours on weekdays, except on major holidays or in congested areas during peak hours.

* Saturday and Sunday movements should be allowed if traffic volumes on such days do not exceed weekday volumes.

* Nighttime movements should be prohibited except in times of national emergency or disaster relief, and even then only after all possibilities of daytime movements have been exhausted.

K. <u>Special Lighting</u>

* Where special lighting is required, either on an escort vehicle or on a wide load, it should be of high intensity as specified in SAE J-5956 or equivalent.

L. <u>Use of Escorts</u>

* Escort vehicles should not be used on divided highways.

* Front escorts should be required wherever short sight distances, narrow clearances, etc., dictate the need for motorist and wide-load driver warnings.

* The states should publish route maps showing locations requiring escort vehicles.

* High intensity rear lighting should be specified in lieu of a rear escort.

* All escort vehicles should be required to have two-way radio communications with the wide-load driver.

M. Additional Research

* A study should be undertaken to establish reasonable axle, braking, and tire requirements for mobile homes.

* A study should be undertaken to determine reasonable size and power characteristics for towing vehicles for 12- and 14-wides.

* A study should be undertaken to investigate the wind effects on the stability of mobile and modular homes.

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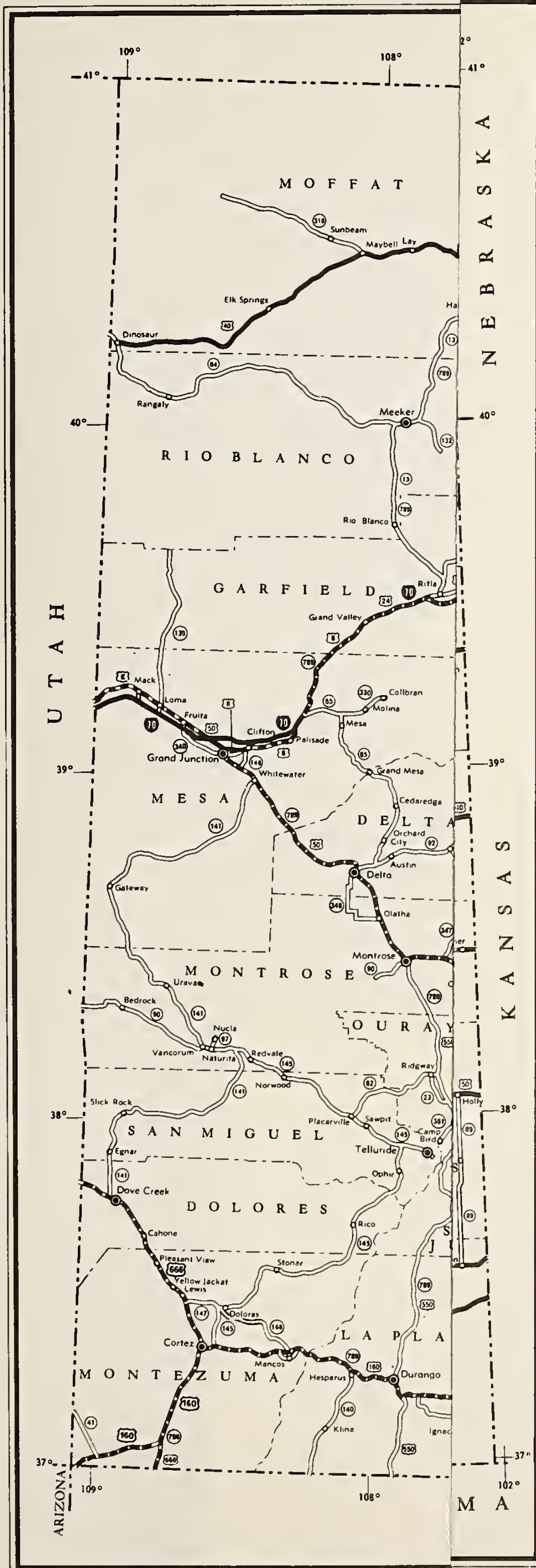


STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS - STATE OF COLORADO

ROUTES DESIGNATED FOR OPERATION OF TRAILER HOUSES 14' IN OVERALL WIDTH
ISSUED UNDER AUTHORIZATION OF THE CHIEF ENGINEER, EFFECTIVE

March 1, 1972

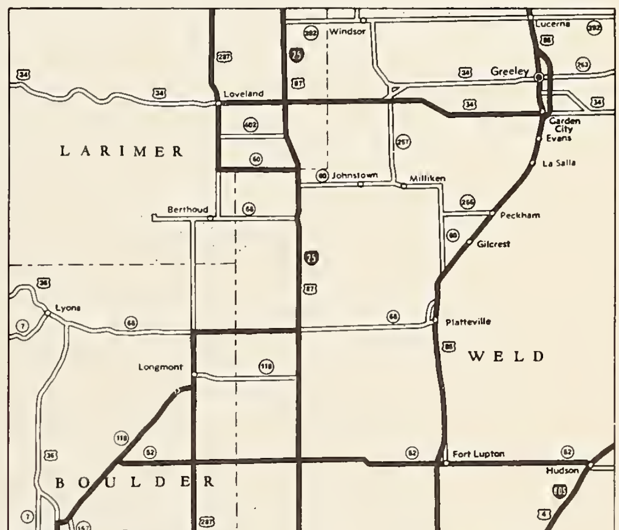
PREPARED BY
STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS - STATE OF COLORADO
PLANNING AND RESEARCH DIVISION

SCALE OF MILES
0 5 10 15 20 25

LEGEND

PILOT CAR REQUIRED	NO PILOT CAR
STATE BOUNDARY LINE	COUNTY BOUNDARY LINE
STATE CAPITAL	INTERSTATE AND STATE HIGHWAY NUMBER
COUNTY SEAT	U. S. AND STATE HIGHWAY NUMBER
OTHER TOWNS AND CITIES	STATE HIGHWAY NUMBER

NOTE: SECTIONS LESS THAN 1 MILE HAVE BEEN OMITTED



DENVER AREA DETAIL

SCALE OF MILES
0 2 4 6 8 10 12

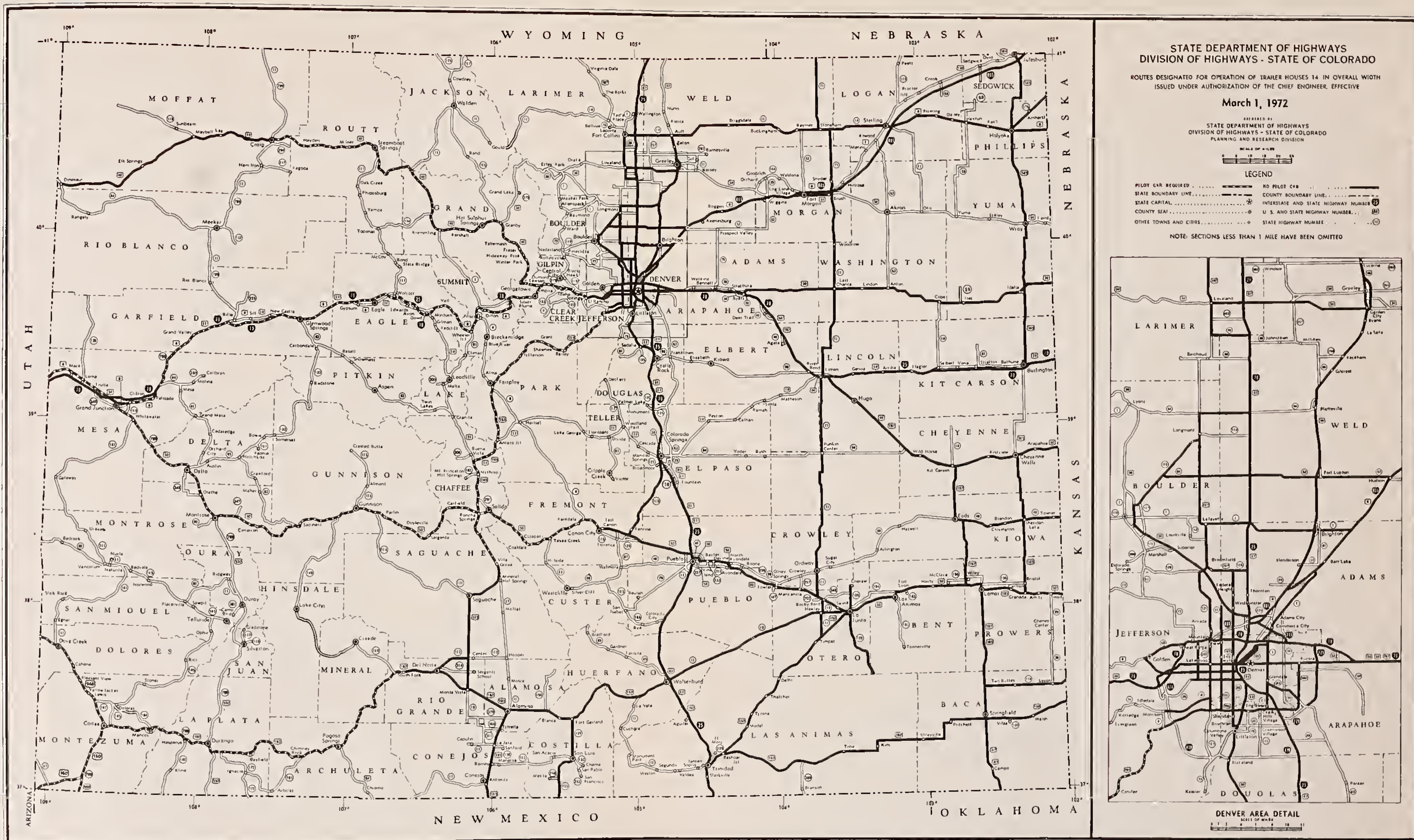


Figure 25 - Sample Route Map Including Escort Requirements

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