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LARGE TRUCK TRAVEL ESTIMATES FROM THE NATIONAL TRUCK TRIP INFORMATION SURVEY

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16. Abstract

This report describes the methodology of the National Truck Trip Information Survey (NTTIS) conducted by the Center for National Truck Statistics of the University of Michigan Transportation Research Institute. The survey was conducted to achieve the two main goals of estimating the registered large truck population of the continental United States and providing detailed data on their annual mileage. Travel in the file can be cross-classified by road type, area type, and time of day and broken down according to truck configuration, cargo type and weight, cargo body style, and driver characteristics.

The report compares national population estimates from the NTTIS file with estimates from the Truck Inventory and Use Survey and with annual figures published by the Federal Highway Administration. In general, the agreement between NTTIS and TIUS was found to be good. The different years in which the surveys were carried out and differences in methodology probably account for the minor discrepancies that were noted. On the other hand, FHWA estimates of both vehicle counts and total mileage were found to be substantially higher than the NTTIS and TIUS estimates. It is likely that data submitted by the states to FHWA contain inaccuracies that result in inflated estimates.

These comparisons underscore the difficulty involved in measuring large truck travel. While ideally it would be beneficial to ascertain the absolute number of miles traveled by trucks, it is also useful to be able to characterize that travel according to some of the parameters relevant to traffic safety. The report concludes with a series of NTTIS travel distributions based on the operating environments of different truck configurations.

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Executive Summary

This report describes in detail the methodology behind the National Truck Trip Information Survey (NTTIS), including the sampling procedure, data collection, and file building. The NTTIS was conducted to achieve two main objectives: estimating the number of large trucks in the continental United States and providing detailed information on their travel. A stratified simple random sample of trucks from the R.L. Polk registration files was selected for the survey. During the first phase, interviewers contacted the owner to obtain basic descriptive information on the truck and the company. In the second phase of the survey, the owner was contacted four times over the course of a year and asked to describe the operation of the truck in terms of configuration, cargo, and routes traveled. Researchers tracked the mileage from reported trips and categorized it according to road class, time of day, and area type. The data in the NTTIS file enable national population estimates of the number of registered large trucks and their annual mileage. Furthermore, the data support questions concerning the travel of specific truck configurations under particular operating conditions.

The NTTIS file includes three independent estimates of the average annual travel of large trucks. The first is the owner's estimate of the annual mileage of the truck. The second was derived from odometer readings obtained at the beginning and end of the survey year. The third was obtained by summing the mileage reported on survey trips and inflating to an annual figure. The three measures of average annual mileage yielded different results. One section of the report is devoted to a discussion of the estimating procedures and the resulting differences among them.

Prior to the completion of NTTIS, the Truck Inventory and Use Survey (TIUS) had been the only national database concerning the use of large trucks. The TIUS is conducted every five years by the Bureau of the Census. One section of the report compares large truck population and travel estimates between the two surveys. The comparisons evaluate similarities and differences in terms of power unit type, gross vehicle weight rating (GVWR), power unit age, cab style, and carrier type. Like NTTIS, the TIUS sample is drawn from the Polk registration files. Since NTTIS sampled a smaller proportion of the national truck population than TIUS, it is important to check for bias between the two files. In contrast to NTTIS, TIUS travel information comes from the owners' characterization of the *typical* use of their trucks rather than from actual trips. Because of this difference NTTIS can provide more detailed information concerning both the physical characteristics of large trucks and their travel patterns.

Comparisons are also made with statistics from the Federal Highway Administration. The FHWA annually publishes basic statistics on the number of registered trucks and their accumulated mileage, based on data submitted by the states. FHWA estimates of the number of registered large trucks and their annual travel prove to be substantially higher than similar estimates from NTTIS and TIUS.

Following the comparisons of NTTIS with TIUS and FHWA data is a section illustrating the kinds of travel estimates that can be produced from the NTTIS file. Distributions of large truck travel are shown according to operating environment in terms of road class, light condition, and area type. The trucks are considered in terms of power unit type, number of units, gross combination weight, and axle configuration. The distributions reflect the diversity of the trucking industry and point out the different operating environments of different truck configurations. Differences such as these must be considered in any assessment of the risk of accident involvement for large trucks.

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1 Introduction

As part of its continuing studies of the safety of large trucks, the Center for National Truck Statistics of the University of Michigan Transportation Research Institute carried out a national survey of medium and heavy truck usage over a 15-month period from November 1985 to February 1987. Termed the National Truck Trip Information Survey (NTTIS), the work produced a wealth of unique data on the travel patterns of different types of large trucks. This report has two primary objectives. One is simply to describe the methodology and findings of the NTTIS survey, expanding on the results presented in an earlier paper (Campbell, 1986). The other is to argue that while the process of collecting information on truck travel is a costly and difficult process, it is vitally needed in order to make informed decisions on a host of topics, particularly those concerning truck safety.

The report begins with a review of other efforts to collect data on large truck travel. This is followed by a discussion of how the NTTIS survey was designed and implemented. In particular, the sampling process and the procedure used to gather information concerning trucks and their travel patterns will be described. Next comes a discussion of the procedures used to calculate average annual travel in NTTIS and an evaluation of the estimates produced. This is followed by a pair of sections that compare NTTIS data with two years of data from the Truck Inventory and Use Survey, the only other detailed source of information on the national large truck population, and with statistics published by the Federal Highway Administration. The final section of the report serves to illustrate the level of detail concerning different types of truck travel that is contained in NTTIS.

2 Large Truck Travel: Available Sources and Additional Needs

Reliable estimates of large truck travel are needed for many purposes. Government agencies require travel data for many regulatory and policy decisions. Highway finance determinations and pavement damage assessments rely on mileage estimates. The trucking industry uses travel information in guiding operations and safety management. Cost-benefit analyses of proposed safety countermeasures require accurate travel estimates. This report focuses on the need for timely, accurate exposure information in order to calculate accident rates of different truck configurations under various operating conditions. In this way, areas for improvement in truck safety can be identified, and, if addressed, the effectiveness of accident-reducing measures monitored (TRB, 1990).

While the need for data on the annual travel of the U.S. large truck population is well established, meeting this need is a difficult task. Travel data collection is quite different from accident data collection. Accidents are discrete events, whereas travel is a continuous process. All state police maintain records of accidents, enabling reliable estimates to be made of the incidence of large truck involvements. However, no comparable data are collected for truck mileage.

2.1 Studies of Truck Travel

States do supply the Federal Highway Administration with travel estimates based on traffic counts as part of the Highway Performance Monitoring System established by FHWA in 1978. This program involves federal, state, and local governments. The states estimate travel based on traffic counts taken along selected road sections (*Highway Statistics*, 1988). National mileage figures are produced for different road classes and types of vehicles. Various criticisms have been made of the FHWA mileage figures, however. The classification system for large trucks is quite coarse, distinguishing only combination vehicles from single-unit trucks. More problematic are criticisms of the estimating procedure itself. In a paper that will be discussed in greater detail later, Mingo (1991) describes a series of inaccuracies and inconsistencies at both the state and federal levels in producing the FHWA mileage figures. Greene et al. (1984) argue that the FHWA estimates are based on a nonrandom sample of vehicle counts and that traffic counts themselves do not represent vehicle travel but merely traffic density at one point on a road.

A different approach to estimating truck travel is taken by the Truck Inventory and Use Survey (TIUS), conducted every five years by the Bureau of the Census. The survey is conducted through questionnaires mailed out to a random sample of truck owners. Except for some data included with the vehicle registration lists on which the samples are based, all of the TIUS information is self-reported. The questionnaires concern the "typical" configuration and operation of trucks over the period of one year. Consequently, travel cannot be broken down by road class or time of day. TIUS estimates are based on a robust sample of truck owners. The 1987 TIUS collected data on a total of 104,606 trucks of all kinds, including light trucks.

The National Truck Activity and Commodity Survey (NTACS) is a planned follow-on survey to the TIUS (McElhaney, 1990). The survey is to be primarily funded by the FHWA and conducted by the Bureau of the Census and will obtain information concerning actual trips taken by trucks on randomly sampled days. The

NTACS survey should include more detailed data on truck configuration, cargo type and weight, and operating conditions than what is available in the TIUS. Evaluation of this survey will have to await publication of the results.

Another travel survey is the Nationwide Personal Transportation Study, which has been conducted every six to eight years since 1969. The study surveys a national sample of households, collecting information on vehicles driven by members of the household and trips taken by those members. Unfortunately large trucks are not included in the survey. Vehicle types are restricted to passenger cars and light trucks and vans.

Occasional special studies have sought to measure travel of large trucks. In a study on the safety impact of FMVSS 121, Campbell (1978) relied on mileage estimates based on actual odometer readings. Field data collection personnel visited owners who were selected by random sample and obtained readings from trucks in their fleets. Trucks were categorized by power unit type and typical trip distance in this study.

In a pair of studies concerned with the effect of large truck size and weight on accident experience and traffic operations, researchers from BioTechnology combined several techniques to gather data on the travel and characteristics of trucks (Vallette and Hanscom, 1981; Hanscom, 1981; Vallette et al., 1981; Vallette et al., 1979). Manual counting of trucks along road segments enabled basic travel estimates, and more detailed information was obtained at nearby weigh stations and truck stops. The traffic stream on the road sections was typically filmed, so that trucks could be matched between the roads and the weigh stations. The end result was a fairly detailed collection of truck travel data, including information on weight, dimensions, configuration, and engine and driver characteristics.

2.2 National Truck Trip Information Survey

The NTTIS shares some similarities with other studies that have sought to measure truck travel, but there are also important differences. Like the TIUS, part of the information in NTTIS was obtained through interviews with truck owners. In contrast to TIUS, however, travel information in NTTIS is based on actual trips made by truck drivers, not their characterizations of "typical" trips. Another strength of NTTIS is that it offers many details concerning truck configuration and operating environment. Travel can be cross-classified by road type, area type, and time of day, and trucks can be classified according to configuration, number of trailers, carrier type, cab style, fuel type, cargo body style, cargo type and weight, and weight, length, and number of axles of trailers and power units. The file also includes information on driver age and experience. The next section describes at length how the survey was conducted, and the rest of the report is devoted to comparisons between NTTIS and other sources of truck travel information and to illustrating the analyses that are possible with NTTIS data.

3 Survey Design and Methodology

The objective of the National Truck Trip Information Survey was to estimate the number of large trucks in the U.S. and provide detailed data on their mileage. The survey was carried out via multiple telephone interviews with truck owners to collect data on the use of their vehicles on particular days. The resulting NTTIS file is a hierarchical dataset consisting of three parts: a truck file, a truck-tractor trip file, and a straight truck trip file (Blower and Pettis, 1988). The truck file contains vehicle, company (owner), and annual mileage information, with one record per vehicle. The tractor and straight truck trip files contain trip information, one record per trip, for each trip taken by a survey vehicle on a survey day. All three files include weight variables so that national truck population and travel estimates may be calculated.

3.1 Sampling Frame

The sampling frame for NTTIS was formed from registration files maintained by the R.L. Polk Company. Versions of these files reflecting registrations as of July 1, 1983 were used, and the files were extensively processed to eliminate duplicate registrations from state to state. The Polk files describe registered vehicles for every state except Oklahoma and except for California trucks with model years prior to 1973. Hence, the NTTIS sampling frame included the 48 contiguous states plus the District of Columbia, except for Oklahoma and pre-1973 model-year trucks in California. The vehicles that were selected from the sampling frame were trucks with a gross vehicle weight rating (GVWR) greater than 10,000 pounds. Excluded were all pick-up trucks (regardless of GVWR), all passenger vehicles (such as passenger vans, recreational vehicles, ambulances, and buses of any type), farm tractors, and government-owned trucks.

The sampling procedure treated each state as a separate stratum, and within each state, straight trucks were sampled separately from tractors. An UMTRI-developed algorithm was used to make the power unit type assignments for the sampling process. Sample sizes were specified for each state, roughly proportional to the size of its truck population, and an interval selection procedure was followed in each stratum. At least 30 straight trucks and 60 tractors were selected from each state, and California and Michigan were oversampled to increase the number of tractors that pull two trailers. A total of 8,144 trucks was selected from the Polk registration lists to form the sample for the survey.

3.2 Data Collection for the Truck File

Once the sample was drawn, the survey work was carried out in two phases. During the implementation phase, conducted from January to May of 1985, each truck selected in the sample was located and a description obtained. Survey interviewers tried to contact the most knowledgeable person available for implementation information. In the case of private persons, the best source was most often the owner. With large companies, contact people were typically fleet supervisors, dispatchers, mechanics, drivers, and so on. Once the initial contact was made, interviewers secured the owner's cooperation, confirmed the vehicle's identification, obtained descriptive information on the company and truck, including a recent odometer reading, and made arrangements for acquiring detailed mileage information on four random survey days. Survey interviewing was conducted by telephone whenever possible. Mail versions of the interview forms were used only when the interview could not be completed by phone.

Of the original sample of 8,144 vehicles, 564 or 6.9% were determined to be non-sample because they had either been destroyed, were no longer registered, had GVWRs under 10,000 pounds, or were not trucks (Table 1). Of the 7,580 remaining vehicles, interviews were completed for 6,305 cases, for a response rate of 83.2%. We were unable to complete 1,275 of the cases, primarily because of problems in locating the owner. Refusals were encountered in only about 3% of the selected vehicles. Information on the 6,305 vehicles with completed interviews is contained in the NTTIS truck file, which includes 3,704 straight trucks and 2,601 tractors.

TABLE 1
Disposition of Original NTTIS Sample

	Original Sample	Completed	Non-Sample	Unable to Locate/Refused
Number	8,144	6,305	564	1,275
Percent	100.0%	77.4%	6.9%	15.7%

After the implementation phase of the survey was complete, a sub-sample was drawn for the trip phase of 2,511 straight trucks and all 2,601 tractors. All diesel-powered straight trucks were taken, as well as all the non-diesels registered in California or Michigan, and all GVWR class 3 and 4 non-diesel straight trucks registered outside of California and Michigan. The remaining vehicles—non-diesel straight trucks from outside Michigan and California in GVWR classes 5 through 8 or with unknown GVWR—were sampled at a half rate. The sampling scheme for straight trucks was driven by a secondary objective of the survey, which concerned air quality issues and was focused on diesel trucks.

During the trip phase of the survey, supplemental information was gathered about the 5,112 vehicles selected for trip calls. For diesel-powered vehicles, information was collected concerning the horsepower and displacement of the engine and the use of fuel efficiency devices. A second odometer reading and usual or typical configuration data were sought for all vehicles during the trip phase. A second set of variables in the truck file describes this additional vehicle-level information concerning the trucks selected for trip calls.

3.3 Data Collection for the Trip Files

Most of the trip phase of the survey was devoted to collecting detailed information on the routes traveled by the selected vehicles and on the truck configuration, cargo, driver, and operating authority. The survey year was divided into four quarters, each consisting of 89 days, called "date codes". Date codes were randomly assigned to each vehicle at the time of selection. In each quarter, when a truck's date code came up, an interviewer contacted the owner to find out how the truck was used on its date code. The survey call was made as soon as possible after the designated date, most often on the following day. Tractor trip calls ran from November 3, 1985 through November 4, 1986, and straight truck calls were made from February 3, 1986 through February 5, 1987. The start date for each survey quarter was chosen so that the survey day of any particular vehicle would fall on a weekend no more than twice over the course of the year. The date codes were distributed evenly over the seven days of the week.

The travel data were collected according to "trips". A new "trip" began whenever driver, operating authority, vehicle configuration (e.g., adding or changing trailers), or cargo type or amount changed. Thus if the driver changed, or cargo was loaded or unloaded, or one trailer type was exchanged for another, the interviewer began a new trip form to track the mileage put on by the new configuration. For each survey day, the owner was asked to describe every trip made and to provide information on trailer use (if any), cargo and cargo weight, and driver age.

The vehicles selected for trip calls took a total of 13,097 trips, 4,966 by straight trucks and 8,131 by tractors. The trips were traced on specially prepared maps and the mileage broken down by road type, rural/urban, and day/night. The straight trucks traveled a combined sum of 206,276 miles, and the tractors logged 707,000 miles, for an overall total of 913,276 miles. The value of the trip files lies in aggregating trip mileage across different travel categories for truck configurations of interest.

TABLE 2
Response Rates for Trip Phase

VEHICLES SELECTED FOR TRIP CALLS					
Truck Type	Selected for Trip Calls	Responded to Trip Calls		Non-Response	
		N	%	N	%
Straight Truck	2,511	2,347	93.5%	164	6.5%
Tractor	2,601	2,442	93.9	159	6.1
Totals	5,112	4,789	93.7%	323	6.3%
POTENTIAL AND COMPLETED TRIP CALLS					
Truck Type	Potential Survey Days	Completed Survey Days		Non-Response	
		N	%	N	%
Straight Truck	10,044	8,856	88.2%	1,188	11.8%
Tractor	10,404	8,804	84.6	1,600	15.4
Totals	20,448	17,660	86.4%	2,788	13.6%

The response rate for trip calls can be measured in two ways (Table 2). Of the 5,112 vehicles selected for trip calls, we were able to get some trip information, even if it was only that the vehicle was not in use, for 4,789 of those vehicles, for a response rate of 93.7%. It was hoped to complete four trip calls on each vehicle over the course of a year, for a total of 20,448 potential trip days. A total of 17,660 survey day cases were actually completed, for a survey day response rate of 86.4%. This rate was 88.2% for straight trucks and 84.6% for tractors. Overall, the in-use rate, that is, the percentage of vehicles that were actually used on the road on their survey date, was lower than anticipated (Table 3). Straight trucks were in use on 27.0% of their survey days, and tractors were used at the slightly higher rate of 35.5%. The overall in-use rate was 31.3%, meaning that the typical vehicle was found to be in use on less than one-third of its survey days.

TABLE 3
Survey Day Responses

Truck Type	Days in Use		Days Not in Use		Total
	N	%	N	%	
Straight Truck	2,391	27.0%	6,465	73.0%	8,856
Tractor	3,124	35.5	5,680	64.5	8,804
Totals	5,515	31.3%	12,145	68.7%	17,660

3.4 Mapping the Survey Trips

After a trip call was completed, research staff tracked the routes traveled on special maps prepared by UMTRI. The maps were based on the Rand McNally *Road Atlas* and followed its road type classification. Roads were divided into limited access highways, major arteries, and all other roads. The limited access roads include all U.S. interstate highways, as well as state highways with fully controlled access. Major arteries include all U.S. and state routes that are not limited access, plus some other primary thoroughfares in large urban areas. All public roads that do not fall in the previous two categories comprise the "other" road type group.

The special maps also included urban and rural zones. Federal Highway Administration classifications were used to define three population categories: large urban areas (population of at least 50,000), small urban areas (population of 5,000-49,999), and rural areas (population under 5,000). We obtained from each state local and county-wide maps showing the FHWA urban areas so that exact boundaries could be marked on the state maps in the *Road Atlas*. This made it possible to precisely map the portion of the trip mileage that was in each of the three population type zones.

In addition to road type and population area, the trips were broken down according to daytime and nighttime mileage. Since it did not seem feasible to ascertain the actual point on a trip where dawn or dusk came, "daytime" was arbitrarily set as 6 a.m. to 9 p.m. and "nighttime" as the nine remaining hours. Therefore, nearly all of the travel classified as "night" was driven during darkness, but a small portion of the travel classified as "day" was actually driven in the dark, depending on the season, etc.

3.5 Adjustment Factors and Weight Variables

A number of adjustment factors were calculated to correct for missing data encountered at several of the stages of data collection. Three adjustment factors apply to data collected during the implementation phase of the survey. One corrects for unknowns on the power unit type variable, another for the fact that Oklahoma and pre-1973 model-year vehicles in California were missing from the Polk registration files, and a third for incomplete cases in the implementation phase. Another variable records the original sampling weight of the vehicles selected from the Polk registration files. The product of the original sampling weight times each of the three adjustment factors is recorded under the final contact weight variable. This weight is used for all the vehicle-level, "implementation" variables to produce national population totals.

A separate set of adjustments covers vehicle-level information for vehicles selected for trip calls. One of these adjusts for the weight at which vehicles were selected for trip calls, and another adjusts for non-response during trip calls. The product of these two factors times the final contact weight results in the final trip weight variable. This is the appropriate weight for truck file data gathered only on vehicles selected for trip calls to use to produce national population totals.

The trip file weights were designed to produce annual mileage estimates from the survey days and to correct for non-response of survey day calls. The annual mileage factor variable inflates the daily mileage from complete responses on the survey days to an annual mileage figure. Multiplying the travel on the survey days by this factor produces an estimate of a vehicle's annual mileage. As will be discussed in more detail in the next section, total annual travel was estimated both from the information collected on the survey days and from two odometer readings obtained during the survey year. A comparison of the two estimates showed that the odometer readings indicated greater annual travel. An odometer adjustment factor inflates the mileages obtained by aggregating the survey day travel to the mileages shown by odometer readings. The product of the annual mileage factor times the odometer adjustment factor times the vehicle-level trip weight results in the final trip weight for the trip file. It is the appropriate weight to obtain national estimates of truck travel from the trip file. (See Blower and Pettis, 1988 for additional discussion of weighting procedures.)

3.6 File Applications

NTTIS was designed to be a reliable sample of the real-world operating experience of trucks on the road. The data were collected based on actual trips made by large trucks and can be used to produce national population and mileage estimates. A major application of the NTTIS travel file is its use in estimating the risk of large truck accident involvement under particular conditions. Large trucks are themselves a heterogeneous group, varying widely in size, configuration, and cargo, and they travel under many different circumstances. They operate on different classes of roads, in areas of varying population density, traveling at all hours of the day and night. All of these factors may influence the risk of accident involvement for large trucks.

In order to assess the risk of accident involvement under particular circumstances, a measure of the opportunity for accident involvement is needed. This quantity is generally referred to as the *exposure* of vehicles to the possibility of an accident and is the denominator used to estimate the risk of accident involvement. One measure of exposure is travel in terms of vehicle-miles. The probability of accident involvement is a function of many factors. For example, there is a different risk associated with driving during the daytime than at nighttime, or with traveling on divided as opposed to undivided highways. In general, it is not sufficient to simply estimate total travel. It is also necessary to be able to cross-classify travel by the factors that distinguish differing risks for different types of travel.

The NTTIS file provides this ability to describe truck travel in detail. Every survey trip can be characterized in terms of day and night miles over three road types and three population zones. By aggregating different types of travel across trips and survey days, annual mileage estimates can be produced for particular truck configurations. For example, mileage distributions can be compared between tractors hauling a van semitrailer and tractors with a flatbed trailer. The total average annual mileage of these two configurations can be calculated, as can the proportion traveled on different road types or during the daytime versus the nighttime. By combining this information with the number of annual accident involvements for these configurations, the actual risk of accident involvement under the particular conditions may be estimated.

4 Average Annual Mileage Estimates in NTTIS

The NTTIS file contains three independent estimates of average annual mileage. The first is the owner's estimate of annual travel, which is referred to here as "self-reported" annual mileage. The second is calculated from odometer readings supplied for specific dates near the beginning and end of the one-year trip survey period. The third estimate is derived from the travel reported on the individual survey days inflated by the selection weights for these dates. A comparison of the three estimates by power unit type (Figure 1) shows that the self-reported figures are the highest and the mileage from the trip days the lowest. An evaluation of these differences requires an understanding of the procedures used to obtain each measure of travel.

4.1 Deriving Average Annual Travel

When the truck owners were first contacted during the implementation phase of the survey, interviewers asked them to estimate how far they planned to drive the power unit over the following 12 months. An estimate based on the previous 12 months was acceptable if they planned to use the power unit in the same way. The self-reported figures are the highest of the three NTTIS travel estimates, averaging 55,149 miles for tractors and 12,547 for straight trucks. It is possible that owners sometimes overestimate the annual travel of their trucks. Since the estimate is made on the spot in the course of a telephone interview, the owner may not consider factors which lower a power unit's actual annual mileage from its planned use. Specific reasons behind the tendency to overestimate might include basing the annual estimate on high-mileage days instead of "average" days, not considering the time a power unit is out of service for maintenance and repairs, and not taking into account the rotating use of tractors in trucking operations.

The second means of deriving annual travel was to annualize actual odometer readings obtained near the beginning and end of the survey year. The odometer-based derivations average 43,180 miles for the tractors and 9,088 miles for the straight trucks. While these figures are about 20-25% lower than the self-reported mileage estimates, one might expect them to be more accurate simply because they are a more objective measure. The main problem with the use of the odometer figures in the NTTIS file is that the data are missing for more than 40% of the trucks included in the trip survey. This reflects the difficulty involved in obtaining odometer readings. Accurate figures require contacting the respondent at two specific times during the year, and problems result if the power unit is not present when the calls are made or if the odometer has been broken or changed during the course of the year.

The third procedure for calculating average mileage was based on the travel information collected on the four survey days. Researchers tracked the actual routes followed by a vehicle for each 24-hour survey period and totaled the mileages. The annual mileage factor was then applied to these survey day totals to inflate daily mileage from complete responses to an annual figure. The mapped annual mileages turned out to be about one-third lower than the odometer readings, averaging 29,001 miles for tractors and 5,935 miles for straight trucks. Since the proportion of trucks reported not to be in use on the survey days was rather high (Table 3), we tend to believe that owners sometimes reported that a truck was not in use when it actually was.

4.2 Discussion of Differences between Mileage Estimates

Part of the difference between the three types of mileage estimates in NTTIS is related to the timing in obtaining the estimates. Self-reported mileage estimates essentially pertain to the year 1985, while odometer and mapped miles roughly describe travel during 1986. Since truck mileage generally declines with the age of the truck, we would expect the self-reported estimates to be somewhat higher than the odometer and mapped estimates, since the former describe a population that is about a year younger than the latter.

It is possible to estimate the effect of the time lag between the self-reported and odometer miles. In Figure 2, three sets of points have been plotted and a regression line has been drawn through each. The three sets of points represent average annual mileage of straight trucks by model year. One set is for self-reported miles, another is for odometer miles, and the third is for odometer miles shifted by one year. For example, the data point for odometer miles for 1981 trucks is plotted at 1980, one notch to the right, for the shifted group. (The model years on the x-axis pertain to the self-reported estimates and the original odometer estimates, not the shifted odometer estimates.) The purpose of the shift is to enable a comparison between self-reported and odometer estimates for trucks of the same age.

The three regression lines in Figure 2 have slightly different slopes, but we can calculate the average distance between them and use this to assess the effect of shifting the odometer estimates by a year. The vertical line labeled **a** in Figure 2 represents the average distance between the two solid regression lines in the graph, representing self-reported miles and unshifted odometer miles. The difference is about 6,552 miles. Line **b** in Figure 2 represents the average distance between the solid regression line for self-reported miles and the dashed regression line for shifted odometer miles. This difference is about 5,280 miles. This indicates that about 19.4% of the difference between the self-reported and original odometer mileage estimates for straight trucks is likely due to the year's difference in timing between the two sets of estimates.

Mileage estimates and regression lines have been plotted in a similar fashion for tractors in Figure 3. In this case the difference between the self-reported and odometer estimates, represented by line **a**, is about 16,107 miles. After shifting the odometer estimates by one year, the average difference from the self-reported estimates, represented by line **b**, is about 11,807 miles. Thus, about 26.7% of the difference between the self-reported and original odometer mileage estimates for the tractors is probably due to the one-year time lag.

The self-reported average annual mileage figure for all straight trucks in NTTIS is 12,547 miles, and the odometer estimate is 9,088, a difference of 3,459 miles. Assuming that 19.4% of this difference is due to the time lag, the new odometer estimate would be raised to 9,760 miles, 2,787 miles below the self-reported figure. For NTTIS tractors, the average self-reported estimate is 55,149 and the average odometer estimate is 43,180, a difference of 11,969 miles. Attributing 26.7% of this difference to the time delay results in a new odometer estimate of 46,375 miles, which is 8,774 miles under the self-reported figure.

We have seen that the difference in the periods in which the two mileage estimates were obtained probably accounts for a small but significant portion of the difference between the self-reported and odometer estimates in NTTIS. Similarly, a small portion of the difference between the self-reported and mapped mileage estimates is likely due to the difference in the times the data were collected. This cannot explain any of the difference between the odometer and mapped estimates, however, since both correspond to roughly the same time frame. The fact that three methods of calculating average annual mileage have yielded three different mileage estimates underscores the notion that estimating truck travel is a very difficult task.

It is difficult to judge which of the three measures of mileage comes closest to representing the mileage actually accumulated by large trucks, but the "real" average mileage figures probably lie somewhere between the self-reported and odometer estimates. The estimates made by the truck owners may not always reflect factors that keep a truck out of operation and are therefore likely to be on the high side. The odometer readings serve as a more objective, reliable means of estimating annual travel, provided two readings are actually obtained for a vehicle. In actual practice, however, two odometer readings were obtained for just 58.6% of the trucks selected for trip calls, which may undermine the overall accuracy of these estimates. Given that the figures based on trip calls are almost certainly low, primarily due to under-reporting, travel estimates in NTTIS based on mapped miles are first inflated by the odometer adjustment factor (described earlier). The cases in the file with two odometer readings were used to create this factor. It compensates for under-reporting by bringing the travel estimates from mapped miles in line with the odometer data.

5 NTTIS and TIUS Comparisons

Every five years the Bureau of the Census conducts the Truck Inventory and Use Survey (TIUS) as part of the Census of Transportation. As with NTTIS, trucks are randomly selected from each state's motor vehicle registration files as maintained by R.L. Polk. The two most recent TIUS surveys were drawn from the July 1, 1982 and July 1, 1987 versions of the Polk files respectively, while the NTTIS sample was drawn from registrations as of July 1, 1983. Unlicensed and government-owned vehicles, as well as ambulances, motor homes, buses, farm tractors, and open utility vehicles are excluded from TIUS samples. Owners of selected trucks are mailed survey forms asking them to characterize the typical physical configuration and use of their trucks.

Prior to the completion of NTTIS, TIUS had been the only national database concerning the use of large trucks. Therefore, it is important to consider whether any bias exists between the two surveys, given that a smaller proportion of the national truck population was sampled by NTTIS compared to TIUS. Whenever possible, NTTIS data elements were designed to be compatible with TIUS in order to facilitate comparison between the two. Several data elements were subsequently changed for the 1987 edition of TIUS, however, so fewer comparisons can be made between that version of TIUS and NTTIS. In this section truck population and travel estimates based on the NTTIS are compared with those derived from the two TIUS surveys.

5.1 Truck Population

Table 4 presents estimates of the large truck population in the continental United States according to power unit type for NTTIS and the two years of TIUS. The estimates for tractors show good agreement between all three surveys. NTTIS estimates about 2 percent more tractors than the 1982 TIUS and about 11% fewer tractors than the 1987 TIUS. The straight truck population estimates are not as close. The NTTIS estimate is about 14% lower than the 1982 TIUS and 32% lower than the 1987 TIUS.

TABLE 4
Truck Population Estimates by Power Unit Type: NTTIS v. TIUS

Power Unit Type	1982 TIUS	NTTIS	1987 TIUS
Straight	2,534,973	2,185,630	3,230,210
Tractor	900,884	919,702	1,038,130
Total	3,435,862	3,105,332	4,268,341

At least three factors affect the degree of correspondence among the estimates from the three files. One is that the samples were drawn from three different registration years. Generally one would expect a small increase in the number of registered trucks from year to year, assuming favorable economic conditions. The other two factors are more complex and will be discussed over the next few paragraphs. One concerns identifying medium- and heavy-duty trucks in the TIUS data, and the other involves the time lapse in NTTIS between sampling the data and conducting the survey.

5.1.1 Large Trucks and GVWR

From the outset, the NTTIS survey was restricted to medium- and heavy-duty trucks, those with a gross vehicle weight rating (GVWR) over 10,000 pounds. In contrast, trucks of any GVWR, including light trucks, are surveyed by TIUS. The GVWR is coded in the Vehicle Identification Number (VIN) for almost all trucks. R.L. Polk has developed decoding algorithms to extract this information from the VIN, and this code was included in the data supplied for the NTTIS survey. The Polk-derived GVWR is also included in the 1982 TIUS file but is not present in the 1987 version.

The VINs of some trucks, particularly those from model years prior to 1981, do not directly contain the GVWR. For many of these cases, the Polk-derived GVWR is based on the truck model as derived from the VIN, with the highest GVWR available for that model (as an option, for example) assigned. For many specific models, the majority of sales are at lower GVWRs. To improve the accuracy of the 10,000-pound GVWR cutoff in NTTIS, UMTRI specified whether particular models should be included or excluded, in some cases overriding the Polk-derived GVWR. Models and series were identified for inclusion or exclusion based on sales information provided by the manufacturers. If the manufacturers indicated that the majority of sales were at a GVWR of 10,000 pounds or less, then all of that specific model and series were excluded. The objective was to prevent the inclusion of an entire series when only a small fraction was actually rated over 10,000 pounds. The models most influenced by this procedure were the small step vans and pickup truck models sold as a cab and chassis. The latter often have a flatbed or stake body added. To further ensure accuracy, the GVWR was confirmed with the owner during the implementation phase of the survey.

Restricting the sample to trucks with GVWRs over 10,000 pounds was not an issue for TIUS since light trucks are included in that survey. The Polk GVWR can be used to identify large trucks in the 1982 TIUS file, but for the reasons just stated some light trucks probably receive a Polk-derived GVWR over 10,000 pounds. This would increase population estimates of medium-duty trucks, primarily straight trucks. The situation is worse for the 1987 TIUS file because that version does not include a GVWR variable. The file contains an average gross vehicle weight variable based on the owner's estimate of the average weight of the vehicle when carrying a typical payload during the last year. This is not the same as GVWR, however, and rejecting all cases with average GVW below 10,001 pounds would result in the exclusion of many medium-duty trucks. The 1987 TIUS population estimates presented in this paper exclude all vehicles identified as a pickup, van, mini-van, utility vehicle, or station wagon on truck chassis. In addition, a vehicle was excluded if the empty combination weight was 6,000 pounds or less and the power unit was coded as having only 4 tires. In this way we are reasonably certain that virtually all of the exclusions are light-duty vehicles. However, it is likely that not all light trucks were excluded, thus inflating, mainly, the population estimates of medium-duty straight trucks.

To summarize to this point, we expect that the difficulty in accurately identifying large trucks in TIUS data results in inflated estimates of straight trucks compared to NTTIS. The problem should be less severe for the 1982 file, since it contains a Polk-derived GVWR variable that should be only slightly less accurate than the GVWR determinations employed by NTTIS. The 1987 TIUS straight truck estimates are probably much more affected since that file contains no GVWR variable at all. The GVWR problem is not thought to seriously affect population estimates of tractors in either TIUS file.

5.1.2 NTTIS Time Lag

The third major factor affecting vehicle population estimates between NTTIS and TIUS concerns a time delay between the date of the registration files used for the NTTIS sample and the implementation of that survey. The sample was based on July 1, 1983 vehicle files, but the NTTIS implementation phase was not conducted until January through May of 1985. Vehicles that were junked or scrapped in the interim were removed from the survey, and there was no opportunity to replace them with vehicles that were purchased during that time. This means that the vehicle population estimates in NTTIS correspond to the number of vehicles registered as of July 1, 1983, minus vehicles that were destroyed in the year and a half to two years following that date.

In the case of TIUS, the sample is drawn from registrations as of July 1 in a particular year, and survey forms are mailed out over several months of the following year. However, if a vehicle has been junked or scrapped in the meantime, it is still included in the survey. Thus TIUS population estimates refer to the date of the registration lists on which the sample was based, with no loss of cases. Other things being equal, TIUS population estimates should come closer to approximating the entire registered truck population on a given date.

5.1.3 Reconciling Population Estimate Differences

It is possible to estimate the number of trucks that were not included in the NTTIS population estimates because they were destroyed. UMTRI extensively processed the Polk registration lists and maintained a file of all sampled cases found to be non-sample vehicles (NSVs). The majority of the NSVs were trucks that had been junked or scrapped, but other NSVs included light trucks, non-trucks, government-owned vehicles, and trucks that were not in fact registered. Based on the original sampling weights, the exclusion of the junked/scrapped vehicles results in an undercount of 97,529 straight trucks and 40,827 tractors from the registered large truck population as of July 1, 1983.

Figure 4 attempts to illustrate three of the factors that affect population estimates between NTTIS and the two TIUS files: the different years in which the surveys were conducted, the problem of identifying large trucks in TIUS, and the undercounting in NTTIS. The 1982 and 1987 TIUS straight truck population estimates appear as the endpoints of the top line on the graph. The empty boxes on the line represent projected estimates for the intervening years, assuming a linear rate of increase in the straight truck population. Below that line two marks indicate the two NTTIS estimates for straight trucks. The lower one is the actual estimate of 2,185,630 trucks and the upper one adjusts for the destroyed vehicles, increasing the number to 2,283,159. Both of these figures are considerably lower than the TIUS projected estimate of 2,674,020 straight trucks in 1983.

The bottom portion of the graph repeats the same exercise for tractors. There is a much greater correspondence between NTTIS and TIUS for the tractor counts. The original NTTIS estimate is 919,702 and the adjusted estimate is 960,529. These figures bracket the TIUS projected estimate of 928,333. Taking into account sampling error and the uncertainty of the projected estimates, the agreement between NTTIS and TIUS for tractor population estimates is quite good.

The two lines in Figure 4 indirectly pertain to the problem of identifying large trucks in NTTIS. The line for straight trucks linking the 1982 and 1987 TIUS population estimates is much steeper than the comparable line for tractors. In fact, the estimate for straight trucks increased 27.4% from 1982 to 1987, while the tractor estimate increased only 15.2%. It is probable that the higher rate of increase for straight trucks is due more to the absence of a GVWR variable in the 1987 file than to an actual increase of that magnitude in the registered straight truck population. Since straight trucks span the range of GVWR classes, the absence of a GVWR variable in the 1987 file probably results in the mistaken identification of a substantial number of class 1 and 2 vehicles as large trucks, thus creating the steep slope of the straight truck line. While probably more accurate than the 1987 estimate, the 1982 TIUS straight truck estimate is likely on the high side as well because of the manner in which Polk derives GVWR from the VIN. This overestimation of medium- and heavy-duty straight trucks in TIUS would help account for the discrepancy between the NTTIS estimate and the projected TIUS estimate. The lack of a GVWR variable should not significantly affect tractor estimates in TIUS because 99% of tractors are class 6 and above. Tractor population estimates are quite close between NTTIS and TIUS.

5.1.4 File Comparisons

We will now leave aside the question of absolute vehicle population estimates in order to concentrate on the composition of the large truck population as characterized by each of the three files. Variables like GVWR and model year provide a good basis of comparison between NTTIS and TIUS (the 1982 TIUS only in the case of GVWR), since they were part of the original sample data provided by R.L. Polk. Most of the other information collected comes from the survey respondent and is therefore subject to respondent error. The data elements provided with the sample are generally expected to be more consistent and more accurate.

A comparison of the distributions of the national truck population by GVWR from the 1982 TIUS and NTTIS is shown for straight trucks in Figure 5 and for tractors in Figure 6. In general, the agreement is very good, especially for the tractors. The main difference is a somewhat higher proportion of GVWR class 3-5 (10,001-19,500 lbs.) straight trucks in TIUS compared to NTTIS, possibly as a result of misclassifications in the Polk-derived GVWRs used in the TIUS file.

Model year comparisons among the three different files could be made in two ways. One would be to examine distributions of the actual model years for each file. Since the samples are from different years, however, this would result in comparisons of the proportions of trucks of different ages. Another way would be to base the distributions on age of the truck at the time of the sample. This has been done in Figures 7 and 8. For example, the cases shown as 0 years old in the graphs represent model years 1982-1983 for 1982 TIUS, 1983-1984 for NTTIS, and 1987-1988 for 1987 TIUS. The age 1 vehicles are from model years 1981, 1982, and 1986 respectively.

The age distributions of straight trucks, shown in Figure 7, show close agreement between the three files. The correspondence is especially good considering that the size of model year classes varies from year to year. The tractor age distributions show more variation between files (Figure 8). Tractors tend to have a shorter lifespan than straight trucks. Over 50% of the straight trucks in each file are at least 10 years old, compared to just 22-32% of the tractors. Since relatively fewer of the tractors are in the 10+ age class, there is more opportunity for variations in the size of model year classes to affect the proportions of the younger age groups.

An example of this can be seen in Figure 8. The 1979 model year class was an especially large one. This year represents the largest individual model year class for both the 1982 TIUS (age 3) and the NTTIS (age 4). It represents the second largest individual model year class for the 1987 TIUS, even though it was eight years old at the time of that survey. Given the effect that economic conditions, as exemplified by model year class size, have on age distributions and given the fact that the two TIUS tractor distributions show a good deal of variation between themselves, the NTTIS tractor distribution seems to be well within the range of acceptability.

The final two distributions of the vehicle population address cab style and carrier type, for tractors only. This information is obtained from the survey respondent, and for the variables chosen, the definitions of the categories are not precise. The cab style categories are cabover, short conventional, medium conventional, and long conventional. Figure 9 shows the distributions for NTTIS and the 1982 TIUS. (Conventional cabs were not subdivided in the 1987 TIUS, so no distribution is included.) The agreement between the 1982 TIUS and NTTIS is extremely good. This is particularly gratifying in view of the lack of a precise definition of what really constitutes a short, medium, or long conventional cab.

The last comparison of interest here is carrier type, which is shown in Figure 10. The carrier types are defined according to whether the company operates interstate or intrastate and whether it is private or for hire. The three files provide different levels of detail for these variables. Private carriers operate close to 50 percent of the tractors in both of the TIUS files, and about 53% in NTTIS. In the NTTIS study, a further breakdown of private carriers is made into *inter*state and *intra*state carriers. Interstate private carriers operate 32.5% of all tractors and intrastate 19.9% in NTTIS. The remainder of the vehicles are for hire in one fashion or another. For-hire vehicles are further broken down in NTTIS and TIUS into interstate for-hire, in which case they are subject to the Interstate Commerce Commission, and intrastate for-hire, where they are governed by state public service commission regulations. Interstate for-hire vehicles are also separated into *authorized* carriers—the common and contract carriers—and those hauling *exempt* commodities. The small group of *unknown* ICC-regulated carriers in the 1982 TIUS are those instances where respondents did not specify whether they were authorized or exempt carriers. If these cases were distributed between authorized and exempt carriers, it would bring the 1982 TIUS survey into fairly good agreement with NTTIS. A category of just "for-hire" carriers is included for the 1987 TIUS file. These are cases where the respondent indicated that the company was for hire but did not specify whether it was subject to ICC regulations. The "for-hire" cases would be distributed among the ICC-authorized, ICC-exempt, and intrastate for-hire categories.

This redistribution of cases would probably result in a higher proportion of intrastate for-hire cases in the 1987 TIUS, which would mean that NTTIS has a relatively low proportion of intrastate for-hire carriers compared to both TIUS files. NTTIS shows relatively fewer daily rental trucks as well. TIUS established a separate category for rental vehicles because they are extremely difficult to classify since the carrier type may change with every new rental. Agencies are reluctant to disclose names and, even if names are obtained, the individuals are difficult to locate and interview regarding carrier type on a particular day. The owners in both of these categories are usually small carriers and difficult to reach except at night and on weekends. These response problems may be partly responsible for the smaller proportion of trucks operated by intrastate for-hire carriers or in daily rental in the NTTIS. Leased, or long-term rental, trucks are classified as if the leaser/renter were the owner.

5.2 Truck Travel

5.2.1 Self-Reported Average Annual Mileage Comparisons

The best means of comparing mileage estimates between NTTIS and TIUS is to use self-reported mileage figures. While the NTTIS file also contains mileage estimates based on odometer readings and mapped trips, the two TIUS files include only the owners' estimates of annual travel. All three surveys asked the owners essentially the same question. While owner estimates may tend to be on the high side, they serve as a consistent means of comparison to check for sample bias between the surveys. The next several comparisons will be based on average annual mileage per vehicle rather than total miles logged by the entire registered large truck population. In this way the different vehicle population estimates produced by the three surveys will not affect the evaluation of mileage estimates.

As shown in Figure 11, the overall agreement in owner-reported average annual travel between the surveys is quite good. The NTTIS straight truck figure is about 18% higher than the 1982 TIUS and about 13% higher than the 1987 TIUS. The estimates for tractors are closer, with NTTIS 4% higher than the 1982 TIUS and 2% lower than the 1987 TIUS. It is interesting that there is a higher degree of correspondence between the files for tractors than for straight trucks. This may be related to the inclusion of some light trucks in the TIUS analysis files. Light trucks would be expected to have lower average annual mileages, thus pulling down the overall straight truck estimates. One should also note that the annual travel of tractors is much higher than that of straight trucks. This contributes to the relative length of service of the two power unit types. As we saw previously, the tractor population is much newer than the straight truck population.

Average annual mileage is compared by GVWR for straight trucks in Figure 12, and for tractors in Figure 13. No distributions are shown for the 1987 TIUS because of the lack of a GVWR variable in that file. The comparison is rather uneven for the straight trucks, with classes 3-6 showing about the same average annual mileage between the 1982 TIUS and NTTIS, and classes 7 and 8 showing an average annual mileage about 24 percent higher in NTTIS. The agreement for the tractors is quite good for all the GVWR classes, with NTTIS slightly higher in each case.

Figures 14 and 15 compare owner-reported travel by age of the power unit. The mileage estimates for the TIUS files correspond to the years in which the sampling was conducted, 1982 and 1987 respectively. Therefore, the age assignments have been made as they were previously for the population comparisons. For example, two year old vehicles represent 1980 models in the 1982 TIUS and 1985 models in the 1987 TIUS. On the other hand, self-reported mileage estimates in NTTIS cover the year 1985. The newest trucks in NTTIS, those in the

1983-84 model year class, would have been roughly two years old at that time, 1982 models would have been three years old, and so on.

NTTIS has consistently higher annual mileage estimates for straight trucks according to power unit age than does TIUS (Figure 14), although it is closer to the 1987 TIUS file than to the 1982 version. The tractor distributions show a better correspondence (Figure 15), although again NTTIS is generally higher and corresponds more closely to the 1987 TIUS than to the 1982 file. One factor to consider in evaluating all of the average annual mileage comparisons is that the three surveys pertain to three different years. Average annual mileage is more of a reflection of the national economic situation than are vehicle population estimates. The 1982 TIUS mileage estimates coincide with the recession of the early 1980s, which would partially explain why they are lower than the NTTIS and 1987 TIUS estimates.

Figures 14 and 15 also illustrate the strong relationship between model year and travel. The newer trucks generally are assigned to the more severe service. As the trucks get older, they are driven fewer miles per year. One aberration in the two graphs is that the very newest vehicles in the 1987 TIUS file do not have the highest average annual mileage estimates, as they do in the 1982 TIUS and in NTTIS. This is related to a change in the estimating procedure in the 1987 TIUS. For the 1982 TIUS, if a vehicle was not in the owner's possession for the entire 12 months on which the estimate was based, the estimate was annualized. However, in the 1987 TIUS the estimate was only annualized if the vehicle was bought used or if it was sold. If it was bought new or junked or scrapped, the estimate was not annualized. Since many of the trucks in the most recent model year class were probably bought new, their unannualized mileage estimates in the 1987 file would significantly lower the average mileage of their class. This was not an issue in NTTIS because of the gap between the sampling and implementation of the survey.

5.2.2 Total Annual Mileage

Earlier we estimated the undercounting of vehicles in NTTIS that was due to trucks being destroyed between the sampling and implementation of the survey. Similarly we may calculate the underestimation of total travel that was the result of the loss of these trucks. This has been accomplished by preparing distributions of the junked/scrapped vehicles according to power unit type and model year and applying the original sampling weights to produce national population totals. Next we produced distributions of average annual mileage for all cases actually included in NTTIS, again by power unit type and model year. By taking the average annual mileage of each group of cases defined by power unit type and model year and multiplying by the number of destroyed vehicles in each group, we arrive at an estimate of the total number of miles that each group of excluded trucks would have logged had they not been destroyed and therefore included in the survey. Summing across power unit type we conclude that the destroyed straight trucks result in a total of 1,111 million miles of lost travel and the destroyed tractors a total of 1,597 million miles.

The total mileage estimates for NTTIS and the two TIUS files are shown for straight trucks in Figure 16 and for tractors in Figure 17. In both graphs the NTTIS bar shows the actual total self-reported travel and the adjusted total travel, accounting for the destroyed trucks. While NTTIS had estimated many fewer straight trucks than the 1982 TIUS, its average mileage per straight truck figure was higher, and the result is a very close agreement between the two files in terms of total straight truck travel (Figure 16). The total travel estimated by the 1987 TIUS is about 30% higher than the NTTIS and 1982 TIUS estimates. This is undoubtedly a reflection of both the contamination of the 1987 TIUS analysis file with light trucks as well as the expected increase in total annual mileage over time.

The adjusted NTTIS estimate of total tractor travel is about 8% higher than the 1982 TIUS estimate and 12% lower than the 1987 TIUS estimate (Figure 17). The three total travel estimates show a reasonable rate of increase through the three different years. Since the NTTIS estimate pertains roughly to travel in 1985, one might expect it to be slightly higher given the TIUS estimates for travel in 1982 and 1987. However, the adjustments we made in the total travel estimates only account for the loss of travel of the destroyed vehicles. They do not account for the fact that the NTTIS travel estimates pertain to a truck population that is relatively two years older than both of the TIUS truck populations. Since annual travel decreases with the age of the truck, this would tend to lower the total travel estimates in NTTIS.

5.3 Discussion of NTTIS and TIUS

Comparisons were made in this section of national truck population and travel figures as estimated by NTTIS and the 1982 and 1987 versions of TIUS. Power unit type, GVWR class, model year, cab style, carrier type, and owner-reported annual mileage were used as the basis for these comparisons. Overall, there is a close correspondence between the two surveys, especially for the truck-tractors. Some of the differences observed may be due to the different years of registration files from which the samples were drawn, the time lapse in the implementation of the NTTIS, and the probable classification of some straight trucks with GVWRs below 10,000 pounds as class 3 or higher in TIUS. Aside from these known discrepancies, there is no indication of a systematic bias between NTTIS and TIUS.

There are some important differences in the type of information included in NTTIS and TIUS surveys, however. One is that the TIUS data pertain to the *typical* rather than *actual* use of trucks. The TIUS travel figures are gross estimates for an entire year. TIUS provides no information on the day-to-day use of trucks in terms of their operating environment or configuration. In contrast, NTTIS sampled the actual use of trucks on a given day, breaking down the travel into specific trips. The NTTIS survey methodology allowed for the collection of more detailed data concerning the physical characteristics of large trucks and their travel. This additional information is necessary for accurate travel/exposure data, which in turn are required for assessing the relative risk of accident involvement of particular truck configurations under given conditions. A later section will illustrate some examples of the detail contained in the NTTIS travel data.

6 Comparisons with FHWA *Highway Statistics*

Before examining the NTTIS travel distributions more closely, there is another set of large truck estimates to consider in relation to those produced by NTTIS and TIUS. Each year the Federal Highway Administration publishes *Highway Statistics*, a tabulation of national transportation statistics based on data submitted by the states. This section compares national population estimates of the number of registered large trucks and their annual mileage from *Highway Statistics* with NTTIS and TIUS estimates.

6.1 Data Sources

Highway Statistics categorizes large trucks as single-units and combination vehicles. Single-units essentially include straight trucks alone, straight trucks hauling utility trailers, and bobtails (tractors without a trailer). Combinations include tractors hauling one or more trailers as well as straight trucks hauling full trailers. *Highway Statistics* is published annually, and the estimates from one year are revised in the following year's edition in an effort to provide comparability of values among states. The data cited here come from the 1986 and 1988 editions of *Highway Statistics*, Table VM-1, representing the revised estimates for the 1985 and 1987 large truck populations respectively. These will be compared with NTTIS and the 1987 TIUS. Numbers for single-units were not available for 1982 *Highway Statistics*, so no comparisons will be made with the 1982 TIUS.

The *Highway Statistics* data include government-owned vehicles and vehicles registered in Alaska and Hawaii. These vehicles should be excluded for purposes of comparison with the NTTIS and TIUS estimates. Since the published *Highway Statistics* data for trucks do not indicate the percentage of government vehicles or the distribution of vehicles by state, estimates were made using other sources of information. The Alaska and Hawaii adjustments for vehicle counts were made based on the state distribution in the 1987 TIUS. The Alaska and Hawaii travel estimate adjustments relied on several years of raw and adjusted state-reported mileage figures submitted to FHWA (Mingo, 1990; Mingo, 1991). It was more difficult to estimate the percentage of government-owned vehicles since they are not included in TIUS or NTTIS. The vehicle count adjustments for government trucks were made using an UMTRI database of large trucks involved in fatal accidents as a starting point, and the mileage adjustments took into account figures cited by Mingo (1991:7).

The NTTIS vehicle count and mileage estimates used for the comparisons are the adjusted figures that account for trucks that were destroyed between the sampling and implementation phases. The estimates were produced in accordance with *Highway Statistics'* single-unit and combination vehicle classification scheme. The NTTIS mileage figures are based on owner-reported estimates. The TIUS 1987 data were also made consistent with the *Highway Statistics* classification system, but this was slightly more difficult since TIUS produces no estimates for bobtails. Adjustments were made using configuration distributions from NTTIS.

6.2 Vehicle Count and Mileage Comparisons

Figures 18 and 19 present the vehicle count estimates for single-unit and combination vehicles respectively among the three files. Since the single-unit trucks primarily consist of straight trucks alone, it is not surprising to see the 1987 TIUS estimate much higher than the NTTIS estimate (Figure 18). We have already noted that part of this difference is due to the inadvertent inclusion of light trucks in the TIUS file. Given this, it is significant to observe that the *Highway Statistics* estimates are even higher than the 1987 TIUS figure. *Highway Statistics* estimates over 14% more single-unit trucks than TIUS for 1987. The population estimates for combination vehicles show greater disparity between NTTIS and TIUS on the one hand compared to the *Highway Statistics* on the other (Figure 19). The 1987 TIUS estimate is less than 9% higher than NTTIS, while the 1987 *Highway Statistics* estimate is nearly one-third higher than the 1987 TIUS.

The total annual mileage estimates are shown in Figures 20 and 21. There is considerable variation in the single-unit travel estimates, with NTTIS showing 25.6 billion miles and the 1987 *Highway Statistics* figure estimating 48.3 billion miles of travel (Figure 20). The situation is similar for combination travel (Figure 21). TIUS 1987 estimates less than 10% more miles than NTTIS, while *Highway Statistics* estimates 45% more travel than TIUS for 1987.

6.3 Discussion of the *Highway Statistics* Estimates

The vehicle count and travel estimates published in *Highway Statistics* are based on data provided by the states. The aggregate statistics are calculated by FHWA using procedures that are intended to provide comparability of values among states. In a recent discussion of the *Highway Statistics* large truck travel estimates, Mingo (1991) cited several indications that the numbers are overestimates. The mileage data submitted by the states are based on traffic counts of 13 vehicle classes on selected segments of 12 types of roads. Most states use both manual and automatic vehicle counting procedures, both of which have their difficulties. Human error in manual counting often results in the misclassification of vehicle types. With automatic classification, detector deficiencies lead to such problems as closely spaced separate vehicles being counted as a single combination vehicle or the unintended counting of vehicles in adjacent lanes. Since large trucks represent a small proportion of vehicles overall, counting errors can lead to large percentage errors in vehicle class estimates, especially if there is a systematic bias in the misclassifications. Aside from these problems, the states do not all employ the same vehicle type classification system. A particular difficulty is straight trucks with trailers, which, depending on the state and the trailer type, may be variously classified as single-unit or combination vehicles.

Another major source of error is that most states count trucks only on weekdays. Generally no correction is made for the fact that truck travel is heavier on weekdays than weekends. Compounding the problem is the fact that counting sites frequently occur on routes with a large volume of heavy trucks.

In addition to these methodological problems, Mingo described other inaccuracies and inconsistencies in the state reporting procedures. State estimates in various travel categories have a low level of precision, with mileage figures sometimes reported with only a single significant digit. In most of the states, vehicle type classifications are entirely omitted for at least some of the road type breakdowns. Mingo observed many instances of tremendous annual variation in travel estimates within states, including one state that reported a one year's increase of over 500% in combination travel.

FHWA attempts to compensate for some of the problems in the state data by adjusting the estimates. For example, a citation on Table VM-1, *1988 Highway Statistics*, indicates that the "stratification of the truck figures is based on the 1982 Truck Inventory and Use Survey (TIUS)." The problem of making these adjustments is compounded because the more recent 1987 TIUS data did not become available until nearly January 1991. The authors cannot evaluate the adjustment procedures because they have not had the opportunity to review them. Mingo concludes that FHWA's efforts to correct the state-reported data contribute to an overestimation of large truck travel.

The issue raised here is that the *Highway Statistics* figures systematically overestimate large truck travel. This is a matter of concern because *Highway Statistics* figures are widely used, both in virtually all FHWA studies requiring truck travel data and in many other studies as well. This section concludes with an example of the relevance of accurate travel information to traffic safety studies.

Since 1980 UMTRI has conducted the Trucks Involved in Fatal Accidents (TIFA) survey. The survey combines information from FARS cases, Office of Motor Carriers accident reports, and telephone interviews to produce a file of detailed descriptions of all large trucks in the continental United States involved in fatal accidents. In Figure 22 the annual number of fatal involvements of combination vehicles has been plotted for the seven years from 1982 through 1988 (Blower, 1991). The frequency of fatal involvements has remained relatively stable over this time period, with a low of 3,376 in 1982 and a high of 3,762 in 1985. On the same graph, the original *Highway Statistics* estimates of the total mileage of combination vehicles for each year have been plotted. *Highway Statistics'* mileage estimates have risen every year. The 90,149 million miles estimated for 1988 represent nearly a *50%* increase over the 60,310 million miles estimated for 1982. The combination of the major increases in estimated travel and the comparatively steady number of fatal involvements results in a sharply declining fatality rate. This is also plotted in Figure 22, against the y-axis on the right edge of the graph. According to the *Highway Statistics* numbers, the fatal involvement rate of combination vehicles per 100 million miles of travel has declined from 5.60 in 1982 to 4.12 in 1987, a drop of 26%.

While it is comforting to think that the fatal involvement rate has shown such a dramatic decrease over the last several years, our concern is that much of this trend is an artifact of systematic error in the travel estimates. It is reasonable to believe that large truck travel has increased from year to year, with the overall expansion of the economy. However, TIUS estimates only a 23% rise in tractor travel from 1982 to 1987, while *Highway Statistics* estimates a 43% increase in combination vehicle travel during the same timespan. Furthermore, *Highway Statistics'* 1982 figure was only 27% higher than the 1982 TIUS estimate, while in 1987 the *Highway Statistics* figure was 47% above TIUS. This suggests that cumulative error in the *Highway Statistics* large truck travel estimates increases the amount of overestimation over time. If the *Highway Statistics* mileage figures are too high, then fatal involvement rates based on those figures will be too low.

Accuracy of large truck travel estimates is clearly an important issue. Travel is exceedingly difficult to measure, and travel estimates are difficult to evaluate. Estimates from three sources have been compared and found to differ. However, the general consistency shown between TIUS and NTTIS suggests that these surveys reflect the actual mileage of large trucks more closely than do the *Highway Statistics* estimates.

7 Travel Distributions

One of the most useful features of the NTTIS file is its level of detail concerning large truck travel. This detail is necessary for any in-depth analysis of accident risk. The risk of an accident depends in part on the exposure of the vehicle, or the number of miles traveled. However, the risk of accident is not uniform from mile to mile. Consequently, it is also necessary to cross-classify travel by the factors that are responsible for this variation in risk. NTTIS focused on three travel factors that had not previously been available in national travel data: road type (limited access, major artery, or other), area type (rural or urban), and time of day (day or night). The travel patterns of trucks, in terms of total travel and distribution of travel according to the three factors just listed, vary with respect to many of their physical features. The power unit type, configuration, cargo body style, number of axles, and gross combination weight all are associated with different travel patterns. In this section the mileage distributions across the three travel categories will be examined for specific truck types of interest in order to illustrate some of the differences that exist. The distributions in this section are based on mileage estimates from the mapped trips, inflated by the odometer adjustment factor.

7.1 Power Unit and Configuration Type

The travel patterns of large trucks vary a great deal according to power unit type and configuration. Straight trucks outnumber tractors in the national large truck population by about 70% to 30%, but this ratio nearly reverses in terms of annual travel, with tractors logging 68% of the total miles and straight trucks only 32% (Table 5). This is because the average annual mileage of a tractor is about five times that of a straight truck (41,176 to 8,231 miles).

TABLE 5
NTTIS Truck Population and Travel Estimates by Power Unit Type

Power Unit Type	Population		Total Annual Travel (in millions)		Average Annual Travel
	Miles	Col. %	Miles	Col. %	
Straight	2,185,630	70.38%	17,990	32.21%	8,231
Tractor	919,702	29.62	37,870	67.79	41,176
Total	3,105,332	100.00%	55,860	100.00%	17,988

In the NTTIS, miles were mapped according to the configuration of a truck. For example, it was noted whenever a power unit dropped or added a trailer, and miles were tracked separately for the resulting new configuration. In this section, travel patterns will be discussed for five main truck configurations: straight trucks alone, straight trucks hauling one or two trailers, bobtails (tractors alone), singles (tractors hauling one trailer), and doubles (tractors hauling two trailers). Tractors with three trailers, or triples, are included with the doubles for these comparisons.

NTTIS estimates that a total of about 55,560 million miles are logged annually by the five main large truck configurations. Figure 23 shows the total mileage logged by each configuration type. Singles put on by far the most mileage, with 63% of the total, and straight trucks are next at 30%. The bobtails, doubles, and straight trucks pulling trailers together account for only 7% of the total travel.

If we break down truck travel by road class, we see marked differences among the configuration types. Figure 24 illustrates the distribution of each configuration's miles over the three road classes. The proportion of limited access travel ranges from less than 20% for straight trucks to more than 72% for doubles. Conversely, travel on major arteries drops from 42% for straight trucks to 20% for doubles, and mileage on all other types of roads falls from 38% for straight trucks to less than 8% for tractors. These distributions provide an example of the importance of considering factors in addition to total travel when calculating the risk of accident involvement. Limited access routes are generally much safer than other types of roads (Campbell et al., 1988). Therefore, mile for mile, vehicles logging a large proportion of their travel on the interstates, such as singles and doubles, are exposed to less of an accident risk than straight trucks, which travel much less frequently on limited access routes.

Considering travel on rural versus urban roads (following the FHWA classifications), there are substantial differences in the distributions between configurations (Figure 25). Single-unit straight trucks log approximately equal numbers of miles in rural and urban areas, while tractor-semitrailers put on over twice as many rural as urban miles. Turning to the third main travel factor, time of day, Figure 26 shows this breakdown by configuration type. All five configurations put on far more miles during the day than at night, but again the proportions vary. Straight trucks accumulate less than 3% of their miles at night, while the nighttime portion is nearly 19% for singles and over 34% for doubles. Just as for road class, area type and time of day of travel are factors that affect a vehicle's risk of accident. As we have seen in Figures 24-26, the mileage distributions over all three of these factors are quite different from one truck configuration to another.

Now that we have compared the mileage distributions for the five configurations along the three travel parameters individually, we will consider an eight-category breakdown of these parameters. The categories are defined by the combinations of two road types (limited access versus all other roads), day versus night, and rural versus urban areas. The labels in Figures 27 and 28 indicate combinations of road type, time of day, and population type. LDR, for example, stands for Limited Day Rural, while ONU represents Other Night Urban.

Figure 27 presents the aggregate travel distribution for the five truck configurations across the eight categories of travel. The category with the largest share of the mileage, at about 30%, is rural "other" roads during the daytime, followed by rural limited access roads during the daytime, with 22%. The figure indicates that there is clearly more travel during the day than at night, particularly for the "other" classes of roads. There is also more travel in rural compared to urban areas, and on other roads compared to limited access roads, although this last difference is not as great.

The travel distribution over the eight categories is shown separately for each of the five configurations in Figure 28. The travel of the individual configurations may be compared with the aggregate travel distribution shown in Figure 27. Straight trucks accumulate much more travel on the other roads, and both straight truck configurations and bobtails put on very little nighttime mileage. Singles, on the other hand, accumulate substantial travel on limited access roads and travel more at night. Perhaps the most striking travel distribution is that of doubles, which is different from all of the others. Because doubles are primarily restricted to limited access roads in most states, they travel less on non-limited access roads.

7.2 Gross Combination Weight

The comparisons discussed so far in this section have classified large trucks according to power unit type and/or configuration. Another dimension to consider is gross combination weight (GCW). Figure 29 presents travel distributions of straight trucks and tractors in 10,000-pound increments of GCW. The category labels for this and subsequent figures are for the lower bound of the GCW increment. So for example, the bars labeled "20" represent GCWs of 20,000 to 29,999 pounds. Cases with missing data on GCW have been excluded from the distributions.

Figure 29 illustrates the tremendous difference according to power unit type in operating GCW. Over half of straight truck travel is conducted at a GCW under 20,000 pounds, and an additional 27% is in the 20-29,999 pound category. The proportion of straight truck travel at each of the higher GCW categories sharply decreases, so that less than 1% of the travel occurs at a GCW of 80,000 pounds or greater. The tractors, on the other hand, have a bimodal travel distribution across GCW, with peaks at the 20-29,999 pound and 70-79,999 pound categories (Figure 29). In sharp contrast to the straight trucks, only 2.34% of tractor travel is at a GCW under 20,000 pounds.

If we now consider GCW for loaded vehicles only, the travel distributions naturally change, but the distinction between straight trucks and tractors remains clear. As a group, straight trucks travel slightly more without any cargo than do tractors. NTTIS estimates that about 36% of straight truck miles are in an unloaded condition, compared to only 30% for tractors (including bobtails). Figure 30 illustrates travel according to GCW category for large trucks that are at least partially loaded. This figure may be compared with Figure 29 to see the effect of excluding empty vehicles. The change in the GCW travel distribution for straight trucks is relatively minor. The under-20,000 pound class has dropped from 51% to 43% of the overall mileage, and all of the heavier categories show a slight rise as a result. In contrast, the tractor distribution has changed substantially with the exclusion of the empty vehicles. The peak at the 20-29,999 pound category has disappeared, while the peak at the 70-79,999 pound class has risen. Over 58% of loaded tractor travel occurs at a GCW of 60,000 pounds or greater, and 43% is conducted at a GCW of at least 70,000 pounds. The comparable figures for loaded straight trucks are 7.5% and 4% respectively.

An additional factor of interest is cargo body style. Figure 31 presents travel distributions for five different cargo body styles of singles over the eight GCW classes. Both empty and loaded trailers are included, and this is reflected in the bimodality of the distributions. Vans typically do not carry cargo as dense as flatbed, tank, or dump trailers. Vans tend to carry cargo that is limited by the volume of the trailer rather than the weight capacity. This shows up in the two highest GCW classes illustrated in Figure 31. Only about 23% of the van travel is conducted at a GCW over 70,000 pounds. This compares to 38% for flatbeds, 40% for tanks, and 42% for dumps. The GCW distribution for auto carriers has a different pattern from the others, with a high proportion of travel in the middle GCW categories and a very low proportion of GCW at 70,000 pounds or more.

In Figure 32, travel for all large trucks has been broken down by road class and GCW. In this graph each bar represents the total percent of overall travel accounted for by the combination of road type and GCW indicated. For example, limited access travel by trucks with a GCW of 70-79,999 pounds accounts for over 12% of all large truck travel, the single largest share of the overall mileage. The patterns of usage of the three road types vary for the eight GCW categories. Trucks with a GCW under 20,000 pounds use both major arteries and "other" roads considerably more than they use limited access routes. Trucks in the next heavier class (20-29,999 pounds) use major arteries slightly more than limited access roads, and they travel much less on other roads. In contrast, the next heavier group uses limited access routes for nearly half their travel, and the next four heavier classes all use limited access highways for considerably more than 50% of their mileage. The pattern changes for the heaviest group of trucks, those with a GCW of at least 80,000 pounds. This class travels nearly as much on the major arteries as they do on limited access roads.

7.3 Axle Configuration

Axle configuration is another large truck characteristic that was considered in the NTTIS survey. The number of axles on each unit of a configuration was recorded, and if this number changed, as when a lift axle was raised or lowered, a new trip form was started. Thus, NTTIS contains the same detailed mileage information according to axle configuration as that already described for configuration type and GCW.

Figure 33 provides an overview of tractor-trailer travel according to number of axles. The first six bars on the graph pertain to singles and the last two to doubles and triples. In each case, the first number indicates the number of axles on the tractor and the next one (or two) the number of axles on the trailer(s). "O/O" and "O/O/O" represent "other" axle combinations for singles and doubles respectively. By far the most common configuration for singles is a 3-axle tractor hauling a 2-axle trailer. Nearly 74% of *all* tractor-trailer travel is conducted with this axle configuration. The next most common configuration for singles is the 2+2 combination, which accounts for 11% of all tractor-trailer mileage. Among doubles, 2+1+2 is the most common configuration. This combination represents about 60% of all multi-trailer travel and 3% of the overall tractor-trailer mileage.

Figure 34 compares travel distributions according to GCW for 3+2 and 2+1+2 axle configurations, which are the most common configurations for singles and doubles respectively. The 3+2 singles have a greater share of travel at both ends of the GCW scale than do the 2+1+2 doubles. Over 37% of 5-axle singles travel occurs at a GCW of at least 70,000 pounds. This compares to less than 27% of the 5-axle doubles travel. However, the doubles drive more of their miles in the very heaviest GCW class (80,000 pounds and over) than do the singles, 6.5% to 4%. Travel at GCWs under 40,000 pounds accounts for over one-third of the 5-axle singles mileage but only a quarter of the 5-axle doubles mileage. The higher proportion of travel at low GCWs for singles is likely due to a typically lower empty weight compared to doubles. The greater share of travel at high GCWs may be due to 5-axle singles frequently hauling higher-density cargo than 5-axle doubles.

In the next comparison, the travel distributions of the four primary axle configurations for singles (2+1, 2+2, 3+2, and other) are shown by GCW class (Figure 35). (The 2+3 and 3+1 configurations are included under "other" here.) Not surprisingly, there is a clear correspondence between the number of axles and the GCW at which the singles are operating. Nearly 65% of the 3-axle singles travel is at a GCW below 30,000 pounds, compared with 36% for the 4-axles and less than 21% for the 5-axles. Nearly half of the 5-axles travel is at a GCW of at least 60,000 pounds, compared with 3.2% for the 4-axles. None of the 3-axles travel occurs at GCWs this high. In general, the travel of singles with other axle configurations occurs at even higher GCWs than the 3+2 group. While the "others" are a diverse group, most of the combinations represented have five or more axles.

Figure 36 presents a similar comparison between 2+1+2 doubles and doubles with all other axle configurations. The most notable difference between the two distributions lies in the proportion of travel at GCWs of at least 80,000 pounds. This represents only 6.5% of the 2+1+2 doubles travel but nearly 26% of the travel of the other group. It seems clear that 5-axle doubles are typically used for general freight, while combinations with more axles are needed to transport the heaviest loads.

Figures 37 and 38 repeat the last two comparisons, excluding empty combinations. The very different ways in which singles with different axle configurations operate is even more apparent when only those that are at least partially loaded are considered (Figure 37). For example, while 53.5% of loaded 3-axles travel occurs at GCWs under 30,000 pounds, over 70% of loaded 5-axles travel takes place at GCWs of 60,000 pounds or more. There is very little overlap in the GCW travel distributions of these two axle combinations. On the other hand, the 4-axle group travels most in the mid-range of GCW, with 75% of its travel being conducted at weights between 30,000 and 49,999 pounds. For loaded doubles, the pattern of the 2+1+2 group operating at somewhat lower GCWs is still apparent (Figure 38). The two most common GCW categories for the 5-axle doubles are 50-59,999 and 70-79,999 pounds, while the remaining doubles travel most at GCWs of 60-69,999 and 79,999 and above.

Finally, Figures 39 and 40 present travel distributions by cargo body style and axle configuration. Four cargo body styles are compared in these two figures: vans, flatbeds, tanks, and dumps. Figure 39 illustrates the distributions for singles. While all four cargo bodies put on the most miles with a 3+2 axle configuration, the proportions range from 72% for vans to 98% for tanks. Over 26% of van travel is with a 2+1 or 2+2 configuration. In fact, 90% of all travel by 2+1 and 2+2 configurations is with a van semitrailer. Of the four cargo body styles compared, dumps have the highest proportion of miles with other axle combinations, which reflects the extremely heavy loads they sometimes haul.

Figure 40 repeats the comparison for doubles and triples, using the same four cargo body styles and 2+1+2 versus all other axle configurations. This is essentially a comparison of the minimum number of axles required to operate a double versus configurations with more than five axles. Vans and flatbeds travel most of their miles with a 2+1+2 configuration, at 66% and 70% respectively. Nearly 90% of all travel with this axle configuration is conducted by tractors hauling twin van trailers. On the other hand, 100% of the travel by tanks and 55% of the travel by dumps is with configurations other than 2+1+2, although the figure for the tanks could be due to insufficient sample size. The overall impression, however, is that a much greater proportion of the travel conducted by tank and dump doubles, compared to van and flatbed doubles, occurs with configurations of more than five axles. This is a reflection of the heavier cargo often hauled by twin tank and dump trailers.

8 Conclusions

The series of comparisons presented in the last section illustrates several important aspects of the national large truck travel experience. The first is that different types of trucks have substantially different distributions of travel across categories defined by road class, time of day, and population area. Since these categories of travel are associated with different risks of accident involvement, the travel patterns of any given type of truck have a strong influence on the likelihood that a truck of that type will be involved in an accident. Secondly, large trucks form an extremely heterogeneous group. This is reflected in travel comparisons that consider power unit type, cargo body style, GCW, and axle configuration. Large trucks vary widely in their physical configuration, and this also has a bearing on the risk of accident involvement.

The diversity of trucking operations underscores the importance of reliable travel data in any analysis that seeks to determine the relative safety of one truck type versus another. To carry out the analysis, it is essential to have both accident data and travel data that can be cross-classified by the factors of interest, especially those categorizing the type of travel. It is not sufficient simply to know the total miles traveled. One must also be able to classify the travel by factors related to accident risk, such as type of road and time of day.

The NTTIS meets these criteria for reliable, detailed large truck travel estimates, but the current file is already becoming outdated. While UMTRI's National Center for Truck Statistics has been conducting a survey of large trucks involved in fatal accidents ever since 1980, the NTTIS was a one-time project that needs to be repeated. The U.S. trucking industry is a dynamic one that changes along with the economy, demographics, size and weight legislation, truck equipment and configurations, technology, traffic densities, as well as the nature of the highways on which trucks operate with other vehicles. Truck safety continues to be a matter of major national importance. To meet the demonstrated need of reliable, *current* estimates of heavy truck travel, the NTTIS should be conducted on a regular basis, ideally once every two years.

References

Blower, D. 1991. Trucks Involved in Fatal Accidents, 1980-1988, by power unit type. Report No. UMTRI-91-36. Ann Arbor: Transportation Research Institute, University of Michigan.

Blower, D. and Pettis, L.C. 1988. National Truck Trip Information Survey. Report No. UMTRI-88-11. Ann Arbor: Transportation Research Institute, University of Michigan.

Campbell, K.L. 1978. Preliminary findings on the safety impact of FMVSS 121. Report No. UM-HSRI-78-56. Ann Arbor: Highway Safety Research Institute, University of Michigan.

Campbell, K.L. 1986. Population estimates from the National Truck Trip Information Survey. Transportation Research Record 1068, pp. 76-84.

Campbell, K.L., Blower, D.F., Gattis, R.G., and Wolfe, A.C. 1988. Analysis of accident rates of heavy-duty vehicles. Report No. UMTRI-88-17. Ann Arbor: Transportation Research Institute, University of Michigan.

Greene, D.L., Hu, P.S., and Roberts, G.F. 1984. Analysis of geographical and temporal variation in vehicle classification count statistics. Transportation Research Record 987, pp. 21-28.

Hanscom, F.R. 1981. The effect of truck size and weight on accident experience and traffic operations. Volume II: traffic operations. Report No. FHWA/RD-80/136. Falls Church, VA: BioTechnology, Inc.

Highway Statistics 1982, 1983, 1984, 1985, 1986, 1987, 1988. 1983-1989. Washington, D.C.: FHWA, Office of Highway Information.

McElhaney, D.R. 1990. Current national highway data requirements. Transportation Research Record 1271, pp. 16-19.

Mingo, R.D. 1990. Safety of multi-unit combination vehicles. Final report submitted to Association of American Railroads.

Mingo, R.D. 1991. Evaluation of FHWA's vehicle miles of travel estimates for heavy vehicles. Final report submitted to Association of American Railroads.

Transportation Research Board. 1990. Data Requirements for Monitoring Truck Safety. Special Report 228. Washington, D.C.

Vallette, G.R. and Hanscom, F.R. 1981. The effect of truck size and weight on accident experience and traffic operations. Volume I: executive summary. Report No. FHWA/RD-80/135. Falls Church, VA: BioTechnology, Inc.

Vallette, G.R., McGee, H., and Sanders, J.H. 1979. The effect of truck size and weight on accident experience and traffic operations. Volume IV: truck exposure classification by size and weight. Report No. FHWA/RD-80/138. Falls Church, VA: BioTechnology, Inc.

Vallette, G.R., McGee, H., Sanders, J.H., and Enger, D.J. 1981. The effect of truck size and weight on accident experience and traffic operations. Volume III: accident experience of large trucks. Report No. FHWA/RD-80/137. Falls Church, VA: BioTechnology, Inc.

Appendix A: Figures

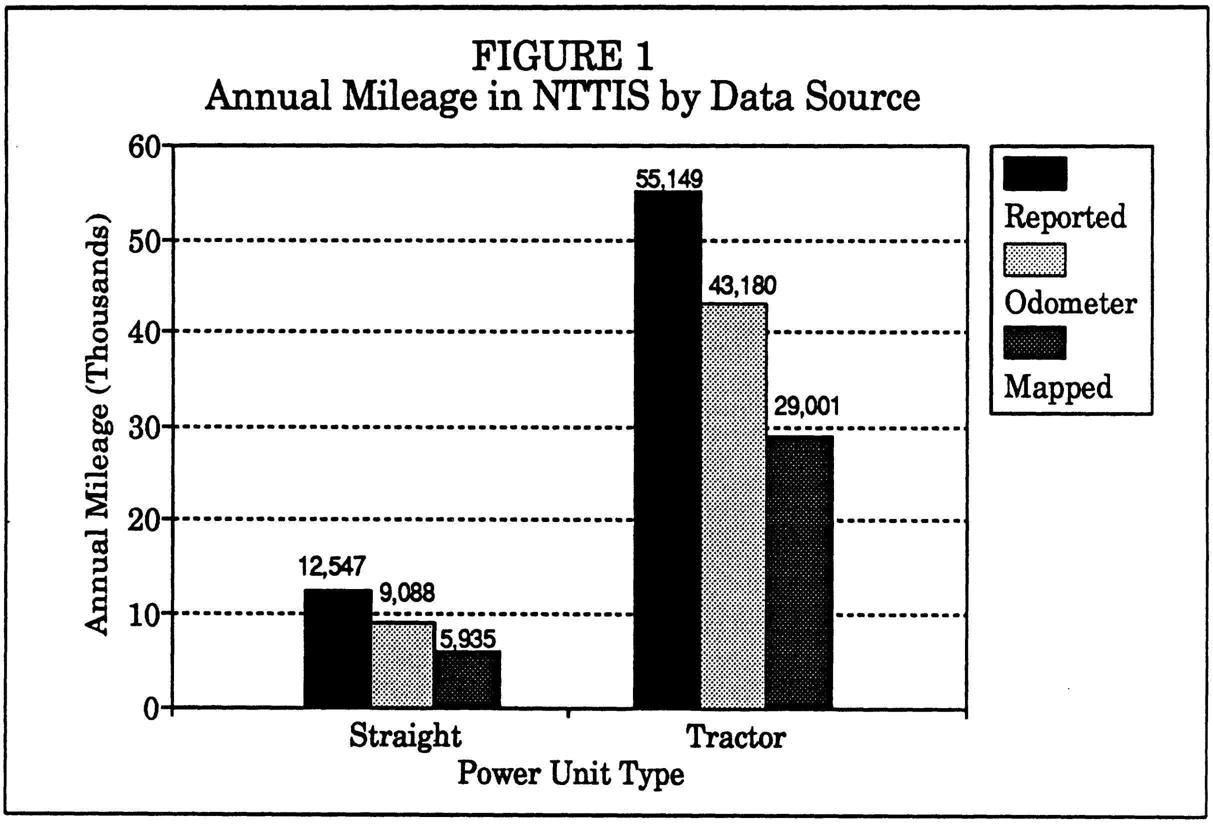


FIGURE 1
Annual Mileage in NTTIS by Data Source
Annual Mileage (Thousands)
60
50
40
30
20
10
0
55,149
43,180
29,001
12,547
9,088
5,935
Straight
Tractor
Power Unit Type
Reported
Odometer
Mapped

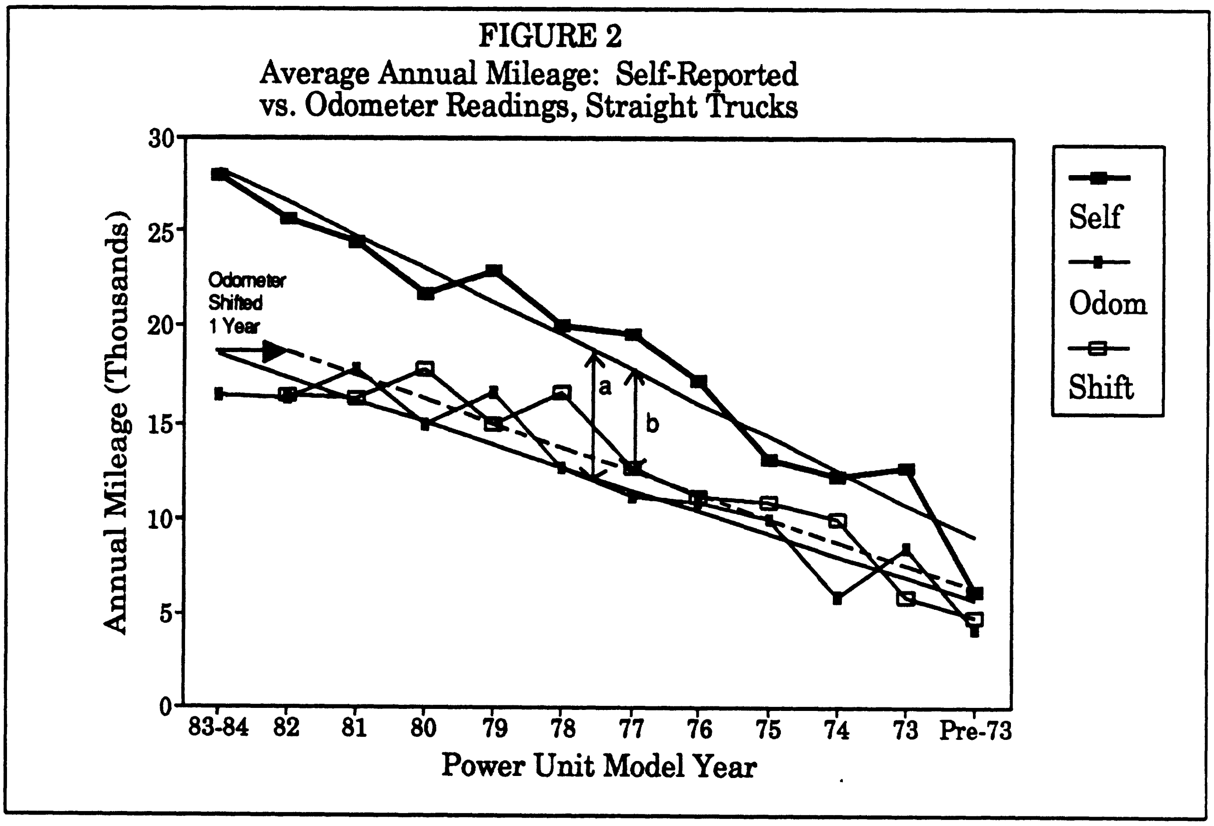


FIGURE 2
Average Annual Mileage: Self-Reported vs. Odometer Readings, Straight Trucks
Annual Mileage (Thousands)
30
25
20
15
10
5
0
Odometer Shifted 1 Year
a
b
83-84
82
81
80
79
78
77
76
75
74
73
Pre-73
Power Unit Model Year
Self
Odom
Shift

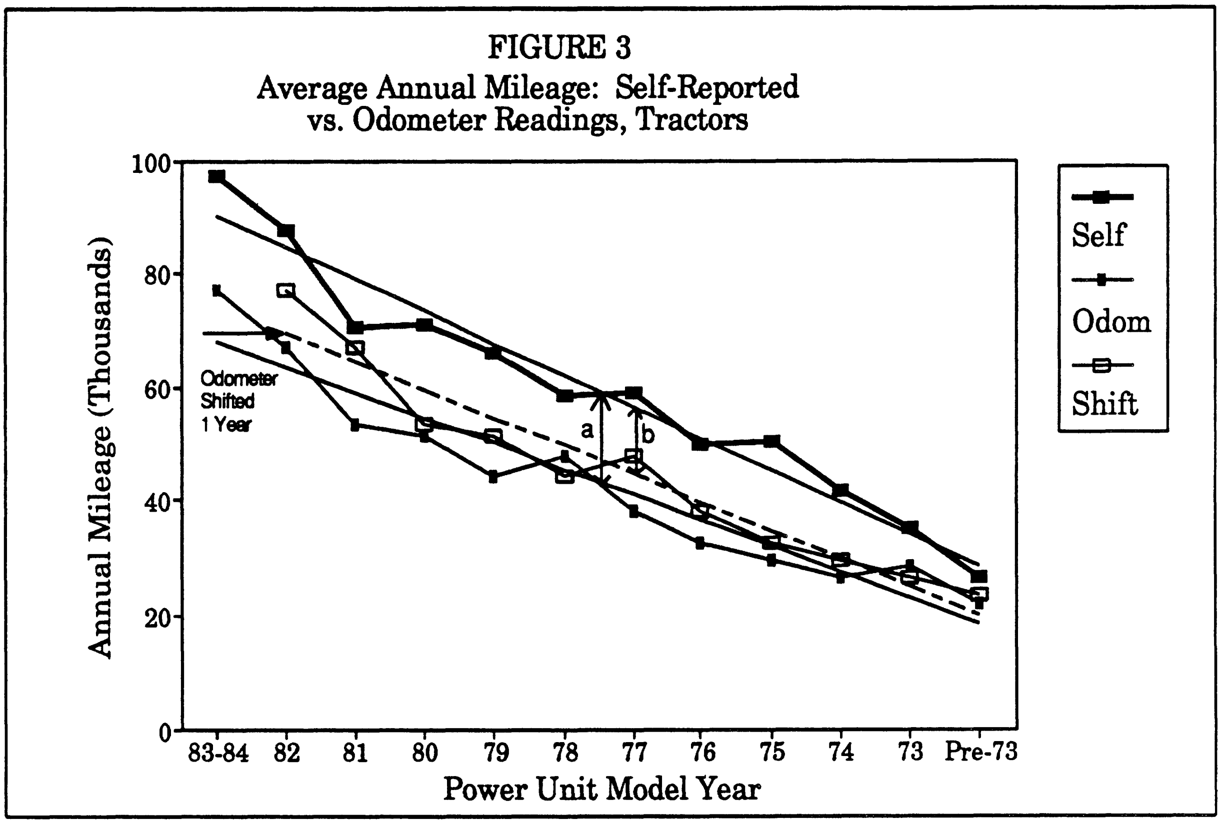


FIGURE 3
Average Annual Mileage: Self-Reported
vs. Odometer Readings, Tractors
Annual Mileage (Thousands)
100
80
60
40
20
0
Odometer Shifted 1 Year
a
b
83-84
82
81
80
79
78
77
76
75
74
73
Pre-73
Power Unit Model Year
Self
Odom
Shift

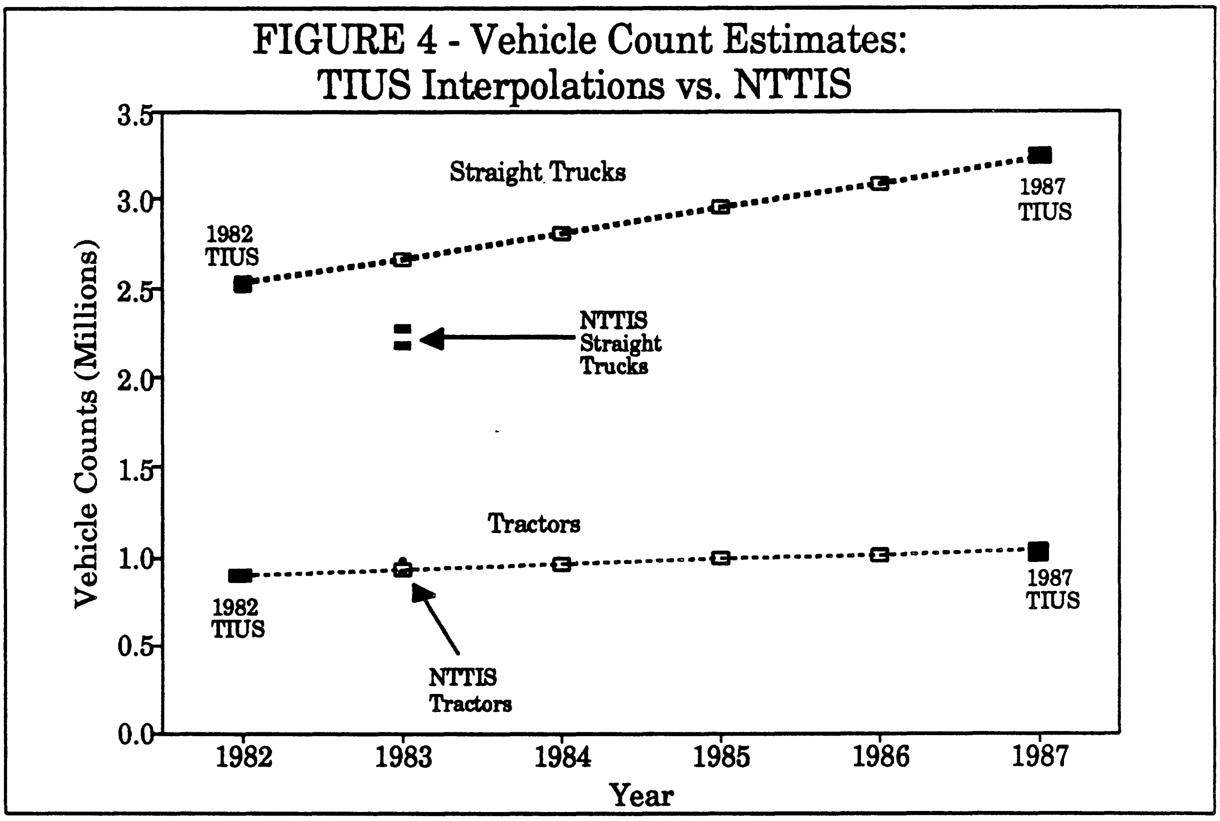


FIGURE 4 - Vehicle Count Estimates:
TIUS Interpolations vs. NTTIS
Vehicle Counts (Millions)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Straight Trucks
1982 TIUS
1987 TIUS
NTTIS Straight Trucks
Tractors
1982 TIUS
1987 TIUS
NTTIS Tractors
1982
1983
1984
1985
1986
1987
Year

FIGURE 5 - Straight Trucks by GVWR
NTTIS v. 1982 TIUS

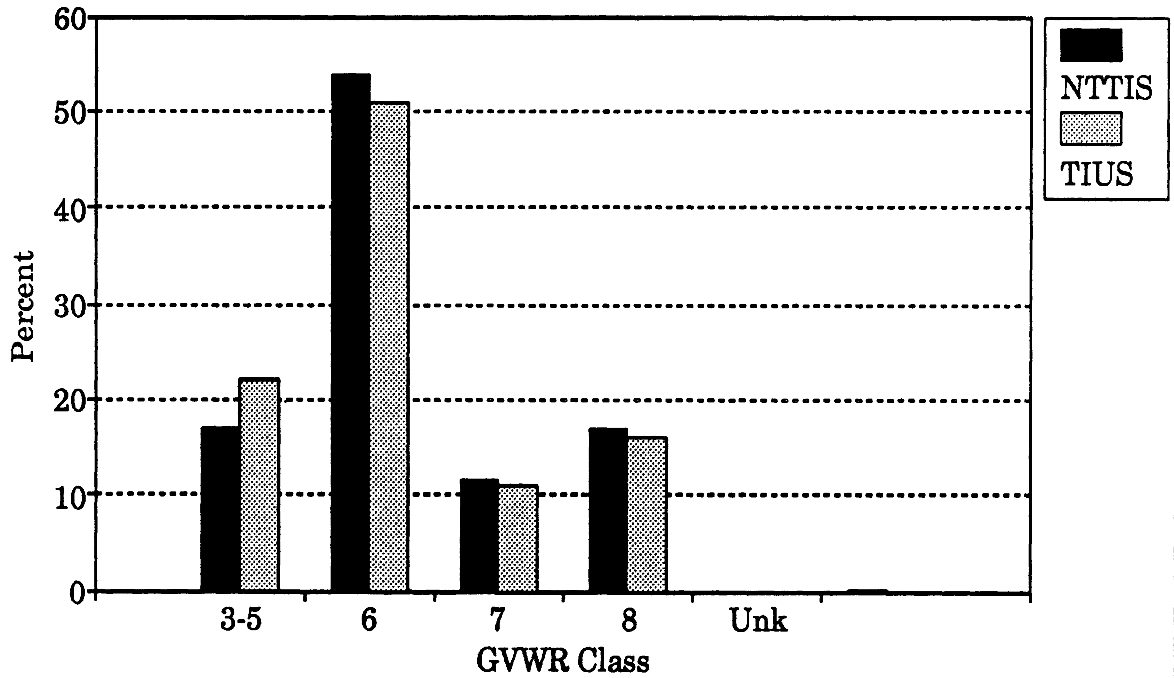


FIGURE 6 - Tractors by GVWR
NTTIS v. 1982 TIUS

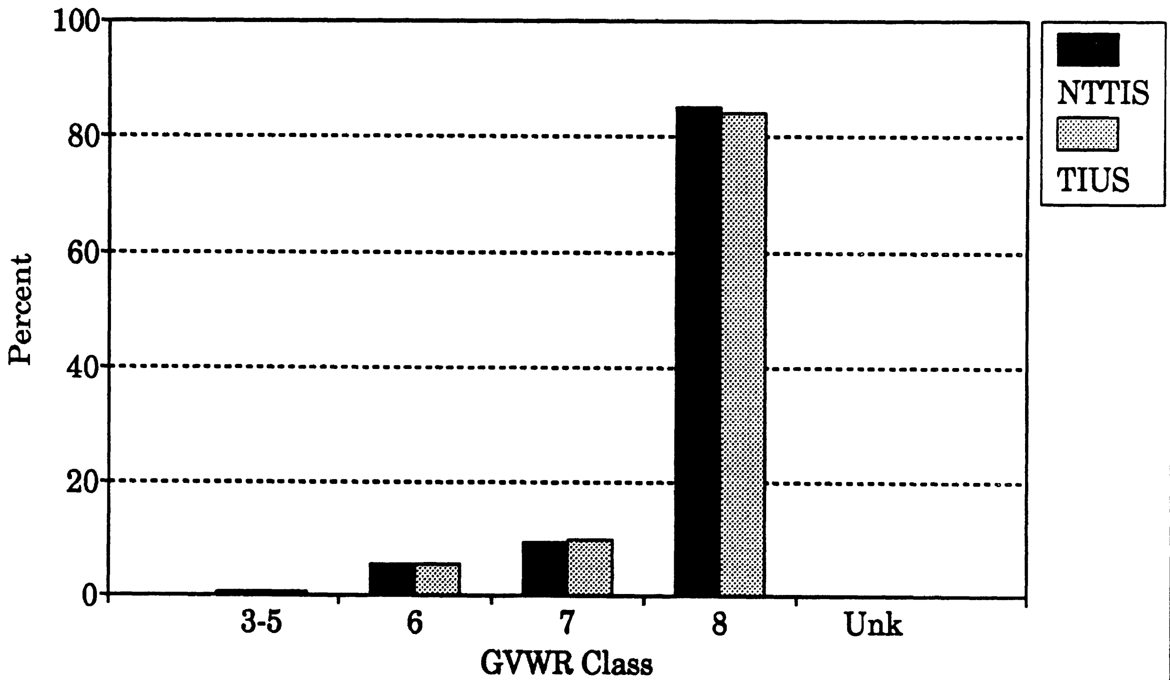


FIGURE 7
Straight Trucks by Age of Power Unit

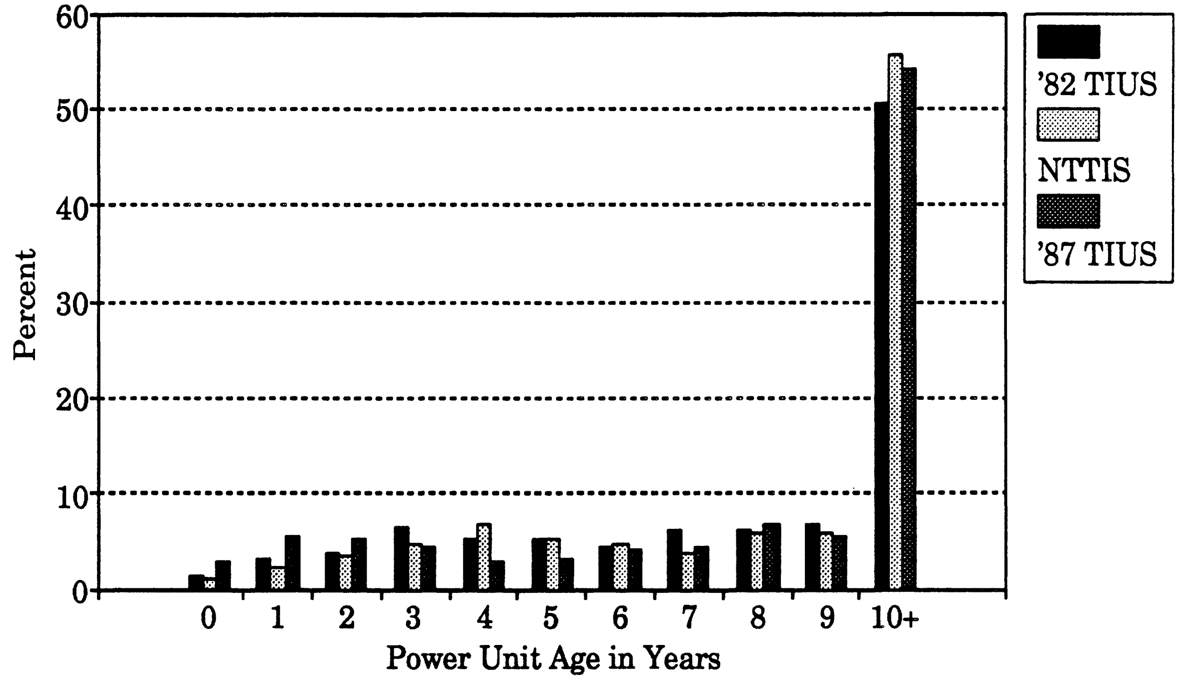
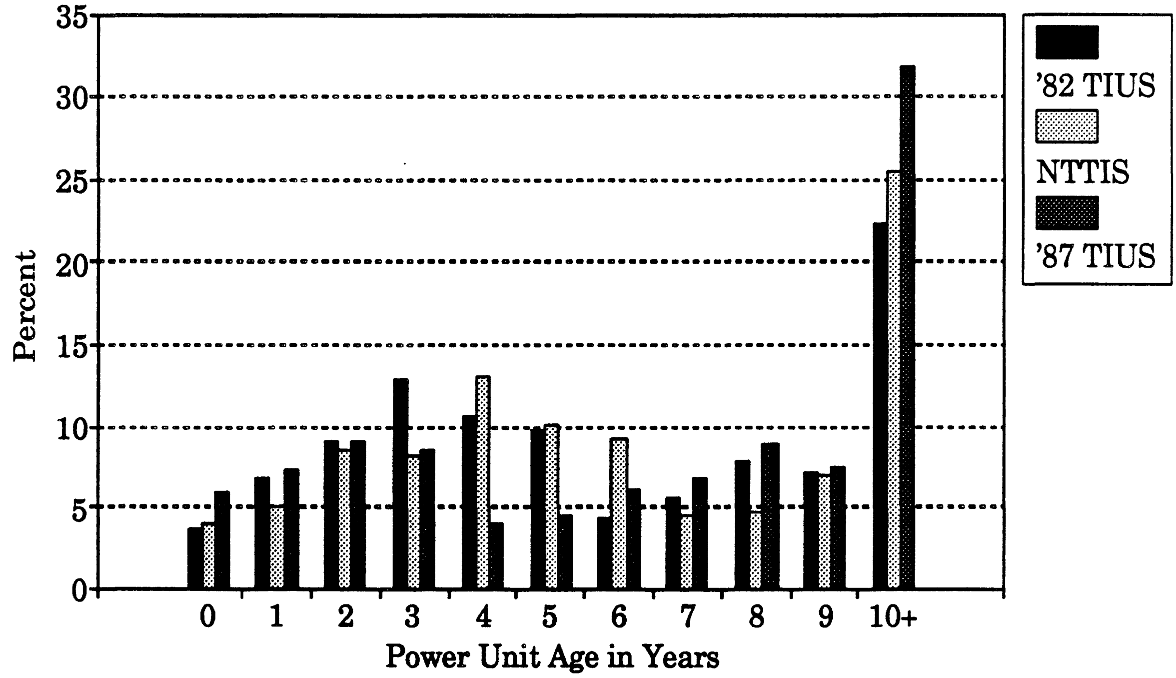


FIGURE 8
Tractors by Age of Power Unit



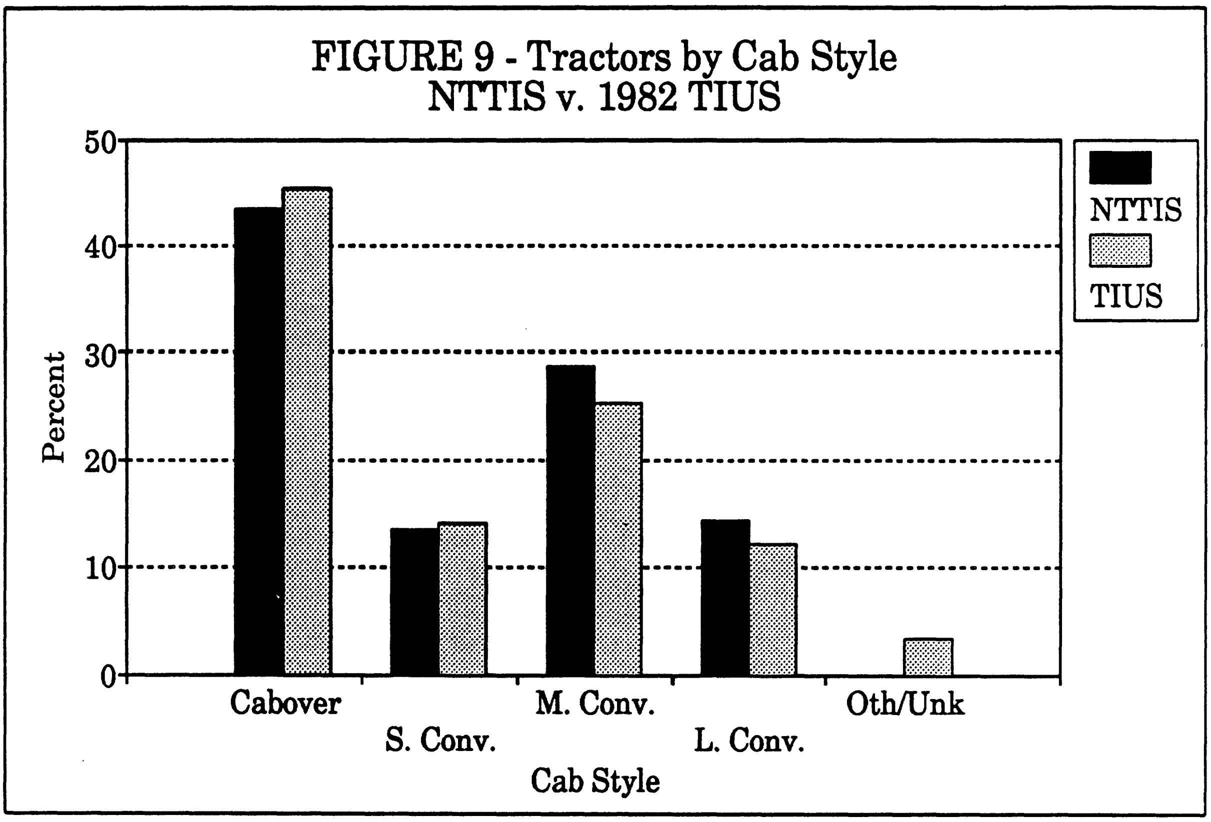


FIGURE 9 - Tractors by Cab Style
NTTIS v. 1982 TIUS
50
40
30
20
10
0
Percent
NTTIS
TIUS
Cabover
S. Conv.
M. Conv.
L. Conv.
Oth/Unk
Cab Style

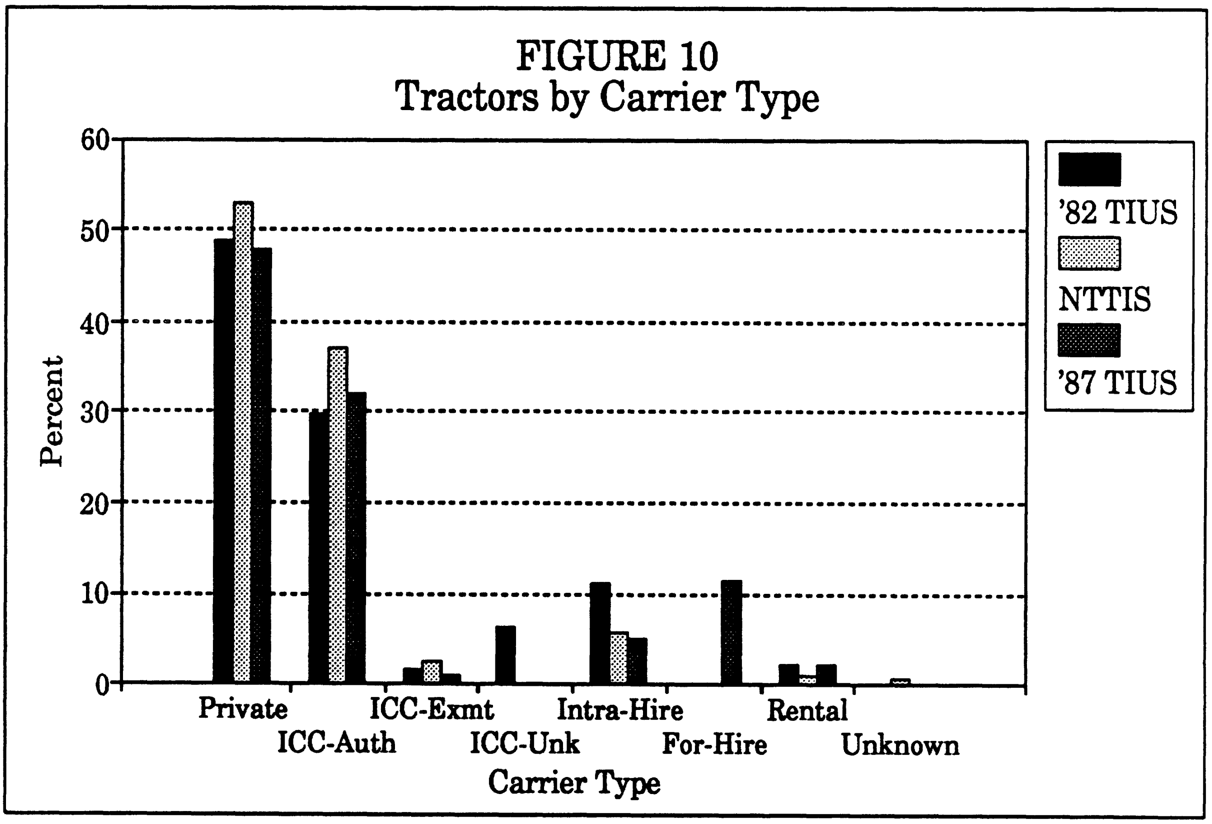


FIGURE 10
Tractors by Carrier Type
60
50
40
30
20
10
0
Percent
'82 TIUS
NTTIS
'87 TIUS
Private
ICC-Auth
ICC-Exmt
ICC-Unk
Intra-Hire
For-Hire
Rental
Unknown
Carrier Type

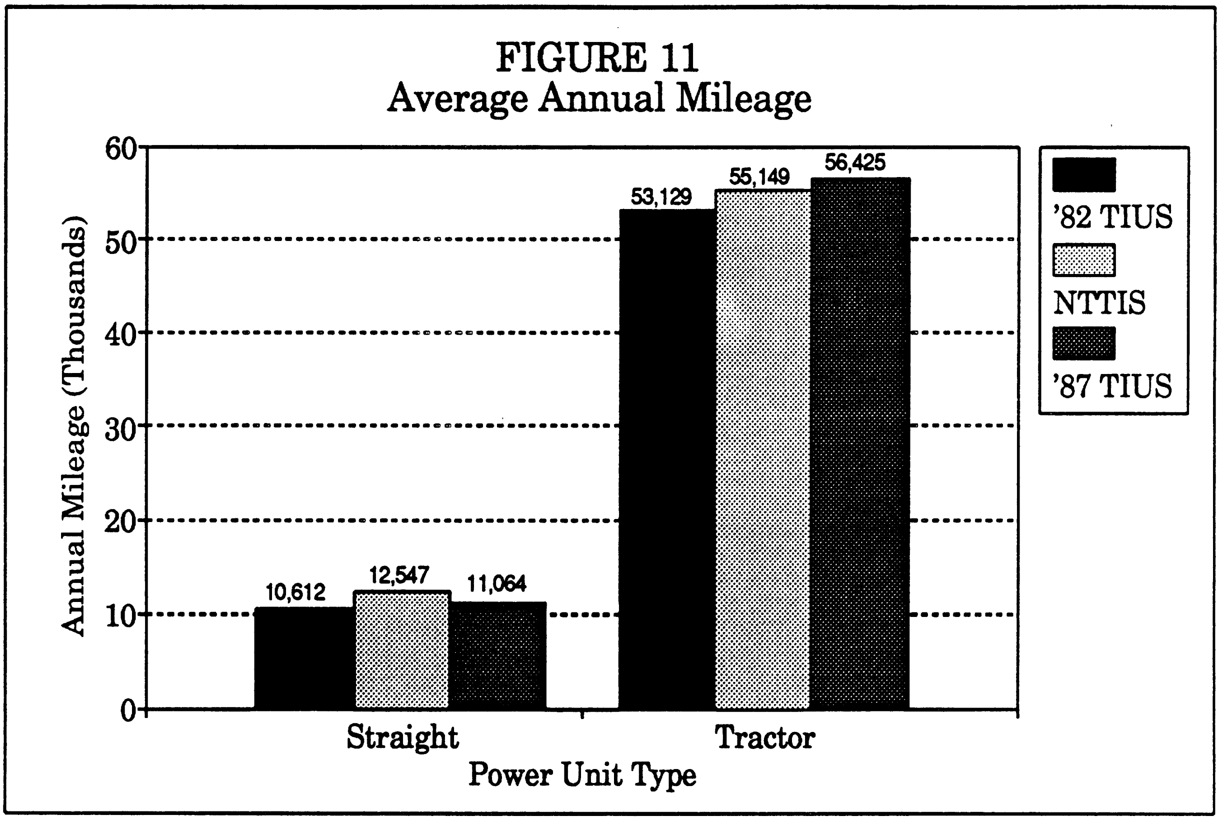


FIGURE 11
Average Annual Mileage
Annual Mileage (Thousands)
0
10
20
30
40
50
60
10,612
12,547
11,064
53,129
55,149
56,425
Straight
Tractor
Power Unit Type
'82 TIUS
NTTIS
'87 TIUS

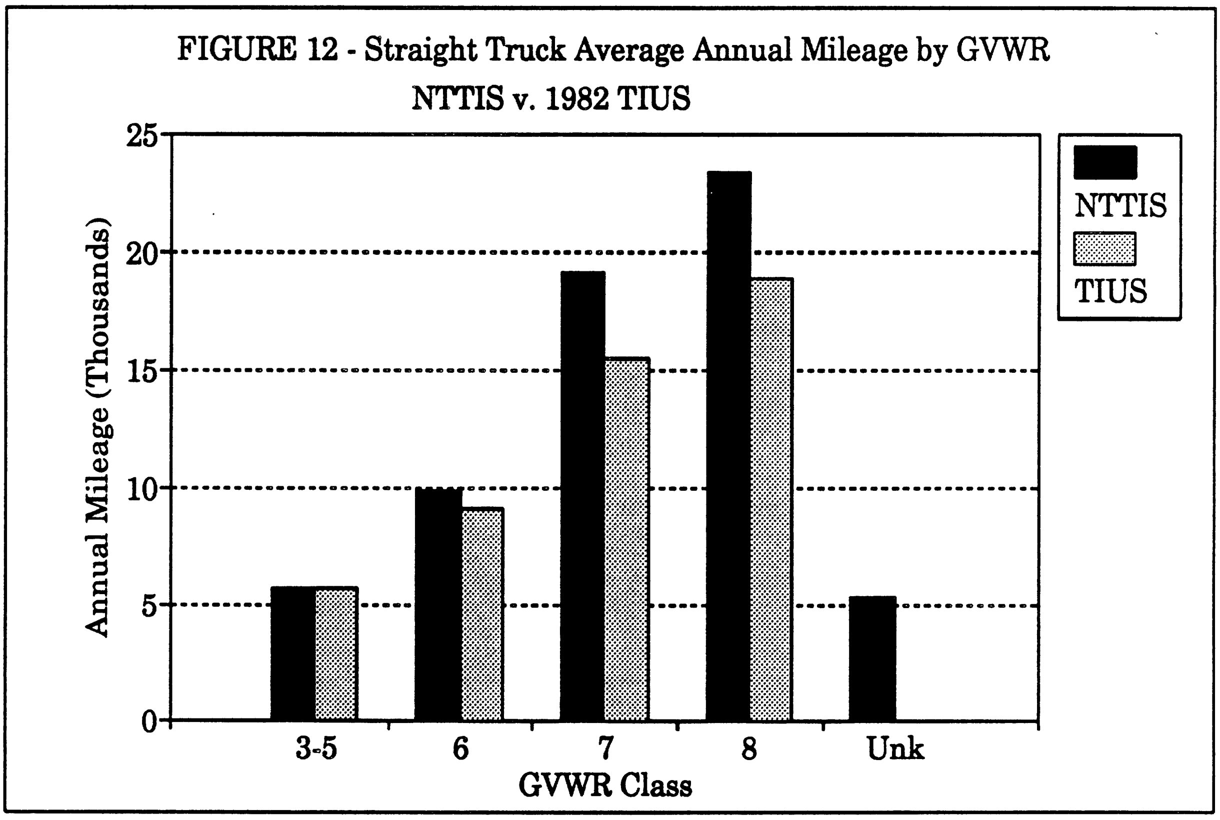


FIGURE 12 - Straight Truck Average Annual Mileage by GVWR
NTTIS v. 1982 TIUS
Annual Mileage (Thousands)
0
5
10
15
20
25
3-5
6
7
8
Unk
GVWR Class
NTTIS
TIUS

FIGURE 13 - Tractor Average Annual Mileage by GVWR
NTTIS v. 1982 TIUS

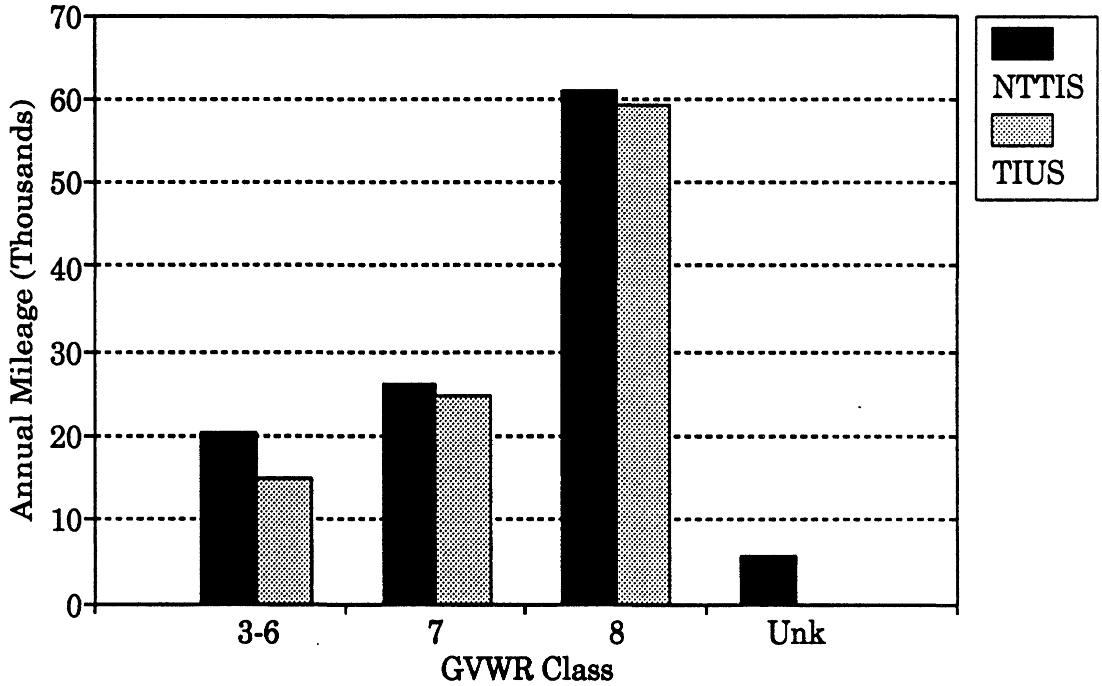
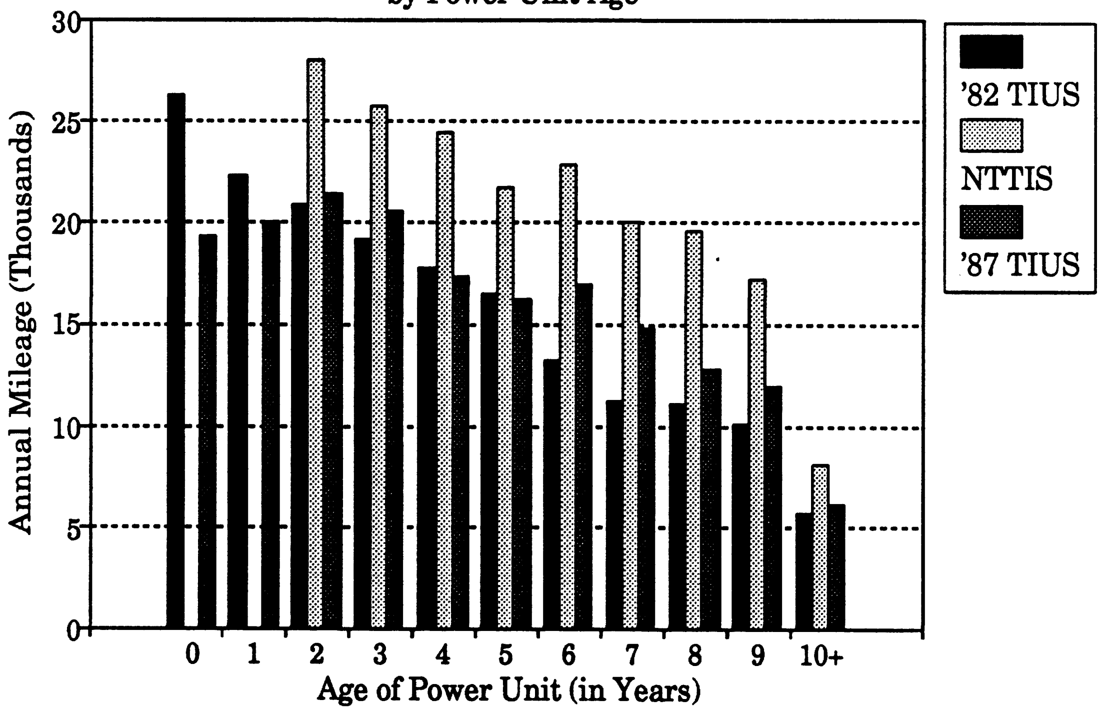


FIGURE 14 - Straight Truck Average Annual Mileage
by Power Unit Age



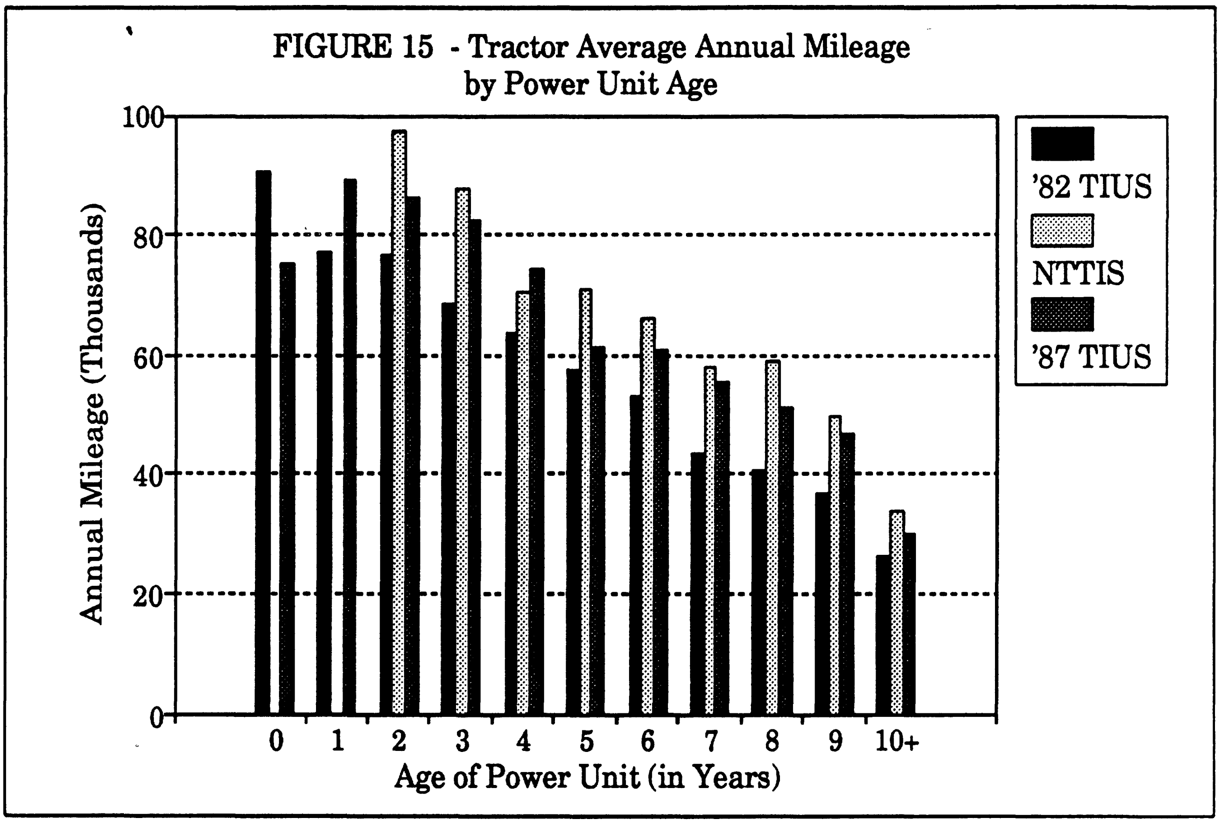


FIGURE 15 - Tractor Average Annual Mileage
by Power Unit Age
Annual Mileage (Thousands)
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10+
Age of Power Unit (in Years)
'82 TIUS
NTTIS
'87 TIUS

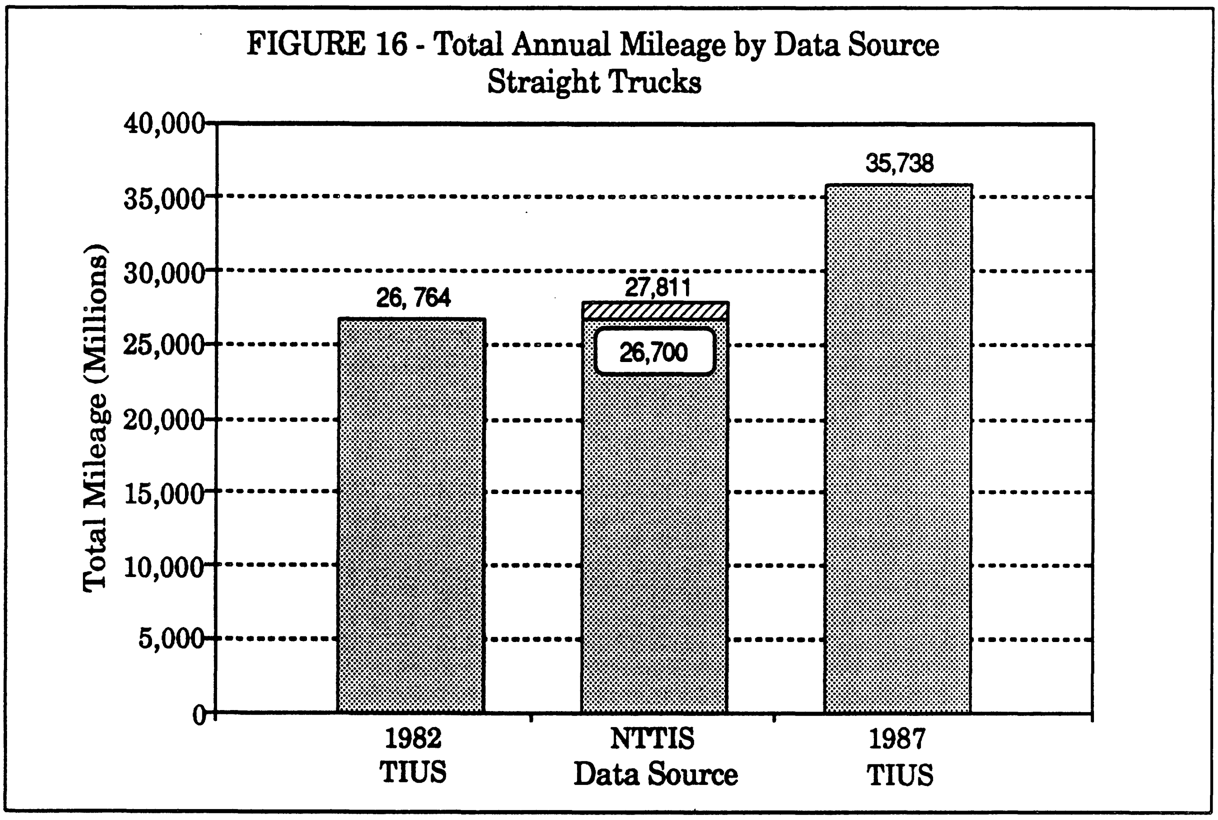


FIGURE 16 - Total Annual Mileage by Data Source
Straight Trucks
Total Mileage (Millions)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
26, 764
27,811
26,700
35,738
1982
TIUS
NTTIS
Data Source
1987
TIUS

FIGURE 17 - Total Annual Mileage by Data Source
Tractors

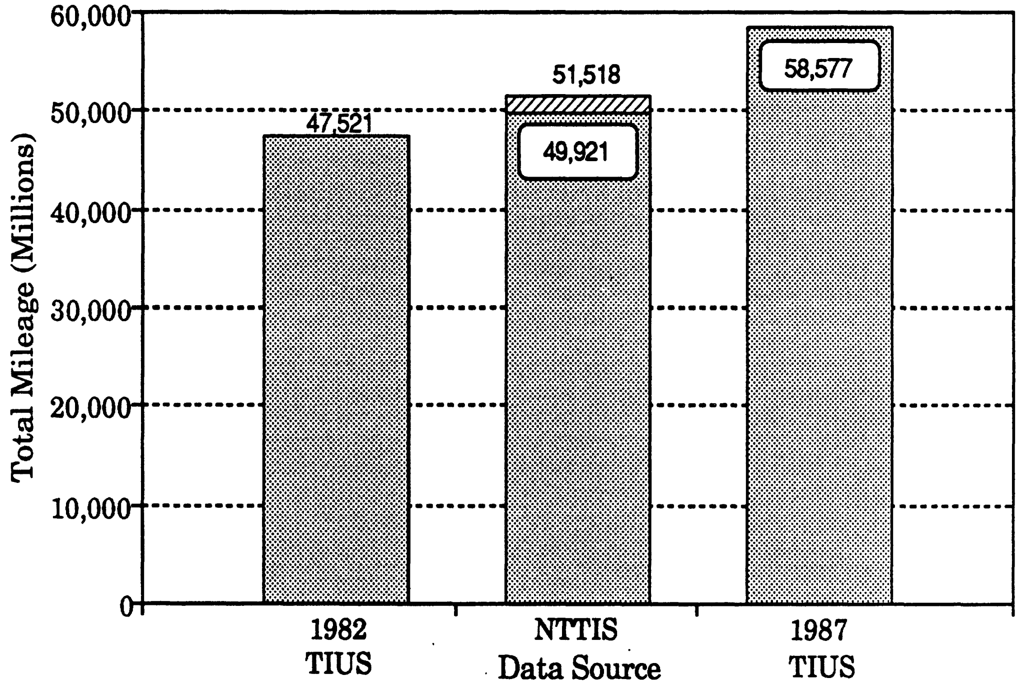


FIGURE 18
Single-Unit Vehicle Count Estimates

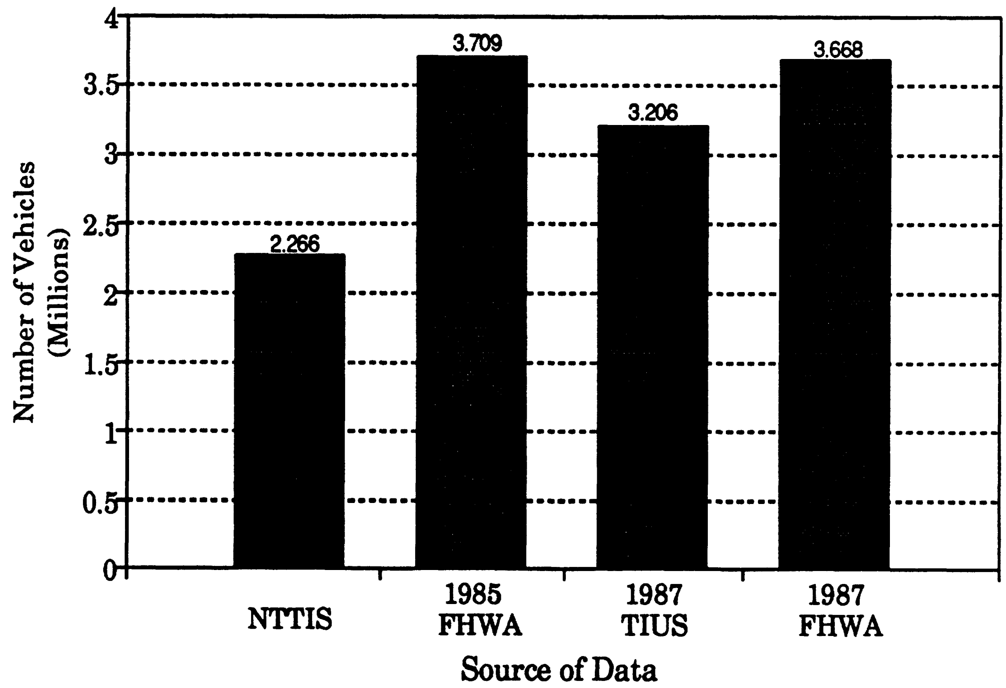


FIGURE 19
Combination Vehicle Count Estimates

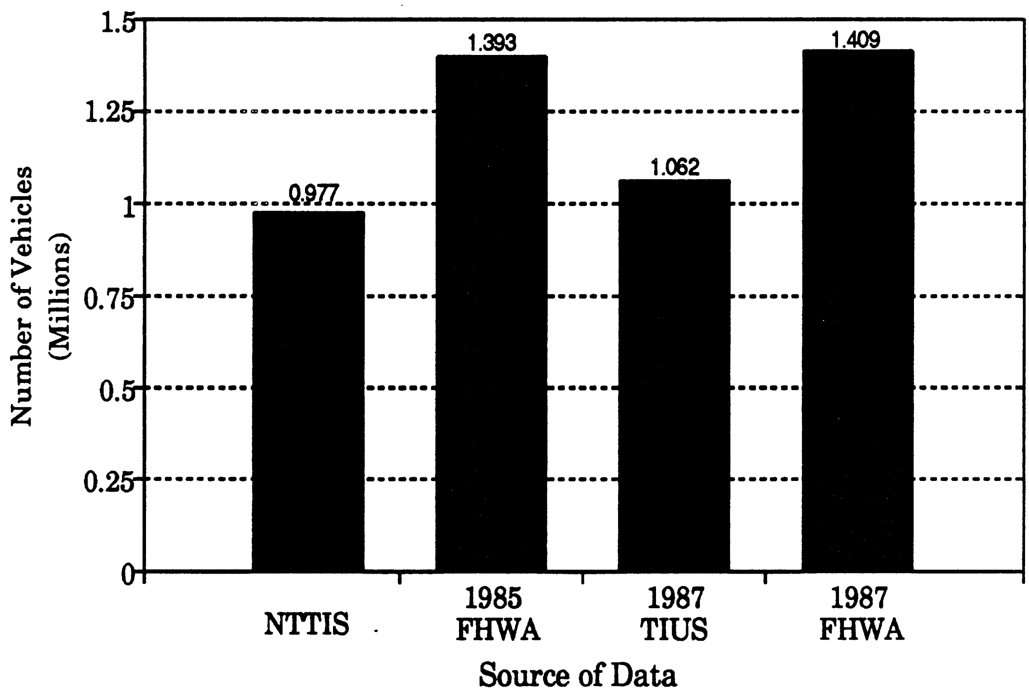


FIGURE 20
Total Miles - Single-Units

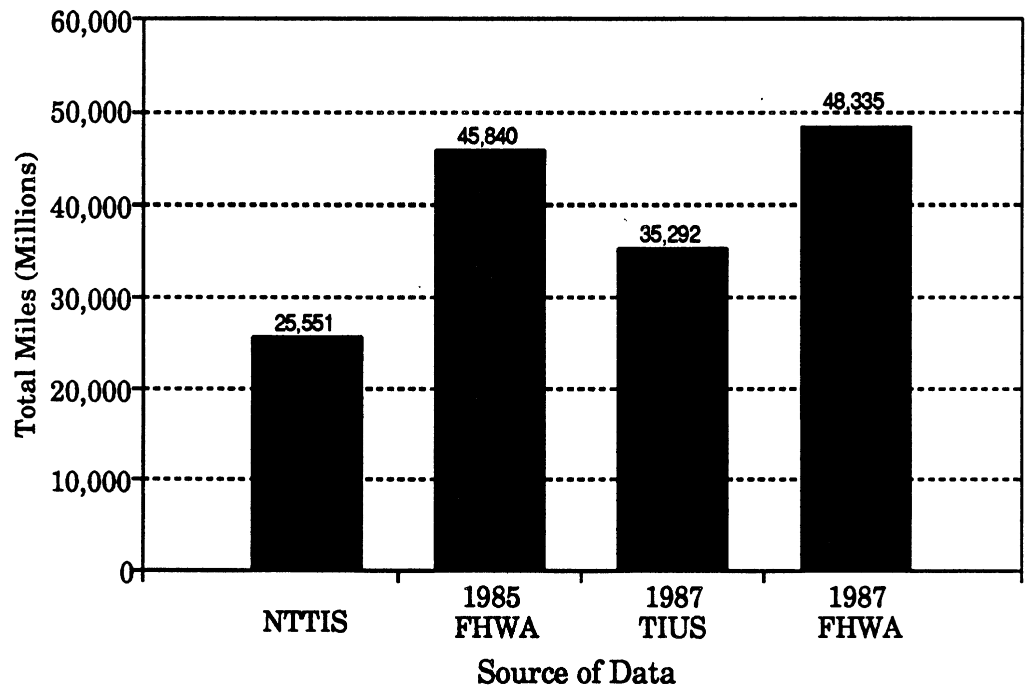


FIGURE 21
Total Miles - Combination Vehicles

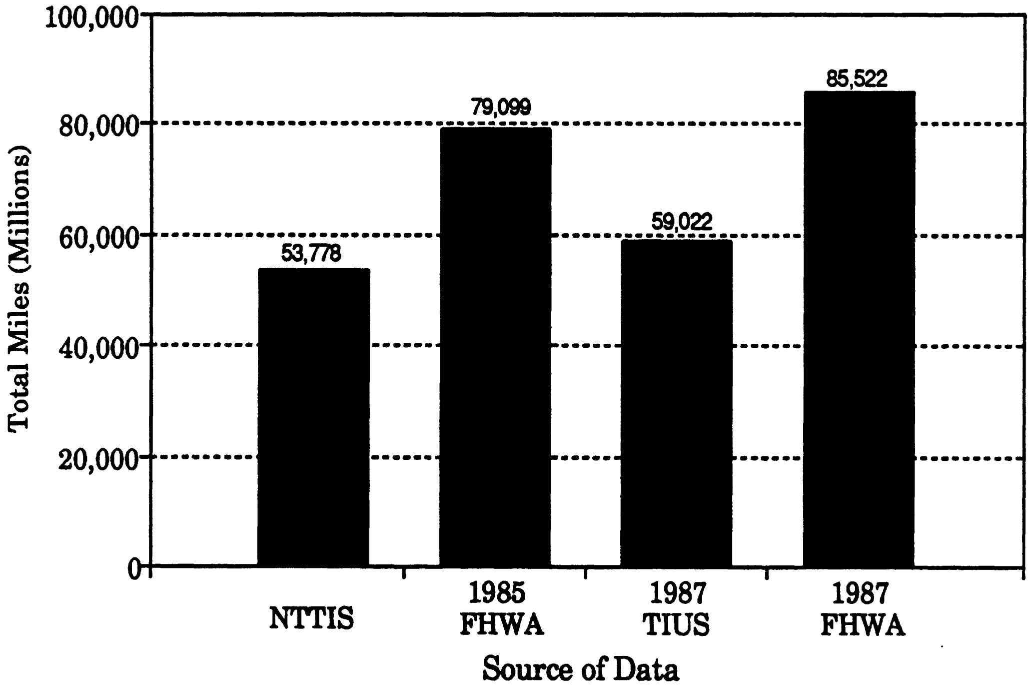


FIGURE 22
Fatal Involvement Rates, Combinations

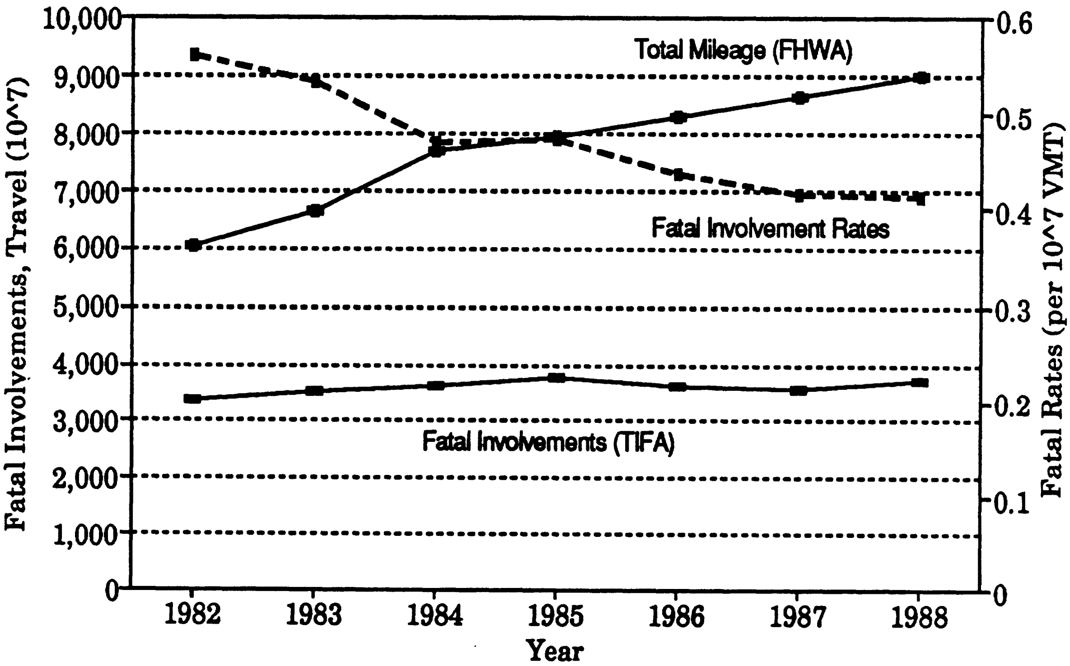


FIGURE 23
Total Annual Travel by Configuration

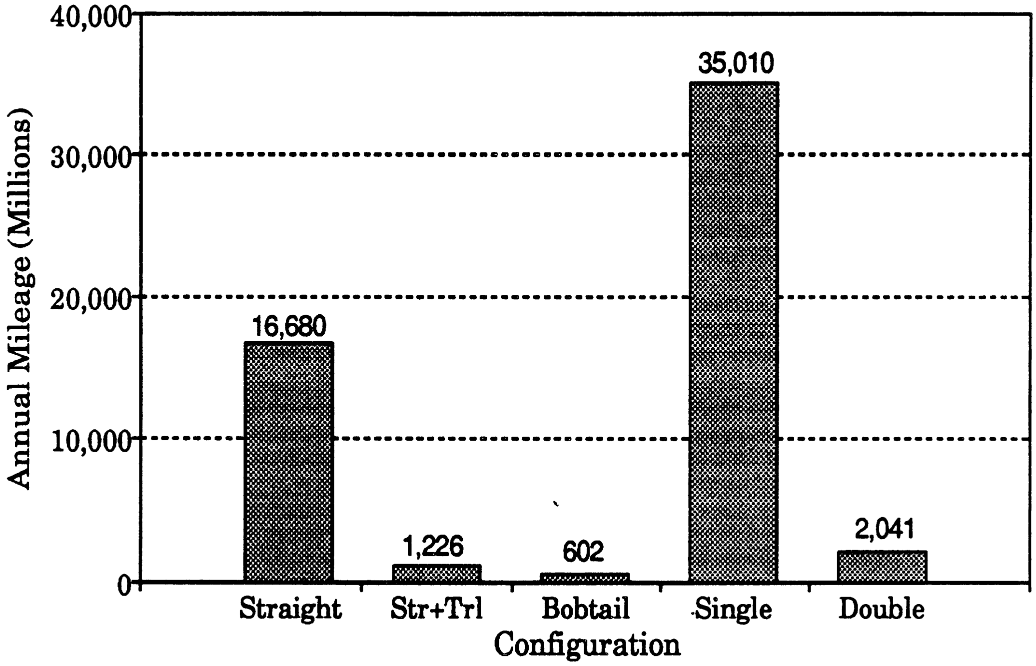


FIGURE 24
Travel by Configuration and Road Type

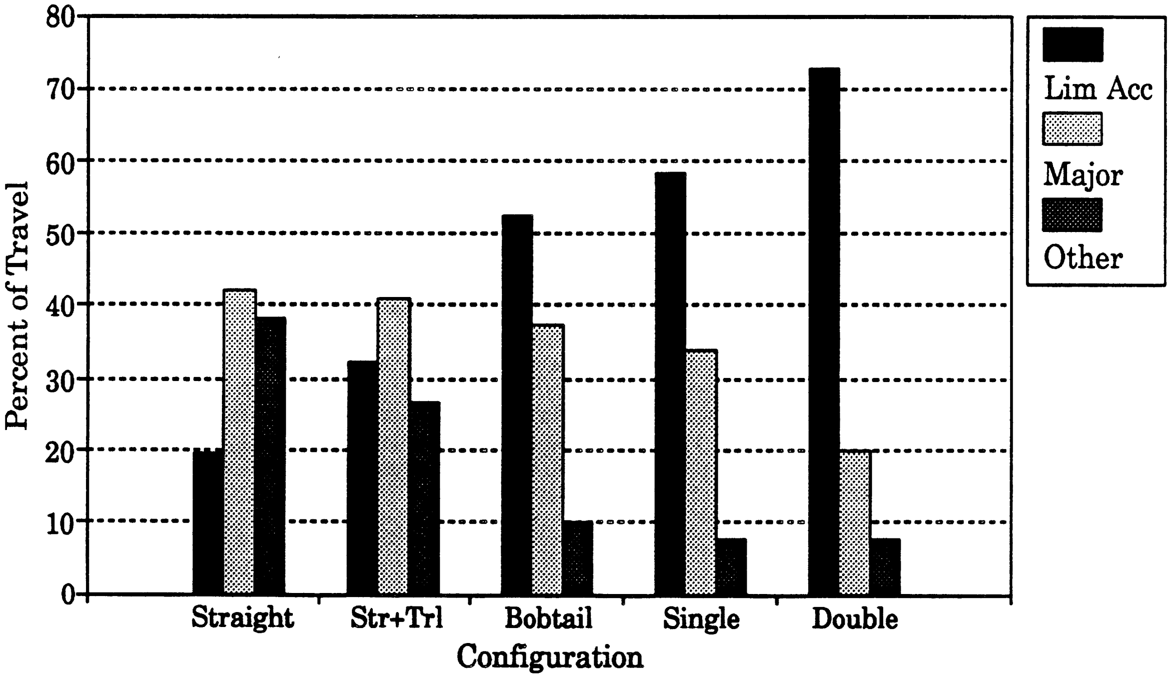


FIGURE 25
Travel by Configuration and Area Type

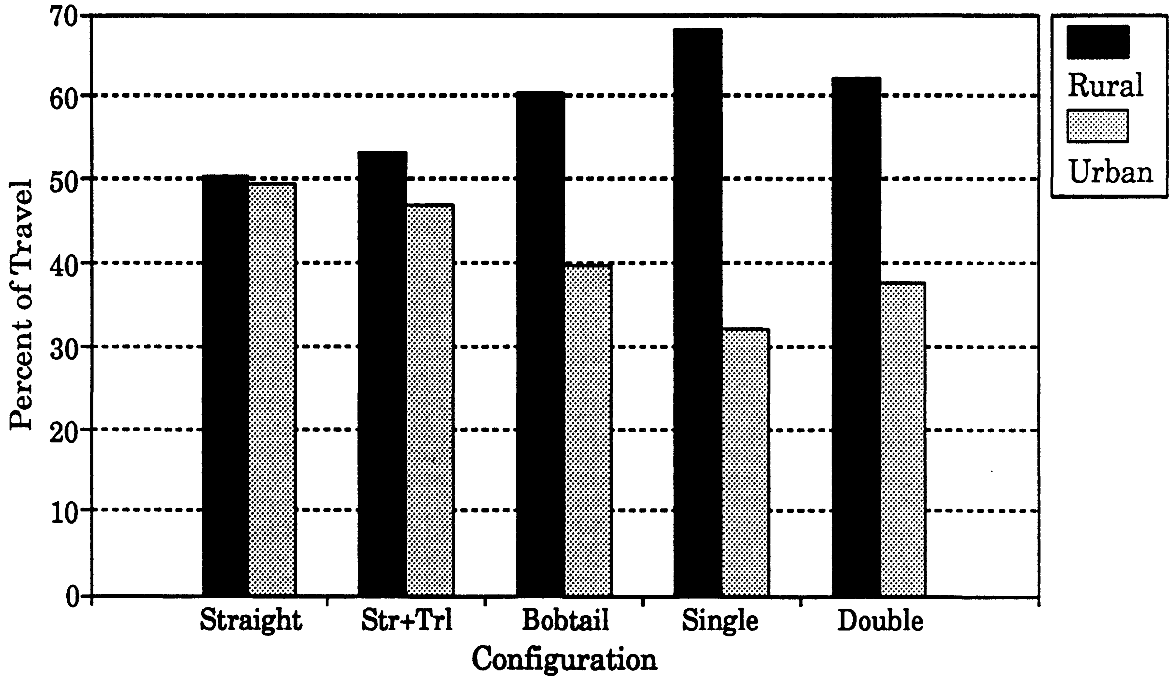
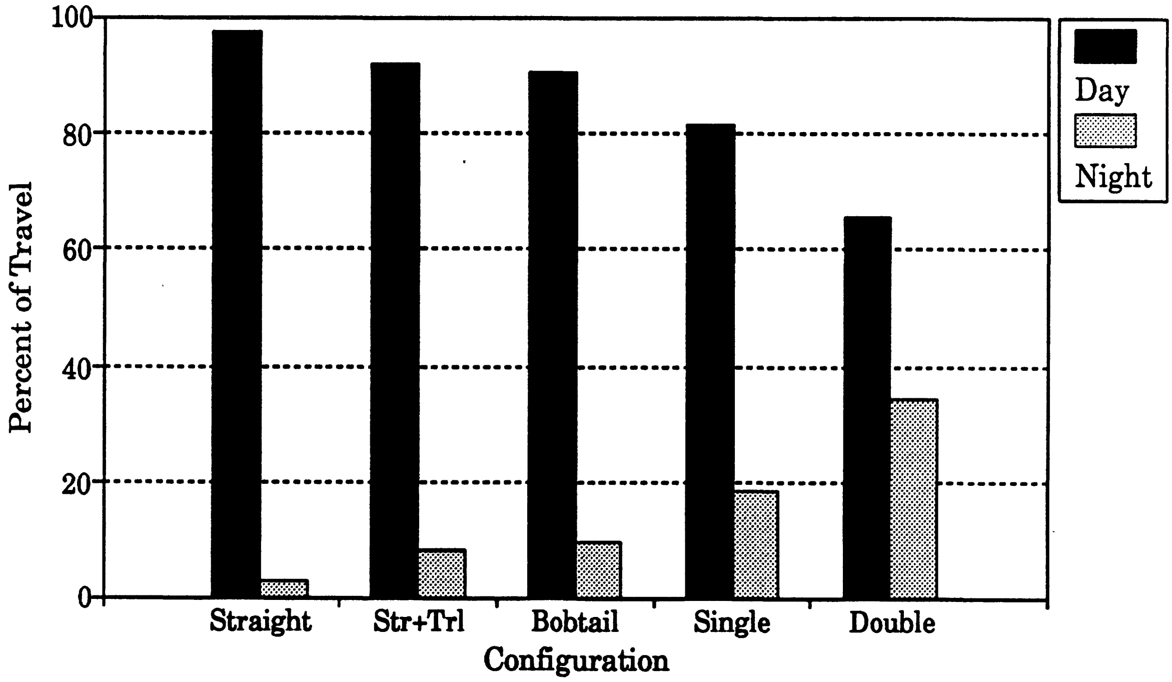


FIGURE 26
Travel by Configuration and Time of Day



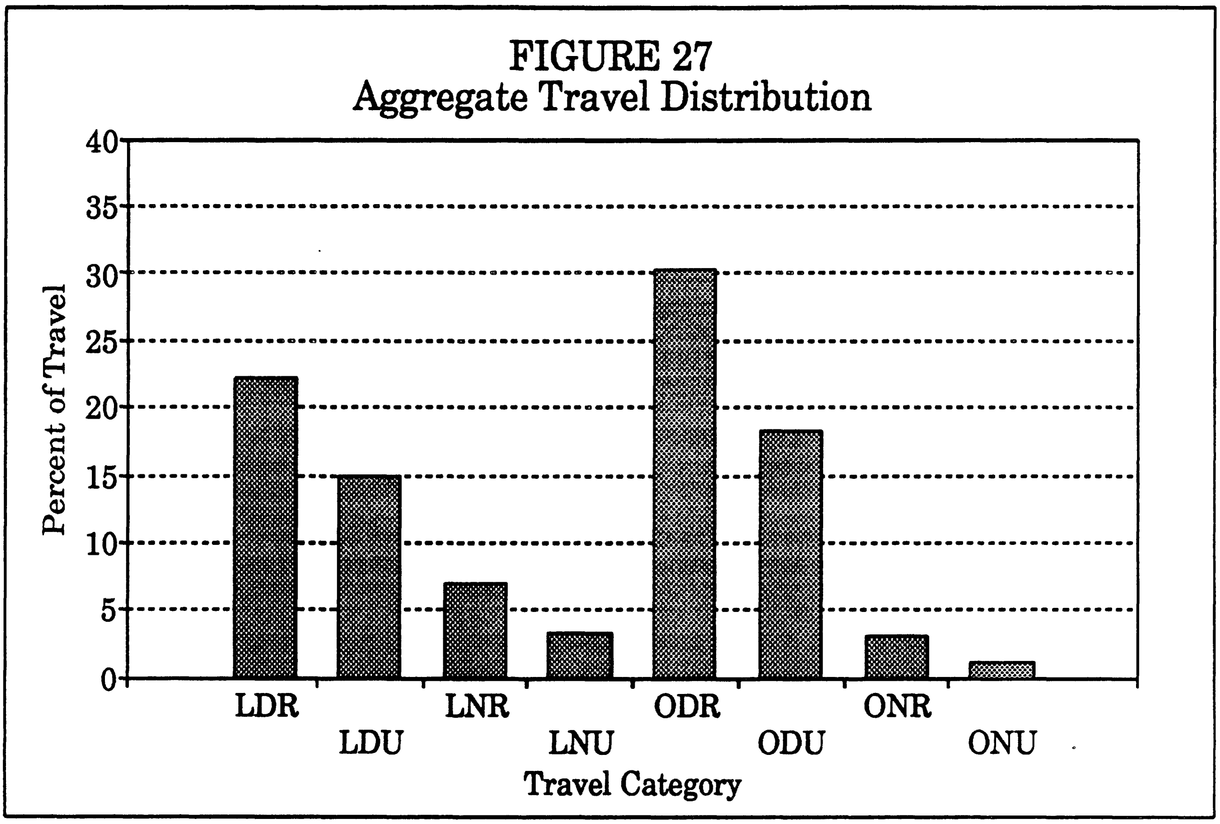


FIGURE 27
Aggregate Travel Distribution
Percent of Travel
40
35
30
25
20
15
10
5
0
LDR
LDU
LNR
LNU
ODR
ODU
ONR
ONU
Travel Category

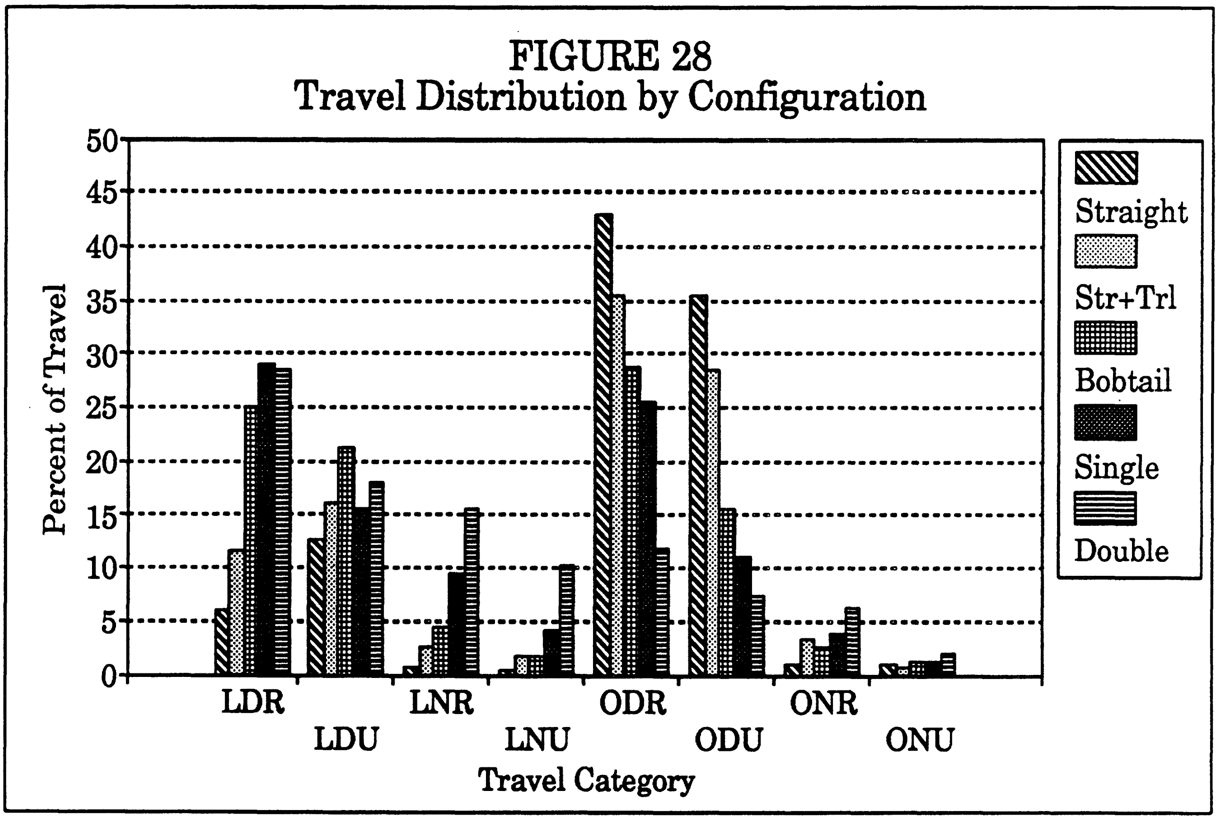


FIGURE 28
Travel Distribution by Configuration
Percent of Travel
50
45
40
35
30
25
20
15
10
5
0
LDR
LDU
LNR
LNU
ODR
ODU
ONR
ONU
Travel Category
Straight
Str+Trl
Bobtail
Single
Double

FIGURE 29
Travel by Power Unit Type and GCW

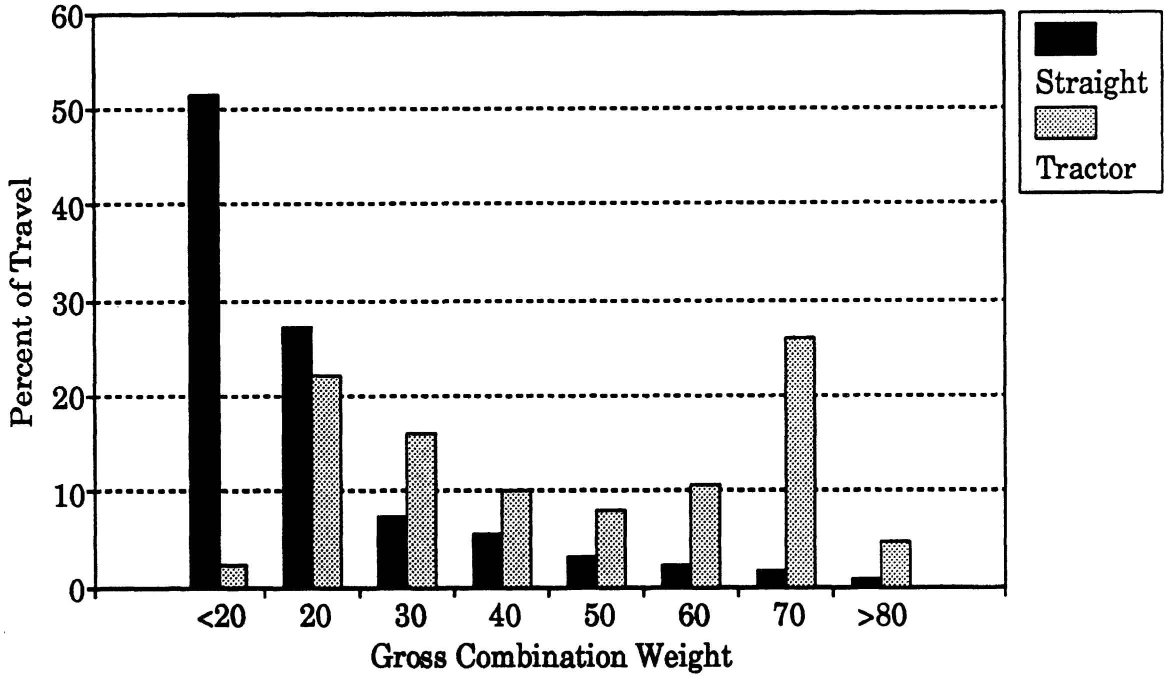
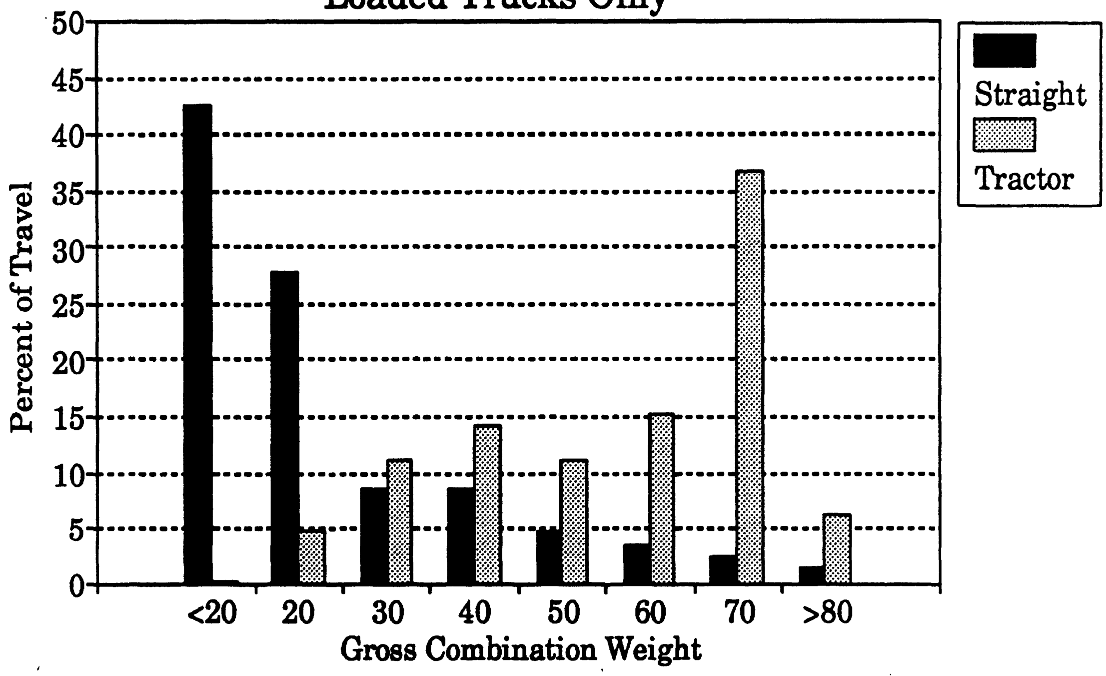


FIGURE 30
Travel by Power Unit Type and GCW
Loaded Trucks Only



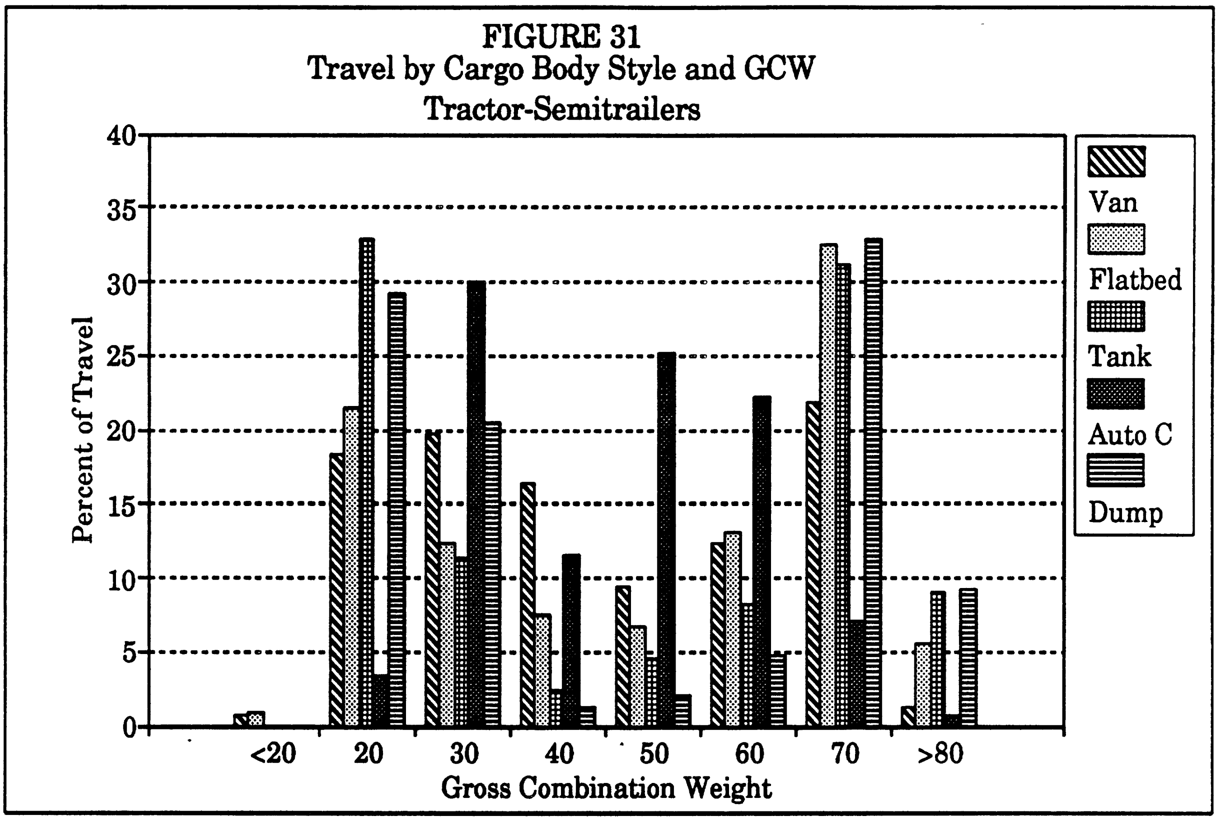


FIGURE 31
Travel by Cargo Body Style and GCW
Tractor-Semitrailers
Percent of Travel
0
5
10
15
20
25
30
35
40
<20
20
30
40
50
60
70
>80
Gross Combination Weight
Van
Flatbed
Tank
Auto C
Dump

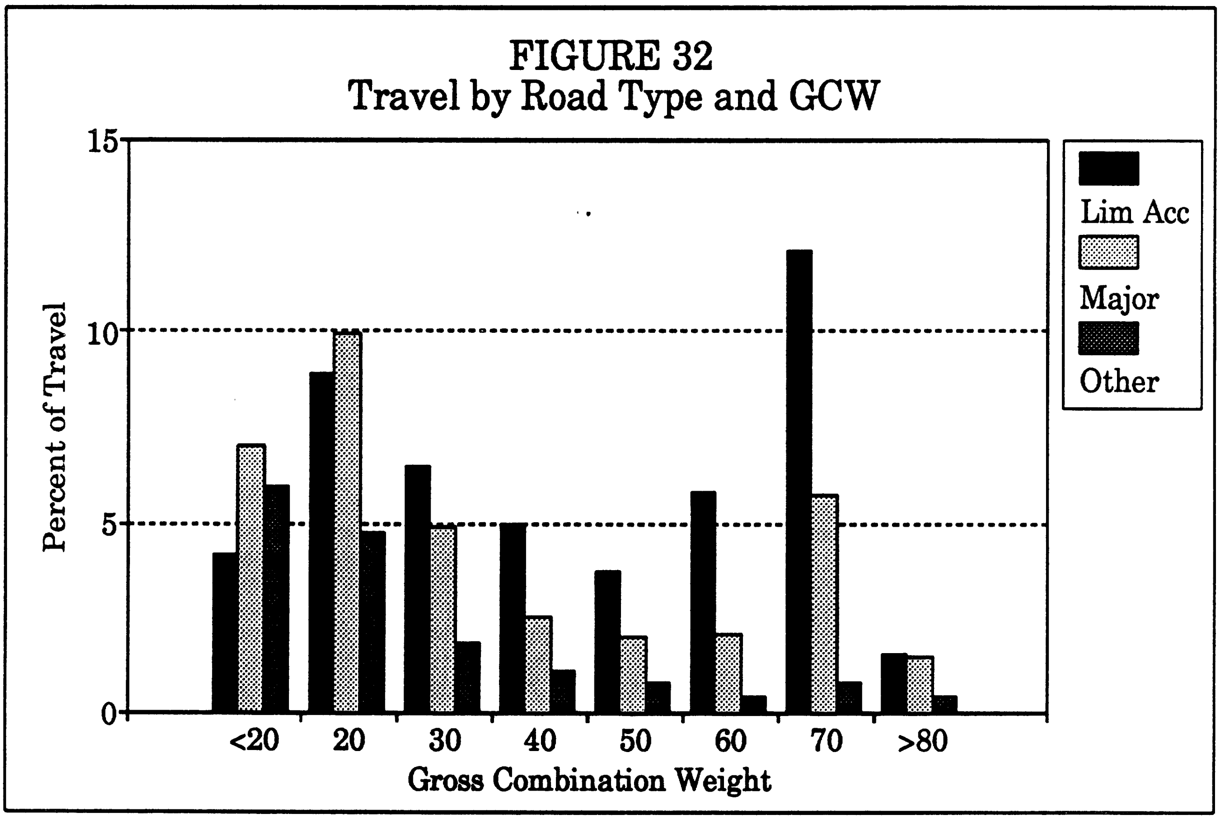


FIGURE 32
Travel by Road Type and GCW
Percent of Travel
0
5
10
15
<20
20
30
40
50
60
70
>80
Gross Combination Weight
Lim Acc
Major
Other

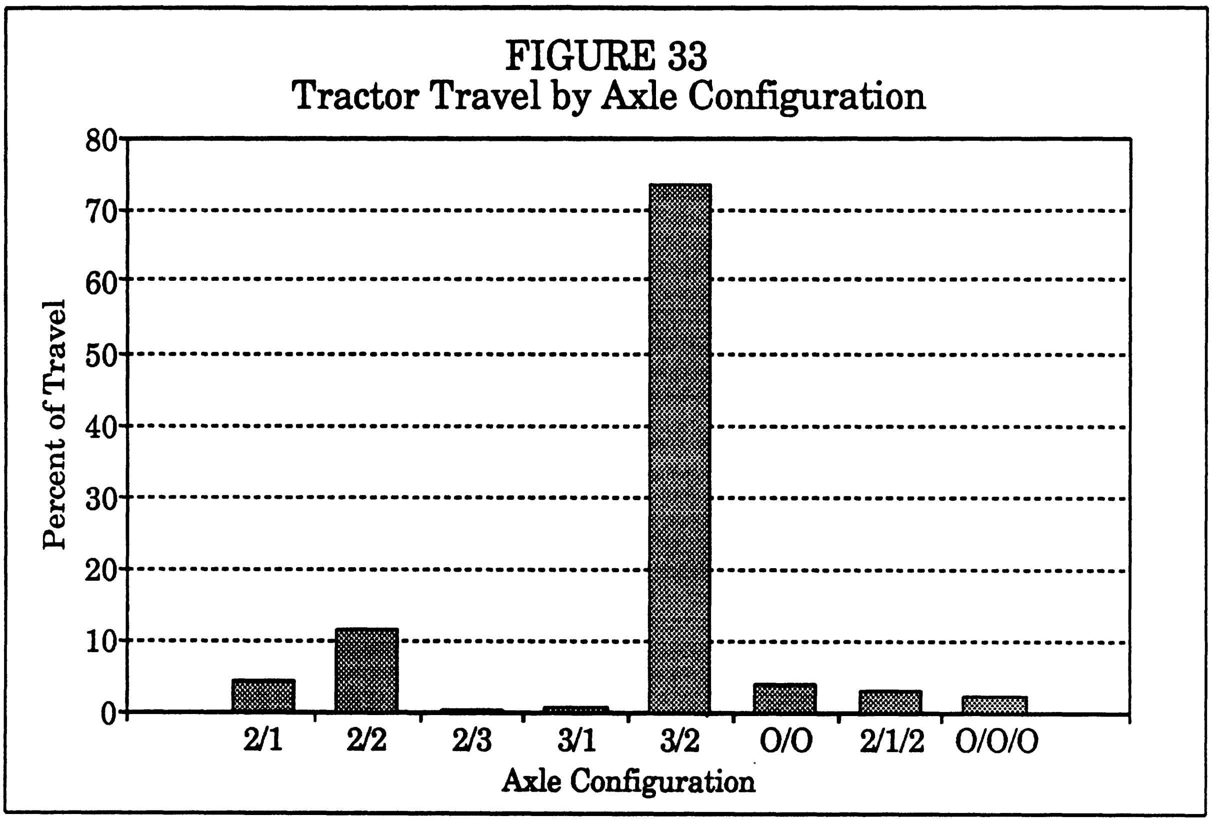


FIGURE 33
Tractor Travel by Axle Configuration
Percent of Travel
80
70
60
50
40
30
20
10
0
2/1
2/2
2/3
3/1
3/2
O/O
2/1/2
O/O/O
Axle Configuration

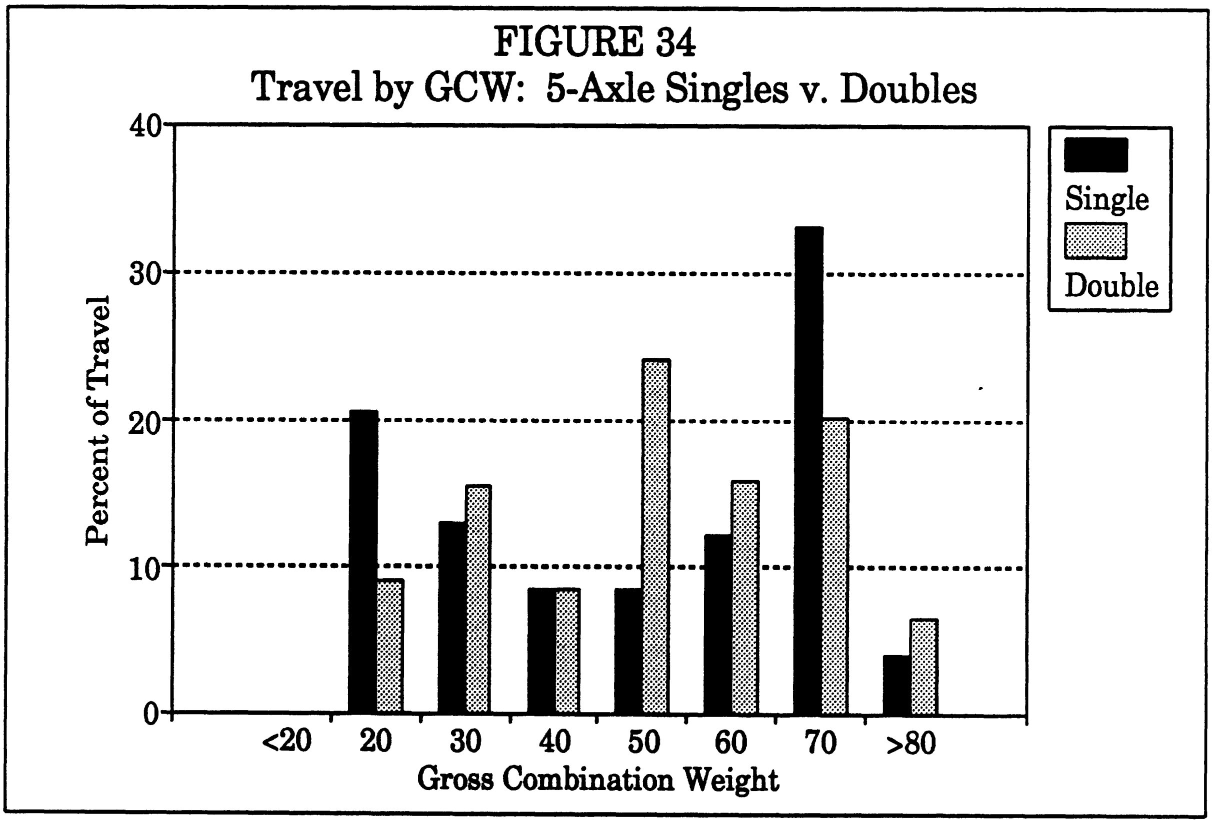


FIGURE 34
Travel by GCW: 5-Axle Singles v. Doubles
Percent of Travel
40
30
20
10
0
<20
20
30
40
50
60
70
>80
Gross Combination Weight
Single
Double

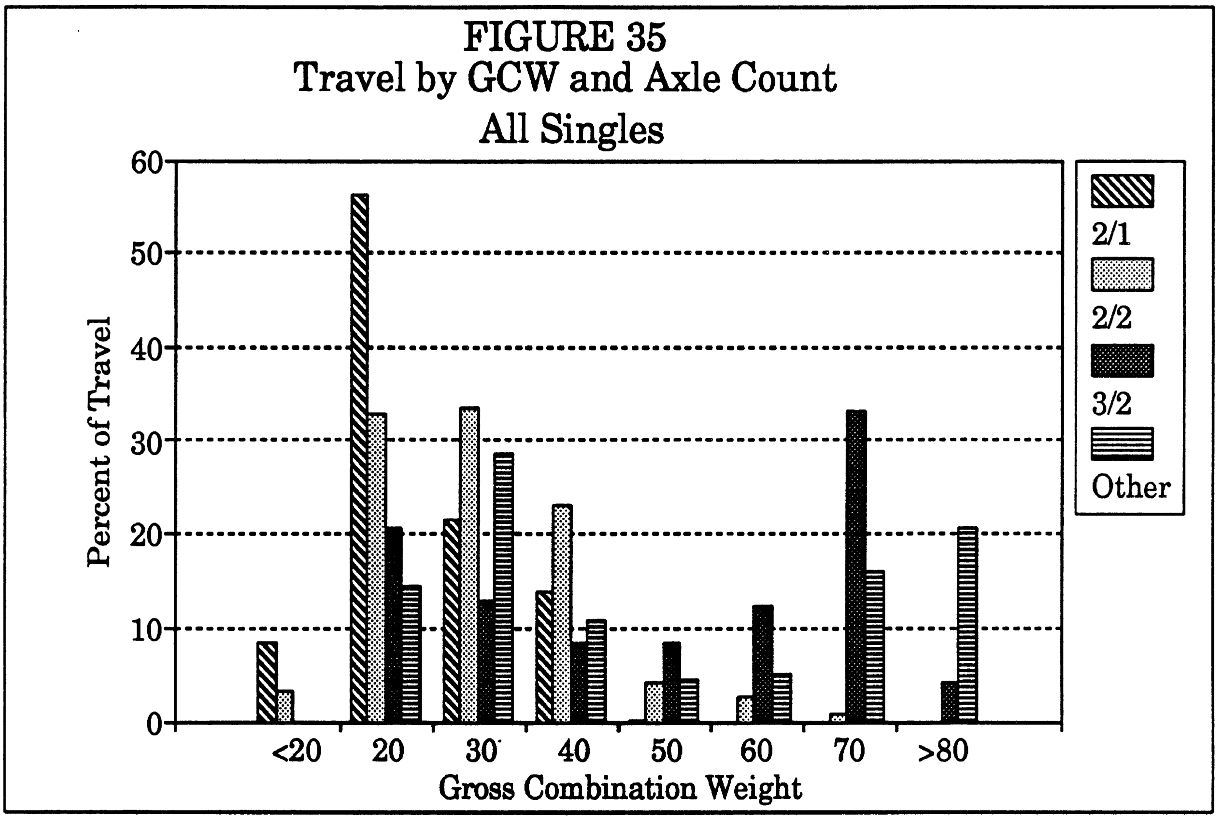


FIGURE 35
Travel by GCW and Axle Count
All Singles
Percent of Travel
60
50
40
30
20
10
0
2/1
2/2
3/2
Other
<20
20
30
40
50
60
70
>80
Gross Combination Weight

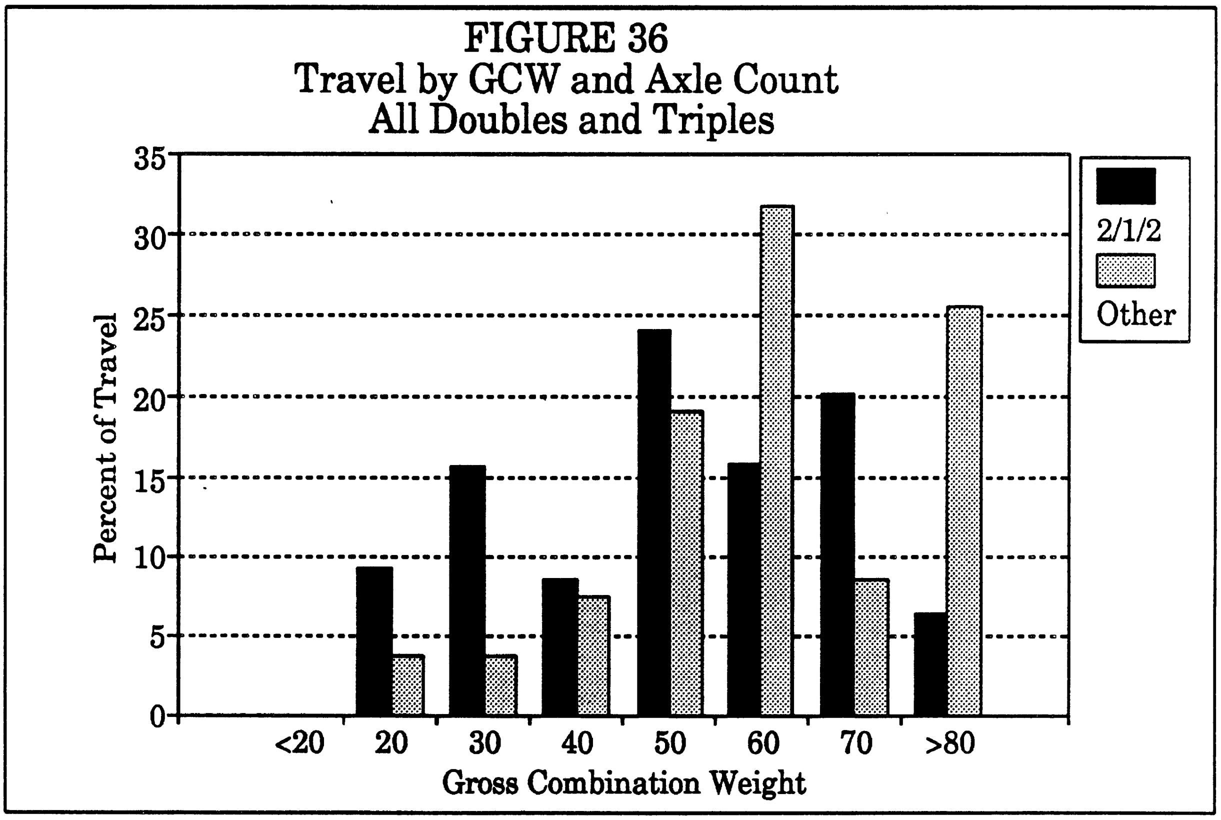


FIGURE 36
Travel by GCW and Axle Count
All Doubles and Triples
Percent of Travel
35
30
25
20
15
10
5
0
2/1/2
Other
<20
20
30
40
50
60
70
>80
Gross Combination Weight

FIGURE 37
Travel by GCW and Axle Count
All Loaded Singles

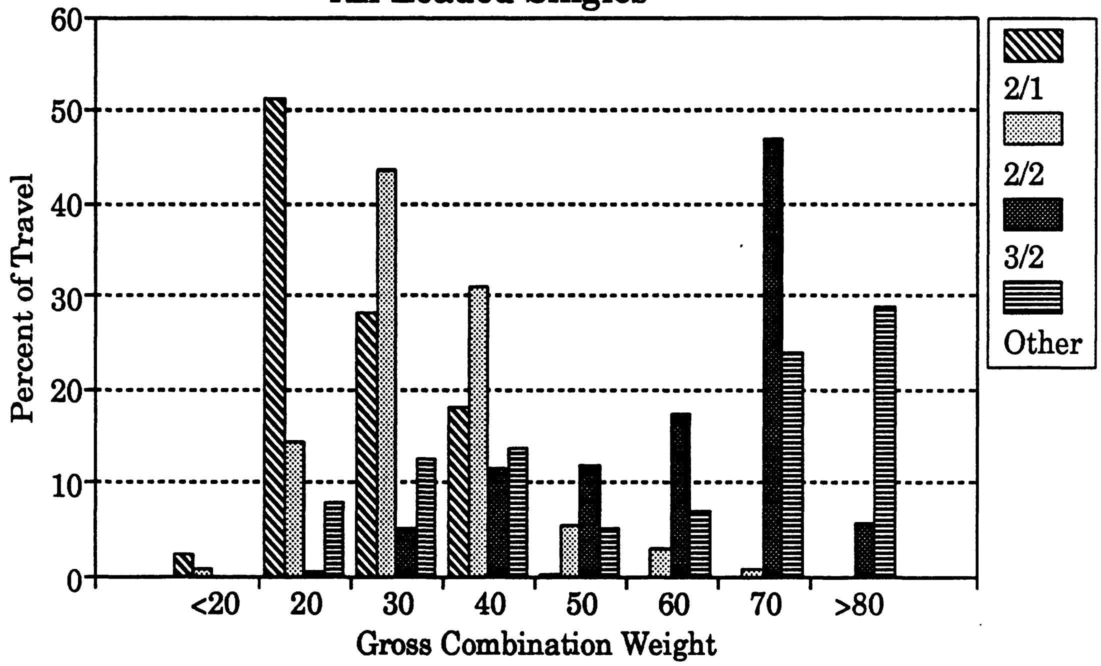
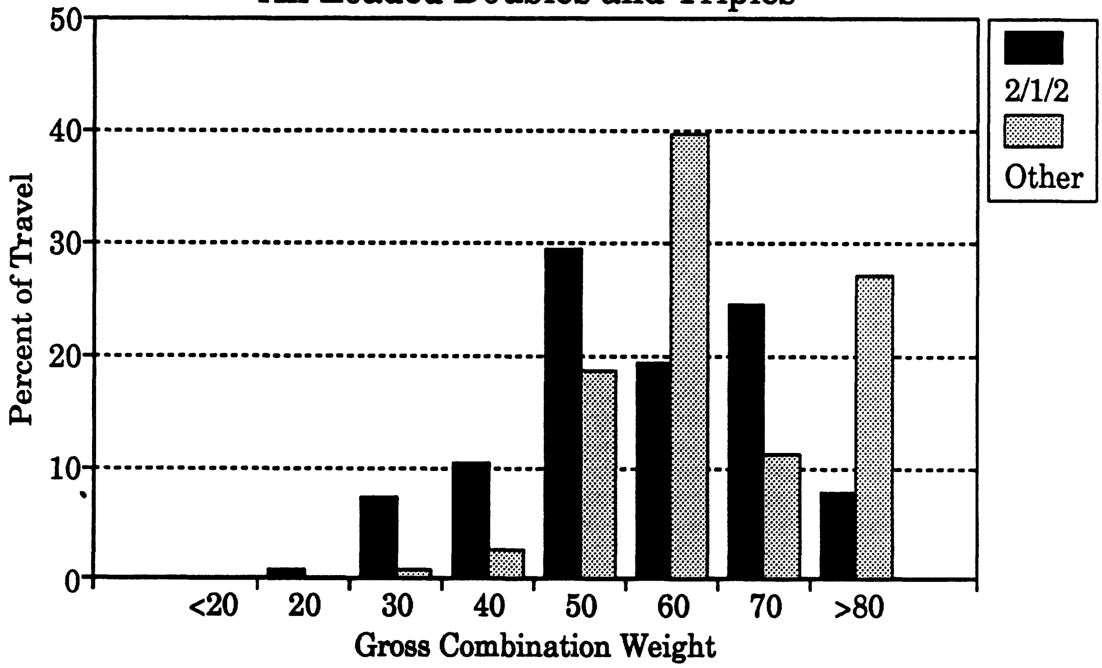


FIGURE 38
Travel by GCW and Axle Count
All Loaded Doubles and Triples



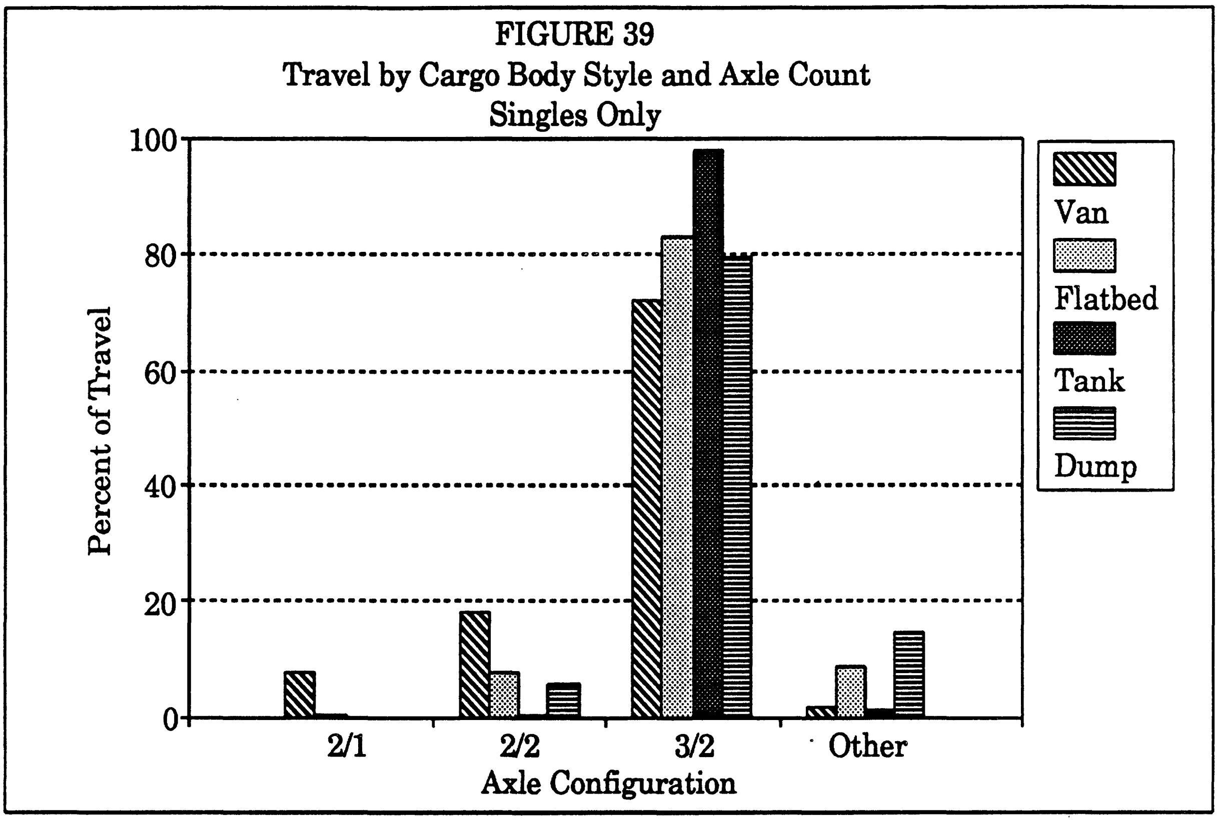


FIGURE 39
Travel by Cargo Body Style and Axle Count
Singles Only
Percent of Travel
100
80
60
40
20
0
2/1
2/2
3/2
Other
Axle Configuration
Van
Flatbed
Tank
Dump

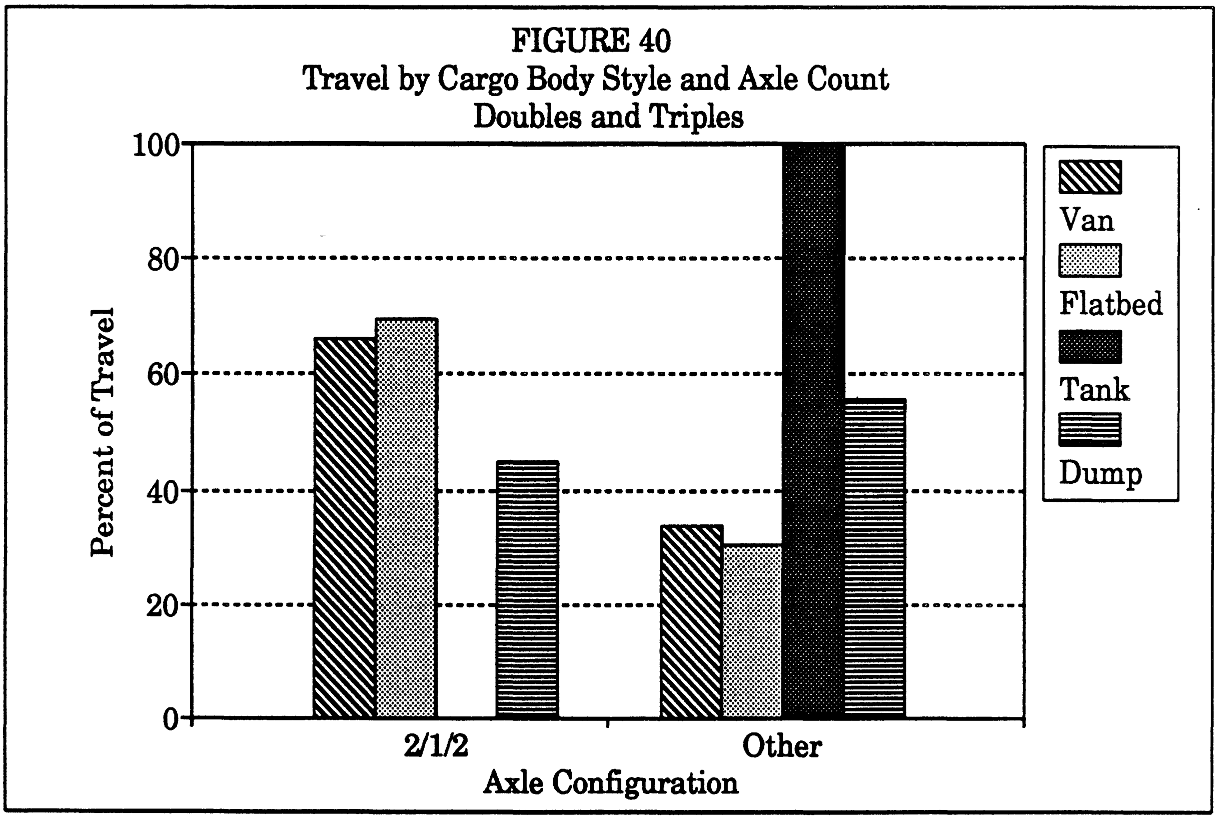


FIGURE 40
Travel by Cargo Body Style and Axle Count
Doubles and Triples
Percent of Travel
100
80
60
40
20
0
2/1/2
Other
Axle Configuration
Van
Flatbed
Tank
Dump