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A STUDY OF INTERSTATE MOTOR CARRIER VEHICLE MILES OF TRAVEL

Patricia S. Hu
Tommy Wright
Shaw-Pin Miaou*
Robert Gorman+
Stacy C. Davis

Center for Transportation Analysis
Oak Ridge National Laboratory

* University of Tennessee, Knoxville, Tennessee
+ Federal Highway Administration, U.S. Department of Transportation

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ABSTRACT

This paper summarizes the evaluation results of six data sources in terms of their ability to estimate the number of commercial trucks operating in interstate commerce and their vehicle miles of travel (VMT) by carrier type and by state, and presents two cost-effective methodologies in estimating these parameters based on the evaluation results. The six data sources were:

(1) Truck Inventory and Use Survey (TIUS) from the Bureau of the Census,

(2) Nationwide Truck Activity and Commodity Survey (NTACS) from the Bureau of the Census,

(3) National Truck Trip Information Survey (NTTIS) from the University of Michigan Transportation Research Institute (UMTRI),

(4) Highway Performance Monitoring System (HPMS) from the Federal Highway Administration (FHWA), Department of Transportation,

(5) International Registration Plan (IRP) of the American Association of Motor Vehicle Administrators (AAMVA), and

(6) State fuel tax reports from each individual state and the International Fuel Tax Agreement (IFTA).

Evaluation results concluded that none of the data sources by themselves were capable of providing reliable estimates at the state level. Although several attempts were made to combine the strengths of different data sources so that reliable estimates could be generated, none of them were successful. Data inconsistency and incompatibility contributed primarily to the failures.

Although several of the six data sources by themselves could provide estimates at the national level, each had limitations. As a result of these findings, two methodologies were proposed to estimate the number of commercial trucks operating in interstate commerce and their VMT by carrier type. Neither method required collecting additional data.

1. INTRODUCTION

The Office of Motor Carriers and other units of the Federal Highway Administration (FHWA) require estimates of **the numbers of commercial vehicles operating in interstate commerce** and their **vehicle miles of travel (VMT)**. These estimates are essential for:

- determining accident exposure and accident rates for vehicles that are subject to FHWA safety operations,
- determining and assessing highway investment needs and cost responsibilities related to vehicles that are subject to FHWA safety operations, and
- estimating the economic and operational impacts of FHWA policies and regulations that affect interstate commercial vehicles.

VMT and the numbers of vehicles operating in interstate commerce are currently estimated from the Bureau of the Census' Truck Inventory and Use Survey (TIUS), FHWA's Highway Performance Monitoring System (HPMS), and vehicle registrations reported by the states. When it becomes available, the Nationwide Truck Activity and Commodity Survey (NTACS), which is being implemented by the Bureau of the Census under the sponsorship of FHWA as a follow-on to the 1987 TIUS, can also be used to estimate these parameters.

There are other potential data sources for estimates of the numbers of vehicles operating in interstate commerce and their VMT. They are:

- Nationwide Truck Trip Survey (NTTIS) of the University of Michigan Transportation Research Institute (UMTRI),
- International Registration Plan (IRP) of the American Association of Motor Vehicle Administrators (AAMVA),
- International Fuel Tax Agreement (IFTA), and
- fuel consumption reports by the states, by the U. S. Treasury Department, and by the U. S. Departments of Energy and Transportation.

While some of these data sources are designed to obtain estimates of the number of trucks (interstate and intrastate combined) and their VMT, some are designed to collect different highway usage characteristics. While some are statistical sample surveys, others are total reports (censuses) rather than samples. Given its specific goals, each data source has its own scope in terms of the data collection method, target population, data items collected, level of data aggregation, and data validation and estimation procedures.

Consequently, different data collection objectives result in incompatible and inconsistent estimates of VMT and of the number of trucks operating in interstate commerce. The levels of inconsistency and incompatibility are amplified significantly when disaggregate estimates are required, broken down by carrier type (i.e., common, contract, exempt, and private) and by state. Controversy exists over the best method of combining these data into estimates of the number of trucks that are operating in interstate commerce as well as estimates of their VMT by carrier type and by state. This study focused on addressing this controversy.

This study had two major objectives: (1) to evaluate the sources of data in terms of their ability to provide estimates of the number of trucks operating in interstate commerce, and the associated VMT, and (2) to recommend and test the most reliable and cost-effective estimation method by using existing data sources. This study was implemented in three different phases. Six candidate data sources in terms of their ability to provide estimates of the parameters of interest were evaluated in the first phase [1]. The evaluation results suggested that none of the six data sources by themselves could provide reliable estimates at the state level. However, in conjunction with other data sources, data from IRP or IFTA were ones of the most suitable data sources in providing estimates of the parameters of interest at the national level. Consequently, a study was performed in the second phase to determine the feasibility of acquiring IRP data and IFTA data. Finally, cost-effective and reliable estimation procedures, based on the evaluation results and the findings of the feasibility study, were investigated in the last phase. This paper summarizes the findings of this study.

The next section defines the parameters of interest. A detailed description of each of the six data sources is presented in Section 3. Section 4 summarizes the evaluation results. This is followed in Section 5 by a summary of the findings from the feasibility study. Two cost-effective and reliable estimation methods, based on the evaluation results and the findings of the feasibility study, are included in Section 6. A summary concludes this paper.

2. PARAMETERS OF INTEREST

In order to evaluate various data sources in terms of their ability to estimate the number of trucks that operate in interstate commerce and their VMT, it is essential to define the parameters of interest first. The *parameter of interest* is a characteristic of a target population. Generally, the value of a parameter is unknown and must be estimated using sample data. The

target population is defined as the set of all units or elements about which information is wanted. For example, in TIUS the target population is the collection of all trucks that were in operation and registered in one of the 48 states and the District of Columbia, except for ambulances, government-owned trucks, buses, and motor homes. VMT of these TIUS trucks for a given TIUS year is an example of a parameter.

First, let the target population of this study be defined as

$$T = \{T_i \mid T_i \text{ is a truck with Gross Vehicle Weight Rating (GVWR}^1\text{) } > 10{,}000 \text{ pounds operating in interstate commerce during a given year in at least one of the 48 contiguous states or Washington, D.C.}\}$$

$$= \{T_1, T_2, \cdots, T_N\}. \quad (1)$$

Within T, each truck will fall into only one of the following four strata for a particular year. These strata are:

Stratum 1 - those trucks that operated most of the time during the particular year as a **private** carrier,

Stratum 2 - those trucks that operated most of the time during the particular year as a **common** carrier,

Stratum 3 - those trucks that operated most of the time during the particular year as a **contract** carrier, and

Stratum 4 - those trucks that operated most of the time during the particular year as an **exempt** carrier.

[1]Gross vehicle weight rating (GVWR) is the weight of a vehicle when loaded to its capacity.

The trucks in T [refer to Equation (1)] can be further categorized as follows:

Stratum 1 (Private)	Stratum 2 (Common)	Stratum 3 (Contract)	Stratum 4 (Exempt)
T_{11}	T_{21}	T_{31}	T_{41}
T_{12}	T_{22}	T_{32}	T_{42}
T_{13}	T_{23}	T_{33}	T_{43}
.	.	.	.
.	.	.	.
.	.	.	.
T_{1N_1}	T_{2N_2}	T_{3N_3}	T_{4N_4}
N_1 Trucks	N_2 Trucks	N_3 Trucks	N_4 Trucks

where T_{ij} is the j^{th} truck in stratum i of a particular year for i= 1, 2, 3, 4, and j = 1, 2, 3, ..., N_i. With N_i trucks in stratum i, there are in total N (i.e., $N_1+N_2+N_3+N_4$) trucks with GVWR greater than 10,000 lbs operating in interstate commerce.

With each T_{ij}, there are two vectors, $\vec{VMT}_{ij}$ and $\vec{S}_{ij}$, associated with it.

Let

$$\vec{VMT}_{ij} = <VMT_{ij1}, VMT_{ij2}, \cdots, VMT_{ijk}, \cdots, VMT_{ij,49}> \quad (2)$$

where

VMT_{ijk} = the number of miles travelled in state *k* for truck *j* of stratum *i* during the particular year.

Let

$$\vec{S}_{ij} = <S_{ij1}, S_{ij2}, \cdots, S_{ijk}, \cdots, S_{ij,49}> \quad (3)$$

where

$$S_{ijk} = \begin{cases} 1 \text{ if } VMT_{ijk} > 0, \\ 0 \text{ if } VMT_{ijk} = 0, \end{cases} \qquad \text{for } k = 1, 2, ..., 49.$$

In other words, S_{ijk} will have a value of **1** if truck T_{ijk} ever travelled in state *k* during the particular year. Otherwise, S_{ijk} will have a value of **0**.

2.1 Parameters at the *state* level

Three parameters of interest **at the state level** are:

(1) the number of trucks of carrier type *i* with GVWR greater than 10,000 pounds that travelled in state *k* during a particular year,

(2) the total VMT travelled in state *k* by trucks in (1) during a particular year, and

(3) the average VMT per truck of carrier type *i* travelled in state *k* during a particular year.

2.2 Parameters at the *national* level

Three relevant parameters **at the national level** are:

(1) the number of trucks of carrier type *i* with GVWR greater than 10,000 pounds operating in interstate commerce,

(2) the total VMT by trucks in (1), and

(3) the average VMT per truck of carrier type *i*.

3. DATA SOURCES

Six major data sources were evaluated in this study:

(1) Truck Inventory and Use Survey (TIUS) of the Bureau of the Census,

(2) Nationwide Truck Activity and Commodity Survey (NTACS) of the Bureau of the Census,

(3) National Truck Trip Information Survey (NTTIS) of the University of Michigan,

(4) Highway Performance Monitoring System (HPMS) of the FHWA,

(5) International Registration Plan (IRP) of the AAMVA, and

(6) State fuel tax reports and/or International Fuel Tax Agreement (IFTA).

The first three data sources are "nationwide" sample surveys which are likely to be conducted periodically - TIUS and NTACS every five years, and NTTIS every two years, provided there is sufficient funding. The remaining three data sources are collected under reporting systems which provide uninterrupted annual data. These data sources were evaluated in terms of data accuracy, data item availability, and estimation precision. They were also assessed based on the following set of criteria:

(1) the number and types of vehicles included;
(2) accessibility of the data to a user;
(3) frequency of the data collection;
(4) time lag between the data collection and availability to the public;
(5) the vehicle configurations and vehicle definitions.

As mentioned earlier, because each data source has its own specific goals in its data collection effort, it should be reemphasized that the evaluations were not made on the basis of how these data sources perform **in general** or with respect to their intended uses. Instead, the evaluations were made on the basis of how these data sources perform in estimating the specific parameters of interest for this study.

3.1 Truck Inventory and Use Survey (TIUS)

As the nation's transportation survey, TIUS provides data on the physical and operational characteristics of the nation's truck population. It is based on a probability sample of all of the trucks that were in operation and registered in one of the 50 States or the District of Columbia during TIUS' sample years - years ending in 2 and 7. Trucks owned by federal, state, and local governments, ambulances, buses, and motor homes were excluded.

The sample selection method for the 1987 TIUS was a stratified random sampling. The truck population within each state was categorized into five body types (strata): (1) pickup, (2) panel truck, van, utility vehicle, jeep and station wagon on truck chassis, (3) small single-unit truck with GVWR less than 26,000 lbs., (4) large single-unit truck with GVWR greater than or equal to 26,000 lbs., and (5) truck tractor. Because vehicle classification schemes vary from

state to state, the state truck registration files were modified by R. L. Polk and Company to achieve uniform truck body type classifications across all states. A random sample was then selected from each stratum within each state. Based on a set of statistical assumptions adopted by the Bureau of the Census, the final sample size of the 1987 TIUS was 134,321 trucks.

The complete results of the 1987 TIUS will not be published until mid 1990, hence the response rate for the 1987 survey was not known at the time of the writing. However, the results from the state of Washington were available, and the response rate for Washington was 81.7%. The response rates for the two previous TIUS surveys were 90% in both 1977 and 1982.

In each stratum, estimates of the number of trucks for each characteristic were estimated by expanding the observations from the respondents to represent all trucks in the stratum. Factors used to expand sample data were (N_{ik} / r_{ik}), where N_{ik} was the number of trucks in stratum i registered in state k, and r_{ik} was the number of respondents in stratum i in state k. This type of estimation procedure relies on an assumption that the characteristics of nonrespondents are the same as those of the respondents. The amount of bias introduced by this practice depends on the extent to which the nonrespondents differ from the respondents.

3.2 Nationwide Truck Activity and Commodity Survey (NTACS)

The NTACS is a follow-on to the 1987 TIUS to obtain additional information on commodities carried, safety features, operational characteristics, and relationships between truck usage, economic factors, geography, and highway classes travelled. The NTACS is also designed to collect from trucks basic commodity flow information which has not been measured since the last Commodity Transportation Survey in 1977.

The target population for NTACS includes all operational trucks in 1989 that were registered in one of the 50 states or the District of Columbia on July 1, 1987, and that fall within the scope of the 1987 TIUS (i.e., excluding government-owned vehicles, ambulances, buses, motor homes, etc.). However, the 1989 NTACS sample will be a subsample of the 1987 TIUS sample respondents.

The sample selection method for NTACS is a stratified two-phase three-stage sampling. Because the NTACS sample is a subsample of the sample respondents to the 1987 TIUS, the selection of the TIUS sample is the first phase, and the NTACS sample selection is the second

phase of the procedure. There are three stages to NTACS sampling. In the first stage, the trucks will be selected from the 1987 TIUS sample respondents. In the second stage, two one-week periods (for long-haul trucks) or one one-week period (for other trucks) of the year will be selected for each selected truck. In the third stage, a sample day and a substitute sample day will be selected from each selected week for each selected truck. The need for a second day of data collection is to provide more information on the greater geographical variability of vehicle movement for long-haul commodity carrying trucks. Approximately 44,000 trucks are included in the NTACS sample.

Mail-out of the questionnaires began in September 1989. The respondents were asked to report detailed travel data during sampled days. Two follow-ups were performed to improve the survey response rate. Responses were edited for reasonableness and consistency. The complete results of the NTACS are expected to be available in late 1991.

3.3 National Truck Trip Information Survey (NTTIS)

The purpose of the NTTIS is "*to provide population estimates and descriptive statistics on the national population of large trucks (with GVWR greater than 10,000 pounds) and their uses. ... The TIUS data provide data on the description of the owner and the truck. However, information on the day-to-day use of the truck is lacking. The NTTIS is designed to provide these additional data elements*" [2]. NTTIS was a one-time data collection effort, implemented during the period between 1984 and 1987. Complete results of the NTTIS became available in 1988.

The target population for NTTIS consists of all large commercial trucks (GVWR greater than 10,000 pounds) in the United States. The source of the sampling frame for NTTIS was R. L. Polk and Company. Vehicle registrations as of July 1, 1983 were used. The Polk data for California did not include trucks with model years before 1973, and the state of Oklahoma prohibited the use of its data for statistical purposes. Hence, the NTTIS sampling frame excluded trucks registered in Oklahoma and pre-1973 model-year trucks in California. With a much smaller sampling frame, duplicate registrations from state to state were able to be eliminated. Trucks included in the survey were categorized into one of the following strata: (1) straight trucks with GVWR greater than 10,000 pounds, (2) all road tractors, or (3) unknown.

A stratified two-stage cluster design was used to select samples. Within each of the 48 states (47 contiguous states, excluding Oklahoma, plus the District of Columbia), a simple random sample of trucks was selected from each stratum. For each selected truck, four days of detailed travel data over a twelve-month period were collected. Taking into account the nonresponse rate, the final realized sample sizes were 2,601 tractors and 2,511 straight trucks.

Data for the NTTIS were collected primarily by telephone. Mail was used when telephone attempts failed. The data collection effort was implemented in five phases. In Phase 1 (between January and mid-May 1985), initial contacts were made with the owners of the selected trucks mainly to secure the owners' cooperation, and to confirm vehicle identification. Vehicle misclassification was discovered in this phase. About 40% of the trucks selected from the tractor strata were found to be straight trucks, while 4% of the straight trucks should have been listed as truck tractors [3]. Phases 2 through 5 corresponded to the data collection of four sample days for each sample truck (Phase 2 was for the first sample day, etc.) Information on individual trips on the survey day were exactly mapped onto special atlantes developed by UMTRI. This approach made it possible to characterize each survey mile in terms of day and night miles and various road types.

Based on a review of UMTRI publications and personal communication with UMTRI staff, NTTIS data editing was both manual and computerized. When a reported value was questionable or when a value to a particular item could not be obtained, an imputed figure was developed by a knowledgeable transportation analyst using available information. The most common data item that was imputed was "cargo weight". The level of imputation was estimated to be under 10%.

The numbers of responses for each of the four sample days differ for different phases. Of the 5,112 trucks selected following Phase 1, the overall response rate was 86%.

The estimated number of trucks in stratum i registered in state k was derived by multiplying the observed numbers of trucks in the sample (being either straight or tractor trucks) by the correspondent weighting factor. The weighting factors were the reciprocals of the probabilities of trucks in stratum ik being selected. The weighting factors also were adjusted to account for the nonresponses and those cases where UMTRI was unable to obtain any information at all on a truck's travel.

A similar procedure was used to expand VMT_{ik}. The mapped mileage for selected days was expanded to obtain an annual estimate. NTTIS data made it possible for UMTRI to produce three different estimates of average annual mileage based on: (1) self-reported mileage, (2) odometer readings, and (3) mapped mileage derived from the travel reported on the individual survey days. UMTRI believes that the estimates based on odometer readings are the most accurate, and that the self-reported estimates are at least 15% higher than the ones derived from odometer readings [3].

3.4 Highway Performance Monitoring System (HPMS)

HPMS has been implemented by the FHWA to assess the highway systems by continually monitoring the physical conditions and usage of the systems. More specifically, HPMS is a data collection effort designed to provide current statistics on the mileage and usage of highways, to evaluate highway programs by monitoring changes in highway characteristics and performances, and to improve knowledge of the condition and performance of highway pavements. It also provides a basis for individual states and for the federal government to forecast their highway needs, to evaluate the impacts of existing highway programs and policies, and to plan future highway investment policies. The state highway agencies in cooperation with local governments implement HPMS with the guidance from field manuals and guide books developed by the FHWA. Summary statistics are published in "Highway Statistics" [4] by the FHWA annually.

The target population for HPMS consists of all non-local highway systems in either rural, small urban, or individual urbanized areas. Unlike other data sources, such as TIUS, NTACS, and NTTIS, which focus on the travel characteristics of individual "vehicles," HPMS focuses on the usage of individual "road sections." However, it should be noted that HPMS does provide information on the amount of travel by vehicle type.

A stratified probability proportional to size design is suggested in selecting a sample of road sections [5]. A stratum is defined as a specific traffic volume group within a functional system and an area type. The selection of the sample is determined in such a way that the longer the road section is, the higher the probability it has of being selected for the sample.

Traffic count data in terms of the total number of axles passing through a monitoring point are collected by Automatic Traffic Recorders for at least 14 consecutive days in a month.

These data are used to determine the "baseline" travel pattern which includes seasonal, day-of-week traffic patterns as well as growth factors (or trend). Since the enormous costs in collecting these data prohibit a large sample size, the selection of sample sections to collect baseline traffic counts tends to place emphasis on cost-effectiveness, and most of the sample sections are likely to be located in existing weight stations. According to the FHWA, a typical state has between 30 and 50 counters distributed throughout the state to collect baseline traffic counts.

To calibrate "baseline" data, coverage count programs are implemented on selected road sections to collect traffic count data for usually a one-day period. These data are then used in conjunction with the baseline data to establish annual traffic counts for these road sections.

Based on the axle count and speed of a particular vehicle, automatic classification equipment is used first to determine the length of the wheel-base. Then, a classification algorithm is used to categorize each vehicle into one of the 13 vehicle types based on the axle count and the length of the wheel-base. A study conducted by Maine's Department of Transportation concluded that four of the tested vehicle classification systems were able to correctly classify more than 91% of the vehicles, which meets the 90% accuracy level required by the HPMS [6]. However, one of the tested systems failed to correctly classify 13% of the vehicles. Another study conducted by Kansas' Department of Transportation pointed out that (1) the accuracy level of classifying passenger vehicles was 97.6%, (2) truck-trailer combinations were accurately classified over 91% of the time, and (3) the tested equipments had a tendency to undercount heavy single unit trucks with an error up to 33.6% [7]. Both studies showed that all tested systems had problems with slow-moving vehicles (< 20 mph) and vehicles in queues. The studies also noted that considerable improvements in classifying longer and multiple axle vehicles were evident since 1982.

The "average number of axles per vehicle," called the "Axle Correction Factor" in HPMS, is used to convert the total number of axles collected into the total number of vehicles. For example, if a total of 2,000 axles is counted passing through a monitoring point in a given stratum and if the "Axle Correction Factor" for that stratum is 2.03 axles per vehicle, then the estimated number of vehicles travelled in that stratum during the monitoring period is 985 (=2,000/2.03).

The total DVMT (Daily Vehicle Miles of Travel) of sample sections in a given stratum is first calculated by summing the products of the estimated number of vehicles in the sample

road section in that stratum and the length of that section of road. The estimated stratum DVMT can be developed by multiplying the total sample section DVMT by the corresponding expansion factor (the ratio of the **total** mileage in a stratum to the total **sampled** mileage in that stratum).

Both hardware and software failures cause nonresponses in HPMS. However, the level of nonresponses cannot be determined without an in-depth study.

3.5 International Registration Plan (IRP)

The International Registration Plan (IRP) is a vehicle registration reciprocity agreement among states of the United States and provinces of Canada. It provides payment of registration fees on the basis of **fleet** mileage operated in each state. IRP, initiated in 1973, is designed specifically for interstate motor carriers. As of the end of 1988, there were 39 states and one Canadian province participating in the Plan.

The target population for IRP includes any vehicle operating in interstate commerce that:

(1) has a power unit which is greater than 26,000 lbs; or

(2) has a power unit which has three or more axles, regardless of weight; or

(3) when used in combination with tractors, has a combined weight greater than 26,000 lbs.

For vehicles not included in these categories, the registration is optional.

Under IRP, a truck operator files a single registration in his/her base state and receives a base state plate and a cab card. Registration fees are collected annually for the period between July 1 and June 30 of the next year based on fleet mileage accrued during the previous period. On the registration forms, the carriers provide information on the total **fleet** mileage, number of trucks in the fleet (fleet size), vehicle type, carrier operation type, individual IRP jurisdictions and non-IRP states in which the fleet will be operating, and the percentages of their operation in these IRP jurisdictions and non-IRP states. Registrants are required to maintain travel logs of the past three years for possible audits conducted by individual states.

Data availability varies from member to member. Some members are able to provide data immediately after the registration period on computerized format. On the other hand, some members do not have adequate resources to prepare the data for external requests. In these cases, the time lag between data collection and assimilation can be as much as six months.

3.6 State Fuel Tax Reports or International Fuel Tax Agreement (IFTA)

Each state collects fuel taxes or compatible taxes (i.e., weight-distance tax) from commercial vehicles which travel in its jurisdiction for the privilege of using its highway system. Each state has different taxation requirements, tax structures, and administrative agencies. Most of the states collect fuel tax reports on a quarterly basis while the remaining states collect on a monthly or annual basis [8]. Data availability varies from state to state.

In 1983, the International Fuel Tax Agreement (IFTA) was formed to improve the inter- and intra-state fuel tax collection process. The main purpose of this Agreement is to simplify the collection and administration of motor fuels use taxes for motor vehicles operated in interstate commerce. At the time of this study (June 1989), IFTA had ten participating state members, and ten more states were to become members of the IFTA by 1991. The concept of IFTA and the vehicles included in this Agreement are similar to that used in the International Registration Plan (IRP).

The target population for the state fuel tax reports consists of all vehicles that are subject to state fuel taxes. Taxation requirements vary from state to state. Some states tax vehicles which are diesel powered; some states tax vehicles with GVWR greater than 18,000 pounds; some states tax vehicles which are interstate buses, etc. Since each state administers its own fuel tax reporting program, there is a significant degree of diversity among states with respect to fuel tax data.

However, under IFTA the target population includes any vehicle operating in interstate commerce that: (1) has two axles and GVWR exceeding 26,000 pounds, or (2) has three or more axles regardless of vehicle weight, or (3) is used in a combination when GVWR of such combination exceeds 26,000 pounds.

4. SUMMARY OF EVALUATION RESULTS

Table 1 summarizes vehicle types, vehicle configurations and weight indicators that are included by each one of the six data sources. Data accessibility, collection frequency, and time lag (between when data are collected and when data become available) of each data source are included in Table 2.

Table 1. Truck types included in different data sources

Data Source	Weight Indicator	Truck Type Included	Truck Type Excluded
TIUS	(1) GVWR $\leq$ 26K lbs: Avg. Wt. GVWR (1982, 87) (2) GVWR > 26K lbs: Empty Wt. Avg. Wt. GVWR (1982, 87)	(1) Pickup (2) Panel truck, van, utility vehicle, and station wagon (3) Small single-unit truck w/GVWR $\leq$ 26K lbs. (4) Large single-unit truck w/GVWR > 26K lbs. (5) Truck tractor	(1) Government owned (Federal, State & Local) Trucks (2) Ambulances (3) Buses (4) Motor Homes
NTACS	Same as TIUS		
NTTIS	Empty Wt. Cargo Wt. Combined Wt. GVWR (from VIN)	(1) Straight Trucks w/GVWR > 10K lbs. (2) All tractors	(1) Pickups (2) Passenger Vehicles (e.g., passenger vans, recreational vehicles) (3) Farm Tractors (4) Oklahoma, Hawaii, & Alaska trucks. (5) Pre-1973 California (6) Government owned
HPMS 1988	No	(1) 2-Axle, 4-Tire, Single-Unit other than passenger vehicles (2) 2-Axle, 6-Tire, Single-Unit (3) 3-Axle, Single Unit (4) 4 or more Axle, Single-Unit (5) 4 or less Axle, Single-Trailer (6) 5-Axle, Single-Trailer (7) 6 or more Axle, Single-Trailer (8) 5 or Less Axle, Multi-Trailer (9) 6-Axles, Multi-Trailer (10) 7 or more Axle, Multi-Trailer	
Fuel Tax	Vary by State		
IRP (39 states)	GVWR	(1) GVWR > 26K lbs. (2) Power Unit $\geq$ 3 Axles (3) Combination > 26K lbs.	(1) GVWR $\leq$ 26K lbs and 2-Axles and (2) Buses are optional

Note: (1) GVWR - Gross Vehicle Weight Rating: the weight of a vehicle when loaded to its capacity.
(2) VIN - Vehicle Identification Number.

Table 2. Data accessibility of each of the six data sources

Source	Initial year	Collection frequency	No. of states covered (contiguous 48 & D.C.)	Data accessibility	Time lag between data collection & assimilation
TIUS	1967	5 yr	All	Public Use Tape	2 yr
NTACS	1989	5 yr	All	Public Use Tape	[a]
NTTIS	1984	[b]	All except Oklahoma	Request to UMTRI	4 yr
HPMS	1978	Continual	All	Request to FHWA	10 months
State Fuel Tax	Vary by State	Continual	All	Vary by State[c]	Vary By State
IRP	1973	Continual	39 (partially)	Vary by State[c]	6 months

[a] Since the NTACS has not been implemented yet, the time lag between data collection and assimilation is unknown.
[b] One time data collection effort.
[c] Some states require written requests, some require funding to support software development in retrieving data, and some provide data upon request.

4.1 Ability to Estimate Parameters at the *State* Level

It should be emphasized that the parameters of interest in this study were the number of trucks of carrier type *i* that have GVWR greater than 10,000 pounds and are travelled in state *k*, and the amount of VMT travelled in state *k* by these trucks. The key factor was the amount of travel occurred in state *k* by these trucks, and not the amount of travel by trucks registered in state *k*. Hence, in order to estimate these parameters, four critical indicators were required for each sample truck in the data source: (1) jurisdiction of operation (interstate vs. intrastate), (2) carrier type (common, contract, exempt, and private), (3) truck weight, and (4) states where travel occurred.

At the time of this study, none of the six data sources collected all four indicators, and therefore, none of the existing data sources could provide estimates at the state level. Additional information will be required for some data sources to be able to provide reliable estimates at the state level. The current survey forms designed for TIUS, NTTIS, and NTACS come close to providing estimates at the state level. However, if TIUS and NTACS were to be used, a set of additional questions in the survey forms will be needed: a list of states where travel occurred and the amount of travel in each state. NTTIS will need an increase in sample sizes. HPMS will be a strong candidate as a data source, in conjunction with other data sources, to determine growth factors over time. IRP or IFTA can provide all of the required state level information on heavy trucks if all states become members of IRP or IFTA.

Based on the evaluation results, it was concluded that none of the six data sources by themselves could provide reliable estimates on the number of trucks (operating in interstate commerce with GVWR greater than 10,000 pounds) of carrier type i (common, contract, exempt or private) travelled in state k, and the amount of travel occurred in state k by these trucks.

4.2 Ability to Estimate Parameters at the *National* Level

The parameters of interest at the national level were: (1) the total number of trucks of carrier type *i* (common, contract, exempt, or private) operating in interstate commerce with GVWR greater than 10,000 pounds, and (2) the associated total VMT. Each of the six data sources was considered for providing estimates of these parameters.

If TIUS data are used to estimate the parameters at the national level, four major limitations need to be addressed: duplicate registration, potentially overestimated self-reported mileage, two-year time lag before data become available, and data interpolations for non-TIUS years. Similar assessments on TIUS can be applied to NTACS.

Not until all of the states become IRP members can IRP by itself provide estimates at the national level. However, this limitation can be overcome by using statistical methods which would have the capability of estimating national parameters based on partial IRP data.

Two limitations need to be addressed if NTTIS data are used to estimate the parameters at the national level. First, there was a four-year lag between the time when trucks were sampled from Polk registration files (1983) and the time when the implementation was completed (1987). The exclusion of trucks registered between 1983 and 1987 was likely to result in underestimations of the VMT and number of trucks. Second, serious misclassification of trucks in the original sampling frame introduced larger variances in the estimates than if there had been no misclassification.

HPMS data are capable of providing total truck VMT by truck type, but not the total number of trucks. Furthermore, since HPMS does not have information on the types of operation (common, contract, exempt, or private) or on the jurisdiction of operation (interstate vs. intrastate), allocation of total truck VMT into different operation types and jurisdiction types by using data from other sources, such as TIUS or NTACS, will be necessary.

Since fuel taxation requirements vary so greatly from state to state, it is not clear how the state fuel tax reports can be of any use to estimate the number of commercial trucks and the associated VMT by carrier type. However, as more states participate in IFTA, IFTA data will have great potential in estimating the parameters at the national level.

Although several of the six data sources by themselves could provide estimates at the national level, each had limitations. As a result of these findings, two methods were proposed. One method was to combine several data sources by bringing together the strengths of these data sources; the other was to take full advantage of the existing IRP data in the hope that the partial data could provide statistical models with sufficient information to estimate the national parameters. Although incomplete, IRP data potentially contain all of the information and indicators required to estimate the parameters at the national level. Table 3 presents an example of the summary VMT statistics by state travelled and by carrier type for trucks

Table 3. VMT estimates of Alabama-based interstate motor carriers by jursidiction and business type (thousands)

Traveled	Exempt	Household goods	Private	Haul-for-hire	Rental	Total
Alabama	10,190	1,896	162,195	327,457	1,619	503,358
Alaska	0	0	0	6	0	6
Arizona	672	126	644	25,374	19	26,836
Arkansas	46	107	3,541	22,403	35	26,133
California	717	202	733	27,387	13	29,051
Colorado	87	67	194	3,667	4	4,019
Connecticut	7	36	294	3,925	26	4,287
Deleware	7	13	147	1,541	5	1,713
DC	1	1	12	115	0	129
Florida	1,603	639	21,941	80,969	310	105,462
Georgia	1,065	621	27,202	115,876	398	145,161
Idaho	58	18	56	2,739	3	2,873
Illinois	54	138	2,892	22,629	68	25,781
Indiana	83	120	3,296	28,229	80	31,807
Iowa	17	48	327	3,807	6	4,204
Kansas	29	168	216	3,065	7	3,484
Kentucky	192	165	7,448	39,998	144	47,947
Louisiana	662	336	10,803	46,806	127	58,735
Maine	18	8	46	833	2	907
Maryland	20	181	886	10,102	30	11,219
Massachusetts	11	26	180	2,696	11	2,923
Michigan	23	51	684	5,881	26	6,665
Minnisota	22	15	163	1,743	7	1,950
Mississippi	1,224	375	24,421	70,101	211	96,332
Missouri	26	124	2,094	16,333	48	18,625
Montana	14	10	43	747	3	815
Nebraska	14	51	155	2,935	4	3,158
Nevada	9	16	89	2,258	1	2,373
New Hampshire	5	4	22	579	1	610
New Jersey	22	68	742	7,953	35	8,820
New Mexico	334	91	486	15,507	9	16,427
New York	9	72	692	7,900	33	8,706
North Carolina	84	286	5,022	42,415	106	47,913
North Dakota	16	6	38	617	3	680
Ohio	70	107	2,538	27,659	96	30,470
Oklahoma	82	97	763	9,846	16	10,803
Oregon	65	42	61	2,609	3	2,780
Pennsylvania	42	105	1,934	22,150	90	24,320
Rhode Island	1	6	52	473	3	536
South Carolina	100	222	5,295	41,412	91	47,120
South Dakota	8	9	52	555	3	628
Tennessee	397	331	23,089	75,167	319	99,304
Texas	2,441	521	4,615	83,785	128	91,491
Utah	51	22	60	2,247	3	2,383
Vermont	5	6	25	654	2	692
Virginia	87	292	5,275	43,072	204	48,930
Washington	66	19	36	1,728	2	1,851
West Virginia	13	30	631	8,512	41	9,227
Wisconsin	62	33	524	5,018	11	5,648
Wyoming	45	31	113	3,883	4	4,076
Total	**20,875**	**7,953**	**322,768**	**1,273,363**	**4,409**	**1,629,368**

Source: Alabama IRP tape provided by Norman Goss of the Alabama Department of Revenue.

registered in the state of Alabama. A similar table can be produced for the numbers of trucks operating in interstate commerce. However, the one limitation in using IRP data was that long-term trends cannot be established using IRP data due to the lack of historical data.

The first question in using IRP data was whether the data were obtainable. The feasibility of acquiring either IRP data or IFTA data was investigated and is discussed in the next section.

5. FEASIBILITY OF ACQUIRING IRP AND IFTA DATA

At the end of 1988, there were 39 IRP states, of which 14 states were participants in the Vehicle Information System for Tax Allocation, VISTA. Since IRP is operated under the guidance of the American Association of Motor Vehicle Administrators (AAMVA), AAMVA will be the liaison between IRP member states and any party requesting the data. IFTA had ten participating states, and approximately ten more states were anticipated to become members by 1991.

The feasibility study began by conducting a series of inquiries. Inquiries were conducted through telephone calls and letters regarding data on the number of commercial vehicles operating in interstate commerce and their associated VMT. All 39 IRP-state administrative offices were contacted throughout the course of each inquiry. Specific purposes of the inquiry were to:

- assess the availability of the data,
- understand the policy on releasing the data and the associated cost,
- determine the procedures required to obtain the data, and
- determine the time lag when the data become available for analysis after the year ends.

In general, a written request from each IRP state will be needed in acquiring the data. The costs involved were essentially service charges, including programming costs, if necessary, and computer processing costs. Some states indicated that data could be made available approximately three months after the end of the year. However, most states indicated that a detailed data request will be needed to determine the amount of effort that was required. Most of the states were willing to assist, if the request was from the FHWA. Tables 3 and 4 of [9] summarize in detail the findings of the feasibility study.

One major factor in successfully using IRP data is the cooperation of AAMVA and the member states. The cooperation of AAMVA will help to assure that IRP member states

respond promptly to requests for data. In the first phase of the study, Oak Ridge National Laboratory (ORNL) planned to obtain data from three IRP member states. The State of Alabama sent the complete dataset in a computer readable format, but the other states did not respond to the data request in time for this study to be completed on schedule. Involvement and commitment from individual member states are essential if IRP data are to be used for estimation purposes.

6. RECOMMENDED ESTIMATION METHODS

Based on the evaluation results, two estimation methods were recommended. Using the existing available data sources, these methods would produce acceptable annual national estimates of the number of trucks with GVWR greater than 10,000 pounds operating in interstate commerce and the associated VMT.

6.1 Method I - Based on IRP and TIUS

The first method suggests using a combination of IRP and TIUS data. At the time of this study, there were only 39 IRP states and it is likely to be a long process before all states become members of the IRP. Until then, the IRP data will remain incomplete. The basic idea of this method is to take full advantage of the IRP data and to nationalize the partially available IRP data based on the TIUS data.

Two concerns need to be addressed in using this method. First, this method can only provide estimates beginning with the current year but not the historical trends because individual states became IRP members at different years. However, it is possible to establish trends using this approach in a few years once there are enough annual data accumulated. Second, since TIUS is only implemented during the years ending in 2 and 7, procedures will be necessary to estimate data for non-TIUS years. Trend analysis can be used, either based on the HPMS data or some other freight economic indexes, to project annual growth rates of the parameters of interest for non-TIUS years. Based on the projected trends, IRP data can be nationalized for the non-TIUS years. Since only limited IRP data were available to this study, this method needs a future in-depth study.

Assume the general setting in Table 4 where, for example, $VMT_{1k}(I)$ is the total (over all states) "reported" IRP mileage (VMT) of **private** carriers that are operating in interstate

commerce and based in state k for a given year and $VMT_{1k}(T)$ is the corresponding total "reported" TIUS (most recent figures) mileage (VMT) of **private** carriers that are operating in interstate commerce and based in state k. For each year, the desire is to know the four parameters:

$$VMT_{i\bullet}(I) = \sum_{k=1}^{49} VMT_{ik}(I), \quad \text{for } i = 1, 2, 3, 4 \tag{4}$$

$$= \text{total VMT of carrier type i operating in interstate commerce for a given year (reported in the IRP)}$$

Note that all of the corresponding figures will be available from TIUS during TIUS' years. Assuming that the first 39 states in Table 4 are the current IRP members, then only the first 39 columns of the IRP figures may be available each year. Thus $VMT_{1\bullet}(I)$, $VMT_{2\bullet}(I)$, $VMT_{3\bullet}(I)$, and $VMT_{4\bullet}(I)$ will be unknown. Assuming that the corresponding IRP and TIUS figures are highly correlated and under certain models ([10] and [11]), the four parameters can be estimated by the following "ratio" estimators:

$$VMT_{i\bullet}(I) = VMT_{i\bullet}(T) \frac{\sum_{k=1}^{39} VMT_{ik}(I)}{\sum_{k=1}^{39} VMT_{ik}(T)}, \tag{5}$$

where i = 1 for **private** carriers; 2 for **common** carriers; 3 for **contract** carriers; and 4 for **exempt** carriers.

Table 4. VMT Parameters for Interstate Motor Carriers Using IRP and TIUS Data

		Base State							
		1	2	3	4 ...	i ...	49*	Total
IRP	Private (1)	$VMT_{11}(I)$	$VMT_{12}(I)$	$VMT_{13}(I)$	$VMT_{14}(I)$ ...	$VMT_{1i}(I)$ ...	$VMT_{1,49}(I)$	$\mathbf{VMT_{1\bullet}(I)}$
	Common (2)	$VMT_{21}(I)$	$VMT_{22}(I)$	$VMT_{23}(I)$	$VMT_{24}(I)$ ...	$VMT_{2i}(I)$ ...	$VMT_{2,49}(I)$	$\mathbf{VMT_{2\bullet}(I)}$
	Contract (3)	.	.	.	.	.	.	$\mathbf{VMT_{3\bullet}(I)}$
	Exempt (4)	.	.	.	.	.	.	$\mathbf{VMT_{4\bullet}(I)}$
TIUS	Private (1)	$VMT_{11}(T)$	$VMT_{12}(T)$	$VMT_{13}(T)$	$VMT_{14}(T)$ ...	$VMT_{1i}(T)$ ...	$VMT_{1,49}(T)$	$\mathbf{VMT_{1\bullet}(T)}$
	Common (2)	$VMT_{21}(T)$	$VMT_{22}(T)$	$VMT_{23}(T)$	$VMT_{24}(T)$ ...	$VMT_{2i}(T)$ ...	$VMT_{2,49}(T)$	$\mathbf{VMT_{2\bullet}(T)}$
	Contract (3)	.	.	.	.	.	.	$\mathbf{VMT_{3\bullet}(T)}$
	Exempt (4)	.	.	.	.	.	.	$\mathbf{VMT_{4\bullet}(T)}$

* Washington, D.C. is included as a state.

Of course, the reliability of the four estimates decreases as one uses fewer IRP states for the sample and if certain model assumptions do not hold. Only when more IRP data are available from other states (like that collected from Alabama) will one be able to begin to determine if the suggested ratio estimators are feasible alternatives. While this discussion focuses on VMT, similar results hold for number of trucks. No numerical estimates are given for this method due to the limited IRP data available for this study.

6.2 Method II - Based on TIUS and HPMS

The second method combines two data sources in a trend analysis. Annual growth rates were estimated using data from a continual reporting system of HPMS that covers all of the states. These growth rates then were used to project the direction and the magnitude of changes from one year to the next. The growth rate of the current year is defined as the ratio of the figure in the current year over that of the previous year. In particular, this method suggests that HPMS data be used to develop the annual growth rates of two parameters (number of trucks and VMT) and that the parameters for years between two TIUS years be estimated based on these annual growth rates.

HPMS is selected for its potential to completely cover the nation's truck population. HPMS is the only data source that generates truck statistics for all states on an annual basis. However, HPMS is unable to separate trucks operating in interstate commerce from the rest of the truck population. Furthermore, there are two major data limitations in HPMS. One is the uncertainty about the **actual** sampling methods implemented by the individual states. The other is the errors introduced during the data collection and conversion process (i.e., convert number of axles to number of vehicles).

By developing growth rates between two years, much of the uncertainty and errors in the HPMS data might cancel out. As a further support for using HPMS data to develop growth rates, a time series regression model relating the HPMS and the Real Highway Freight Transportation Outlays data [12] was studied. The purpose of this exercise was to make certain that the trends of the HPMS data follow the trends observed in the Transportation Outlays indices. A highly statistically significant correlation between these two data series was found and arguments against using the HPMS data in developing growth rates were partly eliminated.

The basic idea of this method is to use TIUS estimates for TIUS years and to project for the non-TIUS years based on **trends** observed in HPMS. TIUS is identified for the statistical validity of its data collection method, its coverage of all states and all types of trucks, and its ability to identify interstate motor carriers. Furthermore, TIUS is the only available data source that can provide acceptable VMT estimates of interstate motor carriers at the national level. However, the major shortcoming of the TIUS data is the lack of data between two TIUS years which are five years apart. An additional shortcoming of the 1982 TIUS data is that there is no information to distinguish "for-hire" carriers in terms of carrier type (i.e., common, contract, and exempt). However, this shortcoming has been improved in the 1987 TIUS data.

Statistics of combination trucks from the HPMS were used to develop the growth rates. The reason for selecting the combination trucks statistics to approximate the rates of change in interstate motor carriers was that the combination truck was the HPMS truck type that was more representative of the interstate motor carriers than the other two truck types (2-axle 4-tire single unit, and other single unit). Based on the 1982 TIUS, VMT of trucks with GVWR greater than 10,000 pounds operating in interstate commerce accounted for 66% of all combination trucks VMT, compared to 17% and 9% of all other single-units and 2-axle 4-tire single-units, respectively.

Although statistics of combination trucks in HPMS include both inter- and intra-state carriers, it was assumed that the economic conditions had similar impacts on VMT changes in either of the two carrier types, and, therefore, the results of including intrastate VMT will be factored out in the growth rate development.

One significant drawback in this method is that statistics for "private-interstate" trucks (i.e., privately-owned and operating in interstate commerce) can only be obtained from the public use tapes. With only the 1982 TIUS public use tape available to us, statistics for this sector of the motor carrier industry are interpolated based on information from the publications, as well as from the 1982 public use tape. Table 5 presents estimates of trucks with GVWR greater than 10,000 pounds operating in interstate commerce, by type of operation (for-hire vs private). Because of the limited availability of data, several assumptions were adopted in calculating these estimates for years prior to 1982, both TIUS and non-TIUS years. These assumptions are documented in Table 5.

Table 5. Number of trucks and VMT estimates for trucks greater than 10,000 pounds and operating in interstate commerce

Based on TIUS and HPMS

Year	For-Hire			Private			Total	
	VMT (10^6)	No. of trucks (10^3)	VMT per truck	VMT (10^6)	No. of trucks (10^3)	VMT per truck	VMT (10^6)	No. of trucks (10^3)
1989*	32,527.0	396.8	81,973.3	69,532.4	2,988.4	23,267.4	102,059.4	3,385.2
1988*	30,831.2	391.2	78,811.9	65,907.3	2,946.3	22,369.5	96,738.5	3,337.5
1987	29,223.8	385.7	75,768.4	62,471.3	2,904.8	21,506.2	91,695.1	3,290.5
1988	27,700.3	380.2	72,857.2	59,214.4	2,863.9	20,676.1	86,914.7	3,244.1
1985	26,944.4	381.3	70,664.6	57,598.7	2,872.1	20,054.6	84,543.1	3,253.4
1984	26,188.6	364.2	71,907.2	55,982.9	2,743.1	20,408.6	82,171.5	3,107.3
1983	23,611.6	354.4	66,624.2	50,474.1	2,669.4	18,908.4	74,085.7	3,023.8
1982**	22,567.1	343.8	65,640.2	48,241.1	2,589.6	18,628.8	70,808.2	2,933.4
1981	24,322.9	359.4	67,676.4	49,725.4	2,454.3	20,260.5	74,048.3	2,813.7
1980	25,116.5	423.7	59,278.9	49,101.2	2,622.2	18,725.2	74,217.7	3,045.9
1979	25,467.2	436.7	58,317.4	47,608.8	2,438.6	19,523.0	73,076.0	2,875.3
1978	24,892.1	441.5	56,380.7	44,497.7	2,245.0	19,820.8	69,389.8	2,686.5
1977	22,872.3[1]	427.9[2]	53,452.4	39,098.2[4]	1,972.3[6]	19,823.7	61,970.5	2,400.2
1976	20,788.7	410.7	50,617.7	36,481.9	1,999.8	18,242.8	57,270.6	2,410.5
1975	19,917.6	368.9	53,991.9	35,883.1	1,898.2	18,903.8	55,800.7	2,267.1
1974	19,961.1	344.0	58,026.5	36,918.2	1,870.6	19,736.0	56,879.3	2,214.6
1973	20,194.4	317.2	63,664.6	38,343.3	1,822.3	21,041.2	58,537.7	2,139.5
1972	18,344.6[1]	287.9[3]	63,718.6	35,757.8[5]	1,748.3[7]	20,452.9	54,102.4	2,036.2
1971	17,179.0	279.7	61,419.3	33,485.9	1,698.0	19,720.8	50,664.9	1,977.7
1970	16,610.9	279.7	59,388.3	32,378.5	1,698.4	19,064.1	48,989.4	1,978.1
1969	16,306.8	274.9	59,319.0	31,785.7	1,669.7	19,036.8	48,092.5	1,944.6
1968	15,577.4	262.4	59,365.1	30,364.0	1,593.3	19,057.3	45,941.4	1,855.7
1967	14,841.7[1]	253.2[3]	58,616.5	28,929.9[5]	1,537.6[7]	18,814.9	43,771.6	1,790.8

*Assume the annual growth rate is identical to the one observed from 1986 to 1987.
**1982 TIUS public use tape.

Table 5. (Continued)

Assumptions when calculating estimates of '**For-Hire Interstate**':

1. In 1982, 96.5% of the total '**For-Hire Interstate**' VMT is by trucks with GVWR greater than 10,000 pounds. Without the 1967, 1972 and 1977 public use tapes to calculate the VMT of '**For-Hire Interstate**' trucks with GVWR greater than 10,000 pounds, the VMT figures for these earlier TIUS years are corrected by a factor of 96.5%.
2. In 1982, 93.5% of the total '**For-Hire Interstate**' trucks are greater than 10,000 pounds in GVWR. Without the 1977 public use tape to calculate the number of trucks of '**For-Hire Interstate**' trucks with GVWR greater than 10,000 pounds, the 1977 figure is corrected by a factor of 93.5%.
3. In order to distribute the 1967 and 1972 numbers of '**For-Hire**' trucks into '**Interstate**' and '**Intrastate**', the average of 1977 and 1982 ratios is used. In 1977, 39.7% (457.7/1,152.7) of '**For-Hire**' trucks are operating in interstate commerce; and 41.6% (367.6/882.6) in 1982. On the average, 40% of all '**For-Hire**' trucks are mostly operating in interstate commerce.

   In 1972, there were 770,000 '**For-Hire**' trucks. Therefore, there are 770,000 x 40% = 308,000 '**For-Hire Interstate**' trucks. This figure is further corrected by a factor of 93.5% to estimate the number of '**For-Hire Interstate**' trucks that are greater than 10,000 pounds (see Assumption 2). Similar method applies to the 677,000 '**For-Hire**' trucks in 1967.

Assumptions when calculating estimates of '**Private Interstate**':

4. Based on data from the 1982 public use tape, 20.3% of all '**Not For-Hire**' VMT (340,505 millions miles) are by '**Private Interstate**' trucks (69,246 millions miles). Since there is no 1977 public use tape available, 20.3% of the published 1977 '**Not For-Hire**' VMT (275,974 millions miles) is assumed to be '**Private Interstate**' VMT. This figure (20.3% of 275,974 millions miles) is further corrected by a factor of 69.7%. This factor is based on the 1982 data where 69.7% of all '**Private Interstate**' VMT are by '**Private Interstate**' trucks with GVWR greater than 10,000 pounds.

Table 5. (Continued)

5. In order to estimate '**Private Interstate**' VMT based on the '**For-Hire Interstate**' VMT (the only available data in 1967 and 1972) the average of 1977 and 1982 ratios is used. Based on 1977 and 1982 data, '**Private Interstate**' VMT is on the average 2.7 times of that of '**For-Hire Interstate**'. This ratio then applies to all previous TIUS '**For-Hire Interstate**' VMT. The 15,380 million miles by the '**For-Hire interstate**' trucks in 1967 and 19,010 millions miles in 1972 are expanded 2.7 times.

   The estimated 1967 and 1972 '**Private Interstate**' VMT are further corrected by a factor of 69.7% to derive the VMT of '**Private Interstate**' trucks with GVWR greater than 10,000 pounds (see Assumption 4).

6. Based on data from the 1982 public use tape, 12.4% of all '**Not For-Hire**' trucks (32,909.7 thousands) are classified as '**Private Interstate**' trucks (4,069 thousands). Since there is no 1977 public use tape available, 12.4% of the 1977 number of '**Not For-Hire**' trucks (25,060 thousands) is assumed to be '**Private Interstate**'. This figure (12.4% of 25,060.7 thousands trucks) is further corrected by a factor of 63.6%. This factor is based on the 1982 data where 63.6% of all '**Private Interstate**' trucks are '**Private Interstate**' trucks with GVWR greater than 10,000 pounds (2,589.6 out of 4,068.9 thousands trucks).

7. In order to estimate the number of '**Private Interstate**' trucks based on the number of '**For-Hire Interstate**' trucks (the only available data in 1967 and 1972), the average of 1977 and 1982 ratios is used. Based on 1977 and 1982 data, the number of '**Private Interstate**' trucks is on the average 8.92 times that of '**For-Hire Interstate**'. This ratio then applies to all previous TIUS statistics. The 308.0 thousand '**For-Hire interstate**' trucks in 1967 and 2,70.8 thousand trucks in 1972 are expanded 8.92 times.

   The estimated 1967 and 1972 '**Private Interstate**' trucks are further corrected by a factor of 63.6% to derive the total number of '**Private Interstate**' trucks with GVWR greater than 10,000 pounds (see Assumption 6).

6.3 Assessments of Methods I and II

Each of the recommended methods has advantages and disadvantages. Due to the limited availability of data, Method I could not provide historical trends at the present time. Furthermore, the major factor in successfully implementing Method I (which combines IRP and TIUS data) is in securing the cooperation of AAMVA and IRP member states. However, once all necessary IRP data become available, Method I is preferred over Method II (which combines TIUS and HPMS data) simply because complete IRP data will provide the exact breakdown of the statistics so that minimum assumptions will be necessary.

On the other hand, Method II, which uses both TIUS and HPMS data, adopts several assumptions in distributing historical data into different categories (i.e., for-hire vs. private, GVWR greater than 10,000 pounds vs. less than 10,000 pounds, interstate vs. intrastate, etc.) At the time of the study, the validity of these assumptions was difficult to verify due to the limited available data. However, when the 1987 TIUS data become available, the validity of the assumption can be better assessed.

7. SUMMARY

This paper summarizes the results of a study aimed at estimating the number of commercial trucks with Gross Vehicle Weight Rating (GVWR) greater than 10,000 pounds operating in interstate commerce, and the associated vehicle miles of travel (VMT) by carrier type (i.e., private, common, contract, and exempt) and by state. Six transportation data sources, including three nationwide truck surveys, one highway performance monitoring system, and two tax-oriented registration plans, were evaluated in terms of their ability to provide these estimates with acceptable reliability. Specifically, we examined whether individual data sources contained enough information to identify the following four "indicators" which were necessary to provide the estimates: (1) jurisdiction of operation (interstate vs. intrastate), (2) carrier type (private, common, contract, and exempt), (3) truck weight, and (4) states where travel occurred. In addition, each data source was assessed based on additional criteria, such as (a) the number and types of trucks included, (b) accessibility of the data to a user, (c) data collection frequency, and (d) timeliness.

Our evaluations concluded that none of the data sources by themselves were capable of providing acceptable estimates at the state level. We further looked into the possibility of

combining different data sources to obtain these estimates at the state level. The attempt failed mainly because of the lack of coherent variable definitions, uniform sampling frames, and consistent sample periods among the different data sources.

However, by combining the strengths of several data sources, we recommended two methods which, in our opinion, were capable of providing acceptable estimates on the number of commercial trucks operating in interstate commerce and their associated VMT at the national level. The first method took advantage of the information contained in the International Registration Plan (IRP) data and nationalized the partially available IRP data (only 39 states were IRP members) based on the Truck Inventory and Use Survey (TIUS) data. Subject to data availability, this method was not examined numerically in this study. The method was, however, considered to have a greater potential in generating reliable estimates when 1987 TIUS data become available. The second method utilized data from the TIUS and the Highway Performance Monitoring System (HPMS). In this method, TIUS was used as the main source for obtaining estimates by carrier type for TIUS years (years ending in 2 and 7), while HPMS was used to project annual growth rates between two TIUS years. Based on the projected growth rates, estimates for non-TIUS years were generated to account for the year-to-year variations -- a dynamic content which was generally lacking in the nationwide transportation surveys, such as TIUS. Since the 1982 TIUS did not contain enough information to further distinguish "for-hire" carriers, numerical estimates were generated for two types of carriers: "**for-hire**" and **private**.

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