

Washington Motor Vehicle Operating Cost Survey

C. K. GLAZE, *Principal Planning Engineer, and*
GEORGE VAN MIEGHEM, *Associate Highway Engineer*
Washington State Highway Commission

The Washington Motor Vehicle Operating Cost Survey was a joint undertaking of the State of Washington Department of Highways, the Western Highway Institute, and the U. S. Bureau of Public Roads. Factual data on operating costs of the different vehicle types was information of importance to all three of the participating agencies, primarily for use in the investigation of tax allocation theories.

Operating cost figures were collected for all vehicle types, segregated by fuel type and type of service. The data were furnished by the individual operators on forms designed specifically for the survey. Figures were obtained from actual records covering current operations. The collection of data was begun in 1952 and covered a full year period or any shorter portion of a year available.

The Western Highway Institute assigned a full-time resident engineer to the project to make contact with truck operators and any required subsequent callbacks.

Passenger car operating cost information was collected during the course of interviewing for the Motor Vehicle Use Study, which was being conducted simultaneously by the Department of Highways. Commercial passenger car data were obtained from several state governmental departments and from private commercial organizations operating passenger cars.

Farm truck data also were obtained during interviews for the Motor Vehicle Use Study, but because of the inadequate sample thus obtained, supplemental data were obtained through many local farm granges that solicited their members for cost records. Data for a 14 percent sample of taxi registration were obtained directly from taxi operators. School bus information was obtained from many individual school districts; commercial bus operators furnished the information for the non-school operations. Information on for-hire trucks was obtained by selecting a periodic sample of carriers from Public Service Commission records, and these carriers were solicited for actual cost data. The private commercial truck sample was chosen from a selection of operators made from business directory listings covering a number of cities throughout the state.

As was expected, much variation was found in the values reported. A large number of curves has been developed, showing the various components of vehicle operating cost depicting the variation with vehicle gross weight for the various vehicle types, fuel types, and types of service in which the vehicles were engaged. Although there may be serious limitations in applying these curves to operating conditions and vehicles in other states, the information is probably more comprehensive than any presently available elsewhere.

- A COMPLETE KNOWLEDGE of operating costs of motor vehicles under actual operating conditions has long been needed by engineers, statisticians, and economists in the field of highway economics. Such information has many uses, primarily in such fields as the establishment of theoretical criteria for optimum

sizes and weights and the determination of the relationship between value of service and highway costs. These factors influence highway location, design standards, and the determination of motor vehicle tax rates. Surveys made under either limited or ideal conditions have but little resemblance to data which is secured in studies of all segments of normal highway operation with long and short hauls, and/or under conditions encountered in congested city traffic. On this premise, a plan was conceived to investigate the motor vehicle field to determine operating cost.

The data is confined to motor vehicle operations within the State of Washington. Vehicles in interstate operation were deleted so that there would be no distortion caused by the variable costs between states. However, the geographical and cultural features in Washington are similar to those in many other western states. There is a large metropolitan area, a major seaport, rural country similar to much of the Pacific coastal area, mountainous terrain typical of other western states, and a plains area as in the more arid western states. Consequently, the data is applicable to vehicle operations in much of the West. The Washington State Highway Commission, Department of Highways, the Bureau of Public Roads of the U. S. Department of Commerce, and the Western Highway Institute agreed to conduct a survey of operating costs of motor vehicles within the state during 1952 and 1953.

The survey gathered cost data for vehicles, ranging from the passenger car to the 72,000-lb maximum weight group of commercial combinations. Primary consideration was given to obtaining the costs of operation for each of the licensed gross-weight groups on a per mile basis and total costs of operation. Segregations were made (wherever feasible) by vehicle type, kind of fuel used, and type of operation. A correlation between licensed gross weight and average operating gross weight was determined from information provided by annual truck weight surveys conducted by the Department of Highways. Both weight bases

were indicated on the curves of the various cost elements.

Since the survey was conducted solely for the purpose of gathering and compiling cost data, no application of the data was made.

The cost per mile for the many types of vehicles varies widely and depends upon the vehicle size, kind of fuel used, type of operation, class of carrier, terrain, and many other factors. Wide cost variations are also found between similar carriers, hauling the same class of commodity, within the same geographic area.

The total unit cost of operation was segregated into its elements to evaluate variations. This procedure combined the cost elements into logical groupings for practical use, and minimized work required to apply the data to different conditions.

The work was confined to a sample of vehicles chosen to produce statistical stability, geographic dispersion, adequate coverage by type of carrier, fuel used, and type of operation.

Operating costs for private passenger cars were obtained from an approximate 10 percent subsample of the vehicles in the Motor Vehicle Use Study conducted by the Department of Highways. That study evaluated motor vehicle ownership and use characteristics, and it was conducted by interview of residents of pre-selected dwelling units in representative economic areas of the state. Estimated operating costs for approximately 300 private passenger cars were obtained by this method. Data for approximately 300 commercial passenger cars were obtained from several state governmental departments and from commercial users throughout the state. Costs for operating taxicabs were made available by one company in a large metropolitan area. The sample contained 165 vehicles, approximately 14 percent of the total state taxicab registration.

Farm truck data were, in part, obtained from the Motor Vehicle Use Study. However, the number of vehicles from this source was statistically inadequate, and vehicles were added through cooperation of the local granges. Data were se-

cured for 114 farm vehicles.

Because the number of buses in Washington is small, information was sought from as many bus operators as possible. School bus data were secured from school districts located in the counties selected for interviewing in the Motor Vehicle Use Study. Intercity and intracity bus data were obtained from all companies that furnished the information. Data were secured for 346 school buses, 405 intracity buses, and 336 intercity buses — or approximately 30 percent of the total bus registration.

The method for sampling trucks and truck combinations, other than farm vehicles, was based on the selection of an owner sample, rather than an individual vehicle units sample, and permitted the inclusion of a larger number of vehicles than would otherwise have been possible. This method afforded more adequate coverage for the items investigated.

The for-hire carrier sample was from a current list of certified carriers in the Public Service Commission. A preliminary investigation showed that the sample would include vehicles in most of the licensed gross weight groups, and have good distribution of other factors affecting cost-weight relationships. A periodic sample of 600 carriers was selected. Approximately 300 carriers were then selected as possible sources of data. About one-half of these carriers agreed to furnish information with the result that the final sample covered 870 vehicles.

Because private nonfarm vehicles are not listed with the Public Service Commission, a sample was obtained from the businesses and industries listed in business directories. A representative cross-section of private carriers was secured. From this list, a sample of approximately 300 well distributed operators was retained. Furthermore, information in the Motor Vehicle Use Study, a relatively small number of vehicles, was incorporated. The final sample was 1469 vehicles.

Although trailers and semi-trailers are registered separately from the power units, a sample study of these vehicles was not necessary. They appeared in cor-

rect relationship to trucks and tractors if the sample were well chosen. Cost data for trailing units were secured wherever connected with power units. To secure data for vehicle combinations up to the maximum licensed gross weight of 72,000 lb, vehicles used in combination were isolated. Expenses for the power unit and the trailed unit or units were combined to obtain combination costs. The assignment of trailer costs to the power unit was made in relationship to the gross weight of the combination.

Variations in the operating cost of vehicles according to licensed gross weight were developed for the following classes of vehicles:

1. Private passenger automobiles, without regard to weight classification.
2. Commercial passenger automobiles, without regard to weight classification.
3. Taxicabs, without regard to weight classification.
4. Intracity buses, regardless of kind of fuel used.
5. Intercity buses, regardless of kind of fuel used.
6. School buses, regardless of kind of fuel used.
7. Farm trucks, gasoline powered. There were no diesel farm vehicles included in the farm truck sample.
8. Gasoline-powered line haul vehicles, both private and for-hire.
9. Diesel-powered line haul vehicles, both private and for-hire.
10. Vehicles engaged in pickup and delivery service, regardless of kind of fuel used. There was a negligible number of diesel trucks in pickup and delivery service. Data for these vehicles were not developed separately.
11. Commercial vehicles in private operation, regardless of kind of fuel used or type of service in which the vehicles were engaged.
12. For-hire vehicles, regardless of kind of fuel used or type of service in which the vehicles were engaged.

The costs of maintenance, tires and tubes, fuel, oil, insurance, depreciation, drivers' wages, licenses, and overhead were determined for each group of vehicles, as well as for the miles traveled. Individual cost elements in overhead were investigated separately. Variations in the individual overhead costs (traffic expense, transportation supervision, all terminal costs, and all administrative and general expense) are attributable primarily to accounting procedures and precluded a more detailed analysis.

Individual cost elements were combined and analyzed to obtain the weight-cost relationship for the conventional subtotals of running-costs, total vehicle costs, direct operating costs, and gross operating costs. Elements included in these classes were as follows:

1. Runnings costs — maintenance, tires and tubes, fuel, oil.
2. Other vehicle costs — insurance, depreciation.
3. Total vehicle costs — running costs plus other vehicle costs.
4. Other operating costs except overhead — license and registration fees, drivers' wages.
5. Direct operating costs — total vehicular costs plus other operating costs except overhead.
6. Overhead — traffic expense, transportation supervision and other expense, terminal costs, administration and general expense.
7. Gross operating costs — direct operating costs plus overhead.

Curves were fitted to each series of data by the method of least squares, in either a straight line, quadratic, or logarithmic curve form. In the case of closely grouped data, conventional tests were followed in selecting the appropriate curve form.

Inasmuch as the curves are based on data for vehicles or vehicle combinations having a licensed gross weight of from 4,000 to 72,000 lb, computed values for weights outside these limits may be considerably different from actual averages. In other words, the curve form fitted to

any set of data was that which best defined the cost function between the given limits of weights. For this reason, the curves should not be extrapolated and used as representative of operating costs for vehicle weights outside the limits shown, unless the results are properly qualified.

Since, in many instances, it might be preferable to apply costs per mile on the basis of average operating gross weight rather than on the basis of licensed gross weight, a correlation between these factors was determined. Investigation of average loads indicated that many operators did not keep records by vehicles in sufficient detail for use in preparing the correlation. Accordingly, data provided by the annual statewide truck weight surveys of the Department of Highways were used. Investigation indicated that there was no material difference in average operating gross weights for trucks of different types and classes of service, therefore the same correlation was shown throughout on the cost graphs.

Individual curves reflecting average operating costs for the sum total of all licensed vehicles were not prepared from the weight-cost relationships presented here. Over-all average costs for all vehicles can be obtained, however, by combining cost values for the first 9 groups of vehicles in correct proportion to their appearance in total vehicle registrations. Furthermore, over-all average operating costs for each of the major types of vehicles (passenger cars, buses, and trucks) can be obtained by correct weighting of the various classes of service. The curves for trucks and buses are representative only of the sample and are not combined in proportion to the total number of vehicles, because relative numbers and weights fluctuate each year.

All costs developed in this study are directly applicable only to vehicles licensed and operated in Washington under prices and taxes in 1952 and 1953. Adjustments for known differences in rates should be made if the data are used elsewhere. Motor-vehicle license and registration fees can be adjusted by substitution of the applicable rates. State fuel

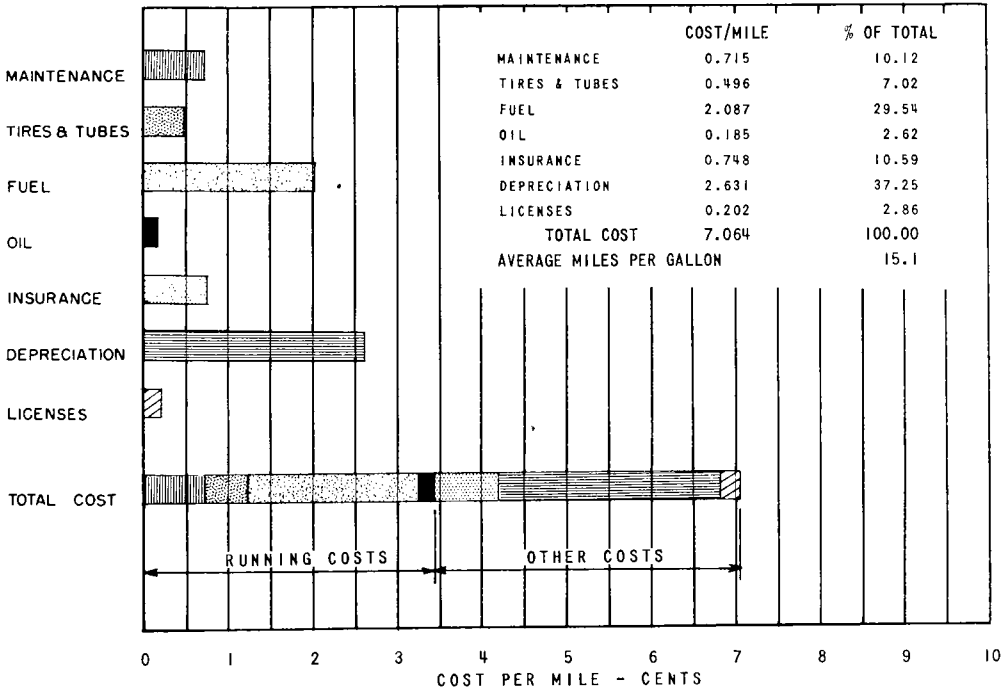


Figure 1. Operating cost for private passenger cars.

taxes (6.5 cents per gallon for both gasoline and diesel fuel in Washington) and Federal taxes (2.0 cents per gallon) can be adjusted on the basis of relative fuel consumption in relation to vehicle weight.

A private passenger car is defined as a privately owned vehicle not exclusively devoted to business.

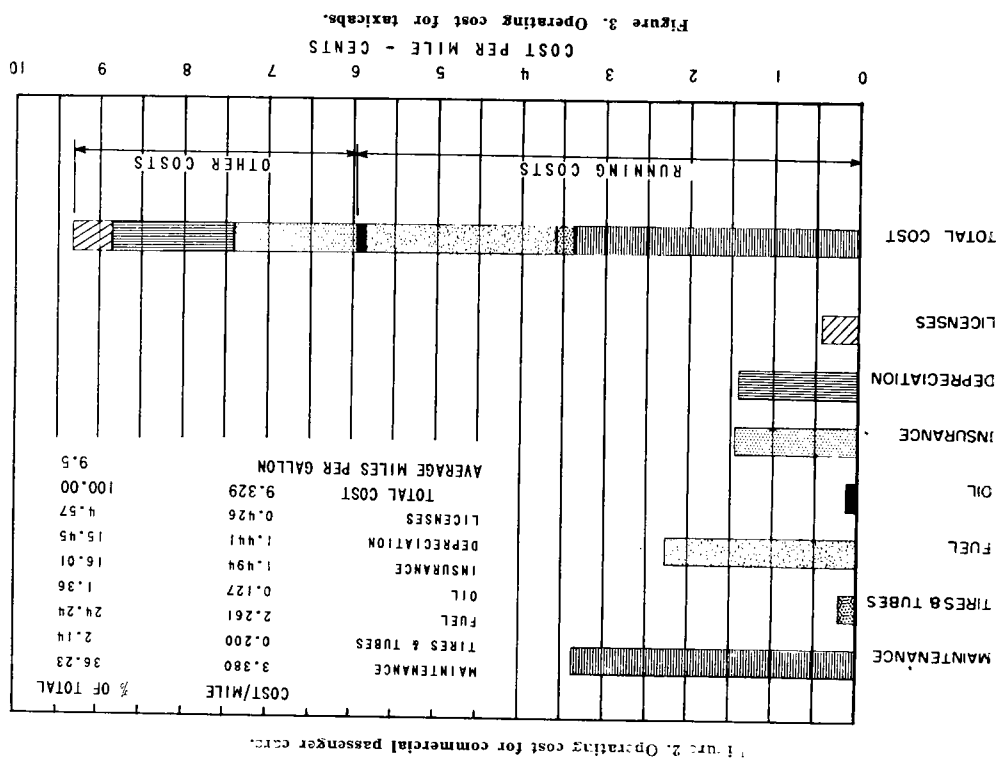
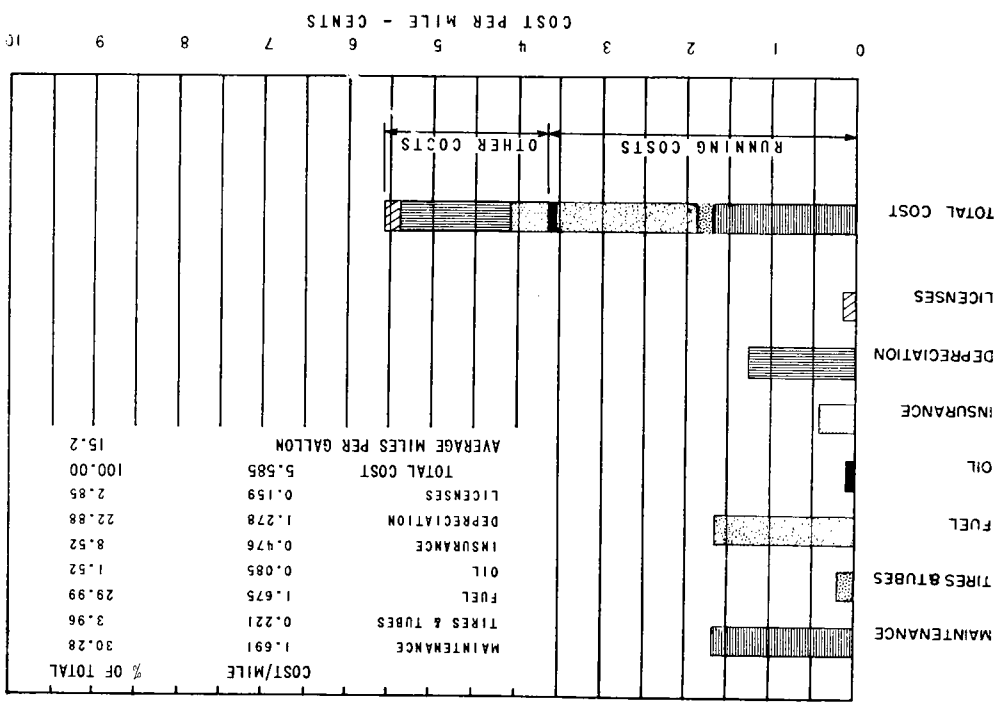
Figure 1 shows the operating costs for maintenance, tires and tubes, fuel, oil, depreciation, insurance, and licenses. These costs are combined to show running costs, vehicular costs, and ownership costs. Drivers' wages or overhead costs (such as, parking and storage charges) for private passenger cars were not included. Passenger cars were not grouped according to weight or age.

A commercial passenger vehicle is used exclusively for business. Data for commercial passenger cars were gathered along with truck data where the operator included this information in his report. Because this group of vehicles was beyond the original scope of the

work, it was kept separate and supplemented with data from vehicles operated by state governmental agencies. Figure 2 shows the operating costs for maintenance, tires and tubes, fuel, oil, insurance, depreciation, and licenses, combined to show running cost, total vehicular costs, and ownership costs. Drivers' wages and overhead costs were not included.

A taxicab is defined as a passenger car type vehicle used exclusively as a for-hire vehicle. Figure 3 shows the operating costs for maintenance, tires and tubes, fuel, oil, depreciation, insurance, and licenses, combined to show running costs, vehicular costs, and ownership costs. For consistency, drivers' wages and overhead were not included.

No composite graph was prepared to show combined average costs for the sum total of private, commercial, and taxicab vehicles. It was not possible to determine the number of commercial passenger cars in the total vehicle registration with relation to private passenger cars. The fact that taxicabs and commer-



cial passenger cars represent a small part of the passenger car total indicates that the over-all average operating costs for all three types combined approximate those for the private passenger car alone.

Pickup and delivery service vehicles are those used for collection or distribution of freight in terminal areas. Figure 4 shows costs for gasoline-powered, single unit vehicles, with a negligible number of diesel units included. The data applies predominantly to city service and includes little rural peddle service.

Operating costs for gasoline-powered line haul trucks are shown in Figure 5. The costs are for gasoline-powered trucks and tractors used predominantly in inter-city service and found to be operating in the licensed gross weight groups between 14,000 and 72,000 lb. Because Washington has small towns located at considerable distances apart and away from large cities, single unit trucks are frequently found to be used in line haul service;

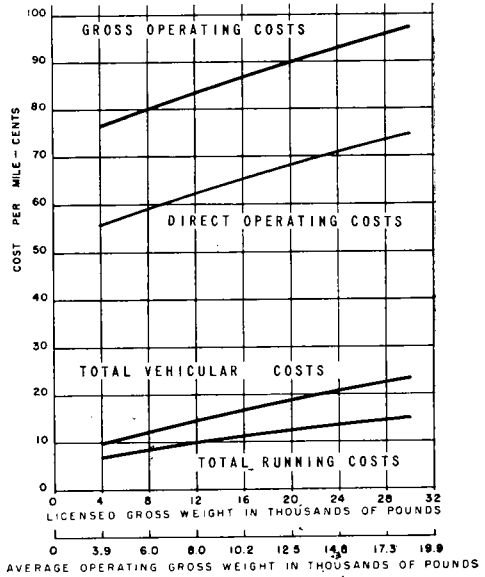


Figure 4. Operating costs for pickup and delivery trucks.

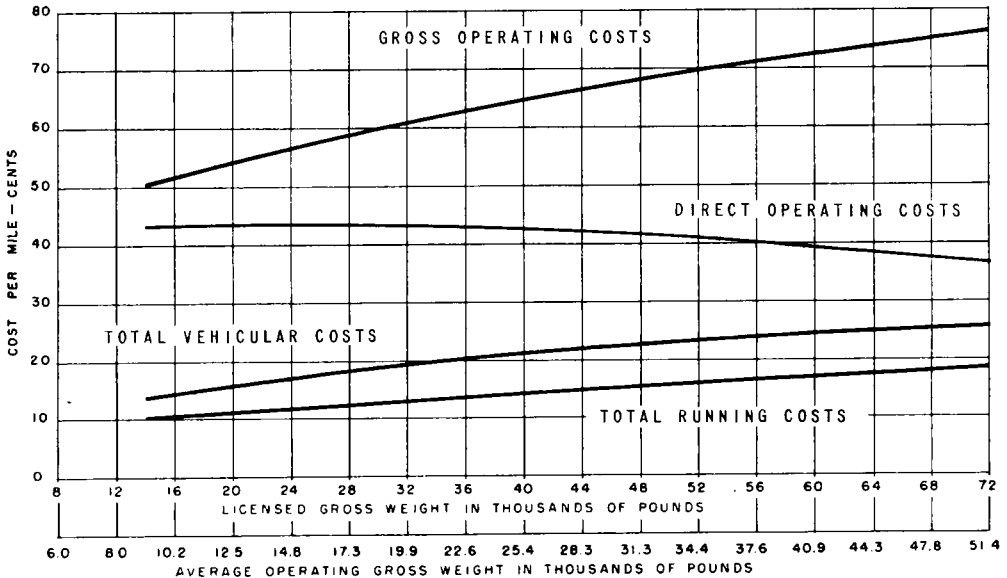


Figure 5. Operating costs for gasoline-powered line haul trucks.

this was not classified as rural peddle service.

Operating costs for diesel trucks and tractors generally represent a line haul

service and heavy combinations. Diesel fuel includes all motor fuel except gasoline. Trucks in private, commercial and for-hire commercial service are included

in the diesel group. Because of the inadequacy of the sample in licensed gross weight groups below 50,000 lb, Figure 6 shows only trucks in the licensed groups between 50,000 and 72,000 lb.

Private commercial trucks, other than farm vehicles and regardless of fuel used, represent both pickup and delivery serv-

ice and line haul vehicles. This grouping was made for informational purposes only, but Figure 7 includes two discrete types of operation and service and, therefore, represents the grouping of discontinuous cost data.

Variations in operating costs according to licensed gross weight for all for-

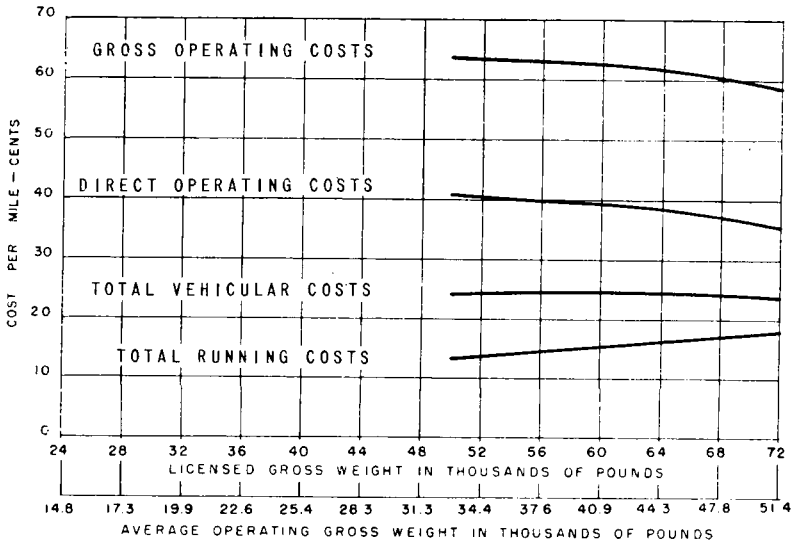


Figure 6. Operating costs for diesel-powered trucks.

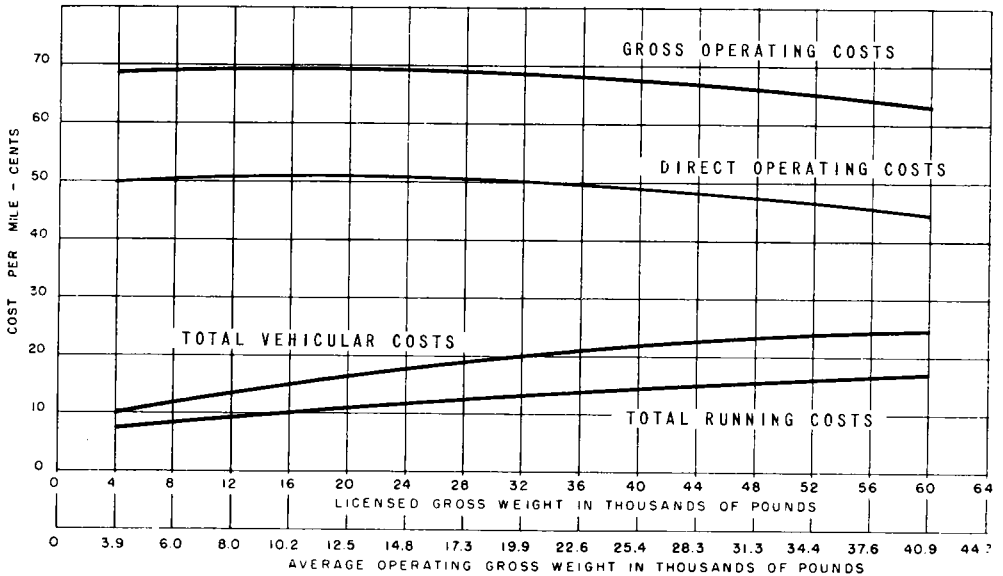


Figure 7. Operating costs for private commercial trucks.

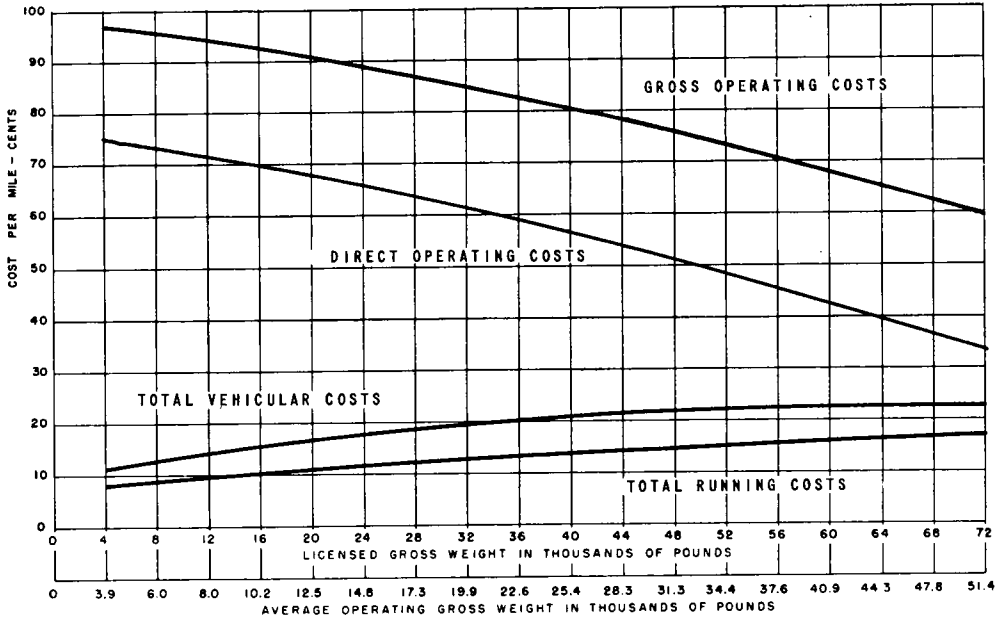


Figure 8. Operating costs for for-hire trucks.

hire trucks, regardless of kind of fuel used, are presented in Figure 8. The grouping of data and resulting curves also include two discrete types of operation and service; namely, pickup and delivery service and line haul service. Here again the grouping is of two discontinuous series of cost data. This curve reflects average costs, primarily for common carriers. The contract carrier sample was not large enough for independent processing.

Fuel consumption curves have been computed for vehicles in pickup and delivery service, gasoline-powered line haul vehicles, and diesel-powered line haul vehicles (Figures 9, 10, 11). Each curve represents the combined average rate of fuel consumption for private commercial (other than farm) and for-hire commercial vehicles.

Factual data on operating costs of the motor vehicle are important for use in applying tax allocation theories. Operating costs, which bear a relationship to the monetary value involved in the operation of motor vehicles upon the highways, might serve as a measure of value

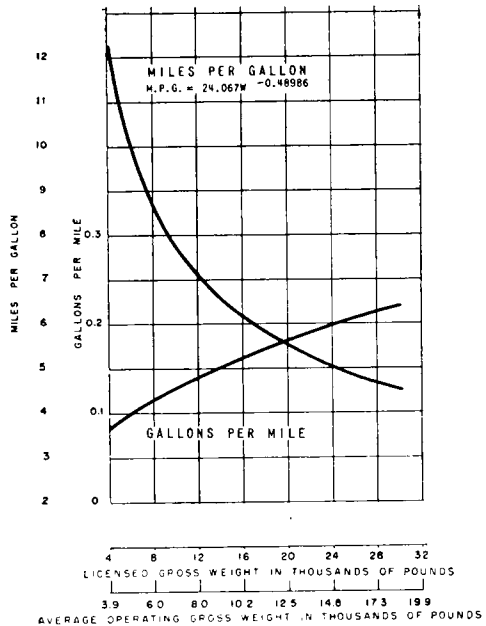


Figure 9. Fuel consumption, gasoline-powered pickup and delivery trucks.

of service; however, much additional work is needed in this field. The curves should be handled with extreme care if applied to operating conditions in other

states. Although there may be limitations in their use, the information is probably more comprehensive than any presently available elsewhere.

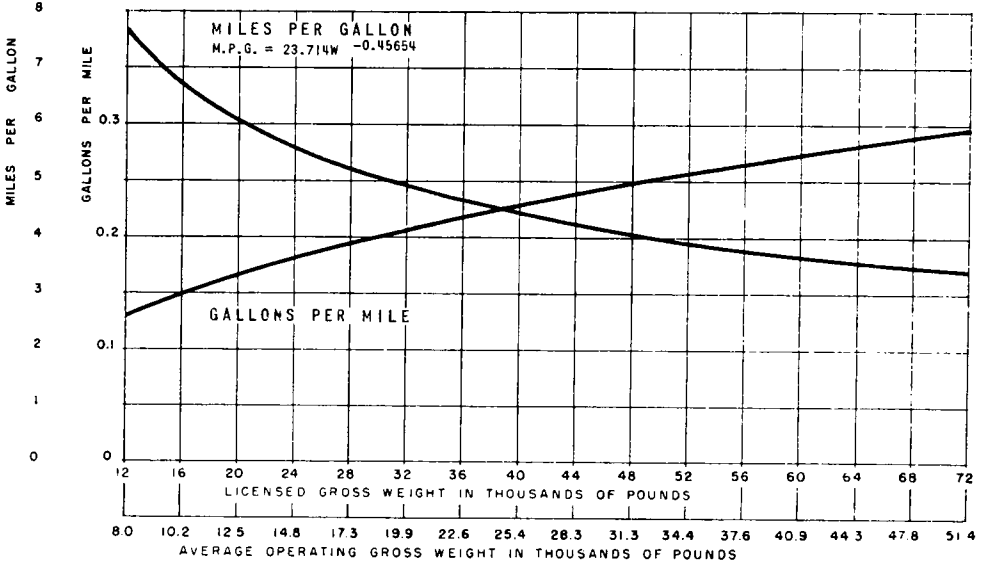


Figure 10. Fuel consumption, gasoline-powered line haul trucks.

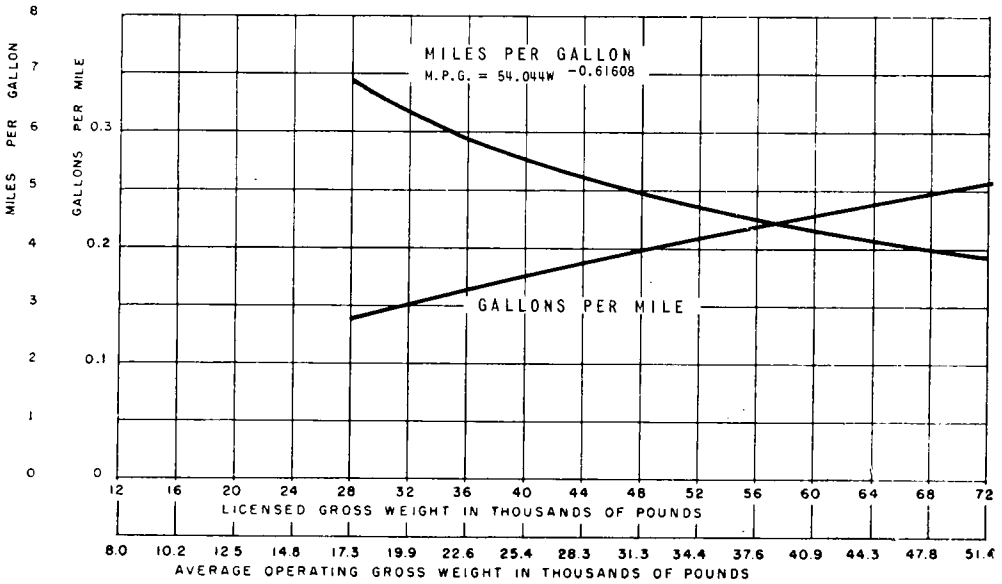


Figure 11. Fuel consumption, diesel-powered trucks.

DISCUSSION

HOY STEVENS, *Highway Transport Research Engineer, Bureau of Public Roads.*

—The report on operating costs of various kinds and sizes of motor vehicles in the State of Washington provides additional data of a type that are wanted by highway economists in approaching two highway transport problems:

1. Calculation of road-user benefits when selecting highways to be upgraded in both geometric and structural capacities.
2. Problem of determination of the economic limits in truck size and weight.

This cost survey has been done in a field in which data are scarce because many motor vehicle operators have found that cost and operational data, of the kinds required by the highway transport researcher, are not needed in the ordinary management of their vehicles. As a result, only a small portion of motor vehicle operators compile vehicular cost data that are useful in research studies, and these do not use a uniform method of accounting. It is a painstaking and time-consuming job to interview the many vehicle operators in the search for the few that have data that can be used. There follows the tedious work of correlating cost and operational data by the different classes of vehicle operations.

The authors have made a useful contribution to the knowledge of motor-vehicle operating costs, but some presentations of the data can be criticized.

In the early pages of the text there are two references to bus data, but no bus information is given in the text. This implies that bus data may be reported later in a more complete published report.

In the charts reporting costs of truck operation, the authors have presented smoothed curves developed by the least squares method. However, no measures of the range of variation of the observed data of these curves is reported. In studies such as these, where there is a great variation both in data values and

in the distribution of the data, the readers should be given an idea as to the extent of such deviations from the smoothed curves. The existence of variations appears obvious when one considers the numerous differences in truck operations, such as, types of service, types of commodities, loading and unloading practices, annual average miles of power units, ratios of trailers to power units, wage rates, fuel and oil prices and vehicle retirement practices.

In the group of overhead expenses there are two items that are not directly related to mileage. These are "traffic expense" and "terminal costs," both of which are related to the tonnage of freight handled and not to the mileage the freight is hauled. These two cost elements should be deleted entirely from the results. Unless such accounts as revenue billing and claim expense, which relate primarily to tonnage and number of shipments can be eliminated from "Administration and general expense," this cost element also should be deleted. The overall element "Gross Operating Costs" could be deleted without impairing the intended uses of the results.

Figures 4, 5, and 6 arrange the data according to two distinct types of service, city pickup and delivery trucks, and line-haul trucks and combinations. These data can be useful in estimating road-user benefits. The separation of diesel-powered line-haul combinations from gasoline-powered line-haul vehicles is informative.

Figures 7 and 8 are very unsatisfactory, and the data presented should not be used in any studies of road-user benefits or economics of size and weight. The authors advise that data include trucking services of two distinctly different types, namely, city pickup and delivery, and line haul, as well as two types of motive power, gasoline and diesel. Of this hodgepodge of data they say in reference to Figure 7, "This grouping was made for informational purposes only, but Figure 7 includes two discrete types of operation and service and, therefore, repre-

sents the grouping of discontinuous cost data." A similar statement is made about Figure 8.

The curves in Figure 8 are severely distorted by the inclusion of the city pickup and delivery data. This is especially true in regard to the "Direct Operating Costs" curve. The slope of this curve is particularly unrealistic and decidedly inconsistent with similarly titled curves Figures 5 and 6. In fact, if one extrapolates this curve even a small distance to the right (which the authors warn against), it is apparent that the indicated cost of drivers' wages and license fees will become nil at about 85,000-lb gross weight, which is absurd.

Figure 7 is not as badly distorted as Figure 8, probably because there are fewer city pickup and delivery trucks in these data, but neither of these charts contains valid data for most uses.

Of the three fuel-consumption charts Figures 10 and 11 are interesting in that they indicate that diesel fuel consumption in gallons per mile is between 80 and 90 percent of gasoline consumption in the range of vehicles between 48,000- and 72,000-lb licensed gross weight. This difference in fuel consumption is somewhat less than frequently is assumed.

GLAZE AND VAN MIEGHEM, *Closure* — In reply to Mr. Stevens' discussion, a report with complete coverage is being prepared. Only a representative series of curves appear in this paper, as all of the more than 100 curves could not be included without resulting in a duplication of the final report itself. Bus curves were not included for this reason. The completed report will show a curve for each cost item within each type of operation as well as the total curves appearing in this paper.

The curves presented are total curves developed by the addition of the values of each of the individual cost item curves. No tables were presented with these total curves to show deviations from curve values and there were no scatter diagrams indicated. In compiling the total curves it was found that the num-

ber of vehicles reporting in each class interval was different for almost every cost item preventing the computation of a mean for each gross weight group. Therefore, no scatter diagram could be developed for the total curves. The completed report will contain a table for each set of individual cost item curves showing the number of vehicles and means of cost values in each class interval.

The cost items included in overhead expenses were investigated separately but, because of the variations attributable primarily to accounting procedures, were combined and handled as a single cost item. There are variations in overhead costs and they are not directly related to mileage. In accordance with the three categories of operating costs in "A Factual Discussion of Motor Truck Operations, Regulations, and Taxation," Department of Commerce, Bureau of Public Roads 1951, overhead costs were developed and presented on a per mile basis. A discussion of the three categories, running costs, vehicular costs, and gross operating costs can also be found in G. P. St. Clair's "Suggested Approaches to the Problems of Highway Taxation." The gross operating curves may be invalid for certain analysis purposes, but they are informative and also consistent with classifications of operating costs suggested in previous investigations and applicable to certain types of analyses in the tax allocation field.

Private commercial truck and for-hire commercial truck curves are recognized as being not valid. However, since many taxation schedules treat for-hire trucks separately from private commercial trucks, these curves were developed for informational purposes only. The authors believe that these groupings should not be deleted, but it must be remembered that the data are discontinuous and that any analysis using this data should be used with extreme care.

A mere reading of this paper does not reflect the difficulties encountered in compiling and presenting a survey of this nature. The authors would like to take this opportunity to thank the numerous

individuals and organizations for their generous contributions of time and information of value to the study. Without the assistance of the interested parties completion of the project would not have been possible.