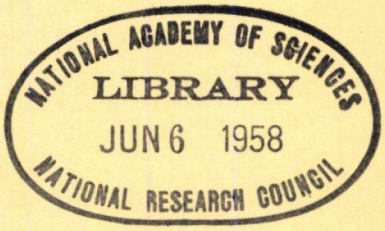
HIGHWAY RESEARCH BOARD

Bulletin 175

Allocating Highway Cost Responsibility

Reports on Studies in Five States



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Allocating Highway Cost Responsibility

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Contents

Washington State Highway Cost Allocation Study

R. G. HENNES, Professor of Civil Engineering, University of Washington; and
and WILLA W. MYLROIE, Associate Professor of Civil Engineering, Purdue University[1]

This paper presents a discussion of the objectives, procedures, methodology and some of the findings of a three-year study of highway cost allocation conducted by the Washington State Council for Highway Research through the agency of the University of Washington and the State College of Washington for the Washington State Legislative Joint Fact-Finding Committee on Highways, Streets and Bridges for the biennia 1953-55 and 1955-57.

Answers to the following questions were the objectives of this study. Who should contribute toward paying the cost of public roads and streets in the State of Washington? What is an equitable division of road cost responsibility among the three principal direct beneficiaries: the highway users, the owners of affected property, and the general public? How can the users' share of these costs be divided equitably among the various types of automobiles, trucks, and buses?

Major reliance was placed on collateral research by the Washington State Highway Department and the United States Bureau of Public Roads. Where data were lacking original fact-finding was done.

The collection and analysis of these data are discussed as well as the manner in which responsibility for Washington's highway costs might be divided between users and others. This is done for each road system (county, city and state—a reasonably functional as well as administrative classification) and for the combined systems on the bases of relative use, earnings credit and relative benefit. The results are also compared with the actual 1953 needs and with the 1954 receipts from users and others for highways.

These comparisons show that the current rate of user contribution is sufficient to support the users' share of the cost of a modern-day system of public roads and city streets.

The users' share of the highway costs is then divided among classes of users on three different bases: the amount of highway use (ton-mile or weight mile), operating costs, and incremental costs.

Alternative procedures for converting user group responsibility into individual fees and the cost of borrowing for highway construction are also discussed.

● THE WASHINGTON State Legislature instructed its 1953-55 Joint Fact-Finding Committee on Highways, Streets and Bridges " . . . to ascertain, study, analyze, report on, and make recommendations as to: (a) Motor vehicle taxation, including the assignment of the total highway costs among property owners, general taxpayers and highway users . . . " (1). A study of who should pay for Washington highways, on what basis they should pay, and how much they should pay was inaugurated. People must pay if they want the service provided by adequate highway systems. The problem is the most equitable method of collecting the costs.

JOINT FACT-FINDING COMMITTEE ON HIGHWAYS, STREETS AND BRIDGES

A Joint Fact-Finding Committee on Highways, Streets and Bridges was first established by the Washington State Legislature in 1947 to review highway, road, and street requirements and to assemble the facts that were necessary for a consideration of that subject. The committee has been reactivated by every legislature since then to continue its study of highway problems specified by the legislature. Membership of this committee is comprised of six senators appointed by the president of the senate and six members

[1]Formerly with the University of Washington

of the house appointed by the house speaker. One of the senate members and one of the house members are appointed from the area included within each of the six state highway districts. This committee exists only during the interim between the biennial sessions of the legislature.

After each session the reactivated committee organizes into subcommittees corresponding to specific sorts of highway policy problems. Some of these problems may have been designated by act of the legislature. On many of these problems the committee will enlist the aid of a consultant or of a research agency. Each spring just prior to the next legislative session the committee holds fifteen to twenty public hearings throughout the state. The studies in progress are explained, and the people of the state present their views on highway problems to the committee. These hearings give the people a chance to find out what is being done to find better solutions to highway problems, and to present problems they feel need study in the next biennium.

WASHINGTON STATE COUNCIL FOR HIGHWAY RESEARCH

In 1951 the Washington State Council for Highway Research was created by the Governor. "The purpose of the State Council for Highway Research is to augment, correlate and classify all highway research resources in the State of Washington for the solution of the State's highway transportation problems. To this end, maximum use will be made of the research facilities of the University of Washington, State College of Washington, the counties, cities, state highway department and any other group which has facilities to bring to bear on the economical solution of the State's many problems involving highways, roads, and streets.

"The Council will consider for assignment to an appropriate agency any problem presented to it by the legislature, highway user group or any other representative body which has problems in the fields of highways, roads or streets." (2)

The nine members of this council were selected to provide a broadly representative group: the Director of Highways; the Chairman of the Highway Commission; the district engineer of the Bureau of Public Roads; the manager of the Automobile Club of Washington; officials of the Washington Highway Users' Conference, the Association of Washington Cities, and the Association of County Commissioners; and professors of Civil Engineering from the State College of Washington and the University of Washington. The Joint Fact-Finding Committee for Highways, Streets and Bridges has frequently used the services of this Council.

Financial Support for Research

The Council has no funds to distribute nor does it make any charge for its services. Since 1951, funds for specified highway research activities have been provided by a special fee authorized by the legislature. The 1953 law reads: " . . . In addition to all other fees prescribed by law, there shall be paid for each motor vehicle the following amounts at the time of the payment of the registration fee as provided by law:

For each truck under 12,000 lbs.	$ .25
For each truck over 12,000 lbs. and under 20,000 lbs.	.50
For each truck over 20,000 lbs.	1.00
For each trailer 4,000 lbs. to 12,000 lbs.	.25
For each trailer 12,000 lbs. to 20,000 lbs.	.50
For each trailer, semi-trailer or pole-trailer over 20,000 lbs.	1.00
For each diesel truck	2.00
For each auto stage	1.00
For each for-hire vehicle over 4,000 lbs.	.50
For each motor vehicle not otherwise taxed herein	.10

Such fees shall be collected for the calendar years 1953, 1954, and 1955, only and shall be deposited in the motor vehicle fund, and shall be used by the joint fact-finding committee on highways, streets and bridges, and the state highway commission to help defray the cost of special highway use and weight studies and tests upon highways as provided for in this act and for other necessary expenses of such committee." (1) A similar law was passed in 1955 for the calendar years 1956, 1957, and 1958 only.

PROCEDURE FOR THE HIGHWAY COST ALLOCATION STUDY

In 1953 the Fact-Finding Committee asked the Washington State Council for Highway Research to make recommendations conforming with the legislature's directive to study the allocation of highway costs. The Council developed a prospectus for the study, suggested it be done at the University of Washington with the assistance of the State College of Washington, and that a board of consultants (M. Earl Campbell, Harmer E. Davis, and Bertram H. Lindman) be asked to advise the Council on the scope and technical procedures of this study. Accepting these suggestions, the legislators also set up an advisory committee of highway-interested citizens to act as liaison between the study group and the public, so that the objectives and the conduct of the study might be more widely understood. The approved plan of procedure is outlined as follows:

1. Review of existing studies and outline of needed areas of investigation by research subgroups.
2. Initial meeting with board of consultants for review of research prospectus, including study plans of the various research subgroups.
3. Collection and organization of data by research subgroups:
   a. Application of Malad and Maryland test road findings to Washington roads.
   b. Compilation of data on effect of road improvement on property values.
   c. Study of commercial value of roads as reflected in competitive transportation rates.
   d. Compilation of material on history of road standards, costs and financing in Washington since 1900.
   e. Limitations on credit financing in Washington.
   f. Vehicle usage data.
4. Interim meeting with the Board of Consultants.
5. Meeting with Advisory Committee at Public Hearing.
6. Application of data of Item 3 above to:
   a. Incremental cost study analysis.
   b. Operating cost analysis.
   c. Weight-distance analysis.
   d. Earning credit analysis.
   e. Relative use analysis.
   f. Relative benefit analysis.
   g. Formulation of a tax structure.
7. Meeting with the Board of Consultants.
8. Compilation of report and its submittal to the Research Council.
9. Transmittal to Interim Committee.
10. Public hearings on report, sponsored by the Joint Fact-Finding Committee.
11. Report of Interim Committee to the Legislature.

ORGANIZATION OF THE STUDY

The study was divided into three phases as shown in Figure 1. Work on all three phases progressed simultaneously except for the final step of the development of the several bases for tax structures. There were nine subgroups in the study headed by teaching and research staff members of the University of Washington and Washington State College. The University teaching and research staff members were from the following disciplines: Civil Engineering, Geography, Economics, Business Administration, and Mathematics. These faculty members supervised the graduate students and others who staffed the various subprojects, mostly on a part-time basis. About 40 graduate students, ten undergraduates, and two or three full-time assistants were em-

ployed during the academic year; with most of the staff working full-time during two summers. The junior author served full-time as the coordinator of these various efforts, while the senior author was responsible for the over-all direction of the study, in addition to other academic obligations. Considerable turnover in staff occurred as students graduated and others took their places. Four master's theses were written on various phases of this study.

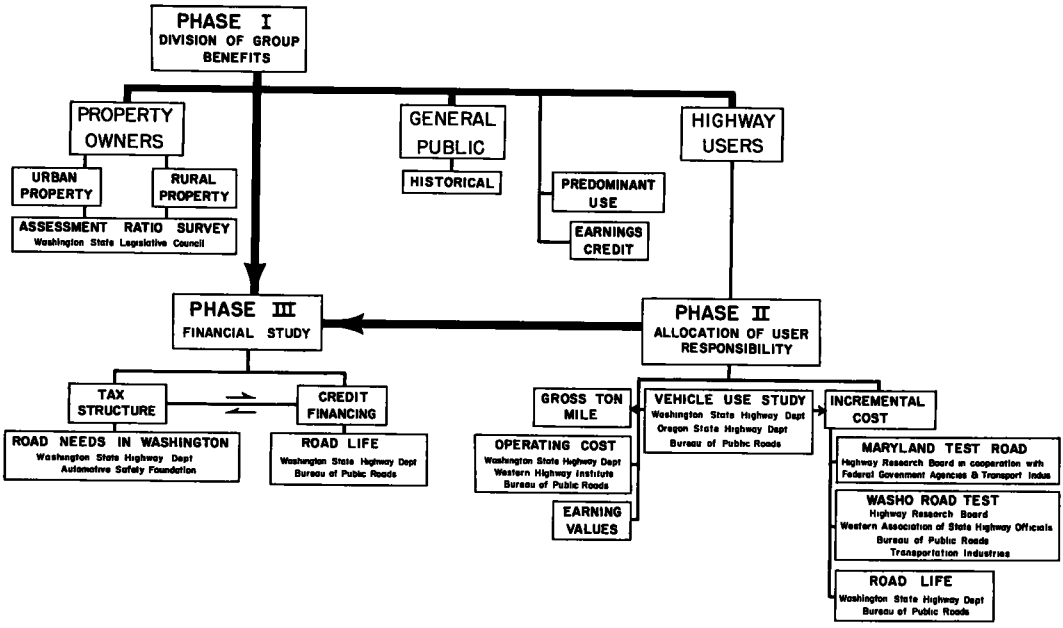


Figure 1. Highway Cost Allocation Study Program, 1955.

The various studies had the common objective of throwing light upon component parts of the two central problems:

1. What is an equitable division of road cost responsibility among the three principal direct beneficiaries: the highway users, the owners of affected property, and the general public?
2. How can the users' share of these costs be divided equitably among the various types of automobiles, trucks, and buses which operated on Washington's roads and streets?

Research Resources

In the conduct of this investigation major reliance was placed upon the results of collateral research by other agencies, such as the Washington State Highway Department and the United States Bureau of Public Roads. These other studies include the WASHO test road, the operating-cost study, the road-life study, the highway-needs study, the vehicle-use study, and "Needs of the Highway Systems 1955-84," House Document No. 120, 84th Congress. Where data were lacking it was necessary to do original fact-finding. The major expenditures of time and money on this project were used to obtain basic information in those areas where the facts were obscure. Thus, the principal subprojects of the research effort have dealt with the effect of road improvement on property value (6) (7), the value of road improvements to commercial users (8), the collection of data needed for weight-distance tax schedules (5), the limitations of credit financing (3), the historical trends in highway financing (3), and the incremental costs of road improvements (3).

RELEVANT COSTS

The study was not limited to state highways because county roads and city streets derive much of their revenues from the same sources that support state highways, and the three systems serve much the same traffic.

After the decision was made to include the costs of all roads and streets, it next became necessary to decide how these costs should be computed. Some investigators of highway finance have been concerned with assigning responsibility for the past expenditures which have provided our existing facilities; others have tackled the problem of who should pay for the future expenditures to be made in carrying out some contemplated program.

Probably the public is more concerned over finding money to buy new roads than over redressing possible inequities in the collection on monies already spent. On the other hand, if today's vehicles are to be taxed according to assumptions of relative use or benefit from facilities planned for construction in future years, most currently held tax theories lose some of their persuasive appeal. A third alternative, allocating costs which represent actual current expenditures, assumes that the present division of available funds among the state, county, and urban systems correctly reflects the relative needs of these systems.

It was decided that all these difficulties are best reconciled when "highway cost" is taken to mean the annual cost (depreciation plus maintenance) of a network of roads, streets, and highways adequate to meet current needs; not actual expenditures, present or past; and not the cost of providing for future traffic. This procedure relates to the cost of a road system designed to serve the same vehicles that are asked to share the expense involved.

The Annual Cost of Adequate County Roads

The annual cost per average mile of county roads in each county was estimated in the County Gas Tax Allocation Study of 1953-54 (10). The resulting values are shown on page 79 of the report on that project, and were accepted for use in the present investigation without modification. The classification of road mileage in each county as arterial or local, as made by the engineers responsible for that same study were used, since these results would give greater uniformity than would be obtained by relying upon the classification by local authorities in the individual counties. Traffic data for the several counties were adjusted from 1952 data published by the state highway department, and divided between arterial and access roads in each county in accordance with estimates obtained from the county engineer of that county (4).

The Annual Cost of Adequate City Streets

There is a notable lack of reliable information on the classification, traffic volume, and annual costs of county roads and city streets. A special effort was made to provide additional information on these basic ingredients of road planning and finance. A comprehensive study of county road needs had been completed for the Joint Fact-Finding Committee in 1954, for their guidance in passing legislation covering the allocation of the counties' share of the gas tax monies among the 39 counties of the state (10). These data were most useful in this study also. However, such data for city streets were not so readily available, if at all in some cases. A questionnaire was sent to each city requesting information on mileage, and annual construction and maintenance costs for arterial, residence and business streets. Information was also requested on average total daily traffic on these three types of streets. Of the 245 cities, 97 returned questionnaires. Many of the questionnaires returned were incomplete. However, the data received from the questionnaires plus information collected annually by the state highway department on city streets provided a basis for interpolating and estimating on the basis of population groupings, city street costs, traffic, and mileages. Data were also collected on vehicle miles traveled on the different classes of roads.

The collected data, as well as the estimates and analyses made of these data, were put into graphical and tabular form for the use of other substudies on the project.

In the summary below the estimate of annual vehicle mileage for city arterials ex-

TABLE 1

ESTIMATE OF ANNUAL ROAD COSTS FOR WASHINGTON COUNTIES[a]

Type	Miles	Annual Traffic, (millions of veh mi)	Annual Cost[b]		
			Total (millions of dollars)	Per Road Mile (dollars)	Per Veh Mile (cents)
Land service	31,053	697	18.3	589	2.63
County trunk	8,397	1,047	20.2	2,406	1.93
All county roads	39,450	1,744	38.5	976	2.20

[a]Deemed adequate for 1953 traffic.

[b]Estimated.

cludes traffic on the urban extensions of state highways. The figures shown for the annual cost of city arterials exclude the cost of urban extensions of state highways. The need for some such arbitrary decision in this instance lies in the conflict between administrative classification and functional classification when state highways traverse urban areas.

The Annual Cost of Adequate State Highways

A basis for estimating the annual cost of an adequate system of state highways is to be found in the 1954 "Needs Report" by the Washington State Highway Commission (11). It was found that present and impending inadequacies should be relieved by a 10-year construction program totaling $454 million, exclusive of a $194 million Seattle freeway, a $22 million Hart's Pass project, and a $25 million Naches tunnel project. By this program 76 percent of the state highway system would be rebuilt to accommodate 1975 traffic at appropriate standards.

In order to make the highway figures fairly comparable with preceding estimates for local roads and streets, the Commission's estimate of future needs must be adjusted to represent the current situation. In this study of tax responsibility, the compelling reasons for working with the annual costs of roads adequate for present needs have already been examined. To compute such a figure for the state highways, it is first necessary to determine the cost of constructing such facilities, and then the annual charges for depreciation and maintenance to service and preserve the indicated investment. To accomplish this, three adjustments in the Commission's program estimate were made:

1. Reduction of the estimate to the level of current needs.

TABLE 2

ESTIMATE OF ANNUAL STREET COSTS FOR WASHINGTON CITIES[a]

Type	Miles	Annual Traffic, (millions of veh mi)	Annual Cost[b]		
			Total (millions of dollars)	Per Mile (dollars)	Per Veh Mile (cents)
Residential	5,316	602	21.4	4,026	3.55
Arterial	1,031	489	8.4	8,147	1.72
All streets	6,347	1,091	29.8	4,695	2.73

[a]Deemed adequate for 1953 traffic.

[b]Estimated.

TABLE 3

ANNUAL COSTS OF STATE HIGHWAYS

Mileage	Annual Costs		
	Total (millions of dollars)	Per Road Mile (dollars)	Per Vehicle Mile (cents)
6,207[a]	30.7	4,946	0.50
6,672[b]	50.6	7,584	0.70

[a]Rural.

[b]All state highways including their urban extensions.

2. Estimation of the first cost of a fully adequate system by expanding the estimate to cover 100 percent, rather than 76 percent of the present state highway mileage.

3. Conversion of the adjusted estimate to an annual cost basis.

Excluding the cost of providing for local urban traffic on the urban extensions of state highways an estimate of the annual cost of adequate state highways is presented in Table 3.

HISTORICAL BACKGROUND

Prudent policy decisions must take into account the way in which existing policy was developed over the years (3). In order to provide information on trends in highway standards and financing, and to find the cost of basic roads, rural, and urban in the pre-automobile period, the history of roads and streets (for the United States generally and for Washington specifically) was reviewed. While interest was concentrated chiefly on cost data and design standards circa 1905, the study also included research into financial and administrative practices prior to 1890 relating to both rural roads and city streets. Other historical statistics related to road mileage growth, road and street revenues 1905-1955, county and state road funds, population 1905-1955, motor vehicle registration 1906-1955, motor fuel consumption, and total vehicular travel 1921-1955.

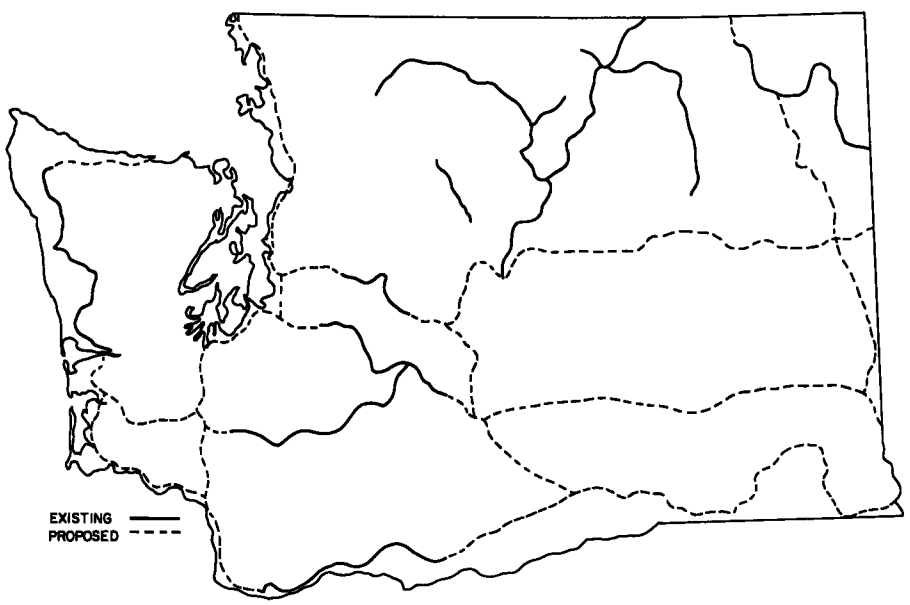


Figure 2. Washington State Highways in 1908.

THE NATURE OF HIGHWAY BENEFITS

The legislative directive for this investigation specifically named the general public the owners of real property, and the highway users as the three groups which are jointly to bear the costs of providing roads and streets. These three groups are, of course, the very groups which traditionally have shared the expense of providing public roads in the United States. That these particular groups have been recognized in this respect is a reflection of the three purposes for which roads have been laid out and improved, namely, to make possible the administration of government, to provide access to private property, and to facilitate personal and commercial transportation. Highway finance policy of the past suggests the prevalence of a popular feeling that any group's proper share of road expense is related to the benefits which that group derives from the road. Even those advocating that cost responsibility be made proportional to road use probably look upon the privilege of road use as a benefit for which payment should be made.

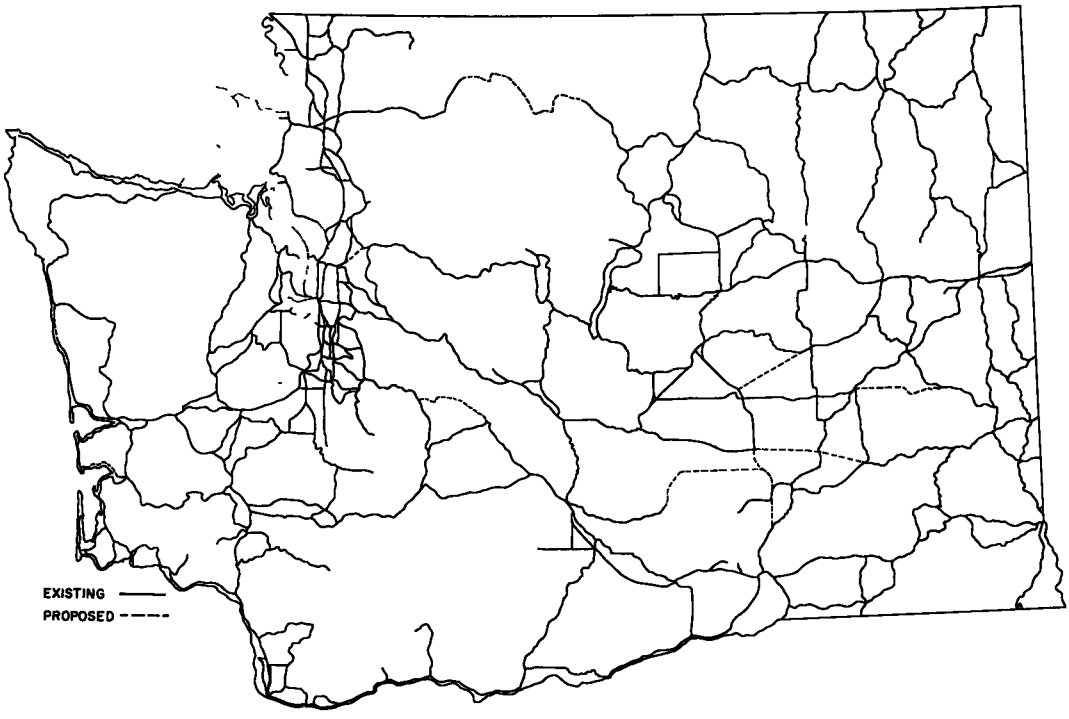


Figure 3. Washington State Highways in 1955.

Although the public preference for assigning total road and street costs to beneficiaries has resulted in a three-way split among the general public, property owners and highway users for many years, the relative responsibility of the individual groups has not stayed the same. As road functions change with our changing economy, the allocation of road costs must periodically be re-examined.

Everyone benefits from good roads; however, despite the fact that all highway benefits are broadly diffused throughout society, they are not uniformly distributed with respect to individual persons. People vary greatly in their ownership of land and in their use of highway transport. Complete reliance on property taxes would give some highway users a free ride; and a complete reliance on user fees for the support of highway improvement would confer on some landowners an unearned increment of value. It could still be true that the average citizen would not gain or lose by a choice between tax theories, but the average citizen exists only in imagination. More importantly, the pressure for specific highway expenditures is apt to be exerted most strongly by those

who expect to profit directly from the proposed work. Under such circumstances it is likely that the public interest will be served best by charging an appropriate share of the cost of the improvement against those who stand to benefit personally and directly from the proposed expenditures.

Benefits are hard to evaluate, qualitatively as well as quantitatively. Government benefits from roads in the very real sense that communication is essential to the exercise of authority and, hence, to that preservation of order which is essential to the survival of organized society. Nor is this benefit measured by the travel mileage of governmental vehicles with much greater validity than the value of our Strategic Air Command during the past decade could be measured by the number of atom bombs which it has dropped on enemy targets.

Real estate is benefited by the considerable increase in property value that is added when land becomes accessible. At least equally conspicuous is the advantage conferred upon the vehicle operator by better roads. These benefits overlap, of course. It would be visionary to conceive that a rigorous definitions of benefits accruing to either the land or the vehicle can be made, or even that an absolute distinction does in fact exist in any real sense. Road improvement raises the value of real property because highway users can then reach the affected property with greater convenience and at less expense. Conversely, most road usage is merely a means to the end of reaching some destination, some specific parcel of land. Convenience, rather than equity, may partly determine in the future as in the past, whether the vehicle owner or the land owner will be charged with the direct cost of highway construction.

TABLE 4

HIGHWAY USER SHARE OF TOTAL ROAD AND STREET COSTS

Theory	System	Share (percent)
Earnings credit	County	22
	City	64
	State	94
	All	62
Relative Benefit	County	56
	City	15
	State	75[a]-88[b]
	All	54[a]-60[b]
Predominant use	County	52
	City	28
	State	100
	All	67
Actual sources in 1953	County	68
	City	31
	State	100
	All	76

[a] Includes contributions to freeway costs from benefited property.

[b] Assumes no charge against property for urban extension of state highways.

Even though the placement of highway cost responsibility is guided to some extent by considerations of expediency as well as of equity, the decision is nonetheless critical. From the practical standpoint the basis for placing cost responsibility is highly important to winning public acceptance of the tax burden, to facilitating wise decisions on program expenditures, to the avoidance of drastic disturbance of our economic structure, and to the most efficient utilization of all means of transportation.

In review, the question of who should pay for roads must depend, in part, upon one's individual conception of the nature of the highway function. What is a highway system? Is it wholly a public utility which happens to be operated by government? If so, it should be run like a business, and the user should be charged in direct proportion to his use of the road. It remains to be determined what is the appropriate measure of use. If, on the other hand, highway operation is wholly a normal function of government the costs should be paid out of general tax revenues; and if, for convenience, a separate highway fund is to be established, such a fund should be supported by taxes levied in accord with general tax theory. Among the possibilities, under this concept, are taxes levied in proportion to the benefit received or in proportion to the ability to pay. Finally, it is possible to view highway improvement as a unique extension of the governmental function, in which the added expense incurred by the government to improve the basic highway facility for the benefit of the public is to be charged against the beneficiaries in proportion to their individual responsibility for added increments of expenditure.

These various theoretical considerations have suggested various methods of assigning responsibility for road costs.

Sharing the Cost

The highway users' share of total road costs was estimated by three theories: earnings credit, predominant use, and relative benefit. In applying the relative benefit theory the highway user and the property owner were assigned appropriate portions of the added expenditure required to improve the road above the standard of a basic road essential to the operation of governmental functions. Table 4 presents the results of this analysis.

The foregoing estimates of user responsibility agree on the point that the current rate of user contribution is sufficient to support a modern-day system of public roads and streets provided that some practical means can be found to increase the contributions from the general public and from owners of benefited property.

DISTRIBUTION OF USER RESPONSIBILITY

Even after highway users, as a class, have been allocated a definite responsibility for meeting the total costs of roads and streets, there remains the major problem of determining how they shall share this responsibility, as individuals. This would be a considerable problem even if all highway users operated identically similar vehicles, because a responsible official might wonder whether to tax them all equally, or to tax them in proportion to the amount of driving they did in a year, or to tax them according to the profit they derived from their use of the road, or according to their ability to pay additional taxes. These alternatives were discussed briefly (3), and it is relatively easy to limit the choice of methods to the two possibilities.

1. Should motor vehicle taxes be imposed in proportion to the use made of the road?
2. Should motor vehicle taxes on any individual represent the cost of providing the additional facilities which his use of the road entails?

In the first case the highway department acts as a landlord, renting the use of his road. In the second case the highway department acts as an agent, collecting from his principal only the repayment of sums spent on behalf of the principal. If road use is thought to be a proper criterion of cost responsibility it is important to decide upon the proper unit for measuring use. The most popular unit is the product of weight and distance, but also there are those who advocate a unit which expresses the value of the use. It is in this field that divergence of opinion becomes most extreme, because there is involved a fundamental concept of the role of government in operating a road system, and because the impact of highway taxation on affected industries will vary notably with the application of one or another theory of taxation.

Weight-Distance Taxation

Mileage taxes find expression in two remarkably contrasting forms. In some cases the road-use principle is used as a basis for assigning tax responsibility, but the assignment is collected from each vehicle in a lump sum based upon average mileages for the vehicle type. In other cases the mileage tax is used only as a means of collecting from each vehicle its share of road costs which are assigned to vehicle types or classes in proportion to the influence that the weight of the typical vehicle has exerted on the cost of road construction and maintenance.

Bases for Weight-Distance Taxation—Automobiles and Taxicabs, Trucks and Buses

Data were acquired through the use of questionnaires sent to Washington registered vehicle owners with the 1955 license applications. (5) These questionnaires were sent to the owners of over 200,000 vehicles in the state and covered 10 percent of registered automobiles, 50 percent of the registered trucks and trailers, and 100 percent of registered buses and taxicabs. Returns were received from 40 percent of the sample. Information was also collected from the files of the State Liquid Fuel Tax Division on fuel consumption and miles traveled by diesel vehicles. The Motor Vehicle License Department provided information on the number and types of vehicles registered over

a period of years. The Highway Planning Survey provided data on actual operating weights for over 75,000 trucks and trailers. Private agencies and firms also provided information.

The data from the questionnaires were punched on cards and processed by machines. Information from all the sources was analyzed statistically and cross-checked. This information was summarized and tabulated for automobiles by make; taxicabs by make; buses by licensed gross weight groups, type of fuel, and type of service; and trucks by licensed gross weight groups, type of fuel and type of truck.

Operating Cost Theory

Motor freight revenues are roughly determined by freight rates, and these rates tend to be proportional to truck operating costs in a competitive situation. Thus, in a very general way, vehicle operating costs are related to the profit or benefit that the industry derives from its use of the highway.

TABLE 5

AVERAGE GROSS TON-MILE CONTRIBUTIONS OF WASHINGTON[a]

Make	Average Contribution per Gross Ton-Mile for Passenger Cars (Mills)	Average Contribution per Gross Ton-Mile for Taxicabs (Mills)
Buick	2.79	2.39
Cadillac	2.15	2.36
Chevrolet	2.63	2.64
Chrysler	2.50	2.70
DeSoto	2.54	2.45
Dodge	2.65	2.59
Ford	2.62	2.56
Frazier	2.36	2.76
Henry J.	2.52	--
Hudson	2.52	2.42
Kaiser	2.49	2.28
Lincoln	2.34	2.07
Mercury	2.62	2.45
Nash	2.29	2.18
Oldsmobile	2.57	2.22
Packard	2.41	2.75
Plymouth	2.61	3.39
Pontiac	2.61	2.62
Studebaker	2.63	2.48
Willys	2.87	3.05
Miscellaneous	2.22	2.41
Average	2.57	2.97

[a]Registered passenger automobiles and taxicabs, by makes, 1954.

The advocates of this proposal suggest that after the users' share of the total annual highway bill has been determined by other methods each vehicle should be charged in proportion to the product of its annual mileage and its operating cost per mile. The operating costs for different vehicle types were determined in an extensive investigation conducted by the Washington Highway Department, the U.S. Bureau of Public Roads, and the Western Highway Institute.

Incremental Cost Study

In the incremental cost method (3) of assignment of tax responsibility the extra cost of building roads to higher design standards to serve heavier and more frequent loads is charged against heavier vehicles which occasion these increments of cost. The following steps were used in this substudy to determine and assign the costs:

TABLE 6

AVERAGE GROSS TON-MILE CONTRIBUTIONS OF DIFFERENT CLASSES OF VEHICLES BY LICENSED GROSS WEIGHT GROUPS, 1954 (MILLS)

Licensed Gross Weight Groups (in lb)	Diesel Trucks and Truck-Tractors (to 36,000 lb)	Diesel Trucks Truck-Tractors and Combinations (to 72,000 lb)	Farm Truck Gasoline	Inter-City Buses-Diesel	Inter-City Buses-Gasoline	Inter-City Truck and Truck-Tractors (to 36,000 lb)	Inter-City Trucks, Truck-Tractors and Combinations (to 72,000 lb)	Intra-City Buses-Diesel	Intra-City Buses Gasoline	Intra-City Trucks and Truck-Tractors	Logging Trucks, Truck-Tractors and Combinations (to 72,000 lb)	Trailers and Semi-Trailers
Under 2,000										6 306		
2,000 - 3,999			4 445[a]			3 014[a]	3 013[a]			6 084	3 034[a]	
4,000 - 5,999	4 620[b]	4.465[b]	4 006		2.29[b]	3 091	3 090		3.50[b]	5 048	2 734	4 916
6,000 - 7,999	4 703	3 935	4 106		2 20	3 112	3 112		2.88	4 127	3.425	1 335
8,000 - 9,999	4 285	3 369	4 294		3 09	2 516	2 455		-	4 520	2 769	2 470
10,000 - 11,999	4 903	3 758	4.022		1 89	2.527	2 474		2 11	3 385	2.409	5.661
12,000 - 13,999	4 350	2.149	3 913		1 98	2.402	2 355		1 88	3 261	3 445	1 951
14,000 - 15,999	2 678	2 088	3.593		1 88	2.233	2 187		1 90	3 059	3 183	0 772
16,000 - 17,999	2 823	2 289	3.715	1 28	1 83	2.440	2.409	1 61	1.73	3.226	3.338	0 966
18,000 - 19,999	3 512	2 664	3 429	1 46	2.19	2 585	2.556	1.28	1 87	3.532	2 723	1 319
20,000 - 21,999	2 612	2.344	3 746	1 32	2 20	2 562	2 432	1 68	2 94	3.482	3 328	2 228
22,000 - 23,999	3 386	2 985	3 841	1.16	1 93	2.464	2 292		1 30	3 247	1 781	0 758
24,000 - 25,999	2 188	1 861	5 356	1 08	1 91	2 492	2.411		1 44	2.769	2 887	1 743
26,000 - 27,999	2 073	1 749	6.723	-	-	2.181	1.967		1 51	3.486	3.071	2.296
28,000 - 29,999	2 295	2.019	2.524	-	-	2 565	2.323		-	3 253	3 195	1 575
30,000 - 31,999	2 469	1 802	3 664	-	-	2 696	2.451		-	4 879	3 548	1 234
32,000 - 33,999	3 381	3 024	4 952	1.22	1 86	2.624	2 386		-	4.560	2.109	7 372
34,000 - 35,999	1 946	1 633	4 097			2 553	2.511		-	5 004	2 166	0 709
Combinations												
32,000 - 33,999							1 371					
34,000 - 35,999							1.460					
36,000 - 37,999		1 311					1 549				1 753	
38,000 - 39,999		1 354					1 653				1 835	
40,000 - 41,999		1 339					1.703				1 906	
42,000 - 43,999		1 362					1 798				1 970	
44,000 - 45,999		1.367					1 683				2 039	
46,000 - 47,999		1 388					1 739				2 076	
48,000 - 49,999		1 394					1 813				2.138	
50,000 - 51,999		1 425					1.606				2.150	
52,000 - 53,999		1 406					1.606				2 165	
54,000 - 55,999		1 405					1.618				2.111	
56,000 - 57,999		1 404					1 640				2.115	
58,000 - 59,999		1.414					1 665				2.081	
60,000 - 61,999		1 415					1.777				2.064	
62,000 - 63,999		1 446					1.813				2 089	
64,000 - 65,999		1.427					1 813				1 986	
66,000 - 67,999		1 413					1 823				2.001	
68,000 - 69,999		1 363					1 822				2 010	
70,000 - 71,999		1 364					1 832				2 021	
(Average contribution per gross ton-mile up to 20,000 lb)			3 847									
Up to 36,000 lb	2 094		3.974	1.24	1 99	2.592		1.61	1.95	4.068	2.466	2 658
Up to 72,000 lb		1 974					2 060				2.476	

[a] Under 4,000 lb

[b] Under 6,000 lb

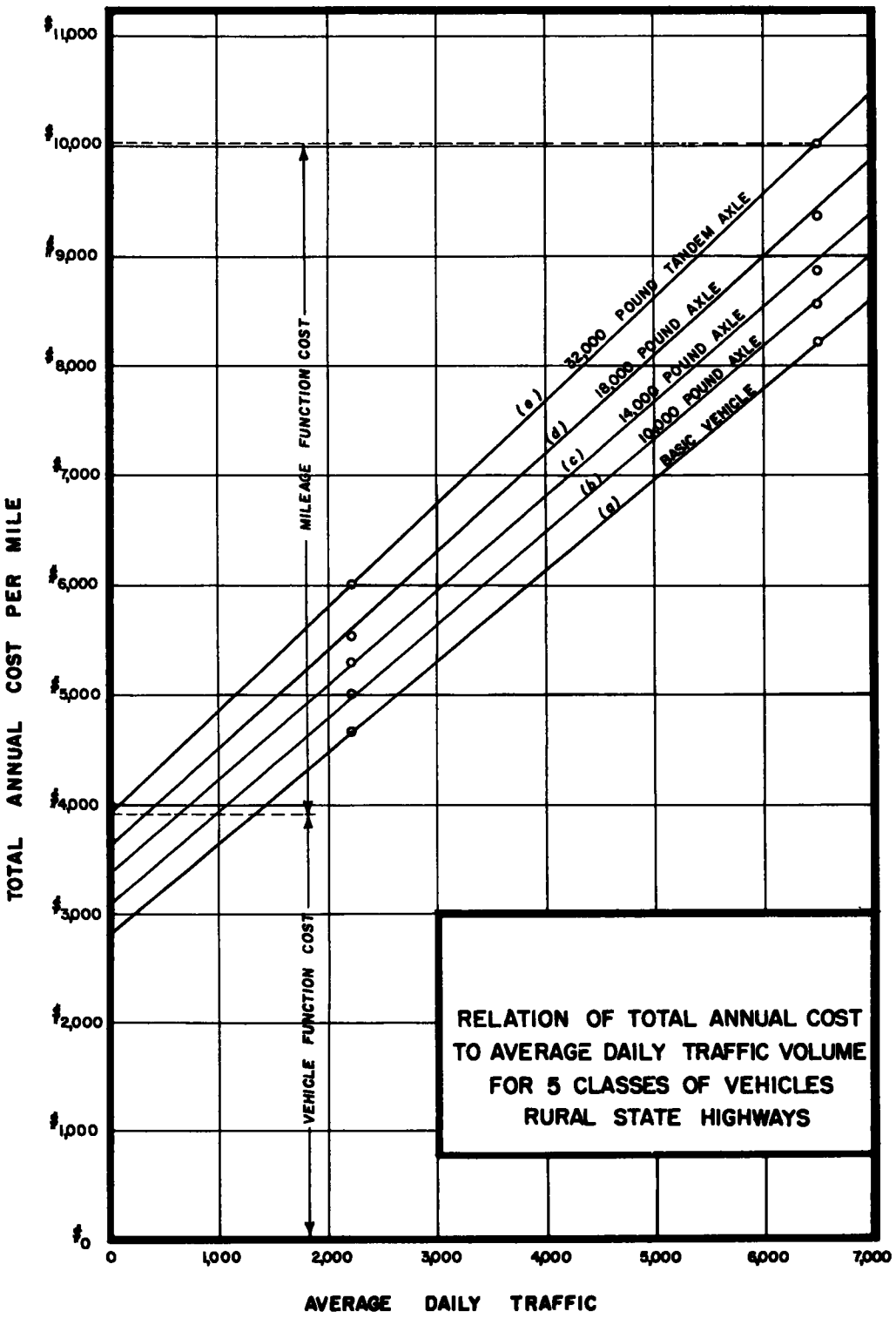

$11,000
$10,000
$9,000
$8,000
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
TOTAL ANNUAL COST PER MILE
MILEAGE FUNCTION COST
VEHICLE FUNCTION COST
(e) 32,000 POUND TANDEM AXLE
(d) 18,000 POUND AXLE
(c) 14,000 POUND AXLE
(b) 10,000 POUND AXLE
(a) BASIC VEHICLE
RELATION OF TOTAL ANNUAL COST TO AVERAGE DAILY TRAFFIC VOLUME FOR 5 CLASSES OF VEHICLES RURAL STATE HIGHWAYS
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
AVERAGE DAILY TRAFFIC

Figure 4.

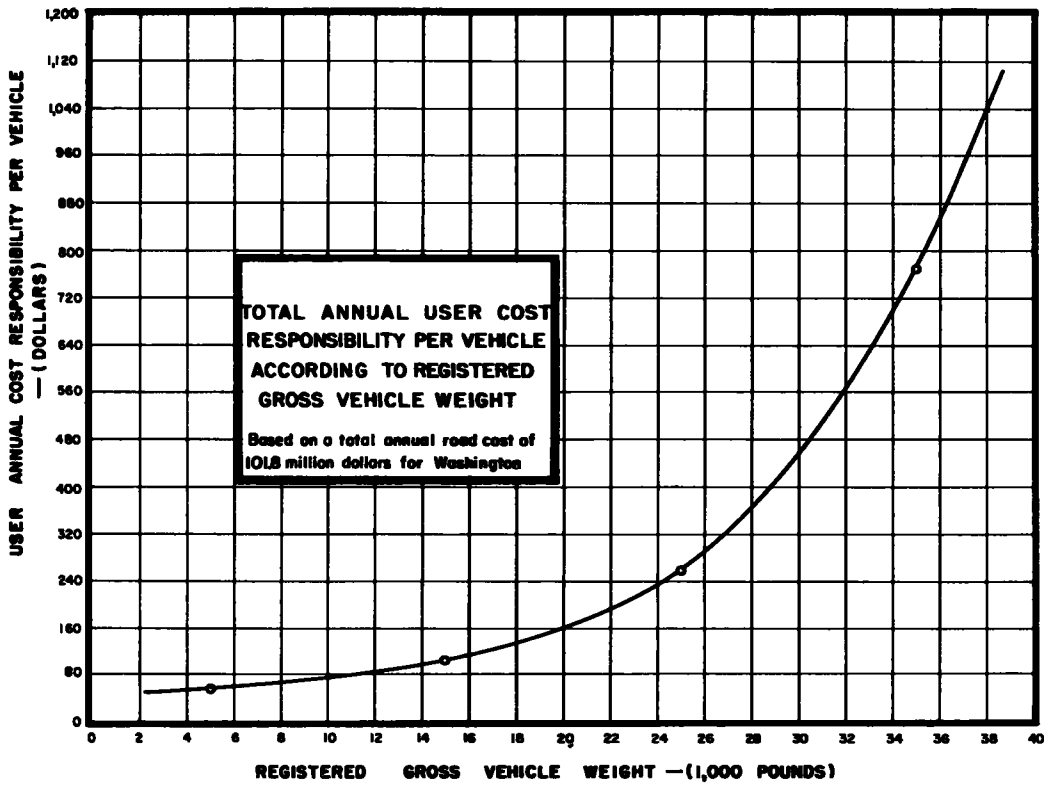


Figure 5.

1. Roads were classified according to usage (usage measured by estimated average daily traffic volume).
2. The increments of the annual cost for each road class were determined on the basis of design standards for that class road.
3. Vehicles were classified into principal types according to gross weight; then the relative use of each class of road by each vehicle type was determined.
4. The finding of the Malad and Maryland test roads were related to the Washington roads as a guide in determining road life and design requirements as affected by vehicle weight classes on each class of roads.
5. Incremental costs were assigned to vehicle weight groups according to the proportionate use that each weight group made of each class of road.

Rural roads and city streets were handled separately in this study.

TABLE 7

Licensed Gross Vehicle Wt. (Ton)	Average Annual Mileage	Annual Impost (Fees plus fuel tax)		
		by operating cost theory (dollars)	by ton-mile theory (dollars)	by incremental cost theory (dollars)
Auto	8,900	61	58	58
6-ton	5,620	79	75	85
10-ton	9,450	154	197	160
14-ton	20,700	283	598	365
18-ton	30,100	634	1,132	860

In the determination of which items of highway expenditures were primarily vehicle function or readiness to serve costs, and which were primarily mileage or traffic function costs, graphs were plotted for each vehicle type using total annual cost per mile as ordinates and overage daily traffic as abscissa. The resulting curves were straight lines. The point of intercept of the curve of the heaviest vehicle with the "O" ordinate was used as the dividing line between vehicle function cost and mileage function costs. Such a graph for rural state highways is shown as Figure 4.

Dividing the User Share of Highway Costs Among Different Vehicle Types

Table 7 shows the amount to be charged the average vehicle in each weight class as its share of a total annual user responsibility of $74 million. The assigned annual mileage is the average value for all vehicles of the specified gross weight.

PROPERTY VALUE STUDIES

The allocation of cost responsibility between highway users and others according to relative benefits required the collection of information on how road improvement does affect land values. Consequently, two important sections of the project were concerned with the economic impact of improved access on rural and suburban property values.

Benefits of Rural Roads to Rural Property

The approach to this study was through the study of rural farm and nonfarm property values and the association of property values with variations in roads (6). The property values used in this study were taken from actual sales records and were restricted to sales believed to represent actual market conditions. The data were taken from records of property sales where a warranty deed was transferred.

Measurements of road location for this study were made to include considerations of (a) the measurement of the location of the property from several reference places, (b) each type of road that would have an effect on property values that was not necessarily equal to the effect due to other road types, and (c) the length of road to affect property values. These measurements along with measurements of land values and other qualities of rural locations were achieved in eight steps.

These eight steps were applied in three geographical areas on two types of rural land use, farm land and residence sites of rural nonfarmers. The three areas chosen are a cross-section of the rural and urban economic structure of the state.

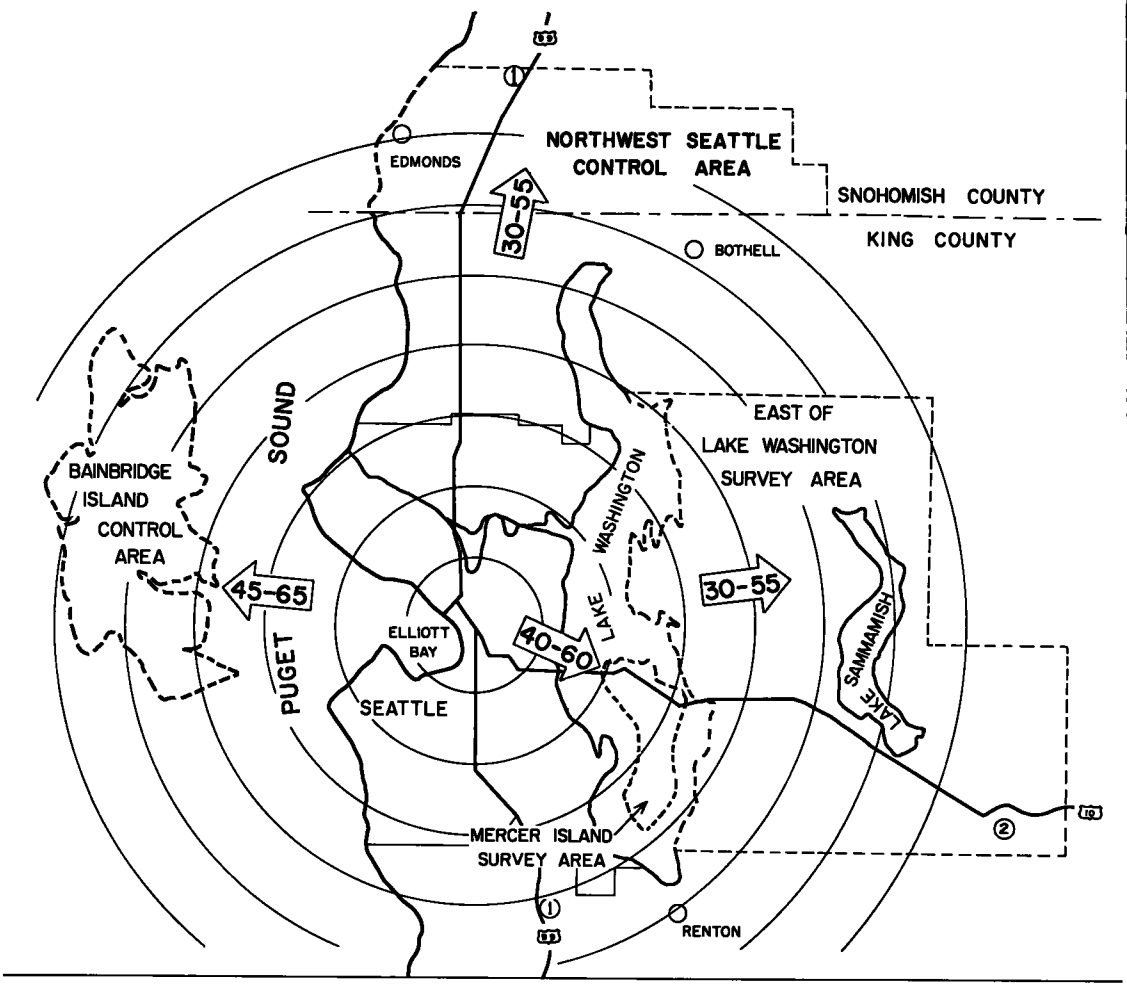
Much of the data for this study was obtained by the personal interview method based on previously designed questionnaires covering the information needed. They were not opinion polls, but factual data polls of residents of sampled properties. Title insurance company records were also used.

The results of this study indicate that the paving of existing roads serves to increase average farm values by 15 percent, neglecting any secondary effects upon the market for farm products or on the demand for farm land.

Freeways and the Suburbs

Conspicuous increases in suburban property values accompany freeway development. (7) The increasing investment in this type of facility cannot keep pace with the increasing demand without the development of a tax structure appropriate to the needs and nature of this new type of road. Primarily these freeways serve the suburban fringes of urban centers, and the future dimensions of the problem are forecast by the fact that almost all of the increase in the population of the United States during the past five years has been suburban in character. This dispersal of urban working population is a development of utmost importance from the standpoint of civil defense, as well as in many other ways; and even today highway administration has no more important job than to reduce the travel time of the daily migrations of the suburbanites.

The effect of freeway access upon suburban property values was examined through the study of a limited access freeway, the Lake Washington floating bridge and its highway approaches connecting downtown Seattle with residential Mercer Island and the mainland to the east.



SURVEY AND CONTROL AREAS

PRE-BRIDGE TRAVEL TIME IN MINUTES AND DISTANCE IN AIRMILES FROM 4th AND MADISON, SEATTLE

CIRCLES AT INTERVALS OF TWO MILES FROM 4th AND MADISON

PRE-BRIDGE TRAVEL TIME IN MINUTES FROM 4th AND MADISON SHOWN THUS: 45-65

Figure 6.

Mercer Island was studied first to test survey methods and sources of information; and to provide a pilot study useful for the subsequent survey of the larger area east of the Lake and of selected control areas. The opening of the floating bridge from Seattle to Mercer Island in 1940 reduced the travel time between the two places from 45 minutes to 20 minutes. The resultant cost saving accelerated the development and settlement

of Mercer Island and the area east of it. The span of 15 years since the completion of the bridge covered sufficient time to yield a useful model of the effect of improved access upon suburban property values. The values studied cover two periods of time: pre-bridge years and late post-bridge years. To measure the change in property values, sales prices were obtained from records of actual sales values for "before" and "after" time periods. Control areas were also used for comparative purposes.

The types of real property used in this study were improved and unimproved residential land suitable for residential development whether platted or unplatted.

It was found that, after adjustment for other factors, the construction of the freeway added 70 percent to the value of the suburban areas which it served. This percentage is the property value increase attributable to the construction of the freeway only and does not represent the total property value increase of the given time period.[1]

COMMERCIAL MOTOR CARRIERS AND HIGHWAY USERS

This study covers competitive and structural analysis of the commercial highway user industry, the volume and character of freight traffic movements by commercial motor carriers and factors relating to earning value of commercial motor carriers. (8) The basic objective of this study was to measure the benefits commercial users receive from the highways and to arrive at basic measures of the ability of these users to pay for the roads over which they operate.

Competition, both among the various truckers and between motor freight carriers and other forms of transportation, was considered in evaluating the ability of carriers to pay additional taxes. This study gave consideration to both qualitative and quantitative aspects of carrier competition in Washington.

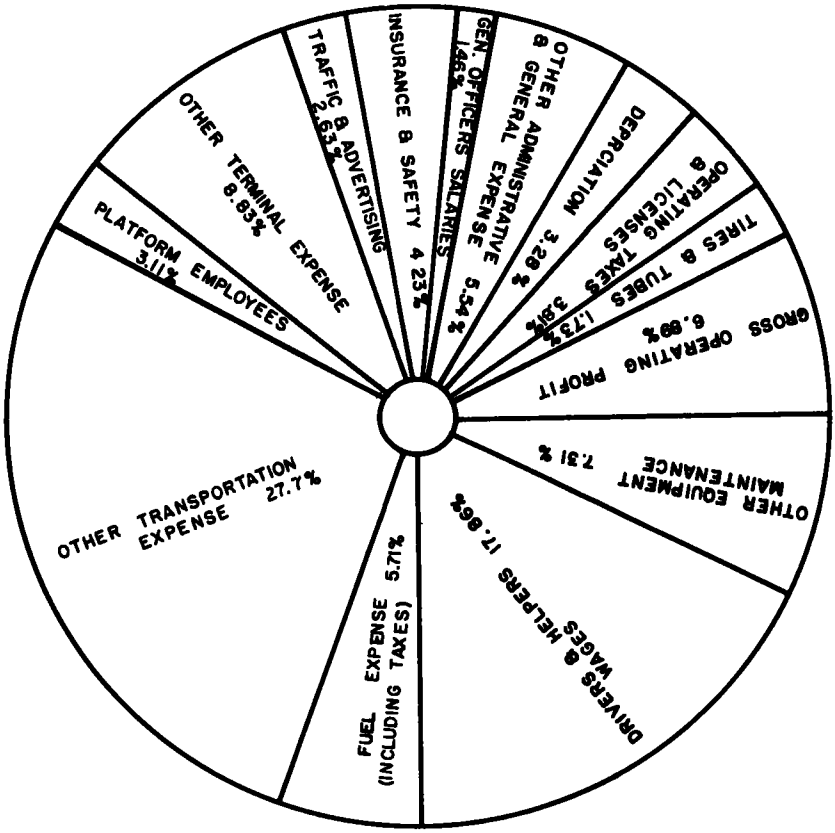
"The study of earning values of commercial motor vehicles using the highways of the state of Washington was a study of many things that affect carriers. Briefly stated, these factors included: (1) Competition among the highway users and with other forms of transportation, (2) the pricing structure of highway carriers, (3) economic regulation of motor carriers by the Washington Public Service Commission in so far as it affects pricing policies and ability to adjust rates charged, (4) the basic franchise or permit to carry products as both a limiting factor in earning values and a basic license to do business, (5) cost data and information, both to determine total per mile and per ton costs, and as a means of analyses of various items of expense to arrive at norms and comparative standards of efficiency and cost determinations and (6) analyses of consists or character of traffic moved to determine to what extent the mixture hauled, seasonal patterns, differences in traffic make-up from varying economic activities, average weights and other factors relating to commodities transported affect earning values." (8a)

To carry out these studies an analysis was made of operating authorities and competition with other transportation modes. A study was also made to determine the type and amounts of commodities carried by the commercial highway users. In order to measure the monetary return to the carriers for transporting commodities, it was necessary to determine the mixture of commodities which move in various regions of the state. Freight bills covering one year's shipments were obtained from selected carriers. Pilot studies were utilized to determine methodology and procedures and in the final study, statistical samples were taken from a total universe of about 2 million freight bills. These data were coded, punched and tabulated by machines, then analyzed to show (a) yearly consist for selected general freight routes or carriers, (b) commodity consist summaries of 15 predominate commodities, (c) monthly traffic pattern for four selected freight routes and carriers, (d) yearly consist of six

[1]The study of highway benefits to rural and suburban property is discussed in greater detail in another paper ("Washington Highway Economic Impact Studies," by R.G. Hennes, Bayard O. Wheeler and William Garrison, Bulletin 169, Highway Research Board, 1957).

selected carriers of special commodities, (e) point to point commodity flow for three major distribution centers to be selected destinations and (f) outbound commodity flows from eight selected cities without regard to destination.

A ranking study was made to determine whether there was correlation between gross revenues earned, total tonnage carried, and total miles traveled by commercial motor carriers. Among carriers having single commodity rights, noticeable correlation was found between these criteria within each grouping of carriers. Very little correlation



OPERATING RATIO 93.11

(RATIO OF EXPENSES TO INCOME)

TOTAL REVENUE ALL CARRIERS REPORTING—$ 538,752,400
TOTAL REVENUE OF CARRIERS REPORTING TONS— 524,329,200
TOTAL REVENUE OF CARRIERS REPORTING MILES— 524,278,800
TOTAL TONS REPORTED—13,353,860
AVERAGE COST PER TON—$ 24.29
TOTAL MILES REPORTED—593,601,800
AVERAGE COST PER MILE—$ 00.55

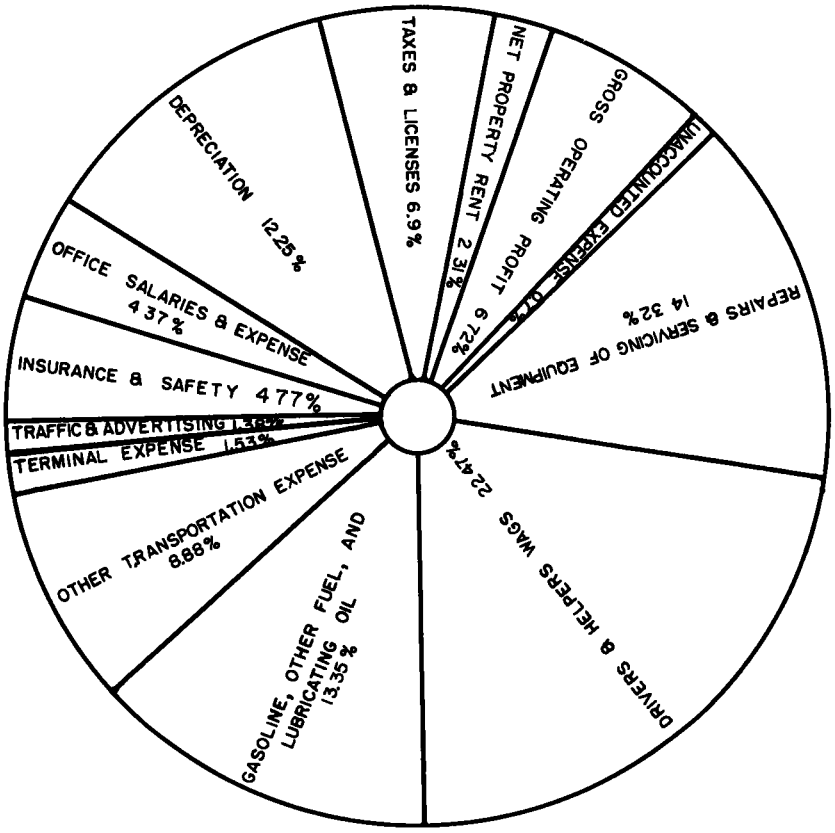
Figure 7. Aggregated averages of expense data, 325 Class I and II motor carriers, 1954.

was found among tons carried, miles traveled or revenue earned among heterogeneous trucking firms.

Since most highway user tax plans take into account distance traveled and weight carried, revenue and expenses of commercial motor carriers were correlated with weight and mileage. A complete analysis was made of revenue, expenses, tonnage and mileage figures for all common carriers reporting these figures annually to the Washington Public Service Commission.

CREDIT FINANCING

It was required that the investigation be broadened to include a discussion of credit financing as it applies to the State of Washington. (3) This substudy discusses the character of the highway finance problems, public ability and willingness to pay for highways, state highway needs in relation to available funds in 1955-56, the alternates for financing highway needs, some pros and cons of credit financing of highway construction, and illustrative examples of highway finance in 1955-56 (including pay-as you-go, borrowing of $20 million, and borrowing of $40 million considering cumulative construction investment, survival value, depreciation value, and bonds outstanding any given year of the ten), revenue bonds as general obligation bonds, and practical debt limits. Highway department historical data and road life data provided by the Bureau of Public Roads were the bases for this substudy. This information on credit financing will provide the legislature with guidance as to the effect of several possible bonding programs on the net worth of the highway system at the end of the program.



OPERATING RATIO 93.28

TOTAL REVENUE ALL CARRIERS REPORTING——$ 36,833,900
TOTAL REVENUE OF CARRIERS REPORTING TONS——23,440,000
TOTAL REVENUE OF CARRIERS REPORTING MILES——25,958,100
TOTAL TONS REPORTED—13,602,647
TOTAL MILES REPORTED—56,211,800
AVERAGE COST PER TON—$1.72
AVERAGE COST PER MILE—$00.46

Figure 8. Aggregated averages of expense data, 1,373 Class III motor carriers, 1954.

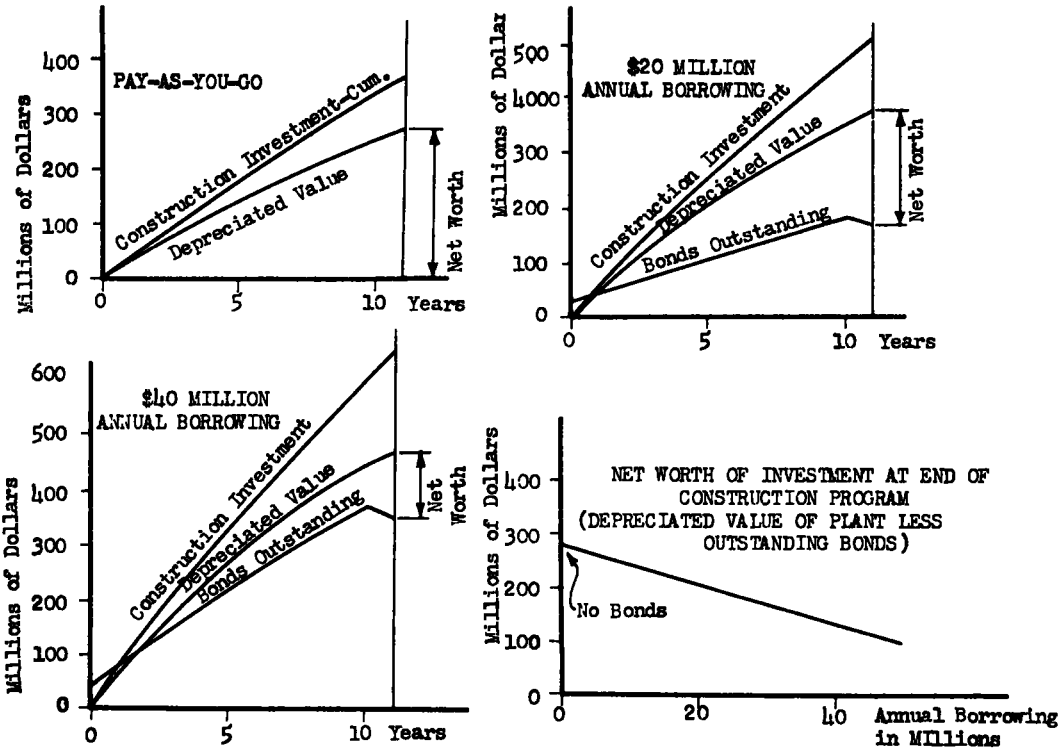


Figure 9. Results of a ten-year construction program, based on anticipated revenues, with and without bond issue.

CONCLUSIONS

The full report of these findings amounts to more than 1,500 pages in nine volumes, in addition to a pamphlet which reports a summary of the findings. Much basic information on road usage, life, costs, as well as property value changes and commercial user benefits and costs as related to roads, has been found and applied to the problem of how much who should pay for roads and streets in Washington State. Percentages of highway cost responsibility chargeable to the user and to others (on the basis of several different taxing theories) were determined. Information on the variation of user responsibility among users as shown by weight-mile, operating or incremental costs was also found. The legislature now has much more data than ever before to help them in establishing equitable tax support for highways and streets (whenever a decision shall have been reached regarding the rate of expenditure which will have public approval). This does not mean that all of the answers are obtained. There will always be a need for more research and study on highway cost allocation.

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b. Vol. 2 The volume and character of freight traffic movements by commercial motor carriers in Washington.

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Comparative Highway Cost Allocations: Incremental and Other Methods

WILLIAM E. KOENKER, Professor of Economics, University of North Dakota

Three methods of allocating highway costs to different classes of users have achieved general recognition. These are the ton-mile, the cost-function, and the incremental methods. An allocation study recently made in North Dakota affords one of the better bases for comparing the relative tax assignments under each of the three methods.

The costs allocated under the North Dakota study were those of a future 15-year program of construction and maintenance. All costs on the state and one-half of the costs on the county system were assigned to users and included in the program. Assignments of cost responsibility were made to foreign as well as to domestic vehicles.

In the ton-mile method the annual program costs were divided by the total ton-miles of travel. The resulting rate was applied to the ton-miles of travel for which each vehicle classification was responsible in order to determine annual cost responsibility. In the cost-function approach the program costs were divided into three functional categories. The costs in each category were then allocated on a somewhat different basis. The following indicates the breakdown of costs and the method of assignment:

Classification	Percentage	Allocated According to:
Standby	4	Number of vehicles
Traffic volume	63	Axle-miles
Weight	33	Ton-miles

For the standby and the travel costs the allocation was made the same as under the cost function, except that vehicles were assigned costs for only those roads which they used. The weight costs, however, were assigned incrementally. All vehicles shared alike on an axle-mile basis in the cost assignable to the basic road. This was a hypothetical road designed to accommodate single-axle weights up to 6,000 lb or tandem-axle weights up to 9,000 lb. Single axles in the 6,000- to 12,000-lb category, or their tandem equivalent in the 9,000- to 18,000-lb class, were assigned, in addition to their basic road responsibility, an additional amount reflecting the higher cost necessary for roads designed for these heavier vehicles. Additional incremental assignments of cost were made for vehicles with still heavier axle weights.

In addition to making program cost allocations according to these three methods, an estimate was also made of how the program costs would be assigned to users under the existing two-structure tax.

On the basis of each of these methods it was possible to arrive at the annual per-vehicle cost responsibility of all vehicle type and weight classifications.

● THREE GENERAL METHODS have been developed, during the past several decades, for allocating highway costs among different classes of users. Each of these methods is designed to indicate the "equitable" share of highway costs which should be assigned to each vehicle type and weight group. These approaches are the ton-mile, the cost function, and the incremental method. The recent highway cost allocation made for North Dakota provides one of the better bases currently available for comparing the tax assignments which would result from each of the approaches. (1)

The purpose of the present article is to compare the allocations to various vehicle type and weight groups which would be made under the different methods. In addition,

these allocations will be compared with the allocation which would be effected by the present form of fuel and license tax. Before making these comparisons, however, it is necessary to outline briefly the procedure in each method and point out the several respects in which the North Dakota procedure deviated from what has come to be accepted as standard practice under each of the three methods.

In each of the various approaches the highway costs to be assigned were those of a 15-yr construction and maintenance program. These program costs included federal aid expenditures, some costs assigned to general property tax payers, and costs properly assignable to highway users. This last category included all the state's share of the cost of state highways and half of the cost of the country roads. The actual allocations were applied to only this user-share of the total program. For convenience the cost for the mid-year of the program (1964) was used. This amounted to 22.9 million dollars for the year which was about 40 percent in excess of current expenditures out of user-derived revenues.

Because of its simplicity and directness, the ton-mile method of allocation permits virtually no variation in the specific technique to be used. It requires that the mid-year program costs be divided by the product of miles of travel times vehicle weight. The resultant ton-mile rate may then be applied to the ton-miles of travel of each vehicle type and weight group to determine the group's share of the total cost. Travel by "foreign" vehicles on North Dakota roads and travel on county and local roads were included in the mileages used. This made it possible to assign a specific share of the user cost to foreign vehicles rather than to employ the usual assumption that out-of-state travel by domestic trucks matched the in-state travel by foreign trucks.

The cost-function method assumes that some highway costs are functions of factors other than miles times weight. Therefore, some of the program costs such as costs of vehicle registration are allocated on a per vehicle basis. Other costs such as traffic control, drainage, and part of clearing and grading have been charged on a travel volume basis. This leaves those costs primarily associated with thickness of pavement and base to be allocated on the basis of ton-miles. In the North Dakota study only 4 percent of the projected costs were allocated on the per vehicle basis, 63 percent were allocated on the basis of travel, and 33 percent on the basis of weight. In most of the cost-function studies made by the American Trucking Association higher percentages of costs were placed in the per vehicle and in the weight category.

The significant difference between the North Dakota cost-function analysis and the ATA studies was that travel costs in the North Dakota study were allocated on the basis of axle miles (2). Tandem axles, however, were considered as equivalent to single axles. In the ATA studies vehicle miles were used. This has the effect of assigning to a 5-axle combination the same portion of the travel costs as are assigned to a passenger car. The use of axle miles for travel cost assignment seems preferable in that it does provide a solution to the problem of whether to classify combinations as one or more vehicles. Use of axle miles also reflects axle repetitions; and, even though these are disassociated from weight in the travel costs, repetitions do have a wearing effect on bearing surfaces. Of greater significance is the fact that axle miles afford a better reflection of vehicle length and weight and, hence, of lane width, sight distance, and other elements that affect the geometrics of road design.

The incremental method is superior to both the ton-mile method and the cost-function in that it breaks away from any benefit basis of taxation and uses instead a cost responsibility basis. Each vehicle class and weight group is assigned only those highway costs which can properly be attributable to that class. Again in this method, as in the cost-function, certain costs such as registration are deemed to be a function only of numbers of vehicles. Hence these costs are properly assignable only on a per-vehicle basis. This included only 4 percent of all costs in the North Dakota incremental analysis. The remainder of the costs under the incremental approach are a function of traffic volume or of weight.

In the allocation of these traffic and weight costs the incremental method makes use of the basic road concept. This is a hypothetical road such as would be designed if only passenger cars and light weight trucks were expected to use it. In the North Dakota study this basic road was defined as one which would accommodate single-axle loads of

6,000 lb or tandem-axle loads up to 9,000 lb. All of the travel costs (61 percent of total costs) were assigned equally among all single and tandem axles, irrespective of weight carried. This equality was achieved through the assignment of all travel costs to the basic axle weight class (under 6,000 lb single or 8,000 lb tandem) since all heavier axle weights have this basic weight as their first component. Axles carrying more than the basic weights would bear their portion of the travel cost on an axle-mile basis and would then also be assigned a share of the weight related costs.

To assign the costs of building roads to standards adequate for vehicles weighing more than the basic vehicle, it was necessary to determine the design standards required for these heavier vehicles. These standards and the associated costs were determined for the following single-axle weights and tandem-axle equivalents. Data are in kips (thousands of pounds).

Single Axle	Tandem Axle
0 - 6	0 - 9
6 - 12	9 - 18
12 - 16	18 - 24
16 - 18	24 - 30

The tandem axle equivalencies were used in recognition of the WASHO test findings that the distress areas caused by single axles of a certain weight were about the same as those caused by tandem axles of 1½ times that weight. (3)

In addition to developing the construction and maintenance costs assignable to different axle-weight groupings, these costs have to be broken down as to the various highway capacity systems. In the North Dakota study, five systems were distinguished ranging from the interstate, designed to carry 4,000 or more vehicles per day, down to the county roads carrying 200 or less vehicles per day. This classification is required because in the incremental analysis each vehicle type and weight class contributes only to the cost of the roads which it actually uses and in proportion to that use.

Because the travel costs were all assigned to the basic axle-weight class, the weight related costs had to all be assigned to the heavier axle-weight classes. In the incremental approach a cumulative procedure is used in allocating these costs.

In the case, for example, of the heaviest single-axle weight, 16 to 18 kips, those axles were to be assigned their share of the travel costs of the basic axle weight, also their share of the costs required to 6 to 12 and 12 to 16 kip loadings and the full cost made necessary by the last increment of design standard. This procedure follows from the theory that each axle-weight class should pay for the specific increase in costs which that class occasions, and also for its proportionate share of the subordinate or underlying design requirements.

The principal departure made in the North Dakota incremental analysis from previous incremental studies was the use of tandem axle equivalencies and the assignment of costs to foreign as well as domestic vehicles. Except for allocating travel costs on an axle-mile basis, the method follows basically that established by Pancoast. (4)

COMPARATIVE COST ALLOCATIONS

Because the costs assigned under each of the three equity approaches were user costs for the mid-year of the program, they are directly comparable, as is also the allocation of the program cost which would be effected under a two-structure (fuel and license) tax. In making these allocations, registrations were projected to 1964. The resulting tax assignments are referred to as "Adjusted 1964 Payments." Table 1 indicates the percentage of program costs assigned to each of the four vehicle types under the equity approaches and under the present type of two-structure tax.

Passenger cars bear a heavier cost under the existing type of gasoline and high license fee than is indicated under any of the equity approaches. For the domestic trucks, the incremental method assigns to them a substantially greater cost responsibility than is indicated under the adjusted 1964 payments or under the cost-function method. For foreign trucks the cost assignment under the incremental method is less than under either the cost-function or the ton-mile method. This is because costs of the various

classifications of highways are assigned only in proportion as particular classes of vehicles use those highways. Under the gasoline tax and license fee method foreign trucks would pay only 60 percent of the costs assigned to them under the incremental solution.

TABLE 1

	Adjusted 1964 Payments	Equity Approaches		
		Incremental	Cost-Function	Ton-Mile
Automobiles	56.3	42.7	54.9	33.8
Domestic trucks	40.0	51.5	38.6	54.6
Foreign trucks	3.3	5.5	6.1	10.8
Intercity buses	0.4	0.3	0.4	0.8
	100.0	100.0	100.0	100.0

In addition to comparing cost assignments for various vehicle types, it is important to make comparisons of the assignments to weight groups within a vehicle class. The annual per vehicle cost responsibility for domestic trucks is shown in Table 2. (5)

TABLE 2

Registered Weight Classification	Number of Vehicles	Adjusted 1964 Payments	Incremental Method	Cost-Function Method	Ton-Mile Method
4,000	89	10	3	3	-
6,000	2,853	27	32	36	24
8,000	39,949	41	35	41	31
10,000	14,455	44	30	34	31
12,000	7,768	36	21	24	23
14,000	6,483	49	22	21	23
16,000	9,943	58	24	21	25
18,000	11,193	67	43	33	43
20,000	8,096	88	93	63	89
22,000	3,669	114	238	140	210
24,000	5,690	226	328	208	320
26,000 - 30,000	349	421	526	364	640
32,000 - 36,000	834	620	802	605	1,087
38,000 - 44,000	347	940	1,778	1,050	1,878
46,000 - 54,000	276	1,725	3,642	2,259	4,456
57,000	77	1,915	3,858	2,388	4,817
60,000 and over	386	2,172	4,012	2,902	6,037
Average Total	112,457	81	95	74	105

In comparing the above cost assignments, the total cost responsibility assigned to the four vehicle types differed under the three methods. This difference affects the per vehicle cost assignments. It is significant that the present two-structure tax would exact substantially more from most of the trucks weighing under 20,000 lb than would be true under any of the equity approaches. This would occur because these vehicles are predominantly farm trucks and incur an annual average travel on public roads of only about 4,000 miles per year. For the heavier trucks the incremental method would assign costs substantially in excess of the two-structure tax but much less than the ton-mile approach.

Comparisons of the cost assignments for foreign trucks can only be made on a weight class basis rather than a per vehicle basis. The relative costs assigned to several important weight classes are shown in Table 3.

For the foreign trucks even the light-weight vehicles are assigned substantially more under any of the equity approaches than under the "Adjusted 1964 Payments." This occurs because under reciprocity and an administratively impractical prorationing system foreign trucks pay very little more than fuel taxes. This results in the 46,000- to 54,000-lb class paying under a two-structure tax only about half of its incremental cost responsibility.

TABLE 3

Weight Group	Adjusted 1964 Payments (dollars)	Total Annual Cost Assignment (dollars)		
		Incremental	Cost-Function	Ton-Mile
12,000	4,648	7,022	8,176	10,228
24,000	68,415	174,898	110,740	176,225
46,000 - 54,000	104,370	213,616	185,702	367,090

It is generally conceded that the incremental approach provides, despite its practical difficulties, the most reliable guide to proper user-cost assignment. If this is the case, the data in the North Dakota study certainly indicate the inadequate share of highway costs assigned to heavy trucks under a fuel tax and high license fee. (It was calculated that only 8 percent of a one cent increase in the gas tax would be paid by vehicles weighing over 24,000 pounds. Their cost responsibility under the incremental method, however, was 33 percent.) However, the data also confirm the motor carrier's contention that the ton-mile method would place an unreasonable burden on the very heavy trucks.

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Comparison of Incremental and Ton-Mile Allocation Methods

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● THE 1955 MONTANA legislative session established an interim group, Fact Finding Committee on Highways, Streets and Bridges, for the purpose of studying the highway problem in the state and making recommendations to the legislative assembly which would convene in January, 1957. The committee was directed to study highway matters concerned with management, long-range costs, motor vehicle taxation, and the assignment of costs between motor vehicle users and other beneficiaries; the determination of a tax base for motor vehicle users, a complete classification of highway systems in the state, and other matters relating to legal problems, transport economics, and the allocation of highway revenues among the various government units in the state.

One of the more interesting aspects of the committee's work dealt with the allocation of highway costs among the various users. This was a particularly pertinent subject in Montana, since the state has inaugurated a seven cent gasoline tax, making passenger car payments relatively heavy in relation to a rather moderate rate fee schedule for commercial vehicles. The legislative assembly appeared to be particularly concerned about this problem and desired the best facts obtainable for a reasonable cost allocation.

It would have been desirable to perform a cost-function analysis, an incremental analysis, and a ton-mile allocation; but, because of the time restrictions and lack of sufficient accounting detail, it was decided not to perform a cost function analysis. The effort was devoted to arriving at comparative allocations by the ton-mile and incremental methods.

Montana sought simplicity of calculation coupled with reasonable accuracy rather than precise measurement in both the ton-mile and incremental allocations. At best, the most precise analyses produce nothing more than measuring sticks to be applied to the tax allocation problem. Often pure theoretical considerations obscure the practical reality of the problem. No philosophy of motor-vehicle tax responsibility is without its shortcomings. In Montana, the increment theory, probably the most supportable of all theories, appears to fail in at least one major respect, to provide a fair or reasonable allocation of road costs to all vehicles. In this state, with its tremendous mileage of secondary and local farm roads serving a sparse population and low traffic, it is necessary to subsidize these facilities with earnings, in excess of the state's cost, produced by vehicles traveling the primary highways. This subsidy is probably just because the provision of primary roads is dependent upon the state's ability to pay, which, in turn, is largely dependent on farm income. However, farm vehicles perform the larger amount of their travel on secondary and local roads (roads with little or no weight-cost elements); thus, the responsibility of heavy farm trucks by the incremental method is less than that of heavy commercial trucks which mainly use the high-weight-cost primary highways. Farm vehicles do not incur so much cost in proportion to their weight, but, since they are subsidized, should they be treated differently from the subsidizing vehicles? It appears that a benefits philosophy must be incorporated to produce a fair tax structure. In fact, a combined system application of the ton-mile theory will result in a similar array of charges against farm and commercial vehicles (on a per mile basis) because their operating gross weights for a given size of vehicle do not differ materially. It has been stated that relative benefits are not validly measured by a ton-mile analysis because of differences in the specific remuneration derived from the transport of weight from the lightest passenger car to the heaviest tractor-trailer combination. There may be some validity, however, in a comparison of the responsibilities of farm trucks and commercial trucks of the same weight on a ton-mile basis. Both derive economic gain somewhat in proportion to the load they are able to carry. The amount of remuneration must, in both cases, be sufficient to underwrite the operating

expense and depreciation on the respective vehicles. (Taxes are a small proportion of the whole burden.) The element of profit is probably similar—at least the farmer earns enough to warrant private rather than for-hire operation. Thus, it may be argued that a ton-mile comparison of the benefits received by these two types of vehicles from roads in general is valid. Whatever the outcome from theoretical consideration, the resulting tax structure must be largely a matter of state policy. All that can be required of the tax analyst is that he provide the legislators with firm measuring sticks based on philosophies that are generally acceptable. The amount of precision applied to any of the approved tax-allocation methods need only be sufficient to assure results that are reasonably accurate and consistent with the applied philosophy.

Both the incremental and ton-mile methods have been used by the Montana Fact Finding Committee on Highways, Streets and Bridges to allocate the costs of a program of construction designed to provide the state with an adequate highway and city street system twenty years hence. The needs and costs analyses were performed by engineers of the State Highway Department with the Automotive Safety Foundation as consultants. Financial studies performed by the committee disclosed that the continuation of present tax schedules would provide sufficient revenue, substantially, to finance the new highways under a long range (32 year) fiscal program. Standard statistical methods of estimate were applied to this determination. (It must be remembered that the bulk of motor-vehicle-user revenue is derived from the fuel tax. Any adjustment of "weight" taxes in the interest of equity will not produce a large change in revenues proportionately. Within the limits of the accuracy of a statistical forecast, the amount of revenue produced for the period will be dependent on the level of taxation imposed on passenger vehicles which is largely governed by the amount of fuel tax.) Accordingly, the amount of cost allocated in the mid-program year was designed to return revenues in twenty years approximately equivalent to those anticipated from the continuation of present taxes. A motor-vehicle-user share of this cost was determined from a practical interpretation of the results of an earnings-credit analysis. Although a theoretical division of responsibilities between motor-vehicle-users and non-motor-vehicle-users was derived by the earnings-credit methodology for each separate highway system, there was no practical significance in the results because of the aforementioned necessity to subsidize secondary facilities by the excess earnings of primary facilities.

Consistent with the benefits philosophy of the gross ton-mile theory; because of intersystem subsidies and interrelated benefits; and because incurred cost is not a factor, all systems were combined for the ton-mile allotment. In the first place, Federal-aid was subtracted from program construction, maintenance, and administration cost, and a user proportion of the remaining state's share, which would return the required revenue in twenty years, was determined. Traffic was projected to the mid-year by groups of indices based on historical trends in registration and vehicular travel. It was assumed that gross operating weights would remain constant for the same registered gross vehicle weights (for lack of specific information to the contrary). The user share of program cost was distributed to different vehicle types by registered weight groups in proportion to ton-miles traveled, and the results were converted to rates of charge per vehicle mile. The first measure of relative responsibility produced, not unexpectedly, a lower charge against passenger vehicles than they are paying under the present fuel tax and registration fee. The assessment against heavy commercial vehicles was higher than that derived by the incremental method but was mitigated by equalization of responsibility between commercial and farm vehicles. The incremental method actually produced responsibility rates for farm trucks which would be entirely met by their present fuel tax and registration fee contribution.

One of the most important measures was a determination of the present taxes paid by all vehicle types on the streets and highways of the state in 1955. The existing tax structure was broken out in fine detail. Annual traffic was estimated for vehicle groups enjoying tax privileges by paying a percentage of regular weight fees: 75 percent fee groups, 60 percent fee groups, and 20 percent fee groups. A further breakdown of traffic was subscribed to vehicles registering annually and to those registering semi-annually who pay half-year registration and weight fees. Tax contributions were calculated for each vehicle type in each of these divisions, and the results were reported

on a per vehicle-mile and a per ton-mile basis. The annual mileage, fuel consumption and weight data for these calculations were gathered from several sources. Most significant sources were loadometer and traffic studies, a 1953-54 road use study with a supplemental truck sample, and a special study of truck and combination vehicle usage and fuel consumption in which field data were collected by the Montana Motor Transport Association. The annual contributions for each group of vehicles were added to obtain total highway user contributions for the year. This total was within 3.5 percent of user revenue collected in 1955, thereby lending considerable support to the assumptions used in the analyses.

In connection with the analysis of revenues contributed under the existing tax structure, it became necessary to develop gasoline and diesel fuel consumption curves. Some data for the gasoline curve were available from the road use study. Additional data were developed for this curve as well as the diesel curve by measurement of fuel usage on controlled operations. These operations were actually "over the road trips" of various vehicles in which gross weight, mileage, and fuel consumed were measured accurately and recorded. The number of diesel fuel observations were sufficient to permit the fitting of a reasonable reliable consumption curve. The gasoline data were so limited that the reliability of the fitted curve might be questioned except that the resultant curve falls close to similar curves developed in Highway Research Board Bulletin 92. The curves developed for the Montana study are shown in Figure 1.

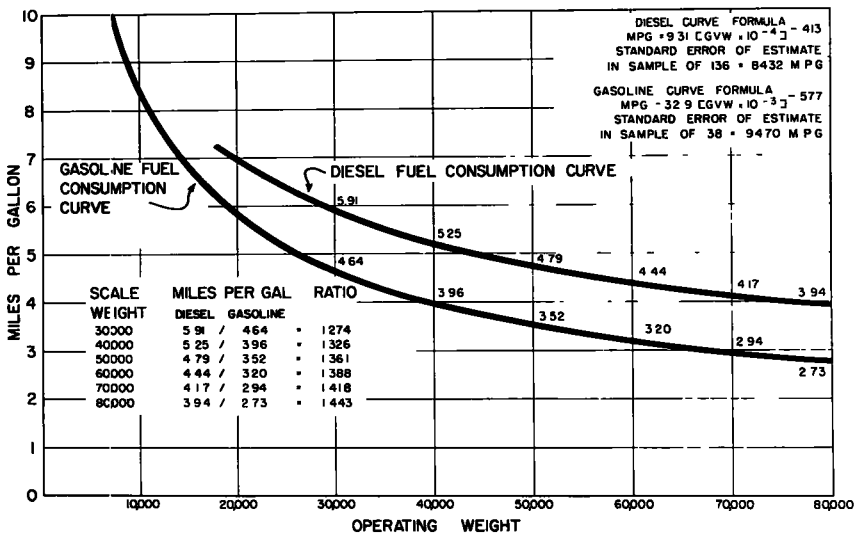

Figure 1. Comparison of average fuel consumption, gasoline vs. diesel powered vehicles State of Montana 1956.

The Montana incremental analysis was especially designed to fit the peculiar highway needs and traffic conditions in this state. While the basic theory was the same as that of the orthodox incremental procedure, a straight-line, rather than a triangular or rectangular solution was devised. A basic premise was interjected along with the usual considerations—that, from an historical viewpoint, all lower-standard roadways are stages in the construction of higher-standard roadways, and, therefore, may be considered to be incorporated in the structural and geometric composition of higher-standard roadways. Engineering judgment provided the basis for a formularized relationship between traffic volume and the magnitude of repeated axle loading to be expected on the newly designed facilities. An intermediate roadway (whose structural standards would not be influenced by climatic conditions) was related to a vehicle of intermediate size and weight which it would accommodate. Its structure would be of sufficient strength for the axle loads imposed; its geometrics would be adequate for the dimensions and speed limitations of the associated vehicle. This basic mean relationship was established between a five-ton truck imposing a 6,000-lb axle load and

the standard of roadway accommodating from 200 to 400 vehicles daily. Additional relationships were formulated between larger axle loads, considered to be representative of vehicular size as well as weight, and highways designed to accommodate successively more traffic volume. Thus a 10,000-lb axle load was related to facilities designed to carry 400 to 1,000 vehicles daily; a 14,000-lb axle to facilities designed to carry 1,000 to 2,000 vehicles daily; and an 18,000-lb axle to facilities designed to carry more than 2,000 vehicles daily.

Incremental costs were determined by subtracting the average cost of these facilities, as determined from the Automotive Safety Foundation needs study, one from another, system by system. The following is an example of this determination: an increment of structural and geometric cost was obtained by subtracting the cost of the designed primary facility for 1,000 to 2,000 vehicles daily from the cost of the designed primary facility for over 2,000 vehicles daily. This amount of cost was charged to vehicles imposing the 14,000- to 18,000-lb axle loads, whose repetitions were considered to have demanded the structural strength employed in the higher-standard roadway design, and whose magnitude defined the size of vehicle demanding the geometrics employed in that design.

A careful consideration of all aspects of geometric cost related to vehicular size and weight was imperative for due support of the procedure. Although geometrics could not be related to a vehicle's size with the same precision that structure could be related to an applied axle load, it was possible to demonstrate a reasonable distribution of geometric cost by weight, when combined costs were used to develop incremental costs by the method utilized.

There was not a large differential in right-of-way costs between different standards of two-lane facility designed to carry more than 400 vehicles daily, and the differences that did occur were subscribable to the improvement of geometrics rather than additional width. Accordingly, right-of-way cost was combined with other geometric and structural costs for the calculation of increments.

Maintenance costs for different roadway designs were derived in the needs study by use of factors based on highway department experience. These costs were found to vary with the standard of highway constructed, so that the highest type of facility would cost slightly less to maintain than the next highest type. It followed, therefore, that vehicles charged with a high standard of construction should benefit from maintenance savings. It appeared that all factors would be properly weighted by the simple expedient of combining maintenance and construction costs. Those maintenance costs which are not affected by the standard to which the roadway is constructed, such as the costs of snow or slide removal, slope protection, weed and brush control, ditch cleanout or off-road drainage work, would be automatically excluded from increments obtained by the subtractive process. Where improved highway standards would result in maintenance savings, increments of construction cost chargeable to large and heavy vehicles would be correspondingly mitigated.

Some administration cost (the direct engineering cost of contract construction) was included with other construction cost upon which it would depend.

From the foregoing description, it may be seen that incremental costs, as developed by the Montana method, accounted for most items of total road expenditure by a simple mathematical process. However, this process was warranted only after advance consideration of each item separately; that is to say, of the relative amounts of each item that would be charged to successively heavier vehicles by combining costs. It is not within the scope of this paper to enter the considerable argument advanced in the Montana technical report.

Having obtained increments of combined costs which were reasonably associated with the requirements of vehicles of different sizes and weights (as measured by their axle loads) these costs were distributed in much the usual manner. Each incremental cost, determined on a per mile basis, was applied to a total mileage of increment in the study system, which included roadway where the increment is to be the uppermost part of the paved structure and roadway where the increment is to exist as part of a higher standard structure. The total incremental cost was distributed among vehicles imposing axle loads of a size to require that amount or more structure. A weighting

procedure was incorporated in the distribution; where each successively larger axle, to the limit of accommodation of the structural increment, was charged with a greater share of incremental cost for the same amount of travel. For differing travel, an additional factor was inserted which was determined from a mathematical relationship between volume of traffic and associated axle load design.

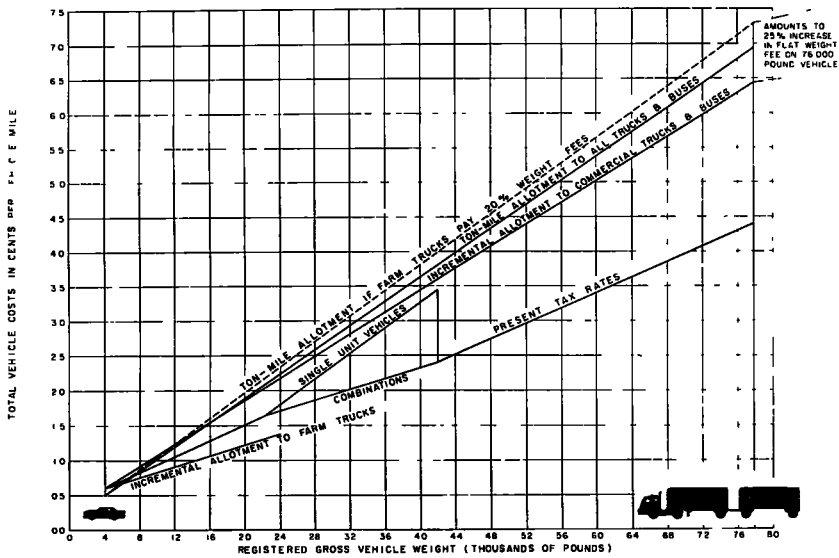

Figure 2. Comparison of responsibility allotments & 1955 taxation in Montana.

A summation of axle miles of travel on Montana's highways disclosed that the logarithm of axle miles increased as design load increased (assuming the empirical relationship between volume of traffic and repeated axle load). In exponential terms axle miles are proportional to a constant raised to a power equal to the load for which the structure is designed. Thus, by dividing the travel of each axle by the constant raised to the load term, the relative load value of travel may be determined. This factor was used to weight the loads on each increment, and the cost was distributed between the weighted loads according to their relative magnitude.

Three increments of cost above the basic mean standard were determined to be the responsibility of three groups of axle loads larger than 6,000 lb. By extrapolating the relationship between weighted load and incremental cost downwards, an undefined increment of structural cost was developed for assignment to all axle loads larger than those imposed by a passenger car. There was no particular theory behind this latter manipulation. It is logical to assume that costs proportional to size and weight, being established from one point upwards, would extend downwards on the same curve to a point where weight is a common denominator. These practical results are desirable for the determination of a tax structure.

The sum of weight costs for the road system, determined and distributed in the manner described, was subtracted from the total cost of the system to obtain the cost of the basic facility of the system, which would be required by all vehicles and which was distributed in proportion to travel. Remaining administrative cost was distributed, likewise, in proportion to travel.

Each of the three highway systems was handled separately by the method outlined - the proposed interstate system, the proposed state highway system, and the proposed secondary system. Urban streets constituted a fourth system. It was assumed that the costs incurred by heavy vehicles on urban state highway extensions would be in the same proportion as those incurred by heavy vehicles on rural state highways; and that the costs incurred by heavy vehicles on arterial streets would be in the same proportion as those incurred on rural secondary highways. Distribution of urban costs was based

on these assumptions. Local city streets and local rural roads were not treated by the incremental method.

Structures were taken as comprising a fifth system. Axle load was again the measure of both weight and size. The minimum standard for stability was H 10 structural design. The difference between H 10 and H 15 structures was considered to be required by axle loads over 16,000 lb. The difference between H 15 and H 20 structures was considered to be required by axle loads over 24,000 lb. Trailer axle loads, since trailers were studied as separate vehicles in the analysis, were rated at 75 percent of their value, which positioned a combination vehicle in the right order, relatively, with respect to a single unit vehicle. The two increments of weight cost were determined for a weighted average width of structure. The distribution of these costs was on the basis of weighted travel - the factor being the difference in magnitude between the weight of the vehicle's axle and the largest axle in the next lowest increment. Two feet of width of the H 10 basic element in the H 15 and H 20 structures were charged to vehicles weighing 5 tons or more. The remaining cost of H 10 elements was charged to all vehicles in proportion to their travel. The cost distribution was not unlike that devised for roadways.

After relative charges were determined, Federal-aid was subtracted from each system separately as a uniform percentage of all charges. Then, total charges were assembled and reduced by a percentage so that the required user share of program cost would be produced. Figure 2 shows the results of the incremental allocation compared with those of the ton-mile allocation.

It had once been thought that Federal-aid funds should be subtracted in advance of responsibility determination. However, where interrelated maintenance and construction cost have been combined by the Montana Incremental Method, determinations which follow are applicable only to an integral highway product containing all construction cost and all maintenance cost. Besides, it is sound in principle to determine proportional responsibility for the total product, and then, in effect, to apply this proportion to the state's cost alone.

A weight-distance tax schedule and a flat fee tax schedule, both based on the incremental determination, have been presented to the 1957 legislature as a result of this analysis. In addition, the lawmakers have been provided with two other measures by which to evaluate the tax policy. The one is a ton-mile allocation of responsibility with due explanation; the other is a complete breakdown of taxes paid by every vehicle type under the existing tax structure. It must be admitted that the tools provided for establishing equity in highway user taxation are at best blunt instruments. Rather than arriving at precise responsibilities, they merely provide a zone of responsibility within which a particular vehicle can reasonably be expected to fall. The several tools have been provided in this instance in order that the lawmakers will have a gauge of the size of the zone of responsibility.

One of the advantages of the ton-mile allocation of costs is the simplicity with which it may be applied and the relative availability of the necessary data. Perhaps the greatest disadvantage in the incremental method is the difficulty of obtaining precise information and of developing all the necessary cost breakdowns and traffic data that is essential to a competent study. While the ton-mile allocation in Montana does result in a more severe allocation to heavy vehicles and a fairly sharp reduction of charges against the passenger car, it does provide an allocation that runs in the same order as incremental cost responsibilities. This fact, along with the possibility that across the board ton-mile allocation may be more fair in the case of the substantial subsidization of local roads, seems to lend credence to this type of allocation in a state such as Montana. There is certainly an indication that the ton-mile results have substantial validity, and if time and data were not available for a more complex incremental analysis, the use of a ton-mile allocation would not be entirely inappropriate.

Results of the Kentucky Highway Finance Study

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The Automotive Safety Foundation's engineering appraisal of Kentucky's roads and streets disclosed numerous deficiencies. If the value of the highway dollar remains constant over the next 20 years, an average of about $160 million a year will be needed for modernization. Estimated revenues under 1955 laws, combined with federal aid, probably would be sufficient to complete the improvement program in 20 years, but they would not be adequate to follow the recommended expenditure pattern, which contemplates completion of two-thirds of the program in the first 10 years. Highway costs may well rise by an average of at least 3 percent annually. If so—assuming the 20-year program is adopted—certainly a user tax increase, and probably credit financing, would be required. The primary purpose of the highway finance study was to determine how the Commonwealth and its subdivisions could most economically finance the recommended 20-year program.

The division of costs between highway users and nonusers was accomplished by first determining the nonuser share on the basis of past revenue contribution and then assigning the residual amount to users. Under this scheme, users would be required to pay about 85 percent of the total cost exclusive of federal aid. The incremental cost approach was employed to obtain a division of user expenditure responsibility among users of various types and sizes of vehicles. A comparison of 1965 incremental assignments with 1965 tax contribution estimates indicates that, with no change in 1955 tax laws, serious inequities would result. Domestic vehicle operators, in total, would contribute slightly more than their relative responsibility; foreign vehicle operators, in total, would meet only 90 percent of their responsibility. Among the types of domestic vehicles, passenger cars and light nonform trucks would be overtaxed; farm trucks and the heavier nonfarm trucks would be undertaxed. The incremental relationships were established before nonuser charges and federal aid were deducted; that is, the assignment of relative responsibility was determined independent of the method of financing.

Equity, adequacy, mitigation of administrative and compliance problems, and minimization of interference with transportation received attention in tax planning. Three user-tax plans embodying various combinations of motor fuel, registration, and third-structure taxes were devised. The motor fuel tax would account for about 83 percent of the user revenue under each plan. A diesel fuel tax rate differential of 50 percent was found necessary to eliminate inequality. For-hire carriers were assigned the cost of regulatory functions, and this added responsibility would be recouped through a utility certificate fee. If highway costs rise by as much as 3 percent a year, a gasoline tax as high as $0.11 per gallon might be required from all users.

In addition to formulating tax plans, possible credit financing was examined. Expenditure programs involving the use of various amounts of bonds were compared with a program involving no credit. The interest cost of each credit finance program would undoubtedly be more than offset by savings that would result from accelerating the construction program. The state could reduce stop-gap work and would obtain ad-

[1] On leave—serving as the Kentucky Commissioner of Finance.

ditional revenue from more extensive use of the modern facilities; motorists would benefit earlier from lower vehicle operating costs, reduced accident rates and time savings. In addition, assuming a rise in highway costs, the earlier in the program the work is done, the lower would be the cost.

● KENTUCKY, like other states, faces the problem of financing a modern system of roads and streets. If the value of the highway dollar does not change from its 1953 level during the next 20 years, an average of almost $160 million a year must be spent to eliminate the numerous deficiencies and otherwise bring the highway system to modern standards. Even though revenue under 1955 laws plus federal funds[2] might be sufficient to complete the program in 20 years, the schedule recommended by the Automotive Safety Foundation could not be followed. This fact (Fig. 1) suggests the use of bond financing.

The available evidence indicates that highway costs will rise by an average of at least 3 percent a year over the next 20 years. In the event of a 3 percent annual increase, an average of around $207 million a year would be needed to follow the Automotive Safety Foundation schedule (Fig. 2). A bond issue large enough to obtain the difference between estimated revenues and recommended expenditures would be politically unacceptable. In any case, means of paying debt service would be essential.

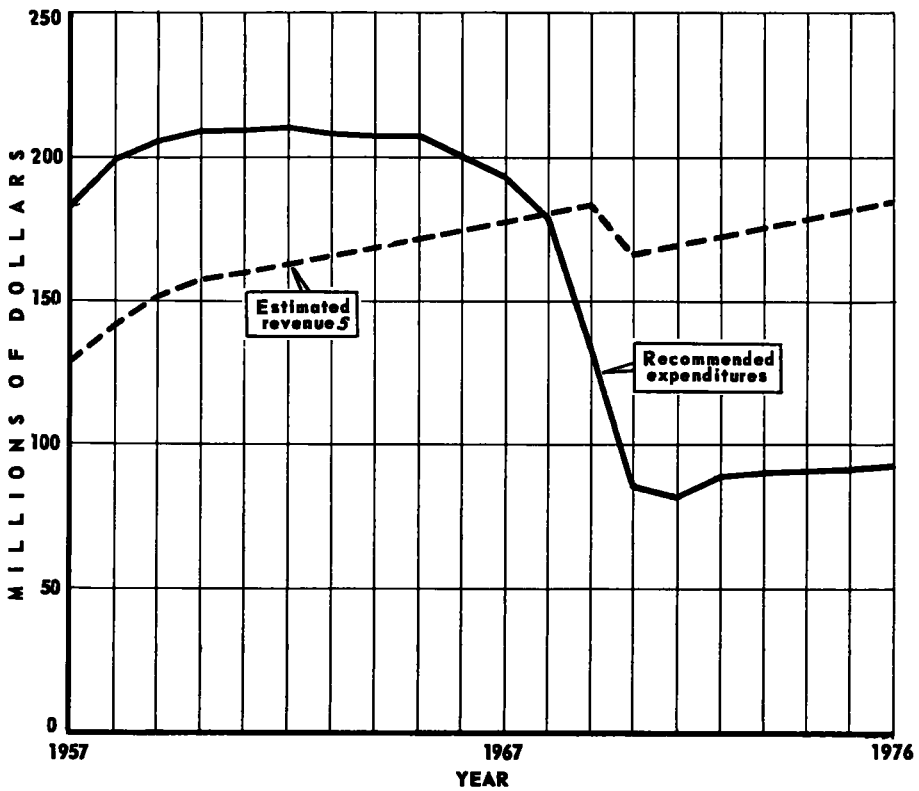

Figure 1. Recommended highway expenditures in 1953 dollars compared with estimated revenues (1957-1976).

[2] The amount of federal aid that Kentucky will receive was assumed to be equal to the latest estimate of interstate construction and replacement costs plus a continuation of the 1959 figure for other systems. It was also assumed that roughly one-third of average annual interstate funds will be added to other federal aid systems when the interstate system is completed.

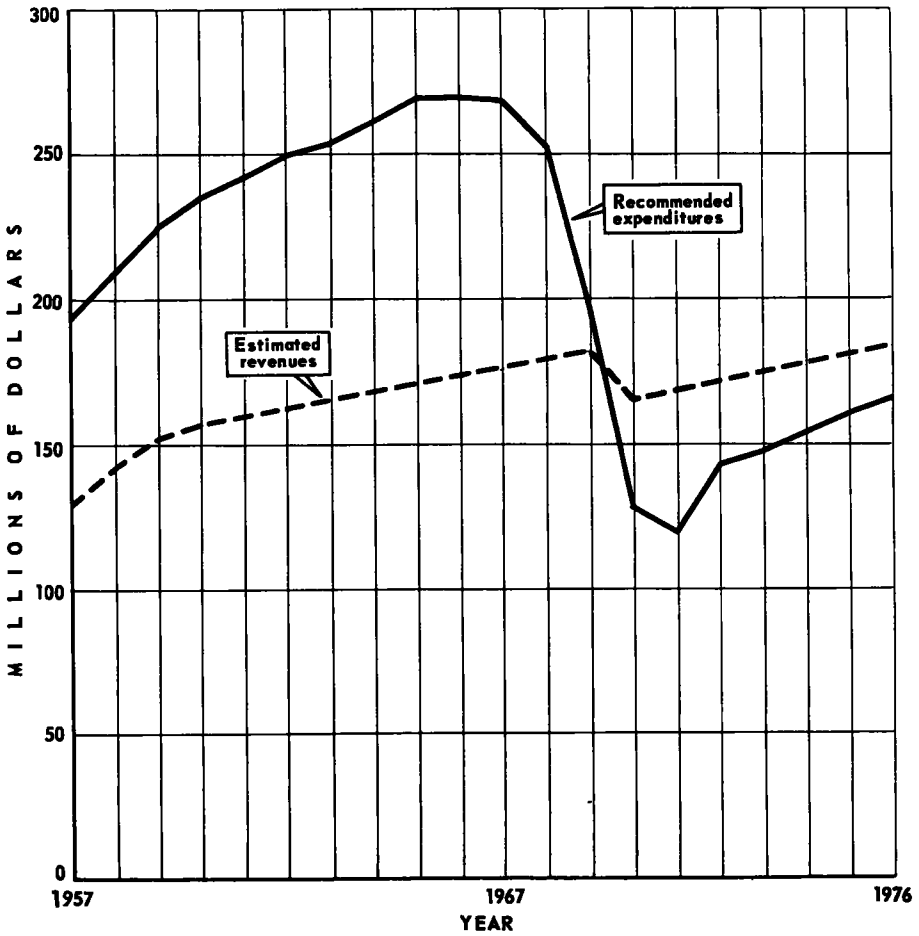

Figure 2. Recommended highway expenditures assuming a 3 percent annual increase in highway cost compared with estimated revenues (1957-1976).

Therefore, if Kentucky's roads and streets are to provide tolerable service with costs rising at the assumed rate, an increase in taxation seems inevitable.

The finance study attempted to provide a basis for equitably distributing the load among taxpayers and also to ascertain what modifications should be made in the level of expenditures. The need for revenue to finance the improvement program is directly related to the expenditure schedule. In addition to fluctuations in the value of the highway dollar the cost of stop-gap improvements, replacements, and interest all vary according to the timing of expenditures. The effect of timing of expenditures was studied by comparing several selected expenditure programs. All of these problems were analyzed under the assumption that the state would adopt the 20-yr program.

SPREADING THE BURDEN

The Kentucky study attacked directly the problem of dividing the costs of highways among the beneficiaries of roads and streets. In doing so, the authors accepted the estimated average annual expenditures for the 20-yr program, as an approximation of annual costs sufficiently accurate for statistical study.

The basic problem of dividing costs as thus approximated was conceived as involving, for purposes of the investigation, division between highway users and other taxpayers and division of user expenditure responsibility among users of various types and sizes of vehicles. The division of responsibility among non-user taxpayers, an

admittedly important matter, was excluded as being largely a problem of general taxation.

The authors referred to the added-expenditure, differential-benefits, standard-costs, relative-use, predominant-use, and earnings-credit solutions.

It was found that, historically, the state has supplied in 1953 dollars a nearly constant amount of highway revenue from general taxes. Recently, that amount has been about $17 million. The long-standing public decision on this point was accepted for purposes of the study. It was assumed that about the same amount in 1953 dollars will continue to be available as a long-range political decision; the remainder will be secured from highway user imposts. This historical approach to the assignment of responsibility between highway users and nonusers is admittedly crude as a measure of fairness, but the same is true of other available methods. This historical plan has the merit of prior public acceptance and of noninterference with established policy decisions respecting the comparatively rigid local finance patterns. Under this scheme, highway users would be required to pay about 85 percent of the total amount expended exclusive of federal aid. Some states in which one or more of the usual methods of study have recently been invoked (California, Illinois, Michigan, and Ohio) show a range of from 56 to 82 percent assignable to highway users.

Before considering the distribution of the tax load among highway users, it is necessary to examine the problem of how to treat federal aid. The usual practice in earlier studies has been to deduct federal aid from the total expenditure requirements for each road and street system before any attempt is made to allocate responsibility among users of various types and sizes of vehicles. This handling of the problem involves possible distortions in the distribution of responsibility. For example, assume that three-axle combination vehicles travel exclusively on the proposed interstate system of highways for which federal aid will provide 90 percent of the expenditure for construction. If federal aid were deducted from expenditure for the system before the assignment of responsibility, these users would be relieved of 90 percent of their tax responsibility for this construction. Suppose another group of vehicles, which otherwise would have equal expenditure responsibility per mile, travels the same number of miles on roads the construction of which the federal government does not aid. The operators of the latter vehicles would be relieved of none of their responsibility. Although common sense would dictate that the responsibility for construction expenditures should be about the same in each of the two cases, strict application of the logic of the usual procedure would assign 10 times as much to the users of the second class of vehicles as to the users of the first class.

Thus, an innovation in method is indicated. The problem was solved for the moment by making assignments on the basis of total expenditures. That is, the relationships among various road and street users were established before any deduction was made for either nonuser or federal contributions to the highway program. This is the first major step toward avoiding distortion by determining the assignment of relative responsibility in a manner independent of the method of financing.

There are two widely held views concerning the relative tax loads of users of various types and sizes of vehicles. The first is that relative financial responsibility should be based on the comparative benefits which operators of different types and sizes of vehicles receive from the use of roads and streets. The second is that such responsibility should be distributed rather on the basis of the comparative expense of providing highway service to users of different types and sizes of vehicles. The first of these two concepts has been the basis for several approaches to the task of devising a measuring stick for the quantitative assignments: relative operating costs, differential benefits, standard costs, and gross ton mileage. The second concept has led to incremental costs analysis as a means of finding the expense occasioned by each type and size of vehicle. There are two quantitative attacks on the problem which appear to involve elements of both theories: the cost function and the space-time solutions.

Of the specific solutions to the problem of distributing highway expenditure responsibility among operators of various types and sizes of vehicles according to the relative benefits from highway use the assignment on the basis of gross ton mileage is the most popular. It is the easiest to apply because of the availability of data and because of its

TABLE I

ESTIMATED 1965 EXPENDITURE RESPONSIBILITY OF KENTUCKY REGISTERED VEHICLES AND THE ESTIMATED AMOUNT OF USER TAXES UNDER 1955 TAX LAWS

Vehicle Type by Weight	Responsibility per Vehicle			User Taxes per Vehicle	
	Gross Ton-Mile Method	Incremental Method Private	Incremental Method For-Hire	Private	For-Hire
Passenger cars	$ 26	$ 40		$ 48	
Farm trucks					
Panel and pickup					
0-22,000	51	59		49	
2-axle dual tired					
0-22,000	126	58		56	
Nonfarm trucks					
Panel and pickup					
0-5,000	45	58	$ 62	66	$ 78
5,001-8,000	74	60	65	84	104
8,001-10,000	94	61	65	94	129
10,001 and over	116	63	67	105	143
2-axle dual tired					
0-5,000	78	101	.	98	110
5,001-8,000	130	105	112	121	141
8,001-10,000	166	107	114	136	171
10,001-12,000	202	125	132	150	188
12,001-14,000	240	136	143	165	207
14,001-16,000	279	148	155	178	225
16,001-18,000	319	155	162	191	245
18,001-21,000	379	170	177	254	280
21,001-24,000	444	193	200	273	319
24,001-27,000	559	223	231	296	405
3-axle single unit					
18,000 and under	125	118	123	145	199
18,001-21,000	187	158	164	235	261
21,001-24,000	270	215	223	285	331
24,001-27,000	367	274	284	335	404
27,001-30,000	478	335	347	394	478
30,001-33,000	609	419	432	452	554
33,001-36,000	742	503	518	514	636
36,001-39,000	916	596	613	591	739
39,001-42,000	1,116	690	709	694	855
3-axle semi-trailer combination					
21,000 and under	$ 149	$ 130	$ 135	$ 214	$ 240
21,001-24,000	170	135	141	226	272
24,001-27,000	192	148	154	233	302
27,001-30,000	293	209	217	297	381
30,001-33,000	411	276	286	359	461
33,001-36,000	548	378	390	430	552
36,001-39,000	693	465	479	505	653
39,001-42,000	862	571	587	604	765
42,001 and over	1,067	659	677	680	841
4-axle semi-trailer combination					
27,000 and under	265	196	204	288	357
27,001-30,000	407	312	322	377	461
30,001-33,000	617	472	486	481	583
33,001-36,000	763	570	587	564	686
36,001-39,000	961	719	739	666	814
39,001-42,000	1,187	964	987	794	955
42,001-46,000	1,362	1,045	1,068	846	1,007
46,001-50,000	1,544	1,255	1,280	902	1,063
50,001 and over	1,826	1,458	1,484	978	1,139
5-axle semi-trailer combination	1,743	1,661	1,686	978	1,139
Buses					
School	129	54		84	
Heavy intercity	1,373		1,208		1,342
Laght intercity	429		419		323
City	332		286		414

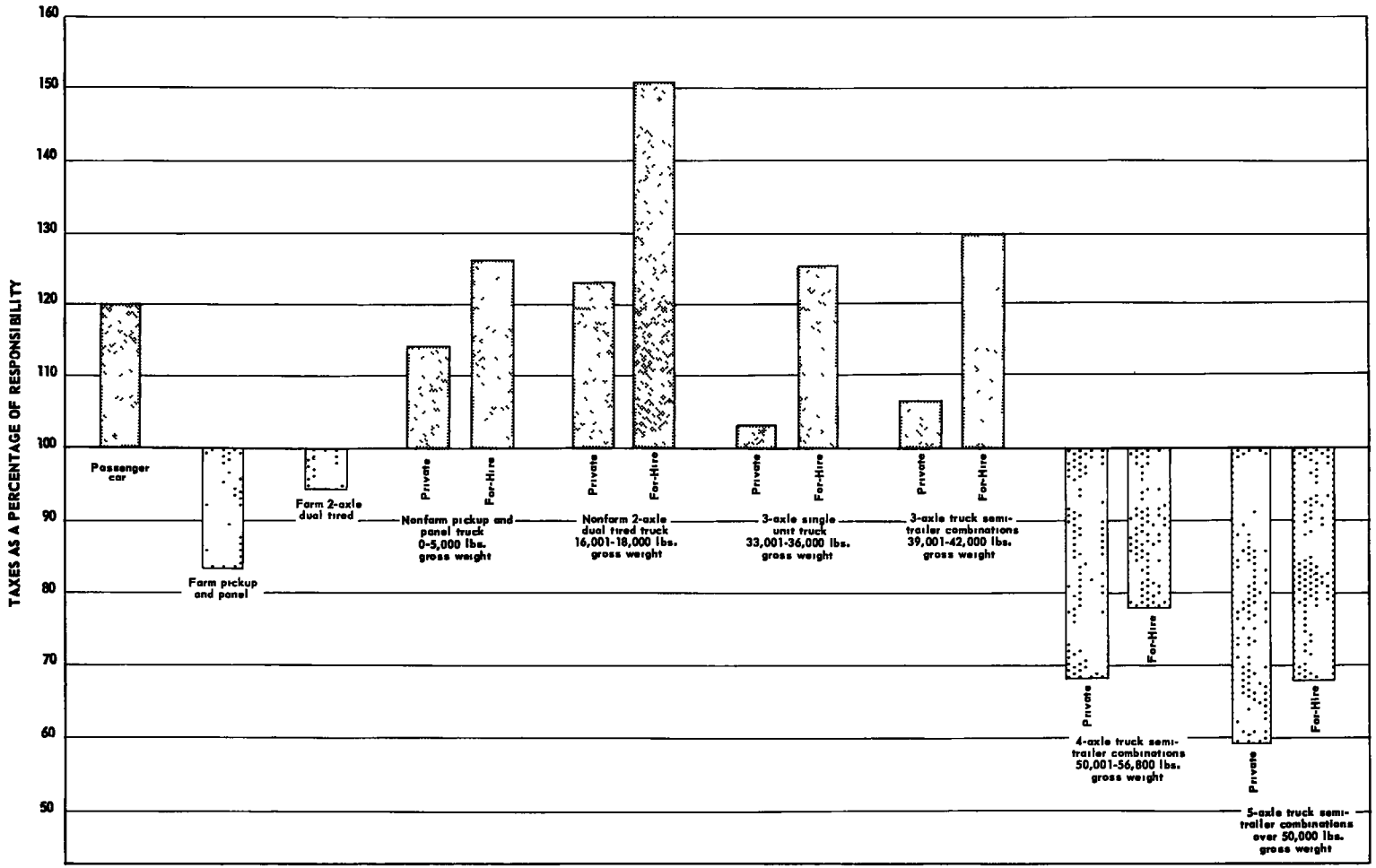

Figure 3. Estimated user taxes under 1955 tax laws compared with incremental expenditure responsibility, for selected types and weights of privately owned Kentucky registered vehicles, 1965.

arithmetical simplicity. Under this plan average annual ton miles of operation (the product of aggregate weight and mileage traveled) is the measure of relative benefit. Thus, a vehicle which with its load weighs 40,000 lb is assigned 10 times as much expenditure responsibility as another vehicle traveling the same distance which with its load weighs 4,000 lb. This method of assignment, which was employed in the Kentucky study for comparative purposes, is subject to objection on the ground that it treats as homogeneous quantities which are known to be nonhomogeneous, for example, ordinary passenger automobiles and their loads and tractor-semi-trailer combinations and theirs. The Kentucky study introduced a refinement not usual in such studies: The ton-mile computation was made system by system, as were the computations for the incremental study. This means that the data for each of the eight systems were treated separately and then aggregated. But some authorities regard this method as the only practical basis for assigning relative expenditure responsibility.

For those persons who accept the view that the proper logical basis for the assignment of expenditure responsibility among types and sizes of vehicles is the cost each class occasions in providing highway service, there is general acceptance of the incremental solution as the best available. Therefore, this attack on the assignment of financial responsibility was accepted as the basis for a distribution of responsibility consistent with the "cost-of-service" theory.

The study found 34 clearly identified design systems for rural and urban highways. They undertook to reduce the number of systems because (a) despite the availability of relatively good traffic data they did not know enough about traffic to justify so many and (b) they found the computation task for 34 systems too formidable. Aside from the interstate highways, the design standards differ only slightly for the various systems having similar traffic density, and it was found feasible to employ but eight classes of roads and streets for purposes of computation. Six groups are based on traffic volume (0-99, 100-399, 400-999, 1,000-1,999, 2,000-2,999, and 3,000 or more vehicles per day). The other two groups are composed of 2-lane interstate and 4-lane interstate highways respectively. This and some other technicalities which involve significant departures from tested methodology have been developed at greater length elsewhere (1, 2).

Highway expenditures were classified. Those attributable to vehicle travel and weight were assigned according to separate indexes of increments depending on whether they were for grading and drainage, for base and surface, or for structures. Those attributable to vehicle travel only, for example, right-of-way acquisition and traffic control, were assigned according to vehicle mileage on the system. Those attributable to neither travel nor weight, such as landscaping and certain administrative overhead, were assigned to all vehicles indiscriminately. The increments were determined separately for new construction, for resurfacing and widening, and for resurfacing alone. (3)

Vehicles were grouped according to vehicle type and vehicle gross weight. Axle loads were distributed into such groups and were combined with estimated traffic to establish the number of axle miles of each weight that the roads must carry per year. The expenditures treated incrementally were distributed among different types of vehicles and weight groups on the basis of the number of axles and the incremental cost indexes. Those expenditures not treated incrementally were assigned to the different registration classes on the basis of vehicle miles of travel or proportionately to all vehicles.

Because $160 million (the average annual expenditure requirements on highways) was the cost figure employed for the incremental solution, it was necessary to obtain the expenditure responsibility assigned to each vehicle class as a percentage of the total expenditures. After federal aid and nonuser charges were deducted from the total, the percentages were used to obtain the users' share by vehicle class. The class assignments were subdivided into responsibility of Kentucky-registered vehicles and responsibility of vehicles registered in other states ("foreign" vehicles). Dividing the share assigned to Kentucky vehicles by the estimated number of Kentucky-registered vehicles in 1965 in each group yielded the expenditure responsibility per Kentucky-registered vehicle. By dividing the domestic and the foreign group assignment by the axle miles of travel for each group, the assignment per axle mile was secured. This

measure provided a basis for comparing domestic and foreign vehicle responsibility. The innovations (a) of finding incremental relationships before eliminating nonuser charges and federal aid and then applying the proportions so established to the amount to be financed by state and local user taxes (2) and (b) of finding incremental values separately for foreign and state-registered vehicles will be apparent to students of the problem. These procedures, especially the former, seem to be among the most significant methodological refinements made in this study. The former is the second major device for keeping the increments entirely independent of the method of financing employed.

The comparative results of the gross ton-mile and the incremental solutions to the problem of distributing Kentucky highway-user expenditure responsibility are what might have been expected. For the smaller sizes of vehicles, the assigned responsibility is much higher if computed by the incremental method. For larger sizes, the contrary is true. The data shown in Table 1 assign expenditure responsibility on a per registered vehicle basis (but excluding traffic by foreign vehicles). The known biases in the Kentucky version of the incremental solution tend consistently toward a relatively higher assignment to the smaller vehicles—and, of course, a relatively lower assignment to the larger vehicles and combinations. The incremental method yields a sort of maximum responsibility for the smaller vehicles—as compared with the gross-ton mile solution and thus a minimum for larger vehicles.

The incremental solution has a sounder theoretical basis and a more widespread acceptance than does the gross ton-mile solution. Most of the results of the Kentucky expenditure responsibility assignments, therefore, can be considered in the light of the former approach. Certain observations may be based on a comparison of the tax yields under 1955 laws as estimated for 1965 with the incremental assignments estimated for the same year. The study showed that foreign vehicle operators would pay less than their relative responsibility, largely because they pay little more than fuel taxes in most cases. Domestic passenger vehicles, exclusive of buses, were shown to be overtaxed as measured by assigned responsibility. Farm trucks and the largest legally authorized 4- and 5-axle tractor semi-trailer combinations would fall considerably short of meeting their incremental responsibility.

As regards annual miles traveled by private and for-hire vehicles, the Kentucky traffic information revealed no significant differences. Thus, under the gross ton-mile method, the expenditure responsibility for private and for-hire vehicles was the same. Under the incremental solution, however, for-hire vehicles were charged with certain administrative costs such as the cost of rate and schedule making which do not apply to private vehicles. Thus, under the incremental method the expenditure responsibility of for-hire vehicles is slightly greater than of private vehicles.

Certain problem areas involved in the Kentucky division-of-costs study are so well defined that they require comment. The recent Highway Research Board studies in Maryland and especially Idaho seem to suggest that, for purposes of incremental analysis of pavement construction costs, the AASHO standard, (one single axle-load of 18,000 pounds = a tandem axle-load of 32,000 pounds) should be rewritten to read roughly: one single axle-load of 18,000 pounds = a tandem axle-load of 27,000 pounds. The Kentucky study, on the other hand treats each axle-load, whether single or in tandem arrangement, as being like each other axle-load. In tax planning, a study area attacked later, some effort has been made to correct for this crudity. Obviously, the incremental study itself suffers from the failure to build the refinement into the incremental treatment itself. The traffic data in Kentucky provide an inadequate basis for determining whether differential assignment of expenditure responsibility to for-hire vehicle operators on grounds of more or less than average mileage is justified. Perhaps a special study would be in order.

Because of differences in the character of traffic in urban areas, it is possible that city data ought to be examined as special incremental systems. This was not seriously considered in the study because of historic traffic data treatment. A subsequent study might well take account of this limitation.

TAX PLANNING

The incremental expenditure assignments adjusted to reflect axle arrangements provided the basis for tax planning. A comparison of 1965 expenditure assignments with estimated 1965 tax contributions (assuming the laws of 1955) clearly indicates, as already observed, that serious inequities would occur. The tax plans should be designed to eliminate at least the major injustices. Fiscal adequacy is another ingredient of an acceptable tax system. In the event highway prices rise by 3 percent annually, 1955 user tax rates would have to be raised an average of approximately 41 percent if the program is to be completed by 1976, and still the work could not be done on a pay-as-you-go basis according to the recommended expenditure schedule. Considerations in addition to equity and adequacy received attention in the tax planning. For example, administrative and compliance problems are quite important inasmuch as a tax theoretically equitable may be quite unjust if it is poorly administered. Another important feature is that taxes should interfere as little as possible with motor vehicle travel.

Implicit in each of the plans is the assumption that motor-fuel taxation, including the gasoline use tax applicable to heavier vehicles with interstate travel, is the major tax measure. In addition, it was assumed that the several miscellaneous user taxes and fees such as local parking meter receipts and drivers' and chauffeurs' licenses will be continued. Available evidence suggests that a diesel fuel tax rate differential of approximately 50 percent is necessary to eliminate discriminations among users. The added responsibility of for-hire carriers would be recouped by requiring a utility certificate. Certificate rates would be slightly graduated by type and size of vehicle.

Three tax plans using various combinations of the three major types of highway-user taxes (motor-fuel, registration, and third-structure) were developed. The first plan employed the fuel and a registration tax with an apportionment feature for large vehicles. The fuel tax, if the rate (nearest whole cent per gallon) exceeded the current rate of $0.07 per gallon, would result in contributions in excess of incremental expenditure responsibility for vehicles of the lower weight groups. Therefore, the current rate was used. Under this plan the bulk of the difference between responsibility and fuel taxes at their present level would come from the basic registration tax. Registration tax rates would range from $3.50 for passenger cars to around $1,500 for the heaviest trucks and buses. However, the tax on all nonfarm trucks and buses having a gross weight in excess of 18,000 lb with interstate travel would be determined by that fraction of the basic rate which their travel in Kentucky is of their total travel in all states. This apportionment privilege would also be available to operators of two or more nonfarm trucks or buses with gross weight 18,000 lb or less. Special licensing provisions for fleets would facilitate the most economical use of such vehicles. An alternative per trip tax of $10 per trip would be available to users making only occasional trips. Thus, all vehicles with gross weights in excess of 18,000 lb would be required to present evidence of paying either the registration or per trip fee. Compliance with the apportioned registration tax may necessitate the payment of a tentative tax liability at the beginning of the year based on estimated travel and a final settlement at the end of the year based on actual travel.

Another plan employs the motor-fuel tax, a registration tax for light-weight vehicles, and a nominal registration tax plus a weight-distance type tax for heavy vehicles, supplemented by the miscellaneous state and local taxes and fees. Under this plan, the fuel tax would be identical with that of the first plan; so would the registration tax for light-weight vehicles. Operators of the heavy domestic types of trucks and buses would pay a registration tax for identification purposes, which would defray a nominal proportion of their expenditure assignment. The weight-distance tax would absorb the difference between their expenditure responsibility and their motor-fuel and other tax contributions. The weight-distance tax would apply to both foreign and domestic vehicles. Tax rates would range from $0.01 to $0.28 per 100 axle miles for trucks. The heaviest intercity buses would pay a nominal registration tax and a weight-distance tax computed at $0.43 per 100 axle miles.

The third plan differs from the other two in that the motor-fuel and miscellaneous taxes are supplemented by a $0.01 per gallon motor-fuel surtax, a registration tax, and a weight-distance tax on vehicles of the heaviest classes. The fuel surtax would apply to foreign and domestic vehicles and combinations having three or more axles and gross weights in excess of 18,000 lb. The surtax would be administered in conjunction with the present fuel use tax.

Under the third plan, the basic registration tax rates would range from $3.50 for passenger cars to $90 for the heaviest 3-axle single unit trucks, none of which would be subject to the weight-distance tax, and to $75 for the heaviest 4- and 5-axle tractor semi-trailer combinations which would be subject to the weight-distance tax. The weight-distance tax rates range from $0.02 per 100 axle miles for a 4-axle tractor semi-trailer combination with a gross weight of 30,001 to 33,000 lb to $0.22 per 100 axle miles for a 5-axle tractor semi-trailer combination of more than 50,000 lb gross weight.

Revenuewise, the motor-fuel tax would account for about 83 percent of the total under each of the three plans, registration and weight-distance taxes roughly 12 percent, and miscellaneous taxes and fees about 5 percent.

The study underscores the need for policing motor vehicle size and weight limit laws. Inasmuch as excessive axle weights damage pavements, the proposed penalty provisions call for the use of a penalty schedule with the penalty directly related to the weight and arrangement of axles. The study illustrated this point by presenting a schedule roughly correlated with relationships between single and tandem axles found in recent engineering tests. That is, for each 2,000-lb increase in excess weight of a single axle the penalty approximately doubles. Tandem axles are treated as being approximately equal to a single axle with a gross weight of $\frac{2}{3}$ as much. For most effective size and weight law administration, local conditions suggest that the state rely on administrative-type penalties, supplemented by criminal provisions.

Because the incremental assignments were based on traffic and expenditure projections, the research emphasizes the need for re-evaluating the tax plans should traffic patterns or expenditure requirements change significantly. An adjustment in the level of federal aid or nonuser contributions would merit an adjustment in the level of taxation but the relationship among users may not be directly affected and therefore may need little or no adjustment.

CREDIT FINANCING

In addition to formulating tax plans, the study reflects an attempt to determine the probable effects of several alternative expenditure programs involving the use of various amounts of credit financing. If highway prices remain constant, revenues, though adequate in total, would not be sufficient to follow the recommended pattern of expenditures which contemplates the completion of almost two-thirds of the program in the first 10 years. If, however, highway prices rise as anticipated, both a tax increase and the use of credit may be desirable. Of more immediate concern was a proposal, submitted to the voters of Kentucky, which would allow the state to borrow $100 million to be used to match federal aid. This proposal was approved by an overwhelming margin in November 1956.

Under the assumption that highway costs remain constant, four different expenditure programs were examined and compared with a program involving no credit financing. In two programs the amount of bonds was limited to $100 million. The third program involved the use of $675 million of bonds, the amount necessary to follow the schedule recommended by the ASF. In the fourth program, expenditures are made for maximum acceleration limited only by the estimated capacity of the state and local governments and the highway construction industry. This program would reach the peak in the fifth year when expenditures almost 2.5 times as large as recent annual expenditures would be made. The issuance of $790 million of bonds would be required for this program.

All bonds are assumed to be retired serially from road fund revenues according to various schedules of repayment. The bonds would be state instruments backed by the full faith and credit of the Commonwealth and would be callable after 10 years from the date of issuance. The average interest rate was estimated to be $2\frac{3}{8}$ percent for 10- to 20-yr repayment.

The interest cost of each of the programs was compared with the estimated savings that would result from acceleration through the use of credit. This, of course, could not be done in precise fashion because of the inability to measure nonmonetary savings and because some of the monetary savings are extremely difficult to estimate. However, it appears that any of the four programs could be justified, because savings to the state and local governments and to motorists would undoubtedly more than offset the interest cost in each case. Some of the most important savings of accelerating the improvement program are (a) stop-gap work could be reduced; (b) motorists would benefit from lower vehicle operating costs, reduced accident rates and time savings much earlier; (c) assuming that motorists would make greater use of modern facilities, additional tax revenue for the state would be generated by speeding up the program.

If the more realistic assumption that highway cost will increase by an average of 3 percent a year is substituted for the assumption that these costs will remain constant, another type of saving becomes apparent. If work can be done early in the program, it can doubtless be done at a considerably lower cost than if it is done later.

If highway costs do rise by an average of 3 percent annually, present laws plus federal aid would produce only 70 percent of the revenue that would be needed to complete the improvement program in 20 years. About $1,250 million of bonds would be required to complete the remaining 30 percent of the program, and these bonds would be outstanding at the end of the 20-yr period. It would not be feasible to issue and repay such a large amount of bonds nor to pay interest on them amounting to about $30 million a year. Thus, the highway finance situation in Kentucky clearly indicates that, if road and street inadequacies are to be eradicated during the next 20 years, an increase in user taxation is necessary.

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The 1956 Rhode Island Highway Finance Study

A PRAGMATIC APPROACH IN A "GENERAL FUND" STATE

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The 1956 Rhode Island highway finance study was directed primarily toward providing answers to two broad questions important for state fiscal planning, as follows:

1. What method of financing the proposed long-range state highway program would require the lowest additional revenue requirements consistent with sound financial practice, and what would the additional revenue requirements be?
2. Should the state provide additional assistance to local communities for highway purposes, and if so, on what basis could it best be allotted to assure adequate local highways?

The study was a pragmatic approach in a "general fund" state, for determination of the additional revenue requirements and selection of the financing method, three basic elements were needed — engineering data, revenue projections, and assumptions as to the pattern of federal aid. Engineering data compiled by the Rhode Island Department of Public Works under the guidance of the Automotive Safety Foundation provided total costs of the proposed highway program over a 34-year period under alternative assumptions of a 10- and a 15-year catch-up program. It was assumed that federal aid would represent 90 percent of construction costs on the interstate system, and would remain unchanged on other federal aid systems. Revenue projections were based on highway user taxes only.

It was immediately obvious that the only way revenue requirements could be kept down during the critical catch-up period would be to cover peak construction costs by borrowing, to be repaid later when program costs were lower and projected revenues higher.

In Rhode Island, city arterial streets, as defined in the engineering study, have customarily been a city rather than a state responsibility. Because of their obvious importance to the state highway system, however, it was felt that additional aid to cities should be related to program requirements for city arterial streets. Nevertheless, in general it appeared that ability to pay should be the measure of highway aid to local communities.

A formula was tested based on aid to the cities, as a group, at 50 percent of average annual program costs for city arterial streets; and aid to the towns, as a group, in an amount which equalized the net remaining average annual program costs to the cities and to the towns in terms of mills per dollar of equalized valuations. The effect of this was to reduce city requirements for highways during the catch-up period 7.5 percent below recent expenditure levels, and to require a 6.5 percent average increase for the towns. This was considered a satisfactory result, since the cities had been spending relatively heavily on highways in recent years, while the towns had spent relatively little. Both cities and towns in Rhode Island are hard pressed for additional funds. Without such state aid, the cities would have had to increase highway expenditures by 7.4 percent, and the towns by 24.8 percent. Equalization of the cost burden seemed fair in view of the importance to the state as a whole of a modern integrated highway system throughout the state.

If additional state aid to cities and towns were made on such a basis, additional state revenue requirements for a 15-year catch-up would be in-

creased to 26.4 percent above the base curve, according to the "20-year bond amortization" plan, as compared with the 16.5 percent increase required for highways of direct state responsibility alone.

●IN RHODE ISLAND, for most practical purposes, there are only two levels of government—state on the one hand, and the cities and towns, on the other. Except for county courts, county government does not exist. Motor vehicle user revenues are all paid into the State General Fund, where their identity is lost. State highway expenditures are made from the general fund. In addition, from about 27 to 28 percent of net tax revenues of the general fund are furnished to cities and towns as state aid, in an amount which is roughly double combined city and town highway expenditures. From 1945 through 1954, Rhode Island expenditures from current state and local tax revenues for state and local highways combined exceeded total highway user taxes by 7 percent.

Since there is no necessary and direct relationship between highway user taxes and highway expenditures in Rhode Island, determination of any definite relationship must be based on working hypotheses or assumptions. The assumption that direct state expenditures for highways from current tax revenues represent an expenditure of highway user taxes appears a reasonable starting point. The further assumption that at least some portion of local highway expenditures is derived from highway user taxes also appears reasonable, in view of the substantial grants from general funds to local communities, even where such grants are not earmarked for highways. However, any assumption which attempts to set a definite value on local highway expenditures from highway user revenues through the medium of the general fund appears debatable.

Because the existing relationship between highway user tax revenues and highway expenditures is so difficult to define satisfactorily, determination of what that relationship ought to be seemed of less immediate practical importance that it would in a state where a precisely defined present relationship could be compared with study findings on that point. Moreover, it was felt that an adequate value judgment on what the relationship should be would require a far more extensive study of this complex question than the time and personnel available for this study would permit. Consequently, it was recommended that further study be made of the question, including, though not necessarily limited to, such techniques as earnings credit and incremental analyses.

Thus the 1956 Rhode Island Highway Finance Study was directed primarily towards providing answers to two broad questions—those raised by state fiscal officers as most important for state fiscal planning: (a) What method of financing the proposed long range state highway program would call for the lowest additional revenue requirements consistent with sound financial practice, and what would those additional requirements be; and (b) Should the state provide additional assistance to local communities for highway purposes, and if so, in what amounts and on what basis could it best be allotted to assure adequate local highways?

To determine additional revenue requirements, three basic elements were needed—engineering data, revenue projections, and assumptions as to the pattern of federal aid (see Fig. 1).

Engineering data were compiled by staff of the Rhode Island Department of Public Works, with the advice and guidance of the Automotive Safety Foundation. These provided annual costs of the proposed highway program over a 34-yr period, under alternative assumptions of a 10- and 15-yr catch-up program. At the time this was done, the provisions of the 1956 Federal Aid Highway Act had not been finally drafted.

As to Federal aid, it was assumed that this would cover 90 percent of the costs of new construction on the interstate system, and would remain unchanged on other Federal aid systems.

The first real problem of the highway finance study itself was the basis to be used for revenue projections. In a general fund state, the most logical approach would appear to be projection of total net tax revenues of the general fund. This was rejected for two main reasons: (a) there appeared to be a greater probability of error in projection of net total tax revenues—a trend existed, but it was less consistent and less

clearly defined than the trend in highway user tax revenues; and (b) to be entirely consistent, a projection of total state revenue requirements would also be needed to determine what would be available for highways. In brief, a projection of the total state fiscal picture over a 34-yr period appeared impractical for present purposes.

Because of the well defined trend in highway user revenues, and because there is a general relationship between the need for highway expenditures and highway user revenues, even if that relationship is not precisely defined, it was decided to project highway user revenues only.

To determine additional state revenue requirements for the proposed program, it was first necessary to ascertain the level of recent highway expenditures from current state tax revenues.

The year 1954 represented the most recent year in which the General State Budget was balanced without use of surplus funds, and it was used for the determinations. Thus, it could be safely assumed that all state highway expenditures, except federal aid and bond funds, were derived from current state tax revenues. For 1955, on the other hand, it could not be stated definitely how much of increased expenditures for highways were derived from current tax revenues and how much directly or indirectly from surplus

Revenues which would be available for future highway purposes from present state

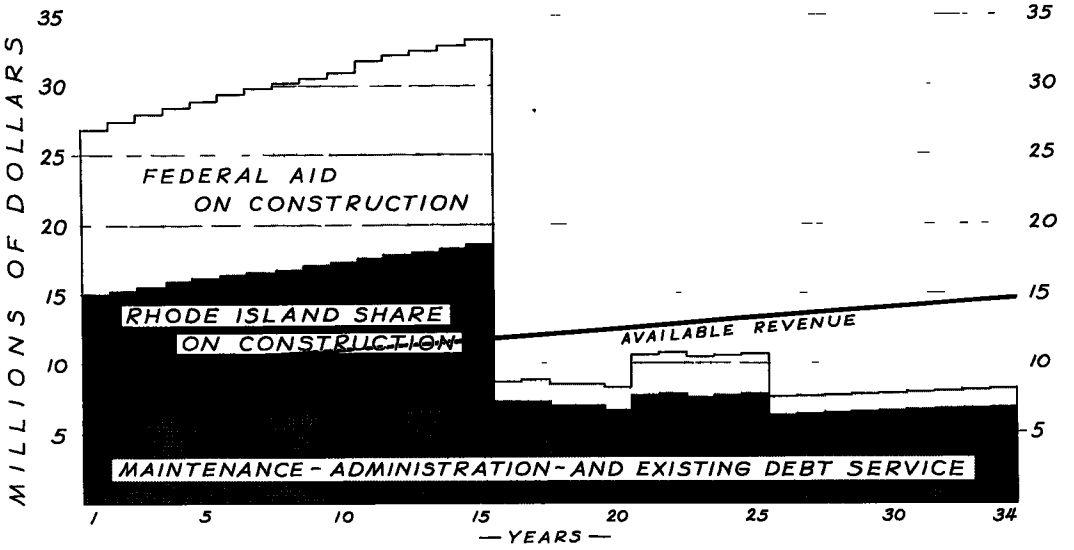

Figure 1. Total 15-year catch-up program on state trunklines and secondaries.

tax sources were taken as the same proportion of the amount of total motor vehicle taxes as was explicitly expended by the state for highway purposes from current tax revenues in 1954, that is, 60 percent. The function of this percentage was to establish a projected base line for comparison with the projected level of revenues required to meet a particular program of financing.

The interval between this base curve—representing "available revenue" in terms of recent levels of expenditure— and the "required revenue" curve represented the additional revenue requirement. Furthermore, since each curve was established as a uniform percentage of projected motor vehicle taxes throughout, the interval between curves in the first year represented the dollar amount by which tax revenues would have to be increased at the present time to provide required revenues for the full 34-yr period, without need for later increases in tax rates. The first year therefore provided the key to revenue requirements for the entire program.

The next major question was the type of financing to be employed. The only way revenue requirements could be kept down during the critical catch-up period would be to cover peak construction costs by borrowing, to be repaid later when program costs were lower and projected revenues higher. This cut-and-fill approach appeared sche-

matically sound, but as directly applied would require bonds with no principal payments in the early years; and tests showed that, as applied to the Rhode Island program, the bulk of principal repayments would fall 25 years or more in the future. Moreover, revenue requirements, although mathematically sufficient, in practice would be 'tight' —that is, there was no leeway allowed for errors of estimate, or for unanticipated cost increases, for example, the recent rises in costs of structural steel and interest rates.

It was decided, therefore, to test a modification of the cut-and-fill approach. Bonds were assumed to be issued in accordance with the established conservative practice in Rhode Island, that is, the bonds would be serial bonds to be amortized in equal installments over 20 years. This, of course, meant that principal payments would be required each year after the first, and would somewhat raise the level of the curve of required revenue. The required revenue curve was set at the level which would just cover all current expenses for the peak year, including interest and principal payments. Thus, a portion of the costs of new construction in the early years would be met from current state revenues, and in no year would borrowings exceed the state share of new construction.

After the initial catch-up period, total highway costs, including interest and princi-

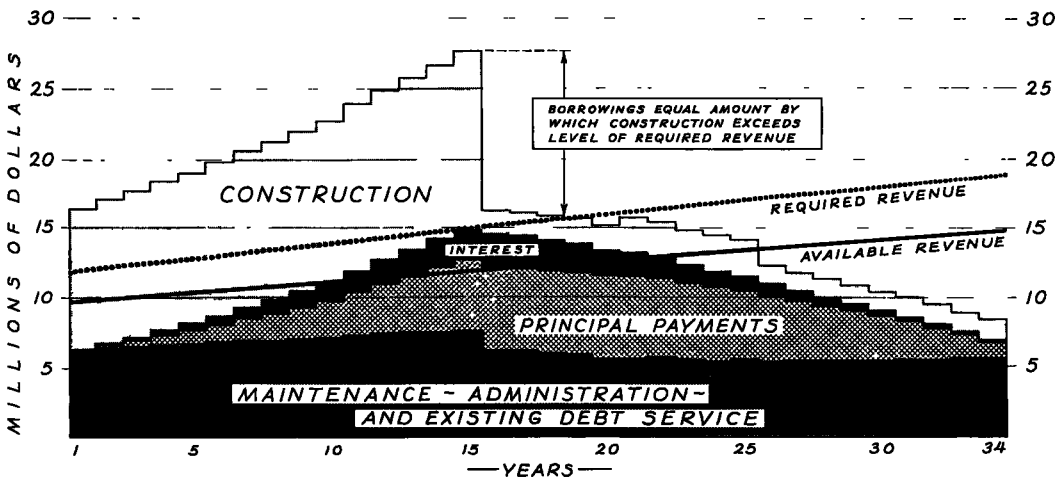

Figure 2. Twenty-year bond amortization method, 15-year catch-up program, state trunkline and state secondary with state aid to cities and towns.

pal payments, would progressively decline. This provided a steadily widening margin between costs and the required revenue curve—a margin which would yield a substantial surplus by the end of the 34-yr period. This surplus provided the leeway considered necessary for sound long-term financing. It could be used to absorb unanticipated cost increases, or to retire the outstanding debt in a shorter period, or to reduce taxes after the catch-up period, if circumstances warranted. Figure 2 and Table 1 illustrate this approach, and include allowances for additional state aid to cities and towns.

This form of financing would reduce total interest costs by about 40 percent, and reduce the peak debt incurred by over 20 percent, as compared with the straight cut-and-fill approach. If the surplus which accumulates after the catch-up period were entirely applied to bond retirement, it would permit complete retirement of new highway debt within 25 to 28 years, depending on the particular program adopted.

The increase in revenue requirements resulting from the use of this approach would be relatively moderate, in view of the size of the program to be undertaken. For the state trunklines and secondary system alone, revenue requirements for the proposed 15-yr catch-up program would be 4.8 percent above the base curve according to the

TABLE 1

15-YEAR CATCH-UP ON STATE TRUNKLINES AND RURAL SECONDARY SYSTEMS WITH STATE AID TO CITIES AND TOWNS, 20-YEAR BOND AMORTIZATION PLAN

(Amounts in thousands)

Year	Construction Minus Federal Aid[a]	State Share of Total Program Costs[b]	Available Revenue[c]	Required Revenue	Actual Program Cost[d]	"Surplus"	Cumulative Surplus	Annual Borrowing	Cumulative Debt[e]	Principal Payments[f]	Net Outstanding Debt	Interest Payments[g]
1956	10,049	16,325	9,456	11,956				4,369	4,369		4,369	
57	10,281	16,683	9,760	12,342				4,690	9,059	218	8,841	131
58	10,500	17,007	10,008	12,654				5,071	14,130	453	13,459	265
59	10,693	17,290	10,229	12,934				5,467	19,597	707	18,219	404
1960	10,850	17,533	10,427	13,185				5,875	25,472	980	23,114	547
61	11,073	17,868	10,606	13,411				6,424	31,896	1,274	28,264	693
62	11,240	18,104	10,768	13,616				6,931	38,827	1,595	33,600	848
63	11,384	18,321	10,922	13,810				7,460	46,287	1,941	39,119	1,008
64	11,514	18,516	11,077	14,006				7,998	54,285	2,314	44,803	1,174
1965	11,669	18,738	11,232	14,202				8,594	62,879	2,714	50,683	1,344
66	12,004	19,322	11,388	14,399				9,587	72,466	3,144	57,126	1,520
67	12,139	19,529	11,544	14,597				10,269	82,735	3,623	63,772	1,714
68	12,276	19,723	11,701	14,795				10,978	93,713	4,137	70,613	1,913
69	12,411	19,927	11,859	14,995				11,736	105,449	4,686	77,663	2,118
1970	12,583	20,172	12,018	15,195				12,579	118,028	5,272	84,970	2,330
71	1,689	7,857	12,168	15,385				922	118,950	5,901	79,991	2,549
72	1,697	7,881	12,318	15,575				654	119,604	5,948	74,697	2,400
73	1,707	7,657	12,469	15,766				112	119,716	5,980	68,829	2,241
74	1,740	7,678	12,621	15,959	15,729	230			119,716	5,986	62,843	2,065
1975	1,748	7,359	12,773	16,150	15,230	920	1,150		119,716	5,986	56,857	1,885
76	2,478	8,085	12,925	16,343	15,777	566	1,716		115,347	5,986	50,871	1,706
77	2,486	8,122	13,078	16,536	15,415	1,121	2,837		110,657	5,767	45,104	1,526
78	2,516	7,951	13,231	16,730	14,837	1,893	4,730		105,586	5,533	39,571	1,353
79	2,547	8,007	13,385	16,925	14,473	2,452	7,182		100,119	5,279	34,292	1,187
1980	2,578	8,062	13,539	17,120	14,097	3,023	10,205		94,244	5,006	29,286	1,029
81	1,227	6,568	13,694	17,316	12,159	5,157	15,362		87,820	4,712	24,574	879
82	1,227	6,592	13,849	17,511	11,720	5,791	21,153		80,889	4,391	20,183	737
83	1,253	6,641	14,005	17,708	11,290	6,418	27,571		73,429	4,044	16,139	605
84	1,256	6,668	14,161	17,906	10,823	7,083	34,654		65,431	3,671	12,468	484
1985	1,283	6,720	14,318	18,104	10,366	7,738	42,392		56,837	3,272	9,196	374
86	1,401	6,887	14,473	18,301	10,005	8,296	50,688		47,250	2,842	6,354	276
87	1,408	6,919	14,628	18,497	9,473	9,024	59,712		36,981	2,363	3,991	191
88	1,413	6,950	14,783	18,693	8,919	9,774	69,486		26,003	1,849	2,142	120
89	1,442	7,001	14,938	18,888	8,365	10,523	80,009		14,267	1,300	842	64
Totals	203,762	414,663	420,346	531,510	451,501							37,880

[a] Includes state trunklines and secondary system plus 50 percent of city arterial streets

[b] Includes state aid to cities and towns, but not costs of new financing

[c] Revenue considered available from present tax sources

[d] For years not shown, actual costs equal required revenue

[e] Total of original amounts of annual bond issues not fully amortized at end of year

[f] Computed at 5 percent of previous line in "Cumulative Debt" column

[g] Computed at 3 percent of previous line in "Net Outstanding Debt" column

simple cut-and-fill approach, and 16.5 percent above according to the modified "20-yr bond amortization" plan. In other words, the 20-year bond amortization plan would raise the required revenue curve an additional 11.7 percent above available revenue. On a pay-as-you-go basis, the average increase in state revenue requirements for the catch-up period would be 55 percent.

If the catch-up period is reduced from 15 years to 10 years, the additional revenue requirements are sharply higher. For a 10-yr catch-up on a pay-as-you-go basis revenu requirements would be 103 percent above the base curve; under the modified 20-year bon amortization plan revenue requirements would be up 27.9 percent; and according to the simple cut-and-fill approach, 8.7 percent (Table 2).

In view of the recent sharp rise in interest rates on state and municipal bonds, it should be noted that the interest rate assumed for financing projections was 3 percent on general obligation state bonds. At the time this assumption was made, comparable bonds were yielding about 2.75 percent, so that some allowance was made for increasing rates. With municipal bond yields now generally averaging above 3 percent, it is evident that continuation of recent trends in interest rates will call for a redetermination of this element of cost.

The highway problems of Rhode Island cities and towns are in several respects quite different from those of the state. The great bulk of locally derived revenues comes from assessments on real estate and tangible personal property. There are no local motor-vehicle user taxes, as such, though ad valorem property taxes are levied on moto vehicles. Furthermore, local property tax levies are limited by state law to not more than $25 per $1,000 of assessed valuation, plus debt service charges—a factor which has contributed to the need for state grants to help meet the mounting costs of local services.

Towns, in general, are responsible for maintenance of only purely local town roads; and the rural secondary system, which roughly corresponds to county road systems in other states, is a state responsibility.

Cities, on the other hand, are responsible not only for purely local access streets, but also for those arterial streets which are not part of the state trunkline system. These city arterial streets are comparable in function to the state rural secondary system; that is, they provide the major links between the basic local systems and the state trunklines.

It might appear that the towns are in a favored position. Actually, however, when long range highway program requirements were compared with local financial resources, in terms of their primary tax base, it was found that the relative financial burdens of the proposed highway programs for the cities and the towns were substantially equal.

In determining the primary tax base for Rhode Island cities and towns, assessed valuations of real and tangible personal property were not in themselves adequate. This was because assessment practices vary considerably from one community to another. Available information indicated that the ratio of assessed to market values of property in different cities and towns ranges from about 30 percent up to 85 percent. It was clear that no valid comparison of tax bases could be made without adjustment to compensate for such differences.

In 1956 the Rhode Island General Assembly established a tax equalization board to determine a sound basis for adjusting local assessed valuations to reflect more accurately actual local property values. The specific purpose of such tax equalization was to develop a factor for use in a formula to allocate state aid to local educational systems. However, once such equalized valuations are properly established, they can be applied to other problems of state and local fiscal relationships.

At the time of the study, no official equalized valuations had been established. Consequently, adjustments based on informed local judgments of the average assessment ratios in each community were made.

A weighted average of these estimates indicated that in 1955 Rhode Island's seven

TABLE 2

ADDED INITIAL REVENUE REQUIREMENTS[a]

For 5 Alternative 34-Yr State Programs, by Length of Catch-Up Program and Type of Financing

Program	Type of Financing			
	Cut and Fill		20-Yr Bond Amortization	
	(Dollars)	(Percent)	(Dollars)	(Percent)
State Trunklines and Rural Secondary only				
10-yr catch-up over-all	819,000	8.7	2,637,000	27.9
10-yr state trunks 15-yr secondary	726,000	7.7	2,288,000	24.2
15-yr catch-up over-all	450,000	4.8	1,559,000	16.5
State Trunklines and Rural Secondary Plus State Aid to Cities and Towns				
10-yr state trunks 15-yr other	1,528,000	16.2	3,110,000	32.9
15-yr catch-up over-all	1,255,000	13.3	2,500,000	26.4

[a]Requirements above revenues considered available from present tax base.

cities, as a group, assessed at about 70.9 percent of current market values; and the state's thirty-two towns, at about 59.2 percent. The two group averages are probably fairly representative of the general differences in assessment practices.

Adjusting assessed valuations for these assessment ratios, and comparing the results with the 34-yr average local program costs for the cities and towns, respectively, it was found that for both cities and towns the average annual cost would be approximately 2.3 mills per dollar of current real and tangible property values. In other words, the higher program costs for the cities resulting from city responsibility for arterial streets were offset by a correspondingly higher tax base.

If ability to pay is taken as a criterion, these facts indicate that additional state aid to cities should be matched by proportionate state aid to towns to preserve a fair balance. If ability to pay is not recognized, the practical effect would be to discourage adequate local highway development in those communities with the greatest needs relative to their financial resources. This would tend to defeat the purpose of the proposed highway program, which was designed to assure a complete and adequate highway network throughout the state. The value of adequate state trunklines would be materially reduced by subordinate and local highways which were not up to standard.

However, regardless of questions of financial equity and primary responsibility, the state has a particular interest in adequate development of city arterial streets. City arterial streets, as defined in the engineering study, perform the same major function as state rural secondary highways—both serve as collectors and distributors of traffic to and from the state trunklines. Because they constitute important links in the overall state system, it appeared desirable that the state should have a voice in their design standards and the timing of improvements.

Consequently, it was decided that additional state highway aid to cities should be geared to program requirements for city arterial streets, and that a formula based on state aid to cities in the amount of 50 percent of programmed construction costs for city arterial streets should be tested. This was found to represent 12.2 percent of the 34-yr cost of the cities' highway programs, exclusive of financing.

To preserve the balance between cities and towns, in terms of ability to pay, the formula allowed the same 12.2 percent of the 34-yr program costs to the towns. Thus, assuming that original program costs for the cities, in relation to their tax base, were equal to those for the towns, the net program costs after allowing for this state aid would also be equal. The guiding principle was that net program costs to local communities should be substantially equal in terms of their principal tax base, or ability to pay.

The engineering study grouped cities and towns for purposes of analysis, so that detailed highway programs for each individual city and town were not available for the finance study. Moreover, proper evaluation of the relationship between individual community highway programs and the respective tax bases could not be made until the recently established tax equalization board provides a more satisfactory basis for adjustment of assessed valuations. However, the study explored the problem of how state aid to individual communities might be allocated sufficiently to demonstrate that a satisfactory formula could be developed to distribute any desired total amount of state highway aid among individual communities on the principle of equalizing, or substantially equalizing, net program costs as related to the tax base.

Analysis of city and town highway program costs for a 15-yr catch-up period, as compared with projected available revenues, indicated that without state aid local program costs would exceed available revenue by 24.8 percent in the towns, and by 7.4 percent in the cities. This wide discrepancy is because in recent years city highway expenditures have been considerably higher, proportionally, than the towns. These relatively high city expenditures had the effect of both raising the level of revenues considered available and decreasing somewhat future program costs.

Without state aid the towns would experience considerable difficulty in increasing local revenues for highways by almost 25 percent for the next 15 years. For the cities, which as a group have been spending substantial sums for highway work, and which are already close to their legal tax ceiling, an average increase of even 7.4 percent for 15 years would also be very difficult. With relatively limited tax resources, and the increasing need for major capital outlays for schools, particularly, additional local bor-

TABLE 3

COMPARISON OF 15-YR NET PROGRAM COSTS WITH PROJECTED AVAILABLE REVENUES

Cities and Towns	15-Yr Totals: Available Revenues (thousands of dollars)	15-Yr Totals: Net Program Costs (thousands of dollars)	Percentage Above or Below Available Revenues
32 Towns			
Without state aid	42,884	53,521	+24.8
With state aid	42,884	45,692	+ 6.5
7 Cities			
Without state aid	94,227	101,184	+ 7.4
With state aid	94,227	87,147	- 7.5

rowing for highway purposes would seem, in general, unwise.

However, with state aid on the basis previously outlined, representing 50 percent of construction costs of arterial streets in cities and a proportionate amount of total program costs in the towns, Rhode Island cities could meet their highway needs for a 15-yr catch-up program with a 7.5 percent reduction in available revenue, while the towns would require an increase of only 6.5 percent (Table 3). In view of the relatively low rate of town highway expenditures in recent years, such an increase for the towns should prove feasible from current tax sources. The state aid formula is designed to provide residual, or net highway costs for both cities and towns which are equal in terms of their respective tax bases.

From the standpoint of providing adequate and effective highway aid to local communities, the proposed formula thus appeared to be satisfactory. It would provide financial aid to local communities in a manner which would make possible adequate local highway programs without additional local borrowing, and without placing an unfair or unrealistic burden on any single community.

From the standpoint of the state, such aid to local communities would, of course, increase revenue requirements for highway purposes. For a 15-yr catch-up, total state revenue requirements would be increased to 26.4 percent above the base curve, according to the 20-yr bond amortization plan, as compared with the 16.5 percent increase required for highways of direct state responsibility alone. Thus the cost of aid to cities and towns on the proposed basis would amount to 9.9 percent of revenues presently considered available.

Again, in terms of a 15-yr catch-up, according to the 20-yr bond amortization plan, and including state aid to cities and towns on the basis proposed, the additional state revenue requirements in the key first year were estimated at $2,500,000 (See Fig. 2 and Tables 1 and 2). Analysis of Rhode Island's motor vehicle tax structure indicated that this amount could be raised by an increase in the gasoline tax of 1 cent per gallon (from 4 cents to 5 cents) plus increases in registration fees for the heavier commercial vehicles, and that both these increases could be made without placing Rhode Island levies out of line with other states, particularly Massachusetts and Connecticut.

However, because Rhode Island is a general fund state, with no necessary tie-in between particular tax revenues and particular expenditures, it was not positively recommended that additional revenues be raised in this manner. The possibility was merely pointed out. It might well be that a review of total state budgetary requirements and the existing tax structure would indicate that another tax or combination of taxes would better serve total needs.

One special problem which developed from a review of the engineering program was the acquisition of rights-of-way. The annual programming of construction costs showed a relatively high percentage of early construction costs representing right-of-way purchases. The practical effect of this would be to hold back actual physical construction, particularly in the first five years. To permit major construction to start as soon as

possible and to assure a more even level of construction throughout the catch-up period, it was recommended that a special revolving fund of from $5,000,000 to $10,000,000 be established for advance acquisition of rights-of-way on Federal aid systems. Such a fund would be, in effect, replenished as Federal aid is received at the time of actual construction, and would ultimately be absorbed into regularly programmed construction costs. It could probably be financed by relatively short term bonds, or notes, without the necessity for annual amortization, so that the additional annual costs involved would represent primarily interest charges. It appeared probable that long range savings resulting from early acquisition of rights-of-way would more than offset the relatively small additional cost resulting from the use of such a fund.

TABLE 4

STATE FUNDS REQUIRED TO MATCH FEDERAL AID[a]

Funds	1st year	2nd year	3rd year	
State funds required to match new federal program	5,943	5,878	6,289	18,110
State funds required to match assumed federal aid under proposed state programs				
10-yr catch-up on state trunks and secondary	7,164	7,345	7,496	22,005
10-yr on state trunks 15-yr on state secondary	7,003	7,185	7,338	21,526
15-yr catch-up on state trunks and secondary	5,137	5,260	5,373	15,770
For construction on state trunks and secondary under proposed 15-yr catch-up	9,228	9,441	9,642	28,311

[a] Under revised Federal aid allocations and proposed state programs, amounts in thousands of dollars.

The finance study was largely completed before the passage of the 1956 Federal Aid Highway Act. When the provisions of that act became available, however, it was obviously important to determine how well the proposed 10- and 15-yr catch-up programs would fit in with those provisions. The key question here was whether sufficient state matching funds would be available to take full advantage of Federal aid.

Analysis showed that for the first three years under the 10-yr catch-up, state funds available to match Federal aid would be more than sufficient, but that the amount of Federal aid itself would fall short of requirements. For the 15-yr catch-up, the amounts scheduled for state funds to match Federal aid would fall short of the requirement by about 13 percent. However, the total allowance for new state construction exceeded requirements for state matching funds by 56 percent, so that the 15-yr catch-up could be adapted to the new Federal program by a cut-back in purely state construction of slightly less than 19 percent (see Table 4).

It was clear that a 13-yr catch-up program would come closest to fitting existing Federal provisions, but since such an analysis would have required complete re-working of the engineering data, probably involving several months delay; and since the results of the finance study were needed as soon as possible, it was recommended that the 15-yr catch-up program be used as the basis for provisional planning, until such time as data for a 13-yr catch-up could be properly worked out.

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The NATIONAL RESEARCH COUNCIL was established by the ACADEMY in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the ACADEMY in service to the nation, to society, and to science at home and abroad. Members of the NATIONAL RESEARCH COUNCIL receive their appointments from the president of the ACADEMY. They include representatives nominated by the major scientific and technical societies, representatives of the federal government, and a number of members at large. In addition, several thousand scientists and engineers take part in the activities of the research council through membership on its various boards and committees.

Receiving funds from both public and private sources, by contribution, grant, or contract, the ACADEMY and its RESEARCH COUNCIL thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the government, and to further the general interests of science.

The HIGHWAY RESEARCH BOARD was organized November 11, 1920, as an agency of the Division of Engineering and Industrial Research, one of the eight functional divisions of the NATIONAL RESEARCH COUNCIL. The BOARD is a cooperative organization of the highway technologists of America operating under the auspices of the ACADEMY–COUNCIL and with the support of the several highway departments, the Bureau of Public Roads, and many other organizations interested in the development of highway transportation. The purposes of the BOARD are to encourage research and to provide a national clearinghouse and correlation service for research activities and information on highway administration and technology.