INTERIM REPORT OF THE

JOINT LEGISLATIVE AUDIT AND REVIEW COMMISSION AND

THE SJR 50 SUBCOMMITTEE ON

METHODOLOGY FOR A VEHICLE COST RESPONSIBILITY STUDY

TO

THE GOVERNOR

AND

THE GENERAL ASSEMBLY OF VIRGINIA

SENATE DOCUMENT NO. 12

COMMONWEALTH OF VIRGINIA
Richmond, Virginia
1981

MEMBERS OF THE JOINT LEGISLATIVE AUDIT AND REVIEW COMMISSION

Chairman
Delegate Richard M. Bagley

Vice Chairman
Senator Hunter B. Andrews

Delegate Robert B. Ball, Sr.
Senator Herbert H. Bateman
Senator John C. Buchanan
Delegate Vincent F. Callahan, Jr.
Delegate L. Cleaves Manning
Delegate Theodore V. Morrison, Jr.
Delegate Lacey E. Putney
Delegate Ford C. Quillen
Senator Edward E. Willey
Mr. Charles K. Trible, Auditor of Public Accounts

Director
Ray D. Pethtel

MEMBERS OF THE SJR 50 SUBCOMMITTEE

From the Joint Legislative
Audit and Review Commission

Delegate Theodore V. Morrison, Jr. (Chairman)
Delegate Vincent F. Callahan, Jr.
Senator Edward E. Willey

From the Senate
Committee on Finance

Senator Peter K. Babalas
Senator J. Harry Michael, Jr.
Senator William A. Truban

From the Senate
Committee on Transportation

Senator Daniel W. Bird, Jr.
Senator Richard L. Saslaw
Senator Lawrence Douglas Wilder

From the House
Committee on Finance

Delegate Archibald A. Campbell
Delegate C. Richard Cranwell
Delegate Norman Sisisky

From the House Committee on
Roads and Internal Navigation

Delegate Orby L. Cantrell
Delegate Earl E. Bell
Delegate V. Earl Dickinson

MEMBERS OF THE COST ALLOCATION PLANNING TEAM

William E. Landsidle, JLARC (Chairman)
Gary T. Henry, JLARC
E. S. Coleman, Jr. VDHT
C. O. Leigh, VDHT
Gary R. Allen, Virginia
Highway and Transportation
Research Council

COMMONWEALTH of VIRGINIA

Joint Legislative Audit and Review Commission

Suite 1100, 910 Capitol Street
Richmond, Virginia 23219
(804) 786-1258

RICHARD M. BAGLEY
Chairman

HUNTER B. ANDREWS
Vice Chairman

COMMISSION MEMBERS

HUNTER B. ANDREWS
Senator

RICHARD M. BAGLEY
Delegate

ROBERT B. BALL, SR.
Delegate

HERBERT H. BATEMAN
Senator

JOHN C. BUCHANAN
Senator

VINCENT F. CALLAHAN, JR.
Delegate

L. CLEAVES MANNING
Delegate

THEODORE V. MORRISON, JR.
Delegate

LACEY E. PUTNEY
Delegate

FORD C. QUILLEN
Delegate

EDWARD E. WILLEY
Senator

CHARLES K. TRIBLE
Auditor of Public Accounts
Ex Officio

RAY D. PETHTEL
Director

January 12, 1981

The Honorable John N. Dalton, Governor
The Honorable Members of the General Assembly
State Capitol
Richmond, Virginia 23219

Ladies and Gentlemen:

We are pleased to transmit to you this Interim Report which contains a discussion of the methodology which will be used to carry out a vehicle cost responsibility study. The methodology was prepared by the Joint Legislative Audit and Review Commission with the cooperation of a study committee designated by Senate Joint Resolution 50 of the 1980 Session.

Sincerely,

Theodore V. Morrison, Jr.
SJR 50 Subcommittee Chairman

Richard M. Bagley
JLARC Chairman

RMB:TVM:ji

Table of Contents

An advisory committee of special interest groups was invited to participate in the development of a study methodology by providing technical and policy information and reaction to the planning team. These groups also testified at a November 24, 1980 meeting and at a legislative hearing on December 17, 1980. Their comments are included as an appendix to this report.

I. Introduction

The construction and maintenance of Virginia's highway system are financed primarily by "user" charges and fees. "Users" are all individuals who use the highway system and pay for that use through taxes directly related to highway travel, such as gasoline taxes, license and registration fees, and sales taxes on automobiles and trucks. The principal exception to user funding is the local tax revenue used by cities to augment or match State expenditures for road construction and maintenance. Overall, however, 99 percent of State highway revenue comes from taxes and fees placed directly on the users of the highway system.

A basic principle of user tax equity is that the proportion of revenues derived from each user should be equal to the proportion of costs the public bears in providing serviceable highways for that user. A balanced tax structure would produce revenues from each user sufficient to cover all costs incurred on behalf of that user. While such a balance is difficult to achieve, knowing the relationship between taxes and highway use and service cost is a first step in designing an equitable tax structure.

The analytic process used to examine the balance between revenues paid by user taxes and the cost associated with providing the highway system is generally referred to as a cost responsibility study.

Cost Responsibility Concept

An underlying consideration of a cost responsibility study is that the highway system is built to accommodate a variety of vehicles. Different vehicles have a wide range of requirements for pavement width, strength, and amount of roadway. In cases where construction and maintenance expenditures are made due to the needs of particular vehicles, those costs should be borne by the vehicle classes that require them. Examples are expenditures such as raising overpasses for truck clearance, or maintaining ferries which only haul automobiles.

In other cases, expenditures are made which cannot be directly related to special vehicle needs. For example, all vehicles benefit from traffic signs in equal measure. Separating costs associated with specific vehicle classes from those which are common to all vehicles requires careful analyses and a complex methodology.

A glossary has been included at the end of this report which identifies key terms and addresses some additional technical considerations.

Summary of the General Approach

Cost responsibility studies have received increased attention nationally in recent years, and the Virginia General Assembly has examined several aspects of the equitable distribution of costs and revenue payments six times since 1932. This report is intended to set forth a methodology for a full scale cost responsibility study mandated by Senate Joint Resolution 50 of the 1980 Session of the General Assembly. SJR 50 called specifically for "a study of the fair apportionment and allocation of the cost of building and maintaining the roads and bridges of the Commonwealth between motor vehicles of various sizes and weights." The cost responsibility report will be presented to the General Assembly prior to the 1982 Session.

The methodology was designed by a planning team of JLARC staff, personnel from the Department of Highways and Transportation, and staff of the Virginia Highway and Transportation Research Council. Technical assistance was provided by the Department of Highways and Transportation, the Department of Motor Vehicles, the State Corporation Commission, the Department of Transportation Safety, the Virginia State Police, and the Secretary of Transportation.

The design effort was guided by three overriding principles.

1. The design process was to be as open as possible with involvement of transportation industry representatives and other interested parties at an early stage.

2. The design process was to provide maximum flexibility in the examination of a range of alternative assumptions and scenarios.

3. The project was to use existing staff and resources, and be capable of institutionalization as part of the revenue forecasting responsibility of the Department of Highways and Transportation.

To comply with the first principle, a special interest group advisory committee was established. Invitations to serve on the committee were accepted by the American Trucking Association, the Virginia Highway Users Association; the Virginia Railway Association; the Automobile Club of Virginia; and the Conservation Council of Virginia. These organizations provided valuable insights to the planning team. JLARC staff also met with representatives of several other states and the Federal Highway Administration, which are presently engaged in cost responsibility studies.

The study design was initiated in May 1980 with an extensive background review and literature search. Several meetings were held with the constituent organizations serving on the advisory committee. A preliminary design was exposed in November to the advisory committee and the various State agencies involved in highway revenue tax collection and transportation policy development. Following review of comments received during these preliminary discussions, a revised methodology was presented to the SJR 50 subcommittee in November. A public hearing on the proposal was held in December. Implementation of the cost responsibility study will be conducted by JLARC and DHT staff beginning in January 1981. A final report will be presented to the 1982 Session of the General Assembly.

II. Design and Methodology

The design for the cost responsibility study is based on Virginia's highway programs, construction and maintenance standards, and revenue sources. Grounding the design and methodology in actual conditions and experience is the best means of obtaining accurate, reliable estimates of highway costs and user payments. Examples cited in the text illustrate the proposed methods and are based on actual projects.

This chapter follows the flow of the study process through its three phases. The first phase deals with establishing a broad framework for estimating construction and maintenance costs and vehicle use of the highway system. The second phase examines several alternatives for allocating costs among and within vehicle classes. The final phase describes the methods for determining revenue payments by vehicle class to compare with the costs for which that class is responsible.

ESTABLISHING A FRAMEWORK

There are two major steps in developing the study framework. First, the costs to be analyzed and the time frame must be selected. Second, vehicles need to be classified by weight and size characteristics.

Definition of Cost

Two points of view can be considered in determining what costs should be included in the study framework.

The first is that the costs should include all the costs generated by the highway system. For example, noise and air pollution can be considered costs for adjacent landowners, although these costs would not generally be represented in the Department of Highways and Transportation (DHT) expenditures for construction and maintenance. Other costs, such as the loss in local government revenue when private property is removed from tax-producing use due to roadway construction, might also be included.

The second point of view incorporates a somewhat different focus. It develops the cost responsibility study as a highway financing tool. Under this point of view, the relevant costs are those which will be reflected in revenue collections and expenditures for highways during the study period.

By limiting the definition of costs to the amount which is anticipated for expenditure, the study should provide more realistic information on which to base tax policy. This perspective can be a problem, however, if key expenditures, such as maintenance, are being deferred to the extent that the highway service level is altered. The evidence in Virginia indicates that maintenance is not being deferred to a degree which could reasonably affect the study results.

The use of actual and projected expenditures, rather than costs, is also a practical choice because the means of measuring true costs are not generally available. Therefore, using expenditures as a measure of system costs is considered the most practical and reliable approach for a study intended for use as a financing policy tool.

> Recommendation 1. For the purposes of this study, actual and projected expenditures should be used as measures of highway construction and maintenance costs. The Department of Highways and Transportation should continue to examine other means of approximating costs for possible use in subsequent cost responsibility studies.

Time Frame Selection

There are two principal options for selecting a time frame for analysis. The simplest is to compare expenditures and revenues for the most recent fiscal period. Data are generally available and estimation is minimized.

A second option is to project expenditures and revenue collections to a future time period. This approach requires substantial estimation of future workload, inflation rates, traffic patterns, and revenue collections. A future time frame compatible with the State budget cycle would need to be selected to enhance the study's usefulness as a highway financing tool.

Although the second option is more complex, it provides better information on cost responsibilities in a changing fiscal and technical environment. Analysis of costs and revenues for the current period might not be adequate for equitable cost sharing under future conditions. The available evidence suggests that Virginia is experiencing change in several areas which could affect cost allocation.

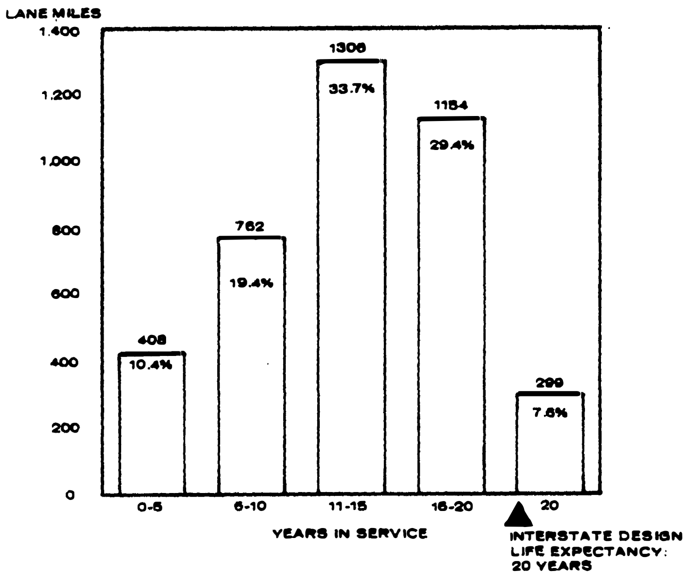
- Virginia's highway system is aging. Figure 1 shows that 299 lane miles of the interstate have already reached their design life expectancy of 20 years. Another 1,154 lane miles of the interstate system will reach the limit of their design life in the next four years, while two-thirds of the system will require increasing maintenance attention and eventually major reconstruction efforts by the end of the 1980s. Similar aging trends characterize the heavily travelled arterial, primary, and urban systems.

- The mix of new construction projects is changing. For example, the rural portions of the interstate system are essentially complete. Interstate construction over the next decade will be primarily for urban sections and interchanges. Design requirements and related costs for urban construction are significantly different than in rural areas.

- Traffic trends are changing with a marked increase in heavy truck mileage (Figure 2). Rising heavy truck use increases highway construction and reconstruction costs by requiring thicker pavement and greater capacity.

Figure 1

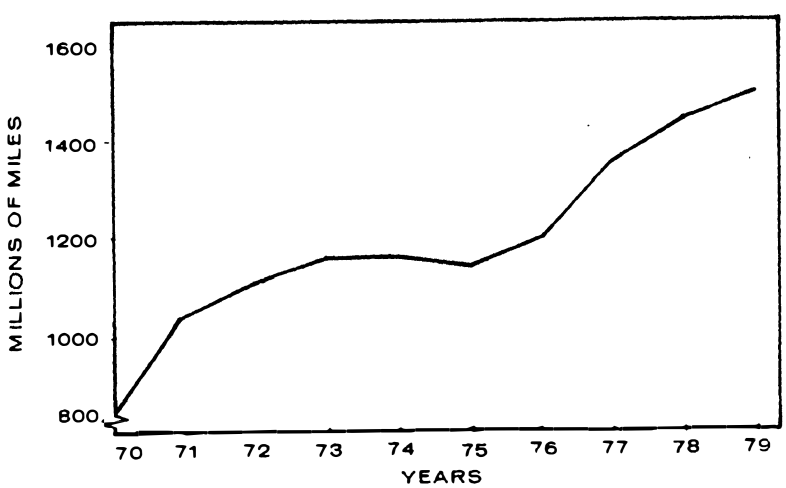
AGE OF VIRGINIA INTERSTATES



Source: Department of Highways and Transportation as shown in R.J. Hansen Associates, Inc., Virginia Highway and Transportation Management.

Figure 2

HEAVY TRUCK MILEAGE IN THE 1970s



Source: Department of Highways and Transportation as shown in R.J. Hansen Associates, Inc., Virginia Highway and Transportation Management.

Combining the time frame options offers the best chance of developing comprehensive cost responsibility findings. Examination of the most recent fiscal period will provide reliable baseline estimates. Examination of projected trends will give estimates which may be more useful in setting future tax policy. Finally, analysis of the two data sets will serve as a cross-check and highlight the cost items that are most sensitive to changing conditions.

The FY 1980 time frame is best suited for analyzing current expenditures and costs. An assessment of data availability and the schedule of the present study indicates that FY 1983 to FY 1986 would provide the best estimates of future costs for several reasons.

1. Data from the present cost responsibility study will not be available until prior to the 1982 Session of the General Assembly, long after appropriations or tax policy decisions have been made for the 1980-82 biennium.

2. Project scheduling data from DHT are based on a six-year advertisement schedule which is updated annually. The current schedule provides estimates of the contract bidding sequence through 1986.

3. The period July 1982 to June 1986 corresponds with the 1982-1984 and 1984-1986 biennia.

Recommendation 2. The present study should analyze cost and revenue data for the periods FY 1980 and FY 1983 through FY 1986. The analyses should be conducted separately. A follow-up cost responsibility study should be completed in 1985 for use in the 1986-1988 and 1988-1990 biennia.

Vehicle Classes Selection

SJR 50 called for a study of cost apportioning among vehicles of various sizes and weights. To accomplish this, vehicles which use Virginia highways must be aggregated into a manageable number of classes. The classification system used must meet two general requirements. First, there should be a relationship between classification and the cost-occasioning size and weight relationships discussed in the next section. Second, as a practical matter, the classes must correspond to the way in which vehicles are defined in law and in which the existing revenue, registration, and traffic volume data are maintained.

The results of an analysis of key vehicle data available in Virginia are shown in Table 1. Estimated numbers of vehicles and average daily miles of travel are shown for the interstate, arterial, and primary systems which carry the great majority of truck traffic.

Table 1

VEHICLE CATEGORIES AVAILABLE FOR ANALYSIS WITH KEY MEASURES

Vehicle Category	Estimated Percent of all Vehicles[1]	Percent of Average Daily Vehicle Miles[1]	Average Loaded Weight (lbs)	Typical Maximum Gross Operating Weight[2] (lbs)	Percent of Equivalent Single Axle Loads[3]
Passenger Car	68%	72%	NA	NA	NA
2-Axle 4-Tire Trucks	16	16	5,772	10,000	1%
2-Axle 6-Tire Trucks	3	3	15,525	24,000	8
3-Axle Single Unit Trucks	1	1	38,426	50,000	4
3 and 4-Axle Combination Tractor and Trailer	2	2	37,827	48,000	[illegible]
5-Axle Combination Tractor and Trailer	10	6	60,537	75,000	[illegible]

[1] Interstate, arterial, and primary systems.

[2] Top of category which includes 90th percentile.

[3] ESAL-18, flexible pavement.

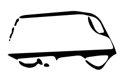
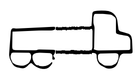
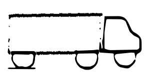
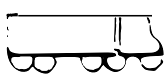
Source: Department of Highways and Transportation, 1979 Truck Weight Study and 1979 Average Daily Traffic Volume Report.

The data in Table 1 highlight several important groupings which can be used to classify vehicles. Passenger cars, pickup and panel trucks, and five-axle combination trucks account for about 94 percent of all vehicles and average daily miles of travel. Medium size trucks and buses are only a small proportion of all vehicles.

However, medium size trucks become more of a factor in the latter three columns of the table which relate to weight. The two-axle, four-tire trucks average less than 6,000 pounds when loaded, while loaded weights for larger single unit trucks show significant increases. The fourth column, which relates to bridge costs, shows a 140 percent increase in typical maximum gross operating weight for two-axle, six-tire trucks (small dump and delivery trucks) over two-axle, four-tire trucks. The three-axle single units (primarily heavy dump trucks) and three- and four-axle combinations are 100 percent above the two-axle, six-tire vehicles in the same category.

The fifth column relates to pavement costs. Equivalent single axle loads (ESAL) are a standard unit of weight measurement used in projecting the need for pavement strength. Vehicles of different weight produce various numbers of ESALs. For example, a passenger car produces two ten-thousandths of one ESAL, while a fully loaded tractor-trailer will produce two and one-half ESALs. The increased significance of the medium size trucks is evident. Although five-axle combinations dominate the axle load statistic, dump trucks and lighter tractor trailer combinations account for significant portions of the column total.

Based on the measures in Table 1, the following vehicle categories offer the best combination of data availability and sensitivity to weight and size relationships important in allocating costs.

	Class I:	Passenger cars, motorcycles, panel and pickup trucks, and two-axle, four-tire trucks
	Class II:	Two-axle, six-tire trucks
	Class III:	Three-axle single unit trucks
	Class IV:	Three- and four-axle combination tractor and trailer
	Class V:	Five-axle combination tractor and trailer

Recommendation 3. For the purposes of this study, the five vehicle classes described above should be used for analysis of cost responsibility and a comparison with revenues received. Class I should be considered the basic vehicle for incremental allocation methods which are discussed in following sections.

COST ALLOCATION

Cost allocation is the second major phase of a cost responsibility study. The basic principle of cost allocation is that costs which can be clearly linked to the special needs of particular vehicles are "occasioned" by those vehicles and should be assigned to them. Costs which cannot be clearly linked to the special needs of particular classes are "common" to all vehicles and can be allocated in any manner which is considered equitable.

There are two steps to cost allocation. First, expenditures are categorized and projects and work activities are selected for inclusion in the data base. Then each of the expenditures is allocated to the five vehicle classes. These two steps have been compared to determining the size of a whole pie and then determining the size of each slice. The result of the cost allocation phase will be an apportionment of a total pie into the slices for which each vehicle class is responsible.

Categorization of Expenditures

Expenditures for constructing and maintaining highways can be divided into four major categories:

1. Roadway Construction. Roadway construction includes all those costs necessary to build a roadway, including preliminary and final design, right-of-way acquisition, clearing, excavation, grading, and construction of the pavement and shoulder surface. This category also includes reconstruction costs incurred as a result of rebuilding a deteriorated or inadequate roadway with some improvements in alignment, grade, pavement or shoulder width, intersections, or other geometric features.

2. Structures. Structures include costs for the construction and reconstruction of bridges and tunnels.

3. Maintenance. Maintenance includes all costs necessary for the preservation and restoration of existing roadways and structures. Ordinary or routine maintenance includes such activities as patching and sealing the road surface, clearing drainage ditches, mowing, snow removal, and repair of signs, guardrails, and signals. Replacement maintenance includes more extensive repair such as overlays, rebuilding shoulders and ditches, and replacement of signs, guardrails, and signals.

4. Other Costs. Other costs are those which cannot be directly related to construction and maintenance of roadway and structures. Major components of this category include general administration and capital outlay and maintenance for highway department facilities.

These categories do not include several kinds of expenditures made from the highway trust fund. These expenditures include assistance funding for mass transit and transfers for the programs of nine other agencies such as the Division of Motor Vehicles and the Marine Resource Commission. SJR 50 directed that the current study review the allocation of highway maintenance and construction costs. Since mass transit and the programs of other agencies have no direct relationship to building and maintaining the highway system, they were considered outside the scope of the study.

Project and Work Activity Selection

Theoretically, each project and work activity which is required to construct and maintain a highway system could be uniquely analyzed and broken down into occasioned and common cost components. However, this approach is not practical because of the quantities of data and data processing required. A generally accepted alternative is to categorize similar projects and work activities and to then use the results of a cost analysis for each category as an estimate to allocate cost responsibility for all projects and work activities in that category. The following sections describe the proposed methods for selecting representative projects and work activities, grouping projects and work activities into similar categories, and allocating costs.

FY 1980 Period. Identification of projects and work activities for the FY 1980 analysis is fairly straightforward. A sufficient number of cases are required to provide reliable cost estimates for allocation by vehicle class. Cost data for these projects must be accurate and indexed where necessary to account for inflation over the construction life of multi-year projects. Approximately 200 to 300 projects were recently completed which include construction expenditures that could provide an adequate sample. Using unit cost and bid item data from the project records, accurate cost estimates indexed to current costs can be developed. Actual expenditure data on maintenance work activities and other costs are also available and adequate for the study purpose.

> Recommendation 4. The study should use recently completed roadway and structure construction projects for the FY 1980 construction cost estimate sample. Use actual expenditure data for FY 1980 by work activity for estimates of maintenance and other cost estimates.

FY 1983-1986 Period. Selecting projects and work activities for a future time period is somewhat more complex. Past experience has shown that not all projects currently scheduled for FY 1983 through FY 1986 will actually be initiated during that time. In addition, a recent consultant study using DHT data forecast a steady decline in funds available for construction. If accurate, the forecast suggests that in FY 1986 Virginia could lose approximately $23 million in federal aid due to a lack of matching funds. Between 55 and 60 federal aid projects would be affected.

This could be significant for the cost responsibility study because a reduced budget would most likely result in a different mix of projects. Since a substantially different project mix would affect study results, any unusual fluctuation, such as the loss of federal aid due to a lack of matching State funds, could produce misleading results. A cost responsibility study done under these circumstances might not be reliable if additional revenues were subsequently made available for matching purposes and the budget returned to a more normal condition.

Table 2 shows the best current estimate of projects to be initiated during FY 1983-FY 1986, assuming that approximately $7 million in additional State funds are provided to fully match available federal revenues. Otherwise the projection is based on the present highway tax structure.

Table 2

PROJECTS PROJECTED FOR INITIATION
BY HIGHWAY SYSTEM
(FY 1983 - FY 1986)

Fiscal Year	Interstate	Primary	Secondary	Urban	Total
1983	30	27	123	15	195
1984	15	31	77	18	141
1985	9	19	18	20	66
1986	15	20	9	8	52
Total	69	97	227	61	454

Source: DHT programming and scheduling directorate.

Recommendation 5. The present study should use a projection of construction projects for both roadway and structures to be initiated in FY 1983 through FY 1986 based on the best estimates of a realistic schedule as derived by the Department of Highways and Transportation programming and scheduling directorate.

Projecting maintenance work for FY 1983 through 1986 is also complicated by the changing requirements resulting from the system age and use trends described earlier. A straight line projection from current trends would probably underestimate expenditures for pavement and shoulder maintenance and possibly other work activities as well. Reasonable estimates of future work patterns can be obtained by modifying a straight-line projection based on an examination of recent trends and the judgments of DHT engineering and maintenance personnel.

Recommendation 6. The present study should adopt a modified projection of maintenance work activities for FY 1983 through FY 1986 based on examination of recent trends, existing design-life records, and the judgmental input of DHT staff.

Projection of other cost items is best accomplished on a case-by-case basis. General administration costs, for example, can usually be projected on a straight-line basis. Capital outlay costs and the cost of operating weighing stations can be derived from existing capital outlay plans and the number of weighing stations projected to be in operation.

Recommendation 7. The present study should adopt projections of other costs based on a case-by-case review of the cost item. Straight-line projections will be used whenever costs cannot be fixed by existing plans or facility inventories.

Grouping Projects and Work Activities

The second step in the cost allocation process is grouping projects and work activities. The grouping should accurately reflect the costs of the Virginia highway system while keeping study workload within reasonable levels. Projects and work activities in each of the four broad cost categories of roadway construction, structures, maintenance, and other costs can be reduced to representative groupings as discussed in the following sections. The approach will be essentially the same for both the FY 1980 and FY 1983-1986 time frames.

Roadway Construction. Most other states which have done cost responsibility studies have categorized projects based on system designation, e.g., "rural interstate" or "major primary collector." Wisconsin and Oregon, for example, have their highway systems broken down into eight designations. Virginia's system designation uses only four categories which would group substantially dissimilar types of roads. More importantly, roadway designs and, therefore, costs are based on expected and actual traffic volumes and the mix of heavy to lighter vehicles rather than system designation. For this reason the present study design is based on a cluster approach to categorizing projects for cost analysis.

The design of a roadway project is based on three principal factors:

1. Expected traffic volume, including both total number of vehicles and the split between trucks and cars.

2. Expected gross weights and axle weights.

3. Soil, topography, and drainage characteristics of the construction site.

Expected traffic volumes and weights are estimated for each project based on traffic studies and trend analyses. Soil, topography, and drainage conditions are assessed through a field examination.

A statistical analysis of traffic volume and weight estimates can identify clusters of projects which tend to share similar estimates and, therefore, can anticipate similar roadway designs. Figure 3 illustrates the clustering procedure which reduces the original number of projects to a limited number of cluster design types with each having an associated traffic weight and volume average.

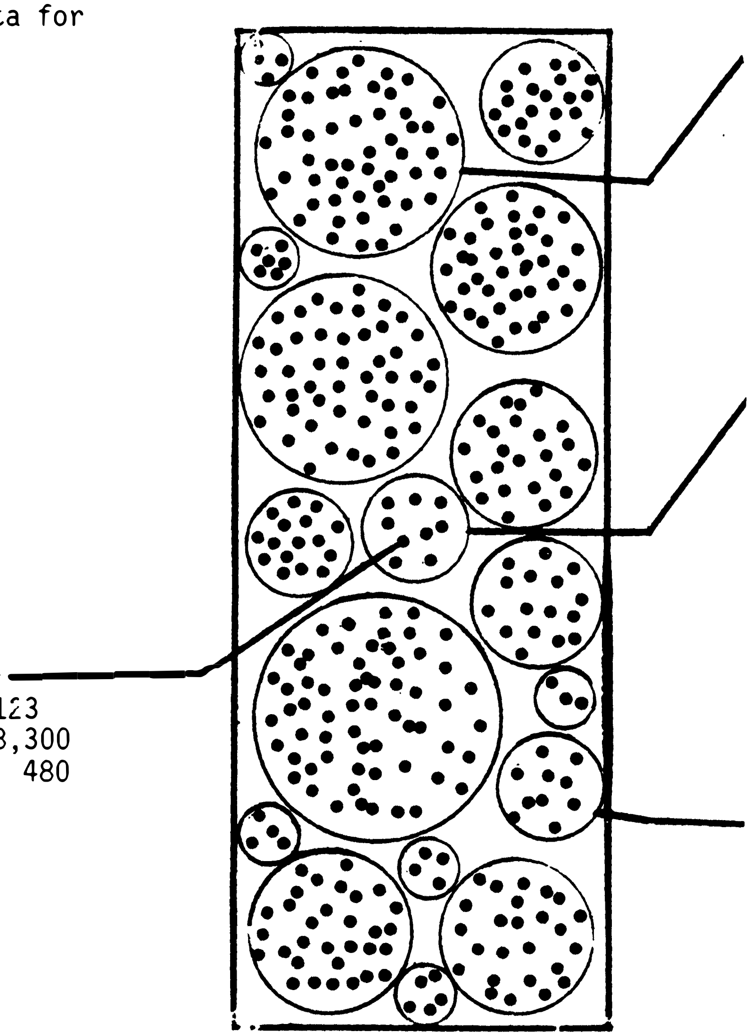
In addition, the actual cost for constructing all projects included in each cluster produces a cost estimate for each cluster. This estimate reflects the relative amounts of earthwork, grading, drainage system development, and pavement construction costs associated with each cluster. For example, if most of the current construction activity for high volume, heavy truck roadways is in the State's mountain areas, the higher cost of earthwork and grading in mountain terrain will be reflected in the costs for the cluster and in the resulting allocation of cost responsibility.

Figure 3

PROCEDURE FOR GROUPING CONSTRUCTION PROJECTS
INTO ANALYTICAL CLUSTERS

Each project in the analysis period provides data for forming the clusters.

This group of construction projects will have a similar average ADT and average ESAL-18 and will be treated as Cluster 1



This group of projects will be Cluster 9 and will include example project #123 because they have an average ADT of 52,941 and average ESAL-18 of 506, which are similar to those in the example project.

For example:
Project #123
ADT: 58,300
ESAL-18: 480

This group of projects will be Cluster 18.

Each dot represents one project in the study period.
Each circle represents a cluster or group of similar projects.
Each cluster is grouped on the basis of ADT and ESAL-18 recorded for each project.

The cluster approach will produce cost estimates that are sensitive to the actual cost of constructing roadways in all of Virginia's geographic and topographical regions.

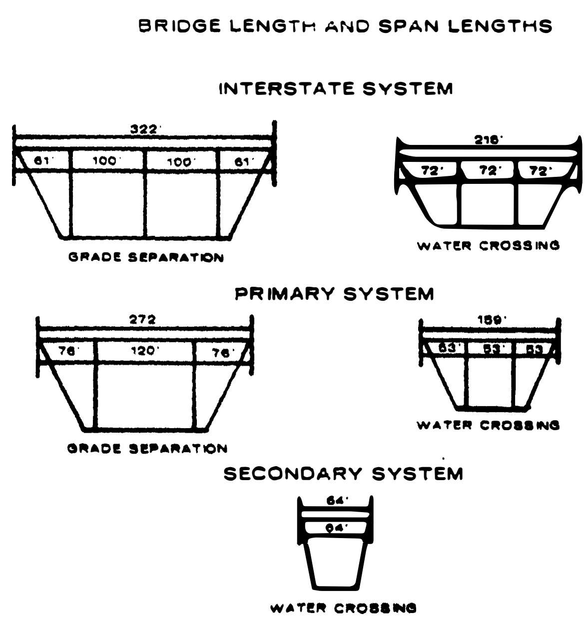
> Recommendation 8. The present study should establish categories of roadway construction and reconstruction projects based on an analysis of clusters formed by grouping similar projects.

Structures. Structures, principally bridges, can be grouped by total length, span configuration, type of crossing, and expected gross weight load bearing capacity for the purpose of developing typical projects. A DHT analysis of bridge projects completed during the 1970s developed an average bridge length for the interstate, primary, and secondary highway systems. The urban system is a designation based primarily on geographic location rather than function and is not considered a separate system for design purposes. From these averages, a typical span configuration which is reasonably representative of current and future bridge construction designs can be developed for each of the three systems.

Analysis also showed that the most significant crossing distinction, in terms of cost differences, was between a stream crossing and a grade crossing where a bridge is necessary to carry one roadway (or railroad track) over another roadway. This would indicate that each of the three system designs should have two variations, stream crossing and grade crossing. In practice, DHT builds virtually no grade crossing bridges for secondary roads. Therefore, five typical bridge designs are sufficient to represent all bridge construction projects (Figure 4).

Figure 4

BRIDGE CONFIGURATIONS



Source: VDHT Bridge Division

Assumptions about a typical gross weight load bearing capacity are based primarily on State policy. Optimally, all bridges should be capable of carrying the heaviest legal load that would be using the associated roadway. Since there is no legal limit on gross vehicle weights in Virginia that differs by highway system, this means that all bridges should be capable of carrying Virginia's legal maximum of 76,000 pounds plus the customary five percent tolerance. In fact, bridges which are not rated as capable of carrying the legal maximum are listed by DHT as "structurally" deficient, even if they are otherwise structurally sound.

It is important to note that the existing design standards for bridges are based more on this policy than expected use. There are many bridges, particularly on the secondary system, which do not carry heavy truck traffic and would be suitable for a lower design standard. However, because of the problems, such as detours, that would be created if traffic patterns changed, and the relatively small marginal cost of building a bridge to the maximum standard, virtually all bridges currently designed by DHT are designed for the maximum limit.

> Recommendation 9. The present study should adopt five categories for bridge design based on the historical average total length for the interstate, primary, and secondary systems, the associated span configuration for each length, and two crossing types (stream and grade).

Maintenance. Categorizing maintenance activities is fairly straightforward. DHT presently collects workload and expenditure data on over 100 categories of ordinary and replacement maintenance. Many of these are subsets of the same basic activity. For example, there are four subset designations for the general activity of repairing a concrete pavement: surface patching with concrete, joint replacement, filling gaps under the pavement, and surface patching with epoxy or bituminous material.

These data can be aggregated without meaningful loss of information, provided that work activities which may be eventually allocated as vehicle weight- or size-related are not mixed with activities without such a relationship. For example, surface overlays can be considered a weight related activity, while mowing is not. DHT maintenance personnel reviewed all work activities in the current data system and developed a categorization based on judgments about the potential weight for vehicle and size relationships for each activity (Table 3).

> Recommendation 10. The maintenance categorization shown in Table 3 should be adopted for this study.

Other Costs. Data on other costs are available from existing DHT sources. These costs include general administration, leave, holiday and sick pay, buildings and grounds maintenance, and capital outlay.

Table 4

PROPOSED CATEGORIES OF MAINTENANCE WORK ACTIVITY

ORDINARY MAINTENANCE: Activities related to preserving each type of roadway, structure, and facility as near as possible in its condition as constructed.

1. Surface Repair - Hardsurface Roads. Sealing, patching, joint replacement, and other spot reconditioning of bituminous and concrete surfaces.
2. Surface Repair - NonHardsurface Roads. Filling holes, grading, and dust reduction applications to dirt or gravel roads.
3. Shoulder Maintenance.
4. Ditch and Drainage Maintenance.
5. Structure Maintenance. Repair and maintenance of bridges, tunnels, pipes, and culverts.
6. Roadside Maintenance. Maintenance of rest areas and litter removal from roadsides.
7. Sign, Signal, and Safety Device Maintenance.
8. Vegetation Control. Mowing, brush cutting, spraying, and tree trimming and removal.
9. Snow and Ice Control.
10. Traffic Services. Service patrols.
11. Maintenance and Operation of Ferries and Drawbridges.
12. Maintenance and Operation of Weigh Stations.
13. General Expenses. Engineering and general supervision costs for ordinary maintenance activities.

REPLACEMENT MAINTENANCE: Activities related to restoring each type of roadway, structure, and facility as near as possible to its condition as constructed. This category primarily includes work on continuous portions of roadways of 1,000 feet or more, replacing signs, signals, lighting fixtures, guardrails, and fences, and major repairs to structures and facilities.

1. Surface Replacement - Hardsurface Roads. Overlays, replacement, and reconditioning of bituminous and concrete surfaces.
2. Surface Replacement - Nonhardsurface Roads. Reconditioning of sections of 1,000 feet or more.
3. Shoulder Replacement.
4. Ditch and Drainage Reconstruction.
5. Roadside Reconditioning. Removing major slides and reconditioning of slopes, replacement of sidewalks, gutters, and fences, and major repairs to waysides and rest areas.
6. Sign, Signal, and Safety Device Replacement.
7. Structure Repair.
8. Drawbridge and Ferry Repair.
9. Weigh Station Repair.
10. Flood Damage Repair. Extraordinary repairs of roadways, structures, and facilities due to floods, storms, and landslides.
11. General Expenses. Engineering and general supervision costs of replacement maintenance activities.

Recommendation 11. An "other" cost categorization which includes all general administrative and overhead expenses should be adopted for this study.

Cost Allocation

Once representative groupings are identified, the actual allocation of roadway and structure construction, maintenance, and other costs can be accomplished using a combination of empirical and judgmental methods.

The first decision necessary for allocating costs is to determine how common costs are to be distributed between vehicle classes. By definition, common costs are not related in any demonstrable way to the size and weight of various vehicle classes. For example, traffic signs benefit all classes equally by providing necessary information to drivers regardless of the type of vehicle driven.

Common costs should be distributed in some manner considered fair and equitable. In most studies, common costs are distributed among vehicle classes on the basis of miles driven on the highway system. If, for example, passenger cars as a class drove 70 percent of all miles driven in Virginia, they should bear the responsibility of 70 percent of the cost of traffic signs. The Division of Traffic and Safety of DHT generates comparative use data based on the miles of travel estimated for each vehicle class. These data provide a convenient and generally accepted means of allocating most common costs.

Recommendation 12. For the purposes of this study, common costs should generally be apportioned on the basis of relative miles travelled on the highway system by each vehicle class. Other methods of apportioning common costs will also be examined.

Allocation of Roadway Construction Costs

Allocation of roadway construction costs can be subdivided into six components.

1. Design and engineering, including preliminary surveys, engineering inspections and estimates, testing, and monitoring of construction projects.

2. Right-of-way acquisition.

3. Site preparation, including clearing, excavation, grading, and construction of drainage systems.

4. Roadway pavement construction, including base and surface construction.

5. Traffic and safety improvements and roadside development, including construction of signs, signals, guardrails, dividers, waysides, and turnouts, and soiling, seeding, and planting of vegetation to prevent dust and erosion.

6. Construction of special purpose improvements such as noise barriers, weigh stations, and scenic overlooks.

Engineering Costs. A review of DHT policies and procedures indicates that costs for construction design and engineering are not related in a demonstrable way to the weight or size characteristics of expected traffic. Instead, the cost of these activities represents the engineering "overhead" costs necessary for roadway construction.

Recommendation 13. Costs for design and construction engineering activities should be considered common to all vehicles and allocated by methods discussed in Recommendation 12.

Right-of-Way-Costs. Right-of-way widths are determined by a combination of tradition, standards, and expected traffic volume. A DHT policy memorandum dated January 1973 establishes the following minimum widths:

Interstate:	200-300 feet
Arterial:	160-200 feet
Primary Class I:	110-200 feet
Primary Class II:	50-110 feet
Secondary:	40 feet

Variations require authorization of the highway commissioner or deputy commissioner.

Actual right-of-way widths can be influenced during the design process based on expected traffic mix by the use of passenger car equivalents. These equivalents represent the relative amount of roadway consumed by vehicles of different sizes. A tractor-trailer may be assigned an equivalency of between three and seven compared to a one for a passenger car. Based on these equivalencies, extra turn lanes may be added or the acceleration lane lengthened. It may, therefore, become necessary to acquire additional right-of-way which would be the disproportionate responsibility of larger vehicles.

Despite the use of volume related measures such as passenger car equivalents in some roadway designs, the decision as to whether there is a significant, demonstrable relationship between the cost of right-of-way and vehicle size or weight is not clearcut. Specifically, DHT acquisition decisions have tended to be guided by the maximum width allowed by policy to take full advantage of the various benefits of a wide right-of-way, including added safety, aesthetics, and noise buffering. By policy, DHT also cooperates with public utilities by providing room for utility lines in roadway right-of-way which may require acquisition of more land than might otherwise be needed. It is important to note that when multiple reasons for design and acquisition decisions are found, the rationale for allocating costs disproportionately among vehicle classes is weakened. As a result, there is not a clear justification for treating right-of-way acquisition as an occasioned cost.

Georgia, Florida, and Oregon, which have recently completed cost responsibility studies, have all treated right-of-way as a common cost. The present cost allocation study by the Federal Highway Administration proposes to examine the relationship between right-of-way width and traffic volume in an empirical fashion. The results of this effort may provide additional information for future consideration in a Virginia study.

> Recommendation 14. Right-of-way acquisition costs should be considered common to all vehicles and allocated by methods discussed in Recommendation 12. DHT should continue to monitor the progress of the Federal Highway Administration study to determine whether there is an empirical relationship between right-of-way acquisition needs and traffic volume. Appropriate adjustments to this study or subsequent studies should be considered as additional information becomes available.

Site Preparation Costs. Site preparation costs, on the other hand, have a relationship to vehicle volume in several ways. Lane and shoulder width and the dimensions of excavated "cut-and-fill" earthwork are considered to vary with expected traffic mix. As a result, site preparation for a roadway designed for mixed truck and light vehicle traffic is relatively more expensive than for a roadway designed only for cars and light trucks.

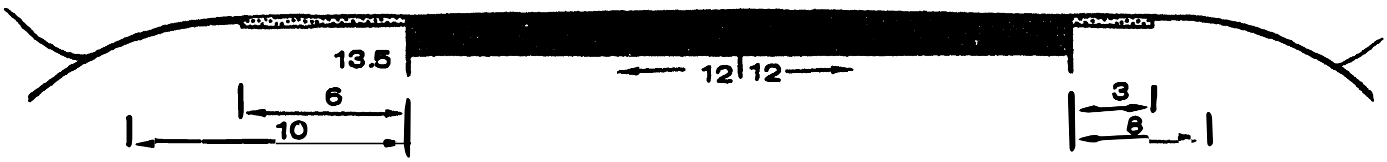
In order to estimate the proportion of occasioned cost in site preparation, the DHT location and design division will examine cross sectional designs for the projects contained in the various clusters previously described. The designs will reflect the difference in costs between the mixed traffic roadway and the basic facility. These differences, expressed as proportions and applied against the cost estimates for the cluster as a whole, will provide the cost responsibilities for both mixed traffic and basic vehicles. A generally representative example of the separation of occasioned from common costs is shown in Figure 5.

Although some site preparation costs are related to weight and volume, based on DHT design standards there does not appear to be a relationship between successively heavier trucks and the occasioned costs for lane width and earthwork. The relative size of trucks and buses as a class compared to cars is the determining factor in cost differentials. Therefore, the total occasioned cost should be shared equitably among all weight categories of trucks. A measure such as relative miles of travel within each truck category would be a reasonable allocation method.

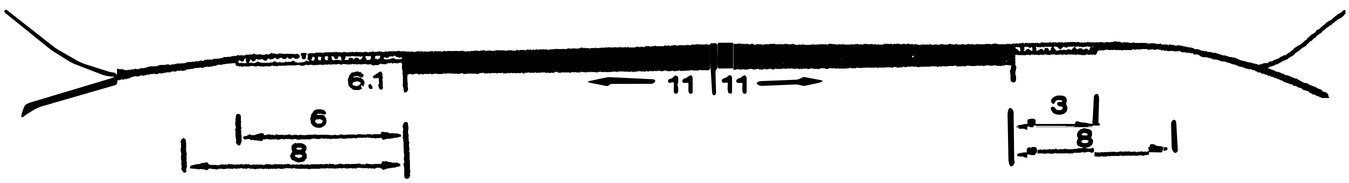
Figure 5

EXAMPLE OF STATE PREPARATION GEOMETRY DESIGN
(0220-011-101, C-512)

STANDARD GEOMETRY DESIGN
(With large and heavy vehicles)



REDUCED GEOMETRY DESIGN
(Without large and heavy vehicles)



EXAMPLE OF SITE PREPARATION COSTS
(0220-011-101, C-512)

	Items	Standard Design	Reduced Design (No Trucks)	Cost Difference
1.	Mobilization	$ 159,517	$ 119,941	$ 39,576
2.	Excavation	1,122,405	832,059	290,346
3.	Borrow	0	0	0
4.	Drainage	117,674	108,812	8,862
5.	Catch Basin	9,210	9,210	0
6.	Box Culvert	50,914	47,631	3,283
7.	Incidental Items	460,353	454,251	6,102
	Total	$1,920,073	$1,571,904	$348,169

SITE PREPARATION COST ALLOCATION

	Truck VPD (Percentage)	Occasioned Share	Total VPD (Percentage)	Common Share	Total Site Preparation Share	Site Preparation Share (Percentage)
Passenger Car & 2A-4%(s)	--%	--	81%	$1,273,242	$1,273,242	66%
2A-6T(s)	17%	$ 59,189	3%	47,157	106,346	6%
3A(s)	10%	34,817	2%	31,438	66,255	3%
3A & 4A(c)	15%	52,225	3%	47,157	99,382	5%
5A(c)	58%	201,938	11%	172,910	374,848	20%
Total	100%	$348,169	100%	$1,571,904	$1,920,073	100%

Recommendation 15. A review of project designs for all projects grouped through the cluster analysis should be used to identify site preparation costs related to the lane and shoulder width and cut-and-fill earthwork costs attributable solely to trucks and buses. These costs should be allocated among the four classes of trucks on the basis of the proportion of miles of travel within each vehicle category to the total miles of travel for all vehicles in the four truck classes. Remaining site preparation costs should be considered common to all vehicles and allocated by methods discussed in Recommendation 12.

Pavement Costs. Pavement construction costs are generally considered weight and volume related and, therefore, occasioned costs. Based on DHT standards and the judgment of design personnel, passenger cars and light trucks would require only 11-foot wide lanes rather than the 12-foot standard design. This would result in assigning to trucks approximately eight percent (1/12) of all pavement costs for roads with standard 12-foot lanes.

Pavement thickness is also clearly related because it is designed based on the anticipated number of repetitions of axle loads over the expected life span of the highway. Pavement thickness will be increased during design in direct relationship to an increased number of anticipated axle loads. In other words, an expectation that the highway will be used by heavier trucks, or by more trucks, will require thicker pavements.

The simplest and most defensible means of identifying and allocating pavement thickness costs occasioned by various vehicle classes is to separate the total pavement into components based on the thickness-to-weight relationship incorporated in the design standards. This approach, generally referred to as an incremental approach, has been used in a number of cost responsibility studies at the state and federal level. Although there are several reasonable variations of this approach, an incremental allocation of new pavement construction remains the most generally accepted method.

The feature most common to the incremental approach is the design of pavement increments for each vehicle class. As illustrated in Figure 6, the design is done after a "theoretical minimum" pavement is determined. The cross-section shows for one project the amount of pavement required as each class of vehicles is added to the traffic stream. Although the increments in this case are designed for only one project, similar cross-sections can be developed for each of the construction project clusters.

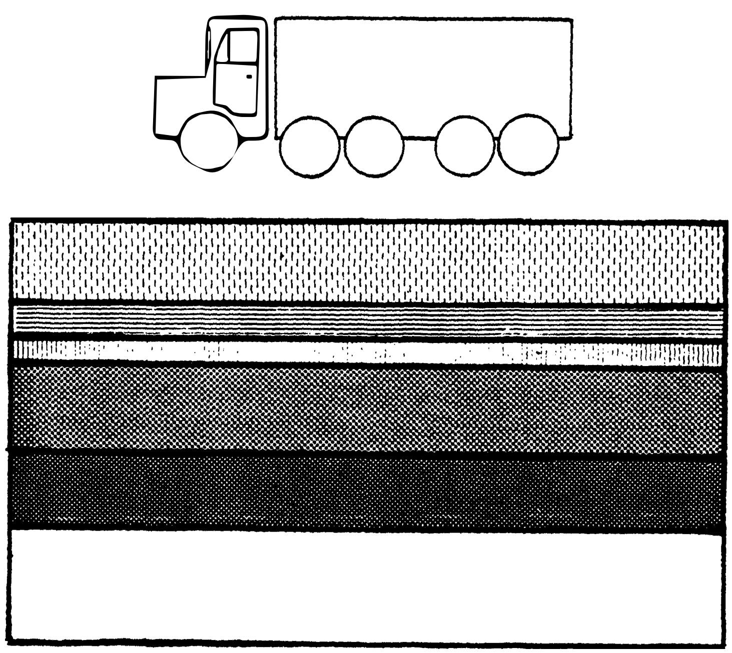
The design shows a total pavement depth of 12.8 units on the thickness index (T.I.). This is a measure used by DHT in their design procedures. The thickness index is used to account for the variety of different material mixes which may be used to achieve the desired pavement strength. For example, six inches of stone with a bituminous

Figure 6

EXAMPLE OF PAVEMENT COST ALLOCATION

Pavement Design

Increment	Vehicle Class		Traffic Volume (VPD)	Axle Weight (ESAL-18)	Required Increment (T.I.)
1	- - - - - - - - - Theoretical Minimum - - - - - - -				3.6
2	I.	Pass & 2A-4T(s)	6200 (81.1%)	3.6 (1.0%)	2.2
3	II.	2A-6T(s)	247 (3.2)	27.0 (7.7)	2.9
4	III.	3A(s)	148 (1.9)	15.5 (4.4)	0.6
5	IV.	3A/4A(c)	216 (2.8)	28.2 (8.0)	0.8
6	V.	5A(c)	838 (11.0)	277.7 (78.9)	2.7
			7650 (100.0%)	352 (100.0%)	12.8



Increment	Required Increment (T.I.)
6	2.7
5	0.8
4	0.6
3	2.9
2	2.2
1	3.6

asphalt overlay has the same thickness index rating and load bearing capability as approximately three and one-half inches of asphalt.

The thickness index determines the amount of pavement required to support the expected traffic. Therefore, the thickness index is used as a relative measure of the "full depth" asphalt material. The study will assume that the material to be used in the design is bituminous asphalt.

This assumption will allow the use of a single standard measure of thickness--the thickness index--rather than inches of varying materials. Since the cost allocation is based on proportions of thickness assigned to each vehicle class, the analysis will produce the results comparable to what could be expected if actual material mixes were used.

A theoretical minimum pavement increment equal to 3.6 on the thickness index (approximately 3.6 inches of asphalt) is shown in Figure 6. This theoretical minimum is the minimum pavement thickness that would be used on the most lightly travelled road in the State system. Virginia's subdivision streets were found to be built to the lightest standard, equal to 3.6 on the thickness index. This represents, empirically, the minimum pavement that is thick enough to survive expected weathering conditions with no appreciable impact from traffic weight.

Increments 2 through 6 show the amount of additional pavement thickness that would be added to the theoretical minimum to provide adequate strength for the traffic weight of each of the five vehicle classes. For example, an adequate pavement for 6,200 vehicles per day of Class I vehicles (cars and four-tire trucks) would require a total thickness on the index of 5.8. Subtracting the theoretical minimum of 3.6 from the 5.8 T.I. would yield a 2.2 increment for Class I.

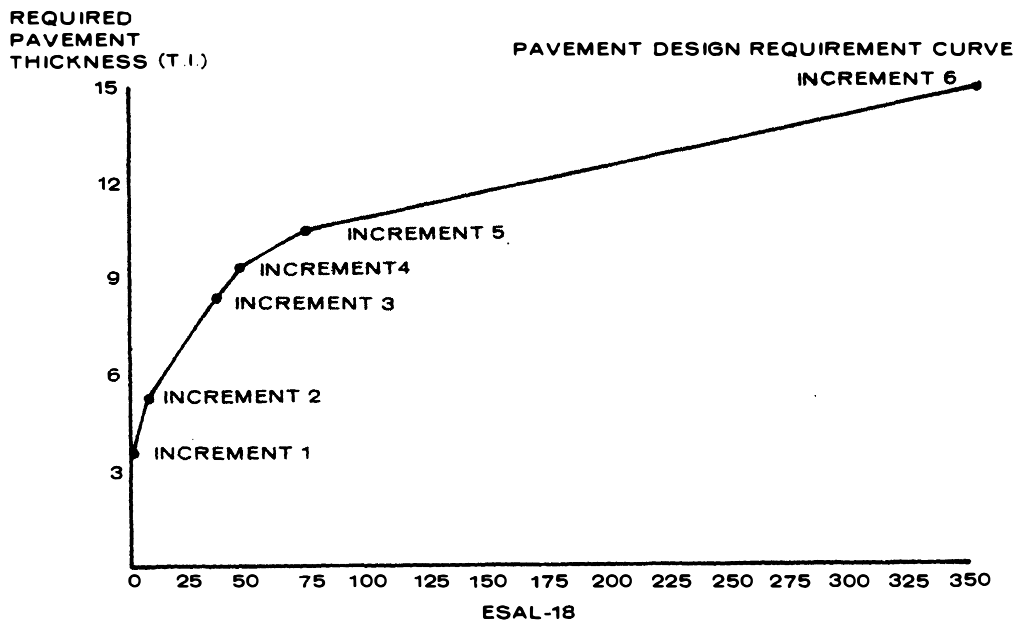
Once the relative proportion of total pavement thickness due to each vehicle class is developed, the cost of that increment can be determined by simply using the ratio of each increment to the total pavement thickness. For example, increment 3 is 22.7 percent of the total thickness (2.9 divided by 12.8) and can be assigned the cost value of 22.7 percent of the total pavement cost. In this way, the cost of pavement for each increment can be developed.

After the costs of each increment are known, they can be allocated as the responsibility of various vehicle classes. The method used to make this allocation involves a judgment about equity; it cannot be arrived at strictly through empirical analysis.

The reason for this is the nature of pavement design as it relates to increasing weight applications. In simplest terms, there are economies of scale in pavement design which affect the distribution of costs. This principle is illustrated in Figure 7, which shows the relationships between the thickness index and equivalent single axle weight for the same example used above. Additional thickness decreases

Figure 7

EXAMPLE OF ECONOMIES OF SCALE
INHERENT IN PAVEMENT DESIGN



* POINTS ON LINE REPRESENT THE EXAMPLE USED THROUGHOUT THE TEXT

as the number of standard weight measurement units - ESALs - increases. For example, adding Class II to the expected traffic mix increases pavement thickness by 50 percent (2.9 divided by 5.8) through the addition of 27 ESALs. In contrast, the increase in axle weight equivalencies between increment 5 and increment 6 - when heavy trucks are added - is 278.3 ESALs, but the additional axle weight requires only a 25 percent increase in pavement thickness (2.7 divided by 10.1).

The important point to be drawn from Figure 7 is that, although the economies of scale exist, there is no technical reason which clearly requires awarding the benefits to the primary beneficiaries--Class V vehicles. Three alternative methods which can be used to distribute the cost of the increments are shown in Table 4. All three rely on the same increments and are within technically recognized bounds for Virginia's pavement design practices. The difference is in the way the economy of scale is dealt with.

In all three methods the costs in each increment are shared by the vehicle classes which require the increment. The first method distributes the cost of each increment to vehicle classes on the basis of their proportion of the vehicles per day. For increments one and

Table 4

OPTIONS FOR ALLOCATING PAVEMENT COST

OPTION 1: ALLOCATION BY VPD

Increment	Class I	II	III	IV	V	Total
1	$48,954	$ 1,950	$1,166	$ 1,709	$ 6,621	$ 60,400
2	29,917	1,193	712	1,045	4,044	36,911
3	--	10,707	6,411	9,363	36,314	62,795
4	--	--	1,283	1,873	7,268	10,424
5	--	--	--	2,852	11,069	13,921
6	--	--	--	--	50,463	50,463
Totals	$78,871	$13,850	$9,572	$16,842	$115,779	$234,914
Percentages	33.6%	5.9%	4.1%	7.2%	49.3%	100.0%

OPTION 2: ALLOCATION BY ESAL-18 ABOVE THEORETICAL MINIMUM

Increment	Class I	II	III	IV	V	Total
1	$48,954	$ 1,950	$1,166	$ 1,709	$ 6,621	$ 60,400
2	351	2,861	1,624	2,960	29,115	36,911
3	--	4,845	2,784	5,096	5,070	62,795
4	--	--	500	918	9,006	10,424
5	--	--	--	1,301	12,620	13,921
6	--	--	--	--	50,463	50,463
Totals	$49,305	$ 9,656	$6,074	$11,984	$157,895	$234,914
Percentages	21.0%	4.1%	2.6%	5.1%	67.2%	100.0%

OPTION 3: ALLOCATION BY ESAL-18 ABOVE BASIC ROAD

Increment	Class I	II	III	IV	V	Total
1	$48,954	$ 1,950	$1,166	$ 1,709	$ 6,621	$ 60,400
2	29,917	1,193	712	1,045	4,044	36,911
3	--	4,845	2,784	5,096	50,070	62,795
4	--	--	500	918	9,006	10,424
5	--	--	--	1,301	12,620	13,921
6	--	--	--	--	50,463	50,463
Totals	$78,871	$ 7,988	$5,162	$10,069	$132,824	$234,914
Percentages	33.6%	3.4%	2.2%	4.3%	56.5%	100.0%

two, all vehicles share the costs in proportion to their presence in the traffic stream. For increment three, Class I is dropped out and the cost is shared by the remaining four classes, and so on until Class V alone is responsible for the last increment.

The second method, allocation by ESAL above the theoretical minimum, allocates the cost of the first increment on the basis of vehicles per day. The remaining five increments are allocated on a proportional ESAL-18 basis.

The final method allocates the first two increments on the basis of proportional vehicles per day as in the first method. Under this alternative, the first two increments represent a "basic road," i.e., one built only for light vehicles. The remaining four increments, which are needed to bring the roadway strength up to the requirements for heavy trucks, are allocated on the basis of ESAL-18.

The three methods have different implications for who receives the benefit of the economy of scale. In the first method, the last class to be added--the heaviest trucks--receive the greatest benefit. In the second method, the benefit of the economy of scale is neutralized because the ESAL-18 contribution is the allocation mechanism. In the final method, trucks benefit from a portion of the economy of scale because all classes are charged on a proportionate travel basis for the first two increments.

The difference in who receives the benefit of the economy of scale affects the distribution of costs. For instance, all classes of trucks except Class V are allocated less cost in the last two methods than in the first. The cost allocated to passenger cars and two-axle, four-tire trucks is the same in the first and third method but lower in the second. Five-axle trucks are allocated greater costs in the two ESAL-18 methods.

The three methods may be considered to lie on a continuum. Allocation by VPDs stands on one end and is considered the most that Class I vehicles should be charged within technically acceptable bounds. The allocation by ESAL-18 above the theoretical minimum stands on the other end of the continuum and represents the least that Class I should be charged. The third method--allocation by ESAL-18 above the basic road--represents a middle point on the continuum. The first method is more traditionally used and allocates less to five-axle vehicles; the second neutralizes the economy of scale benefit and therefore allocates less to Classes I-IV. The third is simply another alternative between the first two. No technical means is available to select the point on the continuum which is most "fair and equitable."

> Recommendation 16. Typical example designs based on the cluster analysis should be used to identify the incremental pavement cost responsibility attributable to each of the five vehicle classes. These costs should be allocated to each class on the basis of alternatives similar to those shown in Table 4. A full display of the possible alternatives should

be included in the final report with accompanying sensitivity analysis of the impact of each alternative on the final comparison of costs and revenues by vehicle class.

Traffic and Roadside Costs. Traffic and safety improvements and roadside development generally complete the expenditures necessary for a roadway construction project. There is some discussion in the literature about the appropriateness of allocating some of these costs on an occasioned basis. For example, a Congressional Budget Office proposal suggests treating guardrails as the unique responsibility of lighter vehicles. However, there is not a clear rationale for the various proposals, and the relatively small proportion of total expenditures involved reduces the issue's significance.

Recommendation 17. Costs for traffic and safety improvements and roadside development activities should be considered common to all vehicles and allocated by methods discussed in Recommendation 12.

Special Improvement Costs. In some cases, special purpose improvements are included in a particular construction project or series of projects. Examples would include noise barriers and scenic overlooks. Most of these special purpose improvements can be identified with the needs of particular vehicle classes. Scenic overlooks can be reasonably assigned to the benefit of passenger car occupants. Noise barriers are generally erected to reduce noise pollution in heavily populated areas, and some data are available on the relative responsibility of vehicle classes for noise generation. It should be noted that special treatment of these improvements is recommended primarily for conceptual consistency because the relatively small amount of expenditures involved will not materially affect the study results.

Recommendation 18. Special purpose improvements should be identified and reviewed on a case-by-case basis to determine whether allocation of cost on an occasioned basis is justified.

Structure Cost Allocation

The allocation of structure construction costs is similar to the pavement cost allocation discussed in the previous section. Structures can be designed to carry incrementally heavier loads, with each vehicle class assigned the responsibility for the increments necessary to carry vehicles in that class. Similarly, the width of lane and shoulder design is a function of the relative size requirements of all trucks and buses as a class.

These relationships can be developed as a ratio of each increment of wider and stronger capacity to the capacity of a structure designed to carry only the basic vehicle. Figure 8 shows the calculations and results of incrementally assigning bridge costs to the five vehicle classes for each of the five bridge configurations.

Figure 8

PROPOSED BRIDGE COST ALLOCATION

System	Length	Type	Class	SUPER STRUCTURE COST	SUB STRUCTURE COST	BRIDGE COST	DESIGN FACTOR	GEOMETRIC FACTOR	COST RATIO C.R.=D.F.×G.F.
SECONDARY SYSTEM	64 FT.	Waterway Crossing	Class I	41,449	41,436	82,885	0.820	0.933	0.765
			II	53,478	41,436	94,914	0.939	1	0.939
			III	58,292	41,436	99,728	0.987	1	0.987
			IV	57,756	41,436	99,192	0.981	1	0.981
			V	59,627	41,436	101,063	1	1	1
PRIMARY SYSTEM	159 FT.	Waterway Crossing	Class I	113,259	109,688	222,947	0.792	0.950	0.752
			II	144,377	111,997	256,374	0.910	1	0.910
			III	162,422	114,306	276,728	0.983	1	0.983
			IV	162,261	113,152	275,413	0.978	1	0.978
			V	166,152	115,461	281,613	1	1	1
	272 FT.	Grade Separation	Class I	264,196	105,389	369,585	0.821	0.877	0.720
			II	299,525	110,073	409,598	0.909	1	0.901
			III	319,054	114,757	433,811	0.963	1	0.963
			IV	316,777	112,415	429,192	0.953	1	0.953
			V	333,281	117,099	450,380	1	1	1
INTERSTATE SYSTEM	216 FT.	Waterway Crossing	Class I	210,567	165,617	376,184	0.820	0.955	0.783
			II	232,794	169,104	401,898	0.876	1	0.876
			III	272,532	172,590	445,122	0.970	1	0.970
			IV	272,343	170,847	443,190	0.966	1	0.966
			V	284,439	174,334	458,773	1	1	1
	322 FT.	Grade Separation	Class I	299,961	157,623	457,584	0.784	0.886	0.695
			II	356,664	164,629	521,293	0.893	1	0.893
			III	389,516	171,634	561,150	0.961	1	0.961
			IV	386,144	168,131	554,275	0.949	1	0.949
			V	408,654	175,137	583,791	1	1	1

$$\text{Cost Ratio (C.R.)} = \frac{\text{Cost to build bridge for other class vehicles}}{\text{Cost to build bridge for Class V vehicles}}$$

SOURCE : VDHT BRIDGE DIVISION

Tunnels are not a major cost component of the time frames included in this study. Tunnel construction cost would generally be related to the size of vehicles using the facility and this cost could be determined incrementally.

> Recommendation 19. Bridge construction, reconstruction, and replacement projects should be classified into one of the five typical design categories. Incremental size and weight-related costs should be allocated among all vehicle classes on the basis of proportionate miles of travel.

Maintenance Cost Allocation

Allocating maintenance costs to vehicle classes is among the more difficult aspects of a cost responsibility study. Whereas the relationship between vehicle size and weight and the construction costs for roadways and structures is generally based on empirical design relationships, the relationship between maintenance costs and vehicle size and weight is often judgmental in nature.

In simplest terms, maintenance costs are linked to gradual deterioration of the roadway, structures, and facilities that make up the highway system. Deterioration is due to use, age, weathering, and the actual versus predicted performance of designs, materials, and construction techniques. There is a general consensus among many highway maintenance engineers that the rate of deterioration, particularly in pavement condition, varies with use of the roadway by heavy trucks. However, there is little empirical information on what the differential rate of deterioration is and, therefore, on what basis costs should be allocated.

To simplify and focus the discussion, the categories of maintenance work activities described in Table 4 can be further aggregated into four groupings of particular importance to allocation of costs: pavement repair, shoulder maintenance, special-purpose facilities, and all other maintenance activities.

Pavement Repair and Replacement. The most controversial issue in cost responsibility studies is the allocation of pavement repair and replacement costs. Pavement maintenance presently accounts for one-third of total maintenance costs, and this percentage can be expected to increase as the age and increased use of highways result in more rapid deterioration.

Since pavement design is directly related to heavy truck use, it follows logically that pavement deterioration is also directly related to heavy truck use. However, a way to measure this relationship has not been empirically established. In other words, although engineering data can demonstrate the need for thicker pavements to withstand the weight of heavy trucks, these same data cannot be used to demonstrate that an adequately designed pavement is disproportionately damaged by the heavy weights for which it was constructed.

The Federal Highway Administration is presently engaged in a major research effort to establish whether other data exist to demonstrate a relationship between pavement deterioration and heavy truck use. This study is not expected to be completed until mid-1981. Until new information becomes available from the FHWA effort, the allocation of pavement maintenance costs remains a judgmental decision.

The planning team for the current Virginia study reviewed several judgmental approaches used in other studies to allocate pavement maintenance costs. Florida and Georgia assigned 75 percent of all surface maintenance costs to heavy trucks. Oregon used 80 percent in its 1974 study and is proposing up to 93 percent for the 1980 update. However, all these states acknowledge that the proportions are judgmental and were selected by maintenance engineers in the various departments.

Based on this review, it was determined that a more defensible approach for Virginia was to assign cost responsibility for pavement maintenance in the same proportion as new pavement construction. This approach has the major advantage of assigning the effect of unknowns (such as weather and materials failure) to vehicle classes in the same proportion as the only known relationship, design characteristics. The resulting allocation is the least arbitrary one available given the existing information and state-of-the-art in pavement engineering. This approach is reasonably applicable to all pavement surface repair and replacement costs.

> Recommendation 20. Pavement surface repair and replacement costs should be allocated to vehicle classes in the same proportion as the incremental cost responsibility for new pavement construction. The same kind of sensitivity analysis should be conducted for this cost category as proposed in Recommendation 16.

Shoulder Maintenance. The equivalent of two feet of shoulder maintenance costs can be considered the responsibility of trucks and buses as a class based on standards discussed previously.

The relatively wide wheelbase of trucks causes particular maintenance problems on narrow roads of 20 feet or less. The outer dual tire will frequently extend beyond the road surface causing damage to the shoulder. Although the problem is evident, its extent is unknown. Shoulder maintenance for narrow roads is also a small proportion of the maintenance budget according to DHT. Therefore, although this cost is occasioned, it does not appear significant enough to justify an estimating procedure for cost allocation at this time but should be incorporated in a more refined maintenance needs assessment for secondary roads.

> Recommendation 21. Shoulder maintenance costs equivalent to the proportion of total shoulder width added for truck use should be allocated to all vehicles larger than the basic vehicle. Other shoulder maintenance costs should be considered common to all vehicles and allocated by methods discussed

in Recommendation 12. Improved needs assessment policies for secondary roads should be considered to identify additional occasioned costs for inclusion in future studies.

Special Purpose Facilities. Some facilities are maintained for the benefit of only specific vehicle classes. For example, DHT operates three ferries which operate with weight limits. Two are for passenger cars only, while the Jamestown-Scotland Ferry has a 16-ton limit. The reversible lanes on the Shirley Highway are prohibited to trucks as is one rest area at Bristol. The special safety/service patrol which operates on interstates is also essential for the benefit of passenger cars. The cost of maintaining these facilities should be assigned only to the basic vehicle class. Weight station maintenance is the responsibility of trucks.

Recommendation 22. The maintenance costs of special purpose facilities should be assigned on a case-by-case basis.

Other Maintenance Costs. All other maintenance costs do not have a demonstrable relationship to vehicle size or weight and are, therefore, common to all vehicles. This category includes maintenance of bridge structures, ditches and drainage systems, roadsides, traffic safety improvements, vegetation control, and snow and ice removal.

Recommendation 23. All other maintenance costs should be considered common to all vehicles and allocated by methods discussed in Recommendation 12.

Allocating Other Costs

Other costs, including such functions as general administration, transportation planning, and research and regulation of outdoor advertising, are not directly related to the construction and maintenance of highways. Allocation of these costs by some measure of relative use of the highway system appears most appropriate.

Recommendation 24. All other costs should be considered common to all vehicles and allocated by methods discussed in Recommendation 12.

REVENUE ATTRIBUTION

The final phase of a cost responsibility study is identifying sources of user payment revenues received by the highway trust fund and attributing those revenues to the vehicle class which paid them. A comparison is then made between the costs charged to each vehicle class with the revenues paid by the class. Equity is achieved to the degree the costs and revenues are in balance.

Virginia's highway revenue comes principally from five sources: (1) the State fuel and road tax, (2) the federal fuel tax, (3) vehicle registration fees, (4) the State motor vehicle sales and use tax, and (5) federal excise taxes. Each revenue source is discussed in the following sections.

There are also several sources of revenue to the highway trust fund which are not generally considered appropriate for inclusion in a cost responsibility analysis. These include fees for record-keeping and regulatory services, and certain permits. In each case the revenues received are designed to recover the cost of providing the service and are not available for highway construction and maintenance purposes. Revenue sources included are:

1. Operator permit fees designed to recover the cost of regulating operator testing and licensing.

2. Vehicle title registration fees charged to recover the cost of protecting personal property and enforcing property-related court orders such as liens.

3. Dealer license fees designed to recover the cost of dealership licensing.

4. Public recording fees charged by DMV for certifying, copying and recording public records.

5. Motor carrier permit fees charged by SCC to recover the cost of certifying carriers in accordance with State law.

6. Highway permit fees charged by DHT for access to right-of-way.

These revenues amount to approximately four and one-half percent of total highway trust fund collections.

State Fuel and Road Tax

Virginia imposes a fixed cents-per-gallon tax on all fuel purchased in the State. In addition, most trucks with more than two axles which are used to carry property are assessed an additional "road tax" of two cents per gallon on fuel used in Virginia regardless of where the fuel is actually purchased. Together the fuel and road taxes contribute about 55 percent of State-imposed highway tax revenues.

To identify the proportion of total fuel and road taxes paid by each vehicle class, a series of assumptions and calculations is required. The best method is to use an estimate of fuel efficiency by vehicle class to estimate fuel tax payments. Road tax payments can be distributed on the same basis. Table 5 illustrates how the proportionate credit for fuel and road tax payments can be estimated using data available for FY 1979.

Table 5

ESTIMATION PROCEDURE FOR STATE FUEL AND ROAD TAX
(FY 1979 Data)

Estimation Steps	Vehicle Class I	II	III	IV	V
1. Fuel Efficiency Estimates (mpg)	14.1	9.1	5.0	4.7	4.7
2. Millions of Miles of Travel in Virginia	35,373	1,089	327	473	1216
3. Millions of Gallons of Fuel Used (Step 2/Step 1)	2,516	120	65	101	259
4. Millions of Dollars Paid in Fuel Tax (Step 3 x $.09)	$226.4	$10.8	$5.9	$9.1	$23.3
5. Percent of Fuel Used Subject to Road Tax (from Step 3, columns III, IV and V)	--	--	15.4%	23.7%	60.9%
6. Road Tax Collections to be Credited by Vehicle Class			$6,300,000		
7. Millions of Dollars Paid in Road Taxes (Step 5 x Step 6)	--	--	$1.0	$1.5	$3.8
8. Millions of Dollars Paid in Fuel and Road Taxes Combined (Step 4 + Step 7)	$226.4	$10.8	$6.9	$10.6	$27.1
9. Percentage of Fuel and Road Taxes Paid	80.5%	3.8%	2.5%	3.8%	9.6%

The estimation procedure in Table 5 produces an estimate of $281.4 million in total fuel and road taxes paid. Actual collections were $282.2 million for an overall estimation error of three-tenths of one percent. Additional refinements will be possible as updated data become available during the course of the study.

Recommendation 25. For the purposes of this study, adopt the fuel and road tax attribution procedure illustrated in Table 5.

Federal Fuel Tax

The federal government imposes a fixed four cents-per-gallon tax on motor fuels. Revenues from the tax are made available to the states as federal aid for highway construction and a limited amount of maintenance replacement work.

The fact that both the federal and Virginia fuel taxes are fixed cents-per-gallon provides a straightforward means of estimating payments by vehicle class. For example, in FY 1979 each class is assumed to pay an additional federal fuel tax equal to 44.4 percent ($.04/$.09) of the Virginia tax. Table 6 illustrates the approach.

Recommendation 26. For the purposes of this study, adopt the federal fuel tax attribution procedure illustrated in Table 6.

Table 6

ESTIMATION PROCEDURE FOR FEDERAL FUEL TAX
(FY 1979 Data)

Estimation Steps	Vehicle Class I	II	III	IV	V
1. Millions of Dollars Paid in Virginia Fuel Tax (from Figure II-10)	$226.4	$10.8	$5.9	$9.1	$23.3
2. Millions of Dollars in Federal Fuel Tax Paid (Step 1 x .444)	$100.5	$ 4.8	$2.6	$4.0	$10.4
3. Percentage of Federal Fuel Tax Paid	82.3%	4.0%	2.1%	3.3%	8.5%

Vehicle License Fees

Passenger cars and buses pay license fees established by Section 46.1-149, Code of Virginia. The amount of collections for each type of vehicle is available from DMV records.

License fees for trucks are established by Section 46.1-154, Code of Virginia. Data on license fee collections are available from DMV by gross weight category and general configuration, such as single-unit vs. combination tractor-trailer. From these data an estimation procedure can be developed to attribute total payments by trucks to the five vehicle classes.

Table 7 illustrates one approach to making these estimations. Using this procedure, DMV data on total collections for all single-unit trucks are apportioned among the three vehicle classes which include single-unit trucks. The apportioning percentages are based on the operating weight distribution found in the 1979 Truck Weight Study. For example, the 1979 study found that 94 percent of all single unit trucks operating in Virginia had four tires (Class I), so 94 percent of license fees for trucks under 10,000 pounds gross vehicle weight can reasonably be assumed to be paid by trucks with four tires.

This approach assumes that, on the average, truck owners will license their vehicles at the weight at which they are operated. The 1979 study results are biased downward in that they reflect both loaded and empty weights while license fees are based on maximum registered operating weights. However, it can be assumed that the bias affects all three vehicle classes equally, i.e., each class experiences approximately the same proportion of loaded to empty travel. Therefore, the relative proportions used to attribute revenue payments should be representative and reliable for the purposes of this study.

Table 7

PROCEDURE FOR ESTIMATING LICENSE FEE COLLECTIONS BY TRUCK VEHICLE CLASS

Weight Category (lbs)	1980 Collections To Be Attributed[1] ($000)	Estimated Percent of Vehicles in Weight Class		Apportioned Payment
		Class I	Class II	Class III
Under 10,000	$1,470	.94 ($1382)	.06 ($ 88)	--
10,000-13,499	207	.11 (23)	.87 (180)	.02 (4)
13,500-19,999	1,082	.03 (32)	.78 (845)	.19 (206)
20,000-21,999	255	.07 (18)	.68 (173)	.25 (64)
22,000-23,999	697	.08 (56)	.61 (425)	.31 (216)
24,000-25,999	850	--	.76 (646)	.24 (204)
Total Collections	$4,561	$1,511	$2,354	$694

[1]Does not include collections under the international registration plan.

The same procedure illustrated in Table 7 can be used to apportion fees for tractor-trailer combinations between three and four-axle vehicles (Class IV) and five-axle vehicles (Class V).

Virginia is also a member of the International Registration Plan (IRP) which governs the distribution of registration fee receipts for interstate carriers among the 23 member states. Under the IRP registration fees are prorated for interstate carriers based on the proportion of the vehicle's total annual mileage accumulated in each state. For example, if a truck is registered in North Carolina but accumulated 60 percent of its annual mileage in Virginia, Virginia would receive 60 percent of the registration fee appropriate for that particular truck under Virginia law. Trucks registered in non-IRP states pay no Virginia registration fees regardless of the amount of travel on Virginia highways.

Virginia received $7.1 million in registration fees under IRP in FY 1980. These revenues can be broken down by weight category using existing DMV data in the same manner as the revenues shown in Table 7. Therefore, the same apportionment approach illustrated in Table 7 can be used for IRP revenues. Since most interstate carriers are five-axle combination tractor-trailers, over 90 percent of all IRP collections are expected to be received from Class V vehicles.

> Recommendation 27. The registration fee attribution procedure for trucks illustrated in Table 7 should be used in the study. Actual collection data should be used for passenger cars and buses.

Virginia Sales and Use Tax

Approximately 15 percent of total highway trust fund collections come from the sales tax imposed on the sale of motor vehicles or mobile homes and the rental of motor vehicles. Section 58-685.12 of the Code of Virginia establishes the tax rates.

At the present time, data are not available on the breakdown of sales and use tax revenues among the vehicle classes used in this study. Although several estimating procedures are available, the most accurate and efficient means to attribute the tax revenues appears to be by requesting DMV to collect the necessary information from tax forms as they are received by the department. DMV staff have agreed to the feasibility of this approach. Data could be collected for a three- to five-month period in early 1981 and be available for use in the current cost responsibility study.

> Recommendation 28. DMV should be requested to begin collection of data on the vehicle class source of sales and use tax revenues over a reasonable sample time frame.

Federal Excise Taxes

There are six federal excise taxes that provide revenue for federal-aid highway programs.

1. A $.06 per gallon tax on lubricating oil.
2. A 10 percent sales tax on the wholesale price of trucks and buses over 10,000 pounds.
3. An 8 percent tax on the wholesale value of certain parts and accessories for vehicles over 10,000 pounds.
4. A $.10 per pound tax on tires.
5. A $.10 per pound tax on tubes.
6. A $3.00 per 1,000-pound vehicle use tax on vehicles over

The only source of data on federal excise taxes is the FHWA statistics published annually. The most recent data are for 1978 and show total collections from Virginia of $44.7 million.

The federal data do not show the vehicle class source of tax payments, so an estimation procedure is necessary.

Lubricating Oil. For lubricating oil, assumptions about oil change frequency have been proposed by researchers at the Virginia Highway Research Council. Using these estimates and the number of miles travelled by class in Virginia, the following distribution is considered reasonable and can be applied against the most recent data on federal collections.

Class I	.35 of total collections
Class II	.01 of total collections
Class III	.10 of total collections
Class IV	.14 of total collections
Class V	.41 of total collections

Tires and Tubes. Collections from this source in 1978 were $20 million. A special study will probably be necessary to determine the relative frequency of tire changes for each vehicle class.

Parts and Accessories. These taxes are paid principally by larger trucks and can reasonably be apportioned on relative vehicle miles of travel.

Class III	.15 of total collections
Class IV	.21 of total collections
Class V	.64 of total collections

Sales Tax. The federal sales tax is applied only to larger trucks and resulted in the collection of $19.6 million in 1978. Since both the Virginia and federal taxes are applied on a percentage basis, the results of the special DMV study proposed earlier can be used to apportion these revenues. For example, if DMV finds that five-axle combination tractor-trailers (Class V) paid 60 percent of Virginia's sales and use tax revenue received from all large trucks, the same 60 percent can be used as an estimate of federal sales tax payments.

Use Tax. The federal use tax added over $5 million to the highway fund in 1978. This tax is collected on vehicles with gross vehicle weight of 26,000 pounds at a rate of $3.00 per 1,000 pounds. Since these taxes are collected on a weight basis similar to Virginia's registration fees, a similar method would be used with only vehicles heavier than 26,000 pounds included.

> Recommendation 29. For the purposes of this study, use estimates of excise taxes for lubricating oil and parts and accessories as shown in this section. A special study should be conducted to determine how best to apportion excise tax revenues on tires and tubes. The federal sales tax should be apportioned among vehicle Classes III, IV, and V on the basis of data developed from the special DMV study proposed in Recommendation 28. The federal use tax will be apportioned following the method used for Virginia registration fees.

GLOSSARY

CLUSTER. A grouping of construction projects which are anticipated to have similar amounts of average daily traffic and equivalent single axle loads.

COMMON COSTS. The expenditures required for financing the highway system without regard to the type or number of vehicles on the roads, such as signs, basic facilities, and ordinary maintenance.

COST ALLOCATION. The portion of a cost responsibility study in which the occasioned and common cost shares of each vehicle class are determined.

COST RESPONSIBILITY. A highway financing study which compares the proportion of expenditures for which each vehicle class is responsible to the proportion of revenues the class contributes.

COST. (1) The expenditures required to construct and maintain highways, including the costs of deferred construction and maintenance. (2) The cost to society for the highway transportation mode, including expenditures of the Department of Highways and Transportation, cost of air and noise pollution, and cost of highway versus alternative land uses.

EQUIVALENT SINGLE AXLE LOAD. The stress placed on the roadway by the application of 18,000 pounds distributed on one axle. Factors are generated for various types of vehicles based upon the vehicles' single axle loading with an 18,000 pound single axle load equaling one.

EXPENDITURE. Money that the Department of Highways and Transportation spends for highway construction and maintenance.

GROSS REGISTERED WEIGHT. The weight declared by a vehicle for the purpose of registration. Generally, the gross registered weight is the upper limit of the loaded vehicle weight. Fees are assessed on the basis of this weight.

GROSS VEHICLE WEIGHT. The actual weight of a vehicle as recorded on scales. The gross vehicle weight may be taken when the vehicle is loaded or unloaded.

GROUPING. The aggregation of individual projects and work activities which permits the application of cost allocation techniques.

OCCASIONED COSTS. The costs which are incurred because of the needs of a particular class of vehicles, such as the costs of thicker pavements for heavier vehicles to travel the roads without causing immediate pavement failure.

REVENUE ATTRIBUTION. The portion of a cost responsibility study which estimates the proportion of revenues contributed by each vehicle class.

VEHICLE CLASS. A group of vehicles defined by similar characteristics, such as number of axles and type of unit. One vehicle class differs from another on the basis of cost occasioning characteristics, such as size and weight.

ABBREVIATIONS

- Average daily traffic

- Department of Highways and Transportation (Virginia)

- Division of Motor Vehicles (Virginia)

ESAL - Equivalent single axle load

- Gross registered weight

- Gross vehicle weight

- International Registration Plan

- Thickness index

- Vehicles per day

18-Kp - 18,000 pounds single axle equivalent

ASSOCIATION OF
AMERICAN RAILROADS
AMERICAN RAILROADS BUILDING · WASHINGTON, D.C. 20036

INTERMODAL POLICY STUDIES GROUP
Office of the President

December 16, 1980

Mr. Ray D. Pethtel
Director of Joint Legislative
Audit and Review Commission
910 Capital Street
Suite 1100
Richmond, Virginia 23219

Dear Mr. Pethtel:

I enjoyed the opportunity to attend your November 17 "exposure" briefing on JLARC's highway financing study. Since that time I have had the opportunity to talk this issue over with Gary Henry and (via telephone) Bill Lansidle and Gary Allen. In this letter I review my continuing concerns with your present approval and suggest alternatives. I would appreciate your comments.

I first classify highway costs, then critique your approach to the arrangement of incremental pavement costs, and finally comment on your interpretation of the results of the AASHO study of road deterioration.

I. TYPES OF HIGHWAY COSTS:

A. Costs vs. Expenditures:

As was noted in your presentations, not all economic costs are represented by government expenditures, nor are all government expenditures costs in an economic sense. You stated your intent to neglect--at this time--all costs not represented by state expenditures. As an expediency, this is defensible in the short run; however, use-induced variations may be extremely important, and should be incorporated into future analyses. In the remainder of my remarks, however, I restrict myself to "costs" which occur in the form of Virginia highway-related expenditures.

B. Direct vs. Common Costs:

Highway expenditures can be divided into "direct" and "common" costs. Direct costs are those for which a casual linkage can be established with some measure of road use ("direct variable cost") or with the expectation that some specific vehicle class will use a highway facility ("direct fixed costs"). Common costs are the residual expenditures that cannot be linked to any specific measure of road use or the expectation that any specific vehicle class will use the road.

It is important that your study recognize the difference between these three types of costs. Estimating both the variable and fixed direct cost responsibilities of each vehicle class is essentially an analytic question; although weakness in data or estimation methods may suggest that you report a cost responsibility range rather than a single point estimate for each vehicle class. In contrast, common costs cannot meaningfully be assigned on any usage or vehicle characteristic basis; since by definition, common costs are the residual costs for which no causal linkage exists.

This distinction should be made explicit, since if Virginia is similar to other states, common costs are likely to represent more than half of the total highway budget. As discussed below, a role for analysis does exist even with respect to common costs. The proper role, however, is that of examining impacts of alternative political schemes for covering overhead costs -- not that of suggesting spurious causality linkages.

C. Direct Avoidable Costs:

These costs, as noted above, are the highway expenditures that would be increased or decreased were highway use to increase or decrease. One example would be the costs associated with licensing vehicles that would be avoided were fewer vehicles to register. Another, and probably the major cost of this type, would be those pavement maintenance costs, including both 3-R and routine maintenance, that would be avoided were less traffic-induced stress placed on the pavement.

To estimate these latter costs, I would suggest you classify Virginia's roads by design, vintage, and initial quality level, and then estimate the amount of pavement maintenance expenditures you anticipate will be required on an annualized basis over the next say five years. Clearly, deterioration is a function of many interacting variables -- the severity of the weather, the number of ESALs per road mile anticipated, the maintenance policies followed, and so forth. Your task is to estimate those expenditures that would have been avoided had use been reduced. (I realize your staff believes that there is no established causal relation here; my discussion of this appears later).

The importance of distinguishing direct variable costs is that they are the one type of cost responsibility that should logically be recovered via an appropriately defined use-related highway tax.

D. Direct Fixed Costs:

Direct fixed costs are the costs of higher design standards directly attributable to a specific class of vehicles for either new or capital improvement projects. For example, the costs of structures, pavements, and geometrics would be less were there no heavy truck traffic. Here I discuss only pavement direct fixed costs, since your initial report repeated the traditional error of mixing those pavement costs which are direct fixed costs and those which are common.

1. Distinction of Fixed and Variable Costs: Direct fixed costs can only be avoided in the design stage. Once the facility is constructed, reductions in use cannot affect the initial construction expenses. Thus, the expenditure categories which should be examined to determine direct fixed costs are construction expenditures on new highway projects or capital improvements to existing highway facilities. As noted above, rehab expenses should be treated separately.

2. Estimating Direct Fixed Costs - The Traditional Approach: Let me turn now to the question of how direct fixed pavement costs should be estimated. Your current approach, basically the traditional approach, is confusing. You first ask what type of pavement would be designed were only light vehicles expected to use the road.* Second, one asks what road would be built were light vehicles to travel (their actual mileage and Class II vehicles -- the next heaviest group of vehicles) their augmented (via the same process discussed above) mileage. This process continues until the last vehicle class is introduced.

The cost assignment process then works in reverse. The heaviest class is assigned the costs associated with the last design increment of pavement (a correct procedure as discussed below); but then the costs associated with the second pavement increment are assigned to both the heaviest and the next heaviest class in proportion to their respective mileages (actually axle mileage). Since, however, total mileage per vehicle class increases as vehicles become lighter (and more numerous), a large share of all pavement increments

---

* The actual calculation is more complex. The question asked is really what pavement would be constructed, were only light vehicles to travel over the road but with the mileage -- and hence vehicles traveling per mile of road -- increased by assuming that the mileage of heavier vehicles is converted on a one-to-one basis into the lighter vehicle mileage.

subsequent to the first are assigned to the lightest group in each increment.**

These, however, are all problems of computation -- the major error here is that of logic. The question that never seems to be asked is that of in what sense any but the first group considered can be said to "cause" or "occasion" pavement expenses? No one asks the logical question: what costs would be saved if each group -- alone, not in conjunction with all heavier groups -- were not to use the road. Your approach accepts, I believe, an indefensible concept of incremental cost responsibility -- a vehicle class is held responsible for those design costs that would have been saved had that class not used the road and had all heavier vehicle classes also not used the road!

Your approach creates a "piggy-backing" problem in which each class of highway user benefits if it is considered the last user. A far more logical approach using exactly the same analytic process would be to examine the design savings on a "one-at-a-time" basis. There would be two major differences with this approach. First, the actual project as actually constructed would become the base point -- not any hypothetical "basic" or "standard" facility. Second, the engineer or other highway expert would be asked separate design questions for each vehicle class: what alternative facility would have been constructed had no light vehicles (no medium vehicles, no buses, no heavier vehicles, etc.) been expected to use the road? The resulting savings from the facility actually constructed that would result from excluding such vehicle class -- and only that vehicle class -- would then be assigned to that vehicle class. In this approach, all groups are treated independently. The costs assigned one group are not a function of where they are placed in the analysis queue.

**Even were such an "onion skin" approach to cost responsibility analysis found to be accurate, the problem would remain that costs would be assignable only to the group as a whole. There is no meaningful way of assigning class cost responsibilities to those individual vehicles making up the class. The traditional approach uses miles or axle miles traveled to assign the costs of the n^{th} increment among the groups alleged to have occasioned this increment to be required, but no defense has ever been offered for such an allocation rule. In effect, the traditional incremental approach -- once the first increment is evaluated and its costs assigned to the heaviest vehicle class--determine a cost that is the shared or common responsibility of two or more vehicle classes. The rule adopted for allocating the costs among these "co-occasioners" is no more legitimate than is the attempt to allocate all common costs on a VMT basis.

This approach will not, of course, assign all pavement costs. But, as should be apparent, the case for assigning all capital improvement projects costs is very weak -- a fraction of new pavement costs are the shared responsibility of all users and thus part of common costs. The traditional approach assigns all pavement costs by lumping common and direct costs in a highly confusing fashion. This is an error -- not a virtue.

E. Summary Treatment of Direct Costs:

In any event, your analysis should, regardless of the method you select to allocate 3-R costs, distinguish between those expenditure categories that are in principle avoidable and those costs that are fixed once one determines the vehicle mix to use the road. I suggest you summarize your results in a tabular format such as that shown below

	VEHICLE CLASSES		
COST RESPONSIBILITY CATEGORY	Passenger Vehicle	...	5-axle Trucks
Direct Avoidable			
Direct Fixed			
Total Direct Cost Resp.			

II. COMMON COSTS:

A. Calculation of Common Costs:

Common costs are readily calculable -- they are simply the difference between total highway expenditures and total direct costs. Total direct costs are the sum of all costs in the last row of the above table. However, it is important that your report explicitly estimate the common cost figure since common costs are the portion of the highway budget that cannot be assigned on technical, analytic grounds (in a "cost occasioned" fashion) but are rather that portion that must be assigned in conformity with principles of political equity. Past studies -- and the approach you have so far adopted -- obscure this fact by allocating common costs via spurious casual links.

Since common costs -- at least in past studies -- represent 60 to 80 percent of all highway expenditures, the issue of how they should be apportioned is of course the most critical question in the highway cost responsibility area. And -- as noted below -- this is an area where analysis can provide useful insights even though it cannot resolve the question.

Specifically, your decision to prejudge the political process by assigning costs as if they were occasioned on a VMT basis should be changed. You should explicitly state that the question of covering overhead costs is political, and then -- as indicated below -- go on to analyze the impact of alternative choices. Adopting the VMT rule eliminates your ability to improve the political choices regarding this issue. Indeed since passenger travel makes up 90 percent or more of all VMT and since common costs are likely to be 60 to 80 percent of total costs, a VMT rule assigns from 54 to 72 percent of all highway costs to passenger travel before any analysis is conducted. Does this seem reasonable, equitable, defensible?

B. Suggested Treatment of the Common Cost Issue:

To assist the political decision process, I suggest you examine how common costs are now paid, and then use various equity principles (mark-up over direct costs, ability-to-pay, or road benefits received) to develop a range of possible apportionment schemes, and finally analyze the impact of each scheme. Let me elaborate on these points:

1. Estimate the Current Common Cost Burden: Examine the tax payments by each user group, deduct their direct cost responsibilities calculated in step I.E. and then report the current pattern of user charge payments. The table below summarizes this approach.

VEHICLE CLASSES

	Passenger Vehicles	...	5-axle Trucks	Total
Highway Tax Contribution				
Minus Total Direct Cost Resp.				
Contribution to Overhead Dollar Contribution Percentage Contribution				

2. Examine Alternative Schemes: Operationalize various equity concepts -- mark-up over costs, benefits, ability-to-pay -- and consider the apportionments that each would produce. For example, to examine a benefits approach you might estimate the total value received by the motorist and the various commercial road users from the use of Virginia's roads and apportion common costs on this basis. (Note: This principle would assign common costs to the out-of-state commercial carrier.)

3. Conduct an Impact Analysis on Each Scheme: To provide the politician useful insights on various common-cost apportionment schemes, you should examine the effect of each scheme on profits, road use, operating costs, payments by in-state vs. out-of-state residents, and so forth. This process would yield much useful data for the political process, but would not preempt judgments which the politician should make. This approach incidentally is being followed in the FHWA study.

III. WHAT DID THE AASHO TEST SHOW:

In the AASHO tests, various roads were built and subjected to various vehicular traffic until they failed. The analysis of these tests yielded the so-called fourth-power law. This law says that the stress induced on a road increases as the fourth power of the axle load. Doubling axle weights increases road stress by 16 times.

The principle is used to design roads. An estimate is made of the expected cumulative number of ESALs that will be experienced per mile of road over the lifetime of the road. If a 20-year road lifetime is selected for the design, the engineer relies on tables to tell him the required structural strength of the pavement which in turn translates into various pavement thicknesses (at least in the case of flexible pavements). That is, roads are designed to experience an expected number of ESALS. If the principle that more or less ESAL affect road deterioration rates is rejected, then you must reject the traditional incremental approach as well as the consumption approach to road cost assignment.

This point is recognized even by ATA, as demonstrated by the Counseltran discussions of road lifetime as a function of design (see Figurel). The Counseltran Report discusses what happens over time when a road is "under" or "over" designed. A road is said to be "over designed" when it handles fewer ESALs than were anticipated at the time it was designed. But this also says that if we had fewer ESALs per time period we would have (in the Counseltran Report language) overdesigned the road. The effect would be that the road's lifespan would extend beyond the initial 20-year design life. Similarly, if ESALs are increased, we would have (in the ATA language) underdesigned the road and it would fail earlier than the 20-year period. In both cases, the ESAL-statistic is the use-metric affecting the mean-time-between-failures; and thus the level of annualized pavement expenditures.

Since we are dealing with a series of roads in different states of their life, the overall effect of more or less ESALs is to increase or decrease the amount of 3-R activity in any one period. It is this fraction of the total 3-R expenses that is avoidable and that should be allocated on ESAL basis. Estimating the fraction that can be avoided requires, of course, a judgment; and here we are preparing materials which may be of use to your staff.*

###

I appreciate the opportunity to comment on your work and hope to maintain close contact with work as it progresses.

Sincerely,

Fred Lee Smith, Jr.
Senior Research Economist

* The enclosed article by N.W. Lister, and my subsequent correspondence may be of use also.

c.c: Mr. Kemper Hyers
Mr. Urchie Ellis
Mr. Landsidle
Mr. Gary Allen
Mr. Gary Henry

COUNSELTRANS INC.

FIGURE 1*

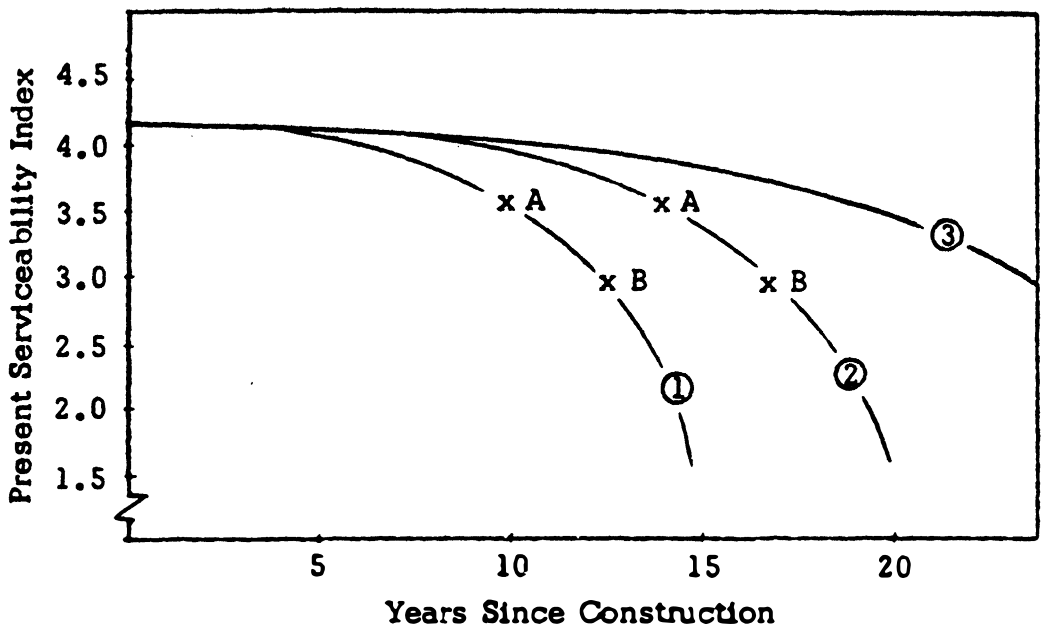


Figure 3 illustrates the possible performance of three pavement designs constructed to handle predicted axle loadings over a 20 year period. Curve 1 represents an underdesign: the pavement will actually reach failure (in AASHO Road Test terms) in 15 years. Curve 3 represents an overdesign: the pavement will not fail until after 20 years, perhaps long after. Curve 2 represents the design that will perform in the expected manner. These curves are generally intended to represent flexible pavement. For rigid pavement, the flat slope on top might be expected to last longer for curves 2 and 3 with a steeper final slope to failure.

* Excerpt from "Technical Inadequacies and Biases of the Highway Cost Allocation Study Plan" - Counseltrans Inc. Rockville, MD. 20852

Conservation Council of Virginia, Inc.

Suite 515
11 South 12th Street
Richmond, Virginia 23219

Executive Direct
Pamela Kent Pettus
804/780-1387

Statement
for
SJR 50 Subcommittee on Cost Allocation
December 17, 1980

This afternoon we have heard detailed and technical presentations on the SJR 50 cost allocation study. Representatives from the trucking industry and the railroad industry are concerned about the effect this study, in particular the methadology for assigning costs and the subsequent tax structure to recover those costs, upon the competitive position of their industries. Their concern is justified. Your decisions on cost allocation will affect the competitive position of those competing freight carriers.

However, SJR 50 and its cost allocation study have not been undertaken to promote or harm either the trucking or the railroad industry. Therefore, it is unfortunate that the discussion on this issue so often becomes one of "trucks vs. trains." However interesting and important that discussion may be, and my friends Mr. Reith and Mr. Ellis have never failed to make it interesting, it causes participants and spectators to lose sight of the larger issue.

We are here to talk about money. Specifically, the lack of money. "Decreasing revenues and increasing costs" is a refrain that's become too familiar to all of us. But it is that refrain that has brought us here today. Cost allocation is a complicated and technical field. But we are here to do more than participate in an academic exercise or to get lost and confused by detail. We must strive to keep our attention on the larger issue. Simply put, we are here to talk about how to protect our investment -- our multimillion dollar investment -- in Virginia's highways.

It seems accepted that Virginia highways will continue to be built and maintained through taxes and fees paid by Virginia highway users. It is your subcommittee, the cost allocation subcommittee, that will decide how much revenue each class of those highway users will have to contribute. Virginians, and highway users nationally, pay less of their income for the construction and maintenance of highways now than they did 20 years ago. I don't think many Virginians would object to paying more to properly maintain this highway system, *if* they can be assured they are paying their *fair share* and no more and that their money is not being *wasted*.

Highway programs and expenditures in Virginia and the rest of the country are shifting away from an emphasis on new construction and expansion toward an emphasis on maintenance and reconstruction. Most of the interstate and arterial system completed and in place. We must now concentrate on taking care of what we have. This brings about the need for a hard and careful look at the reasons for highway damage and therefore the causes for expenditures for maintenance and reconstruction

Certainly the age of the highway is a partial cause of deterioration. Other causes are the volume of traffic as well as the traffic mix. Traffic mix refers to the number of heavy vehicles in proportion to the number of light vehicles. Statements by engineers and highway officials throughout the country indicate an awareness that a large number of heavy trucks significantly shortens the expected life of highway pavement.

A spokesman for the American Association of State Highway and Transportation Officials, speaking before a Congressional Subcommittee in 1979, stated "For the most part our interstate and other highways were designed for a maximum 18,000 pounds single axle and a 32,000 pound tandem axle loadings...Our previous study showed an increase from 18,000 pound load to a 20,000 pound load can result in an average loss of the remaining highway life between 25 and 40 percent."

The California Department of Transportation completed a study entitled "Damage to Pavement Due to Axle Loads" in December of 1976. That study concluded that 58% of *total pavement costs* can be assigned to trucks and buses while 10.5% of *pavement damage* can be assigned to buses and 89% of *pavement damage* can be assigned to trucks.

Studies undertaken by the states of Oregon, Florida, Tennessee and others as well as public statements by state highway officials through the years indicate wide acceptance of the idea that heavy trucks are responsible for a disproportionate share of highway damage. These same studies state that the trucking industry is not currently paying its fair share of highway revenues in proportion to the amount of expenditures it causes to be made on the highway system. Since traffic counts around the country indicate that the number of trucks in proportion to the number of cars on the highways is increasing, this underpayment by the trucking industry will become greater.

In light of this information, I find it hard to agree with Mr. Reith's statement that Options 1, 2 and 3 developed by the JLARC staff (and shown in Figure II-B) are all "incorrect" and "punitive" to 5 axle combination trucks. These options, especially 2, finally address the question of 'who should pay for Virginia's highways.

If, in preparing this report, the JLARC staff has erred in any direction, it is on the side of the trucking industry. The statement that there is no "empirical proof" of the wear and tear upon roads by heavy trucks appears in several places and in several forms throughout the report. That statement concerns me. In a narrow and technical sense it can be said to be accurate. However, given studies and statements by highway officials and professional engineers (like those referred to earlier in this presentation) it seems misrepresentative to emphasize such a statement. In the strictest sense, we may lack "empirical proof". However, enough carefully accumulated information exists for us to draw some obvious conclusions: Since Virginia's current highway user tax structure was adopted, the number of trucks on Virginia highways has increased; the weight of those trucks has increased; the number of studies undertaken around the country, concluding that trucks are responsible for the *majority* of highway pavement damage, has increased; the relative number of smaller, lighter (and thus even less damaging) cars has increased; and the need for additional highway revenues has increased.

Those conclusions are obvious. Another seems to follow. Option 2 as prepared is not "incorrect" or "punitive". Instead, it suggests a long overdue and much needed first step at assigning the cost responsibility for Virginia highways.

SJR 50, even the cost allocation study alone, is a major undertaking. We commend the staff for their efforts so far. Much work remains to be done. We look forward to working with the staff, this subcommittee and the Commission.

8111 GATEHOUSE ROAD, FALLS CHURCH VIRGINIA 22047 ● 703 AAA-6000 ● CABLE AMERAUTO ● TELEX 89-9485

December 23, 1980

Mr. Roy D. Pethtel
Joint Legislative Audit
and Review Commission
910 Capitol Street - Suite 1100
Richmond, Virginia 23219

Dear Mr. Pethtel:

This is a follow up to my letter of August 5 regarding the cost responsibility study which you are making in accordance with SJR 50.

I have had an opportunity to review some of the material which has been developed thus far and in the main I believe that you are proceeding in an orderly and technically sound manner consistent with the methodology used in other states where such studies have been conducted recently (California, Florida, Georgia, Oregon, and Tennessee).

In the most recent material coming to my attention I note that the methodology calls for Right of Way to be assigned on a common cost basis. On page 12 of the document under "Construction Cost Allocation Recommendations" it notes that ROW will be assigned on a common cost basis with qualification for 1985. I don't know what the "qualification" is but certainly extra ROW needed where climbing lanes are required should be attributed to trucks. Also in areas where heavy truck traffic is so extensive as to reduce capacity some part of the cost of additional travel lanes should be attributed to heavy vehicles.

On page 14 it appears as though only six feet of paved shoulder is provided even where heavy vehicles are expected. Since most of the large rigs are eight feet wide shouldn't the paved shoulder be at least that wide so as to permit such rigs to pull completely off the travelled way when disabled? Shouldn't this extra two feet of paved shoulder be attributed to the large vehicles?

On page 33 two options are presented for pavement maintenance cost allocation. There is a third option and that is the computation of a percentage based upon the accumulation of ESALs by the different classes of vehicles. If heavy axle loadings are responsible for 80 to 95% of accumulated ESALs in the design life of a facility then it would seem only fair that the owners and operators of such vehicles pay a similar percentage of the resurfacing costs occasioned by such use.

I believe that you will be interested in the attached study by Caltrans of California DOT which compares the pavement structural damage caused by passenger cars and truck loadings. Take particular note of Table 1 on page 16. This shows that large trucks (those over 6000 lbs. gross weight) account for 89% of pavement damage although they represent only nine percent of vehicle registration. This is consistent with findings in Oregon, Tennessee and other states. As a result of these findings California found some 58% of total pavement construction cost assignable to vehicles having gross loads in excess of 6,000 lbs. (pg. 3). Also the Arroyo Seco Freeway which carries only passenger car traffic served some 35 years without structural pavement overlay whereas Route 99, built to essentially the same standards but serving mixed traffic, required several overlays in the same time period (pg. 11).

Sincerely,

Charles N. Brady
Director
Highway Department

CNB:lbh
Enclosure

Statement

by

John L. Reith

Director, Department of Interstate Cooperation
American Trucking Associations, Inc.

before the

Subcommittee on SJR 50 Study Committee

on the

Proposed Highway Cost Allocation Study Plan

Representing the

Virginia Highway Users Association

Richmond, Virginia
December 17, 1980

Mr. Chairman and members of the Subcommittee, my name is John L. Reith, I am Director of Interstate Cooperation of the American Trucking Associations, a resident of Fairfax County and spokesman today for the Virginia Highway Users Association. During more than twenty years of experience in transportation analysis, I have prepared and directed highway cost allocation studies, have analyzed more than twenty state studies and have prepared or assisted in the preparation of several papers in connection with the 1965 Federal Highway Cost Allocation Study and the current Federal Study which has now been underway for more than a year.

Careful review of the proposed JLARC study plan reveals a reasonable basic framework with some very good aspects. There are, however, some areas which are very incorrect and will lead to an extremely biased allocation report. The proposed JLARC methodology has been referred to as an "engineering incremental" analysis. In many respects this is correct and we commend the JLARC staff for their recognition of the validity of the "engineering incremental" approach to highway cost allocation. The study plan adopts many of the procedures pioneered by the Federal Highway Cost Allocation Study in 1965 and widely accepted since that time. In certain critical respects, however, the proposed study plan abandons the engineering incremental analysis. It is these areas where the study plan has gone wrong that we wish to discuss with the subcommittee this afternoon.

The major problem in the study plan is the pavement cost allocation where an entirely new procedure is adopted, which is labeled an "incremental" approach. While it has some of the characteristics of an incremental approach, this method of pavement cost analysis is not an incremental study in any respect.

To understand this issue, let's talk first about the incremental method of pavement cost analysis which was derived and used by the Federal Highway Administration and in most state cost allocation studies. The incremental pavement cost analysis begins with determination, through careful engineering analysis, of the characteristics and costs associated with a basic road adequate to handle passenger cars and light pickup trucks at reasonable highway speeds. This basic road becomes the standard -the first increment - which would be used in the absence of heavier axle loadings and is therefore the equal responsibility of all vehicle classes. Next in the standard incremental analysis, a careful engineering determination is made of the additional pavement, base thickness and other characteristics which would be required to handle axle loadings slightly higher than those of passenger cars and pickup trucks. The second increment generally is designed for axle loadings of up to 8,000 to 10,000 pounds. Successive increments of 3,000 or 4,000 pound additions to the axle weight are then developed by careful engineering appraisal of the added costs and pavement thicknesses brought about by this increased axle weight. Thus, through successive additions of pavement thickness and cost the various increments which are required to reach the thickness and cost of a highway built to Interstate standards or state Primary System standards are devised.

I would call your attention to two factors about this traditional incremental method of pavement allocation. First of all, note that a large vehicle would be involved in several increments. That is, the front axle of the combination truck which might weigh 10,000 pounds would be allocated cost responsibility in relation to the 10,000 pound increment. The succeeding axles which might weigh 16,000 to 18,000 or 20,000 pounds per axle would be allocated highway costs in relation to the higher axle loading increments. Secondly, note that since the costs are developed incrementally and added together, each axle is responsible for the costs associated with the increment in which it is located and a proportionate share of all the costs of the lower increments.

In practice the proposed study plan is not based on doing any of this. The JLARC Study would begin with a so-called minimum road which is a theoretical design which supposedly would be built whether there were any motor vehicles or not. This theoretical design is then allocated among all vehicle groups. Secondly, the proposed study plan would develop increments for a few vehicle classes based on the pavement thickness and characteristics associated with the AASHO Design Guide. Based on the so-called equivalent axle load concept derived from the AASHO Road Test, the pavement thickness required for each vehicle class is determined and the cost for the assigned thickness is then distributed simply by dividing the total costs by the proportion of pavement thickness assigned to each class. This method greatly simplifies the engineering analysis required and at the same time abandons the whole incremental concept.

This method eliminates the consideration of axle weights for each vehicle group separately. In other words, all the axles of a 5-axle combination are added into the class and all of the so-called equivalent axle loads for a 5-axle combination are used as a basis for determining the pavement thickness required for 5-axle combinations. Similarly based on the equivalent axle loadings, the pavement thickness required for 4-axle combinations, 3-axle combinations and various straight trucks is determined. Since all of the equivalent axle loads for each individual group are used in determining the pavement thickness required for that group, there is no interrelationship between the load classes in this methodology. Further, the incremental relationships developed in Figure II-7B, that is the relationships shown in Option 1, Option 2 and Option 3 are all incorrect. By the methodology which has been developed in conjunction with this proposed study, increment 1 should be distributed to all the vehicle groups by vehicle miles or axle miles or some other methodology. But incremental cost developed for each additional increment is the cost associated only with the equivalent axle loads of that increment. Therefore, there should be no responsibility, for example, for increment 2 for any vehicle class except passenger cars and pickup trucks . The cost of this increment is based on all of the equivalent axle loads of that group only. Options 2 and 3 compound this error by not only distributing each of these increments to all vehicle types but doing so directly on the basis of the equivalent axle loads which are extremely punitive to 5-axle combination trucks.

Now I recognize that this discussion has been pretty technical because the issue involved is a very technical one, so let's look at this issue instead from the standpoint of a reasonable man. If you will look at Figure II-7A, the pavement cost allocation example presented on Page 31 of the revised draft, we come to the real heart of the issue and the real heart of the entire highway cost allocation study. What this table shows is that on this typical Virginia highway, passenger cars and 2-axle trucks run up 81 percent of the vehicle miles and all of the truck classes travel about 19 percent of the vehicle miles with 5-axle combinations accounting for 11 percent. But that 81 percent of the vehicle miles traveled by passenger cars and pickup trucks represents only 1 percent of the equivalent axle loads and the 11 percent of the vehicle miles traveled by 5-axle combinations represents 79 percent of the equivalent axle loads. Finally in total, all trucks represent 99 percent of the equivalent axle loads.

In effect what the equivalent axle loads say is that weight alone is the only determining factor in pavement deterioration. Now does that make sense to you as reasonable men? Does it make sense to you that all trucks cause 99 percent of pavement deterioration and that the effects of weather and chemicals and the environment and everything else really has nothing to do with pavement wear? Well that's the effect of distributing costs on the basis of equivalent axle loads.

Finally, notice that the required increments shown in Figure II-7A are not directly based on the equivalent axle load formulas. The 1 percent equivalent axle loads represented by passenger cars and pickup trucks are assigned an increment of 2.2, while the 79 percent of equivalent axle loads of the 5-axle combinations are assigned a pavement requirement of 2.7. So clearly the pavement designers recognize that weather, chemicals and other factors are major determinants of pavement thickness. Consequently, Options 2 and 3, which would assign all incremental costs directly on the basis of the equivalent axle loads, can not be justified in terms of any engineering concept and are simply variations of methods of punishing trucks. The trucking industry cannot accept any of these three options as representing a method by which reasonable allocation of highway costs can be developed. All of these options as currently written are so technically incorrect and strongly biased against trucks that the overall result of the cost allocation study cannot be equitable or fair in any respect. To demonstrate the validity of this position, one need only look at the actual performance of a highway which heavy trucks have never been allowed to use.

If, in fact, the equivalent axle load concept is a correct measure of determining pavement deterioration or pavement cost, then the restricted portion of the Baltimore-Washington Parkway should have lasted at least 400 years. The only traffic that's permitted on the Baltimore-Washington Parkway are passenger cars and pickup trucks, except for an occasional few busses. Yet the highway was designed to standards practically the same as nearby Primary and Interstate highways. According to the equivalent axle load formula under which those passenger car and pickup truck axle loadings practically don't count, the number of equivalent axle loads that have passed over that highway, even today, represent probably less than 5 percent of the design equivalent axle loadings. But the Baltimore-Washington Parkway didn't last 400 years or even 100 years. Its pavement deteriorated, as those of you who have travelled it know, and it was resurfaced in twenty-two years, just like any other highway.

The second major problem that we have with the development of the pavement cost increments is the distribution of these costs in direct proportion to the total pavement thickness. That is, the method which has been proposed is simply to take the total cost of building, for example, a pavement that is 12 inches thick and dividing that total cost by the proportion represented by each increment. In fact, pavement costs are not accumulated by that method and the cost per unit is significantly different for a 6 inch pavement than it is for a 12 inch pavement.

There also appears to be some problems in relation to the proposed distribution of highway taxes. As I've mentioned in Figure II-7A, the example indicates that 5-axle combinations represent 11 percent of the vehicle miles. Figure II-1 finds that such vehicles represent 6 percent of the average daily vehicle miles, presumably on all highway systems. Finally, in Figure II-9 on Page 43, we find that 5-axle combinations travel 4.7 miles per gallon of gasoline while passenger cars travel 14.1 miles per gallon. So 5-axle combinations used about three times as much fuel for every mile of travel as do passenger cars. And, of course, the 5-axle combination also pays a 2 cent per gallon road tax in addition to the motor fuel tax paid by the passenger cars. So that means the 5-axle combinations pay nearly 3½ times as much per mile of travel in fuel taxes as a passenger car does.

But somehow or other Figure II-9 comes up with the finding that 5-axle combinations pay only 9.6 percent of the fuel and road taxes. Now I admit that I'm not a mathematical genious, but that doesn't make any sense to me at all. How can 5-axle combinations travel 6 percent or more of the vehicles miles, pay 3½ times as much as passenger cars in fuel taxes for every vehicle mile traveled and end up paying only 9.6 percent of the fuel taxes? I admit to being totally baffled.

But, in the final analysis the major problem with this proposed methodology is the technical inaccuracy involved in the way incremental costs are established. Pavement costs are in no way directly proportional to equivalent axle loads. In fact, all engineering evidence shows just the opposite. Pavements are not consumed, or do not deteriorate, directly in proportion to vehicle weights. The best available measure of relative pavement cost occasioned by different axle loads is the conventional incremental cost technique as developed by the Federal Highway Administration.

The biggest single contract which has been let by the Federal Highway Administration in conjunction with its present Highway Cost Allocation Study is a contract to look into the proportionate share of pavement cost which should be assigned to axle weight as compared to the share which should be assigned to weather, chemicals and other environmental factors. That Study is due to be presented to the Federal Highway Administration late next Summer or early in the Fall. I am sure that it will not result in a definitive analysis of precisely what proportion of highway costs should be charged to weight as compared to other factors. But it certainly ought to give us some means of developing a logical analysis which does not charge all pavement costs on the basis of vehicle weight.

Figure II-7A
PAVEMENT COST ALLOCATION EXAMPLE

Pavement Design

Increment	Vehicle Class		Traffic Volume (VPD)	Axle Weight (ESAL-18)	Required Increment (T.I.)
1	- - - - - - - - Theoretical Minimum - - - - - - - -				3.6
2	I.	Pass & 2A-4T(s)	6200 (81.1%)	3.6 (1.0%)	2.2
3	II.	2A-6T(s)	247 (3.2)	27.0 (7.7)	2.9
4	III.	3A(s)	148 (1.9)	15.5 (4.4)	0.6
5	IV.	3A/4A(c)	216 (2.8)	28.2 (8.0)	0.8
6	V.	5A(c)	838 (11.0)	277.7 (78.9)	2.7
			7650 (100.0%)	352 (100.0%)	12.8

Figure II-7B

PAVEMENT COST ALLOCATION EXAMPLE
OPTION 1: ALLOCATION BY VPD

Increment	Pass. & 2A-4T	2A-6T	3A	3A & 4A	5A	Totals
1	$48,954	$ 1,950	$1,166	$ 1,709	$ 6,621	$ 60,400
2	29,917	1,193	712	1,045	4,044	36,911
3	--	10,707	6,411	9,363	36,314	62,795
4	--	--	1,283	1,873	7,268	10,424
5	--	--	--	2,852	11,069	13,921
6	--	--	--	--	50,463	50,463
Totals	$78,871	$13,850	$9,572	$16,842	$115,779	$234,914
Percentages	33.5%	5.9%	4.1%	7.2%	49.3%	100.0%

PAVEMENT COST ALLOCATION EXAMPLE
OPTION 2: ALLOCATION BY ESAL-18
ABOVE THEORETICAL MINIMUM

Increment	Pass. & 2A-4T	2A-6T	3A	3A & 4A	5A	Totals
1	$48,954	$ 1,950	$1,166	$ 1,709	$ 6,621	$ 60,400
2	351	2,861	1,624	2,960	29,115	36,911
3	--	4,845	2,784	5,096	5,070	62,795
4	--	--	500	918	9,006	10,424
5	--	--	--	1,301	12,620	13,921
6	--	--	--	--	50,463	50,463
Totals	$49,305	$ 9,656	$6,074	$11,984	$157,895	$234,914
Percentages	21.0%	4.1%	2.6%	5.1%	67.2%	100.0%

PAVEMENT COST ALLOCATION EXAMPLE
OPTION 3: ALLOCATION BY ESAL-18
ABOVE BASIC ROAD

Increment	Pass. &2A-4T	2A-6T	3A	3A &4A	5A	Totals
1	$48,954	$ 1,950	$1,166	$ 1,709	$ 6,621	$ 60,400
2	29,917	1,193	712	1,045	4,044	36,911
3	--	4,845	2,784	5,096	50,070	62,795
4	--	--	500	918	9,006	10,424
5	--	--	--	1,301	12,620	13,921
6	--	--	--	--	50,463	50,463
Totals	$ 78,871	$ 7,988	$5,162	$10,069	$132,824	$234,914
Percentages	33.6%	3.4%	2.2%	4.3%	56.5%	100.0%

SENATE JOINT RESOLUTION NO. 50

Implementing the provisions of the Legislative Program Review and Evaluation Act of 1978, relating to systematic review of State government by the Joint Legislative Audit and Review Commission.

Agreed to by the House of Delegates, February 29, 1980

Agreed to by the Senate, February 18, 1980

WHEREAS, the Legislative Program Review and Evaluation Act of 1978 (§§ 30-64 et seq., of the Code of Virginia) provides for the Joint Legislative Audit and Review Commission to conduct a systematic evaluation of State government according to schedules and areas designated for study by the General Assembly; and

WHEREAS, § 30-66 of the Code of Virginia provides for the nineteen hundred eighty Session of the General Assembly to establish by joint resolution a review schedule, based on the functional areas of State government as defined in the act; and

WHEREAS, § 30-67 of the Code of Virginia provides for each session of the General Assembly to specify to the extent possible by joint resolution the agencies, programs, and activities to be reviewed by the Joint Legislative Audit and Review Commission according to the schedule established; and

WHEREAS, in accordance with Senate Joint Resolution No. 133 passed by the nineteen hundred seventy-nine General Assembly, the Joint Legislative Audit and Review Commission is evaluating during fiscal year 1979-80 agencies and activities in the Standards of Living subfunction including the Homes for Adults, Title XX, and General Relief programs and selected issues in the organization and administration of social services in the Commonwealth; and

WHEREAS, Senate Joint Resolution No. 133 directs the Joint Legislative Audit and Review Commission to schedule the functional area of Resource and Economic Development for review; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That, pursuant to § 30-64 et seq. of the Code of Virginia, the functional areas of State government shall be reviewed and evaluated by the Joint Legislative Audit and Review Commission according to the following schedule, the order of which may be reviewed and revised by future sessions of the General Assembly:

Functional Area
Transportation
Resources and Economic Development
General Government

The Commission shall make an interim report to the Governor and General Assembly on the functional area of Transportation focusing on programs and activities of the Department of Highways and Transportation including: an overview of the Department and transportation functions and expenditures; highway and transit needs; revenues and methods of financing those needs; [the fair apportionment and allocation of the cost of building and maintaining the roads and bridges of the Commonwealth between motor vehicles of various sizes and weights;] and such other matters as the Commission may direct, prior to the nineteen hundred eighty-one Session of the General Assembly. For purposes of the interim report, the Commission shall coordinate its review effort with a joint committee consisting of three members appointed by the Chairman of the House Roads and Internal Navigation Committee, three members appointed by the Chairman of the Senate Transportation Committee, three members appointed by the Chairman of the House Finance Committee, and three members appointed by the Chairman of the Senate Finance Committee; and, be it

RESOLVED FURTHER, That the review and evaluation in the functional area "Resource and Economic Development" shall be initiated at such time as sufficient Commission resources become available and, such review shall generally include, but not be limited to, programs, activities, and agencies concerned with the regulation of professions and occupations as specified in § 30-77 of the Code of Virginia, and other consumer affairs regulation. The Commission shall coordinate its review effort concerning regulation of professions and occupations with the House Committee on General Laws and the Senate Committee on General Laws, and other appropriate legislative committees as may be deemed necessary; and, be it

RESOLVED FINALLY, That the reports, findings and recommendations prepared by the Joint Legislative Audit and Review Commission for the studies to be performed under this resolution shall be transmitted to the appropriate standing committees of the House of Delegates and the Senate, all members of the General Assembly, and the Governor.

REPORTS ISSUED BY THE JOINT LEGISLATIVE AUDIT AND REVIEW COMMISSION

The Virginia Community College System, March 1975
Virginia Drug Abuse Control Programs, October 1975
Working Capital Funds in Virginia, February 1976
Certain Financial and General Management Concerns, Virginia Institute of Marine Science, July 1976
Water Resource Management in Virginia, September 1976
Vocational Rehabilitation in Virginia, November 1976
Management of State-Owned Land in Virginia, April 1977
Marine Resource Management Programs in Virginia, June 1977
Sunset, Zero-Base Budgeting, Evaluation, September 1977
Use of State-Owned Aircraft, October 1977
The Sunset Phenomenon, December 1977
Zero-Base Budgeting?, December 1977
Long Term Care in Virginia, March 1978
Medical Assistance Programs in Virginia: An Overview, June 1978
Virginia Supplemental Retirement System, October 1978
The Capital Outlay Process in Virginia, October 1978
Camp Pendleton, November 1978
Inpatient Care in Virginia, January 1979
Outpatient Care in Virginia, March 1979
Management and Use of State-Owned Vehicles, July 1979
Certificate-of-Need in Virginia, August 1979
Report to the General Assembly, September 1979
Virginia Polytechnic Institute and State University Extension Division, September 1979
Deinstitutionalization and Community Services, September 1979
Special Study: Federal Funds, December 1979
Homes for Adults in Virginia, December 1979
Management and Use of Consultants by State Agencies, May 1980
The General Relief Program in Virginia, September 1980
Federal Funds in Virginia, October 1980

JOINT LEGISLATIVE AUDIT AND REVIEW COMMISSION

Professional Staff

F. Daniel Ahern, Jr.
John M. Bennett
L. Douglas Bush, Jr.
Lucretia S. Farago
Mark S. Fleming
Gary T. Henry
Kirk Jonas
R. Jay Landis
William E. Landsidle
Philip A. Leone
Joseph H. Maroon
Barbara A. Newlin
Ray D. Pethtel
Walter L. Smiley
Patricia G. Smyth
Ronald L. Tillett
Glen S. Tittermary
Susan L. Urofsky
Karen F. Washabau
Mark D. Willis
William E. Wilson

Administrative Staff

Debbie Armstrong
Sandy C. Davidson
Phyllis M. Dyer
Sharon L. Harrison
Joan M. Irby
Betsy M. Jackson
Kim Rexrode