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A FRAMEWORK FOR THE TEXAS HIGHWAY COST ALLOCATION STUDY

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16. Abstract

In fiscal year 1998, Texas spent $2.8 billion on the state-maintained road network, which includes the Interstate highways. This project estimates the contribution to these costs of different vehicle classes. Alternative methods of breaking down ("allocating") the total expenditures between vehicle classes are implemented for comparison. The project also estimates a breakdown between vehicle classes of 1998 revenues from taxes and government charges on Texas road users; of these revenue sources, fuel taxes were the most important. The findings suggest that buses and combination trucks pay shares of revenue that fall well short of their shares of highway system costs.

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Highway Cost Allocation in Texas

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the

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by the

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and the

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RESEARCH OBJECTIVES

The present research project will investigate the fairness of the structure of taxes and charges imposed on Texas highway users. The focus will be on equity between vehicle classes. For each defined vehicle class, the project will estimate the share of total revenues from highway user taxes and charges that the class contributes. For comparison, it will also estimate the share of highway system costs that stem from each class. If the structure of taxes and charges is fully equitable, each class's revenue share will equal its cost share.

There is much to be said for a whole-of-government perspective when examining the equity of highway user taxes and charges. However, only a minority of highway cost allocation (HCA) studies have included local government. (Studies including local government were prepared by the Federal Highway Administration [FHWA 1997] and for the state governments of Arizona, California, Idaho, Minnesota, and Vermont.) Previous Texas HCA studies excluded revenues from local government taxes and charges, along with the costs of roads owned by local government. The present investigation will do likewise. To keep its scope manageable, it will examine only the state-maintained highway network and federal and state revenues from highway users.

1. COST ANALYSIS

One can objectively measure how much different classes of vehicles are paying in taxes and government charges. But there is no way to objectively allocate many of the costs of the highway system. Notions of fairness, which vary from person to person, necessarily intrude. As a result, there is a rich menu of cost allocation methods. In reviewing the methods below, the following desirable properties will be taken into account:

Completeness: Highway costs are fully paid by participating vehicle classes.

Rationality: Vehicle classes do not pay more than they would if they chose to be part of any smaller coalition of vehicle classes for which an exclusive facility is assumed available.

Marginality: Vehicle classes are charged at least enough to cover their marginal costs.

These mathematical methods have been applied in various HCA studies. A comparison of these studies follows the review of the methods. The recommendations of the current study are presented in light of the strengths and weaknesses identified in the methods and their applications.

1.1 COMPARISON OF HIGHWAY COST ALLOCATION METHODS

The following objectives were accomplished in this portion of the HCA study:

- identify important relevant HCA methods (overview),
- determine the scope of the methods, and
- determine comparison criteria for the methods.

A brief discussion of each of these objectives follows.

1.1.1 Overview of HCA Methods

Four methods were selected to provide an adequate menu of allocation methods. The first two methods, known as the *incremental method* and the *proportional method*, are traditional methods for highway cost allocation. Two additional methods, known as the *modified incremental approach* and the *generalized method*, represent significant departures from the traditional methods. TxDOT used the two latter methods in the last highway cost allocation study (Euritt et al. 1994), which will be referred to as the 1994 Texas HCA study.

Incremental Method

According to the incremental method, the cost of a highway facility designed for the class of lowest weight vehicles is initially calculated. Then a highway facility is designed for the two lightest vehicles classes, with the second-lightest vehicle class assuming responsibility for the increase in cost over the previously considered facility. The process continues, adding vehicle classes and assigning responsibility for additional costs to the most recently included class. Several variations of the basic incremental method have been considered (FHWA 1982).

This method satisfies the three fundamental properties previously listed: completeness, rationality, and marginality. However, it is not consistent because the cost allocated to each vehicle class depends on the order in which vehicle classes are included in the analysis. This particular fact is illustrated in Appendix A.

Proportional Method

Costs are proportionally distributed among vehicle classes according to a specified measure. The cost allocator could be vehicle-miles of travel (VMTs), equivalent single-axle loads (ESALs), or some other variable. While this procedure may not satisfy marginality and rationality, it does satisfy the completeness principle.

Modified Incremental Approach

This method was originally proposed by Villarreal (1985) to overcome the inconsistency of the traditional incremental method. The modified incremental approach (MIA) satisfies completeness, marginality, and rationality. Furthermore, it is a consistent method. In essence, this method first determines *cost portions* that can be attributed to individual vehicle classes. Then it determines cost portions that can be attributed to groups of two or more vehicle classes. In order to arrive at the cost allocation for a vehicle class, the MIA adds the portion belonging solely to that class to fractions of all portions corresponding to groups containing the class. This division of group portions is made proportionally according to VMTs. Obviously, resorting to group cost portions increases the burden of data collection. Appendix B contains a brief analytical description of the procedure.

Generalized Method

The generalized method (GM) is based on concepts from the theory of cooperative games (von Newman and Morgenstern 1944), and was proposed for conducting highway cost allocation by Villarreal (1985). The method satisfies completeness, marginality, and rationality because these principles are formulated as constraints in its mathematical formulation. As with the MIA, forcing group cost conditions to be met increases the data collection burden. Appendix C shows the mathematical formulation of the generalized method.

Table 1 summarizes some of the key features of the procedures introduced above.

Table 1. Comparison of Allocation Methods

	Incremental Approach	Proportional Method	Modified Incremental Approach	Generalized Method
Rationality and marginality satisfied?	Always	Not necessarily	Always	Always
Cost responsibilities affected by order of including sequence?	Yes	No	No	No
Data requirements?	Few	Few	Many	Many

If data requirements can be met, then the MIA and the GM are superior methods. The MIA as implemented in the 1994 Texas HCA study divides group cost portions proportionally by VMTs, but VMTs are a poor indicator of responsibility for pavement rehabilitation and maintenance costs and do not indicate which classes require the thicker pavements that increase pavement construction costs. ESALs are load-related quantities that account for both of these costs well. The GM as implemented in the 1994 Texas HCA study relies on cost equations that account for load-related costs through ESALs. This method would assign load-related costs using load-related statistics. It would thus be preferable in many applications to the MIA as implemented in the 1994 Texas HCA study.

1.1.2 Scope of Methods

The scope or range of operations that defines the extent of treatment provided by a highway cost allocation method depends on several factors. The following three factors are among the most important:

- vehicle classes,
- highway types, and
- cost components.

These factors (along with other desirable characteristics) can be used to perform a systematic, sound, and logical comparison of available methods. This comparison will be the purpose of the following section.

1.1.3 Comparison Criteria for the Methods

A comparative analysis of the methods from 1997 Federal HCA procedure, the state-recommended procedure (currently being developed), and the 1994 Texas HCA procedure was performed as Task 2 of this research project. The selected comparison criteria are listed below:

- scope (identified using the factors indicated in the above section),
- data requirements,
- conceptual approach,
- advantages, and
- disadvantages.

1.2 ANALYSIS OF METHODS FROM HCA PROCEDURES

Federal HCA studies were finished in 1997, and the FHWA-recommended framework for state HCA will be completed soon. The most recent Texas HCA study was undertaken in 1994. The methods from these three HCA procedures are compared here using the comparison criteria identified in the section above.

1.2.1 Federal HCA Procedure (1997)

Scope of Methods

The scope of the Federal HCA procedure can be described in terms of the previously selected factors as indicated below:

- twenty vehicle classes,
- twelve highway types (six rural and six urban), and
- thirteen cost components.

The cost components included in the analysis are:

- new capacity: new construction, added lanes, and major widening;
- system preservation: reconstruction, resurfacing, and rehabilitation (3R); minor widening; bridge replacement; and major and minor bridge rehabilitation;
- system enhancement: safety, transportation systems management (TSM), environmentally related, and other projects;
- mass transit account; and
- others.

Data Requirements

Data requirements for the federal HCA procedure are listed below:

- expenditures,
- VMT data by vehicle class and highway type,
- allocation factors,
- pavement and bridge data,
- axle weight data, and
- other inputs.

Conceptual Approach

The purpose of this section is to indicate which allocation strategy was used to allocate each cost component among the vehicle classes. A summary of these results is shown below.

Pavement Costs. One of the components of pavement costs is the cost of the *base facility*. The base facility is a hypothetical pavement that would serve a purpose common to all vehicle classes. It is not the minimum facility that a highway agency could build, nor is it the facility that would be required to carry only automobiles. The base facility would provide skid resistance and all-weather capability and would serve as a “platform” for providing the base and surface thickness required to accommodate projected traffic loadings. The base facility portion of pavement construction costs is related to providing additional capacity to safely accommodate projected future traffic volumes, and the remaining portion of pavement construction costs provides the base and pavement thickness necessary to accommodate projected vehicle loadings (FHWA 1997).

In addition to the base facility cost, there are load-related and rehabilitation costs. The approach of the procedure can be conceptually summarized as follows:

- base facility, engineering, right-of-way, and other costs associated with adding new highway lanes: incrementally by passenger-car equivalent (PCE) VMTs;
- load-related portion: proportional to ESALs;

- 3R (rehabilitation, reconstruction, resurfacing)
    - Load-related: Nationwide Pavement Cost Model (NAPCOM)
    - Nonload-related (preliminary engineering and right-of-way): proportional to VMTs; and
- grading and drainage:
    - Those related to vehicle weight: weight-to-horsepower ratio
    - Those related to vehicle width: incrementally by vehicle width
    - Others: incrementally by PCE-VMTs.

Bridge Costs. Typical bridge costs included in the analysis are:

- new bridges/bridge replacement: incrementally by live load moment (depending on vehicle's axle load and axle spacing) of vehicle class/weight group; all vehicles in any specific increment have costs distributed proportionally by VMTs;
- bridge rehabilitation: similar to bridge replacement but more complex; and
- other bridge improvement (minor bridge rehabilitation and repairs): incremental by VMTs

System Enhancement. System enhancement costs can be considered to be proportional to either PCE-VMTs or VMTs.

Others. This cost category includes uniquely occasioned costs, other highway trust fund obligations, and mass transit account expenses.

Advantages

The following is a list of significant advantages of the Federal HCA Procedure:

- detailed results,
- many cost categories, and
- flexibility (up to twelve highway types and up to twenty vehicle classes).

Disadvantages

The following are the most important disadvantages found in this procedure:

- requires detailed expenditure data,
- complicated allocation method, and
- simplifications needed for adaptation to states.

1.2.2 State-Recommended HCA Procedure

The current version of this program is a beta version because work is still in progress to add default data files for each state. As a result, it cannot yet be implemented and thus cannot be compared to the procedure being developed in the current study. A comparison will be made in the second year of the study when the state-recommended procedure has been finalized.

The procedure being developed can be considered a simplification of the Federal procedure, thus making it more suitable for use at the state level in conducting highway cost allocation studies and related analyses of highway cost responsibility, user fee equity, and impacts of alternative user fee structures. The work is based in part on work conducted by the Federal Highway Administration for the 1997 Federal Highway Cost Allocation Study.

Scope of Methods

The scope of the state-recommended procedure can be described in terms of the factors listed below:

- up to twenty vehicle classes,
- twelve highway types (six rural and six urban), and
- nine cost components.

The following cost components are included in the analysis:

- new pavements,
- pavement rehabilitation,
- bridge costs: new bridges, bridge replacement, and bridge rehabilitation,
- grading,
- maintenance and other construction, and
- multi-highway system costs.

Data Requirements

Data requirements are the same as those for Federal HCA.

Conceptual Approach

Figure 1 summarizes the conceptual approach to cost allocation followed by this procedure. One program allocates all highway-related expenditures. Another converts data expressed with respect to operating gross weight (OGW) to data expressed with respect to registered gross weight (RGW), and vice versa. The third program calculates load equivalency factors (LEFs—a federally used measure similar to ESALs) for pavement cost allocation based on detailed pavement data (FHWA 1997).

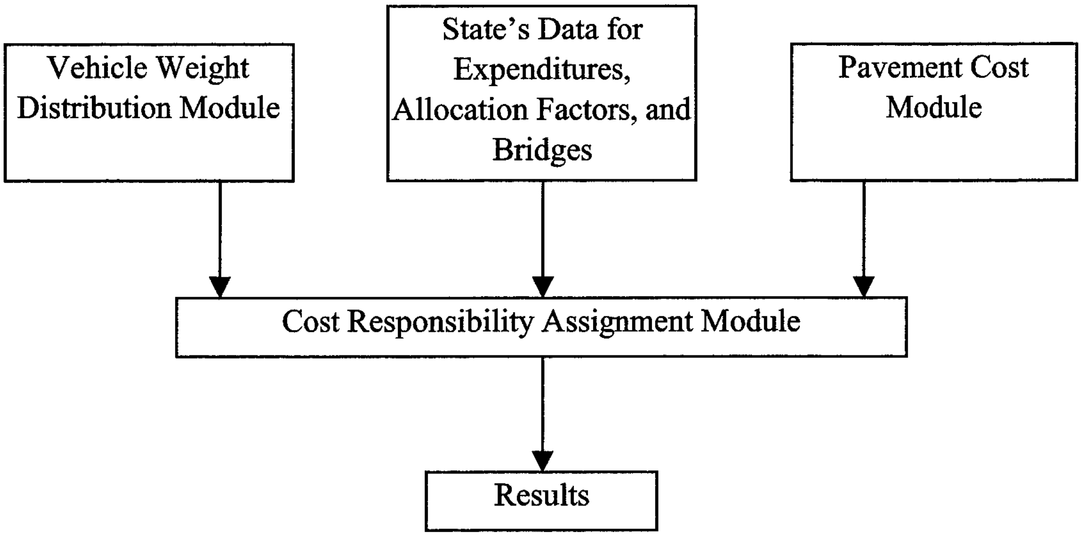

Figure 1. Conceptual Approach of State-Recommended HCA[*]

Advantages

Advantages of the state-recommended procedure are listed below:

- flexibility (up to twelve highway types and up to twenty vehicle classes),
- detailed results, and
- many cost categories.

Disadvantages

Disadvantages of the state-recommended procedure are listed below:

- intensive expenditure data required,
- current version not implementable, and
- complete documentation not yet available.

1.2.3 1994 Texas HCA Procedure

Scope of Methods

The scope of the 1994 Texas HCA procedure can be described by the factors listed below:

- climatic regions: East Texas, West Texas, South Texas, and North/Central Texas,
- highway types: interstate highways (IH), U.S. and state highways (US), and farm-to-market roads (FM),

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[*] A more detailed conceptual approach is presented in Appendix D.

- vehicle classes: twelve, and
- cost components: flexible pavement, rigid pavement, rehabilitation and maintenance, bridge, common costs.

Data Requirements

An application of the procedure requires specific input from each of the following data categories:

- vehicle classes,
- VMT data by vehicle class and highway type,
- axle weight data,
- regions,
- equivalency factors, and
- cost equations or expenditures.

Conceptual Approach

In essence, the 1994 Texas HCA procedure uses both the MIA and GM as summarized below (and illustrated in Figure 2):

- MIA for flexible and rigid pavement construction,
- MIA for bridge construction, and
- GM for pavement rehabilitation and maintenance.

A particularly important characteristic of both the MIA and the GM procedures is that the final allocation of cost responsibilities among vehicle classes is determined after consideration of costs associated with all possible coalitions of vehicles. These costs are usually determined from statistical *cost equations* developed by regression analysis of historical expenditures, ESALs, or some other relevant quantity.

Figure 2 shows four major components of the 1994 Texas HCA procedure along with the input data required for each component. Each component corresponds to a FORTRAN program. FMIA is the program for allocating flexible pavement construction costs. RMIA is the program for allocating rigid pavement construction. BMIS is the program for allocating bridge construction costs.

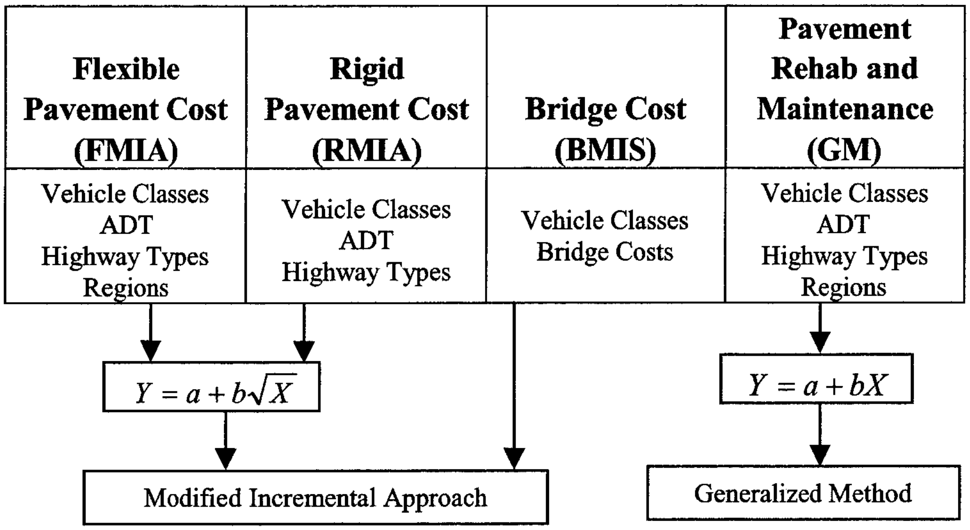

Figure 2. Conceptual Approach of the 1994 Texas HCA Procedure

Finally, GM is the program for allocating pavement rehabilitation and maintenance costs by the generalized method. The cost equations used in the procedure for both flexible and rigid pavement construction cost and for bridge construction cost are also shown in Figure 2.

Advantages

The advantages of the 1994 Texas HCA procedure are listed below:

- accounts for dependence of costs on the four climatic regions,
- Texas data,
- consistency, and
- completeness, rationality, and marginality.

Disadvantages

The disadvantages of the 1994 Texas HCA procedure are listed below:

- cost equations need to be carefully developed,
- results are strongly affected by VMTs, so that cost/ESAL may not be the same for all classes (*i.e.*, cost responsibilities do not reflect contributions to road deterioration), and
- road deterioration stemming from environmental factors is not directly studied.

1.2.4 Comparative View of Procedures

Table 2 illustrates a comparison of the three procedures. The state-recommended and federal HCA procedures allow for more vehicle classes and highway types than does the 1994 Texas HCA procedure. They also use historical expenditure data directly for cost allocation, while the 1994 Texas HCA procedure uses the data to construct statistical cost equations that the MIA and GM require for determining group cost responsibilities. The 1994 Texas HCA procedure considers four climatic regions of Texas in determining maintenance costs.

Table 2. Comparison of the Three Procedures

	Federal	**State-Recommended**	**1994 Texas HCA**
Number of vehicle classes	20	Up to 20	9-12
Number of highway types	12	12	3
Allows multiple regions	No	No	Yes
Historical cost data used indirectly for statistical cost equations	No	No	Yes
Historical cost data used directly	Yes	Yes	No
Methods employed	Incremental, Proportional	Incremental, Proportional	MIA, GM

The methods of the 1994 Texas HCA procedure are superior to those of the federal state-recommended procedures for reasons given in Section 1.1, so the 1994 Texas HCA procedure provides a reasonable starting point for the current study. The procedure explained in Section 1.3 builds on the strengths of the 1994 Texas HCA procedure and eliminates some of its weaknesses. Table 3 lists some of the ways that the current study improves on the procedure from the 1994 Texas HCA study.

The current study will consider new costs and more geographic regions. It will analyze group cost responsibilities for more cost components. It will also make an explicit attempt to choose from among the multiple fair cost allocations that the GM may produce. By optimizing two measures of fairness in succession, the current study will achieve analytical control over the choice from among the multiple fair allocations; the 1994 Texas HCA study did not give an explicit description of how multiple fair allocations are to be judged after optimizing a single measure of fairness.

Table 3: Comparison of Procedures from the Current Study and the 1994 Texas HCA Study

	Current Study	**1994 Texas HCA Study**
Allocation of load-related pavement construction costs	Generalized Method (two optimization criteria)	Modified Incremental Approach (with VMTs)
Allocation of load-related pavement rehabilitation and maintenance	Generalized Method (two optimization criteria)	Generalized Method (one optimization criterion)
Cost equations developed for:	Flexible pavement construction Rigid pavement construction Flexible pavement rehabilitation and maintenance Bridge construction	Flexible pavement construction Bridge construction
Regions for analysis of flexible pavement costs	Five regions	Four regions
Shoulder costs	Considered	Not considered

1.3 DEVELOPMENT OF METHODOLOGICAL FRAMEWORK

Based on our reviews in Sections 1.1 and 1.2, we propose an HCA procedure. The framework for the procedure is outlined in the following four steps:

Step 1: Identify cost components
Step 2: Build database
Step 3: Apply HCA methods
Step 4: Examine results and identify needed changes

These steps will be discussed in the following subsections.

1.3.1 Step 1: Identify Cost Components

Three cost components are recommended for cost allocation because these classifications are the usual ones:

- pavement costs
  construction/reconstruction
  rehabilitation
  maintenance

- bridge costs
  - construction/reconstruction
  - rehabilitation and maintenance
- common costs
  - residual costs that do not belong to the other two components

The classification for cost components can be suggested in a different way: load-related components and nonload-related components. Different methodological frameworks are proposed for load-related components and nonload-related components. Because vehicles do not affect nonload-related costs according to their weight, it is generally considered fair to allocate these costs according to a measure like VMTs, which do not depend on vehicle weight. However, vehicles do affect load-related costs according to their weight, so these costs are fairly allocated by a measure like ESALs, which account for vehicle weight. For fair cost allocation, it is thus important to classify the cost components identified above as load-related and nonload-related costs and to allocate those components by a method that considers an appropriate measure of use.

Load-related Components

Load-related components are:

- pavement construction,
- pavement rehabilitation and maintenance,
- bridge construction, and
- bridge rehabilitation and maintenance.

Nonload-related Components

Nonload-related components are:

- base facility,
- excavation,
- right-of-way,
- traffic control/protection,
- landscaping,
- walkways,
- smoother deck surfaces, and
- administration.

1.3.2 Step 2: Build Database

Tables 4 and 5 show data requirements for each cost component. To derive cost equations, RENU3 and FPS software may be used. Tables 6 and 7 illustrate data requirements for the computer software.

Table 4. Pavement Data Requirements

Highway Section(s):	
Years:	
Location (Region and District):	
Pavement Type (Flexible or Rigid):	
(Urban or Rural) and (IH, US/State, or FM):	
VMT by each vehicle for each year:	
ESAL by each vehicle for each year:	
Construction/Reconstruction Expenditures for Each Year	
Load-related cost ($/mile): pavement	Nonload-related cost ($/mile): base facility, excavation, right-of-way, traffic protection, and landscaping
Rehabilitation Expenditures for Each Year	
Load-related cost: pavement	Nonload-related cost: traffic control
Maintenance Expenditures for Each Year	
Load-related cost: pavement	Nonload-related cost: traffic control

Table 5. Bridge Data Requirements

Highway Section(s):	
Region and District:	
Years:	
(Urban or Rural) and (IH, US/State, or FM):	
Bridge Design: HS20, HS25, etc.	
Weight for Each Vehicle:	
VMT by Vehicle Class for Each Year:	
Load-Related Expenditures for Each Year: construction/reconstruction, rehabilitation and maintenance	Nonload-Related Expenditures for Each Year: walkways smoother deck surfaces landscaping

Table 6. RENU3 Input Data

Highway Section(s): IH 35, etc.
Region and District:
Years:
Highway Type: IH, US/State, or FM
Lane-Mile/Age Data (pavement miles of each age):
ADT by Vehicle Types for Each Year:
Axle-Weight Data (Single, Tandem, Empty) for Each Year:
GVW by Vehicle Types:
Lane Width:
Types of Pavement: flexible or rigid hot mix, surface treated, or overlaid rural or urban
Shoulder Data: percent of paved shoulders average paved shoulder width per lane (feet) average granular shoulder width per lane (feet)

Table 7. FPS Input Data

Highway Section(s): IH 35, etc.
Region (4) and District:
(Urban or Rural) and (IH, US/State, or FM)
Pavement Design Type (5 types):
ADT of First Year:
ADT of 20 Years Later:
Average Percent of Trucks in ADT:
First Year Cost of Routine Maintenance:
Annual Incremental Increase in Maintenance Cost (Dollars/Lane mile):
20 Year Accumulated No. of ESALs (18 KSA) :
Lane Width:

1.3.3 Step 3: Apply HCA Methods

For the various cost components, we will use a variety of mathematical methods, some of which require the creation of cost equations to estimate hypothetical costs.

Proposed Framework for Pavement and Bridge Construction Cost

Figure 3 shows the conceptual approach to the allocation of pavement and bridge construction costs. In this figure, in the case of pavement construction cost, X is the number of ESALs, and in the case of bridge construction cost, X is weight. The parameters a and b depend on the geographic region in which the facility is located.

Proposed Framework for Pavement Rehabilitation and Maintenance

Figure 4 summarizes the overall conceptual approach to allocating pavement rehabilitation and maintenance costs. In order to develop cost equations there are two valid alternatives, each one with its own strengths and limitations. On the one hand, it is possible to develop the cost equations using statistical regression methods on the basis of actual expenditures. On the other hand, if the expenditures data are unavailable or are limited, it is possible to use the RENU3 (Garcia-Diaz 1986) to estimate costs to be considered as input for the statistical cost equation generation procedure.

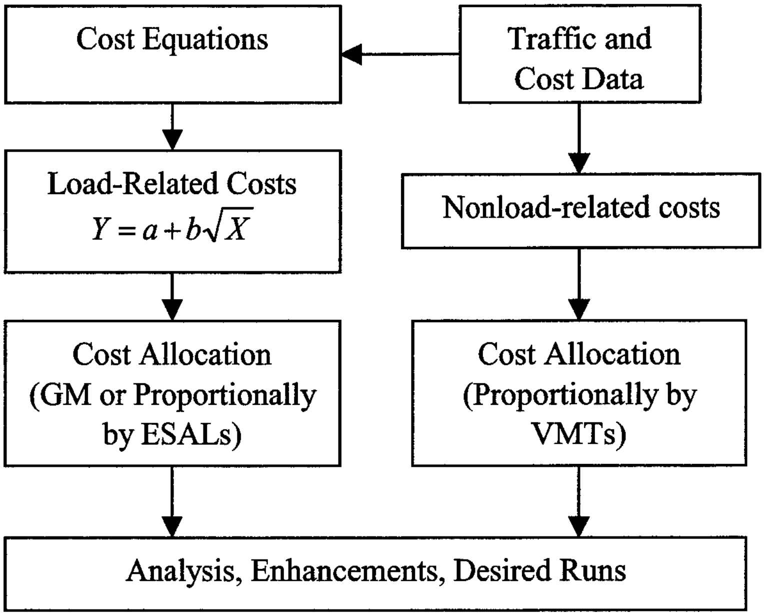

Figure 3. Proposed Framework for Construction and Bridge Cost

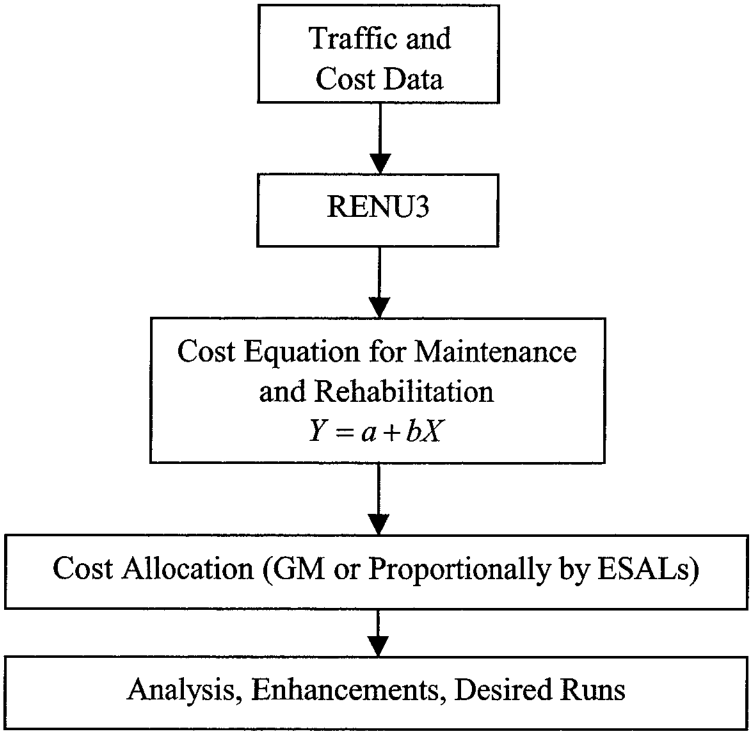

Figure 4. Proposed Framework for Rehabilitation and Maintenance Costs

1.3.4 Step 4: Examine Results and Identify Needed Changes

Results are obtained from these procedures for all combinations of road type and geographical region. These results are to be summarized, analyzed, and interpreted in our final report to the Texas Department of Transportation. Through studying the results and comparing them to the allocation results from other mathematical methods, we will identify additional work that will be needed in the second year of the current study to refine our allocation methods and overall HCA procedure. Texas Department of Transportation feedback and requests based on the final report will also direct our work in the second year.

1.3.5 Illustrative Example

The purpose of the following example is to show how different allocation procedures, each having a valid rationale, can yield conflicting results. Given this reality, the only sound and logical approach is to examine cost components using different allocation procedures and to compare the results to those obtained from the revenue analysis. The hypothetical data used below are meant to approximate historical data from the 1994 Texas HCA study. The number of vehicle classes has been reduced to simplify the explanation, and the ADT data have been correspondingly adjusted.

- The road is an interstate highway in Region 4 made of flexible pavement. It has two lanes in each direction. Each lane is 12 feet wide.

- The ADT (in one direction) is 6,679.
- Percentage of total ADT:

passenger cars (denoted "Auto")	76 percent
pickup and panel trucks ("Pickup")	17 percent
single-unit trucks with three or more axles ("3 Ax+ SU")	1 percent
single-trailer trucks with five axles ("5 Ax ST")	6 percent

- The nonload-related cost is assumed to be 45 percent of the total cost.

Allocation of Pavement Construction

First, ESALs per vehicle class must be computed for the lifetime of a road. The number of ESALs per vehicle pass is given by vehicle class:

Auto	0.00040
Pickup	0.00086
3 Ax+ SU	0.44762
5 Ax ST	0.91457

Each vehicle class is responsible for a certain number of the total 6,679 average daily vehicles:

Auto	6679×76%	= 5076
Pickup	6679×17%	= 1135
3 Ax+ SU	6679×1%	= 67
5 Ax ST	6679×6%	= 401

The number of daily passes for each vehicle class times the number of ESALs per pass gives the daily number of ESALs applied per vehicle class. Multiplying this result by 365 days and the 20-year lifespan of the road gives the total number of ESALs applied per vehicle class over the road lifetime. Adding these figures gives the total number of ESALs applied to the road over its lifetime:

Auto	5076×0.00040×365×20
Pickup	1135×0.00086×365×20
3 Ax+ SU	67×0.44762×365×20
5 Ax ST	+ 401×0.91457×365×20
	2.9 million ESALs

Assuming that 65 percent of the traffic in each direction uses the design lane, the number of 18-kip-equivalent single-axle load applications X will be

$$X = 0.65 \times 2.9 \text{ million} = 1.9 \text{ million.}$$

For the given geographic location, the cost equation from the previous study yields a cost of

$$Y = 2.378 + 3.027 \times \sqrt{\frac{1.9\text{ million}}{1\text{ million}}} = 6.55$$

that is, Y = \$6.55 per square yard. For two lanes that are four yards (12 feet) wide at 1760 yards per mile, the load-related cost is equal to 2 × 4 × 1760 × 6.55 = \$92,224 per mile. Assuming that nonload-related costs are 45% of the total construction cost, the nonload-related cost in this case is \$75,456. The total cost per mile in each direction is thus \$167,680. This cost is the quantity to be allocated among the given vehicle classes. The results of the various allocation methods are summarized in Table 8 and Table 9 for the load-related portion of the cost and for the total cost, respectively. In Table 9, the nonload-related costs have been allocated proportionally by VMTs in each case.

Table 8. Load-Related Cost for Pavement Construction (%)

	ESALs	MIA	GM
Auto	0.5	31.5	13.2
Pickup	0.2	7.3	13.0
3 Ax+ SU	7.5	4.3	15.4
5 Ax ST	91.8	56.9	58.4

Table 9. Total Pavement Construction Cost (%)

	ESALs	MIA	GM
Auto	34.5	51.5	41.5
Pickup	7.8	11.7	14.8
3 Ax+ SU	4.6	2.8	8.9
5 Ax ST	53.1	34.0	34.8

Allocation of Pavement Rehabilitation and Maintenance

The number of 18-kip-equivalent single-axle load applications per year is 145,000. For the given geographic location, the current rehabilitation and maintenance cost equation $Y = a + bX$ gives

$$Y = 72.34 + 0.022 \times 145{,}000 = \$3262/\text{year/mile}.$$

The results of the allocation methods are summarized in Table 10.

Table 10. Pavement Rehabilitation and Maintenance Cost Results

	ESALs	GM
Auto	0.5	1.0
Pickup	0.2	0.8
3 Ax+ SU	7.5	7.9
5 Ax ST	91.8	90.3

2. REVENUE ANALYSIS

2.1 STEP-BY-STEP PROCESS

The revenue allocation analysis will proceed in two stages, each entailing many steps. Some early steps in the first stage are listed below.

The first stage will entail the development of a basic model with limited detail. Preliminary results will be derived from the model and assessed against other evidence (such as evidence from other HCA models).

Simultaneously, the team will be collecting and evaluating the information needed for Stage II, which will involve refinement and testing of the model.

Proceeding in two stages will help to ensure timely completion of the project. A risk in model development is having a grand model that is still not fully operational by the deadline for completion. By deferring potential refinements until Stage II, this possibility will be avoided. Another advantage of the staged approach is easier detection and diagnosis of errors.

Early steps:

- Decide the base year for the analysis, which must be the same as in the cost allocation analysis.
- Resolve any ambiguities concerning the legal framework for taxes and charges.
- Submit to TxDOT a detailed request for registration counts. Initial discussions with the registration division, held November 1999, suggest that the required data are available.

2.2 COMPONENTS

The revenue analysis will allocate among classes of vehicles the revenues from government taxes and charges on highway users. The vehicle classes will be the same as in the cost allocation analysis. As was already mentioned, the focus will be on federal and state revenues; local government revenues will not be considered.

2.2.1 Federal Revenues

The federal government supports the Highway Trust Fund with the following taxes:

- motor fuel taxes,
- sales tax on heavy trucks and trailers,
- tax on heavy tires (over 40 lb), and
- heavy vehicle use tax (over 55,000 lb).

The present study will allocate revenues from each of these taxes.

2.2.2 State Revenues

Like the previous Texas studies, the present study will allocate revenues from the following state taxes and charges:

- registration fees,
- motor fuel taxes, and
- lubricating oil tax.

The revenue from the lubricating oil tax is relatively minor, but allocating it requires little additional effort.

The 1997 Federal HCA study allocated revenues from other state taxes and charges on road users:

- drivers' license fees,
- fines and penalties,
- vehicle title fees, and
- other taxes and charges (such as overweight/oversize permit fees).

This study will exclude these taxes and charges, as they account for only a small share of revenues from Texas highway users (under 7 percent in 1998) and allocating the revenues among vehicle classes would not be altogether straightforward. For example, allocating the costs of administering drivers' licenses would be necessary if one were to allocate revenues from drivers' license fees. To do the job properly would probably require more effort than is warranted, given that the revenues and costs involved are relatively minor. In addition, the more important of the taxes and charges to be excluded apply broadly across vehicle classes (e.g., drivers' license fees); for this reason as well, their omission would not strongly bias the HCA results.

Also to be excluded from the present study is the state vehicle sales tax, which is seldom included in Highway Cost Allocation studies.

Certain minor categories of registration revenues were not allocated in the previous Texas study. The present study will not allocate these categories either. If time allows and it proves feasible, revenues might be allocated from one of the previously ignored categories (like travel trailers).

A planned minor improvement over the previous Texas study will be more accurate allocation of revenue from the Heavy Vehicle Use Tax. The previous study calculated for each vehicle class the average weight among those vehicles paying the tax (over 55,000 lb). The average tax per vehicle was estimated as the tax paid by a vehicle of average weight. However, the $550 cap on the tax, which goes into effect at 75,000 lb, makes the tax schedule nonlinear. Hence, the average tax per vehicle will, in fact, be less than the tax paid by a vehicle of average weight. What makes this nonlinearity a concern is that many combination trucks weigh over 75,000 lb, with a large cluster weighing around 80,000 lb. Admittedly, allowing for the nonlinearity would have only a minor effect on the final results. (For an 80,000 lb truck, removing the cap would increase the tax by $110, which is very little compared to the total taxes and charges paid by such a vehicle.) But allowing for the nonlinearity should be straightforward, so it would probably be worth doing.

2.2.3 Revenues Used for Nonhighway Purposes

For some highway-related taxes and charges, a portion of the revenue is earmarked for nonhighway purposes. HCA studies have varied in their treatment of this revenue. Some have allocated all revenue from highway-related taxes and charges, regardless of its disposition. Other studies have allocated only the portion of such revenues that is used for highways. The 1994 Texas HCA study, for example, excluded state fuel tax revenues that go toward public education, along with revenues from the Federal Highway Trust Fund that are used for mass transit.

The plan for the present study is to experiment with several approaches to allocating highway user revenues: (a) allocate all revenues regardless of their disposition; (b) allocate only those revenues that go toward highway expenditures; or (c) allocate only those revenues that go toward Texas highway expenditures. The results will be compared to see whether the choice of approach makes much difference.

Texas has long been a net "donor" state under the Federal Highway Trust Fund: its contributions to the fund exceed what it receives from the fund. Under approach (c), the excess of contributions over receipts would not be allocated among Texas vehicle classes.

2.3 DATA REQUIREMENTS

2.3.1 Distribution of Texas Motor Vehicle Registrations

The building block for the revenue database will be the distribution of Texas motor vehicle registrations. The distribution will tabulate the vehicle population according to characteristics that influence the registration fee or other taxes and charges:

- exempt status (for government vehicles and school buses),
- vehicle type (passenger car, bus, combination truck, etc.),
- gross registered weight,
- vehicle age (in the case of passenger cars),
- farm usage, and
- type of fuel used.

The procedures for deriving this distribution in the 1994 Texas HCA study seem sound and were well documented in spreadsheets. Special tabulations of TxDOT registration files were the primary data source and can be repeated for the present study. Supplementary sources were:

- *Texas Transit Statistics,* for buses (Texas Department of Transportation, various editions);
- Truck Inventory and Use Survey, including unpublished tabulations;
- Data on Texas traffic by vehicle type from the Highway Performance Monitoring System; and
- Weigh-in-motion data on gross weight by type of truck.

The present study will draw on the same sources. The truck survey is now known as the Vehicle Inventory and Use Survey (in anticipation of its eventual extension to cover automobiles and buses). Results from the 1997 survey were recently published; for the unpublished tabulations, it will be necessary to purchase a CD-ROM with microdata, which should be available in early 2000.

Fuel Type

One reason for distinguishing fuel type in the database is that some diesel-powered vehicles attract an 11 percent registration surcharge. More importantly, tax rates and fuel economy depend on the type of fuel.

For truck classes, we plan to incorporate information on fuel type from other HCA databases and possibly from the Vehicle Inventory and Use Survey. The researchers have already examined the database for the 1997 Federal HCA model and the associated, incomplete, documentation. We will also examine the database for the generic state HCA model being developed for the FHWA when it becomes publicly available (early February according to plans).

The distribution of buses by fuel type in the 1994 Texas study database was as follows: transit buses and intercity buses were all diesel-powered, and "private buses" (not operated for hire or compensation) were 75 percent gasoline and 25 percent diesel. For the present study, we will seek to investigate the realism of this assumed split and adjust it as necessary based on the information obtained.

A related issue is how many fuel types to distinguish. The 1994 Texas study distinguished only "gasoline" and "diesel." For trucks, special fuels such as LPG were counted as diesel. For other vehicle classes, it is not altogether clear how special fuels were treated. The database for the generic state model (trial version) distinguishes four fuel categories: gasoline, gasohol, diesel, and other fuel. We will attempt to add such detail in the present study, although the predominance of diesel and gasoline makes this a relatively low priority. Of the other fuels, gasohol is the most widely used. The remaining fuels, such as LPG, have a negligible market share. In 1997, only 0.33 percent of all trucks and 0.95 percent of heavy trucks used these fuels.

Exempt Status

The taxes and charges being considered differ in their exemptions: all government vehicles are exempt from registration fees; federal vehicles are exempt from other state taxes; and state and local government vehicles are exempt from federal taxes.

The previous Texas study did not classify public vehicles by level of government, whereas the present study will draw on *Highway Statistics* and other possibly sources to obtain a breakdown between federal ownership and state or local ownership.

Other Issues

The distribution between vehicle classes presents two challenges:

1. The Texas registration scheme has a special category for truck-tractors that are hitched to semitrailers. Trucks that are combined with regular trailers are registered as "commercial motor vehicles," along with a far larger number of single-unit trucks. Previous Texas studies have classified all "commercial motor vehicles" as a single unit and so have ignored the truck-trailer combinations. We will attempt to reassign such vehicles to the appropriate combination category in the present study, e.g., assigning three-axle truck-trailers to the same category as three-axle truck-semitrailers.

2. The distinction between passenger cars and sport/utility vehicles is fuzzy in the Texas registration scheme. Owners can register their sport/utility vehicles either as passenger cars or as "commercial vehicles" with truck plates (regardless of whether the vehicles are actually used for commercial purposes).[1] The FHWA classifies sport/utility vehicles as light trucks in its data collections and HCA modeling. The intention was to do likewise in the present study. However, on the revenue side, this

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[1] Texas statute defines "commercial vehicles" to include vehicles designed mainly for transporting property, even if they are not actually used for that purpose. As interpreted by TxDOT, this definition gives the owners of sport utility vehicles, some vans, and some minivans the option to register their vehicles as either commercial vehicles with truck plates or passenger cars.

might require considerable massaging of the registration data. If the task looks unfeasible, CTR will sidestep the problem by combining passenger cars and light trucks into a single category for revenue allocation.

2.3.2 Estimates of Fuel Economy

The 1994 Texas study obtained data on fuel economy (MPG) from various sources: FHWA's *Highway Statistics*, the Truck Inventory and Use Survey, Federal HCA estimates, and the *ORNL Transportation Energy Data Book* (for the latest in the ORNL series, see Davis 1999). All the data used were national-level, rather than Texas-specific, figures.

Fuel economy was estimated for vehicles of different types, weights, and, in the case of cars, ages. It was not, however, estimated by type of fuel. As a result, the same MPG estimates underlie the estimates of diesel and gasoline consumption. However, the database for the Texas study reveals a strongly predominant fuel type for almost every vehicle class. Passenger cars run almost exclusively on gasoline, five-axle combination trucks on diesel. Single-unit trucks with three or more axles show the most mixed pattern.

The previous Texas study relied only to a limited extent on the Federal HCA database. The study relied on other sources — *Highway Statistics* and the 1987 Truck Inventory and Use Survey — to estimate an average MPG for each truck class. These estimates are based purely on national data (as was noted above). For each truck class, however, the study allowed for differences between Texas and the rest of the nation in the vehicle weight distribution to cause corresponding differences in average MPG. To allow for these compositional effects, the Texas study also obtained national-level estimates of MPG by truck class and weight from the Federal HCA database. These were combined with the data on the numbers of Texas trucks by class and weight.

Options for Fuel Type and Truck Weight

The present study could follow basically the same approach to estimating MPGs as did the previous Texas study. However, the following alternative options are worth considering:

1. *Not collect information on MPG by truck weight,* but otherwise follow the previous study's approach. This approach would avoid the need to rely on data from other HCA models. Loss of accuracy could be slight if the weight distribution in Texas is similar to that in the nation as a whole. Although not ideal, this approach could be useful for the preliminary analysis. It could also save time involved in extracting information from other HCA databases and conforming it to the Texas database categories.

   The loss of accuracy in this approach may, in fact, be fairly modest. If the previous Texas study had omitted the weight dimension to MPG, its estimates of MPG would have changed by less than 6 percent for each truck class. For single-unit trucks, the estimates would have been about 4 percent lower, reflecting that the average vehicle weight in Texas is somewhat less than the national average, according to the study's database. For three- and four-axle combination trucks, the estimates would have been about 5 percent higher; for other combination categories, the estimates would have been virtually unchanged.

2. *Differentiate MPG by fuel type and truck weight.* Compared with the approach in the previous Texas study, this approach would entail more detail and increased reliance on other HCA databases. The drawback is the extra time required to evaluate the quality of the additional data and extract it. We will aim for this approach in the present study, although the gain in accuracy may be small because most vehicle classes rely overwhelmingly on just one fuel type.

3. *Extract data on MPG from the Texas sample in the 1997 Vehicle Inventory and Use Survey.* Unlike the other options under consideration, this could allow for differences in MPG between Texas and the rest of the nation, comparing vehicles of the same weight and class. A problem with this approach is that for some of our truck cases, the Texas sample contains too few observations for reliable estimates.

Passenger Car Weight

None of the recent models reviewed has much detail regarding passenger car weight, which strongly influences fuel performance. The 1997 Federal model used 5,000 lb intervals, with the vast majority of cars falling in the first interval (0-5,000 lb). Previous Federal HCA studies did more to distinguish between large and small cars. The 1997 study sacrificed such detail in order to focus more on trucks, because it was performed in conjunction with the truck size and weight study. The generic state model being developed will have the same level of detail.

The 1994 Texas HCA study based the passenger car categories on the registration fee schedule, whereby the fee depends on vehicle age, except for vehicles weighing over 6,000 lb. The categories were 0-3 years old, 4-6 years old, over 6 years old, and over 6,000 lb. For each of these categories, the study estimated the MPG. However, to estimate fuel consumption by Texas cars, it would be useful also to know the weight distribution for each of the age-defined groups.

We will consider the feasibility of adding more detail on passenger car weight. A key factor is whether additional weight data are available from TxDOT registration files.

Buses

The 1997 Federal study omitted distinctions between types of buses. Earlier Federal HCA studies had classified buses as school, transit, or intercity and estimated MPG for each class. The previous Texas study relied on these estimates and on the *Highway Statistics* series on average

MPG for all buses. The 1997 Federal study distinguished a single category, "buses," as does the nearly completed generic state model. For the present study, we are considering several options for estimating MPG: (a) assume that average MPG for all buses in Texas is the same as that nationally; (b) assume that relativities in MPG between bus categories have stayed the same and use the *Highway Statistics* series to update the estimates in the previous Texas study; and (c) look for more recent data. For the preliminary analysis, option (b) would seem preferable; upgrading to option (c) is a medium-low priority for the final analysis.

Although the 1997 Federal study omitted distinctions between bus types, it did include a bus weight distribution, as does the generic state HCA model. For the present study, we will attempt to obtain a weight distribution for each of the above-described categories of buses other than school buses (which are generally exempt from taxes and charges on highway users).

2.3.3 Estimates of Annual Mileage-Per-Vehicle

For annual mileage-per-vehicle, the data sources and estimation procedures in the Texas study were much the same as those for fuel economy. The main difference is that some of the mileage data are Texas-specific.

Likewise, for the present study, estimating annual mileage-per-vehicle poses problems and options similar to those posed by estimating fuel economy. The 1994 Texas HCA database indicated that for trucks of a given type (e.g., three-axle single unit), annual mileage varies significantly by vehicle weight. Should such differences be incorporated in the present study? Probably yes, but perhaps not for the preliminary analysis.

Incorporating differences in annual mileage between diesel and gasoline-powered trucks would be a lower priority. Although some previous HCA studies have allowed for such differences, either diesel or gasoline tends to strongly predominate within each truck class.

Data Availability

Some of the mileage data used in the 1994 Texas study are unavailable from recent years. For the present study, CTR will have to use somewhat dated figures, find alternative data sources, or sacrifice detail.

For passenger cars, the previous Texas study drew mileage data from the Residential Transportation Energy Consumption Survey (RTECS). The survey yielded estimates of annual mileage by vehicle age among household vehicles. The Texas study used these data to measure relativity in annual mileage between Texas registration categories for passenger cars. However, the survey was last conducted in 1994. Another source of annual mileage data, the National Personal Transportation Study, was last conducted in 1995. These data, which are based on how much people say they are using their vehicles, are less accurate than the data from the RTECS, which are based on odometer readings.

For transit buses, the previous Texas study obtained an estimate of average annual mileage from *Texas Transit Statistics*. After 1996, however, that publication combined buses with rail/trolley systems in its annual mileage statistics. The new series included mileage on Galveston trolleys and on the rail systems that opened in Dallas and Fort Worth in 1996.

2.3.4 Data on Heavy Truck/Trailer Prices and Annual Sales

Revenues from the federal sales tax on trucks and trailers depend on prices and the volume of sales. The spreadsheets from the previous Texas study do not clearly document the estimation of truck/trailer prices. The primary data source appears to relate to 1977 (or perhaps 1980). Prices for that year were updated to the 1990s using the consumer price index for new cars. For the annual sales ratio of new vehicles to the total vehicle stock, the spreadsheets did not document sources of data, except to indicate a partial reliance on the Vehicle Inventory and Use Survey.

The present study will obtain data on prices and sales ratios from one of the other recent HCA models. Price data will be updated as needed using the consumer price index or some other price index. If the sales ratios require updating, data for this purpose may be obtained from *Highway Statistics* and industry sources. Neither the sales ratios nor the vehicle prices will be Texas-specific.

2.3.5 Benchmark Estimates

For each tax or charge, the estimates of revenue from each vehicle class will be adjusted to conform to an independent benchmark estimate of total revenue. The researchers will derive initial estimates of federal gasoline tax revenues by class of Texas vehicle. However, these estimates will not equal exactly the *Highway Statistics* estimate of federal gasoline tax revenues from all Texas vehicles. The estimates are independently derived and both contain errors. The present study will accept the *Highway Statistics* estimates as the "correct" total and distribute the total across vehicle classes using the percent distribution defined by our initial estimates.

Benchmark estimates will be readily available from *Highway Statistics* and other sources. Certain estimates that were used as benchmarks in the previous Texas study will not be used this time. TxDOT supplies the FHWA with annual estimates of registration revenues for broad vehicle classes and for trailers. The previous Texas HCA study used these estimates as benchmarks. The present study, however, will not use them, as it is doubtful that they are any more accurate than corresponding estimates that the study itself will generate. The study will nevertheless use as a benchmark the TxDOT total for registration revenue (not broken down by vehicle class).

2.3.6 Legal Information

Certain legal aspects of taxes and charges have yet to be clarified for this study. An example is the federal taxation of fuel consumed by intercity buses. The 1997 Federal HCA study states that changes to the law subsequent to the 1978 Energy Tax Act "resulted in intercity buses paying 3 cents per gallon on the motor fuel they consume" (p. IV-9). However, a footnote to *Highway Statistics 1998* reads as though the intercity buses have to pay 3 cents per gallon *less* than the prevailing fuel tax rate, rather than 3 cents per gallon. Indeed, this was the interpretation in the previous Texas HCA study. Resolving this and the other legal ambiguities that have arisen should be fairly easy.

3. EQUITY ANALYSIS

The equity analysis will calculate an equity ratio for each vehicle class. The numerator is the share of revenues from highway users that is attributable to a particular class; the denominator is the share of highway costs for which the class is responsible.

After completing the research report, the project team will be available to test scenarios at the request of TxDOT, legislators, or other stakeholders (Task 11 in the project proposal, revised May 24, 1999). For each scenario, equity ratios will be derived.

APPENDIX A

INCREMENTAL APPROACH

The lack of consistency in results obtained from the incremental approach is illustrated in Figure 5 and Figure 6. In these figures R_1 represents the cost responsibility for class 1. Figure 5 shows cost responsibilities for vehicle classes 1, 2, and 3 when they are sequentially included starting with class 1, followed by class 2, and then class 3. Figure 6 shows cost responsibilities for the same vehicle classes starting with class 3, then adding class 2, and ending with class 1.

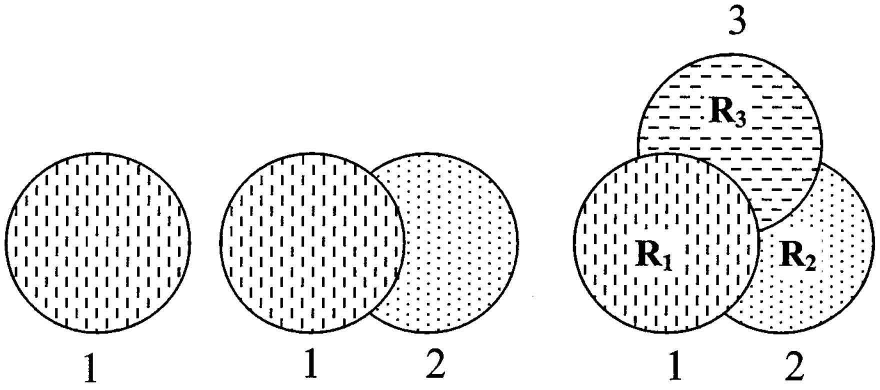


Figure 5. Incremental Method for Order 1, 2, 3

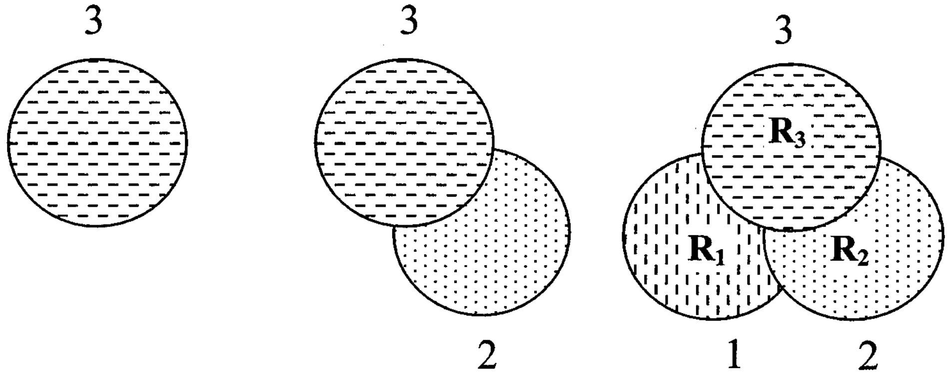


Figure 6. Incremental Method for Order 3, 2, 1

APPENDIX B

MODIFIED INCREMENTAL APPROACH

Figure 7 shows cost responsibilities for each vehicle combination. In this figure, C_1 is the cost responsibility for vehicle class 1. Moreover, C_{12} represents the total cost for a coalition formed with classes 1 and 2, and C_{123} represents the total cost for the coalition formed with the three vehicle classes considered in this illustration.

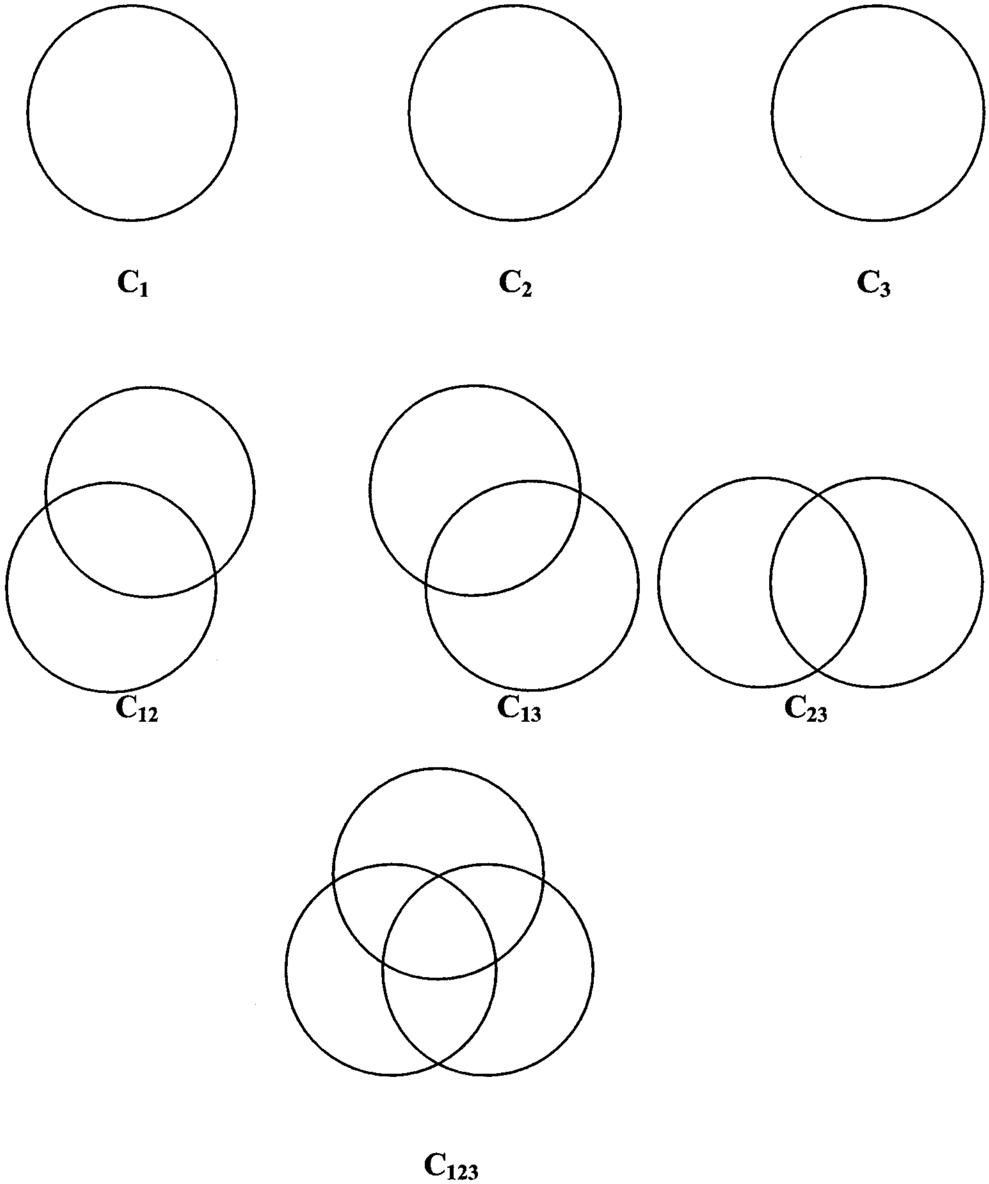


Figure 7. Cost Responsibilities/Vehicle Coalitions

Based on results derived from Figure 7, cost portions attributable to groups of one, two, or three classes are calculated. First, the nonoverlapping cost portions attributable to each vehicle class are computed:

$P_1 = C_{123} - C_{23}$
$P_2 = C_{123} - C_{13}$
$P_3 = C_{123} - C_{12}$

Second, the overlapping cost portions corresponding to each pair of vehicle classes are computed:

$P_{12} = C_{123} - C_3 - P_1 - P_2$
$P_{13} = C_{123} - C_2 - P_1 - P_3$
$P_{23} = C_{123} - C_1 - P_2 - P_3$

Finally, the overlapping cost portion corresponding to the three vehicle classes considered in this illustration is calculated:

$P_{123} = C_{123} - P_1 - P_2 - P_3 - P_{12} - P_{13} - P_{23}$

The results obtained from the previous calculations are graphically illustrated in Figure 8.

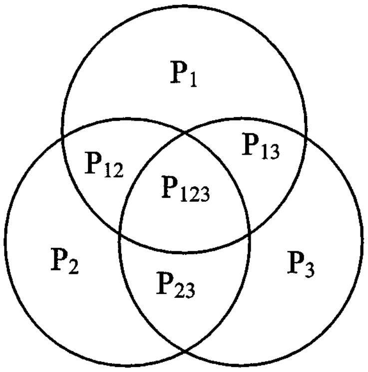


Figure 8. Overlapping Cost Portions

Continuing with the analysis, let V_1, V_2, and V_3 be the number of vehicle miles of travel associated with vehicle classes 1, 2, and 3, respectively. As illustrated in Figure 8, the allocated cost for vehicle class 1 is equal to the sum of P_1 and appropriate fractions of the portions P_{12}, P_{13}, and P_{123}. These fractions can be defined in terms of VMTs.

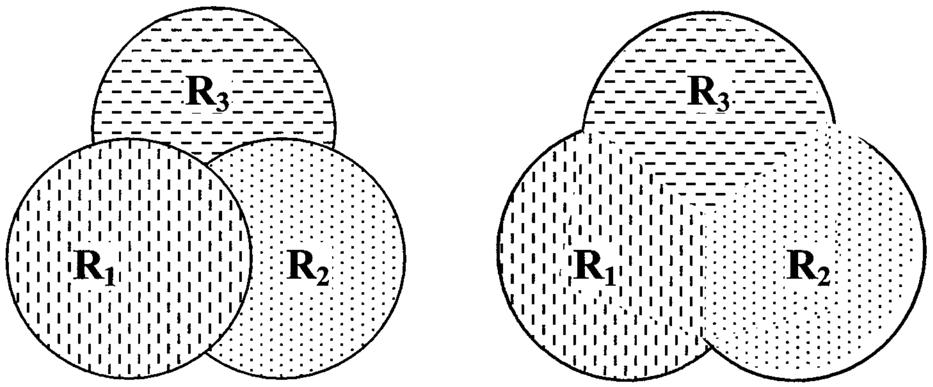
Final cost allocations for each vehicle class can be computed as indicated below:

$$R_1 = P_1 + P_{12}\frac{V_1}{V_1 + V_2} + P_{13}\frac{V_1}{V_1 + V_3} + P_{123}\frac{V_1}{V_1 + V_2 + V_3}$$

$$R_2 = P_2 + P_{12}\frac{V_2}{V_1 + V_2} + P_{23}\frac{V_2}{V_2 + V_3} + P_{123}\frac{V_2}{V_1 + V_2 + V_3}$$

$$R_3 = P_1 + P_{13}\frac{V_3}{V_1 + V_3} + P_{23}\frac{V_3}{V_2 + V_3} + P_{123}\frac{V_3}{V_1 + V_2 + V_3}$$

The cost responsibilities identified by the incremental approach and the modified incremental approach (MIA) are shown in Figure 9.



INCREMENTAL **MIA**

Figure 9. Comparisons of Incremental Approach and MIA

APPENDIX C

GENERALIZED METHOD

Using the notation introduced to describe the modified incremental approach, the linear programming formulation for three vehicle classes is shown below:

Maximize t

Subject to

$R_1 \le C_1 - t$
$R_2 \le C_2 - t$
$R_3 \le C_3 - t$
$R_1 + R_2 \le C_{12} - t$
$R_1 + R_3 \le C_{13} - t$
$R_2 + R_3 \le C_{23} - t$
$R_1 + R_2 + R_3 = C_{123} - t$
$R_1, R_2, R_3, t \ge 0$

Figure 10 shows the graphical representation of the equation $R_1 + R_2 + R_3 = C_{123}$, along with the region resulting from the simultaneous consideration of the remaining constraints. This feasible region is known as the *core of the game* using game theory terminology. In essence, the optimization of the above model results in a single point (solution) in the core. The coordinates of this point are the cost responsibilities allocated to the vehicle classes.

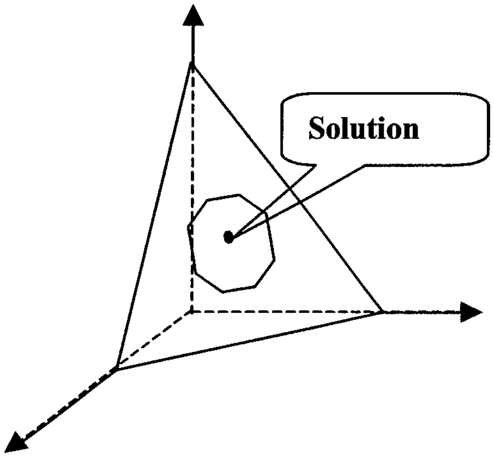
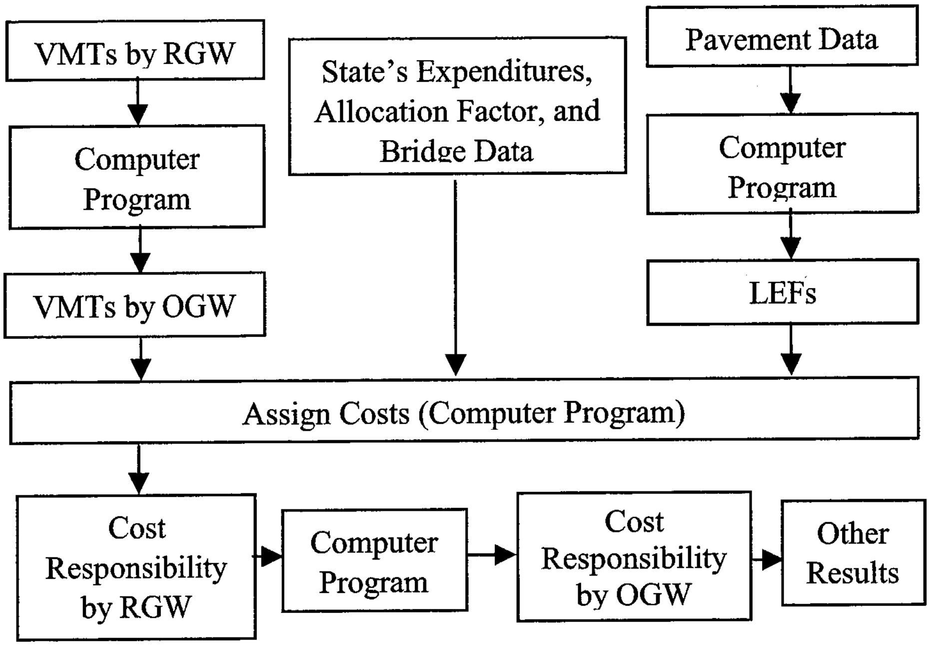


Figure 10. Feasibility Regions for Generalized Method

APPENDIX D

1994 TEXAS HCA CONCEPTUAL APPROACH



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