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List Of Acronyms

HCAS	Highway Cost Allocation Study
STAA	Surface Transportation Assistance Act
TS&W	Truck Size and Weight
DOT	Department of Transportation
3R	Reconstruction, Resurfacing, and Rehabilitation
HCA	Highway Cost Allocation
TRI	Trucking Research Institute
ESAL	Equivalent Single Axle Load
VMT	Vehicle Miles Of Travel
HTF	Highway Trust Fund
HVUT	Heavy Vehicle Use Tax
GVW	Gross Vehicle Weight
FHWA	Federal Highway Administration
WDT	Weight Distance Tax
IRS	Internal Revenue Service
FTD	Federal Tax Deposit
DRA	Deficit Reduction Act of 1984
ATA	American Trucking Associations
AASHTO	American Association of State Highway and Transportation Officials
TRB	Transportation Research Board
NHS	National Highway System
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
MTA	Mass Transit Account
CMAQ	Congestion Mitigation and Air Quality
FMIS	Fiscal Management Information System
HPMS	Highway Performance Monitoring System
TIUS	Truck Inventory and Use Survey
C&P	Conditions and Performance
NHTSA	National Highway Traffic Safety Administration

LCCA	Life Cycle Cost Analysis
M&R	Maintenance and Rehabilitation
VOC	Vehicle Operating Costs
PSI	Pavement Serviceability Index
FTA	Federal Transit Administration
NEPA	National Environmental Policy Act
CO	Carbon Monoxide
CO_2	Carbon Dioxide
No_x	Nitrogen Oxides
EPA	Environmental Protection Agency
PCE	Passenger Car Equivalent
AADT	Annual Average Daily Traffic
WsDOT	Washington Department of Transportation
HUR	Highway User Revenue
LUST	Leaking Underground Storage Tank
EPACT	Energy Policy Act of 1992
CNG	Compressed Natural Gas
GVW	Gross Vehicle Weight
DoD	Department of Defense
MPG	Miles Per Gallon
HRFM	Highway Revenue Forecasting Model
DOE	Department of Energy
GPM	Gallons Per Mile
HOV	High Occupancy Vehicle
SOV	Single Occupancy Vehicle
NAPCOM	Nationwide Pavement Cost Model
LTPP	Long Term Pavement Performance
NBI	National Bridge Inventory
BNIP	Bridge Needs and Investment Process
TSM	Transportation Systems Management
BTS	Bureau of Transportation Statistics

ITS	Intelligent Transportation System
FY	Fiscal Year
AUTO	Automobiles and Motorcycles
LT4	Light Trucks with 2-Axles and 4 Tires (Pickup Trucks, Vans, Minivans, etc.)
SU2	Single Unit, 2-Axle, 6 Tire Trucks (Includes SU2 Pulling a Utility Trailer)
SU3	Single Unit, 3-Axle Trucks (Includes SU3 Pulling a Utility Trailer)
SU4+	Single Unit Trucks with 4- or More Axles (Includes SU4+ Pulling a Utility Trailer)
CS3	Tractor-Semitrailer Combinations with 3-Axle
CS4	Tractor-Semitrailer Combinations with 4-Axle
CS5T	Tractor-Semitrailer Combinations with 5-Axles, Two Rear Tandem Axles
CS5S	Tractor-Semitrailer Combinations with 5-Axles, Two Split (>8 feet) Rear Axles
CS6	Tractor-Semitrailer Combinations with 6-Axles
CS7+	Tractor-Semitrailer Combinations with 7- or more Axles
CT34	Truck-Trailers Combinations with 3- or 4-Axles
CT5	Truck-Trailers Combinations with 5-Axles
CT6+	Truck-Trailers Combinations with 6- or more Axles
DS5	Tractor-Double Semitrailer Combinations with 5-Axles
DS6	Tractor-Double Semitrailer Combinations with 6-Axles
DS7	Tractor-Double Semitrailer Combinations with 7-Axles
DS8+	Tractor-Double Semitrailer Combinations with 8- or more Axles
TRPL	Tractor-Triple Semitrailer or Truck-Double Semitrailer Combinations
BUS	Buses (all types)

Executive Summary

This is the first Federal Highway Cost Allocation Study (HCAS) since 1982. There are two key reasons for conducting this study. The first is to determine how changes in the Federal highway program and user fees which support that program have affected the equity of Federal highway user fees. The second is to coordinate this effort with the concurrent U.S. Department of Transportation Comprehensive Truck Size and Weight (1997 U.S. DOT TS&W) Study. The 1997 U.S. DOT TS&W Study uses analytical tools developed for this HCAS in estimating impacts of TS&W scenarios on infrastructure, environmental, and other costs and in estimating changes in user fees on various vehicle classes that would reflect changes in highway program costs associated with those scenarios.

Study Objectives and Scope

The primary objective of this study is to analyze highway-related costs attributable to different highway users as a basis for evaluating the equity and efficiency of current Federal highway user charges. The principal basis for evaluating the equity of the Federal highway user fee structure in this study, as in previous Federal HCASs, is to compare the responsibility of different vehicle classes for highway program costs paid from the Federal Highway Trust Fund (HTF) to the user fees paid into the HTF by the different vehicle classes. The closer that user fee payments match the cost responsibility for a particular vehicle class, the more equitable the user fee structure is for that class. This study also extends the analysis of highway cost responsibility to examine environmental, social, and other costs associated with the use of the highway system that are not reflected in highway improvement budgets. Marginal costs of highway use by different vehicle classes are compared with user fees they pay to evaluate the efficiency of the highway user fee structure. Estimates of air pollution and global climate change costs could not be developed in time to be included in this report. Estimates of highway-related air pollution costs will be submitted in an addendum to this report.

The base period for this study is 1993 to 1995, which covers the most up-to-date information available on Federal highway expenditure patterns since the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) was enacted. The analysis year is 2000. A 3-year average of highway costs and revenues is used to represent the base period (1993 to 1995) to reduce the effects of annual variations in costs and revenues.

Summary of Highway Cost Allocation Study Methods

Overall, methods used in this study are similar to methods used in the 1982 Federal HCAS. More detailed data on travel and operating weight distributions for different vehicle classes have been developed than were available in 1982, and more detail on the composition of the highway program is available from FHWA's Fiscal Management Information System (FMIS). Methods for allocating various types of costs among vehicle classes have been refined, especially for pavement, bridge, and capacity-related costs, but the study retains the overall cost-occasioned approach used in the 1982 Federal HCAS for allocating transportation agency costs. New methods have been developed for the allocating transit-related costs and other multi-modal transportation costs that were not considered in the 1982 Federal HCAS. The analysis of social costs associated with highway transportation has been expanded to include not only marginal costs but total social costs of highways as well. Social costs that can be quantified and attributed to different vehicle classes are considered in equity and efficiency analyses. Costs that cannot easily be quantified are discussed in qualitative terms.

Table ES-1. 2000 Travel and Number of Vehicles by Vehicle Class

	Travel (millions of miles)		Number of Vehicles	
Passenger Vehicles	**Total**	**Percent**	**Total**	**Percent**
Autos	1,818,461	67.5%	167,697,897	70.0%
Pickups/Vans	669,198	24.8%	63,259,330	26.4%
Buses	7,397	0.2%	754,509	0.3%
All Passenger Vehicles	2,495,049	92.6%	231,711,736	96.7%
Single Unit Trucks	83,100	3.1%	5,970,431	2.5%
Combination Trucks	115,689	4.3%	1,971,004	0.8%
All Trucks	198,789	7.4%	7,941,435	3.3%
Total All Vehicles	2,693,845	100.0%	239,653,170	100.0%

Vehicle Travel Characteristics and Population by Different Vehicle Classes

Table ES-1 shows total estimated 2000 vehicle miles of travel (VMT) by different groups of vehicles. Passenger vehicles account for about 93 percent of total VMT in the United States. Single unit and combination trucks account for 3 and 4 percent of total travel, respectively.

Data on VMT and the population of vehicles are organized by operating and registered weight distributions for 20 different vehicle classes (see Chapter II). Vehicle classes include automobiles, pickups and vans, buses, three types of single unit trucks, six types of tractor-semi trailer combinations, three types of truck-trailer combinations, four types of twin-trailer combinations, and a triple trailer combination. Data needs of the 1997 U.S. DOT TS&W Study were important considerations in selecting configurations to be included in the 1997 Federal HCAS. Truck travel and operating/registered weight distributions on each of 12 highway functional classes are estimated for each vehicle configuration.

2000 Federal-aid Highway Program Costs

The distribution of Federal obligations by improvement type and highway functional class has a strong influence on the relative cost responsibility of different vehicle classes.

Obligations for new capacity constitute about one-fifth of total Federal obligations for highways under the Federal-aid highway program. System preservation represents about 40 percent of total obligations, system enhancement about 15 percent, obligations from the Mass Transit Account (MTA) of the HTF one-eighth, and other miscellaneous costs about 9 percent. Figure ES-1 summarizes the estimated 2000 distribution of HTF obligations by improvement type.

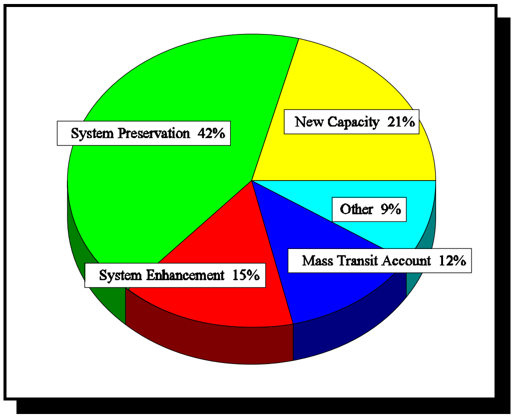

Figure ES-1. 2000 Distribution of Federal Highway-Related Obligations by Function

For purposes of simplifying the analysis, the Federal highway obligations in 2000 are assumed to equal total highway user revenues (HUR) paid into the HTF in that year. Actual obligation levels are determined by Congress and may be below, equal to, or above revenues to the HTF. The assumption has no effect on the analysis of user fee equity since that analysis compares shares of user fees paid by each vehicle class to shares of highway cost responsibility. As long as the composition of the program is assumed to remain constant, the shares of cost responsibility will remain the same under any absolute investment level used in the analysis.

Figure ES-2 shows the projected distribution of Federal-aid obligations by location and type of highway. The distribution of obligations by highway functional class is assumed to be the same in 2000 as in the 1993 to 1995 base period. Approximately two-thirds of Federal obligations are on urban highways and one-third on rural highways. In both urban and rural areas more Federal monies are obligated for improvements on higher order highway systems (Interstate and other principal arterial highways) than on lower order systems.

The distribution of program expenditures by highway type can significantly influence the relative cost responsibilities of different vehicle classes. The distribution of travel on different types of highways varies substantially by vehicle class, and other physical and operational characteristics of highways that can affect cost responsibility also vary by highway type. Significant changes in the composition of the highway program that may result from new surface transportation authorizing legislation in 1997 could affect how Federal highway and transit funds are spent and the highway systems upon which highway funds are expended.

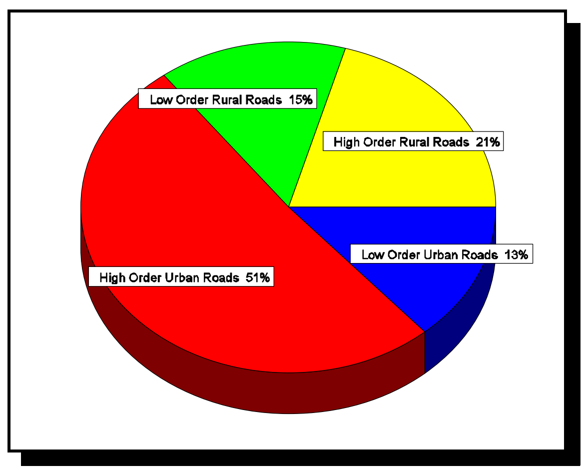

Figure ES-2. 2000 Distribution of Federal Obligations by Location and Highway Type

Allocation of 2000 Federal Highway Program Costs

Federal highway program costs are divided into several cost categories, each of which is allocated among vehicle classes in a different manner:

Pavement costs associated with constructing new lanes on new location are divided into base facility costs related to providing added capacity to safely accommodate future traffic volumes and load related costs required to accommodate the expected axle loadings from future traffic. Base facility costs are allocated to vehicles on the basis to each vehicle's VMT weighted by its passenger car equivalents (PCEs), a measure used by traffic engineers to compare the influence of

different types of vehicles on highway capacity. Costs for the additional pavement thickness needed to accommodate anticipated traffic are allocated based on the latest American Association of State Highway and Transportation Officials (AASHTO) pavement design procedures.

Costs for pavement reconstruction, rehabilitation, and resurfacing (3R), which are estimated to represent 25 percent of total Federal obligations in 2000, are allocated to different vehicle classes on the basis of each vehicle's estimated contribution to pavement distresses that necessitate the improvements. The same general approach is used as in the 1982 Federal HCAS, but new pavement distress models were developed for this study that reflect the latest theoretical advances in understanding factors that influence pavement distress.

Costs of constructing new bridges are allocated to vehicles using an incremental approach similar to that used in the 1982 Federal HCAS. As with new pavements, costs for constructing the base facility of a new bridge are allocated to all vehicle classes in proportion to their PCE-VMT. Incremental costs to provide the additional strength needed to support heavier vehicles are assigned to vehicle classes on the basis of the additional strength required on account of their weight and axle spacings.

System enhancement costs neither increase the number of lane-miles of highway capacity nor improve the physical condition of the highway system. These costs include (1) transportation system management (TSM) projects; (2) safety improvement projects; (3) Intelligent Transportation System (ITS) projects; (4) transit facilities; (5) bicycle and pedestrian facilities; (6) environmentally-related costs including costs of mitigate adverse environmental impacts during planning, design, right-of-way, and construction; and (7) other system enhancements. Several different factors are used to allocate system enhancement costs among vehicle classes. Many of these costs were so small in the 1982 Federal HCAS that they were not treated explicitly, and new allocators had to be selected.

Other attributable costs include grading and drainage; pavement width; ridesharing programs and facilities; and special truck facilities such as weigh stations. These costs are allocated on the basis of the relationships between the cost element and specific vehicle characteristics, and are allocated to only the vehicle classes responsible for the costs.

Figure ES-3 shows the estimated distribution of 2000 Federal cost responsibility by broad groups of vehicles. Automobiles which account for 70 percent of all vehicles and about two-thirds of all travel are responsible for 44 percent of Federal program costs followed by combination trucks, pick-ups and vans, and single unit trucks.

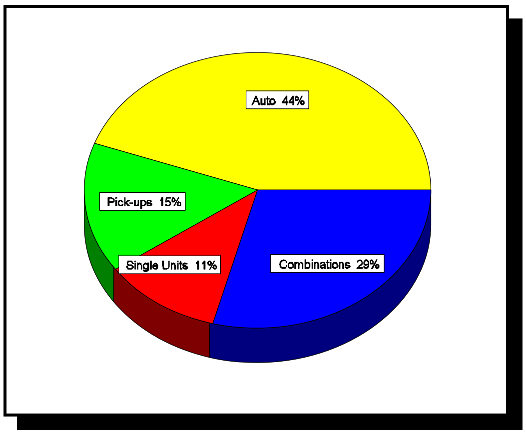

Figure ES-3. Distribution of 2000 Federal Program Cost Responsibility Among Vehicle Classes

Life Cycle Cost Analysis

The potential for more widespread use of life cycle cost analysis (LCCA) to reduce overall system preservation costs was evaluated on a preliminary basis in this study. The LCCA of infrastructure investment decisions is intended to identify alternatives that have the lowest cost over their entire life, not just alternatives with the lowest initial costs. Many States apply LCCA principles to varying degrees in pavement and bridge management systems, but there is a widespread belief that greater use of LCCA could reduce long-term program costs. The implications of LCCA for highway cost allocation (HCA) are that if long-term infrastructure costs could be reduced, those costs would represent a smaller share of the overall program and vehicle classes responsible for the greatest share of infrastructure costs would have lower cost responsibility and improved equity ratios.

A preliminary analysis suggests large potential benefits from the adoption of LCCA, especially in reducing vehicle operating costs associated with traveling on deteriorated pavements and delay around work zones where highway maintenance and rehabilitation is being performed. Estimates of nationwide savings in construction and maintenance costs resulting from the use of LCCA are not as large, although the analytical tools used for this analysis may not capture the full range of potential agency benefits believed to accrue from use of LCCA. Further research to improve estimates of potential benefits of LCCA is planned, not only for cost allocation but for investment analyses conducted for the Department's Condition and Performance (C&P) Report.

Estimates of 2000 Federal Highway User Revenues

Figure ES-4 shows the estimated share of Federal highway user fees that will be paid by broad vehicle groups in 2000. Federal highway user taxes include taxes on various highway fuels, an excise tax on the sale of heavy trucks, a graduated tax on tires weighing over 40 pounds, and a heavy vehicle use tax (HVUT) on trucks with registered weights over 55,000 pounds. Each of these taxes has been in place for many years, although rates and the specific equipment that is taxed have changed from time to time. Historically, the primary purpose for imposing highway user fees at both the Federal and State levels has been to raise revenues to finance highway improvement programs. The linkage between highway user fees and highway program financing is central to HCASs which seek to determine whether fees paid by each vehicle class cover infrastructure and other transportation agency costs occasioned by those vehicles.

Federal HURs projected to be paid by the 20 vehicle classes in 2000 were estimated assuming the Federal highway user fee structure remains unchanged. As Figure ES-4 indicates, passenger vehicles, which account for 93 percent of total highway travel, pay 64 percent of total Federal highway user fees. Combination trucks, on the other hand, pay over 25 percent of total highway user fees even though they travel less than 5 percent of total mileage.

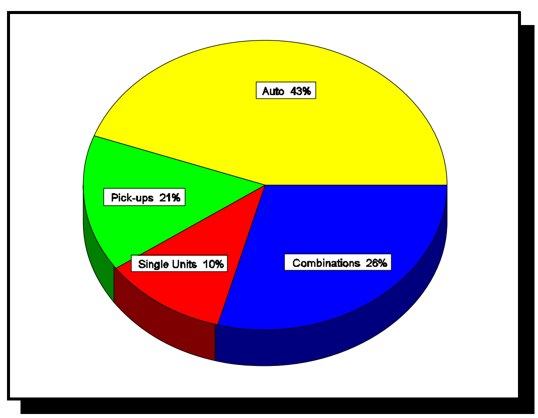

Figure ES-4. 2000 Federal User Fee Distribution by Vehicle Class

2000 Federal Highway User Charge Equity Ratios

The equity of highway user charges typically is measured in HCASs as the ratio of the shares of revenues contributed by each vehicle class to the shares of highway costs that vehicle class occasions. This ratio is often called a revenue/cost ratio or an "equity ratio." An equity ratio greater than 1.0 means overpayment; less than 1.0 means underpayment of Federal highway user fees.

Table ES-2. Ratios of 2000 Federal User Charges to Allocated Costs by Vehicle Class

Vehicle Class/Registered Weight	Ratio
Autos	1.0
Pickups/Vans	1.4
Buses	0.1
Passenger Vehicles	1.1
Single Unit Trucks	
$\leq$25,000 pounds GVW	1.5
25,001 - 50,000 pounds GVW	0.7
> 50,001 pounds GVW	0.5
Total Single Unit	0.9
Combination Trucks	
$\leq$50,000 pounds GVW	1.6
50,001 - 70,000 pounds GVW	1.1
70,001 - 75,000 pounds GVW	1.0
75,001 - 80,000 pounds GVW	0.9
80,001 - 100,000 pounds GVW	0.6
>100,001 pounds GVW	0.5
Total Combinations	0.9
Total All Vehicles	1.0

Table ES-2 shows estimated equity ratios in 2000 assuming the current highway user charge structure and the same highway program composition as during the ISTEA base period. As a class, automobiles pay the same share of Federal highway user fees as their share of highway costs, but pickups and vans pay substantially more than their share of highway costs. This difference is primarily attributable to the automobiles' better fuel economy which means they pay less fuel tax per mile of travel than pickups and vans.

User fee equity for single unit and combination trucks is highly dependent on the weight of the vehicles. As a class single units will pay less than their share of highway costs, but the lightest single units will pay more than their share of highway costs. Combination trucks as a group will pay 90 percent of their highway cost responsibility in 2000, but like single units, there is large variation depending on the weight of the vehicle. Combination trucks registered at less than 50,000 pounds will pay 60 percent more in user fees than their share of highway costs while combinations registered over 80,000 pounds will pay on average only about 60 percent of their highway cost responsibility. As the discussion in Chapter V shows, there is significant variation even among combinations in the same weight group largely because of differences in the cost responsibility of different vehicle configurations. In general the more axles a vehicle has, the lower its cost responsibility at any given weight and the more nearly it comes to paying its share of highway costs.

Tables ES-3 and ES-4 show the absolute overpayment or underpayment (represented by negative numbers) of highway cost responsibility by different vehicle classes. Pickups and vans have the largest over or underpayment of any vehicle class; as a group those vehicles pay $1.6 billion more in highway user fees than their highway cost responsibility. Other vehicle classes that in the aggregate pay more than their highway cost responsibility are 2-axle single unit trucks, all truck-trailer combinations, and 5- and 6-axle twin-trailer combinations. Five-axle tractor-semitrailers have the largest underpayment of any vehicle

Table ES-3. 2000 Federal Over and Underpayments by 20 Vehicle Classes	
Vehicle Class	**Total Over or (Underpayment) (000s)**
Automobiles	($323,330)
Pickups and Vans	$1,613,410
2-axle single units	$270,007
3-axle single units	($306,739)
4+ axle single units	($275,845)
3-axle tractor-semitrailers	($12,414)
4-axle tractor-semitrailers	($76,229)
5-axle tractor-semitrailers (tandem)	($651,480)
5-axle tractor-semitrailers (split tandems)	($41,162)
6-axle tractor-semitrailers	($134,212)
7-axle tractor-semitrailers	($29,767)
3-, 4-axle truck trailers	$128,304
5-axle truck trailers	$30,362
6+ axle truck trailers	$4,460
5-axle twin trailers	$3,499
6-axle twin trailers	$11,188
7-axle twin trailers	($17,063)
8-axle twin trailers	($22,659)
7-axle triple trailer	($2,141)
Buses	($169,478)

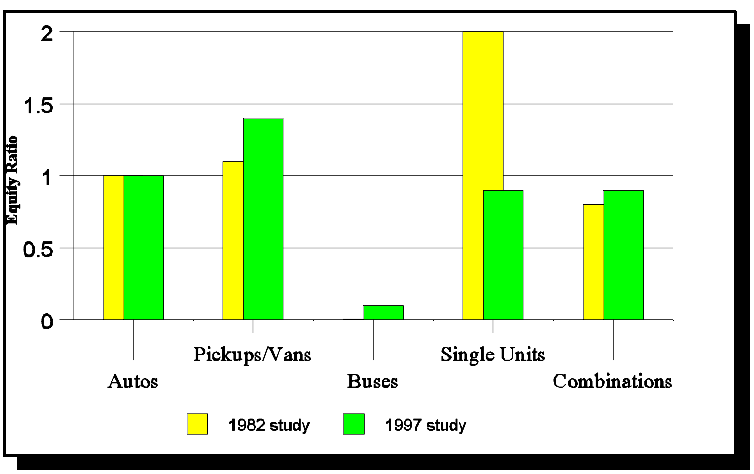

Figure ES-5. Comparison of 2000 Equity Ratios for 1982 and 1997 Federal HCASs

class, followed by automobiles and 3- and 4-axle single unit trucks. These classes account for 32 percent, 16 percent, 15 percent and 13 percent respectively of underpayments by all vehicle classes.

Table ES-4 shows the expected overpayment or underpayment by vehicles in different registered weight groups in 2000 for selected vehicle classes along with the average over or underpayment per vehicle at each weight. Over or underpayments clearly vary substantially with weight. At lighter weights vehicles in each class pay more than their share of highway costs while at heavier weights they all pay less than their share of highway costs. The number of vehicles in each weight category varies widely for different vehicle classes. The per vehicle overpayment or underpayment for the weight group with the most vehicles in each class is underlined in Table ES-4.

Figure ES-5 compares 2000 equity ratios estimated for various vehicle classes in this study with equity ratios estimated in the 1982 Federal HCAS. The most notable differences are that equity ratios for single unit trucks will be much closer to 1.0 than in 1982 and that pickups and vans will be paying substantially more than their share of highway costs. Much of the change in equity ratios for single unit trucks is attributable to changes in Federal highway user fees enacted in the STAA of 1982 following the 1982 Federal HCAS. That study found most single units to be overpaying Federal user fees and recommended reductions in user fees levied on those vehicles. Equity ratios for single units are now much closer to 1.0, but on average single

Table ES-4. 2000 Federal Over and Underpayment by Selected Vehicles								
	3-axle Single Units		4+ axle Single Units		5-axle Semitrailer		6-axle Semitrailer	
Registered Weight	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle
20,000	$204	$244						
30,000	$7,956	$236	$29	$1,229				
40,000	$8,803	$151	$1,189	$1,122				
50,000	($32,519)	($116)	$307	$220	$12,945	$1,811	$235	$2,132
60,000	($164,588)	($634)	($18,448)	($816)	$43,594	$1,538	$1,414	$2,104
70,000	($119,386)	($2,059)	($88,205)	($2,039)	$20,372	$603	$2,732	$1,508
80,000	($7,207)	($3,260)	($143,292)	($2,966)	($591,971)	($561)	$27,370	$342
90,000			($18,367)	($3,672)	($109,044)	($3,864)	($21,286)	($2,188)
100,000			($9,057)	($4,193)	($17,987)	($5,176)	($41,391)	($4,985)
110,000					($9,389)	($6,022)	($33,239)	($7,746)
120,000							($67,497)	($10,710)
Total	($306,739)		($275,845)		($651,480)		($134,212)	

units now underpay whereas they had been substantially overpaying in 1982. The most common over-the-road combination truck, the 5-axle tractor-semitrailer registered at 80,000 pounds, pays about 90 percent of its cost responsibility, but the heaviest combinations pay only 60 percent or less of their highway costs.

Highway Cost Allocation for All Levels of Government

Evaluating relationships between Federal user fees and Federal highway cost responsibility is essential for evaluating the equity of the Federal highway user fee structure. However, comparisons of total user fee payments and total highway cost responsibility for all levels of government are important in evaluating overall subsidies to various classes of vehicles that might give them a competitive advantage over other modes of transportation. In fact, State and local governments collect three-quarters of total HURs and the equity of their user fee structures is a very important component of overall user fee equity.

An important fact is the prominence of fuel taxes in the Federal highway user fee structure compared to State and local user fees. Fuel taxes account for almost 90 percent of Federal user fees compared to only half of State HURs and only one-third of local HURs. Vehicle registration fees account for one-third of State HURs and over 40 percent of local highway user revenue, compared to less than 3 percent for the Federal counterpart to the registration fee, the HVUT. While fuel taxes vary by extent of use and registration fees do not, truck registration fees generally are graduated by weight and can reflect the large differences in cost responsibility of heavy trucks compared to lighter trucks.

Table ES-5 shows estimated ratios of user fee payments to highway cost responsibility by vehicle class for all levels of government in 2000. It is important to note that these results represent an average for revenues and expenditures for all State and local governments. Results for individual States could vary substantially from those shown in this table. It is also important to note that unlike other ratios of revenues and costs in this report, total revenues and costs for all vehicle classes are not equal. At the State level total user fee collections are approximately equal to total expenditures, but total local user fee payments are only about 10 percent of local highway expenditures. At the Federal level expenditures on highways on Federal lands that are paid from general funds rather than from user fees paid into the HTF are included in this table, but not in other tables.

Table ES-5. Ratios of 2000 User Fee Payments to Allocated Costs for All Levels of Government

Vehicle Class	Federal	State	Federal and State	Local	All Levels of Government
Autos	0.9	1.0	1.0	0.1	0.7
Pickups and Vans	1.2	1.2	1.2	0.1	0.9
Buses	0.1	0.8	0.5	0.0	0.4
All Passenger Vehicles	1.0	1.0	1.0	0.1	0.8
Single Unit Trucks					
#25,000 pounds	1.4	2.2	1.9	0.1	1.5
25,001 - 50,000 pounds	0.6	1.0	0.8	0.0	0.6
>50,001 pounds	0.5	0.5	0.5	0.0	0.4
All Single Unit Trucks	0.8	1.2	1.1	0.1	0.8
Combination Trucks					
#50,000 pounds	1.4	1.7	1.6	0.1	1.3
50,001 - 70,000 pounds	1.0	1.3	1.1	0.1	0.9
70,001 - 75,000 pounds	0.9	1.1	1.0	0.1	0.8
75,001 - 80,000 pounds	0.9	0.9	0.9	0.1	0.8
>80,000 pounds	0.6	1.0	0.9	0.0	0.7
All Combinations	0.9	1.0	0.9	0.1	0.8
All Trucks	0.9	1.1	1.0	0.1	0.8
All Vehicles	0.9	1.0	1.0	0.1	0.8

NOTE: These ratios are based on total revenues and expenditures nationwide. Ratios for individual States and local governments are expected to vary from these ratios. Federal ratios include obligations not financed from the HTF, and thus vary from equity ratios presented in other tables.

Other Highway-Related Costs

In recent years there has been increasing interest in estimating the total costs of highway transportation, not just the direct agency costs. Executive Order 12893, "Principles for Federal Infrastructure Investments," requires that Federal infrastructure investment and management plans be based upon a systematic analysis of expected benefits and costs. Among the social costs of greatest interest to HCA and highway pricing decisions are congestion, air pollution, noise, and crash costs.

Data and analytical tools developed in other studies were adequate to assess costs associated with safety, noise, congestion, and many other social costs of highways, but published studies on air pollution costs were not available in time to be used for this report. Because air pollution costs are so important in assessing both total and marginal costs of vehicle emissions, the Department currently is working closely with the Environmental Protection Agency (EPA) to estimate air pollution costs of highway travel. The

Department will present those costs in an addendum to this report. The Intergovernmental Panel on Climate Change (IPCC) concluded that it could not endorse any particular range of values for the marginal damage of CO_2 emissions on climate change, because of limited knowledge of impacts, uncertain future technological and socio-economic developments, and the possibility of catastrophic events or surprises. Because of the tremendous uncertainty in climate change costs, no estimates of costs related to highway transportation are developed for this study.

Detailed estimates of the benefits of highway use and highway investment are beyond the scope of this study although there were many comments that benefits should be included. As noted above, Executive Order 12893 requires that benefits as well as costs be considered in highway investment and regulatory decisions, and substantial research has been conducted in recent years to improve estimates of both the user benefits of highway investment as well as broader benefits of highways to the economic productivity of different industries. This research is summarized in Appendix D.

Social costs may be evaluated in different ways that each provide their own perspectives on policy issues surrounding the costs of highway transportation. One perspective is to examine marginal costs of travel by different vehicles. Marginal costs represent the added costs associated with an additional trip, and are particularly relevant for questions about prices that should be charged to improve economic efficiency.

Marginal Highway Costs

The 1982 Federal HCAS also estimated how highway costs would be allocated among vehicles to promote economic efficiency. In general, the closer the price of travel is to the total cost of that travel, the greater the efficiency. There are certain costs that highway users normally do not consider when deciding whether to make a trip, including government-borne costs of infrastructure deterioration and traffic services that vary with the amount of travel; user-borne costs, especially congestion and other costs that are imposed on other users when a user makes a trip; and community-borne costs, principally air pollution, noise, global warming, and crash costs that vary with the amount of travel. For the system to operate efficiently, users should pay those costs they do not otherwise consider when deciding to make a trip.

Table ES-6 shows current estimates of marginal pavement, congestion, crash, and noise costs for selected vehicles operating under different conditions. Marginal costs on rural and urban Interstate highways represent weighted averages of marginal costs estimated for a broad cross section of highways on those two systems. Estimates of air pollution costs reflecting the latest EPA research could not be completed in time to be included in this report, but will be included in an addendum to this report.

Total Costs of Highways

In addition to the interest in estimating marginal costs of highway use to estimate economically efficiency highway user fee levels, there is considerable interest in estimating total costs associated with highway transportation. This information is useful for several purposes, including (1) estimating the relative magnitude of various costs associated with highway transportation; (2) estimating how costs are changing over time, particularly in response to programs aimed at reducing environmental congestion and safety-related costs; and (3) evaluating overall costs and benefits of alternative public policies such

Table ES-6. 2000 Marginal Pavement, Congestion, Crash, Air Pollution, and Noise Costs for Illustrative Vehicles Under Specific Conditions						
	Marginal Costs (cents per mile)					
Vehicle Class/Highway Class	Pavement	Congestion	Crash	Air Pollution	Noise	Total
Autos/Rural Interstate	0	0.78	0.98	TBD	0.01	1.77
Autos/Urban Interstate	0.1	7.70	1.19	TBD	0.09	9.08
40 kip 4-axle S.U. Truck/Rural Interstate	1.0	2.45	0.47	TBD	0.09	4.01
40 kip 4-axle S.U. Truck/Urban Interstate	3.1	24.48	0.86	TBD	1.50	29.94
60 kip 4-axle S.U. Truck/Rural Interstate	5.6	3.27	0.47	TBD	0.11	9.45
60 kip 4-axle S.U. Truck/Urban Interstate	18.1	32.64	0.86	TBD	1.68	53.28
60 kip 5-axle Comb/Rural Interstate	3.3	1.88	0.88	TBD	0.17	6.23
60 kip 5-axle Comb/Urban Interstate	10.5	18.39	1.15	TBD	2.75	32.79
80 kip 5-axle Comb/Rural Interstate	12.7	2.23	0.88	TBD	0.19	16.00
80 kip 5-axle Comb/Urban Interstate	40.9	20.06	1.15	TBD	3.04	65.15

NOTE: (1) S.U. = Single Unit, Comb. = Combination; (2) Costs reflect middle range.
(3) TBD - To be determined. Air pollution costs will be estimated in an addendum to this report.
(4) Total excludes air pollution costs.

as investment, regulatory, and pricing policies. Estimates of noise, congestion, and crash costs total $406 billion for 2000. Crash costs represent 84 percent of these social costs, congestion 15 percent, and noise 1 percent. About 88 percent of these social costs are borne in the first instance by highway users including congestion costs and most crash costs. While social costs that are not borne by users are a relatively small percentage of the total, they nevertheless are significant -- $50 billion in 2000. Estimates of total air pollution costs will be included in an addendum to this report and will increase the total social costs borne by non-users.

Potential User Fee Changes to Improve Equity

A number of general user fee options designed to improve Federal user fee equity as traditionally defined without considering social costs were analyzed in this study. Four options involving changes to existing user fees and two changes that would require imposing new fees are summarized in this report. Options involving existing user fees include raising the diesel differential by 1 cent and 6 cents per gallon, eliminating the cap on the HVUT, and adjusting the rate schedule on the HVUT along with lifting the cap. New user fee options include imposing a weight distance tax (WDT) and an axle-WDT. Table ES-7 shows the alternative Federal user change structures for 2000. These alternatives offer

Table ES-7. 2000 Ratios of User Charges to Allocated Costs by Vehicle Class Under Alternative Federal User Charge Structures							
Vehicle Class	**Current Structure**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Autos	1.0	1.0	0.9	1.0	0.9	0.9	0.9
Pickups/Vans	1.4	1.4	1.3	1.4	1.3	1.3	1.3
Total Single Unit	0.9	0.9	1.0	0.9	1.2	0.9	1.0
Total Combinations	0.9	0.9	1.0	0.9	1.0	1.0	1.0
Total All Vehicles	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Scenario 1 -- Increase diesel differential by 1 cent
Scenario 2 -- Increase diesel differential by 6 cents
Scenario 3 -- Eliminate cap on HVUT
Scenario 4 -- More progressive HVUT rate structure
Scenario 5 -- WDT and motor fuel in place of other truck taxes
Scenario 6 -- Axle-WDT and motor fuel in place of other truck taxes

varying flexibility in addressing the cost responsibility issues of vehicle weight and VMT outlined in the following scenarios:

- Scenario 1: Adding 1 cent per gallon to the diesel differential would reduce the underpayment of heavy trucks, but is not sufficient to be reflected in improved equity ratios for those vehicles.

- Scenario 2: Adding 6 cents per gallon to the diesel differential would reduce underpayment and improve the equity ratios for trucks, but it would not eliminate the underpayment by heavier trucks.

- Scenario 3: Eliminating the cap on the HVUT for all vehicles registered above 75,000 pounds would reduce underpayment by the heaviest vehicles reduce underpayment by the heaviest vehicles but would do nothing to improve equity ratios for trucks registered at weights less than 75,000 pounds.

- Scenario 4: Creating a two-tier HVUT structure for single units and combinations with more progressive rates for the heaviest trucks could reduce underpayment by trucks as a group, but it increases inequities between low mileage and high mileage vehicles.

- Scenario 5: Introducing a WDT can better address the vehicle weight and mileage problem than the above-mentioned tax scenarios and the current Federal user fee structure. A weight and distance oriented highway tax structure provides more flexibility to the current tax structure. The equity ratios for trucks, including heavier/high mileage trucks, improves as compared to current user-fee structure.

- # Scenario 6: Imposing an axle-WDT provides more flexibility to address vehicle weight and mileage factors, and improves the equity ratios of trucks, including heavier/high mileage trucks as compared to the current Federal structure.

While a Federal WDT could not account for every factor that affects heavy vehicle cost responsibility, it could account for the major influences, vehicle weight and distance traveled. In its 1994 study, *Highway User Fees: Updated Data Needed to Determine Whether All Users Pay Their Fair Share*, the General Accounting Office recommended, "If the results of FHWA's (highway cost allocation) study indicate that certain highway users underpay their share of highway costs, the Congress should consider examining policy options, including a national weight-distance user fee, that would increase equity and promote a more efficient use of the nation's highways."

Federal WDTs were examined in the Department's 1984 Report to Congress, *Alternatives to Tax on Use of Heavy Trucks and in the 1988 Report, The Feasibility of a National Weight-Distance Tax*. The latter study concluded that "...administrative and compliance costs for a national WDT would not be prohibitive, nor would there be significant adverse impacts on interstate commerce or on other industries." Overall administrative and compliance costs would depend on exactly how a WDT were administered and how many vehicles were subject to the tax. The study concluded that acceptable levels of compliance could be achieved if a proof-of-payment system similar to the existing system for the HVUT were implemented, and noted that mileage records that most carriers already maintain should be adequate to comply with a WDT. While WDTs have been very controversial at the State level and only five States currently impose such taxes, there is no reason to believe that the basic conclusions about the administrative feasibility of a Federal WDT have changed since the 1988 report was completed.
A Federal WDT would have to be considered within the context of major revisions to the Federal highway user fee structure. The 1988 study assumed that existing Federal truck taxes would be eliminated if a WDT were imposed, and the illustrative tax rates developed for this study were based on the same assumption. Current budgetary environment is not conducive to user fee increases. Revenue-neutral changes in Federal user fees could be developed that would improve overall equity, while this would necessitate reducing Federal fuel tax rates.

Study Conclusions

Many factors that affect the equity and efficiency of the highway user fee structure have changed since the last 1982 Federal HCAS. User fees have been modified several times, the composition of the highway program has changed, and the use of the highway system for personal and freight transportation has changed. These changes are reflected in equity ratios estimated for the various classes of vehicles analyzed in this study. In general, the overall equity of highway user fees as measured by ratios of Federal user fees paid by different vehicle classes to their shares of Federal HTF obligations, has improved since 1982. However, improvements within and among vehicle classes could be realized with changes to the current user fee structure.

Decisions that could significantly affect estimates of future highway cost responsibility will be made soon. The first decision is the reauthorization of surface transportation programs. This study has assumed that the distribution of program costs will be similar to the current distribution, but if major changes were made in reauthorization, these assumptions would no longer be valid and future distributions of highway cost responsibility could change significantly. The second factor that could significantly affect decisions regarding potential Federal user fee changes to improve equity is the uncertainty regarding future TS&W policy. If any changes in TS&W policy were proposed, cost recovery issues should be examined, and if any significant changes in TS&W limits are implemented, user fee options, including the potential for significantly improving user fee equity through a national WDT, could be evaluated. Table ES-8 summarizes key findings in this 1997 Federal HCAS.

More frequent cost allocation studies in the future would provide valuable information not only about user fee equity but also intermodal subsidy issues, changes in social costs of highway transportation, and other policy issues. Several States routinely update their HCASs, and the same will be done for Federal cost allocation. Periodic updates would allow emerging issues to be analyzed in a timely fashion, much in the same way that the Department's C&P Report has considered emerging issues in recent years. Further, additional research is planned to refine estimates of social costs of highways, the economic efficiency of alternative user fee structures, continuation of improvements to pavement distress analyses, and other technical improvements to various aspects of HCA that will allow continuous improvement in estimates of highway-related costs and user fee payments by different vehicle classes that can inform user fee and other policy decisions.

Table ES-8. Summary of Key Findings in the 1997 Federal HCAS
T Passenger vehicles (autos, pick-ups, vans) travel 93 percent of all VMT, account for 96 percent of all vehicles and will pay about 64 percent of all Federal highway user fees in 2000. Trucks on average pay almost 10 times more Federal highway user fees per mile of travel than passenger vehicles.
T Overall, the Federal user fee structure is more equitable today than it was in 1982. Changes in the composition of the Federal highway program and changes in Federal user fees account for most of the difference.
T Passenger vehicles are expected to overpay Federal user fees by about 10 percent, while single unit and combination trucks will underpay by about 10 percent in 2000. These averages, however, mask inequities among vehicles. For example, while automobiles pay their share of highway costs, pickups and vans overpay. In virtually all truck classes the lightest vehicles pay more than their share of highway costs and the heaviest vehicles pay considerably less than their share of costs.
T In general, the more axles under heavy vehicles, the lower their highway cost responsibility at any given weight and the more closely they come to paying their highway cost responsibility.
T State governments collect over two-thirds of total HURs and the equity of their user fee structures strongly affects the overall equity of user fees collected by all levels of government. Federal user fees are somewhat more equitable than average State user fees for lighter vehicles, but State user fees on average come somewhat closer to capturing the cost responsibility of the heaviest truck classes.
T Increasing the diesel differential or eliminating the $550 cap on the HVUT could result in incremental improvements to user fee equity. Modifications to the HVUT rate schedule or new taxes such as a WDT or axle-WDT could result in larger gains in equity.
T Safety, congestion, environmental, and other social costs of highway use remain large despite significant progress in reducing those costs through regulatory and highway improvement programs. Imposing charges to reduce those costs holds promise, but many social costs are highly localized and are more amenable to local pricing rather than pricing at the Federal level.

I. Study Background, Objectives, Scope, and Approach

Background

This document represents the first Federal HCAS in more than 15 years. The last Federal HCAS was completed in 1982 pursuant to the Surface Transportation Assistance Act of 1978 (STAA). As directed by the STAA, the 1982 Federal HCAS focused on estimating the responsibility of different vehicle classes for Federal highway program costs and evaluating the equity of Federal user fees in terms of whether different vehicle classes were paying a proportionate share of highway program costs for which they were responsible.

No comprehensive review of Federal highway user fee equity has been conducted since the 1982 Federal HCAS. Meanwhile, the composition of the Federal-aid highway program has changed substantially, as have Federal highway user fees. An important reason for undertaking this 1997 Federal HCAS was to determine how changes in the Federal highway program and user fees that support that program have affected the equity of the Federal highway user fee structure.

In addition to updating analyses of Federal user fee equity conducted in the 1982 Federal HCAS, the 1997 Federal HCAS addresses issues that were not covered extensively in the 1982 Federal HCAS, including the responsibility of different vehicle classes for external costs associated with highway use and for highway program costs for all levels of government. These issues are particularly important in understanding the extent to which total Federal, State, and local highway user fees paid by each vehicle class cover overall highway-related costs occasioned by that vehicle class.

Another important reason for conducting a Federal HCAS at this time is that the U.S. DOT also has a Comprehensive TS&W Study underway. Among the factors that must be considered in the TS&W Study are whether various truck classes pay the highway costs they occasion under existing TS&W limits, how potential changes in TS&W limits might affect highway infrastructure and related costs, and potential changes in highway user fees that might be desirable to cover changes in highway cost responsibilities of different vehicle classes.

What Is Highway Cost Allocation?

The HCA is the assignment of highway-related costs to various classes of highway users (and sometimes non-users), usually to estimate the share of highway costs that various users pay and to evaluate the equity of highway user fees. The Federal Government and about half the States have conducted HCASs over the years. In 1956 and again in 1978 Congress mandated that Federal HCASs be conducted to evaluate the equity of the Federal highway user fee structure. The 1978 mandate also required that alternative highway user fee structures be evaluated to identify options that could improve overall user fee equity.

The Federal highway construction program and most State highway programs are financed primarily from various taxes and fees imposed on highway users. This direct connection between highway user fees and highway program costs is central to most HCASs. In general, the closer the match between user fees and highway cost responsibilities for each vehicle class the more equitable the user fee structure. Cost allocation studies often examine alternative highway user fee structures that could bring user fee payments by each class closer to that user's highway cost responsibility.

All recent Federal and State HCASs have used a "cost-occasioned" approach to allocate costs among vehicle classes. In the cost-occasioned approach, physical and operational characteristics of each vehicle class are related to expenditures for pavement, bridge, and other infrastructure improvements. Details of how the cost-occasioned approach is applied vary somewhat among studies, but the same underlying principles apply. The cost-occasioned approach is discussed in detail in Chapter V.

In addition to the cost-occasioned approach for allocating highway costs among vehicle classes, other approaches have been discussed for estimating highway user fees that different vehicles should pay. One approach would allocate costs according to the relative benefits realized by different vehicle classes from highway investments. The greater the benefits, the greater the share of user fees a vehicle class should pay, regardless of its contribution to highway costs. Benefits-based cost allocation was discussed in the 1961 Federal HCAS, but was not fully developed or used. Another approach would charge vehicles according to environmental, congestion, pavement, and other marginal costs associated with their highway use. Unlike other approaches the objective of the marginal cost approach is not to assign all highway agency expenditures to different vehicle classes, but rather to estimate user fees that would cover marginal costs of highway use by different vehicle classes. However, the marginal cost approach could be adapted to recover full agency costs. Neither the benefits approach nor the marginal cost approach have ever been completely applied in a major study.

The HCA has evolved over the years as the nature of the highway program has changed, as data and analytical tools available to attribute costs and revenues to different users have improved, and as the scope of policy concerns related to HCA have expanded. Each successive Federal HCAS has developed improved data and analytical methods and has attempted to add more precision by allocating costs for more detailed cost categories. As the scope of highway programs has expanded to include pedestrian, bicycle, transit, and intermodal improvements, the scope of HCASs has expanded as well.

The focus of previous Federal and State HCASs has been on determining an equitable distribution of highway agency costs among different groups of highway users. Recently there has been growing interest in external costs of highway use and operation, including environmental, congestion, crash, and various other social costs. Highway users currently do not directly pay those costs, although they contribute to reducing some external costs through their payments for environmental and safety equipment on automobiles, and through user fees that are expended for noise barriers, wetlands protection, landscaping, and other improvements to mitigate social, economic, and environmental costs of highways. State HCASs have not considered external costs, but the 1982 Federal HCAS compared user fees paid by different vehicle classes to marginal air pollution, noise, and congestion costs to evaluate the economic efficiency of highway user fees. In general, the closer that each vehicle's user fee payments come to its marginal highway costs, the more economically efficient the user fee structure. In the current study, analyses of external highway-related costs are extended further to consider total external costs attributable to different vehicle classes and potential policy implications of those costs.

Recent Studies Related to Highway Cost Allocation

Several studies have recently been conducted related to HCA issues. Major Federal studies are summarized below along with a study comparing various approaches to cost allocation that was conducted by the Trucking Research Institute (TRI) of the American Trucking Associations (ATA). Recent State HCASs are summarized in Appendix G.

1982 Federal Highway Cost Allocation Study

Between 1979 and 1982, the U.S. DOT conducted a Federal HCAS pursuant to Section 506 of the STAA of 1978. The purpose of the 1982 Federal HCAS was to allocate Federal highway program costs among the various classes of vehicles occasioning those costs, to assess the equity of the existing Federal user fee structure, and to recommend changes in Federal highway user fees that could improve overall equity. The 1982 Federal HCAS was in many ways a seminal study because it developed new and sophisticated procedures for allocating system preservation costs that previously had not been considered in Federal cost allocation studies. Also, the 1982 study explicitly recognized that highway user fees could help promote economically efficient use of the highway system and compared user fees to marginal costs of highway use including environmental and congestion costs that had not been considered in previous cost allocation studies.

The new method developed in the 1982 Federal HCAS for allocating pavement 3R costs is frequently called the "consumption method" because it allocates costs of those improvements based upon the degree to which different vehicle classes "consume" the pavement's strength and contribute to its deterioration. Estimates of the contribution of vehicle axle loads to each of the principal pavement distresses that necessitate 3R improvements were developed, and these relationships were used to allocate 3R improvement costs among different vehicle classes.

Fundamental changes were also made to the allocation of new pavement costs. The 1965 Federal HCAS had used an incremental method that allocated the costs of additional pavement thickness to vehicles that were judged to require the additional thickness because of their heavier axle loads. Because the relationship between pavement thickness and pavement strength is not linear, costs to provide the last increment of thickness to accommodate the heaviest vehicles were much lower than the costs to provide the first increments that were assigned to light vehicles. Heavy vehicles thus unfairly benefited in terms of allocated pavement costs from the inherent economies of scale in pavement design. The 1982 Federal HCAS corrected this inequity by allocating new pavement costs to all vehicles in proportion to their equivalent single axle loads (ESALs), a measure of the relative effects of different axle loads on pavement life. Thus no vehicles benefited more than others from the economies of scale in pavement design.

The 1982 Federal HCAS allocated agency costs for two different periods, a base period of 1976-1978 and a forecast period, 1980-1990, with a target year of 1985. Results were also presented for 1990 and 1995. Revenues in the base period were 1977 Federal user charge payments, whereas revenues for the forecast period were expected 1985 payments under alternative Federal user charge structures. Costs in the base year were Federal expenditures from the HTF; forecast period costs consisted of the expected Federal share of projected average annual highway capital improvement costs for all levels of government for the 1980-1990 period.

Analyses for the 1982 Federal HCAS were conducted using 38 vehicle classes representing 15 different vehicle configurations with up to 4 weight groups per class, and the results were reported for 12 classes. Analyses were further disaggregated into eight highway classes, Interstate Highways, other arterials, collectors, and local roads in rural and urban areas.

A key issue in the overall analysis was determining the share of total costs attributable to various vehicle classes. Costs that were not directly attributable to the various classes of vehicles were treated as common or residual costs and were allocated to all vehicle classes based on their relative VMT. Attributable costs represented 53.3 percent of the total costs for the forecast period and common costs represented the remaining 46.7 percent of costs. For the forecast period autos and motorcycles were found to be responsible for 16.8 percent of attributable costs and combination vehicles 56.9 percent with the remaining 26.7 percent attributable to other vehicles (single-unit trucks and buses).

Other key issues that the 1982 Federal HCAS addressed include:

- Ratios of current user charges to allocated costs.
- Alternative user charge structures that apply to gasoline, diesel fuel, lubricating oil, tires, inner tubes, new vehicles, parts and accessories, and heavy vehicle use.
- Economic effects of user fee alternatives on different sectors of the economy.
- Ease of tax administration.
- Comparisons of alternative user charge structures to the current one and expected changes on the number of vehicles affected, as well as impacts on vehicle ownership and operating costs.
- The role of long term pavement monitoring in HCA.

Several potential changes to highway user fees were considered by the study, including:

- Increasing the tax on diesel fuel to reflect the greater fuel efficiency of diesel fuel relative to gasoline and, optionally, as a possible substitute for the HVUT.
- Indexing the gasoline, diesel-fuel and special-fuel taxes for inflation.
- Various changes in the excise tax on new trucks that would increase the tax on most of the heaviest power units and reduce or eliminate the tax on lighter units, piggyback trailers, and, perhaps, other trailers.
- Changes to or elimination of the tax on truck parts and accessories.
- Revisions to the HVUT that would include rates that are graduated with gross vehicle weights (GVW), a higher weight threshold, indexing for inflation, and State assistance in collecting the tax.
- Changes to or elimination of the taxes on tires, tubes, and tread rubber.

- # Elimination of the tax on lubricating oil.

- # Introduction of a WDT.

Unpublished analyses after the 1982 study considerably expanded the scope of alternatives examined. In connection with legislative debate on the STAA, the Federal Highway Administration (FHWA) and U.S. DOT recommended simplifying the previous package of user fees, and replacing the fixed annual HVUT with a higher fee that would have varied depending upon miles traveled — heavy vehicles traveling less than 90,000 miles per year would have paid a prorated share of the annual fee. The final user fee package adopted by Congress substantially increased the HVUT but did not include a provision for prorating the fee by mileage. Although this aspect of the new user fees was not as equitable for low-annual-mileage heavy vehicles, by and large the new user fee package resulting from the 1982 study simplified highway user fees and improved equity.

Alternatives to Tax on Use of Heavy Trucks

A study, *Alternatives to Tax on Heavy Vehicles,* was called for in Section 513(g) of the STAA. The study examined potential alternatives to the HVUT which had been raised substantially in that Act. Alternative bases upon which to levy heavy truck taxes were considered, including vehicle size, vehicle operating weight, and distance traveled, all of which affect the highway cost responsibility of different vehicles. The study analyzed several "diesel differential" alternatives that would increase the fuel tax paid by diesel vehicles with GVWs above 10,000 pounds and reduce or eliminate the HVUT for various classes of vehicles. The study also analyzed WDT alternatives that would replace the HVUT, and possibly the vehicle excise and tire taxes as well, using either a single rate schedule (based on registered GVW) for all vehicles or separate schedules for single-unit trucks and combinations.

The Section 513(g) Study report concluded that, in the short term, the equity of the user fee structure could be improved somewhat by reducing the HVUT and instituting a diesel differential tax. However, the study concluded that major improvements in equity were not possible within the existing user fee structure because existing user fees do not directly reflect the two principal variables affecting cost responsibility — weight and distance traveled. The report recommended continued investigation of the benefits and potential implementation problems of a WDT as a possible long-term solution.

Heavy Vehicle Cost Responsibility Study

The Deficit Reduction Act of 1984 (DRA) called for a *Heavy Vehicle Cost Responsibility* Study which concluded that most pavement costs are directly related to heavy vehicles, and that axle loads are more important than gross weight in determining a vehicle's pavement cost responsibility. This study analyzed highway cost responsibility and user fee payments by 14 different truck configurations in 25 weight brackets, using 5,000-pound increments. The study concluded that:

- # As a group, trucks with taxable weights over 80,000 pounds pay less than their share of highway costs.

- # For each configuration, the share of highway costs covered by user fee payments declines with increasing weight.

- # Six-axle tractor-semitrailers and multi-trailer combinations with 7- or more axles may pay their share of highway costs at weights somewhat above 80,000 pounds.

- # Twin-trailer combinations with 9- or more axles may pay their share of costs at weights up to about 120,000 pounds.

- # Analyses of TS&W policy should pay particular attention to the effects of policy changes on axle loads.

- # Changes in the way Federal funds are allocated to highway systems could have a significant effect on the relative responsibility of different vehicle classes for Federal highway expenditures.

Feasibility of a Federal Weight Distance Tax

The DRA also called for a study of the *Feasibility of a Federal Weight-Distance Tax*. That study analyzed three versions of a WDT: a registered gross vehicle WDT; a registered axle WDT; and a configuration-based gross vehicle WDT. The study evaluated two administrative plans for these taxes: administration by the Federal Internal Revenue Service (IRS), and State administration under Federal guidelines and regulations. The study also considered a system consisting of the HVUT and the fuel tax, with no other Federal truck taxes.

The study findings covered administrative costs, compliance costs, evasion potential, impacts on Interstate commerce, and the equity of WDTs. The study found that administrative costs will vary based on the weight threshold of the tax and the payment procedures. To minimize costs, a threshold of 55,000 pounds could be adopted, along with periodic payments through a Federal tax deposit (FTD) system, and a single WDT return. The IRS estimated that administrative costs would be from 14 percent less to 26 percent more than the current tax structure, depending on the type of tax and level of examination coverage.

The study concluded that if a WDT replaced the vehicle excise tax, tire tax, and HVUT, and were administered through an FTD system, carriers' compliance costs would not significantly increase relative to compliance costs associated with the HVUT. The study also concluded that while potential WDT evasion needed additional analysis, evasion did not appear to be such a significant problem that it would make a WDT infeasible. Further, the study concluded that a WDT would have no significant impacts on interstate commerce and could improve equity.

Finally, the study concluded that a Federal WDT was feasible from the standpoint of administrative costs and enforcement, but that additional analysis of the cost responsibility of different vehicles operating at different weights was necessary before such a tax could be implemented.

Trucking Research Institute Review of Highway Cost Allocation

This study, sponsored by the ATA , TRI, sought to assess alternative methods for conducting HCASs, provide guidelines for conducting such studies, and offer improvements that should be made in the methods and data.

The study compared and contrasted four HCA methods:

i. Benefits Based (allocating cost responsibility in proportion to the benefits).
ii. Incremental (the methods used in the 1965 Federal HCAS).
iii. Federal (the methods used in the 1982 Federal HCAS, also called the "consumption method").
iv. Marginal Cost (changes based on congestion costs and pavement damage costs).

The TRI study concluded that under all four methods, the relative cost responsibility of heavier vehicles is greater than that of light vehicles. However, the differences in relative cost responsibility among heavy and light vehicles are much less under the benefits-based approach than under the incremental or Federal methods. The differences in relative cost responsibility per mile among vehicle classes under the marginal cost method are also smaller than under the incremental or Federal methods, although all vehicle classes would pay much higher total user fees than they do today.

The study concluded further that it is desirable to use different methods in performing cost allocation studies to permit comparisons and to help inform public and political debate.

Finally, the study included guidelines for conducting HCASs. Among the more important suggestions were the following:

- Use a long-range forecast period for HCA.

- Use optimal pavement designs that minimize life-cycle costs as a basis for pavement cost allocation.

- Modify the allocation of pavement rehabilitation costs under the incremental method.

- Include in HCASs revenues derived entirely or mainly from highway users and highway-related program expenditures regardless of the agency responsible.

1997 Federal Highway Cost Allocation Study Outreach

Numerous opportunities for public comment on the 1997 Federal HCAS scope and methods were provided during the course of the study. Two workshops were conducted, one at the very inception of the study and one during the middle of the study. A Notice was published in the Federal Register seeking comments on the study work plan and specific study issues. Formal and informal briefings were conducted with interested parties during the study. A particularly important element of the outreach process was the establishment of a Peer Review Committee through the Transportation Research Board (TRB) to provide a mechanism for independent and expert review of key technical elements of the study. The first HCAS workshop was conducted in October 1994 in cooperation with the AASHTO. The primary purpose was to discuss emerging issues that should be considered in the Federal HCAS. Over 75 persons representing interested Federal agencies, State Departments of Transportation, industry groups, consulting firms, and academic institutions attended the 2-day workshop. Participants discussed implications of legislative changes since 1982 that have affected the composition of the Federal-aid highway program and user fees supporting that program.

Several participants at the October 1994 workshop recommended that a committee of experts be established to review technical work on the cost allocation study. In 1995, a committee of nationally recognized authorities on pavements, bridges, transportation economics, and transportation policy analysis was established by the TRB to review technical and other aspects of the study. The committee met four times during the course of the study and submitted two letter reports to the Federal Highway Administrator summarizing discussions of key technical issues being addressed in the study. Subcommittees were established to provide more detailed review of several technical issues including pavement and bridge analysis, the estimation of external costs of highway transportation, applications of marginal cost and external cost concepts to highway finance decisions, and considerations of cost allocation for all levels of government. Liaison members of the committee included representatives of the U. S. DOT, ATA, Association of American Railroads, and AASHTO. The Peer Review Committee commented on early drafts of technical sections of the final report, but did not review or comment on study conclusions.

The second cost allocation study workshop, held in December 1995, summarized study progress to that point and outlined in detail methods being used to address various technical aspects of the study. Also, the Chairman of the TRB Committee, Dr. David Forkenbrock, summarized committee activities. Breakout sessions were conducted during the workshop to give everyone greater opportunity to discuss issues or concerns.

Highway Cost Allocation Study Issues

There was a strong sense from many participants at the HCA workshops that this study should not simply update the 1982 Federal HCAS. Changes in the highway program since 1982 included: (1) the creation of a National Highway System (NHS), (2) the increased flexibility provided by the ISTEA to fund transit, intermodal projects, and other State and local priorities, and (3) increased concern that external and other social costs of highway use and operation all affect HCA and all need to be thoroughly considered in the study. The workshop participants discussed relationships between Federal HCA and the allocation of highway program costs across all levels of government, and implications of multimodal investment programs for HCA. Participants believed that analyzing these emerging issues would enrich the report and its usefulness for a variety of policy analyses. There was consensus, however, that significant attention should be paid in the final report to traditional HCA issues related to evaluating the equity and economic efficiency of Federal highway user fees. The comparison of highway user fee payments by different vehicle classes with HTF outlays attributable to those vehicles is still believed to be a valuable indicator of the equity of the highway user fee structure that is understood by decision makers in the executive and legislative branches at both the Federal and State levels of government.

Participants noted that previous Federal and State HCASs have focused considerable attention on analyzing the responsibility of different vehicle classes for pavement, bridge, and other highway agency costs. Methods for attributing costs to different vehicle classes have evolved over time, but generally have followed a "cost-occasioned" philosophy. Engineering and economic studies have been conducted to estimate the extent to which various vehicle classes contribute to highway costs because of their weight, axle loadings, width, length, or other physical or operational characteristics. For instance, a vast body of research has demonstrated the relationship between axle loads and pavement wear. Heavy axle loadings contribute significantly to costs for rehabilitating and reconstructing pavements, and anticipated axle loadings also are major factors influencing the design thickness of new pavements. All pavement costs cannot be attributed to vehicles based upon their relative axle loadings. However, analytical methods are being refined to estimate shares of pavement improvement costs that are load-related and shares that should be allocated to vehicles based on other factors. Likewise, research has been conducted to allow costs for other types of highway improvements to be assigned to different vehicle classes based on characteristics of each vehicle class that influence costs.

In the 1982 Federal HCAS many costs were lumped together as “common costs” and allocated to different vehicle classes in proportion to the VMT for each vehicle class. Participants at the October 1994 HCA workshop discussed the desirability of reducing the number of cost categories treated as common costs. They believed that careful analysis would allow many of those costs to be attributed to the various vehicle classes based on characteristics of the different vehicle classes and their operations. Participants also discussed whether VMT is necessarily the best allocator for costs that truly are common.

Workshop participants discussed a number of issues concerning how various highway user fee issues should be treated in the HCAS. Federal HURs have been dedicated for transit improvements since 1982 when the STAA established the MTA in the HTF and 1 cent of the Federal fuel tax was deposited to that account for use in Federal transit assistance programs. Since then, an additional 1 cent per gallon of Federal fuel tax revenues has been dedicated to the MTA. The 1982 Federal HCAS report did not explicitly allocate costs of transit programs since, at the time, virtually no Federal HURs were expended on transit projects except for very small amounts of Federal-aid Urban System monies.

Many workshop participants believed that with the passage of ISTEA, future expenditures for transit improvements from the HTF may increase, as well as projects to improve air quality and to fund transportation enhancements that previously may not have been eligible for Federal participation. Attributing some such costs to different vehicle classes may be difficult under traditional cost-occasioned philosophies, and new rationale for allocating those costs among highway users may have to be developed.

Participants noted that the evaluation of highway user fee options must consider how each user fee contributes to equity, efficiency, and other policy objectives. Equity is important both across user groups and for vehicles within the same user group. Economic efficiency generally is improved when fees that vehicles pay reflect the full costs associated with their operations including environmental and other external costs. Many consider marginal cost pricing to be impractical to implement at the Federal level, but there may be opportunities to improve the efficiency of the Federal highway user fee structure without implementing full marginal cost pricing. Relationships between equity and efficiency in highway taxation and opportunities to improve both the equity and the efficiency of the user fee structure are considerations in evaluating user fee alternatives.

Over the years there have been suggestions that highway user fees be used to achieve air quality, energy, land use, and other broad social, economic, and environmental objectives. In 1990 and again in 1993, a portion of Federal taxes on transportation fuels was dedicated for Federal budget deficit reduction. This was the first time that Federal highway user fees had been diverted from transportation programs. Some workshop participants also raised questions about the treatment of some enhancements that may only loosely serve highway-related purposes.

Another issue raised at the October 1994 HCA workshop and in meetings of the TRB Peer Review Committee was the allocation of highway costs across all levels of government. An important reason to examine cost responsibility for highway program expenditures at all levels of government is to evaluate the overall level of subsidies that may accrue to different vehicle classes. Some vehicles may pay less than their proportionate share of Federal highway user fees but more than their proportionate share of State user fees, leaving them paying very close to the share of overall highway costs for which they are responsible.

Other vehicle classes may pay less than they should at both the Federal and State levels while other classes may pay more than they should at both the Federal and State levels. While there may be no immediate changes in user fees that would be feasible or necessarily desirable to reduce cross subsidies among vehicle classes, knowing the nature and magnitude of those cross subsidies is important in making other policy decisions, particularly decisions affecting competition with other modes.

Another important reason for analyzing cost responsibility for highway program expenditures by all levels of government is to improve our understanding of how changes in the Federal highway program might affect Federal cost responsibility and equity by vehicle class. Federal-aid highway funds traditionally have been used primarily for capital improvements on the highest order highway systems. While this is still true, ISTEA granted State highway agencies greater flexibility in the use of Federal-aid highway funds. For instance, preventive maintenance on NHS highways is now an eligible activity, and a variety of demand management strategies and transportation enhancements also are eligible for Federal funds. Analyzing cost responsibility for highway expenditures at the State level will provide a basis for estimating how changes in the composition of the Federal-aid highway program might affect the cost responsibility of different vehicle classes for future Federal program expenditures. It will also provide insight on how States have allocated costs for certain items that have not been considered in previous Federal HCASs.

Relationship Between the Federal Highway Cost Allocation and Comprehensive Truck Size and Weight Studies

The U.S. DOT currently is conducting a Comprehensive TS&W (1997 U.S. DOT TS&W) Study to evaluate potential impacts associated with a range of TS&W policy scenarios. There is a close relationship between the Federal HCA and the TS&W Studies. Many of the same infrastructure, environmental, and traffic operations impacts are being evaluated in both studies, although for somewhat different purposes. Many of the costs estimated in the HCAS will be used in analyzing impacts of TS&W scenarios. Any policy changes that might alter the mix of truck configurations operating on the Nation's highways may also affect highway costs and the cost responsibility of different vehicle classes.

There has been a longstanding Federal position that increases in highway costs resulting from TS&W policy changes should be recouped to the extent possible through increased user fees on those vehicles causing the added costs. The U.S. DOT Freight Policy Statement reiterates this user pays principle — "Whenever feasible, fees and taxes adequate to cover the cost of building, operating, and maintaining public infrastructure facilities should be recovered from the parties that use and benefit from them." The HCAS and related highway revenue analyses thus must anticipate the kinds of policy options that will be addressed in the TS&W Study and factors related to those policy options that may affect infrastructure and external costs.

Close coordination with the TS&W Study was maintained throughout the HCAS. Analytical tools developed for the HCAS will be used to estimate infrastructure, environmental, and other costs attributable to different vehicle configurations. Since vehicle configurations that currently are seldom used may become attractive under some TS&W policy options, provisions were made in the HCAS to analyze the cost responsibility of these vehicle configurations even though they currently are not widely used. Annual travel and other operating characteristics of new vehicle configurations will be estimated in the TS&W Study, while HCAS tools will be used to estimate cost responsibility and user fee payments based on operating characteristics of the new configurations. The 1997 Federal HCAS developed tools to analyze new user fee or permit fee options that could equitably recoup added highway costs associated with operations under TS&W policy alternatives.

External and Other Non-Agency Costs

Executive Order 12893, "Principles for Federal Infrastructure Investments," calls for a systematic analysis of expected benefits and costs of infrastructure investments. The Executive Order specifies that, "To the extent that environmental and other nonmarket benefits and costs can be quantified, they shall be given the same weight as quantifiable market benefits and costs."

The term "external costs" refers to costs of highway travel that are not borne by individual trip-makers, but that are imposed on other motorists, public agencies, or society as a whole. External costs include congestion costs imposed on other travelers, noise, air and water pollution, other environmental costs, certain safety-related costs, and a variety of other social and economic costs on different segments of the population. The TRB recently completed a study, *Public Policy for Surface Freight Transportation*, which examines the marginal external costs of freight transportation by different modes.

Because external costs are not borne by the driver, they are not factored into trip-making decisions. Many economists advocate trying to reflect those external costs in highway user fees. It may be difficult, however, to directly charge for some external costs of highway travel. Other options are available to reduce the severity of those costs. For instance, many highway agencies have aggressive programs to erect noise barriers where residences and other noise-sensitive land uses are exposed to high noise levels from passing vehicles. Likewise, there are requirements that highway agencies take measures to reduce air pollution, to restore wetlands taken for highway construction, and to mitigate other social, economic, and environmental impacts of highways. No estimates are available of the total costs of programs to mitigate external costs of highways, but they are substantial.

Changes in safety, environmental, and other external costs are important considerations in evaluating TS&W policy options. This study focused considerable attention on estimating external costs associated with different types of vehicles operating under different conditions. As with infrastructure costs, the analysis was conducted in such a way that external costs can be estimated for new vehicle configurations and new traffic mixes that must be analyzed in the TS&W Study. Changes in the number and severity of crashes generally will be estimated in the TS&W Study and information developed in the 1997 Federal HCAS will be used to estimate changes in the economic costs of crashes. Environmental costs associated with TS&W policy options generally will be estimated based on emission rates and economic cost factors developed in the 1997 Federal HCAS, while changes in the relative travel by different vehicle classes will be estimated in the TS&W Study.

Interest in external and other social costs of highway transportation extends beyond impacts associated with TS&W policy options. There is considerable interest in the external costs of automobile travel and in total costs of highway travel. Substantial controversy surrounds estimates of the total costs of highway transportation, and estimates of various types of costs may vary by an order of magnitude or more. The 1997 Federal HCAS did no original research into the economic costs of various externalities, but rather synthesized the state-of-the-knowledge of social cost analysis to estimate the relative magnitude of various social costs of highways and the range of uncertainty surrounding cost estimates.

There are several potential uses for information on external costs of highway use and operation. One is to estimate total marginal costs of highway travel in order to estimate efficient user fees. Issues of equity versus efficiency in highway taxation were discussed in detail in the 1982 Federal HCAS, although the STAA of 1978 had stipulated that equity was to be the primary basis for evaluating user fee alternatives. Efficient user fees generally reflect the marginal cost of highway travel. In general, when price (including user fees) equals marginal cost, net benefits to society are maximized and economic efficiency exists.

As suggested in Executive Order 12893, a second use of information on external costs of highway transportation is for infrastructure investment decisions. Executive Order 12893 emphasizes that all costs and benefits should be considered in infrastructure investment and management decisions. Knowledge of and concern about environmental, congestion, and other external costs of highway use has resulted in transportation agencies giving these factors greater consideration in overall program development and in project planning, design, and construction. The Congestion Mitigation and Air Quality (CMAQ) Improvement Program was established in ISTEA to focus funds on reducing congestion and improving air quality, and States are using increasing amounts of other Federal monies as well to mitigate adverse impacts of highway use.

The issue of "external" benefits of highway use was discussed at some length in meetings of the TRB Peer Review Committee. Economists generally believe that there are few if any true external benefits of highway use that are not directly considered by the personal or commercial traveler when deciding whether or not to make a trip. This is not to say, however, that benefits of highway investment accruing to communities and businesses should not be considered when decisions are made about highway funding levels and where and how the HURs should be spent. Care must be taken, however, not to double count benefits that accrue in the first instance to highway users and that are then passed on to others.

Considerable work recently has been done to estimate both the macroeconomic impacts of highway investment on the output of the overall economy and the microeconomic impacts of highway improvements on the productivity of firms in specific industries. Research in the last 5 years at the macro and micro levels shows that the return on investment on non-local highways during the 1980s was significantly higher than the prevailing rate of return on private capital investment. During the period 1980 to 1989, the latest years for which data are available, highway capital investments contributed between 7 and 8 percent to national productivity growth.

Future highway investment is expected to continue to contribute to increased economic productivity and to overall net benefits to society. Net benefits can be maximized, however, only if the external costs as well as the benefits of highway investment are considered in all phases of the program and project development process. A detailed analysis of highway benefits was beyond the scope of this study. The Department's Surface Transportation C&P Report considers highway user benefits in depth in estimating the incremental benefit cost ratios of different highway investments, and on-going FHWA research is examining relationships between highway investment and economic productivity in greater detail. Appendix D of this report discusses general considerations in the estimation of highway-related benefits and references recent studies.

Study Objectives and Scope

The scope and objectives of this Federal HCAS were strongly influenced by recommendations from the October 1994 HCA workshop. The primary objective of this study is to analyze highway-related costs attributable to different highway users as a basis for evaluating the equity and efficiency of current Federal highway user charges. This is consistent with objectives of previous Federal HCASs, although the current study examines certain items in greater detail than previous studies. The STAA of 1978 explicitly limited the scope of the 1982 Federal HCAS to examining Federal highway program costs paid from the HTF and the equity of Federal user charges. While there is no similar legislative direction on this study's scope, the extent to which Federal user fees paid by different vehicle classes correspond to Federal highway costs attributable to those vehicle classes remains an important policy issue and is a principal focus of the study. Environmental, safety, congestion, and other non-agency costs attributable to different vehicle classes are analyzed in detail for this study. Several other emerging highway policy issues that were outside the scope of the 1982 Federal HCAS also are considered in this study.

This study analyzes the various costs associated with highway use and operations, estimates costs attributable to different classes of highway users, and compares user fees paid by different users with highway-related costs for which they are responsible. The study also evaluates alternative highway program structures to estimate how different types of programs might affect the relative cost responsibility of different user groups.

Several user fee options are examined to determine the kinds of changes that could improve Federal highway user fee equity and efficiency, but the study does not evaluate options in as much detail as the 1982 Federal HCAS. Congress had mandated that the 1982 Study include recommendations on alternative user fee structures that could improve equity, but there is no similar requirement for this study. Furthermore, detailed evaluation of alternative user fee structures should await completion and deliberations of the Comprehensive TS&W Study since TS&W policy changes could have substantial implications for the cost responsibility of particular vehicle classes.

Requirements of the Comprehensive TS&W Study have been major considerations in designing the HCAS. The vehicle classes that might be evaluated in the TS&W Study have been included in the HCAS, and the various analytical models used in the HCAS have been designed with requirements of the TS&W Study in mind.

Summary of Study Approach and Methods

Methods used in the 1997 Federal HCAS are generally consistent with methods developed for the 1982 Federal HCAS. More types of truck configurations are considered in this study than in 1982 and much more detailed data on travel and operating weight distributions for each vehicle configuration have been developed. Many areas of the report benefited from recommendations made by members of the TRB Peer Review Committee.

Data on the composition of the highway program have also been developed in more detail for this study than the 1982 Federal HCAS. The primary source of cost data is FHWA's FMIS which contains information on FHWA obligations for Federal-aid highway projects, direct Federal projects, and all other purposes. There is no source of information on Federal highway expenditures that provides as much detail about how Federal monies are actually used as obligation information contained in FMIS, so the obligation information is used, even though money obligated in a particular year may not actually be expended until a later year.

Obligations for over 80 specific improvement and work types are separately allocated and those obligations are further broken down by the highway functional class upon which the improvement is made. Methods for allocating the various costs among vehicle classes have been refined from methods used in the 1982 Federal HCAS, especially for pavement, bridge, and capacity-related costs. New methods were developed for allocating transit-related costs and other multi-modal transportation costs that were not considered in the 1982 Federal HCAS. Chapter V and various appendices contain detailed explanations of HCA methods. Suggestions from members of the TRB Peer Review Committee were valuable in key study areas.

The base period for the 1997 Federal HCAS is 1993-1995 and the analysis year is 2000. Base year distributions of highway program costs by improvement type represent an average of obligations over the 1993-1995 period and base period revenues are averaged over the 1993-1995 period as well. Costs are averaged over several years because the distribution of particular types of improvements on the various highway systems varies from year to year. A 3-year average of costs by improvement type and location is thus more representative of current patterns of highway costs than estimates in a single year.

Because highway cost responsibility is so strongly influenced by a vehicle's axle configuration and axle weights, and because many potential vehicle configurations and gross weights are being evaluated in the U.S. DOT Comprehensive TS&W Study, highway revenue and cost analyses for this study are conducted for 20 different vehicle configurations. Table I-1 lists the 20 vehicle classes, acronyms used in this study for each class, and a brief description of the types of vehicles included in each vehicle class. Figure I-1 presents a graphical image of the axle configuration for each vehicle class.

Travel, HURs, and highway cost responsibility are estimated in up to thirty 5,000 pound weight intervals for each vehicle class. Weights range from 5,000 pounds or less to more than 145,000 pounds. Since cost responsibility is related to the nature and location of highway improvements and to the location of travel by different vehicle classes, travel and associated cost responsibilities are estimated separately for each of the 12 highway functional classes, but results are not reported at that level of detail since revenue estimates for particular functional classes are not meaningful. All axles on single unit and combination trucks are assumed, throughout this study, to be fully load-bearing axles during all modes of operation.

Table I-1. HCAS Vehicle Class Categories		
VC	**Acronym**	**Description**
1	AUTO	Automobiles and Motorcycles
2	LT4	Light trucks with 2-axles and 4 tires (Pickup Trucks, Vans, Minivans, etc.)
3	SU2	Single unit, 2-axle, 6 tire trucks (includes SU2 pulling a utility trailer)
4	SU3	Single unit, 3-axle trucks (includes SU3 pulling a utility trailer)
5	SU4+	Single unit trucks with 4- or more axles (includes SU4+ pulling a utility trailer)
6	CS3	Tractor-semitrailer combinations with 3-axles
7	CS4	Tractor-semitrailer combinations with 4-axles
8	CS5T	Tractor-semitrailer combinations with 5-axles, two rear tandem axles
9	CS5S	Tractor-semitrailer combinations with 5-axles, two split (>8 feet) rear axles
10	CS6	Tractor-semitrailer combinations with 6-axles
11	CS7+	Tractor-semitrailer combinations with 7- or more axles
12	CT34	Truck-trailers combinations with 3- or 4-axles
13	CT5	Truck-trailers combinations with 5-axles
14	CT6+	Truck-trailers combinations with 6- or more axles
15	DS5	Tractor-double semitrailer combinations with 5-axles
16	DS6	Tractor-double semitrailer combinations with 6-axles
17	DS7	Tractor-double semitrailer combinations with 7-axles
18	DS8+	Tractor-double semitrailer combinations with 8- or more axles
19	TRPL	Tractor-triple semitrailer or truck-double semitrailer combinations
20	BUS	Buses (all types)

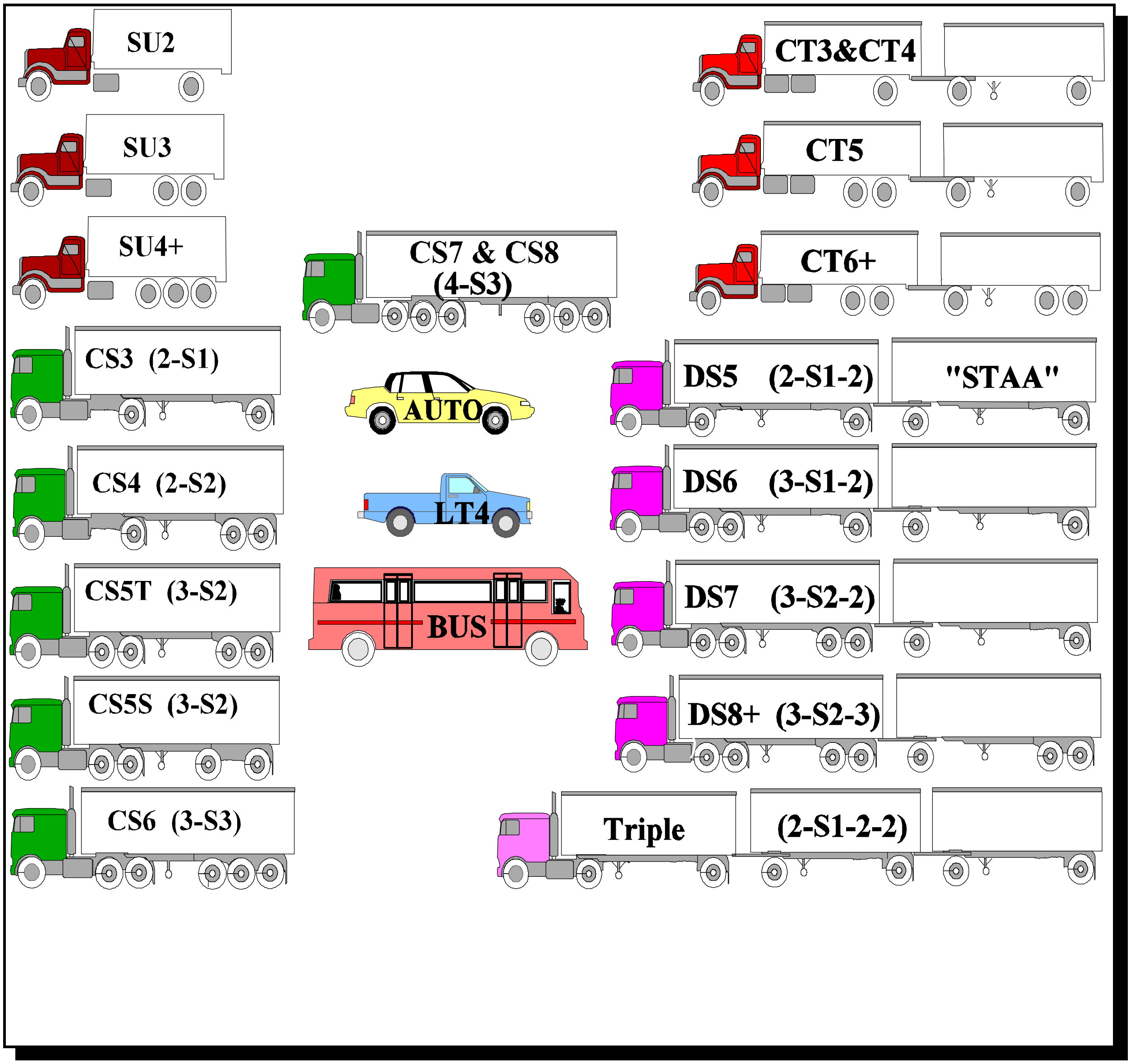

Figure I-1. Graphical Illustration of HCAS Vehicle Classes

II. Trends and Forecasts of Highway Use

Most highway improvement costs are directly related to the use of the highway system by various classes of highway users. Too much use of particular facilities causes congestion and necessitates capacity improvements, demand management strategies, transit improvements, or similar investments to improve the level of service and efficiency of transportation facilities within the corridor. Similarly, system preservation improvements are required to rehabilitate pavements, bridges, and other highway features when use of those facilities has deteriorated their physical condition. Many environmental, congestion, safety, and other external highway costs also are related to highway use.

This chapter presents information on travel characteristics of the major types of vehicles using the highway system, including distributions of travel at various weights and on various highway functional classes. The range of registered weights of vehicles in each vehicle class is shown along with operating weight distributions for vehicles at each registered weight. This latter information is particularly important for evaluating options to improve highway user fee equity because each vehicle's overall cost responsibility and user fee payments are best compared over the full range of weights at which vehicles operate during the year.

Vehicle Classes

The classification of vehicles for HCA should reflect differences that affect either their highway cost responsibility or the highway user fees that vehicles pay. At the most general level, vehicles are grouped into five categories: automobiles, pickups and vans, buses, single unit trucks and combination trucks. Additionally, vehicles are grouped into 5,000 pound weight categories ranging from 5,000 pounds to 150,000 pounds to capture differences in cost responsibility that vary with weight. Finally, the single unit and combination trucks are divided into 17 classes reflecting differences in the number of cargo carrying units and the number and types of axles. The 20 vehicle classes used for this study are:

- Automobiles and motorcycles.
- Pickups, vans and other light 2-axle, four tire vehicles.
- 2-, 3-, and 4- or more axle single unit trucks.
- 3-, 4-, 5-, 6-, and 7- or more axle tractor-semitrailer trucks with two categories of 5-axle vehicles, one with standard tandem axles and one with split tandem axles.
- 3-, 4-, 5-, and 6- or more axle truck-trailer combinations.
- 5-, 6-, 7-, and 8- or more axle twin trailer/semitrailer combinations.
- Triple trailer combinations.
- Buses.

The classification of vehicles for this study is somewhat different from the classification used in the 1982 Federal HCAS. The earlier study had broken down automobiles into large and small autos, and distinguished three types of buses, school buses, transit buses, and intercity buses. It did not have as many truck classes. Because the current study is being done in conjunction with Department's Comprehensive TS&W Study (1997 U.S. DOT TS&W), some detail in the automobile and bus categories was sacrificed for greater detail in the truck categories.

Base and Future Year Vehicle Stock

The number of registered vehicles within each vehicle class is often referred to as the vehicle stock. Vehicle stock is important for estimates of HURs contributed by different vehicle classes because several user fees including the HVUT, the excise tax on new trucks and trailers, and the tire tax are related at least in part to the vehicle stock.

Estimates of the number of registered vehicles in each of the 20 vehicle classes used in this study were developed from several sources, including R. L. Polk, data reported by the States and summarized in FHWA's *Highway Statistics*, and the Truck Inventory and Use Survey (TIUS). First control totals for broad groupings of the vehicle classes (e.g., automobiles, light trucks, single unit trucks, and combination trucks) were estimated using Polk and *Highway Statistics* data. Then these broad vehicle classes were subdivided into the 20 vehicle classes based primarily on TIUS data. In some cases data from other sources including truck weight data collected by the States and recent State cost allocation studies were used. Table I-1 and Figure I-1 provide information about the population of specific vehicle classes.

Estimates of 2000 stock by vehicle class and registered weight were developed assuming that increases in the stock of vehicles would be proportionate to increases in travel by each vehicle class. Thus the average miles per vehicle and the mix of vehicle types (among the vehicle classes) in 2000 are the same as in 1994. The actual vehicle population and mix of vehicles is influenced by business cycles, current economic conditions, and shippers' demand for specific truck types. A simplified future year scenario facilitates analysis of alternative scenarios by avoiding compound effects caused by manipulating more than one input variable. This is of particular concern for the 1997 U.S. DOT TS&W Study.

Table II-1 shows estimates of the number of vehicles in each of the 20 vehicle classes for 1994 and 2000. Annual growth rates from 1994 to 2000 for the various vehicle classes are estimated to be 2.2 percent for autos, pickups, and vans; 2.6 percent for single unit and combination trucks, and 2.4 percent for buses.

Autos, pickups, and vans account for over 96 percent of all vehicles. The largest truck class is 2-axle single units which accounts for 2 percent of all vehicles. The next largest truck class is the 5-axle tractor-semitrailer which accounts for one-half percent of all vehicles.

The bus fleet is made up of three general types of vehicles: school buses, transit buses, and intercity buses. Of the total bus population of 654 ,000 vehicles in 1994, 71 percent were school buses, 24 percent were transit buses, and 5 percent were intercity buses. Each type of bus has different operations that result in wide variations in average annual travel. School buses average about 11,000 miles of travel each year, transit buses 22,000 miles, and intercity buses 66,000 miles per year.

Vehicle Class	Number of Vehicles 1994	2000	Percent
AUTO	147,171,000	167,697,897	70.0%
LT4	55,516,133	63,259,330	26.4%
SU2	4,417,891	5,153,463	2.2%
SU3	594,197	693,130	0.3%
SU4+	106,162	123,838	0.1%
CS3	101,217	118,069	0.0%
CS4	227,306	265,152	0.1%
CS5T	992,816	1,158,118	0.5%
CS5S	34,944	40,762	0.02%
CS6	95,740	111,681	0.05%
CS7+	8,972	10,466	0.004%
CT3,4	87,384	101,934	0.04%
CT5	51,933	60,579	0.03%
CT6+	11,635	13,572	0.01%
DS5	51,710	60,319	0.03%
DS6	7,609	8,876	0.004%
DS7	7,887	9,201	0.004%
DS8+	9,319	10,871	0.005%
TRPL	1,203	1,404	0.001%
BUS	654,432	754,509	0.3%
TOTAL	210,149,491	239,653,170	100.0%

Table II-1. Number of Vehicles by Vehicle Class for 1994 and 2000

NOTE: See Chapter I for vehicle definitions.

Vehicle Population By Weight Groups

Vehicle weight is an important factors affecting highway cost responsibility. While the number, type, and spacing of axles interrelate with vehicle weight, weight is nevertheless one of the primary determinants of cost responsibility. Tables II-2 and II-3 show the number of vehicles in each vehicle class by registered weight in increments of 10,000 pounds for 1994 and 2000. For most vehicle classes, registered weight distributions are estimated based upon maximum declared weights in the TIUS database. For some vehicle classes, additional sources of information, including FHWA's *Highway Statistics*, truck weight study, and prior State HCASs, were also used. Details of how registered weight distributions by vehicle class were estimated are discussed in Appendix C. Registered weight distributions are assumed to be the same in 2000 as in 1994.

Figures II-1, II-2, and II-3 show the operating weight distributions of single unit trucks, combination trucks with semitrailers, and multi-trailer combinations. Among the single unit trucks, there are three distinct distributions that correspond to maximum allowable weights for those configurations based on Federal and State axle load limits. Among the semitrailer combinations, the 5- and 6-axle combinations have sharp peaks at 80,000 pounds, the maximum allowable weight on Interstate highways. More 6-axle tractor-semitrailers operate above 80,000 pounds than do 5-axle tractor-semitrailers. The 3- and 4-axle single trailer combinations do not have pronounced peaks in their registered weight distributions, reflecting the variety of uses of those vehicles. Among the multi-trailer combinations, there is a pronounced peak at 80,000 pounds for the 5- and 6-axle combinations, and lesser peaks at 80,000 pounds for 7- and 8- or more axle multi-trailer combinations. There is another peak for the 7- and 8- or more axle multi-trailer combinations about 110,000 pounds, the maximum allowable weight in several Western States that have grandfather rights to allow higher weights on the Interstate System. allowable weight in several Western States that have grandfather rights to allow higher weights on the Interstate System.

Base Year and Future Year Highway Travel

The VMT by each vehicle class is critical to virtually all aspects of HCA. It enters into estimates of HURs paid by each vehicle class, cost responsibilities of different vehicles, and the allocators that are used to assign

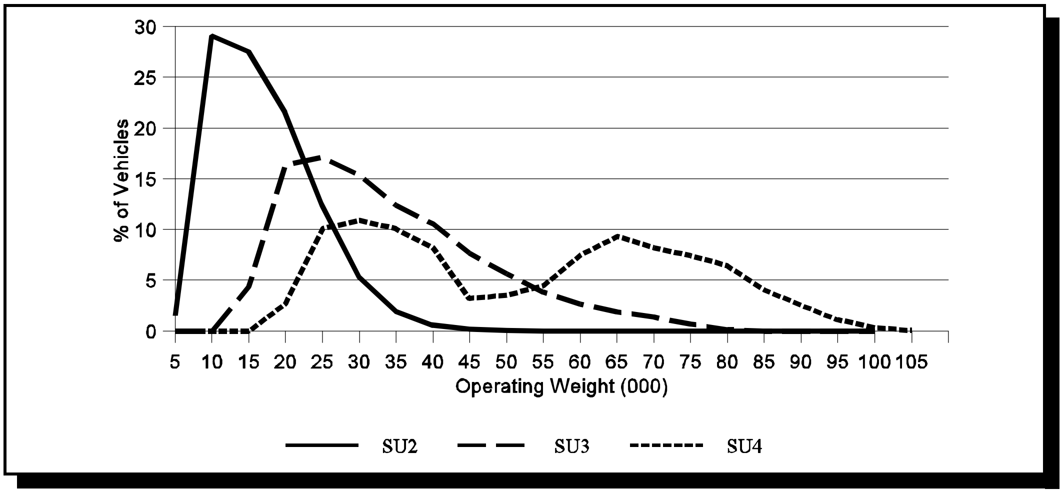

Figure II-1 2000 Operating Weight Distributions for Single Unit Trucks

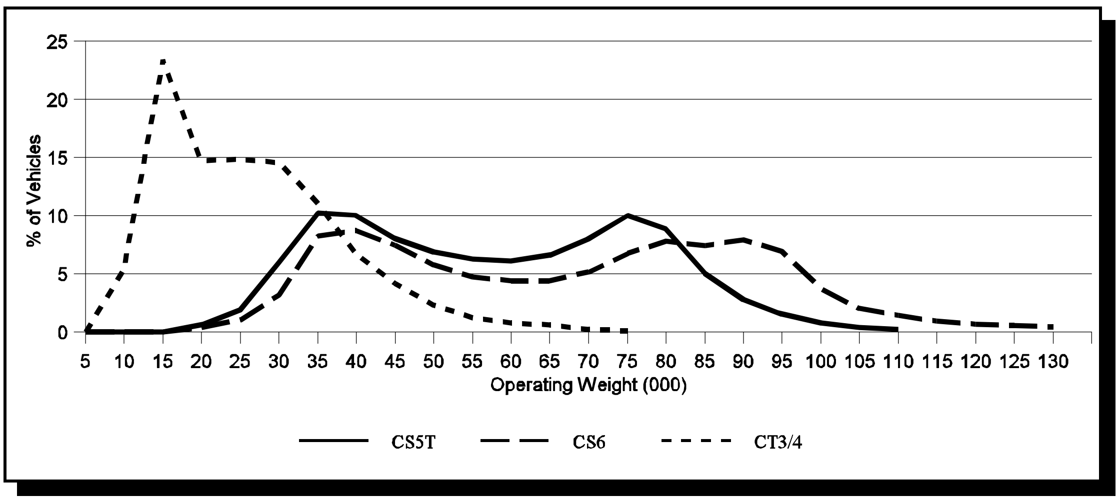

Figure II-2. 2000 Operating Weight Distributions for Selected Combination Trucks

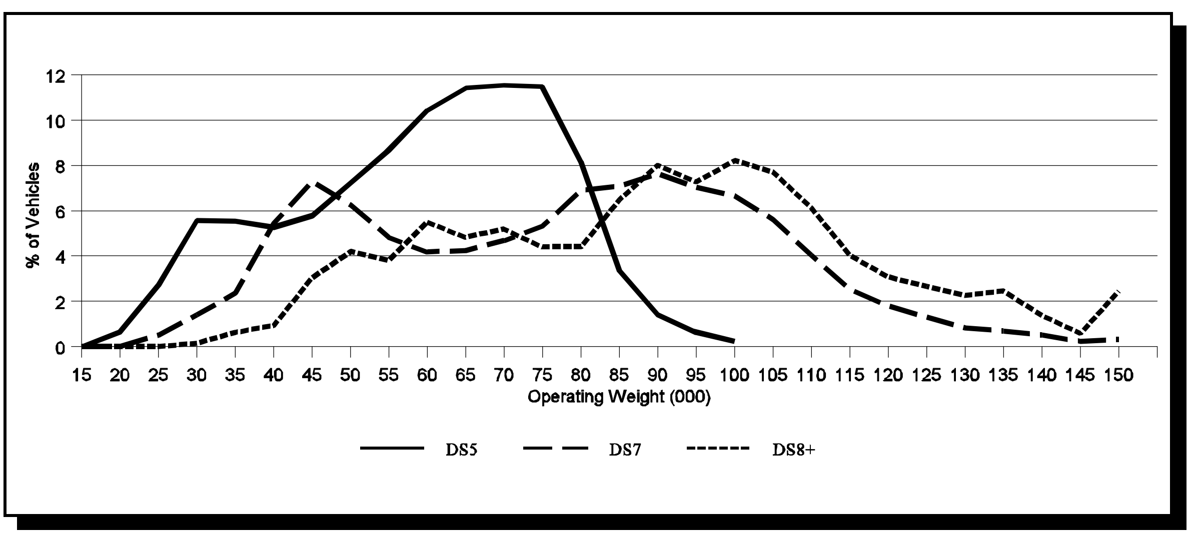

Figure II-3. 2000 Operating Weight Distributions for Selected Multi-trailer Truck Types

Table II-2. 1994 Number of Vehicles by Vehicle Class and Registered Weight (in 10,000 pound Increments)

VC	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	TOTAL
AUTO	147,171,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	147,171,000
LT4	54,602,227	913,907	0	0	0	0	0	0	0	0	0	0	0	0	0	55,516,133
SU2	1,943,741	1,187,256	908,606	358,344	13,254	6,689	0	0	0	0	0	0	0	0	0	4,417,891
SU3	0	715	28,927	50,110	240,413	222,431	49,704	1,896	0	0	0	0	0	0	0	594,197
SU4+	0	0	20	909	1,196	19,387	37,093	41,417	4,288	1,852	0	0	0	0	0	106,162
CS3	0	507	6,628	33,732	32,100	21,777	6,326	146	0	0	0	0	0	0	0	101,217
CS4	0	0	3,417	14,488	37,312	54,800	37,562	79,478	248	0	0	0	0	0	0	227,306
CS5T	0	0	0	0	6,126	24,297	28,972	904,915	24,190	2,979	1,336	0	0	0	0	992,816
CS5S	0	0	0	0	216	855	1,020	31,850	851	105	47	0	0	0	0	34,944
CS6	0	0	0	0	94	576	1,554	68,579	8,341	7,118	3,679	5,595	204	0	0	95,740
CS7+	0	0	0	0	0	0	0	3,404	460	2,750	1,552	616	170	20	0	8,972
CT3,4	4,478	24,723	24,003	12,132	13,263	3,658	589	3,719	819	0	0	0	0	0	0	87,384
CT5	0	0	499	741	2,365	3,217	2,377	39,419	3,149	146	20	0	0	0	0	51,933
CT6+	0	0	0	0	84	349	811	3,890	938	1,071	1,307	2,673	87	426	0	11,635
DS5	0	0	0	0	0	633	2,736	47,606	201	1	533	0	0	0	0	51,710
DS6	0	0	0	0	0	0	495	5,578	383	541	522	52	37	0	0	7,609
DS7	0	0	0	0	0	0	525	1,927	254	115	3,421	498	112	7	1,028	7,887
DS8+	0	0	0	0	0	0	0	1,352	394	73	3,234	854	1,204	149	2,059	9,319
TRPL	0	0	0	0	0	0	52	150	49	0	924	1	28	0	1	1,203
BUS	0	150,519	340,305	104,709	58,899	0	0	0	0	0	0	0	0	0	0	654,432
TOTAL	203,721,445	2,277,628	1,312,405	575,166	405,321	358,668	169,818	1,235,326	44,566	16,752	16,575	10,289	1,842	602	3,088	210,149,491

Table II-3. 2000 Number of Vehicles by Vehicle Class and Registered Weight (in 10,000 pound Increments)

VC	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	TOTAL
AUTO	167,697,897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167,697,897
LT4	62,217,954	1,041,375	0	0	0	0	0	0	0	0	0	0	0	0	0	63,259,330
SU2	2,267,371	1,384,933	1,059,888	418,008	15,460	7,802	0	0	0	0	0	0	0	0	0	5,153,463
SU3	0	835	33,744	58,454	280,442	259,464	57,980	2,212	0	0	0	0	0	0	0	693,130
SU4+	0	0	23	1,060	1,395	22,615	43,269	48,312	5,002	2,160	0	0	0	0	0	123,838
CS3	0	591	7,732	39,348	37,444	25,403	7,380	171	0	0	0	0	0	0	0	118,069
CS4	0	0	3,986	16,900	43,525	63,924	43,816	92,711	289	0	0	0	0	0	0	265,152
CS5T	0	0	0	0	7,146	28,343	33,796	1,055,582	28,218	3,476	1,559	0	0	0	0	1,158,118
CS5S	0	0	0	0	252	998	1,190	37,153	993	122	55	0	0	0	0	40,762
CS6	0	0	0	0	110	672	1,812	79,998	9,730	8,304	4,291	6,526	238	0	0	111,681
CS7+	0	0	0	0	0	0	0	3,971	537	3,208	1,811	718	198	23	0	10,466
CT3,4	5,224	28,840	27,999	14,152	15,471	4,267	688	4,339	956	0	0	0	0	0	0	101,934
CT5	0	0	582	865	2,758	3,753	2,773	45,982	3,673	170	24	0	0	0	0	60,579
CT6+	0	0	0	0	98	407	946	4,537	1,094	1,249	1,524	3,118	102	497	0	13,572
DS5	0	0	0	0	0	738	3,191	55,532	235	2	621	0	0	0	0	60,319
DS6	0	0	0	0	0	0	578	6,507	447	631	609	61	44	0	0	8,876
DS7	0	0	0	0	0	0	613	2,248	296	134	3,991	581	131	8	1,199	9,201
DS8+	0	0	0	0	0	0	0	1,577	460	85	3,773	996	1,404	174	2,402	10,871
TRPL	0	0	0	0	0	0	60	175	58	0	1,078	1	33	0	1	1,404
BUS	0	173,536	392,345	120,721	67,905	0	0	0	0	0	0	0	0	0	0	754,509
TOTAL	232,188,446	2,607,093	1,474,259	653,496	463,000	418,386	198,092	1,441,006	51,986	19,541	19,336	12,001	2,150	702	3,602	239,653,170

different costs to different vehicles. Travel is estimated for each of the 20 vehicle classes by 5,000 pound operating weight interval and by each of 12 functional highway classes.

Table II-4. Highway Functional Classes	
Rural	**Urban**
Interstate	Interstate
Other Principal Arterials	Other Freeways and
Minor Arterials	Other Principal Arterials
Major Collectors	Minor Arterials
Minor Collectors	Collectors
Local	Local

Table II-4 shows the 12 highway functional classes that have been designated for planning purposes by the AASHTO in cooperation with FHWA. Analysis of travel by highway functional class is important because higher-order systems (Interstate, Other Freeways and Expressways, and Other Principal Arterials) are designed differently from lower-order systems and the various vehicles analyzed in this study have substantially different travel patterns by highway class.

Methods for estimating VMT involved several steps. Total VMT reported in FHWA's 1994 *Highway Statistics* was the control total for broad vehicle classes in the base case analysis. Using the truck VMT control total from *Highway Statistics* and data from the 1992 TIUS on the distribution of VMT across the various truck classes and weight groups, control totals for the various truck vehicle classes were derived.

For the distribution of VMT across vehicle classes, weight groups, and highway functional classes, an additional analysis was conducted on 12,000,000 truck weighings from truck weight study data collected by the States and several recent HCASs. A major reason for incorporating other data sources than the *Highway Statistics* and Highway Performance Monitoring System (HPMS) data was that some vehicle classes were substantially different than those usually used by States in collecting traffic count and truck weight data.

Figure II-4 shows the distribution of total VMT by all vehicles across the 12 highway functional classes. About 60 percent of total travel is in urban areas; in both rural and urban areas there is more travel on the higher order systems than on lower order systems.

Figure II-5 shows the distribution of travel on higher order and lower order systems for selected vehicle classes. Sixty-five percent of automobile VMT is in urban areas with the majority being on higher order systems. The distribution of 3-axle single unit truck VMT is more evenly split — 53 percent in urban areas and 47 percent in rural areas. Sixty-three percent of 5-axle tractor semitrailer VMT is in rural areas, with the majority of that being on the higher order systems. Only 20 percent of tractor-semitrailer traffic is on lower order systems in either rural or urban areas.

Tables II-5 and II-6 show estimated VMT by vehicle class and highway functional class. As noted earlier, the assumption is that the distribution of VMT by highway functional class will not change between the base period and 2000.

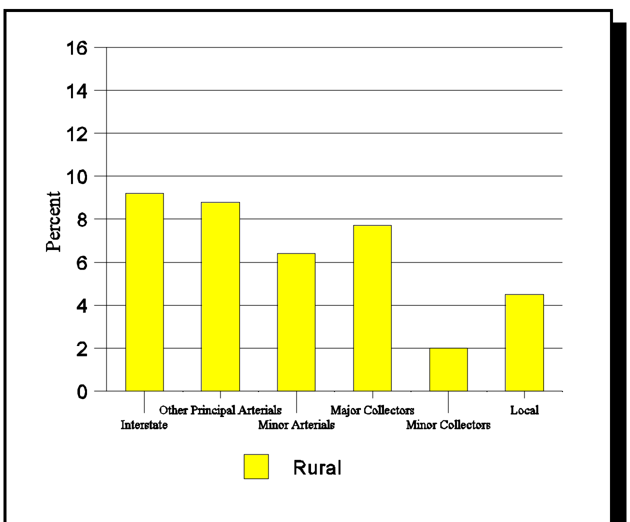

Figure II-4. 2000 VMT Distribution by Highway Functional Class

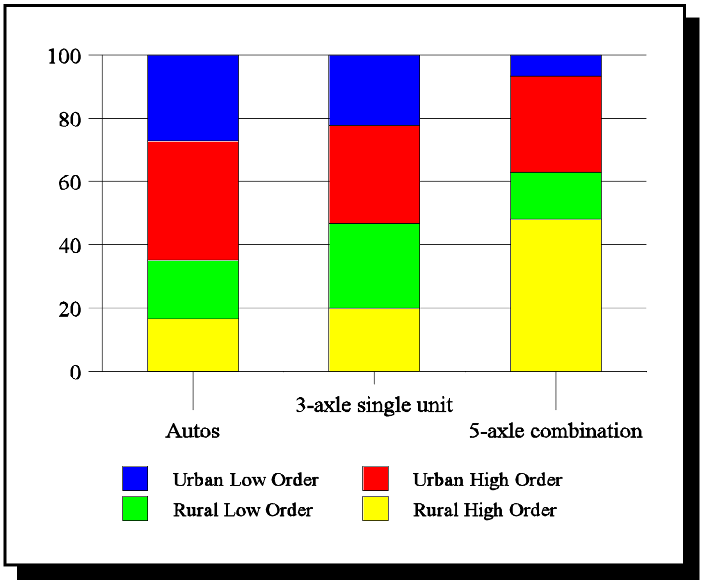

Figure II-5. Travel by Different Vehicle Classes on Different Highway Types

Tables II-7, II-8, II-9, and II-10 show the distribution of VMT by vehicle class and registered/operating weights. The data are derived primarily from truck weight study data submitted to FHWA by the States. As with the distribution of VMT by functional class, it is assumed that operating weight distributions for the various vehicle classes will not change on average between the base period (1993-1995) and 2000. Figure II-6 shows the operating weight distribution for selected vehicle classes. The operating weight distribution of 3-axle single units has a single peak of about 17 percent at 25,000 pounds after which the percentage of travel falls steadily. Only about 5 percent of travel by those vehicles is at weights greater than 50,000 pounds. The 5-axle tractor-semitrailer has a bi-modal operating weight distribution with one mode at about 35,000 pounds and another mode at 75,000 pounds. About 5 percent of 5-axle tractor semitrailer travel is at weights greater than 85,000 pounds. The 5-axle twin trailer combination also has a slightly bi-modal operating weight distribution with one mode at about 35,000 pounds and another at about 75,000 pounds.

Similar to the method used for the number of vehicles, the base future VMT in the Year 2000 employed relatively simple growth rates (to facilitate alternative HCAS revenue scenarios and TS&W policy options). Proportional vehicle class and weight group shares were held constant, with all values being grown by the appropriate growth rate for automobiles, light trucks, other trucks, or buses. The future year vehicle VMT was based on three general assumptions for the different vehicle groupings (based on recent trends). Automobile and light truck VMT were assumed to increase by 2.2 percent per year from 1994 to 2000. The VMT for all truck classes was assumed to increase 2.6 percent per year. Bus VMT was assumed to increase by 2.4 percent per year. These projected VMT values are shown in Table II-11.

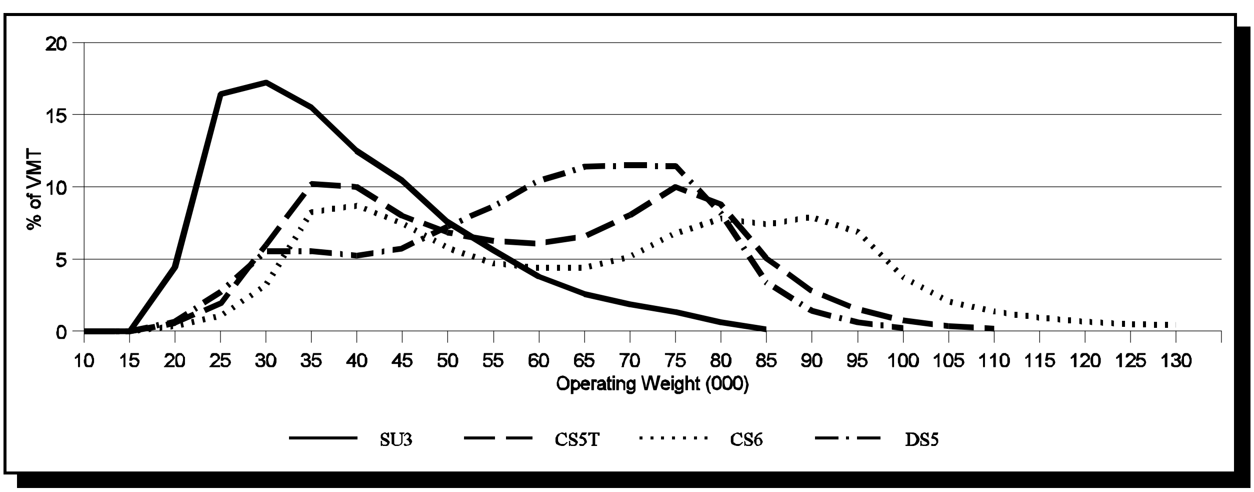

Figure II-6. 2000 Operating Weight Distributions for Selected Truck Types

Relationship Between Operating and Registered Weights

As noted earlier, vehicles pay certain taxes on the basis of their registered weight, and the overall equity of highway user fees is best evaluated by comparing user fee payments and highway cost responsibility over the full range of operations by vehicles at each registered weight during the year. However, relationships between vehicle weight and pavement and bridge costs are best understood by examining cost responsibilities at different operating weights. In fact, all cost responsibilities for each vehicle class are estimated in the first instance on the basis of VMT at each operating weight. To compare user fee payments and cost responsibilities on a registered weight basis for each vehicle class, the annual distribution of operating weights for vehicles at each registered weight must be estimated. These relationships were initially developed based on an analysis of the R. L. Polk registered weight data and the operating weight data in the 1992 TIUS. Because States differ on their definition of registered weight, only States that define registered weight as the GVW were analyzed (see Appendix C).

Figures II-7 and II-12 show relationships between operating weights and registered weights for different vehicle classes. Figures II-7 to II-9 compare operating weight distributions with registered weight distributions for 3-axle single units, 5-axle tractor-semitrailers, and 8-or-more axle twin trailer combinations. These figures show that registered weight distributions tend to have one or more peaks, usually centered around maximum GVWs in different States. Figures II-10 to II-12 illustrate operating weight distributions for 3-axle single unit trucks at three registered weights: 35,000 pounds, 45,000 pounds, and 55,000 pounds; a 5-axle tractor-semitrailer at three registered weights: 65,000 pounds, 80,000 pounds, and 90,000 pounds; and an 8-or-more axle twin trailer combination at three registered weights: 110,000 pounds, 120,000 pounds, and 130,000 pounds. These figures show that the distribution of operating weights, and thus the overall highway cost responsibility, for the same vehicle at different registered weights can be quite different.

Table II-5. 1994 VMT by Vehicle Class and Highway Functional Class (Millions)

Vehicle Class	FUNCTIONAL HIGHWAY CLASSES												
	RURAL						URBAN						
	Interstate	OPA	Minor Arterial	Major Collector	Minor Collector	Local	Interstate	OFE	OPA	Minor Arterial	Collector	Local	Total
AUTO	132,734	130,407	94,646	114,788	29,743	58,807	234,781	109,567	256,308	206,780	86,248	141,060	1,595,869
LT4	43,947	54,822	42,752	55,432	15,798	40,154	68,681	29,612	87,977	66,896	29,033	52,180	587,284
SU2	6,404	6,059	4,456	5,174	1,416	3,474	8,060	3,489	8,887	6,177	2,537	4,305	60,437
SU3	755	910	706	817	239	457	982	396	1,201	920	367	572	8,322
SU4	259	284	194	265	66	115	309	107	374	280	91	135	2,480
CS3	527	339	190	183	41	61	351	140	419	307	82	93	2,733
CS4	2,074	1,160	671	668	153	242	1,303	425	1,185	814	274	341	9,311
CS5T	23,151	10,248	4,692	3,561	780	1,211	13,012	2,804	5,346	2,519	896	1,278	69,498
CS5S	804	384	184	113	20	38	431	99	188	88	31	43	2,422
CS6	1,049	880	518	409	89	131	706	164	593	372	96	179	5,186
CS7+	99	91	45	40	8	13	54	17	51	28	8	14	468
CT3,4	236	145	76	75	16	26	144	51	146	103	36	43	1,098
CT5	670	228	55	48	5	14	305	65	121	32	27	19	1,590
CT6	167	63	20	13	3	4	78	18	41	18	4	4	432
DS5	1,744	617	185	117	25	41	943	274	388	91	39	49	4,512
DS6	278	83	22	18	4	5	119	18	43	21	8	7	627
DS7	148	87	38	36	5	9	82	18	75	29	10	4	542
DS8+	165	106	46	47	8	6	109	31	83	37	11	1	650
TRPL	63	13	2	2	0	1	23	1	3	0	0	0	108
BUS	645	639	450	524	141	282	728	265	1,062	847	319	514	6,417
TOTAL	215,918	207,567	149,949	182,328	48,561	105,092	331,200	147,560	364,492	286,359	120,118	200,840	2,359,984

NOTE: See Chapter I for vehicle definitions.

Table II-6. 2000 VMT by Vehicle Class and Highway Functional Class (Millions)

Vehicle Class	FUNCTIONAL HIGHWAY CLASSES												
	RURAL						URBAN						
	Interstate	OPA	Minor Arterial	Major Collector	Minor Collector	Local	Interstate	OFE	OPA	Minor Arterial	Collector	Local	Total
AUTO	151,248	148,596	107,847	130,798	33,891	67,010	267,528	124,849	292,058	235,621	98,278	160,735	1,818,461
LT4	50,076	62,468	48,715	63,164	18,002	45,754	78,261	33,742	100,248	76,227	33,083	59,458	669,198
SU2	7,470	7,068	5,198	6,035	1,651	4,053	9,402	4,069	10,367	7,205	2,959	5,021	70,500
SU3	881	1,062	824	953	278	533	1,145	462	1,401	1,073	428	667	9,707
SU4	302	332	226	309	77	135	361	125	437	326	106	158	2,893
CS3	615	396	222	213	48	71	409	163	489	358	96	108	3,188
CS4	2,419	1,354	783	779	179	283	1,519	496	1,382	950	320	397	10,861
CS5T	27,005	11,954	5,474	4,153	910	1,413	15,178	3,271	6,236	2,939	1,045	1,491	81,069
CS5S	937	448	214	131	24	44	503	116	219	102	36	50	2,826
CS6	1,224	1,026	605	477	104	152	824	191	692	433	112	208	6,049
CS7+	116	107	53	46	9	15	63	20	59	32	10	16	546
CT3,4	275	170	88	87	19	30	168	60	171	120	42	51	1,280
CT5	781	266	64	56	6	17	356	76	141	38	31	23	1,855
CT6	195	74	23	15	3	4	91	21	47	21	5	5	503
DS5	2,034	720	216	137	29	48	1,099	320	452	106	46	57	5,263
DS6	324	97	26	21	5	6	139	21	50	25	9	8	731
DS7	173	102	45	42	6	10	95	21	88	33	12	5	632
DS8+	192	123	54	55	9	8	127	36	97	43	13	1	759
TRPL	73	15	3	3	0	1	27	1	4	0	0	0	126
BUS	744	737	519	604	163	325	840	305	1,224	977	367	593	7,397
TOTAL	247,086	237,113	171,197	208,079	55,414	119,912	378,135	168,365	415,863	326,632	136,998	229,051	2,693,845

NOTE: See Chapter I for vehicle definitions.

Table II-7. 1994 VMT by Operating Weight Group (Millions)

Vehicle Class	OPERATING WEIGHT (1,000s of pounds)															Total
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
AUTO	1,595,869	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,595,869
LT4	579,215	8,069	0	0	0	0	0	0	0	0	0	0	0	0	0	587,284
SU2	18,507	29,656	10,617	1,523	133	1	0	0	0	0	0	0	0	0	0	60,437
SU3	0	1,727	2,704	1,911	1,100	534	268	66	0	0	0	0	0	0	0	8,322
SU4	0	67	520	454	167	295	433	343	166	34	1	0	0	0	0	2,480
CS3	31	512	1,280	662	214	30	2	0	0	0	0	0	0	0	0	2,733
CS4	0	852	2,520	3,025	1,688	781	321	99	25	0	0	0	0	0	0	9,311
CS5T	0	395	5,501	14,052	10,312	8,587	10,145	13,061	5,483	1,584	378	0	0	0	0	69,498
CS5S	0	26	239	383	237	223	380	606	248	63	15	4	0	0	0	2,422
CS6	0	19	220	881	687	471	496	757	795	551	179	81	49	0	0	5,186
CS7+	0	0	3	37	33	39	36	61	64	104	49	30	11	3	0	468
CT3,4	59	419	322	195	71	22	9	1	0	0	0	0	0	0	0	1,098
CT5	0	32	308	217	119	118	210	437	116	27	7	0	0	0	0	1,590
CT6+	0	2	22	88	68	52	63	66	29	14	15	8	3	1	0	432
DS5	0	30	374	487	586	861	1,034	886	216	39	0	0	0	0	0	4,512
DS6	0	1	16	81	116	132	129	90	35	17	7	2	0	0	0	627
DS7	0	0	10	42	74	49	48	66	80	74	52	24	12	7	3	542
DS8+	0	0	13	51	88	58	58	80	96	90	62	28	14	2	4	650
TRPL	0	0	0	3	6	6	10	21	22	17	10	6	3	2	0	108
BUS	0	1,355	2,400	2,255	354	52	0	0	0	0	0	0	0	0	0	6,416
TOTAL	2,193,682	43,163	27,071	26,346	16,062	12,312	13,644	16,639	7,374	2,613	775	183	92	20	7	2,359,984

Table II-8. 2000 VMT by Operating Weight Group (Millions)

Vehicle Class	OPERATING WEIGHT (1,000s of pounds)															Total
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
AUTO	1,818,461	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,818,461
LT4	660,004	9,195	0	0	0	0	0	0	0	0	0	0	0	0	0	669,198
SU2	21,589	34,594	12,384	1,777	156	1	0	0	0	0	0	0	0	0	0	70,500
SU3	0	2,014	3,155	2,230	1,296	623	312	76	0	0	0	0	0	0	0	9,707
SU4+	0	78	606	529	194	344	505	400	194	40	1	0	0	0	0	2,893
CS3	37	598	1,494	772	250	36	3	0	0	0	0	0	0	0	0	3,188
CS4	0	994	2,939	3,529	1,969	910	375	116	29	0	0	0	0	0	0	10,861
CS5T	0	461	6,417	16,392	12,029	10,017	11,834	15,236	6,395	1,848	441	0	0	0	0	81,069
CS5S	0	30	279	446	276	260	443	707	289	73	17	5	0	0	0	2,826
CS6	0	23	256	1,027	801	549	579	883	927	643	208	95	58	0	0	6,049
CS7+	0	0	4	43	38	46	42	71	75	121	57	34	13	3	0	546
CT3,4	69	488	376	227	83	25	10	1	0	0	0	0	0	0	0	1,280
CT5	0	37	359	253	139	138	244	510	135	32	8	0	0	0	0	1,855
CT6+	0	3	26	102	79	61	74	76	34	17	18	9	3	1	0	503
DS5	0	35	436	568	684	1,004	1,206	1,033	252	45	0	0	0	0	0	5,263
DS6	0	1	19	95	135	154	151	105	41	20	9	2	0	0	0	731
DS7	0	0	12	50	86	57	57	77	93	87	61	28	13	8	4	632
DS8+	0	0	15	59	103	68	68	93	112	104	73	33	16	9	4	759
TRPL	0	0	0	4	7	7	12	24	26	19	12	7	4	2	0	126
BUS	0	1,562	2,767	2,600	408	60	0	0	0	0	0	0		0	0	7,397
Total	2,500,159	50,113	31,545	30,702	18,733	14,361	15,915	19,410	8,602	3,048	904	214	107	24	8	2,693,845

Table II-9. 1994 VMT by Vehicle Class and Registered Weight (Millions)

Vehicle Class	REGISTERED WEIGHT (1,000s of pounds)															Total
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
AUTO	1,595,869	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,595,869
LT4	577,616	9,668	0	0	0	0	0	0	0	0	0	0	0	0	0	587,284
SU2	26,591	16,242	12,430	4,902	181	92	0	0	0	0	0	0	0	0	0	60,437
SU3	0	10	405	702	3,367	3,115	696	27	0	0	0	0	0	0	0	8,322
SU4+	0	0	0	21	28	453	866	967	100	43	0	0	0	0	0	2,480
CS3	0	14	179	911	867	588	171	4	0	0	0	0	0	0	0	2,733
CS4	0	0	140	593	1,528	2,245	1,539	3,256	10	0	0	0	0	0	0	9,311
CS5T	0	0	0	0	429	1,701	2,028	63,345	1,693	209	94	0	0	0	0	69,498
CS5S	0	0	0	0	15	59	71	2,208	59	7	3	0	0	0	0	2,422
CS6	0	0	0	0	5	31	84	3,715	452	386	199	303	11	0	0	5,186
CS7+	0	0	0	0	0	0	0	178	24	143	81	32	9	1	0	468
CT3,4	56	311	301	152	167	46	7	47	10	0	0	0	0	0	0	1,098
CT5	0	0	15	23	72	99	73	1,207	96	4	1	0	0	0	0	1,590
CT6+	0	0	0	0	3	13	30	144	35	40	48	99	3	16	0	432
DS5	0	0	0	0	0	55	239	4,154	18	0	46	0	0	0	0	4,512
DS6	0	0	0	0	0	0	41	459	32	45	43	4	3	0	0	627
DS7	0	0	0	0	0	0	36	132	17	8	235	34	8	0	71	542
DS8+	0	0	0	0	0	0	0	94	27	5	226	60	84	10	144	650
TRPL	0	0	0	0	0	0	5	13	4	0	83	0	2	0	0	108
BUS	0	1,476	3,336	1,027	577	0	0	0	0	0	0	0	0	0	0	6,416
Total	2,200,132	27,719	16,807	8,331	7,240	8,496	5,886	79,950	2,578	890	1,059	532	120	28	214	2,359,984

Table II-10. 2000 VMT by Vehicle Class and Registered Weight (Millions)

Vehicle Class	REGISTERED WEIGHT (1,000s of pounds)															Total
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
AUTO	1,818,461	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,818,461
LT4	658,182	11,016	0	0	0	0	0	0	0	0	0	0	0	0	0	669,198
SU2	31,018	18,946	14,499	5,718	212	107	0	0	0	0	0	0	0	0	0	70,500
SU3	0	12	473	819	3,927	3,634	812	31	0	0	0	0	0	0	0	9,707
SU4+	0	0	1	25	33	528	1,011	1,129	117	50	0	0	0	0	0	2,893
CS3	0	16	209	1,062	1,011	686	199	5	0	0	0	0	0	0	0	3,188
CS4	0	0	163	692	1,783	2,618	1,795	3,798	12	0	0	0	0	0	0	10,861
CS5T	0	0	0	0	500	1,984	2,366	73,892	1,975	243	109	0	0	0	0	81,069
CS5S	0	0	0	0	17	69	82	2,576	69	8	4	0	0	0	0	2,826
CS6	0	0	0	0	6	36	98	4,333	527	450	232	354	13	0	0	6,049
CS7+	0	0	0	0	0	0	0	207	28	167	94	37	10	1	0	546
CT3,4	66	362	352	178	194	54	9	54	12	0	0	0	0	0	0	1,280
CT5	0	0	18	26	84	115	85	1,408	112	5	1	0	0	0	0	1,855
CT6+	0	0	0	0	4	15	35	168	41	46	57	116	4	18	0	503
DS5	0	0	0	0	0	64	278	4,845	20	0	54	0	0	0	0	5,263
DS6	0	0	0	0	0	0	48	536	37	52	50	5	4	0	0	731
DS7	0	0	0	0	0	0	42	154	20	9	274	40	9	1	82	632
DS8+	0	0	0	0	0	0	0	110	32	6	263	70	98	12	168	759
TRPL	0	0	0	0	0	0	5	16	5	0	96	0	3	0	0	126
BUS	0	1,701	3,847	1,184	666	0	0	0	0	0	0	0	0	0	0	7,397
Total	2,507,726	32,054	19,561	9,704	8,437	9,910	6,865	93,262	3,007	1,038	1,235	621	140	32	250	2,693,845

Table II-11. Trends and Projections of VMT by Vehicle Class (millions)			
	1990	**1994**	**2000**
AUTO/LT4	1,997,283	2,183,153	2,487,659
Single Unit Trucks	64,114	71,239	83,150
Combination Trucks	89,257	99,176	115,639
Buses	5,822	6,416	7,397
TOTAL	2,156,476	2,359,984	2,693,845

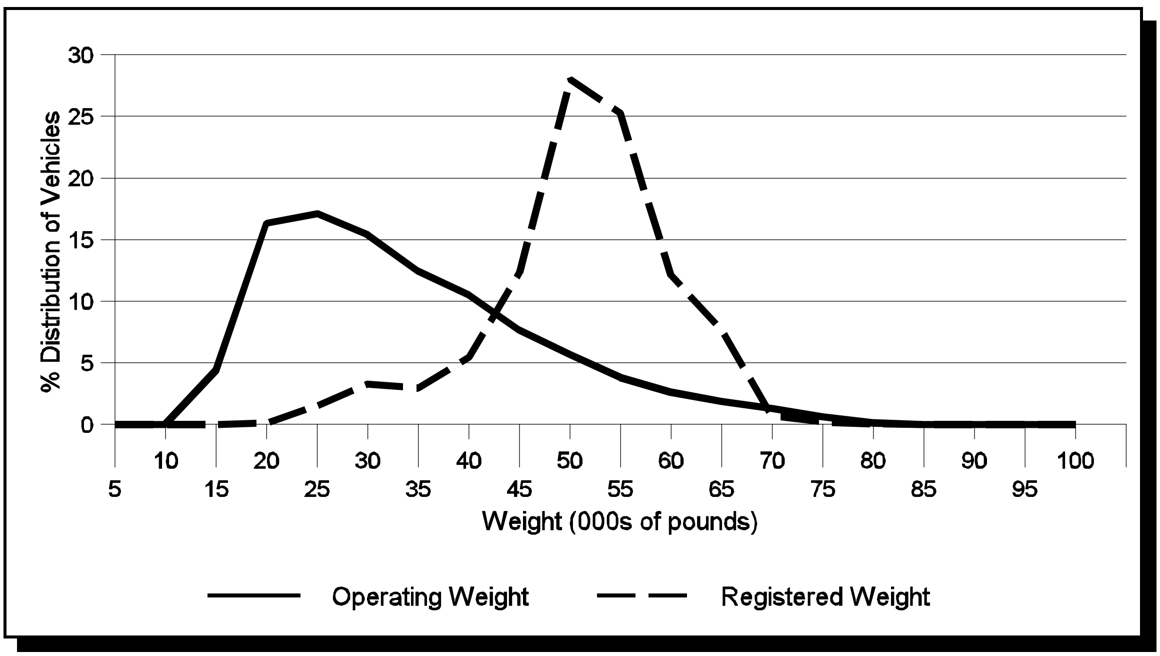

Figure II-7. Comparison of Operating vs. Registered Weight for 3-axle Single Unit Trucks

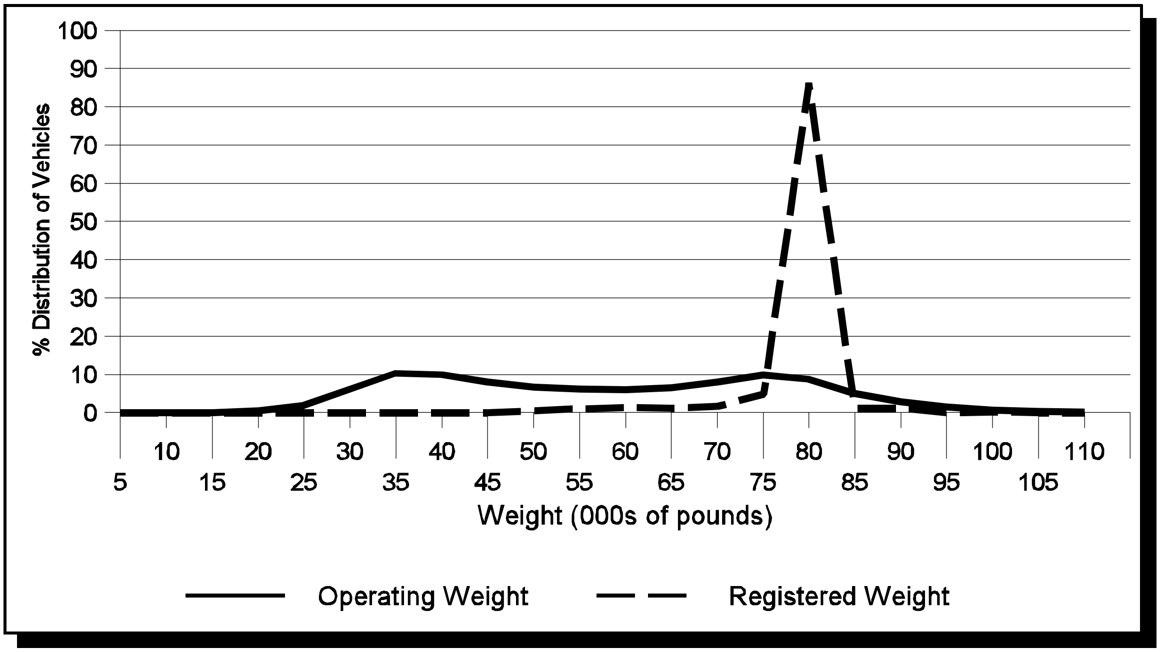

Figure II-8. Comparison of Operating vs. Registered Weight for 5-axle Tractor-Semitrailer

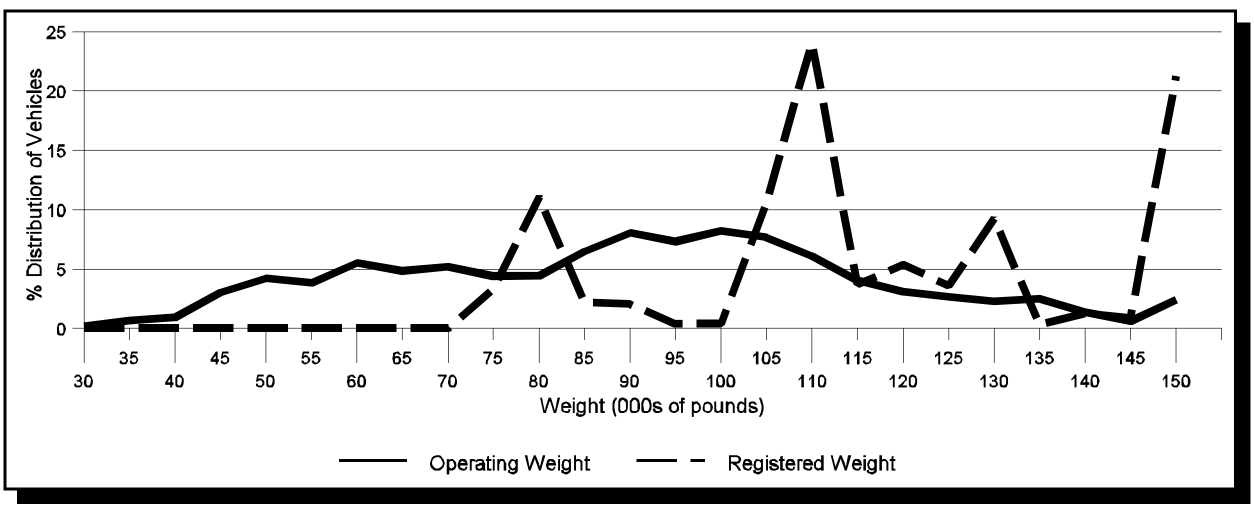

Figure II-9. Comparison of Operating and Registered Weight Distributions for 8+ axle Twin-Trailer Combinations

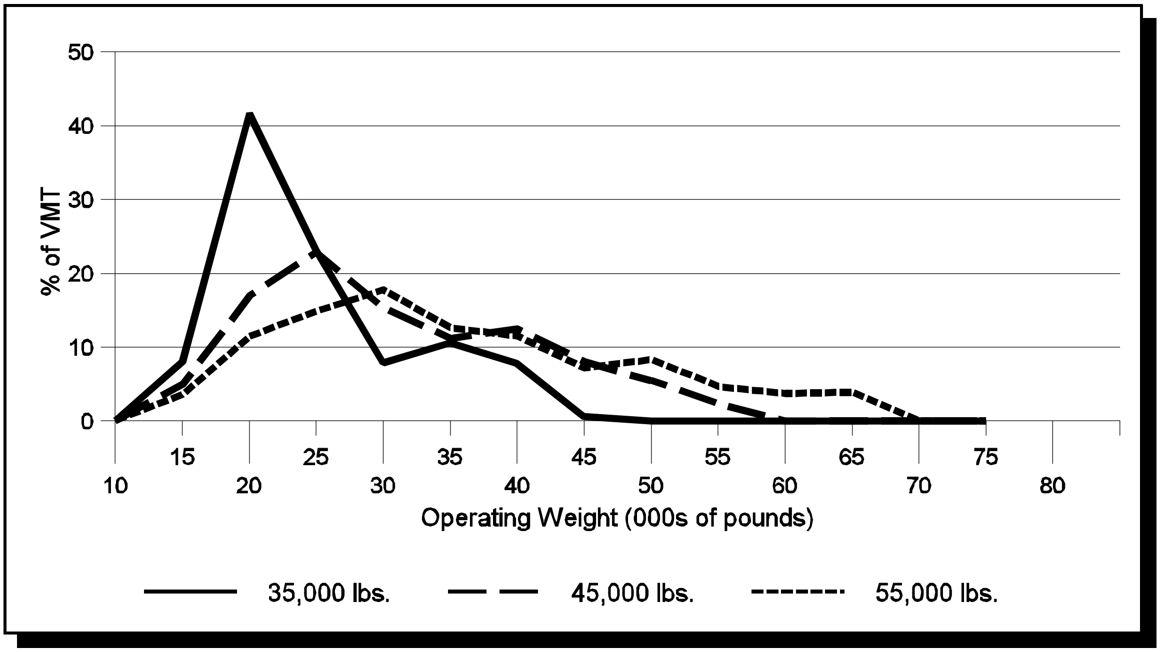

Figure II-10. Operating Weight Distributions of 3-axle Single Unit Trucks Registered at 35,000, 45,000 and 55,000 pounds

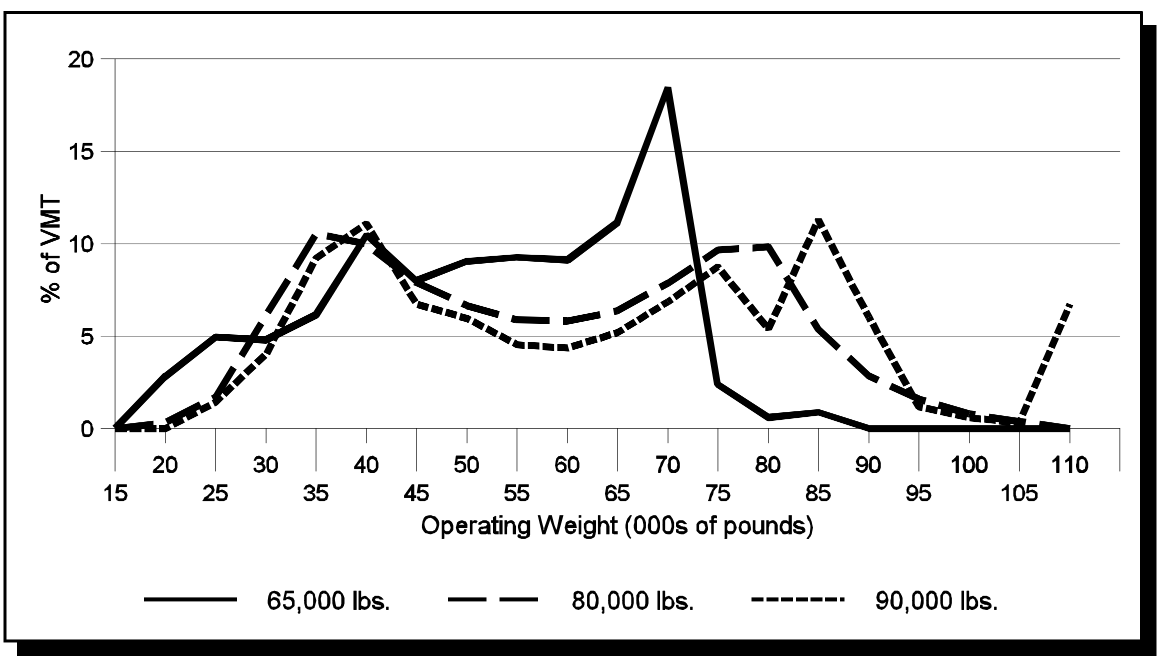

Figure II-11. Operating Weight Distributions of 5-axle Tractor-Semitrailers Registered at 65,000, 80,000 and 90,000 pounds

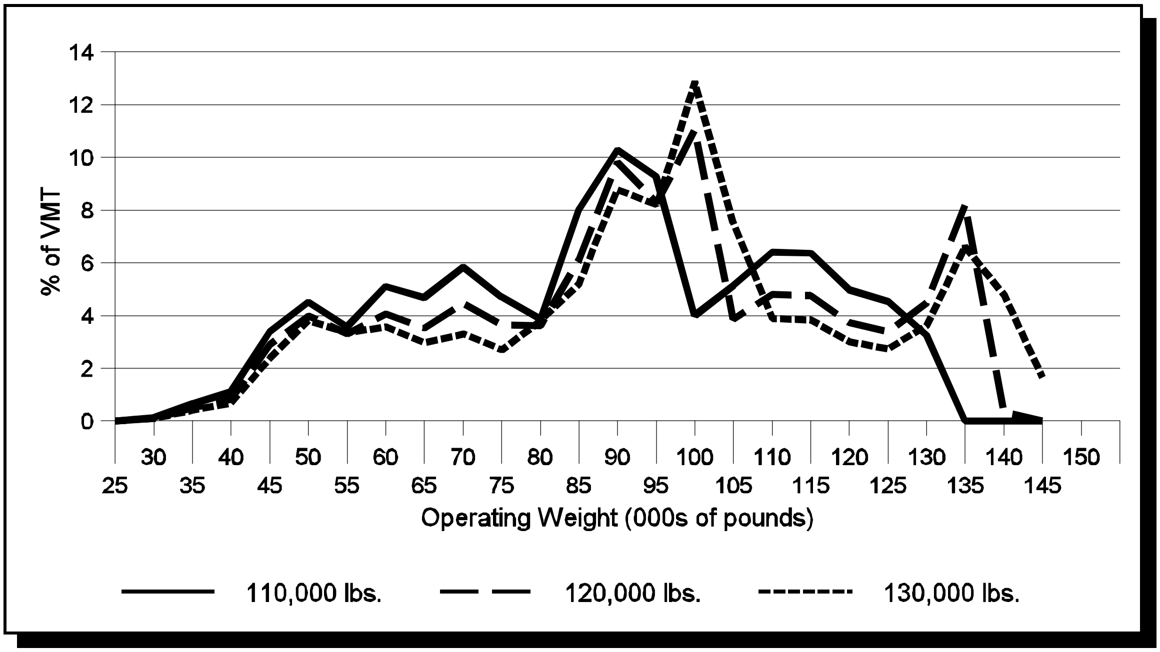

Figure II-12. Operating Weight Distributions of 8+ axle Twin-Trailer Combinations Registered at 110,000, 120,000 and 130,000 pounds

III. Trends and Forecasts of Highway Costs

Introduction

This chapter describes the various highway-related costs considered in this study and provides estimates of those costs for the ISTEA base period (1993-1995) and the 2000 analysis year. Previous Federal HCASs have focused primarily on allocating actual or anticipated highway improvement costs paid from the HTF, including costs of providing new highway capacity, preserving the physical condition of the highway system, safety improvements, TSM, environmental enhancement, and other improvements. State HCASs also have focused on allocating highway-related costs paid from HURs, because, like the Federal studies, they have been primarily interested in questions of whether highway user fees are being levied among different groups of users in proportion to their share of highway cost responsibility.

The HCASs historically have allocated either actual or anticipated expenditures/obligations by highway agencies. They have not allocated amounts that should be spent to maintain system condition, reduce congestion, or achieve other broad policy objectives. While this might be useful information if some change in either highway program level or composition were being considered, most HCASs have focused on the specific question of how much of actual or planned program costs should be paid by different vehicle classes?

Allocating infrastructure and other costs paid from the Federal HTF continues to be a key focus of the current Federal HCAS, but a number of costs that have not been treated extensively in previous Federal cost allocation studies are examined in this study. For instance, costs for pedestrian and bicycle facilities, mass transit improvements, and enhancements that have become increasingly important since passage of ISTEA were not included in the 1982 Federal HCAS, but are included in this study.

Federal costs paid from the HTF are estimated primarily from the FMIS which contains data on obligations of Federal funds and State matching funds by improvement type and highway functional class for projects constructed through the Federal-aid highway program. The FMIS data are supplemented with information from other sources on key components of construction projects that are not available from the FMIS.

This study also evaluates highway-related costs such as air pollution, noise, global warming, and community disruption that are borne by the general public rather than by highway users or highway agencies. There is increasing concern that failure to consider such costs in investment and other infrastructure management decisions may lead to inefficient resource allocation and may unfairly subsidize users of one mode over another. Regulatory programs have been successful in reducing some external costs, notably air pollution and crash costs, and significant HURs are spent on programs such as transportation demand management, safety improvements, CMAQ improvement, noise barrier construction, and beautification to mitigate external highway costs. The responsibility of different vehicle classes for these external costs is estimated and compared to cost responsibilities for agency costs as a further indicator of highway user fee equity. This information also provides a framework for evaluating additional actions that can be taken to reduce external costs.

One approach advocated by some to reduce external costs is to charge highway users for either the full or marginal costs of their trips, including congestion, air pollution, and other external costs they impose on others as a result of their travel decisions. Only those users who value their trips at least as much as the cost of those trips, including costs imposed on others, would travel during periods when congestion and other external costs were high. Some users would decide not to make a trip, others would change either the time or destination of the trip to avoid paying the highest tolls, and still others would switch to alternative modes that have lower costs. Congestion, air pollution and other external costs thus would be reduced, and users who continue to travel during times when external costs are high would generate substantial revenues for transportation agencies.

True congestion pricing has never been applied by transportation agencies in this country, although a private toll road in California has instituted variable tolls by time of day, and a project is underway in San Diego under the Congestion Pricing Pilot Program that will have tolls which vary according to the level of congestion. Other areas are evaluating the feasibility of variable pricing under the Congestion Pricing Pilot Program. Peak period pricing is common in other sectors of the economy. Utilities, phone companies, theaters, restaurants, and other businesses routinely charge more during peak periods to ration demand and maximize profits. Forms of congestion pricing have been applied on a very limited scale to highway transportation in several foreign countries. An example of charges being levied to reduce transportation-related externalities in the United States is the "gas guzzler" tax imposed on vehicles that do not achieve a minimum fuel economy standard.

External costs were discussed in an appendix to the 1982 Federal HCAS in which marginal highway costs, including environmental and congestion costs, were examined to estimate economically efficient user fee rates that would have to be charged for different vehicles operating under different conditions. A comprehensive treatment of external costs of highways is beyond the scope of this study, but Chapter V examines key external costs of highway use and operation as they pertain to evaluating the equity and efficiency of highway user charges. In addition to estimating marginal costs under different conditions, total external costs attributable to different vehicle classes are estimated. While there is considerable uncertainty surrounding estimates of these external costs, their magnitude makes it essential to consider these costs in highway policy studies.

Just as the broader costs of highway use have received increasing attention recently, so too have the broader economic benefits of highways, especially benefits to industry productivity and international competitiveness. During the course of this study there was considerable discussion concerning the treatment of highway benefits. Much of the discussion revolved around the issue of whether there are external benefits of highway use comparable to external costs of highway use. The consensus among most economists was that there are few if any truly external benefits associated with the use of the highway. Almost all commercial benefits associated with highway use represent transfers of benefits realized by highway users, and to include those benefits along with benefits to highway users would result in double-counting. There was general agreement, however, that there are substantial public and private benefits of highways over and above savings in travel time and vehicle operating costs realized by highway users. Estimating the magnitude of those benefits was outside the scope of this study, however. Appendix D summarizes relationships between highway user benefits and costs and results of recent FHWA research on relationships between highways and economic productivity. Other benefits such as the contribution of highway programs to sustainable redevelopment and brownfields redevelopment are not discussed in this report, but these clearly are examples of how targeted and coordinated highway investment can contribute to a variety of local social and economic development objectives. The Department's biennial C&P Report presents results of extensive analyses of benefits of alternative investment levels in surface transportation programs and demonstrates the significant benefits of highway investment.

Table III-1. Total Federal, State, and Local Highway Expenditures—1985-1994 ($ Millions)				
Expending Agency	**Source of Funds**	**1985**	**1990**	**1994**
Federal	Federal	$1,086	$746	$1,734
State	Federal	$12,669	$13,617	$17,485
	State	$21,782	$31,309	$36,703
	Local	$411	$683	$1,381
Local	Federal	$1,433	$793	$699
	State	$6,290	$7,980	$8,838
	Local	$13,275	$19,757	$23,253
Total		$56,946	$74,885	$90,093

Source: *Highway Statistics*, various years, Table HF-10, with slight refinements for 1994.

Base Period HighwayProgram Costs

Table III-1 shows trends in total expenditures for highways by all levels of government. Since substantial amounts are transferred among different levels of government, sources of funds are also shown. Funds for mass transit programs are not included in this table although they are included in subsequent analyses of Federal costs. Highway construction and maintenance activities by Federal agencies in national parks, forests, and other Federal lands constitute the largest share of direct Federal expenditures for surface transportation. Direct Federal highway expenditures represent 9 percent of total highway expenditures from Federal funds. The bulk of Federal HURs are paid to States as reimbursements for the Federal share of project costs under the Federal-aid highway program.

State and local shares of total highway expenditures have remained fairly stable over the period at about 61 percent and 37 percent, respectively. Federal funds currently constitute about 31 percent of total funding for State highway construction programs. Relatively little Federal money goes into local highway programs, but substantial amounts of State HURs are transferred to county and municipal governments to finance local highway programs. Figure III-1 shows the sources of funds for 1994 State and local highway programs.

Federal Highway Program Costs and the Fiscal Management Information System

Federal highway program cost data were extracted and analyzed from FHWA's FMIS. The FMIS is a formal, interactive, on-line database which provides detailed information on Federal-aid highway projects. Project-related information originates at the State departments of transportation, but is entered in the FMIS by FHWA staff. The FMIS represents the best source of project-related information for Federal-aid highway projects, and was analyzed in detail to provide insight on the use of Federal highway program funds. The FMIS includes information on obligations of Federal and State matching funds for Federal-aid projects, not on actual expenditures. Funds are obligated when specific obligation authority is attached to a project. Adjustments to obligated funds are made as the project progresses through various stages of completion. Project expenditures do not necessarily occur at the same time as obligations, and obligations for a project in 1 year may result in actual expenditures over more than 1 year.

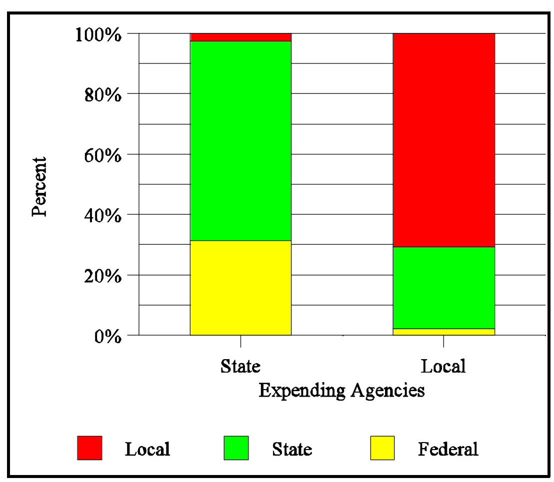

Figure III-1. 1994 Source of Funds for State and Local Highway Programs

In addition to obligation data, the FMIS contains additional project-related data that are useful to analyze project costs. For example, there are FMIS fields that contain information for each project on State, urbanized area, county, urban/rural, highway type, improvement type, work class, bridges, pavements, safety type, and work type. Given the number of projects contained in the FMIS, extracting and organizing this information is a substantial task. For this study, Federal highway obligations data were primarily collected and reported by improvement type (e.g., new capacity, major widening) and highway functional class (e.g., Urban Interstate, Rural Interstate). However, further detailed information was available on individual work types and this data was extracted and incorporated to ensure appropriate vehicle class attribution. For example, numerous queries were made to separately quantify Federal obligations for truck-related expenditures, such as truck scales, loading facilities, terminal and transfer facilities, and various truck safety programs.

Obligation of Federal Funds for Highway-Related Improvements

The distribution of Federal highway obligations by improvement type and highway functional class varies from year to year for several reasons including distortions caused by major projects obligated during a year, emphasis on a particular type of improvement by States during the year, or other reasons. To minimize annual variations in patterns of obligations and to present a more accurate picture of the composition of the current program under ISTEA, Federal obligations are averaged for the Years 1993, 1994, and 1995 to represent the ISTEA base period.

Table III-2 compares obligations of Federal highway funds in 1990 with the ISTEA (1993-1995) base period. The composition of Federal obligations for highways has changed since passage of ISTEA in 1991. Approximately the same percentage of Federal obligations went for system preservation in the ISTEA period as prior to ISTEA, but the percentage of funds obligated for new capacity declined by about five percentage points while the percentage for system enhancements increased by five percentage points. This reflects the emphasis on enhancements in ISTEA and increased reliance on alternatives to constructing new highway lanes to improve traffic operations and reduce congestion.

Figure III-2 summarizes the composition of Federal highway by improvement type in the ISTEA base period (1993-1995). Over 20 percent of obligations were for added capacity, 42 percent for system preservation, 15 percent for system enhancement, 13 percent for mass transit improvements financed from the MTA of the HTF, and 9 percent for other purposes, including improvements on Federal lands and FHWA administrative expenses. This table does not include obligations for transit improvements and certain other miscellaneous costs, but shows trends in obligations for key highway improvement types.

Table III-2. Comparison of Pre-ISTEA (1990) and ISTEA (1993-1995) Period Federal Highway Obligations by Improvement Type

Improvement Type	Pre-ISTEA Obligations ($1,000)	Pre-ISTEA Obligations Percent	ISTEA Obligations ($1,000)	ISTEA Obligations Percent
New Capacity				
New Construction	2,427,065	17.40%	1,762,388	10.16%
Major Widening	1,032,588	7.40%	1,488,507	8.58%
Reconstruction-Added Lanes	157,762	1.13%	759,544	4.38%
New Bridge	740,391	5.31%	622,527	3.59%
Total	4,357,806	31.25%	4,632,966	26.71%
System Preservation				
Pavement 3R	4,815,703	34.53%	5,879,083	33.90%
Bridge Replacement	1,454,892	10.43%	1,714,104	9.88%
Major Bridge Rehabilitation	965,513	6.92%	971,275	5.60%
Minor Bridge Rehabilitation	212,396	1.52%	360,586	2.08%
Minor Widening	306,988	2.20%	392,275	2.26%
Total	7,755,492	55.61%	9,317,323	53.72%
System Enhancement				
Safety/Traffic Ops/TSM	1,359,741	9.75%	2,061,020	11.88%
Environmentally-related	155,249	1.11%	429,592	2.48%
Other Projects	316,889	2.27%	902,392	5.20%
Total	1,831,879	13.14%	3,393,004	19.56%
TOTAL	13,945,177	100.00%	17,343,294	100.00%

In the ISTEA base period, adding highway lanes, either on new location

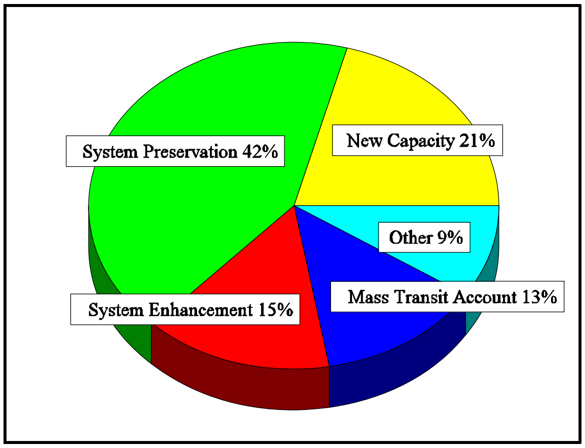

Figure III-2. Distribution of ISTEA-Period Obligations

(new construction) or to existing highways (major widening and reconstruction with added lanes) represented over 85 percent of total new capacity costs. New bridges represented less than 15 percent of new capacity costs. Likewise, system preservation costs are dominated by costs to reconstruct, rehabilitate, or resurface pavements. Almost two-thirds of system preservation costs are for pavement improvements compared to about one-third for bridge improvements. System enhancement costs represent remaining costs under the Federal-aid highway program that are neither for new lanes, new bridges, nor preservation of existing pavements and bridges. These costs include costs for safety improvements, TSM, environmental enhancements, transit improvements funded from the Highway Account of the HTF, and other costs. Costs for mass transit funded from the MTA of the HTF are shown separately from transit costs funded from the Highway Account to emphasize the fact that these funds generally do not flow through State transportation agencies in the same manner as transit projects funded from the Highway Account. Obligations from the MTA were approximately 13 percent of total Federal highway-related obligations from the HTF in the ISTEA base period. The remaining obligations from the HTF were for direct Federal construction on Federal lands, contributions to National Highway Traffic Safety Administration (NHTSA) safety programs, FHWA administration, and other miscellaneous expenses altogether constituting about 9 percent of total HTF obligations.

The detailed data available in the FMIS include the functional highway class upon which improvements are made. Disaggregation of improvement costs by highway functional class allows differences in traffic composition, highway design, and other factors that vary by highway type to be fully considered in estimating the cost responsibility of different vehicle classes.

Table III-3 shows the distribution of ISTEA base period Federal obligations by highway functional class. Thirty-five percent of total obligations are on rural highways and 65 percent on urban highways. Over half of all obligations on rural roads are on higher order systems (Interstate or other principal arterial highways) and three-quarters of urban obligations are on higher order systems (Interstate highways, other freeways and expressways, and other principal arterial highways). Other factors being equal, vehicle classes with greater shares of travel on higher order systems will have relatively greater cost responsibilities than vehicles traveling predominantly on lower order systems because so much of the money is spent on higher-order systems.

Table III-3. Base Period Federal Highway Program Costs by Highway Functional Class ($1,000)

Functional Class	$ Obligations	Percent
Rural		
Interstate	$ 1,901,292	8.54%
Other Principal Arterial	2,701,431	12.13%
Minor Arterial	1,062,551	4.77%
Major Collector	980,338	4.40%
Minor Collector	638,547	2.87%
Local	553,751	2.49%
Total Rural	7,837,910	35.19%
Urban		
Interstate	6,059,703	27.21%
Freeway and Expressway	1,759,633	7.90%
Other Principal Arterial	3,643,667	16.36%
Minor Arterial	952,725	4.28%
Major & Minor Collector	1,704,459	7.65%
Local	312,546	1.40%
Total Urban	14,432,733	64.81%
TOTAL	$22,270,643	100.00%

Figure III-3 summarizes the distribution of highway improvements on different functional highway classes. There are substantially more capacity improvements on high-order systems than on lower order systems. The proportion of obligations for new capacity on high-order urban systems is more than twice as great as on low-order systems in either rural or urban areas. Relatively more is spent on system preservation on rural highways than urban highways, especially low-order rural highways where system preservation accounts for over two-thirds of total obligations. System enhancements including safety improvements, TSM, transit improvements, and various other enhancement projects account for 40 percent of obligations on low-order urban highways, a substantially greater share than on other highway systems.

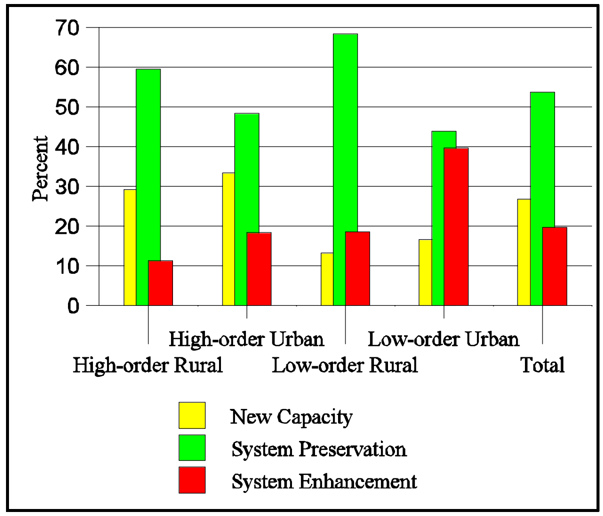

Figure III-3. Distribution of Base Period Costs by Highway Class

Detailed Work Types

The FMIS contains more detailed data on specific types of highway improvements than were available for the 1982 Federal HCAS. The most detailed information in FMIS is the project work type. Detailed data on work types provides the basis for a more accurate assignment of highway cost responsibility among different vehicle classes because many different types of work may be included in a single broad improvement type. Detailed work type data help to assure that costs are not incorrectly attributed to the wrong vehicle class and allow some costs that otherwise might simply be lumped with common costs to be identified and allocated to particular vehicle classes. Table III-4 summarizes obligations for work types used in this study categorized by the nature of the work. Table III-5 shows the distribution of Federal obligations for 12 highway improvement types into which Federal-aid highway program obligations are grouped. Obligations for each improvement type are distributed across the 12 highway functional classes.

Life Cycle Cost Analysis

The potential for more widespread use of LCCA to reduce overall system preservation costs was evaluated on a preliminary basis in this study. The LCCA of infrastructure investment decisions is intended to identify alternatives that have the lowest cost over their entire life, not just alternatives with the lowest initial costs. Among the factors that can affect life cycle costs are the materials selected for particular types of construction, the initial design, and maintenance and rehabilitation (M&R) practices. Many States apply LCCA principles to varying degrees in pavement and bridge management systems, but there is a widespread

Table III-4. Base Period Obligations for Selected Work Types

Major Cost Category	Individual Work Types Included In Major Cost Category	$ Obligations
Auto/HOV-Related	HOV, Fringe Parking Facilities, Carpool/HOV Facilities, Vanpool Acquisition, Ride-Matching Programs	$118,704,371
Transit- Related	Transit Passenger Facility, Bus Purchase, Purchase of Rolling Stock, Operating Expenses, Ferry Boats	$528,118,937
Truck-Related	Commercial Vehicle Information Systems Project, Truck Loading Facility, Motor Carrier Safety Assistance Program Development and Enforcement, Commercial Drivers License Development and Enforcement, Truck Scales, Terminal and Transfer Facilities	$104,540,164

Table III-5. Base Period (1993-1995) Federal Highway Program Obligations by Improvement Type and Highway Functional Class ($ 000)

	RURAL						URBAN						
	Interstate	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local	Interstate	Freeway & Expressway	Other Principal Arterial	Minor Arterial	Major & Minor Collector	Local	TOTAL
New Construction	35,497	449,821	66,464	39,470	6,840	10,012	401,194	299,508	335,280	56,125	45,104	17,066	1,762,387
3R Preservation	1,053,305	954,193	428,618	400,935	85,887	172,567	1,270,306	227,762	734,131	271,973	198,147	8l,225	5,879,083
Minor Widening	38,950	79,373	45,876	38,336	4,221	7,590	37,802	26,636	55,562	29,777	22,917	5,225	392,274
New Bridge	29,202	99,986	15,676	12,962	1,537	5,766	226,467	94,657	107,874	19,964	6,025	2,384	622,526
Bridge Replacement	48,115	157,121	192,938	190,066	60,428	170,817	295,995	55,049	247,979	136,049	92,405	67,135	1,714,104
Major Bridge Rehabilitation	101,515	57,347	24,177	16,896	3,408	9,016	352,333	88,372	221,523	46,559	25,949	24,176	971,276
Minor Bridge Rehabilitation	48,834	17,596	8,624	11,313	37,486	17,127	113,465	16,510	50,274	9,927	18,751	10,672	360,585
Safety/Traffic Ops/TSM	176,257	138,031	59,986	53,629	91,923	47,199	643,133	155,733	287,895	124,666	229,063	53,500	2,061,019
Environmentally-related	46,716	39,200	10,886	9,798	15,878	6,344	103,188	30,007	35,153	12,683	107,201	12,578	429,592
Other Projects	6,066	76,616	12,817	6,713	190,820	14,093	76,649	51,171	65,130	10,118	391,866	353	902,391
Reconstruction-Added Lanes	49,890	96,176	51,037	27,643	5,148	5,900	263,710	32,865	120,914	67,252	31,520	6,944	759,543
Major Widening	132,796	360,873	84,650	28,215	3,532	3,946	363,743	68,191	303,204	112,531	21,830	4,989	1,488,507
TOTALS	1,767,147	2,526,880	1,001,758	835,980	507,114	470,414	4,147,990	1,146,468	2,564,898	897,606	1,190,785	286,254	17,343,294
Percent	10.19%	14.57%	5.78%	4.82%	2.92%	2.71%	23.92%	6.61%	14.79%	5.18%	6.87%	1.65%	100.00%

belief that greater use of LCCA could reduce long-term program costs. The implications of LCCA for HCA are that if long-term infrastructure costs could be reduced, those costs would represent a smaller share of the overall program and vehicle classes responsible for the greatest share of infrastructure costs would have lower cost responsibility and improved equity ratios.

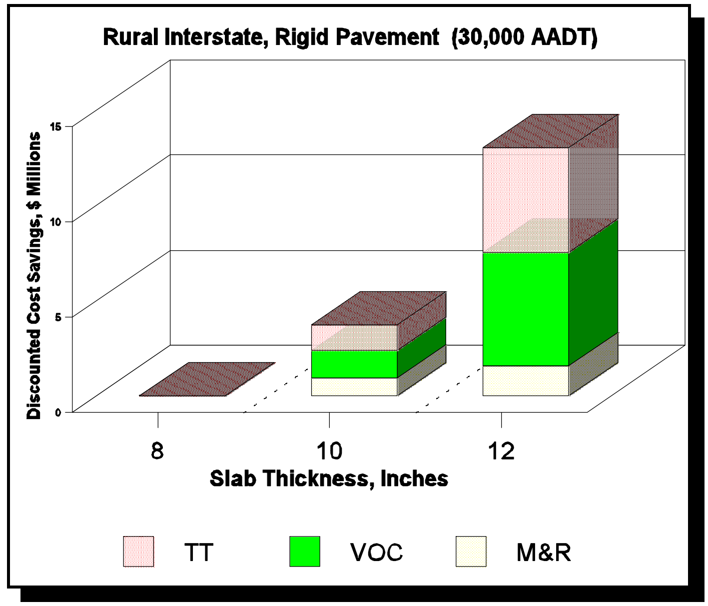

Figure III-4. LCCA Results Expressed as Cost Savings

The NHS Designation Act of 1995 (P.L. 104-59, 109 Stat. 568 (1995)) requires the use of LCCA on NHS projects having a usable project segment costing $25 million or more. The FHWA recently issued a final policy statement on LCCA implementing LCCA provisions of this Act and generally encouraging the use of LCCA in evaluating major infrastructure investment decisions.

A preliminary analysis suggests large potential benefits from the adoption of LCCA, especially in reducing vehicle operating costs associated with traveling on deteriorated pavements and delay around work zones where highway M&R is being performed. Typical life-cycle cost results are illustrated in Figure III-4, showing the variation in agency costs (M&R combined), vehicle operating costs (VOC), travel time costs, and total costs (agency plus user) as a function of pavement structure assuming a given traffic level. The specific example shown in Figure III-4 applies to rural Interstate highways with 30,000 annual average daily traffic (AADT), and rigid pavement structures ranging from a slab thickness of 8 to 12 inches. These costs were obtained by simulating the performance of the indicated pavement structures under a traffic load of 30,000 AADT, comprising a mix of vehicles estimated for this functional class.

An analysis period of 50 years was used, and costs were discounted at 4 percent. While these results in Figure III-4 apply to the specific case described, they typify the results seen in other cases in the following ways:

- User costs dominate agency costs in terms of total magnitude.

- Total discounted life-cycle costs decrease with increasing pavement structure. This indicates the benefit of a stronger pavement in carrying a fixed volume and composition of traffic, both in reducing the need for subsequent M&R and in providing higher serviceability to users over a longer period.

To determine whether rehabilitation policies approach an optimal or least cost pavement strategy, analyses were made of a given pavement and traffic situation (flexible pavement, structural number of 5.0, carrying 50,000 vehicles per day). Figure III-5 shows cost savings, primarily in vehicle operating costs, associated with rehabilitating pavements before pavement condition, as measured by the pavement serviceability index (PSI) gets too poor. The additional M&R costs of these policies, shown as negative cost savings, are the agency costs to perform more rehabilitation. The analysis conducted for this study did not examine options of allowing pavement to deteriorate below a PSI of 2.5, but in some case agency cost savings might be expected from policies that prevented pavements from deteriorating to the point where they needed major reconstruction. The cost savings with each successively higher PSI occur in both vehicle operating costs

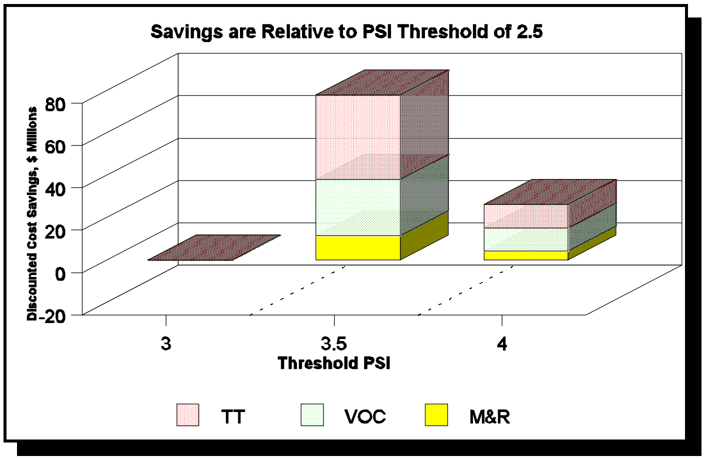

Figure III-5. Savings Due to Varying Rehabilitation Threshold

and travel time costs, according to the EAROMAR model. It is instructive to note, however, that while savings in travel time costs increase in the steps from threshold values of 2.5 to 3.0 and from 3.0 to 3.5, no such gain occurs from a threshold of 3.5 to 4.0. Two effects contribute to this situation: (1) in the range of PSI from 3.5 to the maximum theoretical PSI of 5.0, the pavement is so smooth that little additional speed is gained as a function of further improvements in pavement surface condition; and (2) the additional congestion costs due to more frequent pavement rehabilitation and the imposition of work zones detract from any travel time savings due to incrementally smoother pavement. The gains in vehicle operating costs at all levels of improvement in rehabilitation policy can be substantial according to the results in Figure III-5. Further research to improve estimates of potential benefits of LCCA is planned, not only for cost allocation but for investment analyses conducted for the Department's C&P Report.

Federal Obligations for Transit

Federal obligations for transit are highlighted in Table III-6. About three-fourths of the total Federal funds for mass transit are from the HTF. About 15 percent of trust fund monies for mass transit are from the Highway Account and 85 percent from the MTA. Of those HTF funds, almost all are for capital outlays.

The Federal Transit Administration (FTA) groups transit expenditures into three broad functions, congestion management, low-cost mobility, and liveable metropolitan areas. These functions are not mutually exclusive, however, and thus the amount that is exclusively for any one function cannot be estimated. Expenditures for congestion management represent the largest share of total transit expenditures, and total estimated expenditures related to congestion management exceed monies obligated for transit from the HTF. In allocating transit costs, it is assumed that all monies from the HTF are related to congestion management, and thus can appropriately be allocated to highway users.

Table III-6. 1994 Federal Obligations for Transit (Billion $)

	HTF			
	Highway Account	MTA	General Fund	Total
Capital Outlay	0.44	2.45	0.66	3.53
Planning	0.02	0.06	0.05	0.10
Operating	0	0	0.78	0.83
Total	0.46	2.51	1.49	4.46

Sources: 1994 Highway Statistics, 1993/1995 Statistical Summaries of Grant Assistance Programs (FTA)

Future Federal Highway Program Costs

There is considerable uncertainty about the future composition and funding level for the Federal highway program. Significant changes in Federal surface transportation programs were enacted in ISTEA which provide unprecedented flexibility for State and local transportation agencies to meet their unique transportation requirements while focusing resources on a new NHS that will be the backbone of surface transportation systems into the next century. This flexibility has been widely heralded, but some believe there is too much flexibility, while others believe there should be even more. Similarly there is much debate concerning the future level of Federal highway funding. Current budgetary limitations have required all Federal agencies to reassess priorities and make do with less funding in many cases.

In the current budgetary environment, it is difficult to predict what the Federal highway program composition and funding level will be in 2000, the forecast year for this study. For purposes of simplifying the analysis, the composition of the highway program in 2000 is assumed to be the same as during the 1993-1995 base period. The distribution of obligations by improvement type is assumed to be the same as well as the distribution across highway functional classes. Furthermore, the program level is assumed to be the same as revenues coming into the HTF. Actual obligation levels are determined by Congress and could be below, equal to, or above HTF revenues.

These assumptions have significant implications for the equity analysis because both the distribution of obligations by improvement type and highway class influence the allocation of program costs among different vehicle classes. Table III-7 shows the assumed distribution of obligations from the HTF in 2000. Because the composition of the Federal program can have such a large impact on the equity analysis, alternative investment scenarios are evaluated in Chapter VI. These scenarios consider a wide range of potential options including greater investment in system preservation, greater investment in added capacity, and greater investment in system enhancement.

Table III-7. Estimated Distribution of Federal Highway Obligations in 2000

Category	Improvement Type	Obligations (Million)	Percent of Total
New Capacity	New Construction	$2,941	10.8%
	Recon. Add Lanes	$937	3.4%
	Major Widening	$1,836	6.8%
	Subtotal	$5,713	21.0%
System Enhancement	Safety/TSM	$2,542	9.4%
	Environmental	$530	1.9%
	Other Projects	$1,113	4.1%
	Subtotal	$4,184	15.4%
System Preservation	3R Preservation	$7,250	26.7%
	Minor Widening	$484	1.8%
	Major. Bridge	$445	1.6%
	Bridge Replace.	$2,114	7.8%
	Minor. Bridge	$1,198	4.4%
	Subtotal	$11,490	42.3%
MTA		$3,380	12.4%
Other		$2,407	8.9%
Total		$27,175	100.0%
Functional Highway Class	High Order-Rural	$5,652	20.8%
	Low Order-Rural	$3,968	14.6%
	High Order-Urban	$13,914	51.2%
	Low Order-Urban	$3,641	13.4%

* Includes FHWA, Other Agencies, and Uniquely Occasioned Costs

State and Local Highway Program Costs

Unlike the detailed data on Federal obligations for highway construction, detailed descriptions of State and local obligations for highway construction and maintenance are not available. As a result, data on State and local highway costs are developed on an expenditure basis. There is no database that provides detailed information on expenditures by specific improvement or work types or by highway functional class as is the case for Federal program costs. Thus, data at a more general level must be used for the analysis. (See Appendix H, "Highway Cost Allocation for All Levels of Government" for more details on State and local expenditures.)

The largest single category of highway expenditures for all levels of government is capital outlay, followed by maintenance services. As explained previously, capital outlays are those costs associated with the planning, engineering, and construction of improvement projects, while maintenance expenditures preserve existing facilities. All other highway-related expenditures by State and local governments have been grouped into other costs. There do not appear to be any consistent changes in types of highway expenditures from year to year, but rather small fluctuations.

Forecast of Future State and Local Highway Program Financing

The forecast of State and local highway expenditures is based on the future demand for highway transportation and the trends in State and local expenditures per VMT. Although highway expenditures have increased steadily over the past few decades, there has been a decline in total expenditures per VMT measured in constant dollars. This reduction in expenditures per VMT is partially attributed to the declining emphasis on new road construction and the growing need to maintain existing roads.

The forecast of State and local highway expenditures is based on changing characteristics of motor vehicle travel and historical trends in expenditures per VMT. Average expenditures per VMT are calculated for different categories of State and local highway expenditures to incorporate changes in efficiency of building, maintaining, and administering highway programs. State capital outlays are divided into urban and rural areas in order to account for shifts of motor vehicle travel; however, the remaining State and local expenditures such as administration, safety, or law enforcement cannot be classified by type of roadway.

Capital outlays on rural roads averaged $9.24 per 1,000 VMT in 1994 and have decreased 1.6 percent annually since 1988. Capital outlays per 1,000 VMT on urban roads decreased 1.0 percent a year for the same period. On a per VMT basis, it is more costly to build and maintain rural roads than urban roads. This is attributed to the large initial cost of building roads and the lower marginal cost per vehicle mile of maintaining the roads. Administration and research is the only State expenditure category that has increased on a per VMT basis at 2.3 percent annually. Total State highway expenditures per VMT decreased 1.4 percent annually, with rural and urban capital outlays representing the largest decrease in spending per VMT.

Local highway expenditures per VMT decreased more significantly than State expenditures, led by declines in capital outlays, law enforcement/safety, and maintenance services. Capital outlays declined more than any other category at -3.54 percent per year (local capital outlays cannot be divided into rural and urban areas with the current data). Bond retirement and interest on debt are the only local costs to increase per VMT which indicates that local governments have been taking on larger debt to finance roadways. The total highway expenditures per VMT decreased at 2.4 percent per year, a full percentage point greater than State expenditures.

Forecast of State and Local Highway Expenditures

The forecast of State and local highway expenditures combines motor vehicle travel forecasts with the average change in expenditures per VMT to project total expenditure levels. This approach incorporates the historical trends in State and local spending for highways with the expected growth in motor vehicle transportation. Each category of State and local highway expenditures is projected in costs per VMT

Table III-8. Highway Obligations or Expenditures for 1994 and 2000 for All Levels of Government ($ Millions)			
Obligations or Expenditures	**1994**	**2000**	**Growth Rate (percent)**
Federal Obligations			
Direct from HTF	1,394	1,819	4.53
Direct from Other Source	340	413	3.30
Total Direct Federal Obligations	1,734	2,232	4.29
Transfers to States from HTF	16,916	21,644	4.19
Transfers to States from Other Funds	569	691	3.30
Transfers to Local Governments from HTF	259	331	4.19
Transfers to Local Govts from Other Funds	440	535	3.30
Mass Transit Expenditures from HTF	2,304	3,380	6.60
Total Federal Aid to State & Local Governments	20,488	26,581	4.43
Total Federal Obligations from HTF	20,873	27,174	4.49
Total Federal Obligations from Other Funds	1,349	1,639	3.30
Total Federal Obligations	22,222	28,813	4.42
State Expenditures			
Capital Outlays	32,059	40,868	4.13
Maintenance	7,152	8,961	3.83
Traffic Services	2,984	4,211	5.91
Administration and Research	4,847	6,841	5.91
Debt Service	4,318	6,094	5.91
Law Enforcement and Safety	4,209	5,940	5.91
Subtotal	55,569	72,915	4.63
Federal Transfers	(17,485	(22,33	4.16
Grants-in-Aid to Local Governments	8,838	11,596	4.63
Local Government Transfers	(1,381)	(1,710	3.63
Motor Vehicle Administration	2,667	3,499	4.63
Motor Fuel Administration	244	320	4.63
Mass Transit Expenditures	1,796	2,356	4.63
Total State Expenditures	50,248	66,641	4.82
Local Expenditures			
Capital Outlays	9,231	10,630	2.38
Maintenance	11,796	14,085	3.00
Traffic Services	1,771	2,115	3.00
Debt Service	3,859	5,325	5.51
Admin. Law Enforcement, and Safety	6,133	8,463	5.51
Subtotal	32,790	40,618	3.63
Federal Transfers	(699)	(866)	3.64
Grants-in-Aid to Local Governments	(8,838)	(11,59	4.63
Transfers to States	1,381	1,710	3.63
Total Local Expenditures	24,634	29,867	3.26
Total Obligations and Expenditures (all levels)	97,104	125,32	4.34

based on the compound annual growth rate for that category between 1988 to 1994. State capital outlays are divided into rural, urban, and unclassified expenditures and are projected separately (unclassified capital outlays are expenditures that have not been designated either rural or urban areas). Forecasted annual VMT is multiplied by the projected costs per VMT to calculate the future State and local annual highway expenditures.

Table III-8 provides the estimates of growth rates for Federal, State, and local highway expenditures for the various categories. All values are in millions of dollars and the growth rates are compound annual rates projected from 1994 to 2000. Mass transit expenditures are projected to increase the fastest at 5.76 percent, while maintenance expenditures and capital outlays are projected to increase at 3.32 and 3.76, respectively. Other highway costs, which include traffic services, administration and research, debt service, and law enforcement are projected to grow at an overall rate of 5.56 percent. Total highway expenditures are forecast to increase from $97.1 billion in 1994 to $125.3 billion in 2000, at an annual growth rate of 4.34 percent. Table III-8 provides a detailed breakdown of expenditures for all levels of government and growth rates between 1994 and 2000.

Non-Agency Costs Associated With Highway Transportation

Expenditures by highway agencies do not cover all societal costs of highway construction and use. Use of the highway system can have unintended adverse impacts on other highway users and non-users. Among these adverse impacts are damage to health, vegetation, and materials due to air pollution; noise and vibration effects of traffic; congestion costs to other highway users; fatalities, injuries, and other costs due to crashes; and waste from scrapped vehicles, tires, and oil.

The construction of highways and their physical presence may also have unintended adverse impacts including environmental impacts during construction; aesthetic impacts on adjacent areas; effects of roadways as barriers to community interaction; water quality impacts such as loss of wetlands and run-off; and loss of parklands and wildlife habitats.

Legislation such as the National Environmental Policy Act (NEPA); Noise Control Act; National Historic Preservation Act; Clean Air Act and Amendments; Section 4(f) of the DOT Act; ISTEA; and legislation establishing NHTSA and funding safety improvements includes a number of important provisions designed to minimize adverse impacts associated with highway construction, highway use, motor vehicle characteristics, and other aspects of the transportation system. Minimizing the unintended costs of highway use and highway construction is a central consideration in transportation planning, programming, project design, and policy development. Another potential way to reduce congestion, environmental and other costs that highway users impose on others would be to charge users for those costs. Indeed, if users paid the marginal costs of their trips, economic efficiency would be improved. The marginal costs of highway use are the added costs associated with a unit increase in highway use (measured, for example, in cents per vehicle mile). These marginal costs include costs to the highway user (e.g., travel time and fuel), costs imposed on other highway users (principally crash costs and congestion) costs imposed on non-users, and costs borne by public agencies responsible for the highway system (e.g., use-related maintenance costs). Highway users take their own vehicle operating and travel time costs into account when they decide whether or not to make a trip, but they generally do not consider costs they impose on others.

Marginal costs are frequently characterized as “short-run” or “long-run.” Short-run costs take the highway system as fixed. Long-run costs allow for the possibility of capital investment (e.g., construction of more lanes or thicker pavements) to accommodate increases in highway use. The basic goal of marginal cost pricing is improved economic efficiency: if highway users are required to pay fees equal to the costs they impose on others (including other highway users, non-users, and public agencies) when they choose to travel, then trips that are valued less than these costs will not be made. In congested urban areas, a substantial portion of the marginal costs of highway use are borne by other highway users and non-users. Marginal environmental, congestion, safety, and other social costs of travel by different vehicles are estimated in Chapter V. This chapter includes only total cost estimates for those various non-agency costs.

Several recent studies have advocated the use of full cost pricing of highways in assessing the equity of highway user tax structures. Full cost pricing of highways is based on the concept that highway user taxes should be set at levels that are sufficient to recover all costs of highway use, not just agency costs (as in a traditional application of the cost-occasioned approach) and not just short-run marginal costs (as in marginal cost pricing). In most past applications of full cost pricing, the primary focus has been on a comparison of total costs of the highway system with total collections from all highway users. However, if the responsibility for all costs can be allocated among vehicle classes, the results of a “full cost pricing” analysis can also be used as a basis for evaluating the relative shares of revenues from different vehicle classes. It is important to point out that environmental cost estimates developed in this report should not be used as a basis for calculating damages from specific infrastructure projects in affected areas.

Air Pollution

Motor vehicles produce emissions that damage the quality of the environment and adversely affect the health of human and animal populations. Highway users are a major source of total air pollution in the United States. The EPA estimated that in 1993 approximately 62 percent of all carbon monoxide (CO) emissions, 32 percent of all nitrogen oxides (No_x), and 26 percent of volatile organic compounds were produced from highway sources. Air pollution generated from transportation vehicles is an external cost that is not fully absorbed by the transportation user. Environmental legislation requiring improved engine technology and cleaner burning fuels has internalized some of the emission damage caused by motor vehicles; however, the technological advances have not eliminated air quality damage from combustion engines.

Key motor vehicle characteristics affecting emission rates include the following:

- Type of engine—emission rates for particulate matter are much higher for diesel-powered vehicles; emission rates for CO are much higher for gasoline-powered vehicles.

- Age—a typical 1993 vehicle emits 80 percent less than a typical 1970 vehicle.

- Heavy duty vs. light duty—for both gasoline and diesel-powered vehicles, heavy duty vehicles have higher emission rates than light duty vehicles.

- Time running—automobiles have much higher emission rates when they are not warmed up.

- Operating speed and acceleration/deceleration profile—The relationship between emission rates and speed for most pollutants is U-shaped, with higher emission rates at very low and very high speeds.

- Condition of emission-control devices—faulty emission control devices can cause huge increases in emissions.

The damage caused by pollutant emissions also varies greatly depending on meteorology, population, and other characteristics of the region in which the vehicle is operating. For a given vehicle, external costs for air pollution (expressed, for example, in dollars per vehicle mile) can vary by several orders of magnitude depending upon (1) the level of congestion under which travel occurs, sensitivity of nearby land uses, and other situational factors and (2) analysis assumptions such as those used to quantify effects of additional emissions on health.

Methods for estimating vehicle emission costs are divided into three primary components: the measurement of the emissions of a single vehicle operating under specific conditions, estimation of the emissions effect on ambient concentration levels, and the damage cost calculation for a unit change in concentration per person. Relating emission costs to changes in person-year concentration levels best captures the locational changes in ambient air quality and relates these conditions to the number of people affected by the pollutant. Unlike other key social costs, published studies did not provide an adequate basis for estimating the costs of air pollution attributable to highway use by motor vehicles. The Department is working with EPA to develop estimates that adequately reflect the lastest understanding of the costs of motor vehicle emissions. These cost will be submitted as an addendum to this report.

Noise

Noise emissions from motor vehicle traffic are a major source of annoyance, particularly in residential areas. Millions of people living near busy highways and roads are affected by vehicle traffic noise.

Key vehicle characteristics and situational factors affecting noise costs include the following:

- # Speed and acceleration/deceleration—noise emissions increase at higher speeds and acceleration rates.

- # Traffic levels—an additional vehicle mile on a low volume road generally has more impact than an additional vehicle mile on a high volume road.

- # Weight—noise levels generally increase with operating weight.

- # Adjacent land uses—the nature and density of land uses adjacent to the highway are key determinants of noise costs.

Noise costs were estimated using information on the reduction in residential property values caused by noise emissions of highway vehicles. Estimates of noise emissions and noise levels at specified distances from the roadway were developed using FHWA noise models in which noise emissions vary as a function of vehicle type, weight, and speed. Data from FHWA's HPMS were used to estimate the types of development adjacent to highways for each highway functional class. Assumptions about residential densities for different types of development were then used to estimate the number of housing units affected. The procedures are described in Appendix E.

The following assumptions in Table III-9 were used to develop high, middle, and low estimates of noise costs:

Table III-9. High, Middle, and Low Assumptions Used in Estimating Noise Costs

	High	Middle	Low
Percent change in value of residential property per decibel over threshold	0.88	0.40	0.14
Adjustment factor for other uncertainties in noise cost estimation	1.2	1.0	0.8

The 0.88 and 0.14 were the second highest and second lowest estimates from 17 noise impact studies conducted from 1974 to 1980 and reviewed by Nelson (1982) (see Appendix E). It should be noted that these costs were derived to estimate external costs and are not intended to be used for assessing damage to developments adjacent to highways.

Table III-10 shows estimates of high, middle, and low estimates of noise costs developed for this study.

Greenhouse Gas Emissions

Most scientists believe that increasing concentrations of greenhouse gases in the atmosphere will cause global warming. Consequences of global warming include (1) changes in agricultural outputs due to changes in rainfall patterns and temperatures, (2) an increase in sea level as ice caps in northern latitudes and Antarctica begin to melt, and (3) changes in heating and

Table III-10. Noise Costs in the Year 2000

	Millions of 1994 Dollars		
	High	Mid-Range	Low
Rural Highways	842	319	89
Urban Highways	10,604	4,017	1,125
All Highways	11,446	4,336	1,214

cooling requirements. The Intergovernmental Panel on Climate Change (IPCC) concluded that it could not endorse any particular range of values for the marginal damage of CO_2 emissions on climate change, but noted that published estimates range between $5 and $125 ($1990 U.S.) per metric ton of carbon emitted now. The IPCC noted, however, that this range of estimates does not represent the full range of uncertainty and that estimates are based on simplistic models that have limited representations of the actual climatic processes. The wide range of damage estimates reflects variations in model scenarios, discount rates and other assumptions. The Energy Information Agency estimates that 380.4 million metric tons of carbon were emitted by motor vehicles in 1995 which would translate into a range of total costs of from $1.9 billion to $47 billion. The IPCC emphasizes that estimates of the social costs of climate change have a wide range of uncertainty because of limited knowledge of impacts, uncertain future technological and socio-economic developments, and the possibility of catastrophic events or surprises. Because of the tremendous uncertainty in climate change costs, no estimates of costs related to highway transportation are developed for this study.

Congestion

Costs of highway congestion include:

- Added travel time for persons and commercial movements.
- Speed-related effects on fuel use and other components of motor vehicle operating costs.
- Increased variability of travel time.
- Increased driver stress associated with operating a motor vehicle under stop-and-go conditions.

The relative impact of different types of vehicles on congestion is measured in PCEs. For example, a truck with a PCE value of three would have the same impact on congestion as three passenger cars. The PCE values depend upon vehicle weight, horsepower and related drivetrain characteristics, and vehicle length. The PCE value for a given vehicle can vary considerably depending upon the type of highway on which the vehicle is being operated. The vertical profile of highways is particularly important in determining PCE values for heavy trucks that operate at lower speeds on long steep grades.

In analyzing congestion costs, added delays to other highway users associated with changes in traffic levels were estimated. The analysis included both recurring congestion and the added delays due to incidents such as crashes and stalled vehicles. Effects of incidents were estimated using data on the frequency of incidents, their duration, and their impacts on highway capacity for different types of facilities. The analysis of incidents focused on freeways, where a serious incident can result in long delays for motorists. On non-freeways, the effects of incidents tend to be much less serious because of lower traffic volumes and opportunities to get by incidents without incurring major delays.

Estimates of PCEs for different types of vehicles were developed using the FHWA's FRESIM model. This model simulates the interactions of individual vehicles on freeways. The model was run under a variety of traffic levels and vehicle mixes, and regression analysis was used to estimate the relative impacts of different types of vehicles on congestion.

Congestion cost impacts of changes in traffic levels are extremely sensitive to whether traffic increases occur during peak or off-peak periods. In heavily congested peak period traffic, the addition of a single vehicle to the traffic stream has a much greater effect on delay than the addition of a vehicle during non-peak periods. In general, trucks account for a lower percentage of peak period traffic on congested urban freeways, since commercial vehicles try to avoid peak periods whenever possible. In the analysis, delays to other vehicles caused by traffic increases were estimated separately for peak and off-peak periods. The results presented are weighted averages, based on estimated percentages of peak and off-peak travel for different vehicle classes.

The effects of increases in traffic volumes on congestion costs was estimated using the QSIM model (see Appendix E). The model explicitly accounts for the effects of traffic variability and queuing on travel time. It also takes into account the effects of freeway incidents (such as stalled vehicles or crashes) on congestion costs.

The following assumptions in Table III-11 were used to develop high, middle, and low estimates of congestion costs:

Table III-11. High, Middle, and Low Assumptions Used in Estimating Congestion Costs

	High	Middle	Low
Value of time (dollars per vehicle hour)	18.57	12.38	6.19
Adjustment factor for other uncertainties (principally speed-volume relationships)	2.0	1.0	0.5

The mid-range assumption about value of time is taken from the HERS model. The HERS assumes that for off-the-clock travel, the average value of time for auto drivers is 60 percent of the wage rate. Plausible estimates of the value of time range from 30 to 90 percent of the wage rate.

Table III-12 shows estimates of high, middle, and low estimates of congestion costs developed for this study.

Table III-12. Congestion Costs in the Year 2000

	Millions of 1994 Dollars		
	High	Mid-Range	Low
Rural Highways	23,014	7,825	2,072
Urban Highways	158,621	53,935	14,280
All Highways	181,635	61,761	16,352

Crash Costs

On U.S. highways in 1994, there were 40,676 fatalities, 3,215,000 injuries, and 6,492,000 crashes reported to police. Annual highway fatalities and injuries declined significantly from 1970 to 1992 as a result of public policies promoting safety, including more frequent seat belt use, air bags, anti-lock brakes, speed limit reductions, aggressive safety inspections, and anti-drunk driving programs. From 1992 to 1994, however, highway fatalities and injuries increased slightly as a result of growth in traffic.

The estimated crash costs used in this study are based on the Urban Institute's 1991 comprehensive crash cost study *The Cost of Highway Crashes* sponsored by the FHWA and NHTSA. That study examined crash costs associated with property damage; lost earnings; lost household production; medical costs; emergency services; vocational rehabilitation; workplace costs; administrative costs; legal costs; and pain, suffering, and lost quality of life[1]. Data from the Urban Institute report also were used to develop estimates of who pays crash costs. The automobile and life insurance compensation were calculated from insurance industry data with the percentages of the population covered and average policy amount. Tax losses to the government were computed by multiplying short-term wage losses times the marginal tax rate and long-term wage losses times the average tax rate. To estimate the non-highway-user portion of pain and suffering costs, data from *Traffic Safety Facts 1994* (NHTSA 1995) on the fraction of fatalities (16 percent) and injuries (5 percent) that were non-motorists were used.

Crash involvement rates by vehicle type and highway functional class were developed using involvement data from *Traffic Safety Facts 1994* (NHTSA 1995) and FHWA estimates of 1994 VMT by vehicle type and functional class. *Traffic Safety Facts* provides data on the number of involvements in fatal, injury, and property damage only crashes for automobiles, light trucks, large trucks, buses, and motorcycles. That document also provides data on the number of vehicle involvements in fatal crashes by highway functional class. These data, together with data on VMT by vehicle type and functional class, were used to estimate involvement rates by vehicle type and functional class for fatal, injury, and property damage only crashes.

To estimate the effects of traffic volume on crash rates for each highway functional class, fatal, injury, and property damage only crash rates by highway type and AADT range originally developed for use in the HERS model we used along with the distribution of VMT by highway type and AADT range for each functional class from FHWA's HPMS database.

The following assumptions in Table III-13 were used to develop high, middle, and low estimates of crash costs:

Table III-13. High, Middle, and Low Assumptions Used in Estimating Crash Costs

	High	Middle	Low
Cost of a statistical death (millions of dollars)	7.0	2.7	1.0
Costs paid by auto insurance companies assumed to be external	Yes	No	No
Uncompensated costs of pain and suffering included	Yes	Yes	No

1 Travel delay costs were also included in the Urban Institute's crash cost study; however, it has been removed from accident cost estimates because it is included in the congestion costs.

Table III-14 shows estimates of high, middle, and low estimates of total crash costs developed for this study.

Table III-14. Crash Costs in the Year 2000			
	Millions of 1994 Dollars		
	High	Mid-Range	Low
Rural Highways	471,956	191,088	67,791
Urban Highways	367,507	148,799	52,789
All Highways	839,463	339,886	120,580

Water Quality

Adverse effects of highway construction and use on water pollution include damage due to the following:

- Road de-icing salts.
- Deposits of pollutants on the road surface due to tire wear and leaks of hazardous fluids.
- Roadside herbicides.
- Leaking underground storage tanks (LUST).
- Increased impervious surfaces.
- Deposits of nitrogen from NO_x emissions in bodies of water.

Miller and Moffet cite estimates from a 1976 study for EPA by Murray and Ernst that total cost of road salt as $8 billion per year, including $600 million per year damage to water supplies, health, and vegetation.

Litman cites estimates from a 1994 Office of Technology Assessment study (*Saving Energy in U.S. Transportation*) that leaking fuel tanks and oil spills associated with motor vehicle use cost $1 to $3 billion per year. Litman estimates total water pollution costs from roads and motor vehicles as $28.8 billion per year. Litman obtained most of these costs ($22.1 billion) by factoring up an estimate by the Washington State DOT (WsDOT) that meeting its stormwater runoff water quality and flood control requirements would cost $75 to $220 million per year. Specifically, Litman averaged the WsDOT upper and lower estimates, tripled the result to account for non-State highways, parking spaces, and residual impacts, and then multiplied the result by 50 to represent national costs.

Delucchi[2] estimates the cost of urban runoff polluted by oil from motor vehicles and pollution from highway deicing as $0.7 to $1.7 billion per year. He estimates the cost of water pollution due to leaking motor-fuel storage tanks as $0.1 to $0.5 billion dollars per year. Also, he estimates that portion of the costs of large oil spills that might be attributed to motor vehicles as $2 to $5 billion per year.

2 Mark A. Delucchi, *The Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991: Summary of Theory, Data, Methods, and Results*; Institute of Transportation Studies: UCD-ITS-RR-96-3(1); October 1996.

Waste Disposal

Table III-15. Estimate of Waste Disposal Costs			
Item	Volume	Unit Cost	Total Cost ($ Million)
Scrapped or abandoned vehicles	15 percent of 188,371,935	$25	$706
Tires	3 billion	$1	$3,000
Used oil and lubricants	960 million quarts	$0.50	$480
Total			$4,186

Improper disposal of waste products from motor vehicles can result in health hazards and environmental degradation. These waste products include scrapped vehicles, tires, batteries antifreeze, and oil. Several recent laws and policy initiatives attempt to internalize these costs: crankcase oil recycling networks, recycling requirements for car batteries, and tire taxes dedicated to tire disposal (Litman). Lee estimates the annual external cost of waste disposal from waste oil, scrapped cars, and used tires at $4.2 billion as shown in Table III-15 (D. Lee, "Fuel Cost Pricing of Highways," TRB 1995 Meeting). The $4.2 billion figure seems high. Lee himself characterizes the $1 per tire as arbitrary and notes that 3 billion is the total population of waste tires in the United States—not annual scrappage. He also notes that recycling of tires is gradually improving, but the consumer still has to pay to have them disposed of.

Vibration Effects on Structures

Vibration caused by traffic can cause annoying vibrations in structures that ultimately may lead to premature deterioration. Vibration is a particular problem in older inner city neighborhoods where buildings are close to the street and may already be in some disrepair. No estimates of the nationwide costs of vibration were found in the literature.

Aesthetic Impacts of Highways

New construction or major expansion of existing highways can significantly degrade the view from adjacent and nearby areas. No estimates of these costs at the national level were found in the literature.

Effects of Roads as Barriers

While improving mobility to motorists, highways can create barriers to non-motorized travel. These costs are often incident upon disadvantaged populations without access to motor vehicles, including children, the poor, the elderly, and the handicapped. There is little in the literature that would allow these impacts to be measured in dollar terms.

Loss of Parklands and Natural Habitats

Highway construction may sometimes involve the loss of wetlands, parklands, and other natural habitats. To protect the environment, such loss is controlled by several provisions of Federal law. The U.S. Army Corps of Engineers has jurisdiction over the Federal permit required by the Clean Water Act concerning wetlands impacts (Section 404). De Santo and Flieger (TRR 1475) discuss factors to be considered in this process:

- Potential for a wetland to serve as a groundwater recharge or discharge area.
- Reduction of flood damage by water retention.

Stabilization of stream banks and shorelines against erosion.
Trapping sediment, toxicant, and pathogen in runoff water from surrounding uplands.
Trapping nutrients in runoff water and preventing the ill effects of nutrients from entering aquifers or surface waters.
Production of food and other usable products.
Fish and shellfish habitat.
Wildlife habitat.
Threatened or endangered species habitat.
Visual quality and aesthetics.
Educational and scientific value.
Recreational opportunities such as boating, fishing, hunting, and other activities.
Uniqueness within the surrounding area.

Under the NEPA, major Federal or Federally-assisted actions must be subject to an assessment that determines the probable effects on the physical environment and social and economic conditions. The main thrust of the Act is to insure adequate consideration of all effects before proceeding with an action.

Section 4(f) of the DOT Act of 1966 is intended to assure that public parklands are not used for transportation facilities except in cases of extreme need. The statute requires that there be no "feasible and prudent alternative to the use of such land."

Environmental Impacts During Construction

Environmental impacts during construction include noise due to construction activities, traffic problems, and fugitive dust, and increased air pollution from congested traffic around work zones and high-emitting construction equipment. Most areas have laws such as time-of-day limits on construction activities and dust control requirements that reduce such impacts. Also, these impacts must be considered along with post-construction impacts in the reports required by NEPA.

More Controversial Impacts Sometimes Attributed To Highways and Highway Use

This section deals with several more controversial impacts that some studies have attributed to highways and highway users, including

Cost of Free Parking.
Cost of Sprawl.
Energy Security Costs.

Cost of Free Parking. Many individuals park for free where they work or shop. Some analysts contend that the cost of providing free parking is an external cost of highway use and, as such, should be taken into account in determining efficient tax rates. Litman estimates the external cost of free or subsidized parking as $110 billion per year. Apogee estimates this cost as $55 billion per year. The tax value of employer-provided free parking has been estimated to range from $4.7 billion to $12.8 billion per year. Gomez-Ibanez questions the validity of treating free or subsidized parking as an external cost of highway use. He notes that competition will force employers to adjust for increased fringe benefit costs (such as providing free parking to employees) by reducing wage rates or other forms of compensation and that the cost of providing free parking at shopping centers is passed on to customers in the prices of goods. Delucchi (1996) also treats parking not as an external cost of highway use, but as a bundled cost included in the price of goods or services, offered as an employee benefit, or included in the price of housing. The availability of free parking reduces costs of automobile use and thus may affect modal choice decisions. Parking cash-out is a potential way for employers to offer their employees who currently receive free of subsidized parking the option of accepting a cash allowance equal to the market value of the parking space in lieu of accepting the parking benefit. The intent of such a program is to equalize commute benefits among the various modal options. Currently, employer-provided parking is offered to the majority of employees on a "take-it-or-leave-it" basis. The voluntary parking cash-out program included in the Taxpayer Relief Act of 1997 aims to 'level the playing field' among commute modes by allowing employers to offer employees the option of accepting taxable cash in lieu of subsidized parking. Employees could apply parking cash-out payments to help offset costs of commuting by other modes or, if walking or riding a bicycle, they could use the money for other purposes. Thus while free parking is not considered an external cost of highway use in this study, parking cash-out is an excellent way for employers to more equitably provide transportation-related benefits to all employees and to help encourage alternatives to the automobile.

Cost of Sprawl. The role of highways in causing urban sprawl (low density development) and the appropriateness of charging highway users for the costs of sprawl is highly controversial. Miller and Moffet discuss the costs of sprawl, citing profligate energy use, rising municipal infrastructure costs, the loss of agricultural lands and wetlands, the loss of community values, the erosion of tax bases in urban centers, and the decline of urban environmental quality. However, they do not quantify the total cost at the national level. Litman asserts that the average cost of sprawl is 14 cents per automobile mile in urban areas and suggests that autos be charged half this amount because other influences such as mortgages and parking policy also contribute to sprawl and because not all communities perceive sprawl as a problem.

Lee (1995) notes that the "costs" of sprawl are balanced by consumer benefits that are difficult to measure (private space, housing, open space, crime, sense of community, aesthetics). Beshers (1994) questions the assumption that, in the absence of sprawl, urban growth would have continued to be concentrated in traditional urban centers. He suggests that at least some of the firms and households that sought low-rent locations on the periphery of cities would have moved to other metropolitan areas more friendly to auto travel or to smaller cities and that sprawl is not the enemy of large cities but their savior—that continued growth in these places would have been impossible without sprawl.

Energy Security Costs. The argument has been advanced that some portion of the U.S. military expenditures are to protect the supply of oil, and thus should be viewed as an external cost of highway use. Delucchi and Murphy[3] contend that the U.S. Congress and the military plan and budget military operations for the Persian Gulf on account of U.S. oil interests there. They develop an estimate of the military cost of using oil in highway transportation by estimating (1) how much military expenditure would be foregone if there were no oil in the Persian Gulf region, (2) how much would be foregone in the United States did not produce or consume oil from the Persian Gulf but other countries still did, (3) how much would be foregone if U.S. producers had investments in the Gulf, but the United States did not consume Persian Gulf oil, and (4) how much would be foregone if motor vehicles in the United States did not use oil, but other sectors still did and the United States and other countries still produced and consumed oil from the Gulf. Based on an

3 Mark A. Delucchi and James Murphy; *U.S. Military Expenditures to Protect the Use of Persian-Gulf Oil for Motor Vehicles*; Report #15 in the series *The Annualized Social Cost of Motor Vehicle Use in the United States based on 1990-1991 Data*; Institute of Transportation Studies, University of California, Davis, UCD-ITS-RR-96-3 (15); April 1996.

illustrative analysis, they conclude that if the U.S. motor vehicles did not use petroleum, the United States would reduce its defense expenditures in the long run by $0.6 to $7 billion dollars per year.

Others have questioned the appropriateness of treating defense expenditures as an external cost of highway use. They contend that the U.S. role in the Persian Gulf is part of a much larger geopolitical and military context, namely countering the former Soviet Union and helping regional stability and economic development. In this view, military expenditures oriented to the Middle East are largely a cost to the country determined by geopolitical factors, little related to auto fuel. Since oil is important to all industrial countries, adding a premium only to U.S. oil use would incorrectly focus U.S. military costs on our use of a small portion of an internationally traded commodity.[4]

4 CRS Report for Congress; *The External Costs of Oil Used in Transportation*; Environment and Natural Resources Policy Division; Congressional Research Service, The Library of Congress.

IV. Trends and Forecasts of Highway User Revenues

What Are Highway User Charges?

Highway user charges are fees imposed primarily upon highway vehicles, motor fuels, drivers and other elements of highway use. Although highway user fees predominantly are used to finance highway and related improvements, in many States fuel taxes and related fees charged to highway users are used for nonhighway purposes. In HCASs, the term highway user fee takes on special significance because a primary purpose of cost allocation studies is to determine whether various classes of highway users are paying a proportionate share of their highway cost responsibility.

User fees and bonds secured by highway user fees have been the predominant source of funds to finance highway improvements in most States since the early 1920s, but it was not until the Highway Revenue Act of 1956 that user fees became the major source of Federal funds for highways. Fees on highway users do not have to be deposited in a dedicated trust fund to be considered HURs. In some States a portion of the motor fuel tax or other tax on highway users may be dedicated to purposes other than highways or related transportation purposes. While highway users do not differentiate between fees going for highway purposes and those that go for non-highway purposes, the fees used for non-highway purposes are not dedicated user fees. The first Federal fuel tax was imposed in 1932, but proceeds were placed in the General Treasury Fund where they were commingled with other general funds.

The Federal highway user tax structure should be evaluated within the context of the overall national highway taxation and funding program, administered cooperatively by all levels of government. Table IV-1 provides an overview of this national system. Federal, State, and local HURs are compared with obligations or expenditures for highways and transit at each of the three levels of government for the base year of 1994 as well as for the Year 2000. The assumptions and procedures used in deriving the forecasts are described later in this chapter.

To provide a complete overview, Table IV-1 shows both revenues and expenditures defined in a comprehensive manner. User revenues included all taxes and fees imposed specifically on motor vehicles and their use. The table does not include general taxes imposed widely on other sectors, such as income or sales taxes, but does include taxes that are not used for highways or transit. For example, motor fuel taxes devoted to deficit reduction at the Federal level and State fees that provide general support to local governments are included in the table. Similarly, a broad range of highway-related functions, such as maintenance, motor vehicle administration, and highway patrol, are included regardless of the source of funding, as are all transit programs funded from highway user taxes. The table reports taxes at the level of government responsible for imposing the taxes, and reports obligations or expenditures at the level of government responsible for the program rather than at the level of government actually administering the construction or operation programs.

At the Federal level, Table IV-1 shows that 1994 HURs substantially exceeded Federal obligations, which include all highway and transit Federal-aid to State and local governments supported from highway user taxes and other sources, as well as direct Federal construction, maintenance, and operation of Federal roads. The primary reason for this is that $10.5 billion of motor fuel taxes is used for deficit reduction and the LUST fund. Fuel tax support for deficit reduction is assumed to continue through the Year 2000 and beyond in this table. Federal revenues are shown growing at the lowest rate because the policy assumption for the base case is that no change occurs in the existing Federal tax structure.

Table IV-1. Comparison of Overall National HURs and Obligations or Expenditures for All Levels of Government for 1994 and 2000 ($ Billion)

Year and Category	Federal	State	Local	All Levels
1994 HURs:				
Used for Highways & Transit	21.0	43.0	2.2	66.0
Other Uses	11.0	7.5	0.1	18.0
Totals	31.0	50.0	2.4	84.0
1994 Obligations or Expenditures:				
From User Revenues	21.0	45.0	2.2	68.0
From Other Sources	1.3	5.0	23.0	29.0
Totals	22.0	50.0	25.0	97.0
2000 HURs:				
Used for Highways & Transit	27.0	62.0	3.3	92.0
Other Uses	13.0	12.0	0.2	25.0
Totals	41.0	74.0	3.5	118.0
2000 Obligations or Expenditures:				
From User Revenues	27.0	62.0	3.3	92.0
From Other Sources	1.6	5.0	27.0	33.0
Totals	29.0	67.0	30.0	125.0

At the State level, 1994 HURs almost exactly equaled expenditures of user revenues for highways and transit. This balance reflects a general users pay policy at the State level. However, many States differ in either direction from this. Some States have user revenues that exceed State expenditures for highway and transit by as much as 10 percent or more; and several other States earmark specific non-user revenues for highways or use substantial amounts of general revenues that significantly exceed State highway and transit expenditures. In contrast to the Federal level, many States do not earmark user taxes, although most States have special accounts and several States have constitutional restrictions that prohibit the use of most or all user taxes for non-highway purposes. Because State HURs are growing more rapidly than State highway expenditures and because of increasing revenue demands for other State programs, a significant surplus of State user revenues over State expenditures for highways and transit is anticipated by 2000, based on extrapolation of recent trends, as described later in this chapter.

At the local level, 1994 user fee revenues were only about 10 percent of expenditures for highways and transit from highway user fees. Since these data do not include much larger transit expenditures by local governments from other sources, the imbalance between revenues and expenditures is significantly understated for overall local surface transportation programs. A reason for this imbalance is that at the local level, construction on major roads is commonly supported with funds from higher levels of government, and construction on minor roads is commonly performed by private developers or land owners. Some increase in local user fees has been occurring in recent years, however, as several States have made highway user fee sources available to local governments, often on a local option basis. Local user revenues are projected to increase more rapidly than local expenditures in percentage terms; however, the absolute dollar gap is expected to grow significantly.

For all levels of government as a whole, 1994 HURs covered only 87 percent of highway and transit expenditures from user revenues despite the broad definition of user revenues used in the table. However, revenues are expected to grow more rapidly than expenditures at each level of government, increasing to about 94 percent of expenditures by 2000 for all levels of government as a whole.

The balance sheet shown in Table IV-1 provides only very summary data and ignores external benefits and costs not included in governmental program revenues and expenditures. These external benefits and costs are equally important, although more difficult to assess, as described in detail previously in Chapter III.

Treatment of Fees Used for Non-Highway Purposes

Previous Federal HCASs have not had to address the issue of how to treat fuel taxes or other user fees that were used for non-highway purposes. State studies have handled this situation in several ways. Some States have not considered the portion of HURs that was used for non-highway purposes in their studies under the philosophy that the cost allocation study is focusing on highway costs attributable to different vehicle classes and should only consider that portion of revenues that is used to finance those costs. Other States have analyzed user fee equity both with and without consideration of user fees that are used for other purposes. The most comprehensive State studies include all fees imposed specifically on highway users regardless of how they are used and all highway- and transit-related expenditures regardless of source of funding, so that the net balance between user revenues and highway-related expenditures is clearly shown.

The 1997 Federal HCAS is complicated by the portion of Federal taxes on gasoline and diesel fuel that is dedicated to deficit reduction. This situation is somewhat different from that in many of the States that have a portion of their highway user fees dedicated to non-highway purposes because the Federal fee is not only on highway fuel usage, but includes fuels used by railroads and barges as well. Thus this tax does not fit the true definition of a highway user fee, but rather, the tax should be termed a "transportation user fee." The legislative history of the deficit reduction tax makes it clear that the tax was not originally intended to be a user fee. Initially the tax was to be a broad-based energy tax that would have applied to coal, natural gas, and other forms of energy as well as to petroleum-based fuels like gasoline and diesel fuels. That the tax ended up being imposed only on gasoline and diesel fuels does not diminish the fact that it never was intended to be a tax only on highway users.

Regardless of the legislative history and the fact that the deficit reduction tax does not meet the formal definition of a highway user fee, some interest groups have argued strongly that they pay this tax and that it should be considered in the study. Perhaps most importantly, the deficit reduction tax does affect equity among classes of users and does affect efficiency, regardless of legislative intent. To evaluate the sensitivity of outcomes of this study to whether the deficit reduction tax is included or excluded from the analysis, several tables throughout the report will show results both with and without consideration of deficit reduction tax revenues. In general, the analysis in the 1997 Federal HCAS excludes the deficit reduction portion of the current fuel tax, unless noted otherwise.

Current Federal Revenue Sources

Since 1956, Federal taxes have been collected from the highway user which have been segregated from other Federal revenues in the HTF. The HTF is a separate fund for the specific purpose of providing separate financing for the construction of public highways and for highway safety related expenditures. Current Federal taxes are assessed on the sale of motor fuel, on the sale of heavier tires, on the new sales of the heaviest trucks and trailers, and on the annual registration of the heaviest vehicles. Each of these revenue sources will be discussed in turn as well as a brief discussion of exemptions from these taxes. The rate of tax on a particular item coupled with the boundary conditions of the tax can target the tax toward certain vehicles. The combination of taxes can approximate the cost responsibility of the majority of the highway users, if they are broadly grouped. The small number of taxing instruments precludes a more precise matching of cost and payments.

Motor Fuel Taxes

Motor fuel taxes comprise the largest portion of the HTF receipts. The Federal tax on gasoline is well known to the general public. The similar tax is imposed on diesel fuel, gasohol and other highway fuels. These taxes are collected from the refiner, manufacturer or importer of the fuel and passed through the retailer to the highway user. The current tax rate on motor fuels includes 4.3 cents per gallon which goes to the General Fund for the purposes of deficit reduction, *not* to the HTF. Further, of the taxes on motor fuel that are transferred to the HTF, 2.0 cents per gallon is placed in a separate account within the HTF for mass transit purposes only. This is the MTA. The remainder of the taxes transferred to the HTF remain in the Highway Account.

The present Federal tax rate on gasoline is 18.3 cents per gallon. (Each State also collects tax on each gallon of gasoline, and the present weighted average of the State taxes is 18.68 cents per gallon.) Currently, 14 cents per gallon accrues to the HTF and, of that, 12 cents per gallon are retained in the Highway Account. In 1994, the net HTF receipts from the Federal excise tax on gasoline were about $10 billion, well over half the total HTF receipts for the year.

The present Federal tax rate on highway use of diesel fuel is 24.3 cents per gallon. The weighted State average diesel fuel tax rate is 19.03 cents per gallon. Currently, 20 cents per gallon of the Federal tax accrues to the HTF and 18 cents per gallon to the Highway Account. Non-highway use of diesel fuel is usually exempt from the highway user taxes. Typical exempt practices include the off-road operation of farm and construction vehicles and stationary fuel uses such as electric generators. Also, heating oil #2 is similar to diesel fuel and is not taxed but can be used by the unscrupulous in lieu of taxed diesel fuel. In 1994, the net HTF receipts from the Federal excise tax on diesel fuel used on the public highways was about $4 billion, the second largest source of revenue to the HTF after gasoline fuel tax.

In 1984, the DRA instituted a higher tax rate on diesel fuel compared to gasoline. Previously, gasoline and diesel fuel had been treated identically under the tax code. The increased diesel fuel tax is referred to as the diesel differential and is 6 cents per gallon. The diesel differential was added to increase the share of highway revenue pay by the heavier trucks. The diesel differential was adopted in lieu of significantly higher HVUT specified by the STAA. The maximum HVUT under STAA was $1,900 annually per vehicle, the DRA set the maximum for the HVUT at $550 per vehicle. The diesel differential was enacted prior to collection of the higher HVUT.

Beginning with the Energy Tax Act of 1978, blends of gasoline with grain alcohol (ethanol) have received separate tax treatment even though the blends, called gasohol, are substitutable for gasoline without any vehicle modification. Initially, blends that contained 10 percent ethanol were eligible for a complete exemption from the corresponding highway user tax of 4 cents per gallon. Since then the tax rate on motor fuel has increased and the exemption has been adjusted several times, and the current exemption for 10 percent blends is 5.4 cents per gallon. Effective January 1, 1993, the Energy Policy Act of 1992 (EPACT) pro rated the exemption to include alcohol blends of 7.7 percent and 5.7 percent which correspond to 2.7 percent and 2.0 percent oxygen by weight, respectively. These levels of oxygen are the oxygen levels required in reformulated gasoline and oxygenated gasoline which are mandated in certain areas that fail to meet national air quality standards. (See discussion of exemptions for further information about the gasohol exemption in this chapter.) Based on the ethanol content, 8 cents per gallon, 9.842 cents per gallon or 10.922 cents per gallon of the Federal excise tax on gasohol blends accrues to the HTF. Of these amounts, 6 cents, 7.842 cents or 8.922 cents per gallon is credited to the Highway Account. The total HTF receipts from the various types of gasohol in 1994 was nearly $1 billion. This is expected to double by 2000.

Other fuels used to power motor vehicles on the public highway are generally taxed at the same rate as gasoline, currently 18.3 cents per gallon. The most common of these fuels is propane. Neat alcohol (defined as at least 85 percent ethanol or methanol) is given separate tax treatment, but current use of these fuels is minimal. Compressed natural gas (CNG) is not currently taxed for highway purposes, although it is used in some buses, trucks, and autos/pick-ups. Also, electricity is not currently taxed for highway purposes, although there are a small number of electric vehicles in use on the public highway. For any of these alternative fuels which are taxed, 2 cents per gallon of the amount transferred to the HTF is segregated for mass transit purposes. In 1994, the total HTF receipts from the remainder of the motor fuels was about $30 million, nearly all of this was derived from the taxes assessed on highway use of propane. However, these fuels could become more prominent as alternatively fueled vehicles enter the vehicle fleet to satisfy the requirements of the Clean Air Act of 1990 and EPACT. Table IV-2 illustrates the current (as of December 1996) distribution of Federal motor fuel taxes by the Highway Trust and General Funds.

Other Federal Highway Taxes

There is a Federal excise tax of 12 percent of the retail sales price on trucks which have a GVW of more than 33,000 pounds and on trailers, semitrailers and power units which, when used in combination with other equipment, have a GVW of more than 26,000 pounds. House trailers, hearses, ambulances and self-propelled motor homes are excluded from this retail sales tax. (See the discussion of exemptions for more details of exemptions from this tax in the chapter.) In 1994, about $1.4 billion was credited to the HTF as a result of this tax. This tax is the only HTF revenue source that will "keep pace with inflation" because it is based on a percentage of the retail price of the heaviest vehicles.

There is an annual fee on vehicles 55,000 pounds or more GVW, called the HVUT. This fee is collected from the heaviest vehicles which travel more than 5,000 miles per year on the public highways. The fee is $100 per vehicle for vehicles with a GVW of 55,000 pounds, increasing at the rate of $22 per thousand pounds or fraction thereof, with a maximum annual fee of $550 per vehicle for all vehicles with a gross weight of 75,000 pounds or more. This annual fee is pro rated for vehicles acquired part way through the year. (See the discussion of exemptions for the details of categories of exempt vehicles in this chapter.)

Table IV-2. Distribution of Federal Highway Motor Fuel Taxes (as of December 1996)[1]						
			Distribution of Tax (cents/gallon)			
			HTF		General Fund For:	
Fuel Type	Tax Rate	Effective Date	Highway Account	MTA	Deficit Reduction	Not Specified
Gasoline	18.3 cents per gallon	1/1/96	12	2	4.3	
Diesel	24.3 cents per gallon	1/1/96	18	2	4.3	0
Gasohol: 10 percent Gasohol made with Ethanol[1]	12.9 cents per gallon	1/1/96	6	2	4.3	0.6
Gasohol: 7.7 percent Gasohol made with Ethanol[2]	14.142 cents per gallon	1/1/96	7.842	2	4.3	0
Gasohol: 5.7 percent Gasohol made with Ethanol[3]	15.222 cents per gallon	1/1/96	8.922	2	4.3	0
LPG (Propane)	18.3 cents per gallon	10/1/95	12	2	4.3	0
CNG	4.3 cents per gallon	10/1/93	0	0	4.3	0
LNG[4]	18.3 cents per gallon	1/1/96	12	2	4.3	0
Ethanol[5] (From Natural Gas)	11.3 cents per gallon	1/1/96	5	2	4.3	0
Methanol[6] (From Natural Gas)	11.3 cents per gallon	1/1/96	5	2	4.3	0

1 Highway Statistics Table FE-21: Federal Excise Taxes on Highway Motor Fuel.
2 Tax rate for Gasohol from methanol is slightly lower.
3 Tax rate for Gasohol from methanol is slightly lower.
4 From the "Special Fuel Other" category of the Highway Statistic Table FE-21.
5 Not From Natural Gas Tax rates are slightly lower.
6 Not From Natural Gas Tax rates are slightly lower.

In 1994, the HVUT was slightly more than $600 million. In 2000, the HVUT is expected to be in excess of $800 million.

There is a Federal excise tax on the sale of heavier tires. This tax is collected from the manufacturer or importer and passed on to the retailer and the ultimate consumer. The tax is based on the weight of the tire, excluding the tire rim. The Federal excise tax on tires is 15 cents per pound for each pound in excess of 40 pounds, up to a total weight of 70 pounds. For tires that weigh between 70 and 90 pounds, the Federal excise tax is $4.50 plus 30 cents per pound for each pound in excess of 70 pounds. For tires over 90 pounds in weight, the Federal excise tax is $10.50 plus 50 cents per pound for each pound in excess of 90 pounds. In 1994, the Federal excise tax on tires contributed over $300 million to the HTF. By 2000, the Federal excise tax on tires is expected to be over $400 million per year. Table IV-3 highlights the tax rates (as of December 1996) for all Federal highway user taxes.

Exemptions from the Federal Taxes

The HTF is designed to be a user financed source of funding for highway construction and safety expenditures. As noted in the discussion of current Federal revenue sources above, there are exemptions from some Federal taxes that are credited to the HTF. Some exemptions are a direct result of the underlying reason for the HTF, and some exemptions are intended to encourage broader social goals. Some exemptions, however, result in certain vehicles receiving special treatment that is counter to fairness and equity goals.

If highway cost allocation equity were the most important societal goal, highway users would pay their share of the annual fees needed to maintain and expand the highway system. The shares would be related to the demands that the individual vehicle placed on the highway infrastructure. Users with identical vehicles that use the public highways equally would pay the same amount of highway user taxes. There would be no exemptions or special treatment of one user or one vehicle over another. However, a variety of exemptions exists.

Table IV-3. Current Federal Tax Rate[1]

Current Tax		Tax Rate Under Current Law[2]
Fuel	Gasoline	18.3 cents per gallon
	Diesel	24.3 cents per gallon
	Gasohol: 10 percent Gasohol made with Ethanol	12.9 cents per gallon
	LPG (Propane)	18.3 cents per gallon
	CNG	4.3 cents per gallon
	LNG	18.3 cents per gallon
	Ethanol	11.3 cents per gallon
	Methanol	11.3 cents per gallon
Vehicle Excise Tax	Heavy Trucks >26,000 pounds (see description in text)	12 percent of retail sales for new vehicles (trucks, tractors, and trailers)
Tire Tax	Over 40 to 70 pounds	15 cents per pound in excess of 40 pounds
	Over 70 to 90 pounds	$4.50 plus 30 cents per pound over 70 pounds
	Over 90 pounds	$10.50 plus 50 cents per pound over 90 pounds
HVUT	Annual tax on Motor Vehicle registered 55,000 pounds gross weight or more.	$100 plus $22 per 1,000 pounds over 55,000 with an annual cap of $550

1 From Highway Statistics Table FE-21: Federal Excise Taxes on Highway Motor Fuel.

2 Taxes are distributed among HTF Highway Account, HTF, MTA, LUST fund, General Fund for Deficit Reduction, and General Fund Not Specified.

The simplest type of exemption is for non-highway use of a vehicle. Since the HTF is a user-financed revenue system, the ideal of fairness would lead to the non-user being excluded from paying highway taxes. For example, agricultural and construction vehicles are mainly used off the highway, and such use should not require the payment of highway user taxes. Typically, gasoline is available only with the highway user taxes included in the purchase price. Therefore, exempt users can apply for a tax credit or a refund of tax paid on gasoline which is used off the highway. Further, highway use items that are exported are not subject to the Federal highway user taxes.

Typically, a user is exempt from one or more of the highway user excise taxes due to the characteristics of the operator of the vehicle rather than the type of vehicle itself. Also, if an exempt user pays a highway user excise tax, for example in the purchase of fuel, then that user can apply for a refund of the tax paid or obtain credit for the tax paid against other tax liabilities. Such credits may be applied against any tax owed to the Federal Government, thus the HTF is debited for both credits and refunds of taxes paid by exempt users.

The broadest category of current exemptions is for minimal highway usage. The HVUT is assessed on an annual basis and has an exclusion for those vehicles which use the public highways less than a minimal amount during the year. Since the HVUT does not vary with increasing mileage, those vehicles that rarely use the public highways are relieved from payment of the HVUT.

Those exemptions from highway user taxes that are extended to certain classes of vehicles for broader social goals include bus exemptions. For example, most buses that were not already exempt for other reasons such as being operated by a government agency were exempted from nearly all highway user excise taxes by the EPACT to encourage energy efficiency and less dependence on foreign petroleum.

The value of exemptions are difficult to measure. The amount of revenue not collected due to the various exemptions cannot be known exactly. Estimates of the magnitude of the exemptions shown in the accompanying table are based on the best information available gathered from a variety of sources.

Categories of Exempt Users

State and local governments are exempt from the Federal highway user taxes. In 1994, the exemption for State and local governments is estimated to be about $750 million. This is expected to grow to $1 billion by 2000.

As mentioned above, buses are exempt from most highway user taxes for broader social goals. A large number of buses are owned and operated by State and local governments, including a significant percentage of school buses and transit buses. The exemption for State and local governments just discussed naturally applies to the buses owned and operated by such entities. Most transit agencies are quasi-governmental in their structure and would likely qualify under most interpretations of the State and local exemption. The Energy Tax Act of 1978 removed the highway user taxes on privately owned intercity, local, and school buses. The rationale advanced for the special treatment of this class of vehicles is that buses are more energy efficient than automobiles. Encouraging the use of buses instead of automobiles is intended to decrease the national reliance on imported petroleum. Subsequent changes in the law have resulted in intercity buses paying 3 cents per gallon on the motor fuel they consume. The bus exemption results in the HTF not collecting about $100 million annually that would otherwise be due from privately owned buses.

Motor Fuel

The general exemptions available to State and local governments and to nearly all buses apply to all motor fuel taxes. As was mentioned in the discussion of the exemption afforded buses, intercity buses are exempt from all highway user taxes except for 3 cents per gallon of the highway user excise tax on motor fuel. As referred to in the example above, off highway use of motor fuel is generally tax exempt. For agricultural and construction vehicles most of the use of those vehicles is not on the public highways; therefore the fuel consumed during such non-highway operation is not subject to the Federal highway user excise taxes. Similarly, the Department of Defense (DoD) uses most of its vehicles off the highway, and generally its motor fuel usage is not liable for the Federal highway user excise taxes. The Federal Government, including DoD, pays taxes on the highway use of motor fuel.

Recreational boating for fishing and other uses is also off-highway use of motor fuel, but motor fuel used in these vehicles is not exempt. The tax collected on the sale of such motor fuel is transferred to other funds for the improvement of boating facilities and for boating safety. Currently, more than $200 million is transferred to boating and recreational safety funds annually. Similarly, provision is made in the law for the transfer of the tax collected from the use of motor fuel in off-road recreational vehicles to the Recreational Trails Trust Fund for improvement of recreational trails and backwoods areas. Commercial fishing vehicles are not required to pay the Federal highway users motor fuel taxes.

Generally, the agricultural and construction usage and DoD usage of nontaxable motor fuel is predominantly diesel fuel. There are provisions in the law for purchase of diesel fuel without the Federal highway user taxes being included in the purchase price, and the potential for evasion of Federal highway user taxes exists. For example, petroleum products such as kerosene or jet fuel can be readily blended into diesel fuel without payment of the required taxes. Therefore, there is a nationwide fuel tax compliance project that among other things led to the requirement to dye diesel fuel on which the Federal, and in some cases State, highway user taxes had not been paid. Vehicle operators who are caught using dyed fuel for taxable purposes are subject to penalties and fines.

As is clear from the discussion of the Federal excise taxes on gasohol, gasohol receives an exemption from part of the gasoline excise tax. The EPACT removed all Federal highway user taxes from mixtures containing at least 10 percent alcohol. The current exemption is 5.4 cents per gallon for gasohol containing 10 percent alcohol. The EPACT made the gasohol exemption available at reduced rates for certain reduced concentrations of alcohol which correspond to Federally defined levels of oxygen in gasoline. The EPACT effectively pro rated the gasohol exemption for reduced levels of alcohol in the newly defined types of gasohol. The EPACT allows gasohol to be used to meet the Federal requirements for specified levels of oxygen in gasoline mandated in certain areas that fail to meet air quality standards.

The current gasohol exemption allows the blender to claim 54 cents per gallon of ethanol blended into gasoline, if blended at any of the three defined levels. However, when at least 10 percent of the mixture is alcohol (ethanol or any other alcohol) and any amount of ethanol is blended, the HTF receives 0.6 cents per gallon less than it otherwise would receive. So, for 10 percent ethanol blends, the HTF receives 6 cents per gallon less than it would have received from a gallon of gasoline. The entire revenue loss due to the gasohol exemption is absorbed by the Highway Account; the MTA receives the same amount from each gallon of fuel taxed. In FY 1994, the gasohol exemption cost the Highway Account of the HTF over $680 million.

Other Taxes

The general exemptions available to State and local governments and to buses apply to all other highway user taxes. There are some specialized exemptions for the other highway user taxes.

The excise tax on new heavy truck sales only applies to vehicles that weigh more than 33,000 pounds GVW or combination vehicles that weigh more than 26,000 pounds GVW. In effect this exempts trucks at 33,000 pounds and less and combination vehicles at 26,000 pounds and less. The exemption for lighter vehicles is because the heaviest vehicles require a disproportionate investment in the construction and reconstruction of the public highways. The heaviest vehicles are a small part of the traffic stream but require more investment in stronger pavements and bridges, therefore they are assessed additional taxes, such as the Federal excise tax on heavier truck and trailer sales.

Camper bodies and mobile homes bodies are not subject to the Federal excise tax on truck sales. House trailers are also exempt. These body types are exempt because they do not use the public highways extensively and the value of the body is unrelated to its weight or highway usage. The vehicles of this type are generally not on the public highways very much, but tend to be stationary even though they are built on a chassis that could be used for other types of vehicles. Equipment or vehicle bodies used to process, prepare, haul, spread, or load or unload feed, seed or fertilizer are exempt from the Federal excise tax on new truck sales. The value of this equipment is unrelated to its highway usage, but this type of equipment or truck body typically is not used on the public highways. Similarly, equipment used to process or prepare concrete is excluded from the computation of the Federal excise tax on the new sale of concrete mixer trucks. The truck itself is taxed but the value of the concrete mixer equipment is exempt. Ambulances, hearses and combination ambulance-hearses are exempt. Trailers designed to be used also as a railroad car are exempt. Trash containers that are not permanently mounted on a vehicle and that are not designed for other transportation uses are exempt. These exemptions generally exclude equipment that is not intended for highway use. These specific exemptions tend to result in taxing only the truck portion of a specialized vehicle.

The Federal HVUT is only assessed on vehicles that operate at 55,000 pounds GVW or greater. Again, this is an implicit exemption for lighter vehicles. The same rationale applies in that the heaviest vehicles require additional investment in the highway infrastructure therefore, they should pay additional taxes. For the HVUT there are some other exemptions. Vehicles that travel less than 5,000 miles annually on the public highways are exempt. Farm vehicles that travel less than 7,500 miles annually on the public highway are exempt. For vehicles that are used exclusively to transport harvested forest materials, there is a 25 percent reduction in the HVUT. Similarly, there is a 25 percent reduction in the HVUT for vehicles registered in Canada or Mexico. For the low mileage vehicles, the exemption recognizes that the HVUT is a flat fee that is invariant with usage. That is, the least used vehicle pays as much as the most heavily used vehicle while the heavily used vehicle will cause more wear on the highway than other vehicles. Therefore, those vehicles that use the public highways only rarely are given relief from the HVUT. The partial exemption for logging trucks recognizes that the back haul for those vehicles is usually empty. Similarly, the partial exemption for foreign registered vehicles recognizes that a significant part of mileage for such vehicles is occurring outside the United States. Finally, the law allows the U.S. Secretary of the Treasury to waive the collection of the HVUT from Federal Government vehicle operators, which has been done. The total HTF revenue foregone as a result of the HVUT exemptions is about $40 million annually.

The State and local government exemption and the bus exemption are the only explicit exemptions from the Federal excise taxes on highway tires. The tax applies to all highway tires that weigh over 40 pounds, therefore there is an implicit exemption for lighter tires. Again this exemption relates to the need for stronger pavements and bridges for the heavier vehicles. The heavier vehicles also use the heavier tires, so the Federal tax applied only to heavier tires attempts to target the collection of revenue from the heavier

Table IV-4. Estimated Value of Federal HTF Exemptions for 1994 and 2000 ($ Millions)		
Exemptions	**1994**	**2000**
State, County, Municipal Exemption	$758.5	$1,008.5
Bus Exemption	94.9	120.5
Gasohol Exemption*	684.3	745.1
HVUT Exemptions for: 1. Limited Traveling Vehicles less than 5,000 miles annually	32.6	43.9
2. Agricultural Vehicles (traveling less than 7,500 miles annually)	2.5	3.4
3. Logging Trucks (25 percent exemption)	2.3	3.1
4. Federal Vehicles	1.0	1.3
Total	$1,576.1	$1,925.8

* Gasohol historical figure based on Income Statement for the HTF, forecasts based on FY 1997 budget documents. NOTES: Exemptions based on extension of current law and assumed to grow at same rate as corresponding tax in FY 1997 budget.

vehicles. Table IV-4 provides estimates of HTF exemptions, as discussed in this section of the report. Per the table, exemptions for State/local governments and gasohol are estimated to total $1.7 billion in 2000 and represent the vast majority of the exemptions from Federal highway user fees.

Current and Forecast Federal Highway User Revenues

Most highway user revenues are paid to the IRS by the sellers of a taxable product, and are collected from users by the sellers. Thus it is difficult to attribute revenues by various vehicle types. Types of taxes have changed over time, with the last major tax scheme changes in 1982. Rates have changed several times since 1982, but the structures of taxes have remained the same. Current Federal highway user taxes are: fuel tax, vehicle excise tax, tire tax, and HVUT. A highway revenue forecasting model (HRFM), developed for this report, was used to forecast highway revenues by revenue option (tax type) and attribute these revenues to particular vehicle classes and weight groups.

Fuel tax revenues for each vehicle class are estimated based on three variables: miles per gallon (MPG), VMT, and operating weight. As a result, the revenue forecasts used in the 1997 Federal HCAS within a vehicle class are a function of operating weight. The MPG estimates were developed for each vehicle class, based on a typical engine type, transmission and vehicle performance characteristics— reflecting the impact of higher gross weight, and are differentiated into 5,000 pound interval operating weight groups and vehicle fuel types. Key input data to the development of these MPG estimates came from the TIUS, several publications by the EPA for new vehicle fuel efficiencies, and information from U.S. Department of Energy (DOE), ATA, the U.S. DOT, and other sources. Given the number of different sources, engineering judgment was necessary at times to resolve inconsistencies between the data and to weigh the relative importance of each factor to MPG. The HRFM estimates the gallons of fuel consumed by multiplying MPG times VMT for each vehicle class and operating weight group, and the revenues are then a function of tax rate and gallons of fuel consumed.

Vehicle excise taxes for each vehicle class are difficult to estimate because revenues are based on the retail price of new vehicle sales. Thus, a number of factors influence revenues including size of the truck/tractor, the body type, and any special equipment added on to a new vehicle. The HRFM contains price data for up to six different body types within each vehicle class: flatbed, tank-trailer, conventional van, insulated-refrigerated van, dump-trailer, and hopper. Stock is estimated for each vehicle class as well as the number of new sales for each year. Sources for price and stock data include: the TIUS, State registrations as reported in FHWA's *Highway Statistics*, various industry sources, and R. L. Polk. The HRFM estimates annual retail sales by multiplying the sales price times the number of new vehicle sales by body type, and revenues are based on a percentage of total retail sales. It is important to note that this tax applies only to trucks which have a manufacturers' gross vehicle rating in excess of 33,000 pounds and this is accommodated by the HRFM.

Tire tax revenues are based on tire consumption and weight of the tire. The HRFM contains data on tire weights and typical tire lives by vehicle class, based on a number of industry sources including commercial vehicle tire suppliers. Tire life is forecasted to decrease as a function of gross vehicle operating weight and miles travel. The number of tires consumed is calculated by dividing VMT by tire life, for each vehicle class/operating weight cell, multiplied by the number of tires on the vehicle. The HRFM computes the appropriate tax, based on the weight of the tire, for each of these cells. Tires which weigh less than 40 pounds are not subject to this tax.

The HVUT revenues are based on the total number of vehicles that are registered at 55,000 pounds or higher. The stock components of the HRFM provide the number of vehicles in each vehicle class/ registered weight group. As mentioned before, the stock model incorporates data from *Highway Statistics*, R. L. Polk, TIUS, and other sources. These vehicle stock for each weight group are multiplied by the appropriate tax rate, subject to the annual cap of $550, resulting in total heavy vehicle use fee revenues.

Figure IV-1 highlights the distribution of Federal HURs in 2000. The auto and pickups account for about 65 percent of the total revenues generated, as compared to 92 percent of total VMT. As for freight vehicles, single units and combination trucks account for 10 percent and 25 percent of revenue, respectively, as compared to 3 percent and 4 percent of total VMT in 2000. This revenue/mile is noticeably higher for trucks as compared to passenger vehicles. Figure IV-2 shows the distribution of total taxes collected by tax type in 2000. Motor fuel dominates with 86 percent of total tax collected, followed by vehicle excise, HVUT, and tire.

Table IV-5 presents the current revenues for each user fee for base year period (1994) by tax type as well

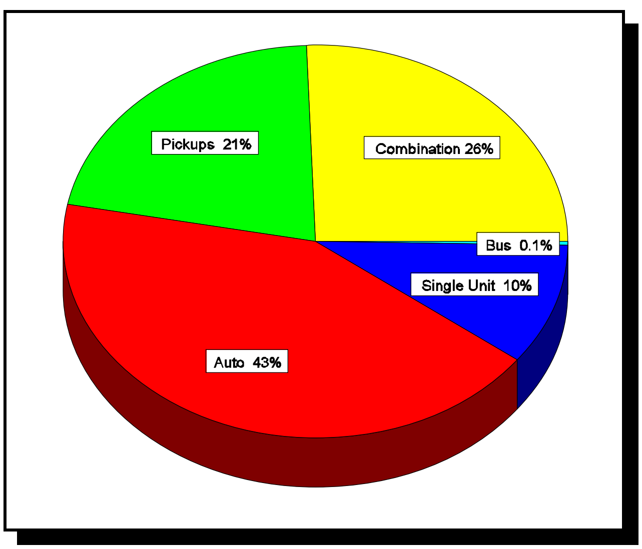

Figure IV-1. 2000 Distribution of Federal Highway Revenues by Broad Vehicle Classes

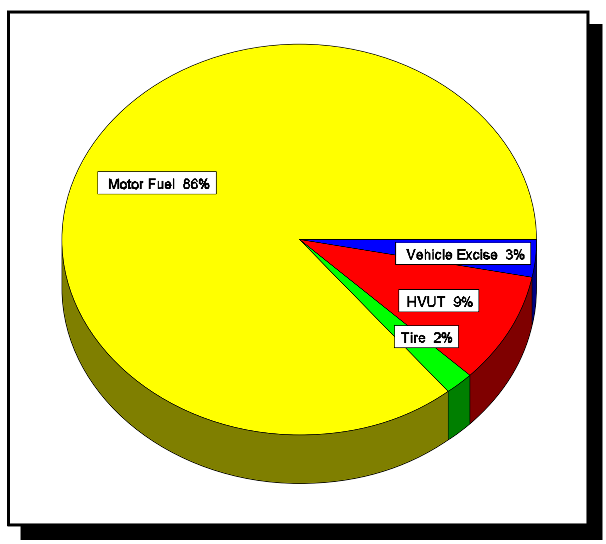

Figure IV-2. 2000 Distribution of Federal Highway User Tax Categories

Table IV-5. Federal Highway User Fee Payments by Vehicle Class — 1994 ($ Millions)								
Vehicle Class	**Fuel Tax**	**Fuel Tax Including Deficit Reduction**	**HVUT**	**Tire Tax**	**Vehicl e Excise Tax**	**Total**	**Shares Percent**	**Shares (Percent) including Deficit Reduction**
AUTO	$8,785	$14,266	$0	$0	$0	$8,785	42.18	45.52
LT4	4,630	7,487	0	0	0	4,630	22.23	23.89
SU2	1,482	2,238	1	24	0	1,507	7.23	7.22
SU3	276	388	54	31	0	361	1.73	1.51
SU4+	111	155	30	23	38	203	0.97	0.79
CS3	63	89	4	4	0	71	0.34	0.31
CS4	230	322	47	18	0	295	1.42	1.23
CS5T	2,284	3,185	376	168	1,011	3,840	18.43	15.13
CS5S	81	113	13	6	36	136	0.65	0.54
CS6	163	228	37	25	101	326	1.57	1.25
CS7+	17	24	4	2	11	34	0.17	0.13
CT3&4	27	40	2	3	71	104	0.50	0.37
CT5	50	70	18	6	44	118	0.57	0.44
CT6+	14	20	4	2	10	31	0.15	0.12
DS5	137	191	20	11	69	237	1.14	0.93
DS6	20	28	3	2	11	36	0.17	0.14
DS7	19	27	3	2	15	39	0.19	0.15
DS8+	24	34	4	3	20	50	0.24	0.19
TPL	4	5	0	0	3	7	0.03	0.03
BUS	18	37	0	1	0	19	0.09	0.12
TOTAL	$18,436	$28,945	$620	$331	$1,441	$20,82	100.0	100.0
NOTES: Sums may not total due to rounding. See Chapter I for vehicle definitions.								

as the shares for each of the 20 vehicle classes. Autos pay only fuel taxes and contribute about 42 percent of the total revenue. Trucks pay all of the tax categories with fuel followed by vehicle excise taxes being the largest revenue producers. Single unit 2-axle truck and combination 5-axle semitrailer with tandem axles pay the highest total taxes with 7 percent and 18 percent, respectively, of total taxes. Note that the second column, Fuel Tax Including Deficit Reduction, includes the extra 4.3 cents/gallon tax.

Table IV-6 highlights the Federal highway user fee revenue estimates for the Year 2000, using the existing tax rates. Autos, as a vehicle class, contribute about 43 percent of the total Federal user fee revenue, while 5-axle semitrailer with tandem axles generate about 19 percent of the revenue.

State and Local Revenues

State and local taxes that apply to both highway and non-highway user such as sales taxes, are not considered HURs because they are not exclusively levied on motor vehicle use. The principal State and local HURs are motor fuel taxes, motor vehicle registration fees, drivers' license fees, WDT, and ad valorem taxes applying principally to motor vehicles.

State governments collect the largest shares of HURs through motor fuel taxes and motor vehicle registration fees. Each State has its own motor fuel and motor vehicle tax structure established by the State legislature. Local governments collect only a small amount or revenues from highway user taxes that are principally motor fuel taxes and motor vehicle registration fees. Table IV-7 highlights the State and local revenue estimates for 1994 and 2000.

Table IV-6 Federal Highway User Fee Payments by Vehicle Class — 2000 ($ Millions)

Vehicle Class	Fuel Tax	HVUT	Tire Tax	Vehicle Excise Tax	Total	Shares (Percent)
AUTO	$11,576	$0	$0	$0	$11,576	42.60
LT4	5,811	0	0	0	5,811	21.39
SU2	1,879	1	32	0	1,912	7.04
SU3	337	47	41	0	425	1.56
SU4+	124	43	30	63	260	0.96
CS3	77	5	5	0	87	0.32
CS4	278	65	24	0	367	1.35
CS5T	2,753	527	223	1,647	5,150	18.95
CS5S	98	19	8	58	183	0.67
CS6	220	52	33	164	470	1.73
CS7+	21	5	3	19	47	0.17
CT3&4	34	3	4	116	158	0.58
CT5	60	25	8	72	165	0.61
CT6+	17	6	3	17	43	0.16
DS5	165	28	14	113	320	1.18
DS6	24	4	2	18	48	0.18
DS7	23	4	2	24	54	0.20
DS8+	28	5	3	32	68	0.25
TPL	5	1	0	5	10	0.04
BUS	19	0	1	0	20	0.07
TOTAL	$23,547	$841	$439	$2,347	$27,174	100.0

NOTES: Sums may not total due to rounding. See Chapter I for vehicle

Highway Finance Data Sources

The principal source of financial data used in this study is the FHWA's *Highway Statistics*. The FHWA publishes data annually in *Highway Statistics* highway finance tables. The FHWA obtains its data based on reports submitted from State highway agencies and from other State agencies responsible for highway functions such as tax and revenue offices. The State reports are submitted annually and follow the reporting guide distributed by FHWA. Local government finance information is based on reports coordinated through State highway agencies and are submitted on a biennial basis and estimated by FHWA for years not reported.

- Motor fuel taxes and registration fees account for over a large portion of total HURs but other user revenue sources are also significant parts of total revenues. A brief description of the types of HUR are provided below.

- Motor fuel taxes are imposed by Federal, State, and some local governments on the consumption of different fuel types such as gasoline, diesel, gasohol, and other special fuels. The Federal and most State tax rates are fixed rates in cents per gallon; however, a few States use indexed variable rates per gallon that are automatically adjusted in response to inflation. The majority of revenues collected through motor fuel taxes are used for transportation expenditures but specific amounts are designated for other purposes such as deficit reduction, mass transit, and LUST fund.

- # All States and some local governments require motor vehicles that are owned and operated on public roads to pay an annual registration fee. Significant variation exists between States in the structure of registration taxes, which vary by characteristics such as vehicle class, weight, operating mileage, and type of ownership. Heavy vehicle registration fees are collected under proration agreements, principally the International Registration Plan, for all heavy vehicles traveling in more than one State.

- # Drivers' licenses fees are collected by State governments as part of the process of regulating operators of motor vehicles located in the State. Various classes of licenses are issued including commercial, non-commercial, motorcycle, chauffeur, and school bus. The license term and fees are determined by the State. Title fees are levied when the title of a motor vehicle is transferred from one owner to another.

Table IV-7. State and Local HURs for 1994 and 2000 ($ Millions)

HURs	1994	2000	Growth Rate (Percent)
State Revenues			
Motor Fuel Taxes			
Gasoline	21,309	30,915	6.40
Diesel	4,395	7,159	8.47
LPG	237	247	0.69
Total Motor Fuel Taxes	25,941	38,321	6.72
Motor Vehicle Taxes			
Registration Fees	14,945	21,917	6.60
Drivers' License Fees	823	1,109	5.10
Title Fees	859	1,301	7.33
Fines and Penalties	174	180	0.57
Other	2,959	5,089	9.30
Total Motor Vehicle Taxes	19,760	29,596	6.97
Third Structure Taxes	578	734	4.06
Tolls	3,612	5,177	6.18
Total State Revenues	49,891	73,831	6.75
Local Revenues			
Motor Fuel Taxes	661	872	4.74
Motor Vehicle Taxes	802	1,157	6.30
Tolls	1,067	1,484	5.66
Total Local Revenues	2,530	3,513	5.63
Total	52,421	77,334	6.69

- # Revenue collected from fines and penalties imposed for infractions of motor-vehicle laws and regulations includes oversize/overweight penalties.

- # Fees are collected for special permits to allow the operation of commercial vehicles above size and weight limits. All States issue special permits for non-divisible loads and approximately half of the States have "grandfathered" authority to issue permits for divisible loads.

- # Third structure taxes are usage taxes that vary by the amount of highway use and may vary by other factors related to cost responsibility. The WDTs (mileage) on commercial vehicles are the principal type of third structure taxes. Tolls may also be considered a third structure tax.

Comparison of Highway User Revenue Data

Figure IV-3 shows the trend in State HURs by revenue type from 1980 to 1994 as reported by the FHWA. State HURs have increased consistently through the 1980s and 1990s. The most significant growth occurred between 1985 and 1992 with annual growth rates averaging 10 percent. The annual growth rate for the entire period was 8.7 percent. In 1994, motor fuel taxes represented over 50 percent of total State HURs, with motor vehicle taxes accounting for 40 percent, and toll revenues less than 8 percent.

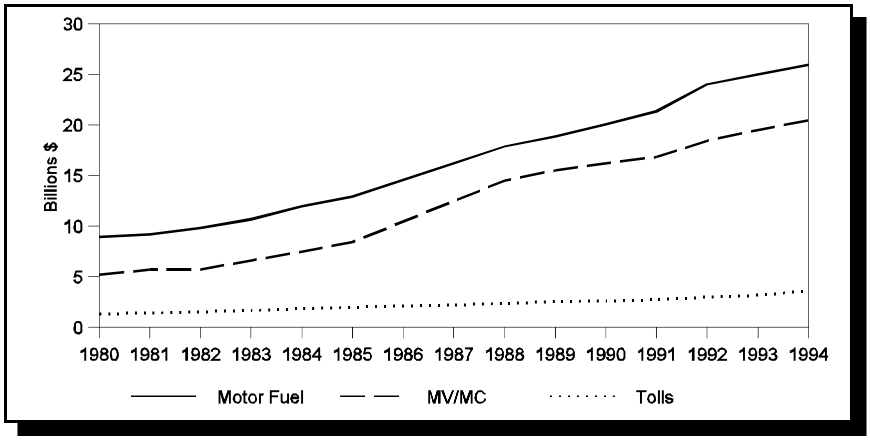

Figure IV-3. State Government HURs 1980-1994

Source: *Highway Statistics*, FHWA

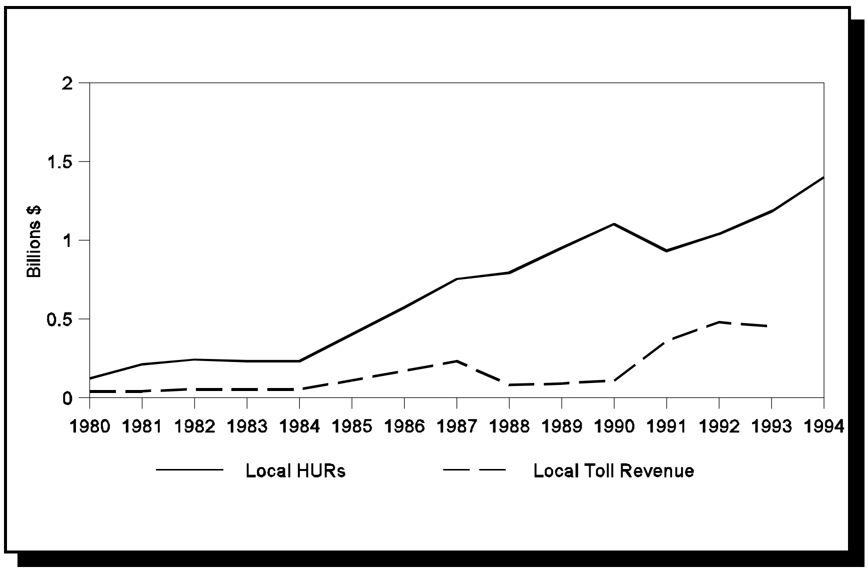

Figure IV-4. Local Government HURs 1980-1994

Source: *Highway Statistics*, FHWA

Local governments collect only a small portion revenues used for highways through highway user taxes. As part of total HUR, local revenues represent less than 4 percent. Approximately one-quarter of local HUR are from motor fuel taxes, one-third are motor vehicle registration fees and operators' license fees, and about 40 percent are tolls. Figure IV-4 shows the trend in local government HUR in current dollars as reported by FHWA.

Local HURs have increased significantly at close to 20 percent per year during the last 14 years. The FHWA historical information shows a significant decrease in local toll revenues during the late 1980s which might be caused by reporting error rather than a true decrease in revenues because there is no apparent explanation for the dramatic decrease in toll revenues.

Trends in Motor Fuel Tax Rates

The majority of motor fuel tax rates are fixed rates which are adjusted only when an increase is approved by a legislative body. A few States have variable rates that are indexed to a change in prices. In general, State tax rates have been increasing over the last 15 years, but because rates are adjusted relatively infrequently, there are periods when the average real tax rate has actually declined.

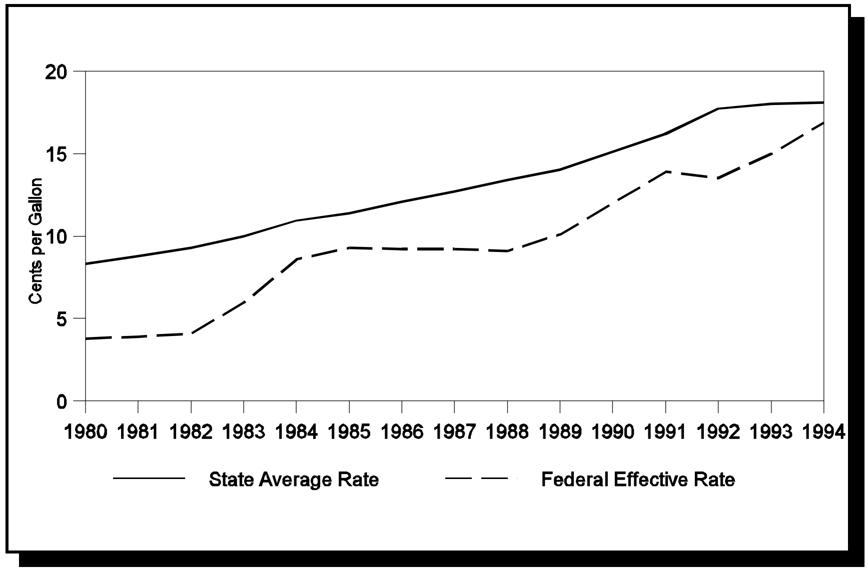

Figure IV-5. Federal and State Motor Fuel Tax Rates

In order to examine trends in motor fuel tax rates, effective tax rates are estimated for all fuel types combined. The effective rate is calculated by dividing the net revenues collected by the gallons of fuel taxed. Using an effective tax rate avoids problems with rate changes during a year and with exemptions for specific fuel use. Figure IV-5 shows the changes in the effective motor fuel tax rate at the Federal and State levels. State motor fuel taxes have increased every year but have begun to level off during the early 1990s. The Federal motor fuel tax rates increased sharply in the early 1980s and again in the late 1980s but declined slightly during the mid 1980s. The average annual growth of motor fuel tax rates was 5.9 percent at the State level and 11.1 percent at the Federal level during the 14 year period.

Trends in Motor Vehicle Fees for State and Local Governments

The majority of motor vehicle fees are collected by States with a small portion raised by local governments. In 1994, over $20 billion was collected in motor vehicle fees, which included registration fees, operator licenses, title fees, fines and penalties, WDTs, and special permits. Total revenues from motor vehicle taxes have been increasing fairly consistently over the last 15 year; however, part of this is attributed to the increase in the number of registered vehicles. In order to the examine the trends in motor vehicle fees each vehicle is paying, trend analysis has been done on a per vehicle basis.

Figure IV-6 presents the changes in average annual motor vehicle fees per registered vehicle for State and local governments. State motor vehicle fees are reported values from *Highway Statistics*. Local motor vehicle revenues are based on FHWA's reported local HURs, but motor vehicle taxes are separated from motor fuel taxes using the distribution reported by the Bureau of the Census. The figure shows that the average motor vehicle in 1994 paid approximately $100 in State motor vehicle fees and only $4 in local fees. The fastest growth in fees occurred from 1985 to 1988 with annual growth averaging 17 percent. Over the entire period, State motor vehicle fees increased 8.5 percent annually and local fees increased 11.5 percent.

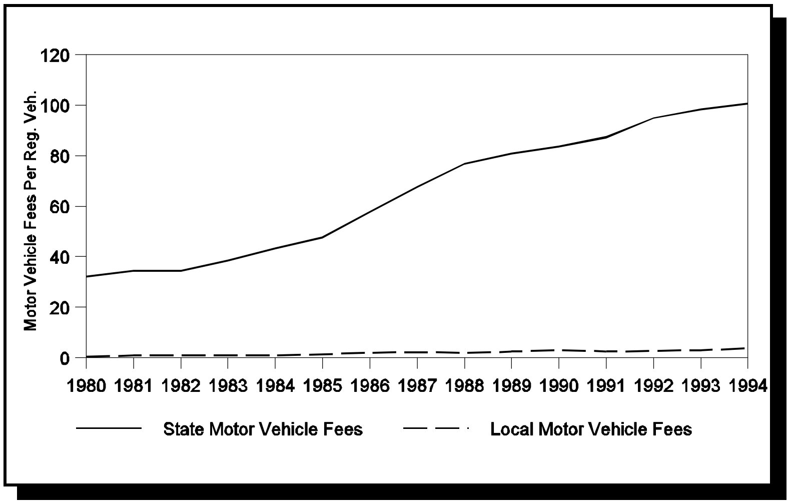

Figure IV-6. State and Local Motor Vehicle Fees Per Registered Vehicle 1980-1994

Source: *Highway Statistics*, FHWA

Highway User Revenues Collected By All Levels of Government

The trend in total HUR collected by Federal, State, and local governments is presented in Figure IV-7. For FY 1993, States collected 66 percent of all HURs, the Federal Government 31 percent, and local governments only 3 percent. However, local governments had the largest growth in revenues at 19.8 percent per year, followed by States at 10.5, and the Federal Government at 8.7 percent annually.

Revenues Per Vehicle Miles of Travel and Per Registered Vehicle

One might expect that HURs would increase as the level of transportation activity increases. Generally, revenues increase as motor fuel is consumed and more vehicles are registered. By analyzing revenues per VMT and per registered vehicle, the increase is attributed to more demand for transportation. Figure IV-8 shows the trend in HURs per 10,000 VMT and per registered vehicle from 1980 to 1994. The revenues are for all levels of government combined, and the VMT and registered vehicle data are from FHWA's *Highway Statistics*.

The revenue trend shows that HURs per VMT and per registered vehicle more than doubled from 1980 to 1994 in current dollars. The HURS per 10,000 VMT increased from $145 in 1980 to $329 while revenues per registered vehicle increased from $137 to $384, respectively. This indicates that highway users are paying twice as much for transportation services than during the early 1980s in current dollars.

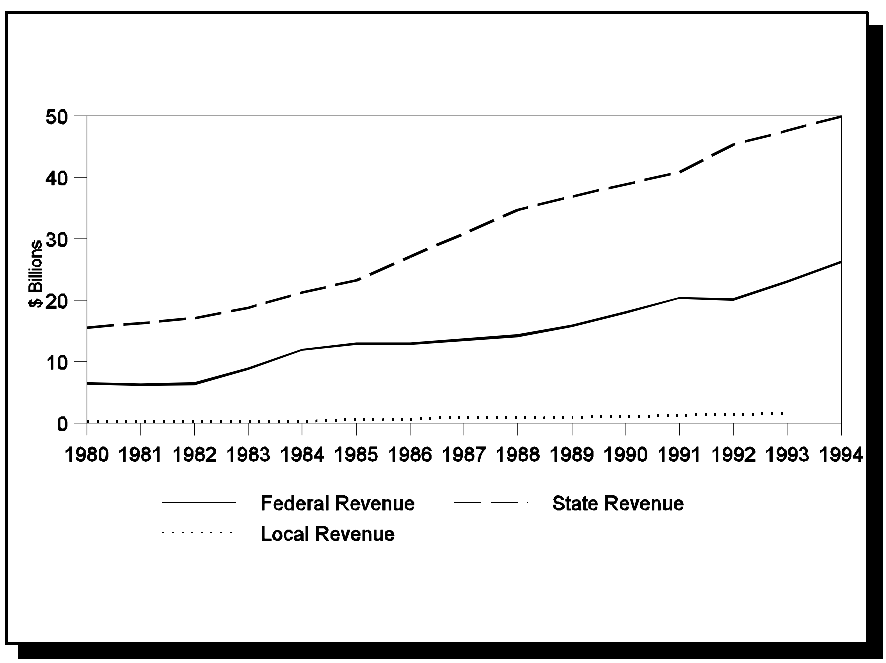

Figure IV-7. Federal, State, and Local Revenues, 1980-1994

Highway User Revenues Collected By All Levels of Government

Total HUR collected by Federal, State, and local governments is presented in Tables IV-8 and IV-9 for 1994 and 2000. These tables provide the actual amounts of HURs for all three levels of government for 1994 and a forecast for 2000 using existing tax rates at the Federal level.

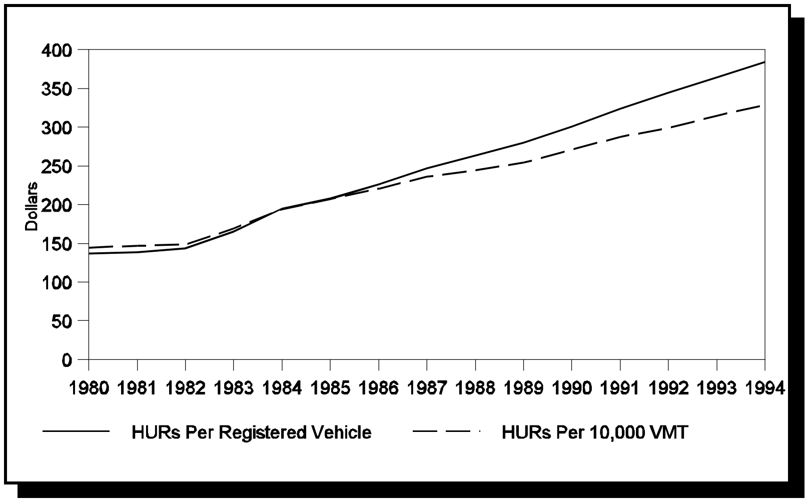

Figure IV-8. HURs for All Levels of Government Per VMT and Per Registered Vehicle, 1980-1994

Source: *Highway Statistics*, FHWA

Comparison of User Payments by Vehicle Class for all Levels of Government

Evaluating relationships between Federal user fees and Federal highway cost responsibility is essential for evaluating the equity of the Federal highway user fee structure, but comparisons of total user fee payments and total highway cost responsibility for all levels of government are important in evaluating overall subsidies to various classes of vehicles that might give them a competitive advantage over other modes of transportation, and in evaluating other effects of national highway financing programs. State and local governments collect 62 percent of total HURs and expend 76 percent of total expenditures when all revenues and expenditures are included. These percentages are much higher (72 percent and 82 percent respectively) if Federal deficit reduction revenues are removed and expenditures by spending agency are considered.

Table IV-8. Total 1994 HURs for All Levels of Government ($ Millions)

	Federal[1]	State[2]	Local	Total
Motor Fuel	$18,436	$25,941	$661	$45,038
Registration and Title Fees	$620	$15,804	$802	$17,226
WDT	N/A	$578	N/A	$578
Vehicle Excise Tax	$1,441	N/A	N/A	$1,441
Tire Tax	$331	N/A	N/A	$331
Drivers' License Fees	N/A	$823	N/A	$823
Fines and Penalties	N/A	$174	N/A	$174
Tolls	N/A	$3,612	$1,067	$4,679
Other Fees	N/A	$2,959	N/A	$2,959
Total	$20,828	$49,891	$2,529	$73,248

N/A: Not Applicable
1 Federal revenues do not include deficit reduction and LUST fund revenues.
2 All forecasts are based on analysis of trends as described in the text.

Table IV-10 shows total 1994 HURs for all levels of government by type of fee. This table provides an elaboration of the revenue side of the summary balance sheet shown in Table 1 in the Federal HCAS Summary Report, breaking down revenues at each level of government into sources by the three broad categories that have traditionally been used to classify HURs:

First Structure Taxes. Fixed fees that do not

vary by amount of highway use, and are therefore insensitive to one of the prime determinants of highway cost responsibility — VMT. However, they can be sensitive to another prime determinant of highway cost responsibility — vehicle weight.

Second Structure Taxes. Fuel taxes, which result in user tax payments that are highly correlated with VMT, but have relatively little

Table IV-9. Total 2000 HURs for All Levels of Government ($ Millions)

	Federal[1]	State[2]	Local	Total
Motor Fuel	$23,547	$38,321	$872	$62,740
Registration and Title Fees	$841	$23,219	$1,157	$25,217
WDTs	N/A	$734	N/A	$734
Vehicle Excise Tax	$2,347	N/A	N/A	$2,347
Tire Tax	$439	N/A	N/A	$439
Drivers' License Fees	N/A	$1,109	N/A	$1,109
Fines and Penalties	N/A	$180	N/A	$180
Tolls	N/A	$5,177	$1,484	$6,661
Other Fees	N/A	$5,089	N/A	$5,089
Total	$27,174	$73,829	$3,513	$104,516

N/A: Not Applicable
1 Federal revenues do not include deficit reduction and LUST fund revenues.
2 All f[illegible]ls as described in the text.

Table IV-10. 1994 HURs by Type for All Levels of Government ($ Billions)

Revenue Categories	Federal[1]	State	Local	All Levels
First Structure (Fixed Fees)				
Registration	---	14.9	---	14.9
Title Fees	---	.9	---	.9
Ad Valorem	---	3.2	---	3.2
Drivers' License	---	0.8	---	0.8
Heavy Vehicle Use	0.6	---	---	0.6
Other or Miscellaneous	1.4	---	0.8	2.2
Subtotal	2.1	19.8	0.8	22.7
Second Structure (Fuel Taxes)	13.9	19.6	0.5	34.0
Gasoline	3.5	4.4	0.2	8.1
Diesel	0.7	1.7	--	2.4
Gasohol	0.4	0.2	--	0.6
Other	18.4	25.9	0.7	45.0
Subtotal				
Third Structure (Use Related Fees)	---	0.6	---	0.6
Weight-Distance	0.3	---	---	0.3
Tire	---	3.6	1.1	4.7
Tolls and Other	0.3	4.2	1.1	5.6
Subtotal				
Total	20.8	49.9	2.5	73.2

[1] Excludes Federal fuel taxes of $10.5 billion earmarked for deficit reduction and the LUST fund.

sensitivity to one of the other prime determinants of highway cost responsibility — vehicle operating weight, or more specifically, axle weight.

Third Structure Taxes. Vehicle usage taxes, which are designed to reflect costs occasioned by vehicles' use of the highways, to a greater or lesser extent depending on the specifics of the tax.

The Federal Government has the lowest proportion of its tax structure in both first and third structure user taxes (10 percent and 1 percent, respectively), of all the three levels of government, and therefore has the highest proportion (88 percent) in second structure taxes. Relatively speaking, the Federal Government has a tax structure that responds well to the amount of highway travel, but does not respond well to the variations in costs per vehicle mile that can be achieved with third structure taxes. However, the Federal fuel tax structure includes a higher diesel fuel tax rate (a "diesel differential" of 6 cents) — a feature that significantly improves the Federal tax structure in relation to cost responsibility.

The States vary greatly in their relative mixes of the three types of taxes. As a whole, States rely more on first structure taxes (39 percent) than either of the other two levels of government. However, a few States have shares of first structure taxes about as low as at the Federal level and have substantial shares of their taxes in third structure taxes. None of the States has a higher proportion of its tax structure in second structure taxes than the Federal Government, although a few come close (70 to 80 percent range). Also, only a few of the States have substantially higher diesel fuel tax rates like the Federal diesel differential of 6 cents.

Although local governments as a whole recover only about 10 percent of their costs from highway users (see Table 1, Federal Highway Cost Allocation Study Summary Report), they do collect the highest share from third structure taxes (about 45 percent), almost all in the form of tolls. Tolls have the potential for reflecting cost responsibility quite well depending on the toll structure and the extensiveness of toll facilities.

Table IV-11 shows estimates of highway user payments by vehicle class for all levels of government for the Year 2000. These user payments include all the revenue sources shown for each level of government in the preceding table. The Federal tax structure in general tends to increase user payments more rapidly with the size and weight of vehicle classes than the State and local tax structures. Federal user fees are 25 percent of total national user fees for passenger vehicles, 28 percent for single unit trucks, and 39 percent for combinations. This progression also occurs to a significant extent as registered weight increases, with one important exception — the heaviest class of combination trucks (>80,000 pounds) pays a smaller percentage of its total national user fees at the Federal level than any of the lighter classes of combinations. The current Federal tax structure does not increase with weight above 80,000 pounds as much as occurs, on average, at the State level.

Table IV-11. 2000 Highway User Fee Payments by Vehicle Class for All Levels of Government ($ Millions)

Vehicle Class/Registered	Federal	State	Local	Total
Autos	$11,576	$34,52	$1,164	$47,264
Pickups and Vans	$5,812	$16,26	$479	$22,554
Buses	$20	$311	$6	$337
All Passenger Vehicles	$17,408	$51,09	$1,649	$70,155
Single Unit Trucks				
#25,000 pounds	$1,500	$3,831	$84	$5,415
25,001 - 50,000 pounds	$611	$1,802	$58	$2,471
>50,001 pounds	$487	$924	$31	$1,442
All Single Unit Trucks	$2,598	$6,558	$173	$9,329
Combination Trucks				
#50,000 pounds	$306	$560	$15	$881
50,001 - 70,000 pounds	$504	$902	$22	$1,427
70,001 - 75,000 pounds	$370	$548	$14	$932
75,001 - 80,000 pounds	$5,521	$7,651	$145	$13,317
>80,000 pounds	$468	$1,156	$12	$1,636
All Combinations	$7,169	$10,81	$208	$18,195
All Trucks	$9,766	$17,37	$380	$27,522
All Vehicles	$27,174	$68,47	$2,029	$97,677

Federal Highway Taxes Paid by Different Vehicle Classes

The Federal highway user tax scheme includes taxes that vary with mileage, operating weight, vehicle purchase price, declared weight, and others. Individually, these taxes vary noticeably by truck type, mileage, and weight. However, collectively, the taxes do not vary as much and do a poor job reflecting costs at the heavier weights, as shown in Chapter VI. Figure IV-9 illustrates how the individual taxes vary by weight for a typical truck type — tractor-semitrailer combination with 5-axles, 2 rear tandem axles.

Fuel Taxes

The motor fuel taxes are based on a cent per gallon. Such a tax would vary by miles traveled by the vehicle and to a lesser degree, weight of the vehicle. Other vehicle parameters, such as engine size, fuel type, transmission design, and truck operations (geographic and driver skills), all influence vehicle fuel economy, thus, fuel consumption and fuel tax. The 1997 Federal HCAS HRFM calculates fuel tax revenue based on VMT × operating weight × gallons per mile (GPM). The GPMs are sensitive to vehicle weight. Figure IV-9 highlights fuel taxes by weight and mileage for selected vehicle types. In general, fuel taxes increase with mileage and to a lesser degree, weight.

Truck and Trailer Excise Tax

The truck and trailer excise tax is levied on new truck purchases above 33,000 pounds manufacturer weight class. For each vehicle class, HRFM calculates sales of up to six types of body styles are priced and multiplied by the excise tax rate to result in revenues. Different body types, as proportions of an entire vehicle class, all for different sizes, types, and special equipment. Figure IV-9 provides revenue (cent/mile) data of the heavy vehicle excise tax for selected truck types. These data reflect average number of annual sales and average value of the truck equipment. However, special equipment such as tank trailers, can cost as much as 4- to 5-fold that of a normal dry van trailer. Therefore, the excise tax is not sensitive to weight and mileage for direct tax purposes. However, operational use of the trailer will influence its replacement cycle.

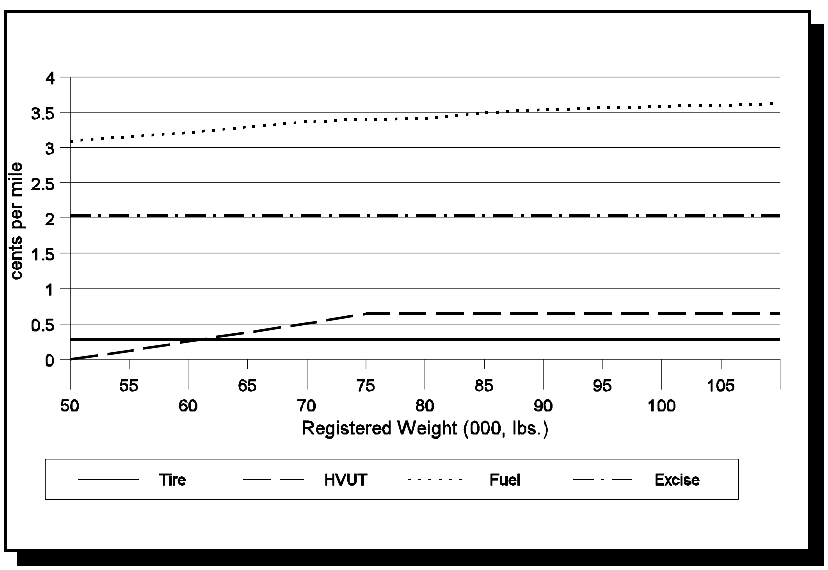

Figure IV-9. Federal Taxes for 5-axle Tractor-Semitrailer Combination by Registered Weight

Tire Tax

The Federal tire tax is assessed on purchase of tires weighing 40 pounds or greater. The HRFM calculates tire tax revenues for each vehicle class and weight group by: estimating tire life VMT, multiplied by number of tires/axle configuration to yield the revenue. The sum of all vehicle classes and weight groups results in total tire tax revenue. Figure IV-9 provides information on tire tax by weight groups for selected vehicle types and, in general, this tax is not sensitive to weight and has some sensitivity to mileage — replacement of the tires.

Heavy Vehicle Use Tax

The Federal HVUT is a declared weight-based tax with a cap of $550 per year. The HRFM calculates vehicle use fee revenue by using truck stock by registered weight multiplied by tax rate by weight to produce total revenue. Figure IV-9 illustrates the smooth slope and plateau of the HVUT given the nature of the cap for selected trucks and the HVUT is sensitive to weight, until 75,000 pounds GVW, but not mileage sensitive.

V. Highway Cost Responsibility

Cost Occasioned Approach

Basis and Philosophy

In HCASs over the past half century, FHWA and its predecessor agencies have used a cost-occasioned approach to allocate highway cost responsibility among different vehicle classes. During this time specific cost allocation methods have evolved, but the basic cost occasioned approach has remained the basis for cost allocation at both the Federal and State levels. The approach was so widely accepted that Congress, in mandating the 1982 Federal HCAS, stipulated that a cost-occasioned approach be used in the study. Specifically, Section 506 of the STAA directed the Secretary of Transportation to undertake a study of "the costs occasioned in design, construction, rehabilitation, and maintenance of Federal-aid highways by the use of vehicles of different dimensions, weights, and other specifications, and by the frequency of such vehicles in the traffic stream."

The underlying philosophy of the cost-occasioned approach is that each user should pay the highway costs that it creates or "occasions." A key question in cost allocation studies is what costs to consider. Previous Federal and State cost allocation studies have focused on highway agency costs paid from highway user charges. The focus on costs paid from user charges relates to an important objective of most cost allocation studies -- to assess the equity of the highway user charge structure. While there may be many definitions of equity, in cost allocation studies equity has been defined as each vehicle class paying user charges proportionate to its share of highway agency costs.

Some critics of the traditional cost-occasioned approach argue that economic efficiency is more important than equity and that highway user charges should reflect the true cost of each vehicle's use of the highway, not the share of highway agency expenditures allocated to different vehicle classes. Those who advocate focusing cost allocation on efficiency rather than equity generally favor a marginal cost approach to cost allocation whereby vehicles would be charged in proportion to their marginal cost of highway use. Equity and economic efficiency are not mutually exclusive or even conflicting objectives. In many cases user fee changes that would improve equity would also improve economic efficiency and vice versa.

In essence both the cost-occasioned and the marginal cost approaches assign cost responsibility based on principles of cost occasioning. The traditional cost occasioning approach limits the scope of "costs" considered to highway agency obligations or expenditures. The marginal cost approach, on the other hand, does not consider highway agency expenditures, but rather estimates the economic cost of additional increments of highway use by each vehicle class, including both infrastructure costs that ultimately result in highway agency expenditures as well as environmental and other social costs occasioned by operations of each vehicle class that are not reflected in highway agency budgets. The two approaches differ not so much in the determination of which vehicle classes are responsible for the costs, but rather on which costs are allocated.

Economic efficiency may be served by setting user fees in accordance with cost responsibilities estimated using the traditional cost-occasioned approach. This is especially true for pavement costs where there is a direct connection between marginal pavement costs and highway agency investment requirements for pavement preservation. The closer that each vehicle comes to paying its share of highway agency costs for pavement improvements, the closer it comes to paying its marginal pavement costs, and thus the more efficient the allocation of resources. While other agency costs do not vary as directly with use as do pavement costs, it could be expected that economic efficiency would improve if each vehicle came closer to paying its responsibility for highway agency costs.

As noted above, previous cost allocation studies have focused on highway agency costs incurred in the provision and preservation of the highway infrastructure. Each vehicle, because of its highway use and its weight, length, width, and other physical characteristics, contributes to the need for and cost of improvements to provide additional capacity or preserve existing highway facilities. Each user's travel also occasions costs that go beyond the costs of providing and preserving the highway infrastructure, including congestion, environmental, and safety-related costs imposed on others. The 1982 Federal HCAS considered such costs, but only in a supplemental analysis that examined marginal costs of highway use by different vehicles in order to estimate economically efficient levels of prices that those vehicles would have to pay under different conditions.

There are other non-agency costs that previous HCASs have not considered, such as the impacts of constructing highways in sensitive physical and cultural environments. It is difficult to address many of these costs in cost allocation because there are no clear engineering or economic "cause and effect" relationships between the costs and characteristics of the vehicles to which costs must be allocated. Many community costs of highways are less related to the use of the highway by different vehicle classes than to disruption of the physical or cultural environment by the mere presence of the highway.

Traditionally, cost allocation studies at both the Federal and State levels have examined highway agency costs because their primary objective has been to determine the cost responsibility of different vehicles for infrastructure and related costs borne by the highway agency. This cost recovery objective in turn is related to the user fee principle that different vehicle classes should pay for the highway infrastructure in proportion to their share of the costs to provide and preserve that infrastructure. Costs attributable to each vehicle class are estimated using a process that considers how physical and operational characteristics of each vehicle class affect the design of various components of the highway system or the rate at which pavements, bridges, and other elements of the highway infrastructure wear out and must be repaired or replaced.

The cost responsibility of different vehicles for pavement, bridge, and certain other types of agency costs varies according to relative amount of travel on different highway functional classes. Since Interstate and other principal arterial highways generally are designed to accommodate higher volumes of heavy trucks, costs per mile of travel by heavy trucks on those highways are lower than on highways that are not designed to handle as many heavy loads. As shown in Chapter II, the distribution of VMT by highway functional class varies considerably among different vehicle classes. Combination trucks used in Interstate commerce travel the majority of their mileage on higher-order systems in rural areas, while single unit trucks used for local trucking travel a significant amount of their annual mileage on lower-order systems that do not have the same high-type design as Interstate highways.

While neither the Federal nor State user fee structures can charge vehicles directly according to the specific highways upon which they operate, average cost responsibilities for different vehicle classes can be estimated based upon their travel and operating weight distributions on different highway functional classes in each State and characteristics of pavements and bridges on each highway class in each State. Details of the estimation of cost responsibilities for pavement, bridge, and other costs are included in appendices to this report.

A consideration in defining the costs to be analyzed in a HCAS is the time frame over which costs are to be estimated. This decision, too, depends on specific objectives of the cost allocation study. Most traditional cost allocation studies have analyzed costs representing the current distribution of agency costs or the anticipated distribution of costs several years into the future. This time frame is appropriate for assessing the equity of the current user fee structure and of potential user fee changes that could improve short run equity. If the objective of the study is to analyze the relative cost responsibility of different vehicle classes over a longer period of time, the time frame over which costs would be evaluated could be extended. While the ideal might be to regularly adjust highway user fees as relative cost responsibilities change, this often is difficult and consideration of both long run and short run cost responsibilities might be appropriate in evaluating potential user fee changes. This is particularly true if significant changes in the composition of the highway program or in such factors as TS&W limits are expected.

While it is appropriate to examine cost responsibilities for agency costs over periods of 1 or more years, some external costs such as congestion costs should be analyzed over hours rather than years if the objective is to estimate true marginal costs for purposes of setting efficient congestion charges. The temporal variation of congestion and some pollution costs makes it difficult to reflect those costs in Federal user fees or in traditional State or local user fees. As will be discussed in other sections of this report, congestion pricing is receiving increasing attention at the local level as a tool to reduce peak period congestion.

Congestion costs vary not only by hour of the day but by geographical area, and many environmental costs also vary geographically. If the cost responsibility of different vehicle classes is to be accurately estimated, it is important to capture geographical variations in those costs. This is especially true if user fees are to be imposed based upon those costs with the expectation that those fees will improve economic efficiency.

As noted above, some HCASs, including the 1982 Federal HCAS, have examined costs other than agency costs in subsidiary analyses to address policy questions other than the equity of the highway user charge structure. In addition to examining marginal costs associated with the operation of different vehicle classes for purposes of estimating how an economically efficient user fee would compare to user fees based on each vehicle's share of highway agency costs, a follow-on to the 1982 Federal HCAS also examined how the responsibility of different vehicle classes for highway costs incurred by all levels of government compared to the responsibility of those vehicle classes for Federal highway costs. This analysis provides a more comprehensive assessment of the extent to which each vehicle class covers its overall highway cost responsibility, but results are not directly applicable to analyses of user fee equity for a particular level of government. Many State cost allocation studies analyze State and Federal costs as well as State-only costs to understand differences in user fee equity when all levels of government are considered.

Applying a cost-occasioned approach for certain types of costs can be difficult and there is no universal agreement on how all costs should be allocated. The greatest certainty is in allocating costs directly related to specific characteristics of different vehicle classes. Pavement and bridge construction costs are among the costs most closely associated with characteristics of different vehicles, although there still is discussion about specific methods for allocating those two categories of costs. For costs that are not as directly related to specific physical characteristics of each vehicle, the uncertainty about how to allocate costs among vehicle classes is more pronounced.

Certain groups of vehicles clearly occasion some specific costs. For example, since truck weigh stations are needed only for trucks, there is general agreement that trucks should be assigned responsibility for weigh station costs, even though all users benefit from weight enforcement programs that help to preserve the infrastructure. The allocation of truck climbing lane costs is not as straightforward. Some might assign the cost responsibility for climbing lanes on long steep grades to larger trucks whose high weight-to-horsepower ratios result in very low speeds that affect safety and delay other users. If there were no trucks, there would be no need for passing lanes. It is the unique characteristics of heavy trucks that necessitate the construction of climbing lanes. Others maintain, however, that climbing lanes are constructed to maintain the capacity and safety of the facility, and that all vehicles should share in the costs in proportion to their PCEs on the steep grade. Using PCEs would assign a significant share of the cost responsibility to heavy trucks, but autos, pickups, and vans would be responsible for most climbing lane costs.

The next section of this chapter discusses the cost occasioning approach used in this study. The chapter describes the composition of the basic cost groups, and then describes the basis for allocating the components of these cost groups to different vehicle classes.

Federal Agency Cost Allocation

As noted earlier, agency costs allocated in this study are obligations from the HTF. Obligations are grouped into 17 categories, 13 of which are identical to improvement types discussed in Chapter III. The other four are subsets of "other" costs in Chapter III that are separated for cost allocation. Table V-1 shows these 17 cost categories along with base period (1993-1995) and Year 2000 obligations for each.

Most highway costs are estimated from detailed FMIS data on obligations by improvement type. The first 11 cost categories in Table V-1 represent specific FMIS improvement types, but FMIS data are refined considerably for cost allocation purposes. The cost categories ridesharing/high occupancy vehicle (HOV) projects, Mass Transit — Highway Account, and truck related projects are FMIS work types, which are subsets of FMIS improvement types. Those costs are separated for cost allocation purposes because they are uniquely occasioned by different vehicle classes and are allocated differently than other costs. Obligations for Federal lands projects and FHWA administration are not included in FMIS but come from other FHWA accounting records. Obligations from the MTA come from FTA records.

The FMIS subdivides improvement type obligations into several work classes including construction, preliminary engineering, right-of-way, transit and training, planning, and research. The construction category is typically the largest work class within each improvement. Most other work classes are incidental to construction. Costs for other work classes often are not allocated in the same manner as construction costs within each improvement type, so they are broken out and allocated separately. As noted above costs for certain work classes such as transit and truck-related costs are removed completely from the improvement type under which they are reported and are allocated as separate cost categories.

Table V-1. Major Federal Cost Categories for Cost Allocation ($,000)		
Cost Category	Base Period Obligations	2000 Obligations
New Pavement Construction	$1,762,388	$2,173,371
Major Widening	$1,488,507	$1,835,622
Reconstruction with added lanes	$759,544	$936,667
Pavement 3R	$5,879,083	$7,250,066
Minor Widening	$392,275	$483,752
New Bridges	$622,527	$767,698
Bridge Replacement	$1,714,104	$2,113,828
Major Bridge Rehabilitation	$971,275	$1,197,773
Other Bridge Projects	$360,586	$444,673
Safety/TSM	$2,061,020	$2,541,643
Environmentally-related	$429,592	$529,772
Ridesharing/HOV Projects	$118,704	$146,386
Mass Transit — Highway Account	$528,119	$651,275
Truck Related Projects	$104,540	$128,919
Federal Lands, FHWA Administration	$1,272,134	$1,480,728
Other	$902,392	$1,112,827
MTA	$2,903,851	$3,380,000
Total	$22,270,642	$27,175,000

NOTE: Base period is 1993-1995.

Pavement Cost Allocation Methods

New Pavement, Added Lanes

Table V-2 shows costs for the two major improvement types that are allocated as new pavement costs. Costs are broken down into nine separate categories, each of which is allocated separately, although some may use the same allocators. The approach used in allocating costs of new pavements and added lanes is similar to the approach developed in the 1982 Federal HCAS. Costs of providing additional lanes of capacity are allocated using a design based two step methodology. The allocation process separates costs into those related to a base facility that provides additional capacity and traffic services and those related to providing the durability to carry projected traffic loadings over the pavement's design life.

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 just automobiles. The base facility would provide skid resistance, 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

Table V-2. 2000 Allocatable Federal Costs for New Pavement Construction ($,000)		
	New Pavements	Major Widening
P.E. and Other	$371,904	$143,817
Right of Way	$292,585	$220,869
G&D-Weight	$3,292	$4,545
G&D-Width	$41,465	$42,182
G&D-Common	$467,672	$442,622
Width	$112,836	$111,216
Rigid Construction	$177,963	$141,942
Flexible Construction	$473,257	$509,827
Base Facility	$232,397	$218,602
Total	$2,173,371	$1,835,622

thickness necessary to accommodate projected vehicle loadings.

The construction of new traffic lanes, whether they be new highways on new locations or additions to existing facilities, reflects the need for added highway capacity to relieve congestion and provide higher levels of service for current and future traffic. Some vehicles, because of their size and operating characteristics, have a greater effect than others on traffic flow and highway level of service. For example, trucks consume more physical space on the roadway than automobiles and have a greater effect on traffic flow because they do not accelerate or maneuver as well as automobiles. Traffic engineers have developed a concept called "PCEs" that measures the relative effects of different vehicles on highway level of service. The PCEs for a particular vehicle will vary according to such factors as grades, lane width, and type of highway, and thus the relative contribution of different vehicles classes to congestion and to the need for additional capacity can be measured across a variety of conditions.

In the 1982 Federal HCAS, base facility costs were allocated to all vehicles on the basis of their relative VMT, although consideration was given to allocating those costs in proportion to VMT weighted by the PCEs for each vehicle class. The PCE-weighted VMT was not used as the final allocator because further research into equivalency factors for different vehicles was believed to be needed. For the 1997 Federal HCAS, new research was conducted to estimate PCEs as a function of such key factors as vehicle operating characteristics, highway functional class, time-of-day, and terrain. This research used traffic simulation models that are more accurate and sophisticated than those available 15 years ago. Base facility costs as well as related engineering, right-of-way, and other costs associated with adding new highway lanes are allocated using PCE-weighted VMT.

Table V-3 presents the shares of new flexible and rigid pavement costs by highway functional class that comprise the base facility and are allocated using PCE-weighted VMT. Base facility shares are smaller for higher-order functional classes than for lower-order functional classes. On all highway classes the base facility represents a larger share of total costs for rigid pavements than for flexible pavements.

The load-related portion of new pavement construction costs is allocated based on the relative ESALs of each vehicle class. The ESAL is a measure of the relative contribution to pavement wear associated with different single and tandem axle loads, using an 18,000 pound single axle as the benchmark. Pavement design equations developed by the AASHTO use ESALs as the principal vehicle specific factor in pavement design. Separate allocations are made for rigid and flexible pavement types because the pavement material is highly related to vehicle ESALs.

Table V-3. Proportion of Federal New Pavement Costs Attributable to the Base Facility

Functional Class		Flexible Pavements (percent)	Rigid Pavements (percent)
Rural	Interstate	17.0	30.0
	Other Principal Arterials	22.5	39.2
	Minor Arterials	31.1	54.0
	Major Collectors	38.8	61.3
	Minor Collectors	45.1	72.2
	Local	57.4	79.8
Urban	Interstate	16.3	29.0
	Other Freeways/Expressways	18.3	32.1
	Major Arterials	22.0	40.3
	Minor Arterials	29.5	52.4
	Collectors	34.7	61.8
	Local	43.6	75.1

Pavement cost responsibilities are estimated using three pavement sections/designs for each highway functional class for each State. Pavement design parameters for each State, such as soil strength, terminal PSI value and the other characteristics are considered in this analysis. Design methods reflect the latest State specific and AASHTO design manuals and guidelines. Cost responsibilities for each of the over 300 vehicle class/weight groups are first produced by State and then combined into a national average.

Table V-4 shows the cost responsibility per mile for new pavement costs for several illustrative vehicle classes along with their share of total new pavement costs. Automobiles account for the largest share of new pavement costs followed by 5-axle tractor-semitrailers. The responsibility of autos for new pavement costs is about 0.05 cents per mile, less than 10 percent of the cost responsibility of 5-axle tractor-semitrailers. Eight-axle and 5-axle twin trailer combinations have the highest average new pavement cost responsibility per mile among the illustrative vehicle classes.

Table V-4. 2000 Federal New Pavement Cost Responsibility for Selected Vehicles

Vehicle Class	Cents per Mile	Share of Total New Pavement Costs (percent)
Auto	.05	38.5
SU2	.26	8.3
SU3	.53	2.3
SU4	.81	1.0
CS5	.67	26.0
CS6	.71	2.0
DS5	.93	2.3
DS8	1.10	0.4
TPL	.83	0.05

NOTE: See Chapter I for vehicle definitions.

Figure V-1 summarizes shares of new pavement cost responsibility by broad vehicle classes. Passenger vehicles are responsible for over half of all new pavement costs, semitrailer combinations 32 percent, single unit trucks 12 percent, and multi-trailer combinations 3 percent.

Grading and drainage costs are not separated in FMIS, but a special analysis of grading and drainage costs was conducted for the 1982 Federal HCAS. A survey of several States conducted for this study indicated that grading and drainage factors developed for the 1982 Federal HCAS are still applicable.

Grading and drainage costs associated with new pavement projects are broken into three components, those related to vehicle weight, those related to vehicle width, and those that are not related to any specific vehicle characteristics. In mountainous and rolling terrain, additional grading and drainage expenses are incurred to reduce highway grades so that heavy trucks with high weight-to-horsepower ratios will not slow more than can be avoided. For operational and safety reasons, the maximum speed reduction allowed for vehicles climbing a grade is 15 miles per hour. Thus a critical grade is defined as any combination of length and degree of grade that produces a 15 miles per hour speed reduction. The allocation of additional grading and drainage costs related to vehicle weight is based on established relationships between highway grade features (critical length and degree of grade) and vehicle performance attributes (weight-to-horsepower ratio). The relative cost responsibility of each vehicle class is estimated from the earthwork savings that would result when comparing each vehicle class to the worst performing

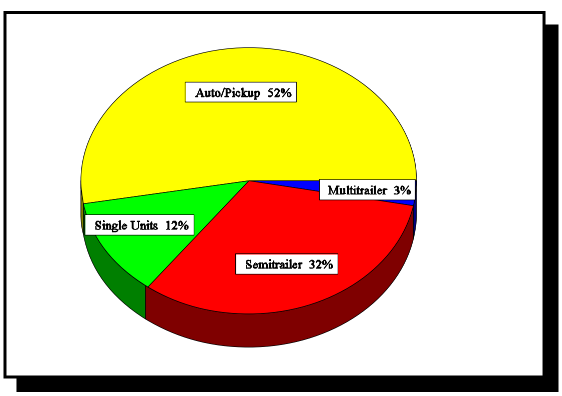

Figure V-1. 2000 New Pavement Cost Responsibility Distribution

vehicle. The incremental earthwork savings are computed as a function of the highway cross section and critical grades for given weight-to-horsepower intervals. The enhanced model developed for this study uses updated information on vehicle horsepower derived from vehicle performance models that reflect present day vehicle characteristics and highway design characteristics from the HPMS database.

In the 1982 Federal HCAS, width related costs were allocated using an incremental approach that estimated incremental construction cost savings when designing for vehicles of different widths. Ten different vehicle width categories were defined in the 1982 Federal HCAS going all the way to a hypothetical zero width vehicle, but all except the lightest trucks, automobiles, and motorcycles were in the widest group. The analysis has been simplified somewhat for this study by eliminating the narrowest width groups and allocating a smaller share of total pavement costs on the basis of vehicle width. This is consistent with trends toward designing wider pavements for safety reasons regardless of the relative number of trucks using the roadway. These changes have been applied to both the allocation of additional construction costs related to vehicle width and to additional grading and drainage costs associated with vehicle width.

The portion of grading and drainage costs for new highway lanes that is related to neither vehicle weight nor width is allocated among different vehicle classes on the basis by PCE-VMT. These costs are essential parts of the overall construction costs that are necessitated by needs to provide additional highway capacity, and are allocated on the basis of each vehicle class' contribution to the need for additional capacity.

Table V-5 summarizes the cost responsibility per mile of travel for new pavement costs by broad vehicle groups at various operating weight ranges. Cost responsibility for passenger vehicles averages about 5/100 of a cent per mile. Costs for buses are higher than for autos, pickups, and vans, but bus travel is a small fraction of total passenger vehicle travel and has little influence on the overall average. The average cost responsibility for new pavements for single unit trucks is 0.31 cents per mile compared to 0.66 cents per mile for combination trucks. Within those two truck categories average costs vary from about 0.20 cents per mile for light single units to almost 3 cents per mile for the heaviest combinations.

Table V-5. 2000 Federal Cost Responsibility for New Pavement Improvements

Vehicle Class/ Operating Weights	Cents per Mile
Autos	0.05
Pickups/Vans	0.05
Buses	0.28
All Passenger Vehicles	0.05
Single Unit Trucks	
<25,001 pounds	0.20
25,001 - 50,000 pounds	0.66
>50,000 pounds	1.58
Total Single Units	0.31
Combination Trucks	
<50,001 pounds	0.29
50,001 - 70,000 pounds	0.60
70,001 - 75,000 pounds	0.96
75,001 - 80,000 pounds	1.15
80,001 - 100,000 pounds	1.71
>100,001 pounds	2.94
Total Combinations	0.66
Total Trucks	0.51
Total All Vehicles	0.08

Table V-6 shows the cost responsibility for new pavement costs for selected vehicles at different operating weights. This table clearly illustrates the relationship between weight and pavement costs for any given vehicle class and also illustrates the important fact that the more axles under a vehicle at any given weight, the lower the pavement costs.

In comparing cost responsibilities for 5-axle tractor-semitrailers and 5-axle twin trailer combinations, the difference in the pavement damage associated with single and tandem axles is evident. The 5-axle tractor-semitrailers has 2 tandem axle pairs while the 5-axle twin trailer combinations has 5 single axles. At every weight the cost responsibility of the 5-axle twin trailer combinations is greater than that of the 5-axle tractor-semitrailers. Similarly, when cost responsibilities of 5-axle tractor-semitrailers and 6-axle tractor-semitrailers are compared, the benefits of the 6-axle tractor-semitrailers tridem axles are apparent. At all but the lowest weights, the 6-axle tractor-semitrailers cost responsibility for is less than 5-axle tractor-semitrailers costs.

Table V-6. 2000 Federal Cost Responsibility for New Pavement Costs for Selected Vehicle Classes (cents per mile)

Operating Weight (000s)	SU2	SU3	CS5	CS6	DS5	DS8
0-10	0.14					
20	0.20	0.18				
30	0.44	0.24	0.24	0.24	0.31	
40	1.28	0.40	0.26	0.27	0.30	
50	3.75	0.79	0.30	0.31	0.41	0.29
60	8.58	1.48	0.42	0.36	0.59	0.33
70		2.70	0.68	0.46	0.87	0.40
80		4.13	1.01	0.62	1.76	0.52
90			1.59	0.96	2.68	0.62
100			2.61	1.35	3.95	0.90
110			4.09	2.02		1.24
120				2.79		1.78
130						2.55
140						3.45
150						5.50

NOTE: See Chapter I for vehicle definitions.

Figure V-2 summarizes the overall assignment of new pavement costs to passenger vehicles and single unit and combination trucks. Despite the differences in cost responsibility per mile of travel, passenger vehicles are assigned over half the responsibility for new pavement costs, combination trucks 35 percent, and single units 12 percent.

Pavement Preservation Costs

Pavement 3R costs constitute the largest single category of obligations from the HTF. Table V-7 shows the breakdown of costs for several cost categories that are grouped as pavement preservation costs. Substantial resources were devoted in the 1982 Federal HCAS to developing new techniques for allocating pavement 3R costs based upon the contribution of each vehicle class to various pavement distresses that necessitate pavement improvements. The basic framework for allocating pavement 3R costs in the 1982 Federal HCAS is used in this study, but significant refinements have been made in several areas.

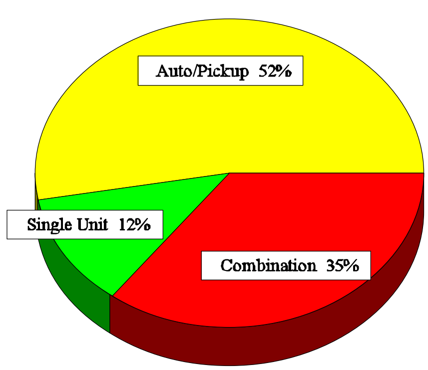

Figure V-2. 2000 New Pavement Cost Responsibility Distribution by Broad Vehicle Classes

An important contribution of the 1982 Federal HCAS was the use of "mechanistic" pavement distress models that directly relate axle loads and repetitions to the stresses, strains, and other pavement responses leading to pavement deterioration. Several mechanistic models used in the 1982 Federal HCAS are retained, but most have been improved based upon new theoretical work and the availability of pavement performance data from the Long Term Pavement Performance (LTPP) Study. Eleven different pavement distress models are incorporated in the new nationwide pavement cost model (NAPCOM) used for HCA. Together these models represent the state-of-the-art in predicting pavement responses to different axle loads and repetitions.

Table V-7. 2000 Allocatable Costs for Pavement Preservation ($,000)

Work Class	Pavement 3R	Reconstruction with Added Lanes
P.E. and Other	$549,114	$139,819
Right of Way	$218,487	$77,092
Rigid Construction	$1,147,027	$128,766
Flexible Construction	$3,675,668	$343,170
Non-Load Rigid	$138,623	$15,552
Non-Load Flexible	$499,567	$61,252
Grading and Drainage	$1,021,580	$171,016
Total	$7,250,066	$936,667

The 1982 Federal HCAS analyzed pavement distresses on a relatively small number of hypothetical pavement sections. The hypothetical pavements have been abandoned for this study and replaced by actual pavement sections from the HPMS database. The HPMS database is a statistically valid sample of over 100,000 pavement sections representing all non-local pavements nationwide. It is used in evaluating highway investment/performance relationships for the Department's biennial C&P Report as well as other policy analyses.

While the HPMS database contains section properties, traffic volumes, percent trucks and other data related to pavement performance, considerable supplemental data needed for the pavement performance models are added for each pavement section. Using the augmented HPMS database in conjunction with the detailed traffic and operating weight data described in Chapter II provides a much more representative analysis of pavement costs associated with travel by different vehicle classes on different highway systems. Estimates of the relative cost responsibility of different vehicle classes for pavement 3R costs on the different highway functional classes are used to allocate load-related components of 3R obligations to the different vehicles. The models also estimate the shares of total costs that are related to factors such as pavement age and climate rather than axle loads. These nonload-related 3R costs are allocated in proportion to VMT for each vehicle class.

Table V-8 shows the percent of flexible and rigid pavement 3R costs estimated to be attributable to non-load factors on each highway functional class. In general the share of costs attributable to non-load factors is about the same for flexible and rigid pavements although there are minor differences across highway functional classes. Non-load costs are a higher proportion of total costs on lower-order systems than on higher-order systems, ranging from less than 10 percent on rural Interstates to more than 20 percent on urban collectors and local roads.

Preliminary engineering, right-of-way, grading and drainage, and other costs related to 3R improvements are allocated separately. With the exception of grading and drainage, those other costs are allocated in proportion to the VMT of each vehicle class. Grading and drainage costs, which represent a smaller share of total 3R costs than new construction costs, are allocated using the same factors as grading and drainage for new construction.

Table V-8. 2000 Proportion of Federal 3R Pavement Costs Attributable to Non-Load Factors			
Functional Highway Class		Flexible Pavements (percent)	Rigid Pavements (percent)
Rural	Interstate	11.0	9.3
	Other Principal Arterials	12.1	15.7
	Minor Arterials	12.2	13.7
	Major Collectors	14.7	14.5
	Minor Collectors	14.7	14.5
	Local	14.7	14.5
Urban	Interstate	10.1	7.9
	Other Freeways/ Expressways	10.6	11.0
	Major Arterials	11.5	12.8
	Minor Arterials	12.7	16.3
	Collectors	13.9	20.5
	Local	13.9	20.5

Reconstruction with added lanes combines elements of both new construction and reconstruction. The FMIS has data on total amounts spent for this improvement type, but amounts for the added lanes cannot be distinguished from amounts for reconstruction of existing lanes from the FMIS data. Each of the work classes under reconstruction with added lanes is allocated using the same allocators as are used for reconstruction projects. If data were available to separate amounts for lane additions from amounts for reconstruction, the portion for new lanes could be allocated in the same way as costs for added lanes, but in the absence of such data all costs are allocated as reconstruction costs. Minor widening is a unique system preservation cost. Minor widening improvements do not add structural capacity and they add only marginally to traffic-carrying capacity. The primary purpose of minor widening projects is to enhance safety through adequate design standards such as: better curve alignments, provision of separation (median) between opposing directional travel, adding or widening shoulders, and similar projects. Since they do not add or restore structural capacity, costs for minor widening cannot be allocated using the same allocators as are used to allocate pavement 3R costs. Nor can they be allocated by PCE-weighted VMT since the improvements typically are not made to increase capacity or reduce congestion. If roadways were widened primarily because of conflicts caused by wide vehicles, there would be some rationale for allocating minor widening costs to the wider vehicles, but that is not believed to be the primary basis for widening decisions. There is no better allocator for minor widening costs than VMT, so VMT is used to allocate all costs related to minor widening.

Table V-9 shows the cost responsibility for pavement 3R costs by broad vehicle class and operating weight range. The cost responsibility per mile of travel is higher than for new pavement improvements, especially for the truck classes. Single unit and combination trucks operating in the heaviest weight ranges have average cost responsibilities greater than 10 cents per mile but that varies widely for specific vehicle classes within those two truck types.

Table V-10 shows variations in the cost responsibility for 3R pavement costs by vehicle classes and operating weight. The same general relationships seen in Table V-5 between weight, the number and types of axles, and cost responsibility are seen in this table. Cost responsibility increases at an increasing rate as the weight of each vehicle class increases. Single axles contribute more to 3R pavement costs than tandem axles and tridem axles contribute less than tandem axles for vehicles with comparable weights.

Table V-9. 2000 Federal Cost Responsibility for 3R Pavement Improvements	
Vehicle Class/Operating Weight	**Cents per Mile**
Autos	0.063
Pickups/Vans	0.075
Buses	1.203
All Passenger Vehicles	0.069
Single Unit Trucks	
<25,001 pounds	0.758
25,001 - 50,000 pounds	3.291
>50,000 pounds	16.368
Total Single Units	1.585
Combination Trucks	
<50,001 pounds	1.023
50,001 - 70,000 pounds	2.811
70,001 - 75,000 pounds	5.312
75,001 - 80,000 pounds	6.969
80,001 - 100,000 pounds	11.716
>100,001 pounds	26.138
Total Combinations	3.644
Total Trucks	2.784
Total All Vehicles	0.271

Table V-10. 2000 Federal Cost Responsibility for Pavement 3R Costs for Selected Vehicle Classes (cents per mile)

Operating Weight (000s)	SU2	SU3	CS5	CS6	DS5	DS8
0-10	0.59					
20	0.73	0.69	0.64	0.62	0.65	
30	1.67	0.86	0.75	0.76	0.73	
40	6.45	1.62	0.89	0.87	0.94	
50	32.89	4.81	1.19	1.10	1.32	1.06
60		12.03	1.86	1.53	1.92	1.24
70		31.70	3.55	2.37	2.90	1.59
80			6.37	3.68	4.68	2.51
90			11.01	6.40	7.55	3.10
100			19.96	10.12	13.55	4.50
110			36.53	17.40		6.84
120				29.24		10.52
130						14.48
140						19.87
150						34.33

NOTE: See Chapter I for vehicle definition.

Figure V-3 shows the overall distribution of pavement 3R cost responsibility among passenger vehicles, single unit trucks, and combination trucks. Whereas Figure V-2 showed passenger vehicles responsible for over half of new pavement costs, those vehicles are responsible for less than one-quarter of pavement 3R costs. The share of cost responsibility for combination trucks, on the other hand, increased from 35 percent for new pavements to 58 percent for pavement 3R improvements.

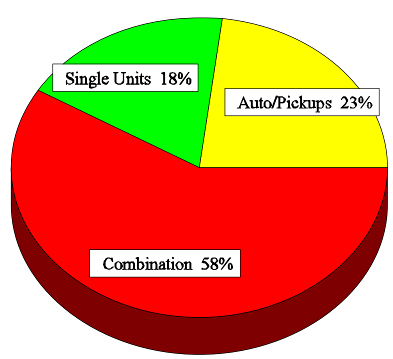

Figure V-3. 2000 Federal 3R Cost Responsibility Distribution by Broad Vehicle Classes

The Appendix describes methods for allocating pavement rehabilitation costs in more detail. These methods represent major improvements over methods used in the 1982 Federal HCAS, but further refinements will be needed as more data from the LTPP program become available and as our understanding of factors affecting various types of pavement distress improve. In particular, additional data from LTPP sites across the country will enable various distress models to be more thoroughly validated.

Bridge Cost Allocation Methods

Table V-11 shows a breakdown of costs for the four bridge cost allocation categories: new bridge, bridge replacement, major bridge rehabilitation, and other bridge. Costs under each bridge category are broken out into four work classes: preliminary engineering, right-of-way, construction, and other. Almost half of all bridge costs are for bridge replacement and another quarter of the costs are for major bridge rehabilitation.

Table V-11. 2000 Allocatable Federal Costs for Bridge Cost Allocation ($,000)

Work Class	New Bridge	Bridge Replacement	Major Bridge Rehab	Minor Bridge Rehab
P.E.	$27,957	$185,784	$94,019	$153,310
Right-of-Way	$5,376	$62,187	$4,942	$2,454
Construction	$734,190	$1,865,855	$1,097,797	$288,466
Other	$175	$2	$1,016	$443
Total	$767,698	$2,113,828	$1,197,774	$444,673

New Bridges

The cost allocation procedure for new bridges substantially improves upon the 1982 Federal HCAS approach. The basic principles, however, are similar to the 1982 Federal HCAS. Bridge design procedures are used to develop the relationships between vehicle size and weight and the cost associated with providing the bridges necessary to safely accommodate the vehicle fleet. The improved approach addresses some of the major shortcomings of the 1982 Federal HCAS, particularly, the simplifying assumptions underlying the approach. The major differences are summarized in Table V-12. The notable improvements are as follows:

Simple and continuously-supported spans are considered separately.

Live load moments are calculated for each vehicle class/weight group, for each functional highway class (based on the mean length of the primary span), and for each bridge support type (simple and continuous). In the 1982 Federal HCAS, the vehicles were aggregated into large groups, all bridges were assumed to be simply supported, all single unit trucks were assumed to be a simple point load, and all combination trucks were assumed to produce a moment that was a simple multiple of single unit trucks.

The FHWA accounting system now identifies four cost categories versus three in the 1982 Federal HCAS, namely: new bridges, bridge replacement, major rehabilitation, and minor rehabilitation.

The number of design/cost increments was increased from 8 to 10. The 1982 Federal HCAS aggregated all vehicles producing moments similar to the HS-15 to HS-20 design vehicles into one group. This was too large an aggregation to permit discriminating among the large number of heavy trucks requiring the last increments of bridge design. The effect was that many medium weight vehicles were assigned responsibility for the highest design increment along with the heaviest trucks. Accordingly, an additional increment was created by dividing the HS-15 to HS-20 increment into an HS-15 to HS-17.5 and HS-17.5 to HS-20 increment. The 10 design increments are shown in Table V-13.

Table V-13. Structures Design Increments

Design Increment	Design Load (pounds)
1. Base facility	N/A
2. Width increment	N/A
3. H-2.5	5,000
4. H-5	10,000
5. H-10	20,000
6. H-15	30,000
7. H-20	40,000
8. HS-15	54,000
9. HS-17.5	63,000
10. HS-20	72,000

...mprovements to Structures Cost Allocation Procedures

			1993 Study	Comments
		Bridges - Repair	4: - New Bridges - Replacement Bridges - Major Rehabilitation - All other	1982: Based on PR-37 1993: FHWA implemented a more detailed system (FMIS) that added the additional bridge cost category.
Number of Design/ Cost Increments (H5, H10, HS15, etc.)		8	10	The addition of a design/cost increment, (HS18), especially at the upper (HS15 to HS20) end, greatly increases the discrimination of cost responsibility among the heavier trucks.
Width of "Narrow" Bridge		10 ft lanes and 4 ft shoulders	11 ft lanes and 5 ft shoulders	For safety and other reasons, the study team concluded that the 10 ft lane width was inadequate for the base facility.
Inter-Increment Allocator		Relative crude approximations using GVW	Live-load moment	This is the most important improvement in the bridge cost allocation process.
The inter-increment allocator (the assignment of vehicle groups to the different design/cost increments were a function of:	Span Length	No	Yes	Span length is the single-most important bridge characteristic in determining live-load moment
	Functional Class		Yes	This is important because bridge span lengths vary significantly for different functional classes.
	Axle Loads	Only when aggregated as GVW	Yes	Axle loads and spacings for all vehicles classes and weight groups were used to rigorously compute live-load moments.
	Axle Spacings	No	Yes	
	Bridge Type	No	Yes	Because of the impact of superstructure type on live-load moments, live-load moments for both simple and continuous bridge types were computed.
Bridge Replacement		National Bridge Inventory (NBI) Sufficiency Rating	Bridge Needs and Investment Process (BNIP)	The BNIP determined which bridges required replacement and the extent to which the replacement was load related.

The bridge allocation procedure generally follows the way in which bridges are designed. In simple terms, bridges are designed so that the bridge can withstand the application of the dead load (the weight of the bridge itself) and the live load of the heaviest truck, plus a safety factor. Except for a fatigue criterion, which rarely governs the final design, the number of applications of the vehicle is irrelevant. The premise of this design procedure is that the heaviest vehicle (actually, the vehicle that produces the greatest stress on any key structural member) governs the size/strength of the bridge. Furthermore, any incremental increase in the size of the heaviest vehicle will require an incremental increase in the size/strength of the bridge.

The procedure relates additional costs necessary to make the bridge incrementally stronger to the set of vehicles that occasion these increased costs. Bridges are grouped by functional highway class. The allocation process works by comparing the live load moment of each vehicle class/weight group on the representative bridge (the representative bridge is described by the mean primary span length) of a specific functional class, with the moment produced by the design vehicles. This comparison allows each vehicle class/weight group to be placed in a specific design increment, based upon whether its live load moment is less than or equal to the moment of the design vehicle associated with specific design increments for each functional class. For example, given identical vehicles on bridges of equal spans, the only distinguishing bridge characteristic data in the NBI that can affect the moment produced by the vehicles is support type.

Two support types, simple and continuously-supported, are considered. The representative vehicle's axle loads and axle spacings are required to determine live load moments accurately; GVWs acting as point loads do not provide a realistic picture of the moments generated under trucks with different axle arrangements and weights.

Secondly, all vehicles in any specific design increment are allocated the costs associated with that increment based on their relative VMT compared to the other vehicles in the design increment. The VMT is considered the most equitable factor upon which to allocate incremental bridge design costs among vehicles in each increment.

Bridge Replacement

The allocation of bridge replacement costs uses the incremental methodology described above. The percentage of replacement costs assigned to the design increments is estimated using the BNIP, the same model that is used in estimating bridge investment requirements for the Department's C&P Report. The program determines, using several bridge sufficiency ratings in the NBI, how many bridges on each functional highway class must be replaced because they are structurally inadequate, functionally deficient, or functionally adequate but with so many deficiencies that the bridge must be replaced anyway. The percentage of bridges inadequate for each of these reasons is applied to total construction costs for bridge replacements and these amounts are further sub-divided into load related and non-load related costs. The rationale to assign some construction costs to the base increment is that all vehicles occasion costs to remedy non-load related bridge inadequacies. In other words, when the bridge is replaced, walkways, smoother deck surfaces, new and better signing, the value of the useful life remaining in the old bridge, etc. are all part of the new bridge. Load-related costs are allocated to the vehicles that occasion the bridge replacement. In the case of the structurally deficient bridges, the largest cost category, load-related costs are allocated to all vehicles producing live load moments greater than that for the H-15 design vehicle. All vehicles share in the cost responsibility of other costs, with appropriate portions being load related and the remainder non-load related.

Major Bridge Rehabilitation

The process for allocating major rehabilitation costs is similar to replacement costs but more complex because 13 types of rehabilitation are considered. These are rehabilitation of bridge deck, superstructure, or substructure, or some combination of the three. As for bridge replacement, a certain percent of the costs is assigned to various categories and others are calculated on the basis of the number of bridges the BNIP identified as having deficiencies. As for the new bridge costs, all other cost sub-groups are allocated by VMT.

Other Bridge Improvements

Minor bridge rehabilitation and repairs generally are not related to vehicle characteristics. All costs are assigned to the base increment using VMT as the allocator.

Table V-14 summarizes bridge cost allocations to major vehicle categories by improvement type. Two-thirds of all bridge costs are allocated to passenger vehicles, 12 percent to single unit trucks, and 20 percent to combination trucks. These percentages vary by type of improvement. Combination trucks are allocated almost 30 percent of bridge replacement costs and single units 20 percent of replacement costs, whereas those vehicle account for only 5 percent and 3 percent respectively of minor bridge rehabilitation costs.

Table V-15 shows the overall bridge cost responsibility of

Table V-15. 2000 Federal Cost Responsibility for All Bridge Costs (cents per mile)

Operating Weight (000s of lbs)	SU2	SU3	CS5	CS6	DS5	DS8
0-10	0.1					
20	0.2	0.2	0.2	0.2	0.2	
30	0.2	0.2	0.2	0.2	0.2	0.2
40	0.7	0.6	0.2	0.2	0.3	0.2
50	2.4	1.7	0.3	0.3	0.3	0.2
60	4.5	4.3	0.4	0.3	0.3	0.3
70		19.1	0.6	0.6	0.4	0.3
80		23.9	1.2	0.9	0.7	0.4
90			2.1	2.4	1.4	0.8
100			4.4	5.5	2.3	1.3
110			12.1	13.1		1.8
120				21.9		3.1
130						7.7
140						8.1
150						16.5

NOTE: See Chapter I for vehicle definitions.

Tabl[illegible]ass and I[illegible]provement Type ($,000)

Vehicle Clas[illegible] Operating Weight	[illegible] Bridge	[illegible] Replacement	[illegible] Rehabilitation	Mi[illegible]r Bridge Rehabilitation	Total	Percent of Total
Passenger Vehicles						
Autos	$437,279	$759,985	$730,716	$298,302	$2,226,281	50.3
Pickups/Vans	$151,944	$299,518	$245,592	$108,104	$805,159	18.2
Buses	$4,002	$9,834	$5,378	$1,177	$20,391	0.5
Total	$593,225	$1,069,337	$981,686	$407,583	$3,051,831	69.0
Single Unit Trucks						
<25,001 pounds	$24,434	$3,238	$2,430	$998	$31,101	0.7
25,001 - 50,000 pounds	$8,926	$32,439	$8,601	$8,461	$58,428	1.3
>50,000 pounds	$14,111	$302,050	$11,629	$9,659	$337,448	7.6
Total	$47,472	$337,726	$22,660	$19,117	$426,977	9.7
Combination Trucks						
<50,001 pounds	$33,587	$44,294	$45,345	$2,650	$125,875	2.8
50,001 - 70,000 pounds	$28,683	$80,608	$35,837	$1,123	$146,251	3.3
70,001 - 75,000 pounds	$12,249	$58,551	$15,007	$386	$86,194	2.0
75,001 - 80,000 pounds	$12,646	$95,060	$14,457	$328	$122,491	2.8
80,001 - 100,000 pounds	$33,275	$297,498	$31,176	$618	$362,566	8.2
>100,001 pounds	$6,561	$90,434	$5,722	$112	$102,829	2.3
Total	$127,001	$666,445	$147,545	$5,216	$946,207	21.4
Total Trucks	$174,472	$1,044,171	$170,205	$24,333	$1,373,184	31.0
All Vehicles	$767,698	$2,073,509	$1,151,891	$431,917	$4,425,015	100.0

Table V-16. 2000 Federal Distribution of System Enhancements Costs ($,000)			
Work Class	**Safety/TSM**	**Environmental**	**Other**
P.E.	$406,015	$100,597	$257,188
Right-of-Way	$124,532	$30,852	$64,172
Construction	$1,996,929	$335,819	$181,581
Other	$14,167	$62,504	$609,886

illustrative vehicles at different weights. Costs are shown on a cents per mile basis since most other costs in this study are summarized in cents per mile, but as noted above, bridge costs, except for fatigue, do not vary directly with VMT. The incremental nature of the cost assignment process is one reason why costs per mile are so high for certain very heavy vehicles in each class. Cost of providing the last increments of bridge strength are assigned only to vehicles that produce the greatest moments, and those vehicles typically account for a relatively small amount of total travel and thus their cost responsibility per mile is high.

System Enhancements

Table V-16 shows the distribution of costs for safety/TSM, environmental, and other improvements classified as system enhancements in this study. Uniquely occasioned costs including ridesharing/HOV projects, transit projects funded from Federal-aid highway funds, and truck-related projects have been removed and are allocated separately as discussed below. Approximately two-thirds of obligations in the safety/TSM improvement type are primarily for traffic operations and other TSM improvements, and one-third are primarily for safety. The distinction between these two general types of improvements is blurred, however, since traffic operations improvements often improve safety and safety improvements may enhance traffic operations. Traffic operations/TSM projects are undertaken primarily to improve highway level of service, reduce congestion, and otherwise improve highway system efficiency. Therefore, construction costs are allocated on the basis of PCE-weighted VMT to reflect the contribution of different vehicle classes to congestion and diminished level of service.

Construction costs for safety improvements also are allocated using PCE-weighted VMT. While the relationship between PCEs, level of service, and safety improvements is not as clear as for TSM improvements, large trucks contribute more to the need for certain safety improvements than do automobiles and light trucks, and some additional safety improvement costs may be incurred to accommodate the operational characteristics of heavy trucks. Other costs within this general category are allocated on the basis of VMT since for the most part they are not related to characteristics of the different vehicle classes. Table V-17 shows the allocation of safety/TSM costs among broad vehicle classes and weight groups in both absolute amounts and cents per mile.

Environmental enhancement costs are allocated on the basis of VMT except for noise-related costs which are allocated among different vehicle classes on the basis of each vehicle classes' contribution to overall noise levels by highway functional class. Methods for estimating each vehicle's contribution to noise levels are described in Appendix E.

Other enhancement costs represent a variety of improvement types that generally are unrelated to characteristics of the different vehicles using the highway and thus are allocated using VMT. These costs include highway beautification; preservation of historic buildings, transportation facilities, and other important features; archeological preservation and salvage; scenic highway programs; wetland mitigation and enhancement; protection of endangered species; hazardous waste remediation; environmental education; tourist information; and vehicle emission inspection and maintenance.

Uniquely Occasioned Costs

Three separate types of uniquely occasioned costs are defined based on data available from FMIS—ridesharing and HOV costs; transit costs paid from Federal-aid highway funds; and truck-related costs. Ridesharing programs, HOV lanes, and transit improvements focus on reducing congestion, environmental, and other costs occasioned primarily by operations of single-occupant vehicle (SOV) commuters in dense metropolitan areas. For this reason, the costs of these improvements have been allocated to automobiles, pickups, and vans in proportion to their travel on higher-order urban highways. Certainly all vehicles benefit to some degree from congestion relief in corridors where HOV and transit services are improved, whether or not they can directly use the facilities themselves. However, the cost occasioned approach is not based on benefits derived from improvements that are made, but on the contribution of each vehicle class to the need for the improvements. Since the primary purpose of HOV, ridesharing, and congestion-related transit improvements is to improve transportation capacity through alternatives to SOVs, and to reduce their adverse impacts of excessive travel by SOVs, costs for those improvements should be allocated to SOVs.

Table V-17. 2000 Federal Cost Responsibility for Safety and TSM Improvements

Vehicle Class/Operating Weight	Costs ($,000)	Cents per Mile
Autos	$1,601,613	0.09
Pickups/Vans	$549,714	0.09
Buses	$10,708	0.15
All Passenger Vehicles	$2,162,035	0.09
Single Unit Trucks		
#25,000 pounds	$96,385	0.14
25,001 - 50,000 pounds	$24,219	0.21
>50,000 pounds	$6,633	0.27
Total Single Units	$127,238	0.15
Combination Trucks		
#50,000 pounds	$105,013	0.19
50,001 - 70,000 pounds	$65,528	0.23
70,001 - 75,000 pounds	$23,699	0.24
75,001 - 80,000 pounds	$21,775	0.25
80,001 - 100,000 pounds	$32,386	0.28
>100,001 pounds	$3,970	0.29
Total Combinations	$252,370	0.22
Total Trucks	$379,608	0.19
Total All Vehicles	$2,541,643	0.10

An alternative to allocating costs for HOV, ridesharing, and transit improvements just to automobiles, pickups, and vans would be to allocate costs to all vehicle classes in proportion to their PCE-weighted VMT. As noted above, that allocator is used for capacity enhancements related both to adding new lanes and to TSM projects. The difference between those types of improvements and HOV, ridesharing, and transit improvements is as follows: while new lanes and TSM meet general needs for new capacity and consider travel demand by all vehicle classes, HOV, ridesharing, and capacity-related transit provide relief for the effects of congestion caused primarily by SOV commuters in dense corridors. While all traffic in these corridors can be said to derive some benefit from the corridor-level efficiencies created by transit improvements, it is the SOV commuters who give rise to the need for additional capacity. Therefore, these users are responsible for the costs occasioned in providing this capacity—in this case, in the form of transit and HOV improvements.

Uniquely occasioned truck-related costs include costs of the commercial vehicle information systems project; motor carrier safety assistance program development and enforcement; commercial drivers license development and enforcement; truck scales; and truck loading, terminal, and transfer facilities. Obligations in each of these areas are focused uniquely on projects to make trucking operations safer, more efficient, and more friendly to the highway infrastructure. Costs are allocated to the various truck classes in proportion to their VMT.

Other Highway Trust Fund Obligations

Obligations discussed above are incurred as part of the Federal-aid highway program with funds being expended in the first instance by State or local highway agencies. There are some obligations of HTF monies that do not go through the Federal-aid highway program including highway improvements on Federal lands, contributions to the NHTSA Section 402 Program, and FHWA administrative expenses. These costs are not included in FMIS and must be estimated from other FHWA accounting information. Federal lands projects are primarily on lower-order rural highways and are allocated among vehicle classes in the same proportions as all other Federal obligations on lower-order rural highways. The FHWA administrative expenses are an overhead expense and are allocated among vehicle classes in the same proportion as all other Federal obligations.

Mass Transit Account

Obligations of funds from the MTA of the HTF are allocated in the same way that obligations for ridesharing, HOV lanes, and transit expenses from the HTF other than the MTA. Like these other cost categories, obligations from the MTA are focused on facilities and services for passengers, especially along high-density corridors handling large volumes of commuter traffic. The transit projects are focused on reducing congestion and other costs associated with the large volumes of SOV traffic. Heavy trucks may benefit from these improvements but, when possible, they try to avoid commuter routes during peak periods and are not the principal contributors to the need for the transit improvements. Thus, costs are allocated to automobiles, pickups, and vans in proportion to their travel on higher-order urban highways.

Summary of Federal Agency Cost Allocation

Table V-18 and Figure V-4 summarize the allocation of Federal program costs among different broad vehicle classes. Passenger vehicles are responsible for all costs from the MTA, 90 percent of system enhancement costs, 50 percent of new capacity costs, 40 percent of system preservation costs, and 70 percent of other costs. The overall Federal cost responsibility of automobiles, pickups, and vans is approximately two-thirds cent per mile of travel while the average overall cost responsibility of buses is about 2.5 cents per mile.

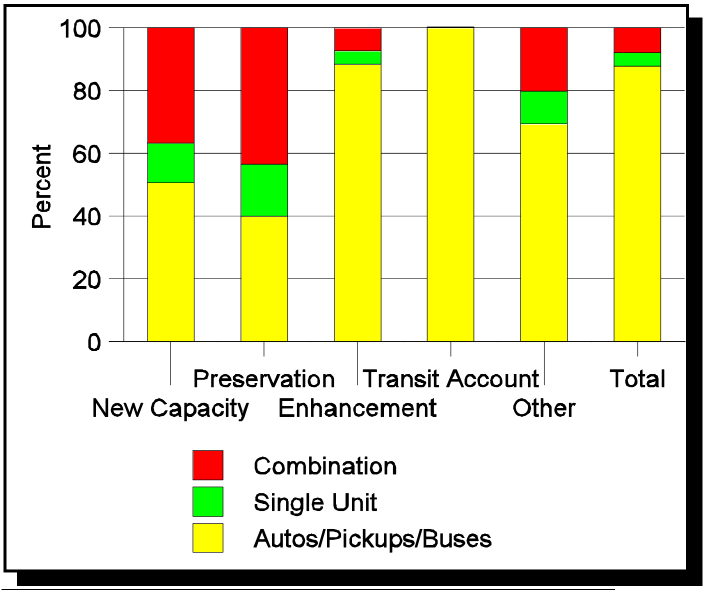

Figure V-4. 2000 Distribution of Federal Highway Programs by Broad

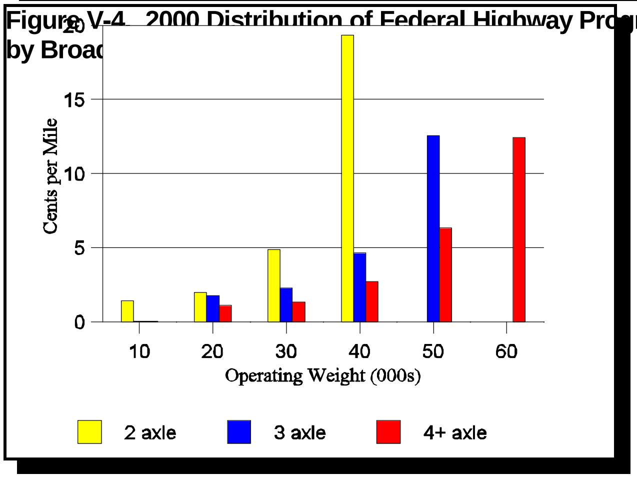

Figure V-5. 2000 Distribution of Federal Costs by Operating Weight for Single Unit Trucks (cents/mile)

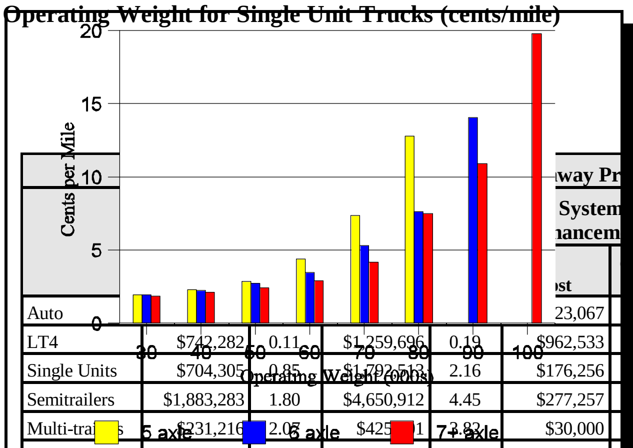

Figure V-6. 2000 Distribution of Federal Costs by Operating Weight for Single Trailer Combinations (cents per mile)

Single unit trucks are responsible for about 11 percent of total highway costs, ranging from about 16 percent of system preservation costs to no responsibility for costs from the MTA. Their overall cost responsibility is 3.7 cents per mile.

Combination trucks are responsible for 30 percent of total Federal highway cost responsibility. They are responsible for more than 40 percent of system preservation costs and almost 40 percent of new capacity costs. Single trailer combinations, on average, have slightly higher cost responsibilities per mile than multi-trailer combinations. On average, per mile costs of both single and multi-trailer combinations are almost double those of single unit trucks and about 10 times the costs per mile for passenger vehicles. Buses account for a very small share of overall highway cost responsibility because of their low annual travel. Average per mile costs of bus travel are approximately 2.7 cents per mile. Within these broad vehicle classes, there are large differences in the relative cost responsibility of different vehicle configurations. Figures V-5 to V-7 show cost responsibilities per mile for different vehicle configurations at different operating weights. Within single unit, single trailer, and multi-trailer truck categories, vehicles with more axles generally have lower costs per

[illegible]way Program Costs Among Broad Vehicle Classes ($,000)

	[illegible]		[illegible]		System Enhancements		MTA		Other		Total	
	Cost	Cents/ mile	Cost	Cents/ mile	Cost	Cents/ mile	Cost	Cents/ mile	Cost	Cents/ mile	Cost	Cents/ mile
Auto	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]23,067	[illegible].15	$2,590,675	0.14	$1,235,907	0.07	$11,898,997	0.65
LT4	$742,282	0.11	$1,259,696	0.19	$962,533	[illegible].14	$789,325	0.12	$444,073	0.07	$4,197,910	0.63
Single Units	$704,305	0.85	$1,792,513	2.16	$176,256	[illegible].21	$0	0.00	$237,022	0.29	$2,910,099	3.50
Semitrailers	$1,883,283	1.80	$4,650,912	4.45	$277,257	[illegible].27	$0	0.00	$437,656	0.42	$7,249,115	6.93
Multi-trailers	$231,216	2.07	[illegible]	3.82	$30,000	[illegible].27	$0	0.00	$42,057	0.38	$729,080	6.54
Buses	$57,358	0.78	$106,739	1.44	$15,127	[illegible].20	$0	0.00	$10,592	0.14	$189,819	2.57
Total	$5,713,358	0.21	$11,490,093	0.43	$4,184,242	0.16	$3,380,000	0.13	$2,407,307	0.09	$27,175,001	1.00

mile than vehicles with fewer axles. At light weights, differences in costs per mile are relatively small, but at weights where axle loads for particular configurations exceed Federal limits (20,000 pounds on single axles and 34,000 pounds on tandem axles), cost responsibilities per mile increase rapidly.

Registered Weight Federal Cost Responsibilities

Cost responsibilities discussed above reflect costs occasioned by different vehicle classes at various operating weights. Analyzing cost responsibilities over a range of operating weights provides a clear picture of relationships between axle loads, GVW, and highway cost responsibility. Evaluating cost responsibility on an operating weight basis is inappropriate, however, for analyzing user fee equity because vehicles do not always travel at the same weight. Over the course of a year, part of a vehicle's travel typically is empty and, even when loaded, most vehicles do not always operate at the same weight. Cost responsibilities for travel at all weights must be used when comparing costs to user fees paid during the year.

Each vehicle class has a unique average operating weight distribution, and in fact separate operating weight distributions are estimated for different functional highway classes — rural Interstates, all other rural highways, urban Interstates, and all all other urban highways — and for different registered weights for each vehicle. Cost responsibilities for vehicles registered at different weights are used in the equity analysis and the primary basis for evaluating the rate structure of the HVUT which is based on registered weights.

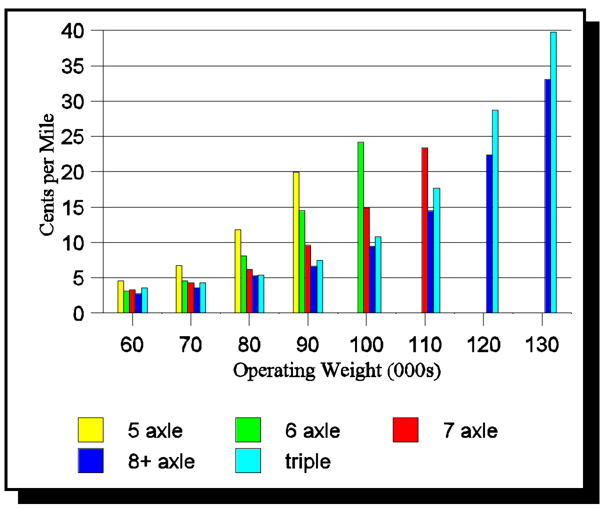

Figure V-7. 2000 Distribution of Federal Costs by Operating Weight for Multi-Trailer Combinations (cents per mile)

Table V-19 compares overall Federal highway cost responsibility for selected vehicles on an operating weight and a registered weight basis. Cost responsibilities in the heavier weight categories for any vehicle class are lower when estimated on a registered weight basis because a large portion of travel for vehicles registered at high weights typically is at weights below the registered weight. This reduces the average cost responsibility per mile compared to costs per mile calculated just for operations at the higher weight.

Table V-19. 2000 Comparison of Federal Cost Responsibility on Registered Weight and Operating Weight Basis

Vehicle Class/ Registered Weight	Cost Responsibility (cents per mile)	
	Registered Weight Basis	Operating Weight Basis
Autos	0.65	0.65
Pickups and Vans	0.65	0.65
Buses	2.57	2.57
All Passenger Vehicles	0.66	0.66
Single Unit Trucks		
<25,000 pounds	1.75	1.81
25,001 - 50,000 pounds	4.38	6.26
>50,000 pounds	14.60	37.25
All Single Unit Trucks	3.51	3.51
Combination Trucks		
<50,000 pounds	2.78	2.42
50,001 - 70,000 pounds	4.25	5.50
70,001 - 75,000 pounds	6.25	9.50
75,001 - 80,000 pounds	7.08	12.36
80,001 - 100,000 pounds	12.50	20.57
>100,001 pounds	16.60	48.96
All Combinations	6.90	6.90
All Levels of Government Cost Allocation	5.48	5.48

Table V-20 shows the overall Federal cost responsibility of selected vehicles classes on a registered weight basis. The cost responsibilities per mile are not as high as cost responsibilities on an operating weight basis because, as noted above, much of the travel of vehicles registered at the upper weight intervals for each vehicle class are at lower weights where costs are not as high.

All Levels of Government Cost Allocation

All levels of government cost responsibility by vehicle class is illustrated in Table V-21. States are allocated about half of the total costs of $125 billion in 2000. Federal and local governments have an equal share of about 25 percent of the total costs. By vehicle class, automobiles have been allocated about half of total costs ($64 billion out of $125 billion) in 2000. As for the freight trucks, combination trucks, registered weighting between 75 to 80,000 pounds have been allocated about 15 percent of total costs ($18 billion out of $125 billion) in 2000.

Allocation of External and Other Social Costs of Highway Use

Table V-20. 2000 Federal Cost Responsibility on a Registered Weight Basis for Selected Vehicles (cents per mile)				
Registered Weight (000s of pounds)	Vehicle Class (cents per mile)			
	SU3	CS5	DS5	DS8
0-10				
20	1.7			
30	1.9			
40	2.8			
50	5.1	2.8		
60	13.2	3.7	3.7	
70	25.8	5.7	4.7	
80	32.5	7.2	5.8	5.6
90		12.9	6.4	7.1
100		14.2		8.3
110		15.4		9.7
120				12.3
130				14.1
140				17.2
150				20.0

NOTE: See Chapter I for vehicle definitions.

In Chapter III methods for estimating highway-related costs of air pollution, noise, congestion, crashes, and greenhouse gases were discussed. In this section those costs are allocated among different vehicle classes on the basis of characteristics of each vehicle class that contribute to the costs. References in this section can be found in Appendix E.

Noise

Table V-22 shows estimates of high, middle, and low estimates of noise costs developed for this study, in cents per vehile mile. Noise emissions and noise levels at specified distances from the roadway were developed using FHWA noise models. Cost are estimated as the loss in residential property value associated with exposure to various noise levels. Costs in rural areas are much lower than in urban areas for all vehicle classes because many fewer properties are exposed to sufficiently high noise levels to affect their values. It is important to note that these adverse effects of noise on property values often are more than offset by increases in property values associated with improved accessibility afforded by highway improvements and that noise impacts on property values will vary from location to location depending on a number of factors unrelated to highway noise.

Table V-22 shows the contribution of different vehicle classes to noise costs, expressed in cents per VMT. Combination vehicles have the highest noise costs per mile of travel followed closely by single units trucks and buses. Automobiles, pickups, and vans have low noise-related costs per mile, but because they account for the majority of travel by all vehicle classes, their contribution to total noise costs is substantial.

Table V-21. 2000 Federal Cost Responsibility for All Levels of Government by Vehicle Class				
Vehicle Class/Registered Weight	Cost Responsibility ($ Millions)			
	Federal	State	Local	Total
Autos	12,405	35,988	15,791	64,184
Pickups and Vans	4,770	13,678	6,328	24,777
Buses	221	383	268	871
All Passenger Vehicles	17,396	50,049	22,387	89,832
Single Unit Trucks				
#25,000 pounds	1,074	1,755	886	3,715
25,001 - 50,000 pounds	981	1,867	1,349	4,197
$50,000 pounds	1,098	1,929	1,212	4,239
All Single Unit Trucks	3,153	5,551	3,447	12,151
Combination Trucks				
#50,000 pounds	222	325	149	696
50,001 - 70,000 pounds	528	722	306	1,555
70,001 - 75,000 pounds	408	517	178	1,103
75,001 - 80,000 pounds	6,329	8,353	2,950	17,632
$80,000 pounds	778	1,125	450	2,353

Table V-22. 2000 Marginal External Costs for Noise (cents per mile)

	Rural Highways			Urban Highways			All Highways		
	High	Middle	Low	High	Middle	Low	High	Middle	Low
Automobiles	0.03	0.01	0.00	0.30	0.11	0.03	0.20	0.06	0.02
Pickups and Vans	0.03	0.01	0.00	0.27	0.10	0.03	0.17	0.06	0.02
Buses	0.35	0.13	0.04	4.55	1.72	0.48	2.79	1.06	0.30
Single Unit Trucks	0.27	0.10	0.03	3.14	1.19	0.33	1.85	0.70	0.20
Combination Trucks	0.68	0.26	0.07	9.86	3.73	1.05	4.24	1.61	0.45
All Vehicles	0.08	0.03	0.01	0.64	0.24	0.07	0.42	0.16	0.05

Figure V-8 shows estimated 2000 noise costs by vehicle class — combination trucks account for 37 percent of total noise costs; while autos, pickups, and vans, 37 percent; and single unit trucks account for most of the remaining noise costs. It is important to note that these cost estimates are high because they do not account for the many miles of noise barriers that have been constructed to protect properties. It should also be noted that while costs are expressed on a cents per mile basis, the impact on property values is not a cumulative cost as are other environmental costs. The greatest impacts would be on property owners at the time a new highway was constructed or a new lane was added that significantly increased traffic volumes and noise levels. Once the property has been sold, the noise impact will largely have been internalized in either a lower selling price for the property or a longer time before the property could be sold to persons who because of their lifestyle or other factors are not as sensitive to highway noise as most persons.

Congestion

In analyzing congestion costs, added delays to highway users associated with changes in traffic levels are estimated. The analysis includes both recurring congestion and the added delays due to incidents such as crashes and disabled vehicles. Effects of incidents are estimated using data on the frequency of incidents, their duration, and their impacts on highway capacity for different types of facilities.

The distinction between marginal and average costs is extremely important in considering congestion costs on a per vehicle mile (or per PCE mile) basis. Average congestion costs on a section of highway are calculated as the total congestion costs experienced by all vehicles divided by total vehicle miles. Marginal congestion costs are calculated as the increase in congestion costs resulting from a unit increase in vehicle miles. Because of the nature of the relationship between traffic levels and speed — at low traffic levels, an additional vehicle mile has

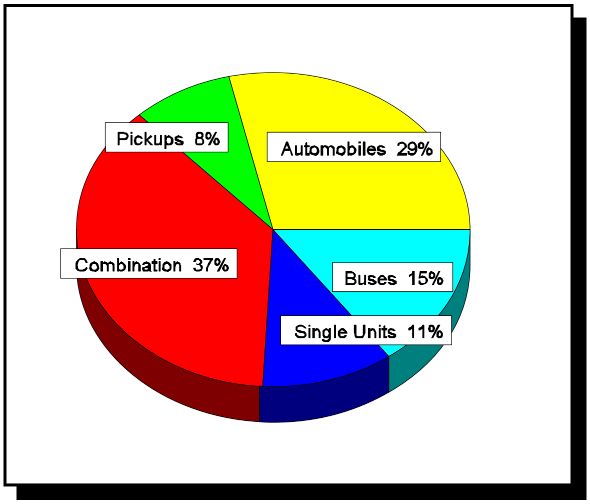

Figure V-8. 2000 Distribution of Noise Costs (Middle Estimate) by Broad Vehicle Classes

little or no effect on the speeds of other vehicles —marginal congestion cost are higher than average congestion costs.

Table V-23 shows high, middle, and low estimates of marginal external congestion costs in cents per vehicle mile. These costs represent added delays to other motorists associated with an additional trip. The costs are external to the trip maker since they are over and above the trip-maker's travel time costs, but they are not external to highway users as a group. Costs are estimated over a range of traffic volumes and vehicle mixes, and include both peak period and non-peak period conditions. The results presented are weighted averages, based on estimated percentages of peak and off-peak travel for different vehicle classes.

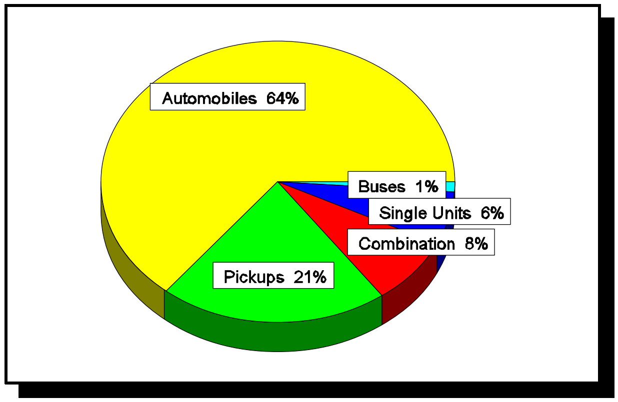

Figure V-9. 2000 Distribution of Congestion Costs (Middle Estimate) by Broad Vehicle Classes

Table V-23. 2000 Marginal External Costs for Congestion (cents per mile)

	Rural Highways			Urban Highways			All Highways		
	High	**Middle**	**Low**	**High**	**Middle**	**Low**	**High**	**Middle**	**Low**
Automobiles	3.76	1.28	0.34	18.27	6.21	1.64	13.17	4.48	1.19
Pickups and Vans	3.80	1.29	0.34	17.78	6.04	1.60	11.75	4.00	1.06
Buses	6.96	2.37	0.63	37.59	12.78	3.38	24.79	8.43	2.23
Single Unit Trucks	7.43	2.53	0.67	42.65	14.50	3.84	26.81	9.11	2.41
Combination Trucks	10.87	3.70	0.98	49.34	16.78	4.44	25.81	8.78	2.32
All Vehicles	4.40	1.50	0.40	19.72	6.71	1.78	13.81	4.70	1.24

Overall congestion costs per mile for trucks are approximately twice as high as costs for automobiles. On average, congestion costs per mile are about five times greater in urban areas than in rural areas, but this can vary considerably depending on traffic volumes on particular highways. In urban areas truck costs are approximately 2.7 times those of automobiles while in rural areas their costs per mile are about 2.9 times those of automobiles reflecting the generally higher PCEs in rural areas. Overall, single unit trucks have a slightly higher congestion cost per mile than combinations even though combinations have higher per mile costs in both rural and urban areas. The reason is that a greater share of single unit truck travel is in urban areas where costs per mile are higher.

Figure V-9 shows estimated 2000 congestion costs by vehicle class. Automobiles, pickups, and vans account for about 85 percent of congestion costs. The effect of trucks on traffic flow is partially offset by their relatively low volumes of travel during peak periods when congestion is greatest.

Crash Costs

The marginal cost for highway crashes is the increase in crash costs resulting from a unit increase in highway travel, commonly expressed in cents per added vehicle mile. Marginal costs for highway crashes include costs paid by those undertaking the additional travel as well as costs they cause to other drivers and non-drivers. In studies of highway user taxation, the focus is on costs to other drivers and non-drivers, since drivers deciding whether or not to increase (or decrease) the amount of travel they undertake are presumed to take the added crash costs to themselves into account. Crash costs to other drivers and non-drivers of a unit increase in highway travel are referred to as marginal external crash costs.

Marginal external crash costs were estimated as the sum of two components:

- Crash costs that are not paid by drivers, individually or collectively, e.g., uncompensated costs to pedestrians struck by motor vehicles, costs of emergency medical response to highway crashes not covered by those injured, etc.

- Costs (or cost savings) associated with possible variations in crash rates with traffic levels. Higher traffic volumes might increase crash rates by increasing the number of multi-vehicle crashes. However, it is also possible that higher traffic volumes might reduce rates for some types of crashes by lowering average speeds and increasing driver awareness.

Table V-24. 2000 Marginal External Costs for Crashes (cents per mile)

	Rural Highways			Urban Highways			All Highways		
	High	Middle	Low	High	Middle	Low	High	Middle	Low
Automobiles	9.68	3.15	1.76	4.03	1.28	0.78	6.02	1.94	1.13
Pickups and Vans	10.21	3.31	1.75	4.05	1.27	0.74	6.70	2.15	1.17
Buses	14.15	4.40	2.36	6.25	1.89	1.08	9.55	2.94	1.62
Single Unit Trucks	5.97	2.00	0.97	2.21	0.71	0.40	3.90	1.29	0.65
Combination Trucks	6.90	2.20	1.02	3.67	1.16	0.56	5.65	1.79	0.84
All Vehicles	9.52	3.09	1.68	3.98	1.26	0.76	6.12	1.97	1.11

Table V-24 shows high, middle, and low estimates of external crash costs for different vehicle classes in cents per vehicle mile. Appendix E contains a detailed explanation of how these crash costs were estimated.

It should be noted that marginal external costs for crashes are much lower than average costs for crashes, since the latter includes costs to both highway users and non-users. For all highways and vehicles, the middle estimates of average crash costs are 18 cents per vehicle mile on rural highways, 9 cents per vehicle mile on urban highways, and 13 cents per vehicle mile on all highways, as compared to the external cost (as shown in Table V-24) of 3.09 cents per vehicle mile on rural highways, 1.26 cents/mile on urban highways, and 1.97 cents/mile on all highways.

Of the five vehicle classes shown, buses have the highest crash costs per vehicle mile. However, buses have much higher occupancy rates than other classes such that they would be lower than the other classes on a per passenger mile basis.

Responsibility for Social Costs

Table V-25 summarizes total 2000 costs of noise, congestion, and crashes allocated to major vehicle groups. These costs include congestion and crash costs borne by highway users and costs that users do not bear but impose on others. Total costs in 1994 dollars are approximately $406 billion of which 69 percent is crash costs borne by highway users and another 14 percent is congestion costs borne by users. Only 12 percent of these social costs are costs that highway users impose on society and do not bear themselves. Air pollution and global warming costs which are borne by non-users are not included in this total. Air pollution costs along with revised total costs will be estimated in an addendum to this report. Regardless of who bears the costs, their magnitude suggests that further steps to mitigate safety, congestion, environmental, and other adverse impacts of highway use should be explored.

In allocating total congestion costs among vehicle classes, the product of marginal congestion costs and VMT was used to distribute costs. Congestion, however, is a highly non-linear phenomenon, and

Table V-25. 2000 Responsibility for Social Costs of Highway Use (mid-range estimates, $ Millions)

	Costs Incident on Non-Users				Costs Incident on Other Highway Users			
Vehicle Class	Air Pollution	Noise	Crash Cost to Non-Users	Subtotal	Congestion	Crash Cost to Users	Subtotal	Total
Automobiles	TBD	$1,396	$30,349	$31,745	$39,717	$201,446	$241,163	$272,908
Pickup and Vans	TBD	$420	$12,155	$12,575	$13,060	$77,195	$90,255	$102,830
Buses	TBD	$77	$197	$274	$304	$1,263	$1,567	$1,841
Single Unit Trucks	TBD	$582	$805	$1,387	$3,698	$4,789	$8,467	$9,854
Combination Trucks	TBD	$1,859	$1,741	$3,600	$4,961	$9,968	$14,949	$18,549
Total	TBD	$4,336	$45,247	$49,583	$61,761	$294,640	$356,400	$405,983

NOTE: TBD - To be determined. Air pollution and global warming costs are not included. Air pollution costs along with revised total costs will be shown in an addendum to this report.

marginal congestion costs for each vehicle class shown in Table V-25 are substantially greater than average cost responsibility per vehicle mile which would be calculated by dividing congestion costs in Table V-25 by VMT for each vehicle class.

Table V-26 shows marginal costs of pavement deterioration, congestion, crashes, and noise associated with operations of several illustrative vehicles on typical rural and urban Interstate highways. Marginal pavement costs are included in this table because in estimating efficient user fee levels at which vehicles cover marginal costs of their travel, pavement deterioration costs must also be considered. Most other infrastructure costs paid by highway agencies do not vary directly with the amount of travel and thus are not truly marginal costs of highway travel. This table illustrates the range over which marginal costs of highway use can vary depending on the type of vehicle and where it travels. Marginal costs for autos operating on rural Interstate highways are about 1.8 cents per mile (excluding air pollution and global warming costs) compared to about 9 cents per mile for operations in urban areas where their contribution to each of the various elements of marginal cost is greater on a per mile basis. Of the illustrative vehicles shown in Table V-26, the 80,000 pound 5-axle tractor-semitrailer operating on urban Interstate highways has the highest marginal cost per mile — 65 cents per mile excluding air pollution and global warming costs — over half of which is related to pavement costs. Even though pavements typically may be designed

Table V-26. 2000 Marginal Pavement, Congestion, Crash and Noise Costs for Illustrative Vehicles Under Specific Conditions						
Vehicle Class/Highway Class	Marginal Costs (cents per mile)					
	Pavement	Congestion	Crash	Air Pollution	Noise	Total
Autos/Rural Interstate	0	0.78	0.98	TBD	0.01	1.77
Autos/Urban Interstate	0.1	7.70	1.19	TBD	0.09	9.08
40 kip 4-axle S.U. Truck/Rural Interstate	1.0	2.45	0.47	TBD	0.09	4.01
40 kip 4-axle S.U. Truck/Urban Interstate	3.1	24.48	0.86	TBD	1.50	29.94
60 kip 4-axle S.U. Truck/Rural Interstate	5.6	3.27	0.47	TBD	0.11	9.45
60 kip 4-axle S.U. Truck/Urban Interstate	18.1	32.64	0.86	TBD	1.68	53.28
60 kip 5-axle Comb/Rural Interstate	3.3	1.88	0.88	TBD	0.17	6.23
60 kip 5-axle Comb/Urban Interstate	10.5	18.39	1.15	TBD	2.75	32.79
80 kip 5-axle Comb/Rural Interstate	12.7	2.23	0.88	TBD	0.19	16.00
80 kip 5-axle Comb/Urban Interstate	40.9	20.06	1.15	TBD	3.04	65.15

NOTE: (1) S.U. = Single Unit, Comb. = Combination; (2) Costs reflect middle range.
(3) TBD - To be determined. Air pollution costs will be estimated in an addendum to this report.
(4) Total excludes air pollution and global warming costs that will be estimated in an addendum to this report.

to higher standards in urban areas, the additional cost of resurfacing and rehabilitation in urban areas accounts for the higher pavement costs in urban than in rural areas. It must be emphasized that these costs vary from location to location and are subject to considerable uncertainty as was discussed above.

Table V-27 illustrates the degree to which just one element of marginal cost — congestion costs — can vary on the same highway class. This table shows congestion costs on low volume (24,000 vehicles per day) and high volume (88,000 vehicles per day) 4-lane Interstate highways during peak and off-peak periods. Even on low-volume highways costs per mile during peak periods are over three times greater than during off-peak periods. On high volume highways marginal congestion costs are over six times greater during peak than off-peak times.

References

C.B. Breed, C. Older and W.S. Downs, *A Study of Highway Costs and Motor Vehicle Payments in the United States*, Association of American Railroads, Washington, D.C., 1993

FHWA, *The Final Report of the Federal Highway Cost Allocation Study*, FHWA, Washington, D.C., 1982.

Table V-27. Illustrative Marginal Congestion Costs on 4-Lane Urban Interstates (cents per mile)

Vehicle Type/ Operating Weight	Low-Volume		High-Volume	
	Peak	Off-Peak	Peak	Off-Peak
Automobile	0.2	0.1	21.7	3.2
CS5, 60,000 pounds	0.5	0.1	59.6	8.9
CS5, 80,000 pounds	0.5	0.2	65.0	9.7

VI. Equity and Efficiency of Highway User Fees

This chapter evaluates the equity of the current Federal user fee structure and assesses general user fee options that could improve user fee equity. Both vertical equity (equity across different vehicle classes) and horizontal equity (equity among vehicles within the same class) are evaluated. Implications of changes in the distribution of highway program expenditures on user fee equity for different vehicle classes also are evaluated. User fee payments to all levels of government are compared to total agency cost responsibility to evaluate the extent to which different vehicle classes pay their share of total highway costs at all levels of government. Finally this chapter analyzes the efficiency of the Federal user fee structure by comparing user fees to marginal costs associated with the use of highways by different vehicle classes and discusses implications of social costs of highways estimated in the previous chapter for user fee equity.

Comparison of Federal Revenues and Occasioned Costs

Highway user fee payments and the highway cost responsibility of different vehicle classes were evaluated in preceding chapters. In this chapter the equity and efficiency of highway user fees are analyzed by evaluating how well user fees match cost responsibility for various groups of vehicles. As in previous Federal HCASs, a principal focus is on the equity of Federal highway user fees. Equity is measured by comparing user fees paid by vehicles in each class to highway costs attributable to each class. The ratio of revenues to costs is called an "equity ratio." If vehicles in a particular class pay 20 percent of total HURs and are responsible for 18 percent of total highway costs, their "equity ratio" is 1.11 (0.20 divided by 0.18). The closer an equity ratio is to one, the more nearly user fees match cost responsibility. A ratio greater than one means that user fee payments exceed cost responsibility and that a vehicle is overpaying its cost responsibility. A ratio less than one indicates that user fees do not cover the cost responsibility of vehicles in that class and that those vehicles are underpaying their cost responsibility.

Comparing equity ratios across vehicle classes measures the "vertical equity" of the highway user fee structure. Equity ratios among vehicles within the same class can vary considerably, however, and those variations must also be considered in evaluating approaches to improve overall user fee equity. Among the factors that affect horizontal equity are vehicle weight, annual mileage, vehicle price, and other characteristics that affect either user fees paid by different vehicles or their cost responsibility. The most significant of these factors at the Federal level is generally weight, but differences in annual mileage and vehicle price also can affect equity ratios. Annual mileage is a more important factor at the State level where registration and other fees that are invariant with mileage represent a greater portion of total user fees than at the Federal level.

All Federal user fees except the HVUT are related in part to mileage, and thus total Federal user fees vary more directly with mileage than do most State user fees. Since weight is the most important factor affecting horizontal equity at the Federal level, the bulk of the analysis of user fee equity presented in this chapter focuses on differences associated with vehicle weight. Everything else being equal, the greater the weight, the lower the equity ratio for vehicles within the same class. This direct relationship between weight and equity ratios does not hold when comparing equity ratios across vehicle classes since, as shown in Chapter V, the highway cost responsibility of vehicles at the same gross weight but in different classes varies dramatically.

Table VI-1. Base Period and Forecast Period Equity Ratios for Broad Vehicle Classes

Vehicle Class/Registered Weight	ISTEA Base Period			2000 Forecast Period		
	User Fee Shares	Cost Shares	Equity Ratio	User Fee Shares	Cost Shares	Equity Ratio
Automobiles	41.2	44.2	0.9	42.6	43.8	1.0
Pickups/Vans	21.6	15.6	1.4	21.4	15.4	1.4
All Personal Use Vehicles	62.8	59.8	1.1	64.0	59.2	1.1
Buses	0.1	0.7	0.1	0.1	0.7	0.1
Single Unit Trucks						
#25,000 pounds	5.6	3.6	1.6	5.5	3.6	1.5
25,001 - 50,000 pounds	2.3	3.0	0.8	2.2	3.1	0.7
> 50,000 pounds	2.1	4.5	0.5	1.8	4.0	0.5
All Single Units	10.0	11.0	0.9	9.6	10.7	0.9
Combination Trucks						
# 50,000 pounds	1.1	0.7	1.7	1.1	0.7	1.6
50,001 - 70,000 pounds	1.9	1.6	1.2	1.9	1.7	1.1
70,001 - 75,000 pounds	1.4	1.3	1.1	1.4	1.4	1.0
75,001 - 80,000 pounds	20.9	21.8	1.0	20.3	22.5	0.9
80,001 - 100,000 pounds	1.0	1.7	0.6	1.0	1.8	0.6
> 100,001 pounds	0.7	1.3	0.5	0.7	1.4	0.5
All Combinations	27.1	28.4	1.0	26.4	29.4	0.9
All Trucks	37.1	39.5	0.9	35.9	40.1	0.9
All Vehicles	100.0	100.0	1.00	100.0	100.0	1.00

Table VI-1 shows for the ISTEA base period (1993-1995) and the 2000 forecast year shares of Federal user fees paid by several vehicle classes, their shares of Federal cost responsibility, and their equity ratios at different weights. In the ISTEA period, user fees paid by three broad groups of vehicles (passenger vehicles, single unit trucks, and combination trucks) were, on average, within 10 percent of their cost responsibility. User fees paid by combination trucks were within 5 percent of their cost responsibility on average while user fees paid by passenger vehicles and single unit trucks were within 10 percent of their highway cost responsibility.

Equity ratios in the 2000 analysis year are expected to be about the same as in the ISTEA base period for these broad groups of vehicles. The most significant change is a decline in the overall equity ratio for combination trucks from 1.0 to 0.9. The principal reasons that equity ratios for combination vehicles are expected to decline in 2000 are (1) beginning in FY 1996 2.5 cents per gallon of fuel taxes that previously had been dedicated for deficit reduction were deposited in the HTF, and (2) VMT growth rates for trucks are projected to be higher than for personal use vehicles.

Table VI-2 compares equity ratios estimated on the basis of vehicle registered weights with equity ratios based on vehicle operating weights. Equity ratios shown in Table VI-1 and those shown in the remainder of this report are estimated based on registered weights and reflect the costs occasioned and user fees paid over the entire spectrum of weights at which vehicles operate during the course of a year. Distributions of operating weights for vehicles registered at particular operating weights represent averages across all vehicles at a particular registered weight. Some vehicles would be expected to operate a higher percentage of their total annual mileage at lower weights than average and some would operate at higher average weights. The extreme would be if a vehicle operated 100 percent of the time at its registered weight. In that extreme case the registered weight equity ratio would equal the operating weight equity ratio.

Table VI-2. Comparison of Equity Ratios Based on Registered Weights and Operating Weights of Different Vehicle Classes

Vehicle Class/Registered Weight	Registered Weight	Operating Weight
Autos	1.0	1.0
Pickups/Vans	1.4	1.4
Buses	0.1	0.1
Passenger Vehicles	1.1	1.1
Single Unit Trucks		
≤25,000 pounds	1.5	1.5
25,001 - 50,000 pounds	0.7	0.7
> 50,001 pounds	0.5	0.2
Total Single Unit	0.9	0.9
Combination Trucks		
≤50,000 pounds	1.6	2.3
50,001 - 70,000 pounds	1.1	1.2
70,001 - 75,000 pounds	1.0	0.7
75,001 - 80,000 pounds	0.9	0.6
80,001 - 100,000 pounds	0.6	0.4
>100,001 pounds	0.5	0.2
Total Combinations	0.9	0.9
Total All Vehicles	1.0	1.0

As shown in Chapter IV, fuel taxes account for all Federal user fees paid by personal use vehicles, but are only a portion of total truck fees. Any increase in fuel taxes going to the HTF increases the share of total user fees paid by personal use vehicles more than the trucks' share of fees. These differential changes in shares of user fee payments tend to increase equity ratios of personal use vehicles and reduce equity ratios of trucks.

The faster VMT growth rates for trucks compared to personal use vehicles also tend to reduce equity ratios for trucks. For personal use vehicles whose revenues per mile of travel are greater on average than their cost responsibility per mile, increases in VMT result in revenues growing more than cost responsibility and equity ratios thus increasing. The opposite is true for trucks; their costs rise faster than their user fee payments as annual mileage increases, resulting in lower equity ratios. Therefore any general growth in travel tends to increase equity ratios slightly for personal use vehicles and decrease equity ratios for trucks as a group. The higher VMT growth rates for trucks accentuate these general relationships between travel growth and equity ratios.

Within these broad groups of vehicles, there are large variations among different vehicle configurations and weight groups. Among personal use vehicles, pickups and vans have poorer equity ratios than automobiles because they consume more fuel than automobiles while having approximately the same cost responsibility per mile of travel. While not explicitly shown in Table VI-1, there are large variations in equity ratios among different automobiles related to differences in their fuel economies. The equity ratio for autos in Table VI-1 is based on an average fuel economy of approximately 25 miles per gallon, but fuel economies for autos may vary from more than 40 miles per gallon to less than 15 miles per gallon. The equity ratio for the average auto is approximately 1.0, but vehicles getting 40 miles per gallon would pay only about 65 percent of their Federal highway cost responsibility, and vehicles getting 15 miles per gallon would pay about two-thirds more than their Federal highway cost responsibility. Within the pickup and van category, there also are large variations in fuel economy, although not as large as for autos. User fees paid by pickups and vans with better than average fuel economy would be closer to their cost responsibility, while vehicles with poorer than average fuel economy would overpay even more than the average pickup and van shown in Table VI-1.

Since fuel taxes are the only Federal user fee that personal use vehicles pay, there are limited opportunities to improve equity ratios among different personal use vehicles under existing user fees. If a mileage tax were substituted for the fuel tax, differences in equity ratios associated with differences in fuel economy could be eliminated, but the incentive provided by the fuel tax to reduce fuel consumption would be lost.

Table VI-3. 2000 Federal Equity Ratios for Single Unit Trucks Based on Registered Weights

Registered Weight (000)	SU2		SU3		SU4+	
	Equity Ratio	Percent of VMT	Equity Ratio	Percent of VMT	Equity Ratio	Percent of VMT
0-10	1.7	44				
20	1.5	27	2.0	<1		
30	1.0	21	1.9	5	4.3	<1
40	0.5	8	1.4	8	3.3	1
50	0.2	<1	0.8	40	1.2	1
60			0.5	37	0.7	18
70			0.3	8	0.5	35
80			0.2	<1	0.4	39
90					0.4	4
100					0.4	2
Overall	1.2	100	0.6	100	0.5	100

NOTE: See Chapter I for vehicle definitions.

Within the single unit truck category vehicles range from small 2-axle delivery trucks to large 4- and 5-axle trucks hauling bulk commodities. In the ISTEA base period, single unit trucks registered under 25,000 pounds paid on average about 60 percent more in Federal highway user fees than their share of highway cost responsibility, while single units registered above 50,000 pounds paid only half their cost responsibility. In the 2000 analysis period, equity ratios for all single units drop slightly.

Table VI-3 shows equity ratios for 2-axle, 3-axle, and 4-axle single unit trucks at different registered weights. Overall, 2-axle single unit trucks pay more than their share of highway costs while both 3-axle and 4-axle single units pay less than their cost responsibility. Within each configuration, equity ratios drop as weight increases reflecting the fact that cost responsibility increases faster with weight than do user fee payments. At any given weight, vehicles with more axles have higher equity ratios because of their lower cost responsibilities. More than 70 percent of 2-axle single units have equity ratios equal to or above 1.4, yet the overall equity ratio for the class is 1.2.

Within the 2-axle single units and 4+ axle single units trucks with 3-axles and 4+ axles classes, the majority of vehicles pay less than their share of highway costs. Many of these vehicles are construction vehicles, garbage trucks, tankers, and other vehicles that haul high density cargo and carry the maximum allowable weight much of the time. Even though they also travel empty part of the time, infrastructure costs when those vehicles do travel loaded push their equity ratios below one.

Figure VI-1 shows estimated overpayments or underpayments per vehicle by single unit trucks at different registered weights in 2000. Two-axle single units registered at less than 30,000 pounds

Registered Weight (pounds)	2-axle Single Units		3-axle Single Units		4+ axle Single Units	
	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle
0-10,000	$329,557	$145				
20,000	$161,971	$117	$203	$224		
30,000	($7,333)	($7)	$7,956	$236	$28	$1,229
40,000	($152,292)	($364)	$8,803	$151	$1,189	$1,122
50,000	($34,119)	($2,207)	($32,520)	($116)	($307)	$220
60,000			($164,588)	($634)	($18,448)	($816)
70,000			($119,386)	($2,059)	($88,205)	($2,039)
80,000			($7,207)	($3,260)	($143,292)	($2,966)
90,000					($18,367)	($3,672)
100,000					($9,057)	($4,193)

Table VI-4. 2000 Federal Over and Underpayment by Single Unit Trucks at Different Registered Weights

pay more than their highway cost responsibility, but overpayments are less than $100 per vehicle.

At 30,000 pounds 2-axle single units underpay by less than $10 per vehicle. The relatively few 2-axle trucks registering at 40,000 pounds each pay about $360 less than their highway cost responsibility and underpayment increases sharply for registrations at higher weights.

Three-axle single unit trucks registered at 40,000 pounds or less pay more than their highway cost responsibility; overpayments range from $250 for vehicles registered at 20,000 pounds to about $150 for those registered at 40,000 pounds. Beyond 40,000 pounds 3-axle single units pay less than their cost responsibility. Underpayments per vehicle increase gradually to about $630 for vehicles registered at 60,000 pounds and over $3,200 for vehicles registered at 80,000 pounds.

Even though they have an additional axle, 4-axle single units underpay about the same amount per vehicle as 3-axle single units at weights between 60,000 and 80,000 pounds. Several factors account for this including (1) the operating weight distribution of 4-axle single units has more total travel at higher operating weights, (2) 4-axle single units travel on average more miles per year than 3-axle single unit trucks, and (2) bridge costs allocated to 4-axle single units are shared among fewer vehicles, thereby increasing the average cost per vehicle. There are estimated to be only about 125,000 4-axle single units, compared to about 700,000 3-axle single units and over 5 million 2-axle single units, but almost all of those 4-axle single unit trucks pay significantly less than their share of highway costs.

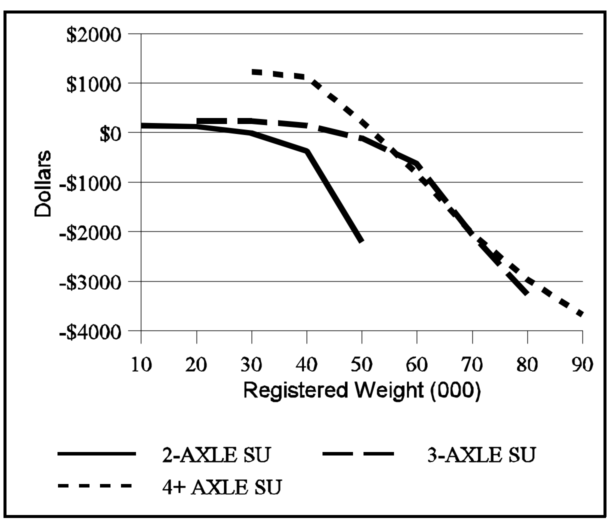

Figure VI-1 2000 Federal Overpayment and Underpayment per Vehicle for Single Unit Trucks

Table VI-4 shows total over and underpayment for single unit trucks at different registered weights and over and underpayments per vehicle. The over and underpayments per vehicle correspond to data shown in Figure VI-1. Total over and underpayments are simply the per vehicle amounts multiplied by the number of vehicles at each weight. In many cases the weight with the highest per vehicle over or underpayment is not the weight with the greatest total because there are relatively few vehicles registered at that weight.

In the ISTEA base period, the lightest combinations paid about 70 percent more in user fees than their highway cost responsibility, but combinations registered above 100,000 pounds paid only about half their cost responsibility. In 2000 equity ratios for combinations are expected to be marginally lower for most vehicle classes and weight groups, primarily because beginning in FY 1996, 2.5 cents of fuel tax that had been going for deficit reduction was deposited in the HTF. This 2.5 cents per gallon was not considered in estimating equity ratios during the ISTEA period because proceeds were used for deficit reduction rather than being deposited in the HTF. After 1996 the 2.5 cents is included in the cost allocation and equity analysis. A general Federal fuel tax increase always has the effect of raising equity ratios for autos and lowering them for heavy trucks because trucks pay other taxes in addition to fuel taxes. The fuel tax increase has a smaller effect on total user fee payments by heavy trucks than it does on total payments by autos.

Table VI-5 shows equity ratios for six types of combination trucks — 5- and 6-axle tractor-semitrailers; 5-, 6-, and 8- or more axle twin-trailer combinations; and a 7-axle triple trailer combination. Overall equity ratios for these vehicles range from 0.8 for the 6-axle tractor-semitrailer and the 8- or more axle twin trailer combination to 1.3 for the 6-axle twin trailer combination. Many factors affect the relative equity ratios of these different vehicles including the number and types (single, tandem, or tridem) of axles, the types of roads on which they travel, and their operating weight distributions.

In general, the more axles a vehicle has, the higher its equity ratio at any given weight, but there are exceptions depending on the operating weight distributions of vehicles at various registered weights. Even though the 6-axle tractor-semitrailers has more axles than the 5-axle tractor-semitrailers, its overall equity ratio is lower because a greater percentage of 6-axle tractor-semitrailer travel is at heavier weights. Both 5-axle tractor-semitrailers and 6-axle tractor-semitrailers register predominantly at 80,000 pounds, and at that weight the benefits of the additional axle is evident. The 5-axle tractor-semitrailers pays less than its share of highway costs at 80,000 pounds while the 6-axle tractor-semitrailer pays more than its share of costs. Although most 6-axle tractor-semitrailers pay more than their share of highway costs, the large underpayment by 6-axle tractor-semitrailers over 80,000 pounds registered weight is enough to cause the entire class to pay less than its share of highway costs.

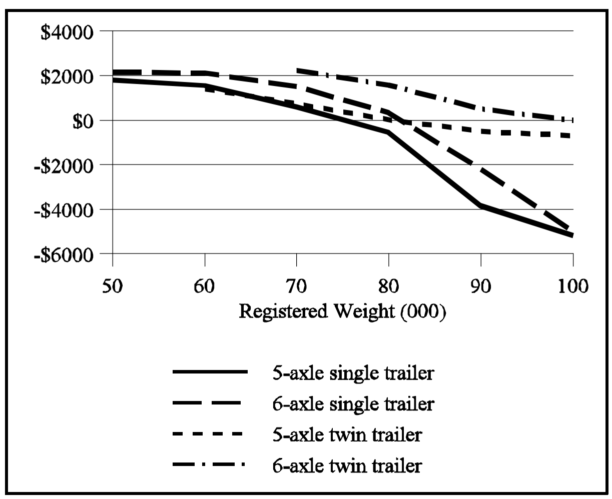

Figure VI-2. 2000 Overpayments and Underpayments per Vehicle by Selected Combination Vehicles

Benefits of extra axles also are evident among the twin-trailer combinations. At registered weights of 80,000 pounds, 5-axle twins have equity ratios of 1.0, 6-axle twins have equity ratios of 1.4, and 8- or more axle twins have equity ratios of 1.9. Eighty thousand pounds is the predominant registered weight for 5- and 6-axle twins, whereas most 8- or

Table VI-5. 2000 Federal Equity Ratios for Selected Vehicle Classes Based on Registered Weights												
	5-axle Tractor Semitrailer (CS5)		6-axle Tractor Semitrailer (CS6)		5-axle Twin Trailer (DS5)		6-axle Twin Trailer (DS6)		8+ axle Twin Trailer (DS8+)		Triple Trailer	
Registered Weight (000)	Equity Ratio	% of VMT	Equity Ratio	% of VMT	Equity Ratio	% of VMT	Equity Ratio	% of VMT	Equity Ratio	% of VMT	Equity Ratio	% of VMT
50	1.9	1	2.7	<1								
60	1.6	2	2.3	1	1.4	1						
70	1.1	3	1.6	2	1.1	5	1.7	7			1.7	4
80	0.9	91	1.1	72	1.0	92	1.4	73	1.6	15	1.4	12
90	0.5	2	0.6	9	0.9	0	1.1	5	1.3	4	1.1	4
100	0.5		0.5	7	0.9	0	1.0	7	1.1	1	0.9	<1
110			0.3	4	0.8	1	0.9	7	1.0	35	0.7	77
120			0.3	6			0.8	1	0.8	9	0.6	<1
130							0.8	<1	0.7	13	0.5	2
140									0.6	2	-	-
150									0.5	22	0.4	<1
Overall	0.9		0.8		1.0		1.3		0.8		0.8	

NOTE: See Chapter I for vehicle definition.

more axle twins register or have permits to operate at 110,000 pounds or more. Equity ratios are less than one for 8+ axle twins registered at 120,000 pounds or more, but are greater than or equal to one up to 110,000 pounds, demonstrating the benefits of additional axles. Equity ratios for light triples are about the same as 6-axle twin trailer combinations at the same weights, but equity ratios for heavier triples fall below those of 6-axle twins, even though the triple has more axles. The triple's 7 single axles are more damaging than the 4 single and 1 tandem axle of the 6-axle twin trailer combinations.

Figure VI-2 shows overpayments and underpayments per vehicle for selected combination trucks at different registered weights. The relatively few combination vehicles that register at 50,000 pounds pay almost $2,000 more than their highway cost responsibility. Five-axle tractor semi-trailers continue to overpay until their registered weights reach 75,000 pounds, and at 80,000 pounds, the most common registered weight, each vehicle underpays its cost responsibility by over $550. Even though cost responsibility on an operating weight basis is greater for 5-axle twin trailers than 5-axle tractor-semitrailers at any given weight, the twin trailer combinations generally overpay more per vehicle at low registered weights and underpay less per vehicle at higher registered weights than 5-axle tractor-semitrailers. The primary reason is that the operating weight distributions of the two vehicle classes are different with the tractor-semitrailer having a greater percentage of its travel at higher operating weights than the twin trailer combination. Both the 6-axle tractor-semitrailer and the 6-axle twin trailer combination have lower underpayments per vehicle than their 5-axle counterparts, but the 6-axle tractor-semitrailer registered at 90,000 pounds still underpays its cost responsibility by almost $2,200.

Table VI-6 shows the over and underpayments per vehicle displayed graphically in Figure VI-2 and total over and underpayment by different vehicle classes at different registered weights. As a group, 5-axle tractor-semitrailers registered at 80,000 pounds pay almost $600 million less than their highway cost

Table VI-6. 2000 Federal Over and Underpayment by 5- and 6-axle Combination Vehicles								
Registered Weight (pounds)	5-axle Semitrailer		6-axle Semitrailer		5-axle Twin Trailer		6-axle Twin Trailer	
	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle	Total (000s)	Per Vehicle
60,000	$43,594	$1,538	$1,414	$2,104	$1,034	$1,401		
70,000	$20,372	$603	$2,732	$1,508	$2,331	$730	$1,282	$2,217
80,000	($591,971)	($561)	$27,370	$342	$939	$17	$10,166	$1,562
90,000	($109,044)	($3,864)	($21,286)	($2,188)	($115)	($491)	$227	$507
100,000	($17,987)	($5,176)	($41,391)	($4,985)	($1)	($692)	$3	$5
110,000			($33,239)	($7,746)			($357)	($587)

responsibility, which is by far the greatest underpayment by any vehicle class. The underpayment per vehicle for this group is about $560, but since there are a million vehicles in the group, the total underpayment is quite large. In general, the registered weight groups with the highest over or underpayments per vehicle for each vehicle class are ones with relatively few vehicles.

Table VI-7 shows total over or underpayments by each of the 20 vehicle classes across all registered weights. The largest overpayment is the $1.6 billion overpayment by pickups and vans that is related primarily to their relatively poor fuel economy compared to automobiles. The other vehicle classes with net overpayments are 2-axle single unit trucks, the three truck trailer combinations, and 5- and 6-axle twin trailer combinations. The $600 million underpayment by 5-axle tractor-semitrailers is the largest of any vehicle class, followed by automobiles, 3-axle single units and 4+ axle single units that underpay by $323 million, $307 million, and $276 million respectively.

Table VI-7. 2000 Federal Over and Underpayments by 20 Vehicle Classes	
Vehicle Class	Total Over or (Underpayment) (000s)
Automobiles	($323,330)
Pickups and Vans	$1,613,410
2-axle single units	$270,007
3-axle single units	($306,739)
4+ axle single units	($275,845)
3-axle tractor-semitrailers	($12,414)
4-axle tractor-semitrailers	($76,229)
5-axle tractor-semitrailers (tandem)	($651,480)
5-axle tractor-semitrailers (split tandems)	($41,162)
6-axle tractor-semitrailers	($134,212)
7-axle tractor-semitrailers	($26,767)
3-, 4-axle truck trailers	$128,304
5-axle truck trailers	$30,362
6+ axle truck trailers	$4,460
5-axle twin trailers	$3,499
6-axle twin trailers	$11,188
7-axle twin trailers	($17,063)
8-axle twin trailers	($22,659)
7-axle triple trailer	($2,141)
Buses	($169,478)

Effects of Alternative Investment Patterns

The equity ratios discussed above are based on an assumption that the distribution of obligations by improvement type in 2000 will be approximately the same as in the ISTEA (1993-1995) base period.

Table VI-8. Distribution of 2000 Federal Obligations by Improvement Category		
Category	**Amount (millions)**	**Percent of Total**
New Capacity	$5,713	21.00%
System Preservation	$11,490	42.3%
System Enhancement	$4,184	15.4%
MTA	$3,380	12.4%
Other	$2,407	8.9%
Total	$27,175	100.0%

Table VI-8 summarizes the assumed distribution of Federal obligations by improvement type in 2000. One-fifth of obligations are assumed to go for new capacity which includes adding lanes to existing highways as well as constructing new roadways and bridges. Over two-fifths of obligations are assumed to go for system preservation including pavement 3R, bridge reconstruction and rehabilitation, and minor widening. Fifteen percent of Federal funds are assumed to be obligated for system enhancement including safety and traffic system management improvements, environmental projects, and other improvements that neither add lanes of capacity nor repair physical deterioration of existing facilities, but which improve the efficiency of the system and contribute to meeting other public purposes.

Table VI-9 shows the percentage of costs for each improvement category allocated to different vehicle classes. Automobiles, pickups, and vans are responsible for about half of new capacity costs, 40 percent of system preservation costs, almost 90 percent of system enhancement costs, all project costs funded from the MTA, and 70 percent of other highway costs. Combination trucks which account for about 4 percent of total VMT are responsible for 37 percent of capacity costs, 44 percent of system preservation costs, 7 percent of enhancement costs, and 20 percent of other costs. As discussed in Chapter V, no mass transit costs are assigned to combination or single unit trucks because transit costs are uniquely occasioned by autos, pickups and vans operating in urban areas.

Table VI-10 shows cost responsibilities per mile of travel for the different vehicle classes. Cost responsibilities for automobiles, pickups and vans are almost identical, with automobiles having slightly higher cost responsibilities per mile of travel for new capacity, system enhancement, and transit. The highest costs per mile for these personal use vehicles are for system preservation, followed by system enhancement, mass transit, new capacity,and other costs. Among the truck classes, the 4-axle single unit trucks stand out as having the highest costs, 18.5 cents per mile. On average, those trucks travel a large percentage of their

Table VI-9. Shares of Cost Responsibility for Different Improvement Types (percent)					
Vehicle Type	**New Capacity**	**System Preservation**	**System Enhancement**	**MTA**	**Other**
Auto, Pickup, Van	49.7	39.3	88.1	100.0	69.8
Single Unit Truck	12.3	15.6	4.2	0.0	9.8
Combinations	37.0	44.2	7.3	0.0	19.9
All Buses	1.0	0.9	0.4	0.0	0.5
All Vehicles	100.0	100.0	100.0	100.0	100.0

Table VI-10. 2000 Federal Cost Responsibility For Different Highway Cost Improvement Categories (cents per mile)						
Vehicle Class	**New Capacity**	**System Preservation**	**System Enhancement**	**Mass Transit**	**Other**	**Total**
AUTO	0.12	0.18	0.15	0.14	0.07	0.65
LT4	0.11	0.19	0.15	0.12	0.07	0.63
SU2	0.68	1.24	0.20	0.00	0.21	2.33
SU3	1.53	5.18	0.26	0.00	0.57	7.54
SU4+	2.58	14.40	0.28	0.00	1.27	18.54
CS3	1.07	1.59	0.23	0.00	0.22	3.11
CS4	1.27	2.29	0.25	0.00	0.28	4.08
CS5T	1.86	4.60	0.27	0.00	0.42	7.16
CS6	2.10	6.99	0.26	0.00	0.63	9.98
DS5	2.24	3.15	0.28	0.00	0.34	6.01
DS6	1.54	2.96	0.26	0.00	0.30	5.061
DS7	2.67	7.62	0.27	0.00	0.65	11.21
DS8+	3.07	7.91	0.29	0.00	0.67	11.94
TRPL	2.45	6.42	0.29	0.00	0.52	9.67
Bus	0.78	1.44	0.20	0.00	0.14	2.57

NOTE: See Chapter I for vehicle definition.

annual mileage fully loaded with dense commodities. While they have tridem axles, they nevertheless are responsible for significant pavement and bridge costs. The only other vehicles with total cost responsibility over 10 cents per mile are 7- and 8- or more axle twin trailer combinations that operate at much higher gross weights than the 4-axle single units. Like the single units, the highest per mile costs for these vehicles are for system preservation, followed by new capacity and enhancements.

If Federal funds were obligated differently, cost responsibilities and equity ratios of different vehicle classes could be affected. Table VI-11 shows distributions of Federal obligations by improvement type for the 2000 base case and for four alternative investment scenarios. Scenario 1 assumes obligations for system preservation based upon estimated investment requirements in the 1995 C&P Report to maintain system conditions. The same overall investment level is assumed as for the base case. In this scenario, increases in obligations for system preservation are offset by reductions in obligations for new capacity and enhancements. The distribution of obligations by highway type is the same as in the base case. In all scenarios, obligations from the MTA are assumed to be equal to revenues to the account, and obligations for FHWA administration, Federal lands improvements, and other related obligations are assumed to be atthe same level as in the base case.

Scenario 2 is similar to Scenario 1 except that obligations are focused on the Interstate System, the NHS, and other principal arterial highways. Obligations on lower order systems are reduced by 50 percent. Scenario 3 assumes greater obligations for new capacity, with related decreases in obligations for system preservation and enhancement. The distribution of obligations by highway functional class is the same as in the base case. Scenario 4 is based upon the Administration’s National Economic Crossroads Transportation Efficiency Act Proposal and specifically includes $600 million per year for AMTRAK allocated to personal use vehicles.

Table VI-12 shows estimated 2000 equity ratios under these alternative investment scenarios. The two reports in which obligations for system preservation increase both result in equity ratios for combination trucks falling from 0.9 to 0.8. In Scenario 1 where the distribution of obligations by highway class remains the same as in the 2000 base case, equity ratios for single unit trucks also drop to 0.8, but in Scenario 2 where increases in obligations for system preservation are assumed to be concentrated on higher order systems, the equity ratios for single unit trucks remain at 0.9. The reason is that combination truck travel is concentrated on higher order systems whereas more single unit travel is on lower order systems where less Federal money is expended. Clearly equity ratios of different vehicle classes are affected by how and where Federal funds are spent.

Table VI-11. Distributions of Federal Obligations Under Alternative 2000 Investment Scenarios (percent)					
Improvement Category	**Base Case**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
New Capacity	21.0	11.4	11.4	43.0	20.5
Pavement Preservation	26.7	38.9	39.1	16.5	25.9
Bridge Preservation	15.6	20.1	19.9	9.7	15.1
Safety/TSM	9.4	5.0	5.0	5.8	9.1
Environmental	1.9	1.1	1.1	1.2	1.9
Other	4.1	2.2	2.2	2.5	4.0
MTA	12.4	12.4	12.4	12.4	12.4
Federal Lands, NHTSA, FHWA administration, Other	8.9	8.9	8.9	8.9	11.0
Total	100	100	100	100	100

In Scenario 3 which assumes increases in obligations for new capacity, equity ratios are the same as for the base case. The cost responsibility for capacity improvements is more evenly shared among all vehicle classes than for other types of improvements. Equity ratios under Scenario 4 which also remains the same as for the base case.

This analysis of implications of alternative Federal investment patterns on user fee equity should not be construed to suggest that impacts on equity should be major considerations in investment decisions. Federal monies should be directed to the programs that have the highest net benefits and that meet other transportation policy objectives. If changes in program composition contribute to improving user fee equity as has been the case with increased spending on system enhancements under ISTEA, so much the better. But if user equity were to become worse under an otherwise desirable distribution of highway funds, that should not be a significant factor against the investment program. Rather, if user fee equity were to become much worse under some future investment program, it might suggest that user fees should be reexamined with the intent of improving equity given the new investment program.

Table VI-12. 2000 Federal Equity Ratios Under Alternative Investment Scenarios					
Vehicle Class	**Base Case**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Automobiles	1.0	1.1	1.1	1.0	1.0
Pickups/Vans	1.4	1.5	1.5	1.4	1.4
Buses	0.1	0.1	0.1	0.1	0.1
Single Units	0.9	0.8	0.9	0.9	0.9
Combinations	0.9	0.8	0.8	0.9	0.9

Federal User Fee Options to Improve Equity

In the 1982 Federal HCAS, the Department evaluated several user fee options and recommended changes to improve the equity of the user fee structure. The STAA had directed that user fee options be evaluated along with impacts of any proposed changes on affected industries and users. There is no similar requirement that the current

1997 Federal HCAS evaluate user fee options, and the study has not done a detailed examination of alternative user fee structures and potential impacts of potential changes. The study did, however, evaluate several general user fee options to determine the types of changes that could have the greatest impacts on user fee equity both across vehicle classes and among vehicles in the same class. Six general options are discussed in this section and described in Table VI-13. The first two are increases in the diesel fuel tax by 1 cent a gallon and by 6 cents per gallon. These options are aimed primarily at improving vertical equity by reducing differences in equity ratios across vehicle classes. Even though there would be no change in gasoline taxes, equity ratios for automobiles, pickups and vans would fall somewhat relative to ratios for heavy trucks that predominantly consume diesel fuel. In addition to improving equity ratios of combination trucks, these options also improve ratios for heavy single unit

Table VI-13. Current and Illustrative Federal User Fee Rates

Tax Type	Current Rates	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Diesel	20 cents/gallon	21 cents/gallon	26 cents/gallon	20 cents/gallon	14 cents/gallon	14 cents/gallon	14 cents/gallon
Gasoline	14 cents/gallon	14 cents/gallon	14 cents/gallon	14 cents/gallon	14 cents/gallon	14 cents/gallon	14 cents/gallon
Alt. Fuel	0-14 cents/ gallon	0-14 cents/ gallon	0-14 cents/ gallon	0-14 cents/ gallon	0-14 cents/ gallon	0-14 cents/ gallon	0-14 cents/ gallon
Vehicle Excise	12 percent	12 percent	12 percent	12 percent	12 percent	N/A	N/A
Tire	0 to 10.50 fee + 15 cents to 50 cents/pounds	0 to 10.50 fee + 15 cents to 50 cents/pounds	0 to 10.50 fee + 15 cents to 50 cents/pounds	0 to 10.50 fee + 15 cents to 50 cents/pounds	0 to 10.50 fee + 15 cents to 50 cents/pounds	N/A	N/A
HVUT	$100 fee + $22/ 1,000 pounds from 55,000 to 75,000 GVW (cap at 75,000 GVW)	$100 fee + $22/ 1,000 pounds from 55,000 to 75,000 GVW (cap at 75,000 GVW)	$100 fee + $22/ 1,000 pounds from 55,000 to 75,000 GVW (cap at 75,000 GVW)	$100 Fee + $22/ 1,000 pounds over 55,000 GVW	Annual fee for SU of $25 at 25,000 GVW to $5,000 at 100,000 GVW and for comb of $100 at 70,000 to $11,750 at 150,000 GVW	N/A	N/A
Weight Distance	N/A	N/A	N/A	N/A	N/A	See Table 22	N/A
Axle Weight Distance	N/A	N/A	N/A	N/A	N/A	N/A	See Table 23

NOTE: N/A - not applicable

trucks that pay little or no HVUT and lower tire taxes than heavy combinations. Increasing the diesel tax has a small effect on horizontal equity as well as vertical equity since heavier vehicles get worse fuel economy than lighter vehicles in the same class. The third and fourth options involve changes to the HVUT. The third option leaves the basic rate structure unchanged but eliminates the $550 cap on the HVUT which results in all vehicles registered above 75,000 pounds paying the same annual HVUT. The fourth option eliminates the $550 cap, extends the tax below the current minimum weight of vehicles subject to the tax below the current 55,000 pound floor, and also evaluates a more progressive-two tier rate structure that better reflects the relative cost responsibilities of single unit and combination vehicles at different weights.

The fifth and sixth options involve WDTs. The fifth option is a simple WDT with different rate structures for single unit and combination vehicles and the sixth option is an axle-WDT that varies according to the number of axles on the vehicle. This option also has a different rate structure for single unit and combination vehicles.

Table VI-14. 2000 Ratios of User Charges to Allocated Costs by Vehicle Class Under Alternative Federal User Charge Structures

Vehicle Class/Registered Weight	Current Structure	Scenario 1	Scenario 2
Autos	1.0	1.0	0.9
Pickups/Vans	1.4	1.4	1.3
Buses	0.1	0.1	0.1
Total Passenger Vehicles	1.1	1.1	1.0
Single Unit Trucks			
≤25,000 pounds	1.5	1.6	1.7
25,001 - 50,000 pounds	0.7	0.7	0.8
> 50,001 pounds	0.5	0.5	0.5
Total Single Unit	0.9	0.9	1.0
Combination Trucks			
≤50,000 pounds	1.6	1.7	1.8
50,001 - 70,000 pounds	1.1	1.1	1.2
70,001 - 75,000 pounds	1.0	1.0	1.1
75,001 - 80,000 pounds	0.9	0.9	1.0
80,001 - 100,000 pounds	0.6	0.6	0.6
>100,001 pounds	0.5	0.5	0.5
Total Combinations	0.9	0.9	1.0
Total Trucks	0.9	0.9	1.0
Total All Vehicles	1.0	1.0	1.0

Scenario 1 — Increase diesel differential by 1 cent
Scenario 2 — Increase diesel differential by 6 cents

Figures VI-3 through VI-6 show relationships between current user fee payments and highway cost responsibility at different weights for 3-axle single unit trucks and 5-axle combination trucks on both a registered weight basis and an operating weight basis. For both vehicle classes the user fees paid per mile of travel exceed highway costs per mile at light weights, but at heavier weights costs per mile exceed user fees per mile on either an operating or registered weight basis. These graphs illustrate the extent of horizontal inequities related to weight for these two vehicle classes.

Figures VI-7 through VI-8 show revenue and cost curves for 3-axle single units and 5-axle tractor semitrailers under user fee Scenarios 1 and 2, a 1 cent per gallon and a 6 cent per gallon increase in the diesel differential. The curves are based on registered weights and thus reflect costs and revenues over the entire spectrum of operations for vehicle at each registered weight. The flat 1 cent and 6 cent per gallon increases in the diesel differential shift the revenue curve for both vehicle classes upward

Table VI-15. 2000 Ratios of User Charges to Allocated Costs by Vehicle Class Under Alternative Federal User Charge Structures			
Vehicle Class/Registered Weight	**Current Structure**	**Scenario 3**	**Scenario 4**
Autos	1.0	1.0	0.9
Pickups/Vans	1.4	1.4	1.3
Buses	0.1	0.1	0.1
Total Passenger Vehicles	1.1	1.1	1.0
Single Unit Trucks			
≤25,000 pounds	1.5	1.5	1.4
25,001 - 50,000 pounds	0.7	0.7	0.8
> 50,001 pounds	0.5	0.5	0.9
Total Single Unit	0.9	0.9	1.1
Combination Trucks			
≤50,000 pounds	1.6	1.6	1.5
50,001 - 70,000 pounds	1.1	1.1	0.9
70,001 - 75,000 pounds	1.0	1.0	1.0
75,001 - 80,000 pounds	0.9	0.9	1.0
80,001 - 100,000 pounds	0.6	0.6	1.1
>100,001 pounds	0.5	0.6	1.1
Total Combinations	0.9	0.9	1.0
Total Trucks	0.9	0.9	1.0
Total All Vehicles	1.0	1.0	1.0

Scenario 3 — Eliminate HVUT cap
Scenario 4 — Progressive HVUT rates

and change the point at which revenues equal costs, but they have little or no effect on horizontal equity.

Table VI-14 shows how changes in the diesel differential would affect equity ratios for broad vehicle classes in 2000. Equity ratios with a 1 cent per gallon increase in the diesel differential show little change from ratios under the current user fee structure. A 6 cent per gallon increase in the diesel differential, however, would move equity ratios for both single unit and combination trucks closer to one. Light trucks that overpay under the current user fee structure would overpay even more with increases in the diesel tax, but heavier trucks that underpay under the current fee structure would underpay less. Thus increasing the diesel differential could improve the vertical equity of the user fee structure by reducing the underpayment of the single unit and combination truck classes, especially if the differential were increased by more than a penny.

Figures VI-9 and VI-10 show revenue and cost curves for Scenarios 3 and 4, which would modify the HVUT. Scenario 3 eliminates the $550 cap on the HVUT and Scenario 4 changes the underlying fee structure to make it more progressive with weight and to establish separate fee structures for single unit and combination vehicles to reflect differences in their cost responsibilities at any given weight.

The revenue curve for Scenario 3 is identical to the curve for existing fees up to 75,000 pounds, and then is slightly higher reflecting the lifting of the HVUT cap. Comparing revenue curves for Scenario 4 with the cost curves in Figures VI-9 and VI-10 indicates that with more progressive HVUT rates, the Federal user fee structure could much more closely reflect differences in cost responsibility due to weight for both single unit and combination vehicles.

Table VI-15 compares equity ratios for the two HVUT scenarios with ratios for the current user fee structure. Simply eliminating the cap would affect only those vehicles registered over 75,000 pounds, but this includes the majority of over-the-road combination vehicles that register at 80,000 pounds. The additional HVUT that those vehicles would pay would only be $110 a year which is not enough to raise their equity ratio above 0.9, the level under the existing user fee structure. Equity ratios under Scenario 4

Table VI-16. Illustrative Annual HVUT Rates for Scenario 4		
Registered Weight (000s)	Single Units	Combinations
30	$25	$0
40	$25	$0
50	$225	$0
60	$1,250	$0
70	$3,000	$100
80	$4,000	$1,250
90	$4,500	$5,000
100	$5,000	$5,750
110		$6,500
120		$8,050
130		$9,550
140		$10,250
150		$11,750

improve considerably more for the heavier trucks because the underlying rate structure has been substantially modified to more closely match differences in cost responsibility of single unit and combination trucks at different weights. Equity ratios for lighter single units and combinations get marginally worse because other user fees are assumed to remain, but it would be possible to improve equity for those vehicles as well if more comprehensive changes to the entire user fee structure were evaluated.

Table VI-16 shows the HVUT rate structure from which equity ratios in Table VI-15 were developed. Unlike the existing HVUT rate structure, the rate per 1,000 pounds increases with increasing GVW, reflecting the shape of the cost responsibility curve. Also separate rate structures are developed for single unit trucks and combinations since the cost responsibility at specific weights varies considerably among those classes of vehicles. This allows both vertical and horizontal equity to be improved considerably over the existing HVUT or the Scenario 3. It must be emphasized that the rate structure in Table VI-16 is purely illustrative and does not represent a recommended or optimal rate structure. Many other factors would have to be considered in developing a recommended revision to the current HVUT rate structure. Nevertheless, this rate structure does indicate the order of magnitude of rates that would be necessary to match cost responsibility for the estimated 2000 program costs assuming that all other Federal user fees remained in place. Other options where an improved HVUT was substituted for some or all of the existing truck taxes were not examined in this study.

The HVUT rate structure in Scenario 4 is more complex than the existing rate structure which could present some administrative or enforcement difficulties, especially for truck trailer combinations, but implementation issues were not assessed in this study. Changes in the HVUT can be effective in capturing differences in cost responsibility among vehicles with different weights, but they do not reflect differences in costs associated with annual use.

Table VI-17 shows differences in HVUT payments per mile for vehicles with different annual mileages. Since other Federal user fees vary with annual mileage, the HVUT represents a declining share of total Federal user fees as the annual mileage of a vehicle increases. The typical 5-axle tractor semitrailer pays approximately 6.4 cents per mile in other user fees. For vehicles traveling only 20,000 miles per year the HVUT represents 30 percent of total annual Federal user fee payments whereas for vehicles that travel 120,000 miles

Table VI-17. Federal HVUT Payments by Vehicles With Different Annual Mileages (cents per mile)		
Annual Mileage	HVUT Rate	
	$550/year	$1,200/year
20,000	2.75	6.0
40,000	1.38	3.0
60,000	0.92	2.0
80,000	0.69	1.5
100,000	0.55	1.2
120,000	0.46	1.0

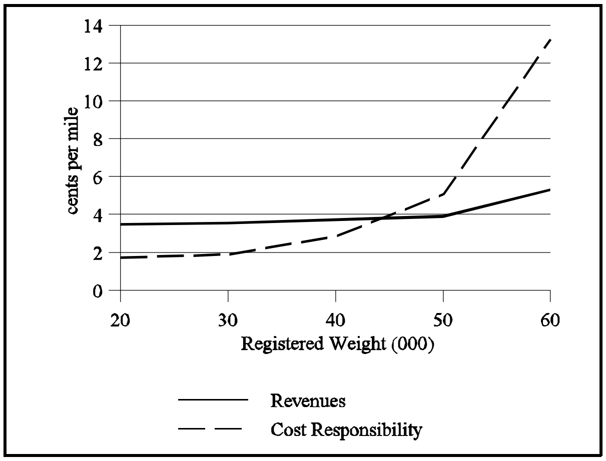

Figure VI-3. 3-axle Single Unit Trucks Revenues and Cost Responsibility

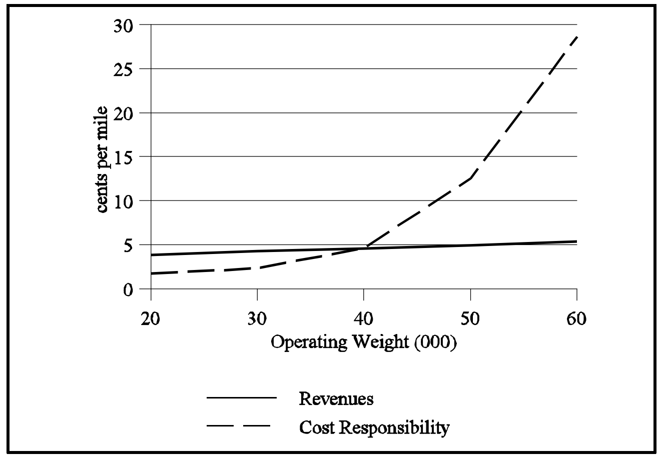

Figure VI-4. 3-axle Single Unit Trucks Revenues and Cost Responsibility

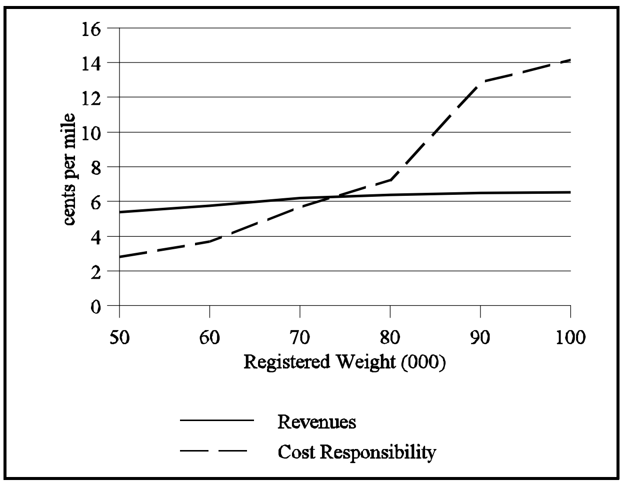

Figure VI-5. 5-axle Tractor-SemiTrailer Revenues and Cost Responsibility

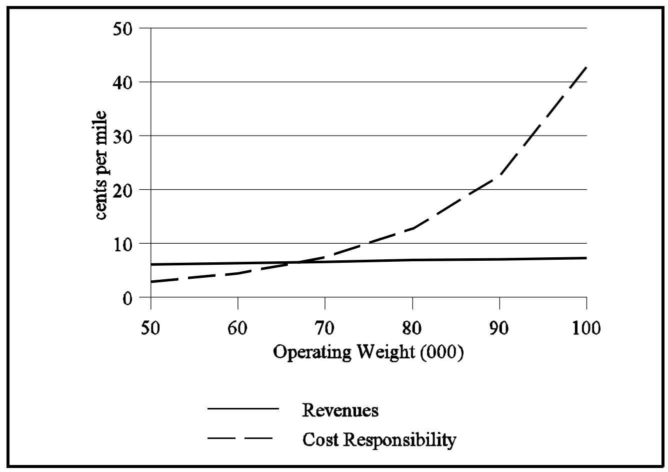

Figure VI-6. 5-axle Tractor-Semitrailer Revenues and Cost Responsibility

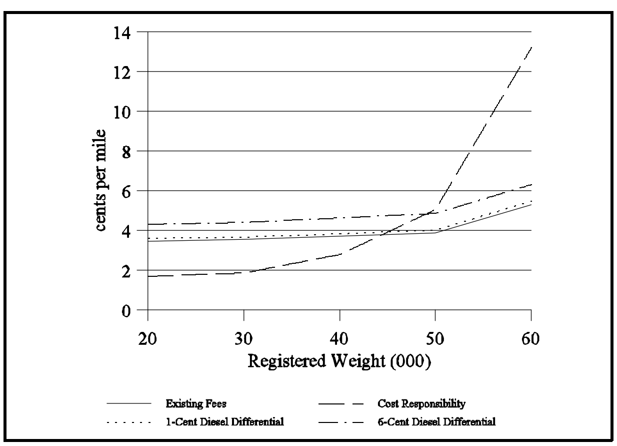

Figure VI-7. Effects of Additional 1 Cent and 6 Cent Differential— 3-axle Single Unit Trucks

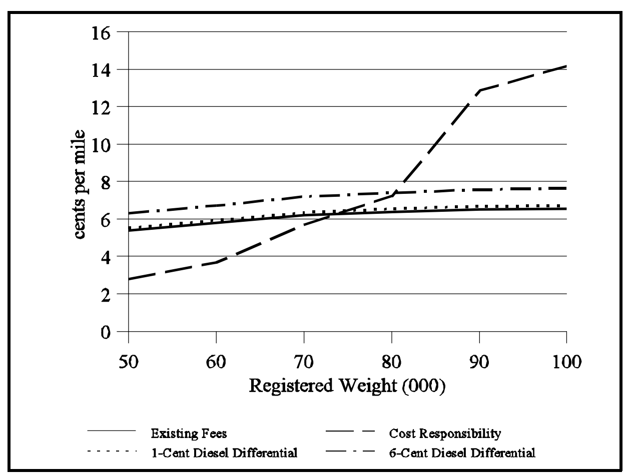

Figure VI-8. Effects of Additional 1 Cent and 6 Cent Diesel Differential— 5-axle Tractor-Semitrailer

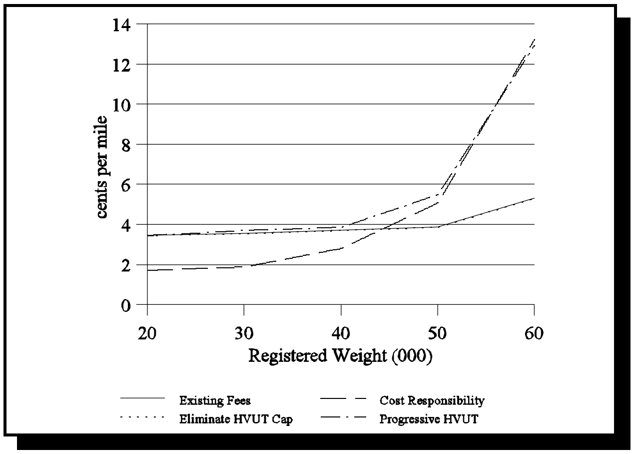

Figure VI-9. Effects of Two HVUT Options — 3-axle Single Unit Trucks

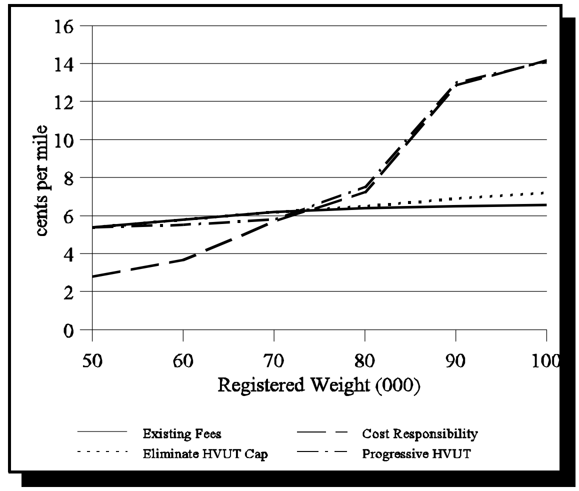

Figure VI-10. Effects of Two HVUT Options — 5-axle Tractor-Semitrailer

annually the HVUT represents only 7 percent of total annual fees. When the HVUT is low as under existing tax rates the overall inequity for vehicles with different annual mileages is fairly small, but if the HVUT were larger it could cause significant inequities among vehicles that travel different annual mileages.

Figures VI-11 and VI-12 show revenue and cost curves for Scenarios 5 and 6, a simple WDT and an axle-WDT. Both taxes can match the cost responsibility curve of the 5-axle tractor-semitrailer fairly well because it is such a predominant vehicle among combinations across a wide range of weight groups. This is not the case for single unit trucks where there is more overlap among 2-, 3-, and 4-axle vehicles. The axle WDT can capture differences in the cost responsibility of those three vehicle classes, but the simple WDT must reflect an average cost responsibility of the various single unit trucks and thus cannot match as precisely the cost responsibility of specific vehicle classes.

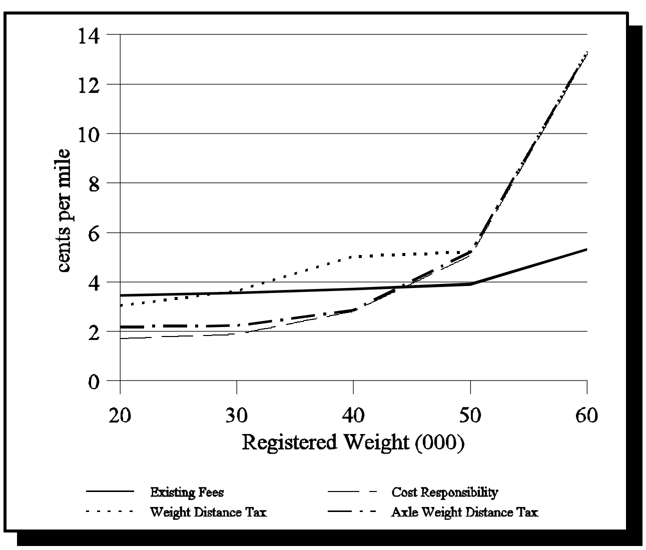

Figure VI-11. Effects of Two WDT Options — 3-axle Single Unit Trucks

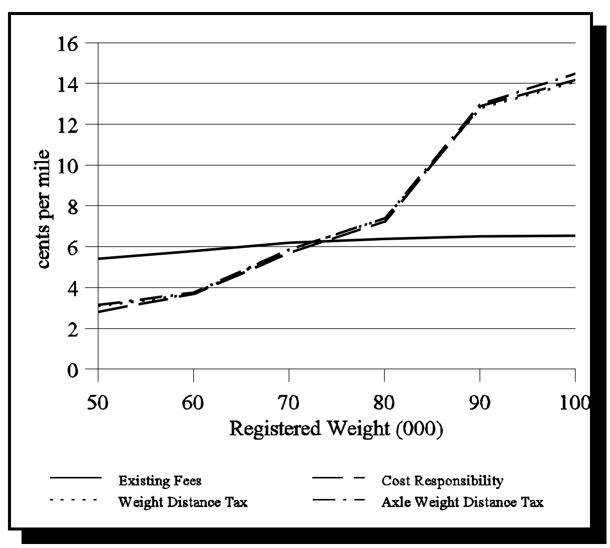

Figure VI-12. Effects of Two WDT Options — 5-axle Tractor-Semitrailer

Tables VI-18 and VI-19 summarize the rate structures for the WDT and axle WDT option. Rates for single unit trucks under the simple WDT range from 0.50 cents per mile to 26 cents per mile for the heaviest weights. Under the axle WDT, single unit truck rates range from 1 cent per mile for the lightest 4-axle single unit to 25 cents per mile for the heaviest 4-axle single unit. At any given weight the more axles on the vehicle, the lower the WDT rates. The WDT rates for combinations range from less than 1 cent per mile to 18.0 cents per mile for the heaviest combinations. Axle WDT rates vary even more widely depending on vehicle weight and number of axles. Again it must be remembered that these are simply illustrative tax rates schedules that match fairly closely the estimated Federal cost responsibility of different vehicle classes.

Table VI-20 summarizes equity ratios for broad vehicle classes for the two WDT scenarios as well the other four user fee scenarios discussed above.

Table VI-18. Illustrative WDT Rate Structure Under Scenario 5 (cents per mile)

Registered Weight (000)	Single Unit Trucks	Combination Trucks
30	0.5	.50
35	1.75	.75
40	1.75	1.0
45	1.75	1.0
50	1.75	1.0
55	4.00	1.25
60	9.75	1.5
65	16.75	2.0
70	20.25	3.25
75	20.25	4.00
80	20.75	5.00
85	22.00	9.00
90	23.25	10.25
95	24.25	11.0
100	25.75	11.50
105	25.75	12.25
110	25.75	13.00
115		13.25
120		13.50
125		13.75
130		14.00
135		14.25
140		15.00
145		16.75
150		18.00

Comparison of Tax Structures for All Levels of Government

Table VI-21 summarizes the findings of the all levels of government cost allocation analysis. At each of the three levels of government, equity ratios for 2000 are shown for each of the major vehicle classes. The equity ratios at each level of government are defined as the ratio of the share of user fee payments for each vehicle class at a specific level of government to the share of highway costs that vehicle class occasions for programs funded at that level of government.

A few important clarifications are necessary in order to interpret the findings summarized in Table VI-21:

1. The results at the Federal level differ slightly from those shown in more detail later in this chapter because they include only Federal programs funded from the HTF; whereas Table VI-21 includes all Federal obligations, i.e., all direct Federal construction and maintenance on Federal lands and Federal-aid to State and local governments, including Federal programs funded from sources other than the HTF.

Table VI-19. Illustrative Axle WDT Rates Under Scenario 6 (cents per mile)								
	Single Units			Combination Trucks				
RW (000s)	2-axles	3-axles	4+axles	3- & 4-axles	5-axles	6-axles	7-axles	9-axles
5	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
10	0.00	0.00	0.00	0.00	0.75	0.15	1.25	0.25
15	0.00	0.00	0.00	0.00	0.75	0.15	1.25	0.25
20	0.00	0.00	0.00	0.00	0.75	0.15	1.25	0.25
25	0.50	0.00	0.00	0.25	0.75	0.15	1.25	0.25
30	1.00	0.00	0.00	0.50	0.75	0.15	1.25	0.25
35	2.50	0.00	0.00	0.75	0.75	0.15	1.25	0.25
40	6.50	0.50	0.00	1.00	0.75	0.15	1.25	0.25
45	13.00	1.50	1.00	1.58	0.75	0.15	1.25	0.25
50	21.25	2.75	3.50	1.75	1.00	0.15	1.25	0.25
55	26.75	5.00	6.25	2.00	1.25	0.50	1.25	0.25
60	29.50	10.75	9.50	2.25	1.50	1.00	1.25	0.50
65	29.75	17.75	12.50	2.50	2.50	1.50	1.25	0.75
70	47.00	23.25	16.00	2.75	3.50	2.50	2.00	1.75
75		27.25	18.75	3.00	4.50	3.75	3.00	1.75
80		29.75	19.75	3.00	5.00	4.75	4.50	2.75
85			21.75	3.25	9.00	7.25	5.75	3.75
90			23.25	3.50	10.50	10.25	6.50	4.50
95			24.50		11.25	12.75	7.25	5.25
100			24.50		12.00	15.25	7.75	5.75
105						18.50	8.50	6.50
110						21.25	9.25	7.25
115						23.25	10.75	8.50
120						25.50	12.75	10.00
125							15.25	11.25
130							16.75	11.75
135							20.00	13.25
140								15.00
145								16.75
150								18.00

2. User revenues do not equal obligations or expenditures at any level of government, unlike the previous analysis based on the HTF, because all user revenues are included in this table, except Federal deficit reduction revenues, regardless of their use; and all highway expenditures (or obligations at the Federal level) are included regardless of their funding source. (Equity ratios are nonetheless equal to 1.00 at each level of government for all vehicles as a whole because equity ratios are defined as shares of user fee payments divided by shares of cost responsibility.)

Table VI-20. 2000 Ratios of User Charges to Allocated Costs by Vehicle Class Under Alternative Federal User Charge Structures							
Vehicle Class/Registered Weight	**Current Structure**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Autos	1.0	1.0	0.9	1.0	0.9	0.9	0.9
Pickups/Vans	1.4	1.4	1.3	1.4	1.3	1.3	1.3
Buses	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Total Passenger Vehicles	1.1	1.1	1.0	1.1	1.0	1.0	1.0
Single Unit Trucks							
≤25,000 pounds	1.5	1.6	1.7	1.5	1.4	1.2	1.2
25,001 - 50,000 pounds	0.7	0.7	0.8	0.7	0.8	1.0	1.0
> 50,001 pounds	0.5	0.5	0.5	0.5	0.9	1.0	1.0
Total Single Unit	0.9	0.9	1.0	0.9	1.1	1.0	1.0
Combination Trucks							
≤50,000 pounds	1.6	1.7	1.8	1.6	1.5	1.0	1.0
50,001 - 70,000 pounds	1.1	1.1	1.2	1.1	0.9	1.0	1.0
70,001 - 75,000 pounds	1.0	1.0	1.1	1.0	1.0	1.0	1.0
75,001 - 80,000 pounds	0.9	0.9	1.0	0.9	1.0	1.0	1.0
80,001 - 100,000 pounds	0.6	0.6	0.6	0.6	1.1	1.0	1.0
>100,001 pounds	0.5	0.5	0.5	0.6	1.1	1.0	1.0
Total Combinations	0.9	0.9	1.0	0.9	1.0	1.0	1.0
Total Trucks	0.9	0.9	1.0	0.9	1.0	1.0	1.0
Total All Vehicles	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Alternative 1 — Increase diesel differential by 1 cent
Alternative 2 — Increase diesel differential by 6 cents
Alternative 3 — Eliminate cap on HVUT
Alternative 4 — More progressive HVUT rate structure
Alternative 5 — WDT plus motor fuel in place of other truck taxes
Alternative 6 — Axle-WDT plus motor fuel in place of other truck taxes

3. At the State and local levels, the projected revenues are based on extrapolation of trends, as described in detail in Chapter IV, rather than on current tax rates, as assumed for the Federal level analysis. The State and local revenue projections imply trend increases in tax rates, and incorporate some shifts in the proportion of revenues from different sources.

4. Because State revenues and programs are larger than those of either of the other two levels of government, the State equity ratios have the greatest effect on the overall national equity ratios.

5. Because local HURs are only a small fraction of local expenditures, the local level equity ratios are a much less important component of overall equity ratios.

Vehicle Class	Federal	State	Federal and State	Local	All Levels of Government
Autos	0.9	1.0	1.0	0.1	0.7
Pickups and Vans	1.2	1.2	1.2	0.1	0.9
Buses	0.1	0.8	0.5	0.0	0.4
All Passenger Vehicles	1.0	1.0	1.0	0.1	0.8
Single Unit Trucks					
#25,000 pounds	1.4	2.2	1.9	0.1	1.5
25,001 - 50,000 pounds	0.6	1.0	0.8	0.0	0.6
>50,001 pounds	0.5	0.5	0.5	0.0	0.4
All Single Unit Trucks	0.8	1.2	1.1	0.1	0.8
Combination Trucks					
#50,000 pounds	1.4	1.7	1.6	0.1	1.3
50,001 - 70,000 pounds	1.0	1.3	1.1	0.1	0.9
70,001 - 75,000 pounds	0.9	1.1	1.0	0.1	0.8
75,001 - 80,000 pounds	0.9	0.9	0.9	0.1	0.8
>80,000 pounds	0.6	1.0	0.9	0.0	0.7
All Combinations	0.9	1.0	0.9	0.1	0.8
All Trucks	0.9	1.1	1.0	0.1	0.8
All Vehicles	0.9	1.0	1.0	0.1	0.8

Table VI-21. Ratios of 2000 User Fee Payments to Allocated Costs for All Levels of Government

NOTE: These equity ratios are based on total revenues and expenditures nationwide. Ratios for individual States and local governments are expected to vary from these ratios.

Table VI-21 shows that the ratio of highway user fees to highway-related expenditures/obligations is estimated to be 0.8 for all levels of government in 2000. Preceding analyses have assumed that 2000 obligations from the HTF will equal 2000 HTF receipts. Because the overall ratio of user fees to expenditures is different in this table than in others, the interpretation of ratios of user fees to cost responsibility for different vehicle classes is somewhat different, and ratios for all levels of government in Table VI-21 cannot be directly compared to ratios in other tables where overall user fees and highway-related expenditures are equal. As noted above, Federal obligations in this table are not limited to funds from the HTF, but also include highway-related obligations financed from the General Fund, principally highway construction by other Federal agencies. Because obligations exceed highway user revenues in this table, revenue-cost ratios at the Federal level are lower for all vehicle classes than in other tables in this report that only include highway programs funded from the HTF.

For Federal and State programs combined, passenger vehicles, single unit trucks, and combinations all pay approximately their share of highway-related costs in the aggregate. Single unit trucks as a group pay slightly more than their cost responsibility while combinations pay slightly less than their highway costs overall. As for previous analyses of Federal equity ratios, there are significant differences in revenue-cost ratios for vehicles at different weights.

Differences in Federal and State user fee structures lead to differences in revenue-cost ratios for specific vehicle classes at the two levels of government. For instance, single unit trucks as a group pay less than their share of highway costs at the Federal level, but more than their share of costs at the State level. Differences are particularly large for the lightest single unit trucks that pay 2.2 times their cost responsibility on average at the State level, but pay Federal user fees that are much closer to their cost responsibility. At both the Federal and State levels the heaviest single unit trucks pay only half their highway cost responsibility when all highway program costs are considered. Whereas at the Federal level the heaviest combinations, those over 80,000 pounds, pay only about 60 percent of total cost responsibility, at the State level those vehicles pay approximately their proportionate share of highway costs. The relatively good equity ratios at the State for combination trucks registered at over 80,000 pounds can be attributed to the fact that a few States have more carefully tailored their tax structure to reflect cost responsibility and allow combinations to operate over 80,000 pounds while charging user fees related to their cost responsibility. A few States regularly adjust their tax structures to reflect cost responsibility, and these States tend to focus equity comparisons on heavy vehicles and equity between trucks and competing modes of transportation.

Consideration of Social Costs of Highway Use in Assessing Federal User Fee Equity and Efficiency

The preceding discussion of potential changes to improve Federal user fee equity focused on options to more closely match user fees paid into the HTF by different vehicle classes to costs paid from the HTF that are attributable to those vehicle classes. The equity of the highway user fee structure has been a long-standing issue in HCASs at both the Federal and State levels, but recently there has been increasing interest in the economic efficiency of highway user fees. The earliest discussions of efficient highway pricing revolved around the potential for using congestion pricing to promote more efficient use of limited highway capacity. The discussion has been broadened to include air pollution, noise, and other external costs that highway users impose on others through their use of the highway.

To maximize net benefits to society of highway use, benefits of each trip should exceed the costs of the trip. The relevant costs that should be considered are variable costs that would not be incurred if the trip were not made. These costs include public costs of pavement deterioration and private costs imposed on others by the trip including delay, air and noise pollution, and safety costs. Most other public costs such as bridge, safety, and other infrastructure costs do not vary directly with the extent of highway usage and are not included with marginal costs. Since motorists typically do not consider pavement, environmental, and other external marginal costs in deciding whether or not to make their trip, there may be some trips made whose benefits do not exceed the costs, resulting in an inefficient utilization of resources.

The 1982 Federal HCAS examined the efficiency of Federal user fees by comparing user fees to marginal costs of highway use, including pavement, air pollution, noise, and congestion costs. Since there is no direct way to allocate marginal costs among different levels of government, the 1982 Federal HCAS estimated the share of total marginal costs that should be recovered at the Federal level as the share of total HURs that comes from Federal user fees. The reasoning was that this would maintain the same relative responsibility for financing highways among the different levels of government. This same approach is used in this study.

Overall marginal costs of highway use were estimated in Chapter V. The share of total HURs coming from Federal user fees is approximately 28 percent, so it is assumed that 28 percent of total marginal costs should be recovered at the Federal level to retain the same relative burden of financing highways by different levels of government. Coincidentally, this is the same percentage as was used in the 1982 HCAS.

Table VI-22 compares the Federal share of marginal highway costs with agency cost responsibilities of different vehicle classes in different operating environments and with estimated Federal user fee payments. As pointed out in Chapter V, congestion, air and noise pollution, and pavement deterioration vary geographically, so the marginal cost of a trip is different in rural areas than in urban areas. Furthermore, each of these costs varies according to the type of vehicle making the trip, so marginal costs must be estimated for different classes of vehicles. Agency costs also vary significantly depending on the type of vehicle and the highway system upon which that vehicle operates.

Table VI-22. 2000 Comparison of Assumed Federal Share of Marginal Highway Costs to Federal Agency Costs and Federal User Fees (cents per mile)

Vehicle Class/Highway Class	Marginal Costs	Federal Program Costs	Federal User Fees
Autos/Rural Interstate	0.5	0.3	0.6
Autos/Urban Interstate	2.5	1.4	0.6
40 kip 4-axle S.U. Truck/Rural Interstate	1.5	1.7	8.5
40 kip 4-axle S.U. Truck/Urban Interstate	8.4	3.7	8.5
60 kip 4-axle S.U. Truck/Rural Interstate	2.7	7.1	9.2
60 kip 4-axle S.U. Truck/Urban Interstate	14.9	12.7	9.2
60 kip 5-axle Comb*/Rural Interstate	1.8	2.7	6.4
60 kip 5-axle Comb*/Urban Interstate	9.2	6.7	6.4
80 kip 5-axle Comb*/Rural Interstate	4.5	7.8	6.9
80 kip 5-axle Comb*/Urban Interstate	18.2	17.5	6.9

Note: Marginal costs do not include air pollution costs

Table VI-22 shows that with the exception of automobiles, agency costs are higher than the estimated Federal share of marginal costs for rural travel by each of the vehicle classes. This reflects the fact that marginal costs of congestion, noise, and safety are relatively low in rural areas; overall agency cost responsibility in rural areas exceeds the sum of the marginal pavement costs plus these other marginal costs. In urban areas the opposite is true. Not only are the costs of congestion and noise higher in urban than rural areas, but marginal pavement costs also are higher, reflecting among other things the higher construction costs in urban areas. An addendum to this report will include marginal costs of air pollution.

For most vehicle classes, Federal user fees exceed marginal and agency costs in rural areas, but are less than those costs in urban areas. Thus vehicle operations in rural areas whose costs are less than therevenues they produce may be said to subsidize operations in urban areas. This is true whether the costs being considered are marginal costs or agency costs.

While Table VI-22 shows significant differences in marginal costs in rural and urban areas, it does not show the full range over which marginal costs vary in different areas. Table V-27 showed that marginal congestion costs for automobiles on 4-lane urban Interstates could vary from 0.1 cents per mile on low volume highways during off peak periods to over 20 cents per mile on high volume Interstates during peak periods. On the same high volume urban Interstate that had peak period congestion costs of 20 cents per mile, congestion costs during off-peak periods might be only about 3 cents per mile. Likewise, air and noise pollution on urban Interstate highways could vary widely depending on ambient conditions and other site-specific characteristics.

Evaluating whether specific user fee options improve overall economic efficiency is a complex process. The TRB Peer Review Committee outlined steps that would have to be taken to evaluate potential changes in economic efficiency associated with alternative highway user fees. Those steps, as discussed in the Peer Review Committee's second letter report, are as follows:

1. Specify one or more practical options for user fee systems.

2. Identify those highway user decisions that are sensitive to the economic incentives embodied in the tax options and that have important cost implications.

3. Estimate how highway user decisions would be affected by adoption of each user fee option in place of the existing system. A prediction of how highway users would respond to a fee change is the critical step of the efficiency analysis. (A complete analysis would also consider whether changing the fee system would create incentives that could influence highway agency investment and maintenance decisions.)

4. Estimate how the changes in behavior affect highway agency costs, user fee revenues, and external costs.

5. Compute the efficiency effect of the tax as the sum of the changes in benefits of freight services to shippers, consumers' surplus from personal travel, user fee revenue, highway agency costs, and costs to non-users. These quantities can be estimated from the results of the preceding steps.

The possibility of external benefits must also be considered in marginal cost pricing. To the extent that there are other beneficiaries of highway use whose interests are not considered by trip makers, analyses of negative externalities will overstate efficient highway user charges and may discourage highway use that results in a net benefit to society. There is disagreement on the relative importance of external benefits of highway use. However, the preponderance of expert opinion lies on the side of saying that nearly all of the benefits of highway use are internal in nature.

> "Social benefits of highway use could be considered to be without a significant external element. The amount of such benefits is very large; private expenditures associated with highway transportation accounted for 12.7% of GDP in 1991. ...However, these benefits could be considered to be fully absorbed by those making the decision to drive. For example, in the case of business-related travel, although greater mobility would increase the geographic scope of transactions, the total benefit associated with such transactions would accrue to the parties directly involved and would be reflected in the prices at which they trade. The increased scope of potential interactions would lead to a higher level of economic activity as more beneficial trades were made possible; however, these benefits would be the sum of benefits to all the individuals involved and would not appear to have a substantial element. The benefits of personal travel would be experienced directly by those making the choice, as well as their friends and family, and therefore could be considered to be largely internal."

Predicting how various users would respond to incremental changes in Federal fuel taxes would be relatively straight forward, but predicting responses to large changes would involve more uncertainty. Responses by various users to changes in other existing Federal user fees would depend on the nature of those changes. Small changes in the tire or vehicle excise taxes likely would not have significant effects on highway use, but large changes in those taxes could potentially affect equipment purchase decisions. Two illustrative options involving the HVUT were examined in earlier sections of this chapter. The first which would simply eliminate the cap on the existing tax while maintaining the same overall rate structure would affect only those vehicles registering over 75,000 pounds. The many combination vehicles registering at 80,000 pounds would be affected, but the annual increase in fees would be only about $100. Vehicles registering at heavier weights would pay a larger additional amount that could affect decisions by carriers on how they use their equipment. Rather than registering all of their vehicles at the heaviest allowable weight, some carriers might choose to segregate their fleet into vehicles that operate at heavier weights and those that operate at lighter weights. Depending on the type of operation this could affect the efficiency with which carriers use their equipment, but in no case would the decrease in efficiency be expected to be greater than the difference in tax rates for operations at heavier and lighter weights. The other HVUT option examined in this chapter changed the overall rate structure and applied different rates to single unit and combination trucks to more closely match the highway cost responsibility of different vehicle classes. This option resulted in higher HVUT rates that potentially could affect operational decisions by different carriers. High HVUT rates would provide an incentive for carriers to register and operate vehicles at lower weights if rates were high enough to offset the additional productivity achieved by heavier vehicles. This could tend to increase overall truck travel unless diversion to alternative modes were large enough to offset shifts to lighter vehicles. The magnitude of responses by different carriers would depend to a large extent on the actual HVUT rate structure.

A WDT would provide similar incentives to the HVUT in terms of changes in truck operations. The main difference is that it could reflect differences in the annual mileage traveled by different types of carriers. Low-mileage trucks likely would have a smaller increase in annual fees under a WDT than under the HVUT and thus effects on their operations might be smaller. Conversely, high-mileage carriers could have larger increases in their annual fees, creating a larger potential incentive for them to change their operations. An axle-WDT would provide incentives for carriers to switch to vehicles with more axles and thus could reduce marginal infrastructure costs without having as great an effect on productivity.

This discussion of potential impacts of user fee options on travel behavior and efficiency is necessarily very general; no specific user fee options were analyzed in this study and detailed analysis of industry impacts or institutional issues in implementing various types of user fee options was beyond the scope of this study.

In discussing issues surrounding efficiency changes associated with user fee options, the TRB Committee noted,

> ... a new tax that was intended to generate revenues equal to marginal costs on average but was not targeted to specific users and circumstances that actually generate costs (e.g., increasing the ¢/gal. gasoline tax rate by an amount intended to produce revenues equal to external costs of motor vehicle travel) might not contribute to efficiency. Such a tax could not necessarily be regarded as a solution to the problem of external costs. Another potential problem with attempting to evaluate highway user fees by comparing them to ideal, efficiency-based charges is that it may be a poor policy choice to impose a fee on one source of an external cost while ignoring other sources. For example, charging only transportation sources for air pollution probably would yield substantially lower net benefit than a policy that produced the same quantity of pollution reduction through charges to all sources.

Because of the geographical and temporal variability of congestion, and some other marginal costs, there is limited ability to target Federal user fees toward users contributing the most to marginal highway costs. Existing user fee structures generally are insensitive to the factors that lead to variations in marginal cost and developing new user fees at the Federal level that could capture variations in congestion and environmental costs would be difficult. Potential improvements to economic efficiency from changes in Federal user fees thus are more limited than improvements that could be realized through State and local fees that can be more closely targeted toward users that create the greatest marginal costs. Furthermore, unless other levels of government also implemented efficient pricing, only partial improvements in economic efficiency could be made using Federal pricing mechanisms.

In addition to the interest in estimating marginal costs of highway use for pricing purposes, there is considerable interest in estimating total costs and benefits of highway transportation for other purposes including (1) estimating the relative magnitude of various costs associated with highway transportation; (2) estimating how costs are changing over time, particularly in response to programs aimed at reducing those costs; and (3) evaluating overall costs and benefits of alternative public policies including investment and regulatory policies. A number of recent studies in the United States and Europe have attempted to calculate the full public and private costs of transportation. In addition to air pollution, noise, congestion, crash, and global warming costs, other costs included in various studies have been parking; energy security; solid waste; and water pollution, but these other costs are more difficult to quantify. While there is significant controversy concerning the association between highway use and these various costs and how information on these costs should be used, there is a general recognition that this information is useful for both project and program analysis. There also is a recognition among most analysts that benefits must be considered along with costs in making investment, regulatory, and pricing decisions. In July 1995, the Bureau of Transportation Statistics (BTS) sponsored a conference on measuring the full social costs and benefits of transportation. Proceedings of that conference are summarized in the BTS' 1996 Transportation Statistics Annual Report and papers presented at that conference currently are being compiled for publication. Social costs are discussed in more detail in Appendix E of this report.

Table VI-23 shows the estimated responsibility of different vehicle classes for major social costs of highways in 2000 and also indicates those costs that are borne in the first instance by highway users and those that are borne by others. Excluding air pollution costs, almost 90 percent of the total estimated social costs of $406 billion in 2000 are borne in the first instance by highway users, including almost $300 billion in crash costs and over $60 billion of congestion costs. Air pollution, noise, global warming, and some crash costs are not borne by highway users but by others in society. Crash costs included in this analysis are more comprehensive than those considered by the NHTSA in its Report, *The Economic Costs of Motor Vehicle Crashes, 1994*, in that they include costs of pain and suffering and other social costs that do not meet the strict "economic cost" criteria used by NHTSA for its report. The costs included, however, are consistent with general DOT policy regarding estimating costs of crashes.

Figure VI-13 summarizes the cost responsibility of different vehicle classes for noise, congestion, and crash costs. Passenger vehicles are responsible for about 93 percent of total costs in these three areas, but cost responsibilities vary significantly across the various impact areas. Combination trucks are responsible for approximately the same percentage of noise-related costs as automobiles.

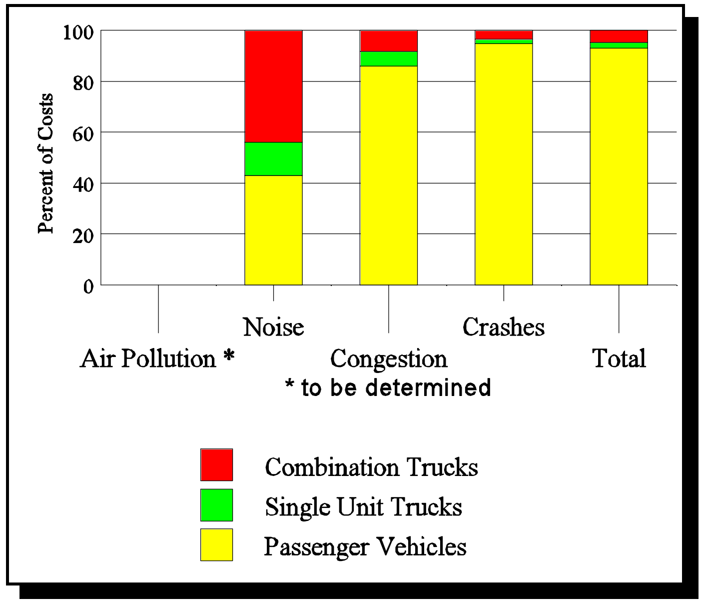

Figure VI-13. 2000 Responsibility for Various Social Costs of Highways

As noted above, there are considerable uncertainties surrounding valuation of these various social costs. The magnitude of even the low range of these social costs, however, suggests the importance for decision makers at every level of government and the private sector to find ways to reduce those costs. A tremendous amount has already been done on many fronts. Initiatives to reduce air pollution associated with highway travel are good examples. Automobiles are much less polluting now than they were 10 years ago. Manufacturers are making automobiles cleaner, inspection and maintenance programs in our most polluted metropolitan areas are keeping the cars cleaner, and highway fuels are cleaner as well. Significant efforts are underway in many metropolitan areas to provide alternatives to the single occupant automobile and to implement other programs to reduce highway-related emissions in recognition that they cannot rely solely on further improvements in vehicle technology to solve future air pollution problems. Highway users pay for these air quality improvement programs either through higher prices for cars and fuel or through their Federal, State, and local highway user fees.

Likewise, crash rates have been significantly reduced in recent years through a variety of programs focused on improving the safety of vehicles, drivers, and the roadways upon which they operate. Vehicle technology and aggressive improvements to reduce alcohol-related crashes have contributed to the reduced crash rates, but improvements to the highway have also had major impacts on crash and fatality rates. Crash rates on rural Interstate

Table VI-23. 2000 Responsibility for Social Costs of Highway Use ($ Millions)

Vehicle Class	Air Pollution	Noise	Congestion (borne by user)	Crashes		Total
				User	Non-User	
Automobiles	TBD	$1,397	$39,717	$201,445	$30,348	$272,907
Pickup and Vans	TBD	$420	$13,061	$77,195	$12,155	$102,831
Buses	TBD	$77	$304	$1,263	$197	$1,841
Single Unit Trucks	TBD	$582	$3,698	$4,769	$805	$9,854
Combination Trucks	TBD	$1,860	$4,981	$9,968	$1,741	$18,550
All Vehicles	TBD	$4,336	$61,761	$294,640	$45,246	$405,983

NOTE: Costs reflect use of middle range estimates. TBD - To Be Determined. Air pollution and revised total cost estimates will be included in an addendum to this report.

highways are less than half the rates on other principal arterial highways which in turn are safer than collector and local highways. Highway users have paid for technological advances in safety built into the automobile and have also paid for improvements in highway design that have made our highways safer over the years. The magnitude of the remaining crash costs, however, suggests that much more remains to be done to reduce highway crash costs.

Congestion is a tremendous burden on the Nation's productivity and everyone has a stake in reducing congestion, not the least of whom are highway users who bear congestion costs in the first instance. Like other social costs, congestion is being addressed on many fronts by all levels of government and the private sector. Congestion, air pollution, and safety are interrelated, and highway improvements to address one category of costs may also reduce other costs as well. The ITS hold great potential for reducing congestion, air pollution, and crash costs. The Department, in partnerships with State and local governments and the private sector, is aggressively pursuing deployment of near-term ITS technologies and services while continuing research, development, and testing of longer term strategies that hold even greater potential for improving the efficiency of the highway transportation system.

Significant efforts thus are already underway to mitigate air pollution, crash, noise, congestion, and other costs associated with highway transportation. Despite the extensive efforts mentioned above to reduce social costs through new technology, TSM, improved highway design, and other initiatives, a recurring question is whether Federal or State highway user fees should be increased as a form of pricing to help reduce highway travel and thereby reduce environmental, congestion, and other social costs. Fuel tax increases to reduce environmental costs have been proposed in the past, and several European countries justify high fuel taxes in part on the basis that they offset social costs of highway transportation. However, as noted above, an important question that has an ambiguous answer is whether such user fee increases would improve overall economic efficiency. Given the relative inelasticity of demand for travel with respect to the price of fuel, and the lack of alternative modes in many parts of the country, large increases in fuel taxes would be needed to realize significant changes in travel behavior. If imposed uniformly at the national level, such increases would fall equally on all travel, whether or not that travel was causing social costs. Furthermore, such general user fee increases could have substantial adverse impacts on productivity that could outweigh reductions in social costs that are actually achieved.

Clearly the more directly focused that user charges are on both the costs they are intended to reduce and on the highway users occasioning those costs, the more likely that fee increases could improve economic efficiency. Thus a WDT aimed at more closely matching the pavement damage caused by vehicles operating at different weights would be expected to improve efficiency more than an increase in fuel taxes or any other user fees that do not vary by both weight and distance traveled. Likewise, a locally imposed congestion toll that varies by time of day and traffic volume would be a more efficient way to reduce congestion costs than a general Federal or State fuel tax increases that is invariant with respect to time, traffic, or environmental conditions. Questions of the overall impacts of user fees on economic efficiency are beyond the scope of this study, and much more work would be needed to evaluate the many complex interactions at play that would affect answers to such questions. This study can evaluate, however, the types of user fee changes that could improve the overall equity of the highway user fee structure considering both agency and social costs.

Figure VI-14 shows that passenger vehicles have a relatively greater responsibility for social costs than for highway agency costs. Shares of cost responsibility for autos, pickups, and vans are higher for State and local highway programs than for the Federal highway program. Conversely, shares of cost responsibility of single unit and combination trucks are higher for the Federal program than for State and local programs.

Figure VI-15 compares shares of agency costs plus non-user social costs for each broad class of vehicles with that class' share of user fee payments at both the Federal level and for all levels of government. Total costs in Figure VI-15 include only social costs imposed on non-users, whereas Figure VI-14 also includes congestion and safety-related costs that users impose on other users of the highway system. Shares of agency and non-user social costs (excluding air pollution and global warming) attributable to auto, pickups and vans exceed the share of HURs those vehicle classes pay at both the Federal level and at all levels of government. Shares of agency and non-user social costs attributable to single unit and combination trucks on the other hand are less than the shares of HURs those vehicle classes pay at the Federal level and at all levels of government.

Summary

In the aggregate changes in Federal highway user fees enacted after the 1982 Federal HCAS and especially changes in the composition of the Federal highway program have made the overall Federal highway user fee structure somewhat more equitable than was found in the 1982 Federal HCAS. Costs for mass transit improvements and many transportation system enhancements that represent an increasing share of overall Federal obligations are largely the responsibility of passenger vehicles, and have shifted some of the overall Federal cost responsibility from heavy trucks to passenger vehicles. System preservation costs, for which heavy vehicles bear a large share of responsibility, still represent a large portion of total Federal obligations, however. The current Federal user fee structure cannot match increases in the cost responsibility of different vehicle classes with increasing weight. While in the aggregate many single unit and combination truck classes are paying approximately their share of highway costs, light trucks in most classes pay more than their share of total Federal highway costs while many heavy trucks pay much less than their share of cost responsibility.

The cost allocation analysis across all levels of government showed that in the aggregate highway agency costs exceed HURs. State

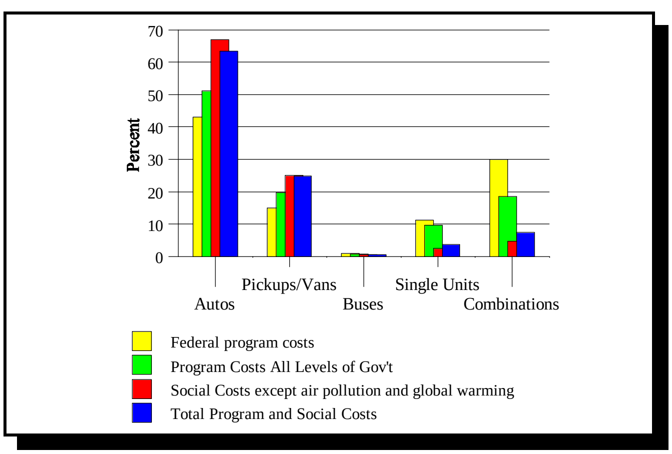

Figure VI-14. Highway Cost Responsibility by Vehicle Class

and local highway agencies supplement highway agency budgets with revenues from sources other than HURs, although some States dedicate portions of their HURs for non-transportation purposes. When shares of total HURs paid by broad vehicle classes are compared with total cost responsibility for construction, maintenance, operations, and other highway agency costs at all levels of government, equity ratios for those broad classes of vehicles are close to one.

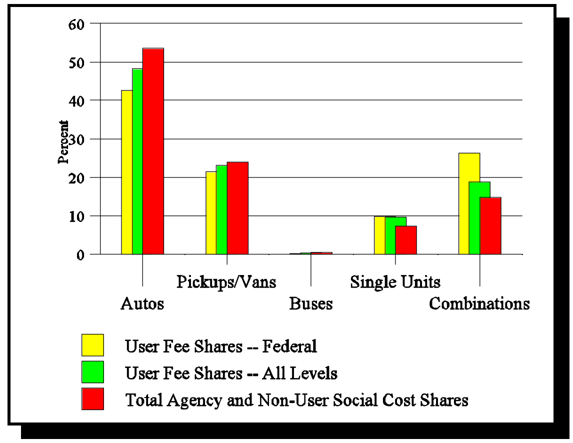

Figure VI-15. Comparison of 2000 User Fee and Cost Shares

In the aggregate, State user fee structures come closer to reflecting the cost responsibility of combination trucks operating over 80,000 pounds than does the Federal user fee structure. Not all States allow widespread operations of such heavy vehicles, but some that do have developed user fee structures that are able to closely reflect the cost responsibility of those very heavy vehicles. The HVUT which is the Federal tax that most closely reflects relationships between vehicle weight and cost responsibility currently has a cap of $550 that applies to all vehicles registered at 75,000 pounds or more.

Analyses of improvements in equity that could be achieved by eliminating the HVUT cap, modifying the overall HVUT rate structure, raising the diesel fuel tax rate, or imposing two different types of WDTs showed varying abilities to improve equity across vehicle classes (vertical equity) and equity among vehicles within the same class (horizontal equity). In general, changes to existing user fees have a larger effect on vertical equity than horizontal equity, and in some cases changes that improve one dimension of equity reduce another dimension. In particular, modifying the HVUT rate structure to make it correspond more closely to relationships between vehicle weight and highway cost responsibility would reduce the equity of the tax for vehicles that have different annual VMT. The two WDT options can produce greater improvements in equity than any of the modifications to existing user fees that were evaluated because they reflect both vehicle weight and annual mileage. Questions about administrative costs, evasion potential, and other implementation issues were not addressed specifically in this study, although a 1988 study of the feasibility of a national WDT evaluated such issues in detail.

In addition to costs borne by highway agencies, there are costs associated with highway travel that are borne by others. These external costs are substantially higher than highway agency costs. Agencies at all level of government have already taken large strides in reducing costs associated with highway crashes, air and noise pollution, and other external costs. Nevertheless, significant costs remain. One potential way to further reduce (but not eliminate) those costs is to charge users who are responsible for the costs. This idea has been examined in the most detail with respect to congestion costs, but it is applicable to air pollution, noise, and other costs as well. A key objective in charging users for these external costs is to improve overall economic efficiency -- to assure that benefits of each trip exceed the costs of the trip. Variations in many external costs by geographic location, time-of-day, and other factors make it difficult to impose a charge at the Federal level that would correspond with costs at particular locations. There is some interest in examining the feasibility of congestion pricing at the state and local level to manage demand on key highway facilities. Local pricing solutions hold the greatest potential for improving economic efficiency. Agencies at all levels of government, however, should examine the variety of opportunities to reduce social costs associated with highway transportation, while recognizing the benefits of highway transportation to the Nation's economy and to the quality of life of its citizens.

VII. Study Conclusions

Many factors that affect the equity and efficiency of the highway user fee structure have changed since the last Federal HCAS. User fees have been modified several times; the composition of the highway program has changed, especially with the dedication of Federal fuel taxes to support mass transit; and the use of the highway system for personal and freight transportation has changed. These changes are reflected in changes in the overall equity of the Federal highway user fee structure for the various classes of vehicles using the highway system. In general, the equity of highway user fees, as measured by ratios of Federal user fees paid by different vehicle classes to their shares of Federal highway-related costs, has improved since 1982.

Although under the current distribution of Federal-aid highway program expenditures the overall Federal user fee structure is more equitable than it was in 1982, inequities remain both across different vehicle classes and among vehicles within the same class. Many of the heaviest trucks continue to pay less than their share of highway costs while many light trucks, pickups, and vans pay more than their share of highway costs. At any given weight, trucks with more axles generally have lower cost responsibility and pay a larger share of their highway cost responsibility than trucks with fewer axles. The equity and efficiency of the highway user fee structure could be improved if each vehicle class more nearly paid the highway costs for which it is responsible.

The bulk of the analysis of user fee equity assumes that the distribution of Federal funds for different types of improvements in 2000 will be similar to the distribution in the 1993-1995 base period. Current budgetary limitations may preclude funding the Federal highway program at levels that would keep pace with traffic growth and the investment requirements to maintain the physical C&P of our highway system. In the long run more funds at all levels of government will have to be spent on system preservation to maintain the physical condition of the highway system. Greater Federal expenditures for system preservation could increase the overall cost responsibility of heavy trucks and result in those vehicles paying a smaller share of their highway cost responsibility than under the current program composition. On the other hand, more effective pavement and bridge management programs and expanded use of LCCA in making infrastructure investment decisions may help reduce long term system preservation costs. If a greater share of Federal funds were obligated for capacity enhancement, the relative cost responsibilities of different vehicle classes would remain about the same as they are today, but increased funding for mass transit and system enhancements would lower the overall cost responsibility of heavy trucks and increase costs for autos and light trucks. While effects on user fee equity should not be a factor in deciding the most desirable mix of program funding, once decisions are made on program composition, implications for user fee equity should be evaluated.

Six general user fee options were analyzed to assess the extent to which they could improve overall Federal user fee equity. This study did not, however, evaluate implementation issues associated with these user fee options such as administrative costs or potential industry impacts.

Several conclusions can be drawn about the types of user fee changes that could have the greatest impact on equity and efficiency. First, adding an additional penny to the diesel differential could reduce the underpayment by all heavy trucks, although little change is observable in overall equity ratios. Adding

6 cents per gallon to the diesel differential could improve equity ratios for all vehicle classes, but would not have as great an effect on correcting inequities among vehicles in the same class that register at different weights. The diesel tax is very good at reflecting differences in the amount of travel by various vehicles, but it does a poor job in reflecting differences in cost responsibility related to vehicle weight.

Eliminating the $550 cap on the HVUT that applies to all vehicles registered above 75,000 pounds would reduce an inequity in that tax that generally benefits heavy vehicles that generally have the greatest cost responsibility. This option would improve user fee equity for the largest heavy truck class -- tractor-semitrailers registering at 80,000 pounds -- and would have a larger impact on vehicles registering above 80,000 pounds, but its overall effect would be marginal. Changing the overall HVUT rate structure to reflect more closely differences in cost responsibility among different vehicle classes would further reduce inequities, not only for vehicles over 75,000 pounds, but also for heavy single unit trucks that as a group have some of the lowest equity ratios of any vehicle class. Large changes in a flat tax such as the HVUT, however, can adversely affect equity among vehicles having different annual VMT. The incidence of a flat tax such as the HVUT on a per mile basis can vary significantly among vehicles with different annual VMT while their cost responsibilities per mile may be very similar. If HVUT rates were increased substantially for the heaviest vehicles, improvements realized in equity across weight groups would be partially offset by increased inequities among vehicles that have different amounts of annual travel. But, of the potential changes to existing user fees that were investigated in this study, changes in the HVUT rate structure produce the greatest improvement in overall equity. The rate structure analyzed was designed to come as close as practical to equity, but lesser changes in HVUT rates also could reduce inequities in the Federal highway user fee structure.

Preliminary analyses of WDT options show that they could reduce inequities both across and within vehicle classes more than changes to existing user fees. Perfect equity cannot be achieved with any tax because of the many different vehicle configurations used to haul various commodities, but much of the inequity in the existing highway user fee structure could be reduced with a WDT because it can be calibrated to match the cost responsibility of different vehicle classes at different weights and operational characteristics. This is particularly true for an axle-WDT whose rates vary not only with gross weight, but also reflect differences in cost responsibility among vehicles with different numbers and types of axles.

The analysis of user fee alternatives conducted for this study was very limited, and was intended only to explore the relative improvements in equity that could be realized from several generic types of user fee options. Other options also could improve user fee equity and efficiency. The analysis of user fee options has not attempted to maintain strict revenue neutrality, but revenue neutrality might be a desirable feature of Federal user fee changes implemented to improve equity, especially during the current period of budget limitations. One method for achieving revenue neutrality would be to reduce the gasoline tax at the same time that rates for one or more truck taxes were modified to more closely reflect truck cost responsibilities.

Decisions that could significantly affect estimates of future highway cost responsibility will shortly be made. The first is reauthorization of the surface transportation programs. This study has assumed that the distribution of Federal program costs will be similar to the current distribution, but if major changes in the composition of the Federal highway and transit programs were made in reauthorization, these assumptions might no longer be valid and future distributions of highway cost responsibility could change significantly.

The second factor that could significantly affect decisions regarding potential Federal user fee changes to improve equity is the uncertainty regarding future TS&W policy. For analytical purposes, this study has assumed that TS&W policies will remain the same through 2000. If any changes in TS&W policy are examined during or following surface transportation reauthorization, cost recovery issues also should be examined. If significant changes in truck size and weight limits are implemented, user fee options, including the potential for significantly improving user fee equity through a national WDT, could be evaluated. Even in the absence of changes in TS&W policy, Congress may wish to consider potential benefits of a WDT or changes to existing Federal user fees that would improve equity.

There are limited opportunities to improve economic efficiency by reflecting external costs of highway transportation in Federal highway user fees. Marginal costs associated with additional trips by different classes of highway users were found to vary widely according to where trips are made. If users pay the full marginal cost of their travel, they will only make trips whose benefits exceed the costs of the travel, and economic efficiency will improve. If, however, users are charged too much for trips that entail few external costs, trips whose benefits exceed their real cost will not be made and economic efficiency will be reduced. A comparison of existing Federal user fees with marginal costs in different types of areas found that most vehicle classes pay at least as much in user fees as the estimated Federal portion of marginal costs in rural areas, but pay less than their marginal cost in urban areas. A complete assessment of potential efficiency gains that might be realized from changes in Federal user fees was beyond the scope of this study, but it appears unlikely that trying to charge users for external costs associated with their highway travel by increasing existing Federal user fees would improve economic efficiency. However, there are opportunities for improving economic efficiency through charges at the local level that reflect congestion, air pollution, and other external costs of highway use. Furthermore, there are opportunities to reduce external costs of highway transportation through highway improvement programs or regulatory actions that make highway transportation safer, reduce congestion, and contribute to reducing air pollution and other environmental impacts of highway use and operation. Through the CMAQ improvement program, funding for enhancements, and activities throughout the planning and project development processes for every highway project, significant progress has been made in reducing adverse highway impacts, improving highway safety, enhancing the Nation's productivity, and providing mobility for all segments of society.

More frequent cost allocation studies in the future would provide valuable information not only about user fee equity but also intermodal subsidy issues, changes in social costs of highway transportation, and other policy issues. Several States routinely update their HCASs every several years, and the same should be done for Federal cost allocation. Periodic updates would allow emerging issues to be analyzed in a timely fashion, much in the same way that the Department's C&P Report has considered emerging issues in recent years. Updating the Federal HCAS on a fixed schedule may not be necessary if factors affecting cost responsibility do not change, but the Department intends to update the cost allocation study more frequently than it has in the past, especially in connection with any proposed changes in the composition of the highway program, changes in TS&W policy, changes in highway user fees, or similar changes that could affect the equity or efficiency of the Federal highway user fee structure.