Highway Cost Allocation Study 2009-2011 Biennium

Prepared for
Oregon Department of Administrative Services,
Office of Economic Analysis

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Summary of Major Findings

The 2009 Oregon Highway Cost Allocation Study finds that:

- Light vehicles (those weighing 10,000 pounds or less) paying full fees should pay 67.1 percent of state highway user revenues, and heavy vehicles (those weighing over 10,000 pounds) paying full fees should contribute 32.9 percent during the 2009-11 biennium.

- For the 2009-11 biennium and under existing, current law tax rates, it is projected full-fee-paying light vehicles will contribute 66.5 percent of state highway user revenues and full-fee-paying heavy vehicles, as a group, will contribute 33.5 percent.

- The calculated equity ratios for full-fee-paying vehicles, defined as the ratio of projected payments to responsibilities for the vehicles in each class, are 0.9915 for light vehicles and 1.0173 for heavy vehicles as a group. This means that, under existing tax rates and fees, light vehicles are projected to underpay their responsibility by 0.8 percent. Heavy vehicles, as a group, are projected to overpay their responsibility by 1.7 percent during the next biennium.

- The equity ratios for the individual heavy vehicle weight classes show some classes are projected to overpay and some to underpay their responsibility during the 2009-11 biennium. Chapter 7 of this report offers alternative fee schedules that would minimize this cross-subsidization of some heavy vehicle weight classes by others.

- The reduced rates paid by certain types of vehicles, principally publicly owned and farm vehicles, mean these vehicles are paying lower per-mile charges than comparable vehicles subject to full fees. The difference between what these vehicles are projected to pay and what they would pay if subject to full fees represents a cost that is borne by all other highway users.

2009-11 Oregon Highway Cost Allocation Study

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Chapter 1

Introduction and Background

COST RESPONSIBILITY IS THE PRINCIPLE that those who use the public roads should pay for them and, more specifically, that users should pay in proportion to the road costs for which they are responsible. Cost responsibility requires each category of highway users to contribute to highway revenues in proportion to the costs they impose on the highway system. Cost allocation is the process of apportioning the cost of highway work to the vehicles that impose those costs, and is therefore necessary for the implementation of the cost responsibility policy of the State of Oregon.

For over 60 years, Oregon has based the financing of its highways on the principle of cost responsibility. This tradition has served Oregon well over the years by ensuring that the state's highway taxes and fees are levied in a fair and equitable manner. Periodic studies have been conducted to determine the "fair share" that each class of road users should pay for the maintenance, operation, and improvement of the state's highways, roads, and streets. Prior to the present study, 15 such studies had been completed; the first in 1937, the most recent in 2007.

Oregon voters ratified the principle of cost responsibility in the November 1999 special election by voting to add the following language to Article IX, Section 3a (3) of the Oregon Constitution:

"Revenues . . . that are generated by taxes or excises imposed by the state shall be generated in a manner that ensures that the share of revenues paid for the use of light vehicles, including cars, and the share of revenues paid for the use of heavy vehicles, including trucks, is fair and proportionate to the costs incurred for the highway system because of each class of vehicle. The Legislative Assembly shall provide for a biennial review and, if necessary, adjustment, of revenue sources to ensure fairness and proportionality."

Purpose of Study

The purpose of this 2009 Oregon Highway Cost Allocation Study (HCAS) is to

(1) determine the fair share that each class of road users should pay for the maintenance, operation and improvement of Oregon's highways, roads and streets, and

(2) recommend adjustments, if necessary, to existing tax rates and fees to bring about a closer match between payments and responsibilities for each vehicle class.

Past Oregon Highway Cost Allocation Studies

Oregon, more than any other state, has a long history of conducting highway cost allocation or responsibility studies and basing its system of road user taxation on the results of these studies. Studies were completed in 1937, 1947, 1963, 1974, 1980, 1984, 1986, 1990, 1992, 1994, 1999, 2001, 2003, 2005, and 2007. As noted above, the Oregon Constitution now requires a study be conducted biennially and highway user tax rates be adjusted, if necessary, to ensure fairness and proportionality between light and heavy vehicles.

Prior to 1999, Oregon used the terminology “cost responsibility studies,” while the federal government and most other states called their studies “cost allocation studies.” Oregon has now adopted the more conventional terminology, although the two terms are essentially equivalent and used interchangeably in this report.[1]

In this and all prior studies, highway users and other interested parties have been given the opportunity to offer their input in an open and objective process. During the 1986 Study, for example, three large public meetings were held to provide information on the study and solicit the input of all user groups.

As part of the 1994 study process, a Policy Advisory Committee was formed to address several cost responsibility issues that arose during the 1993 legislative session. This committee consisted of 12 members including a representative of AAA Oregon and five representatives of the trucking industry. The committee held six meetings devoted to understanding and recommending policies for the 1994 Study as well as future Oregon studies.

In 1996, the Oregon Department of Transportation (ODOT) formed the Cost Responsibility Blue Ribbon Committee to evaluate the principles and methods of the Oregon cost responsibility studies and, if warranted, recommend improvements to the existing methodology. This eleven-member committee was chaired by the then Chairman of the Oregon Transportation Commission and included representatives of the trucking industry, AAA Oregon, local governments, academia, and Oregon business interests. The committee held a total of seven meetings and reached agreement on a number of recommendations for future studies. Since the trucking industry, in some cases, did not agree with the full committee recommendations, it was given the opportunity and elected to file a Minority Report that was included in the committee report.

All studies prior to 1999 were conducted by ODOT staff. In February 1998, the ODOT and Oregon Department of Administrative Services (DAS) Directors reached agreement to transfer responsibility for the study from ODOT to DAS. The 1999, 2001, 2005, and 2007 studies, as well as the current study, were conducted by consultants to the DAS Office of Economic Analysis. ODOT’s role in these studies was to provide technical assistance and most of the data and other required information. In the 2003 study, ODOT conducted the study using the model developed for the 2001 study.

The Oregon studies prior to 1999 relied on an internal technical advisory committee to provide the expertise and some of the many data elements required for the studies. As noted, highway users and other interested parties were also provided the opportunity to offer their input as the studies were being conducted. For the 1999 and subsequent studies, DAS formed a Study Review Team (SRT) to provide overall direction for the studies. The SRT’s role has been to provide policy guidance and advisory input on all study methods and issues.

The SRT for the 2001 Study consisted of ten members and the SRTs for the 2003 and 2005 studies had eight members. The SRT for the 2007 study and the present study again consisted of ten members. The composition of the SRT has changed from study to study, but all have included motorist, trucking industry and Oregon business representatives, academics, and

[1] It should be noted that to be precise, neither term is technically correct. Since all state studies, including Oregon’s, have to this point allocated expenditures rather than actual costs imposed, they are really “expenditure allocation” studies.

state officials. All SRTs have been chaired by the State Economist. ODOT did not have a representative on the 1999 SRT but was represented on the SRTs subsequent studies.

Other Highway Cost Allocation Studies

Although Oregon has the longest history of conducting highway cost allocation studies, a number of other states also have conducted such studies. The majority of those have been completed over the past two decades. Since the first HCAS, 32 states have performed at least 84 cost allocation studies. Since the late 1970s, 30 states have conducted such studies.

The interest of other states in undertaking these studies has, in many cases, been sparked by the completion of similar studies by the federal government. Several states undertook studies following the release of the 1982 Federal HCAS. With the release of the 1997 Federal HCAS and the Federal Highway Administration's (FHWA) interest in helping states do their own studies, there has again been a renewed interest among the states. Upon completion of the 1997 Federal Study, FHWA formed a state representatives' Steering Committee to assist the states in adopting the research and methods employed in that study.

A 1996 Oregon Legislative Revenue Office report concluded most of the differences in study results among states can be explained by differences in the types of expenditures that are allocated.[2] Oregon, for example, includes no state police expenditures in its studies because, since 1980, state police do not receive Highway Fund monies. California, on the other hand, includes large Highway Patrol expenditures in its studies. Since policing expenditures are typically viewed as a common responsibility of all highway users and are assigned to all vehicle classes on the basis of each class's relative travel, they are predominantly the responsibility of automobiles and other light vehicles. Therefore, it is not surprising the California studies find a higher light and lower heavy vehicle responsibility share than the Oregon studies.

A review of state studies conducted in connection with the 1997 Federal Study found those studies attempting to clearly allocate costs between light and heavy vehicle classes have commonly found heavy vehicles to be responsible for 30 to 40 percent of total highway expenditures. The past several Oregon studies have produced results in this range. Both the 1982 and 1997 Federal HCASs found trucks and other heavy vehicles to be responsible for 41 percent of federal highway expenditures.[3]

Oregon Road User Taxation

Oregon's constitutionally dedicated State Highway Fund derives most of its revenue from three major highway user taxes: vehicle registration fees, motor vehicle fuel taxes (primarily the gasoline tax), and motor carrier fees (primarily the weight-mile tax). The basis of each of these taxes is governed by the concept of cost responsibility. This three-tiered structure is used to collect a fair share of revenue from each highway user class.

Road user taxes were initially levied against motor vehicles to cover the cost of registration. A one-time fee of $3 was

[2] "Oregon Cost Responsibility Studies Compared to Other States," Legislative Revenue Office Research Report #4-96, September 10, 1996.

[3] It should be noted, however, that the results of the federal studies are not directly comparable to those of state studies. The reasons are that highway maintenance is largely a state funded activity and so not included in the federal studies, and the heavy vehicle responsibility share is generally lower for most maintenance activities than for construction, particularly major rehabilitation projects. Therefore, the responsibility for federal expenditures will typically be more weighted toward heavy vehicles than is the case for state expenditures.

instituted in 1905. Since this proved to be a productive source of revenue, the state soon annualized the fee and began to increase the rates and used the proceeds to finance highways.

The registration fee is considered payment for the fixed or non-use related costs of providing a highway system. These costs include minimal maintenance of facilities and equipment along with certain administrative functions necessary to keep the system accessible. Since these costs account for a small portion of total highway costs, registration fees in Oregon have traditionally been low (for both cars and trucks) in comparison to the corresponding fees in most other states. From 1990 to 2003, the registration fee for automobiles and other vehicles weighing 8,000 pounds or less was $30 biennially. It currently is $54 biennially.

The second tier in the Oregon system is the fuel tax. In 1919, Oregon became the first state in the nation to enact a fuel tax on gasoline. It was regarded as a "true" road user tax since those who used the roads more paid more. The fuel tax came to be viewed as the most appropriate means of collecting the travel-related share of costs for which cars and other light vehicles are responsible.

The state fuel tax was extended to diesel and other fuels in 1943. Since that time, the tax on diesel and other fuels, referred to as a "use fuel" tax, has been at the same rate per gallon as the tax on gasoline. Oregon's fuel tax rate is $0.24 per gallon. It was last increased in 1993.

The third tier in the Oregon highway finance system is the weight-mile tax. Oregon's first third-structure tax was put into effect in 1925 in the form of a ton-mile tax. It was used to cover the responsibility of the growing number of trucks and other heavy vehicles appearing on the public roadways at that time.

Oregon's first weight-mile tax was enacted in 1947 and implemented in 1948. The tax applies to all commercial motor vehicles with declared gross weights in excess of 26,000 pounds. It is based on the declared weight of the vehicle and the distance it travels in Oregon. The weight-mile tax is a use tax that takes the place of the fuel tax on heavy vehicles. Vehicles subject to the weight-mile tax are not subject to the state fuel tax.

The Oregon weight-mile tax system consists of a set of schedules and alternate flat fee rates. There are separate schedules for vehicles with declared weights of 26,001 to 80,000 pounds and those over 80,000 pounds. Additionally, log, sand and gravel, and wood chip haulers have the option to pay flat monthly fees in lieu of the mileage tax.

Since 1990, carriers hauling divisible-load commodities at gross weights between 80,001 and 105,500 pounds pay a weight-mile tax (statutory Table "B") based on the vehicle's declared weight and number of axles. There are separate schedules for five, six, seven, eight, and nine or more axle vehicles with each schedule graduated by declared weight. The rates are structured so that, at any declared weight, carriers can qualify for a lower per-mile rate by utilizing additional axles.

Also since 1990, carriers hauling non-divisible loads at gross weights in excess of 98,000 pounds under special, single-trip permits pay a per-mile road use assessment fee. Non-divisible (or "heavy haul") permits are issued for the transportation of very heavy loads that cannot be broken apart such as construction equipment, bridge beams, and electrical transformers.

The road use assessment fees are expressed in terms of permit gross weight and number of axles and are currently based on a charge of 5.7 cents per equivalent single axle load (ESAL[4]) mile of travel. As with the Table "B" rates, carriers are assessed a lower per-mile

[4] An ESAL is equivalent to a single axle carrying 18,000 lbs. (80kN).

charge the greater the number of axles used at any given gross weight. The road use assessment fee takes the place of the weight-mile tax for the loaded, front-haul portion of non-divisible load trips. With rare exceptions, empty back haul miles continue to be subject to the weight-mile tax and taxed at the vehicle's regular declared weight.

In the years since 1947, the weight-mile rates have been adjusted 14 times based on the results of updated cost responsibility studies. The most recent revision occurred on January 1, 2004 when the 2003 Legislature increased weight-mile rates by approximately 9.9% when enacting OTIA-3. Prior to 2004, on September 1, 2000 rates were reduced across-the-board by approximately 12.3 percent to reflect the results of the 1999 Study. The rates were also reduced by 6.2 percent on January 1, 1996 based on the results of the 1994 Study. The last time the rates were increased was January 1, 1992, when they were increased to maintain equivalency with the fuel tax increases enacted by the 1991 Legislature.

The 1999 Oregon Legislature repealed the weight-mile tax and replaced it with a 29 cent per gallon diesel fuel tax and substantially higher heavy truck registration fees. This measure, House Bill 2082, was subsequently referred to the voters and defeated in the May 2000 primary election.

After the May 2000 vote, the trucking industry challenged the Oregon tax in the courts. The primary focus of the legal action was the feature that allows haulers of logs, sand and gravel, and wood chips to pay alternate flat fees in lieu of the mileage tax. The industry argued these fees are, from a practical standpoint, available only to Oregon intrastate motor carriers, and this provision of the Oregon system therefore unfairly discriminates against non-Oregon based interstate firms. In February 2002, the Third District Circuit Court ruled in favor of the State in the lawsuit. The ruling was reversed in the Court of Appeals in 2003. The Oregon Supreme Court affirmed the original Circuit Court decision in December 2005.

Organization of this Report

This volume of the 2009 Study provides an overview of the study issues, methodology, and results as well as recommendations for future studies. There are a number of exhibits throughout this report to illustrate specific data. Please note that amounts shown are rounded and may not total exactly.

This chapter has provided an introductory discussion of the purpose, scope, and process of the 2009 Study as well as a brief background discussion of the history of Oregon highway cost allocation studies, studies by the federal government and other states, and the evolution of Oregon road user taxation.

Chapter 2 briefly summarizes the basic structure and parameters of the 2009 Study including the analysis periods, road (highway) systems, vehicle classes, revenues attributed, and expenditures allocated to the vehicle classes.

Chapter 3 presents the general methodology and approach used for the study. It includes a description of the special analyses conducted for the study and discussion of the major methodological and procedural changes from previous Oregon studies.

Chapter 4 summarizes the data and forecasts used in the study, and compares them to the data and forecasts used in recent studies.

Chapter 5 presents the study expenditure allocation and revenue attribution procedures and results, and compares the methods and results to those of previous Oregon studies.

Chapter 6 brings together the expenditure allocation and revenue attribution results from the previous chapter to develop ratios of projected payments to cost responsibilities for light vehicles and the detailed heavy vehicle weight classes. It also compares these ratios to those from the prior two Oregon studies.

Chapter 7 contains recommendations for changes in existing tax rates and fees to bring about a closer match between revenues contributed and cost responsibilities for each vehicle class.

The Appendices to this report include:

A. Glossary of terms;
B. A set of Issue Papers developed for this study;
C. The agenda and minutes of each of the SRT meetings;
D. Model description and detailed documentation of the model.

Basic Structure and Parameters of Study

THE UNDERLYING APPROACH AND METHODS used in this study are, with a few significant exceptions, similar to those used in the last four Oregon studies. The analytic framework and basic parameters of the 2009 Study are briefly summarized below.

Study Approach and General Methodology

This study uses the cost-occasioned approach, employing an incremental, design-based allocation methodology for bridges and the National Pavement Cost Model (NAPCOM) for pavement costs. This is the same general approach as was used in previous Oregon studies and virtually all studies conducted by the federal government and other states.

Analysis Periods

Base Year: Calendar Year 2007, the most recent full year for which data was available when the study was undertaken (2008).

Forecast Year: Calendar Year 2010, the middle 12 months of the 24-month study period.

Study Period: The 2009-11 State Fiscal Biennium, or July 1, 2009 to June 30, 2011.

The expenditures allocated are those projected for the 2009-11 biennium using ODOT's Cash Flow Forecast model. All traffic data used in the study were first developed from data for the 2007 base year, and then projected forward to the 2010 forecast year using weight-class-specific growth rates.

Road (Highway) Systems

This study uses the Federal Highway Administration's classification system for highway functional classes. Every public road in Oregon is assigned to one of 12 functional classes:

1. Rural Interstate
2. Rural Other Principal Arterial
3. Rural Minor Arterial
4. Rural Major Collector
5. Rural Minor Collector
6. Rural Local
7. Urban Interstate
8. Urban Other Freeway
9. Urban Other Principal Arterial
10. Urban Minor Arterial
11. Urban Collector
12. Urban Local

Each roadway segment also is assigned to one of four ownership categories: state, county, city, or federal. Note that US Highways and Interstates are owned by the state; federal ownership consists mostly of Forest Service and Bureau of Land Management roads.

In addition to the 12 federal functional classes, we developed three additional categories of our own to facilitate the allocation of costs for projects on multiple functional classes or where the functional class was not known. Those additional categories are: all roads, all state-owned roads, and all locally-owned roads.

Vehicle Classes

Light, or basic, vehicles include all vehicles up to 10,000 pounds gross weight, consistent with Oregon law and registration fee schedules. In previous studies, light vehicles were defined as all vehicles up to 8,000 pounds.

Vehicles weighing over 10,000 pounds are divided into 2,000-pound vehicle classes. All vehicles over 200,000 pounds are in the top weight class. Those over 80,000 pounds are further divided into subclasses based on the number of axles on the vehicle. The five subclasses are five, six, seven, eight, and nine or more axles.

Vehicles over 26,000 pounds are assigned to weight classes based on their declared weight, which may be different from their registered gross weight. For example, a given tractor may operate with different configurations (number and type of trailers) at different times, and may have different declared weights for different configurations.

For modeling purposes, each weight class under 80,000 pounds is assigned a distribution of numbers of axles, and each combination of weight class and number of axles is assigned a distribution of operating weights. For vehicles over 26,000 pounds, these distributions are obtained from Special Weighings data supplied by ODOT.[1]

For reporting purposes, the expenditure allocation and revenue attribution results reported in Chapters 5 and 6 are presented in terms of the following seven summary-level vehicle weight groups:

1 to 10,000 pounds
10,001 to 26,000 pounds
26,001 to 78,000 pounds
78,001 to 80,000 pounds
80,001 to 104,000 pounds
104,001 to 105,500 pounds
105,501 pounds and up

In this study, weight classes between 26,001 and 78,000 have been combined into a single group. The only other variation in these groupings from those used in the 2001, 2003, and 2005 Oregon studies is an increase in the upper weight limit for the lightest weight class to 10,000 pounds (from 8,000 pounds), the same groupings used in the 2007 study. One- to 8,000-pound vehicles accounted for 92.2 percent of vehicle miles traveled in Oregon in 2005; one- to 10,000-pound vehicles account for 92.5 percent.

The various weight classes were selected on the basis of the characteristics of the vehicles in each group, logical divisions in the tax structure, and the number of vehicles and miles in each group. Operators of vehicles in the 10,001 to 26,000 pound group, for example, pay the state fuel tax and higher registration fees rather than the weight-mile tax. Additionally, a large majority of these vehicles are two-axle, single-unit trucks or buses used in local commercial delivery operations or passenger transport. Thus, they have relatively similar characteristics with respect to their cost responsibility and tax payments, and it is therefore logical to combine them for reporting purposes.

Similarly, it makes sense to combine the individual weight classes above 105,500 pounds because these vehicles are: (a) operated under special, single-trip, non-divisible load permits, (b) operated with multiple axles and legally allowed higher axle weights than regular commercial trucks, (c) subject to the road use assessment fee rather than the weight-mile tax for their loaded front haul miles, and (d) typically used for short-mileage hauls (e.g., transporting heavy equipment from one construction site to another) and so account for a very small proportion of total truck miles in the state.

[1] During a special weighing, every truck passing the weigh station is weighed and the weight recorded, even if the truck is empty.

The weight classes of 78,001 to 80,000 and 104,001 to 105,500 pounds are by far the largest two truck classes by miles of travel. These two classes alone account for a majority of the total commercial truck miles in Oregon. Because of the dominant role of these two classes in terms of miles of travel, cost responsibilities, and revenue contributions, it is logical they be kept as separate groups.

Expenditures Allocated

State Expenditures

All state expenditures of highway user fee revenues are allocated, as are all state expenditures of federal highway funds (e.g., matching funds). Federal funds are included because they are interchangeable with state user fee revenues. Any differences in the way they are spent are arbitrary and subject to change.

State expenditures of bond revenues are included because the bonds are repaid from state user fees. Such expenditures are, however, reduced to the amount that will be repaid in the study period before these expenditures are allocated. The remaining expenditures will be included in future studies using the allocation to vehicle classes applied in this study, consistent with the approach taken in the 2005 and 2007 studies. Thus, expenditures of bond revenues in the last study will be included in this and the next eight studies.

Local Government Expenditures

The study allocates all expenditures by local governments of state highway user fees and of federal highway funds. Federal funds are included because, again, they are interchangeable with state user fee revenues.

Some local-government own-source revenues are allocated because they are interchangeable with state highway user fees. The study excludes local-government own-source revenues reported as coming from locally-issued bonds, property taxes (including local improvement districts), systems development charges, and traffic impact fees. These revenue sources generally must be spent on certain projects or certain types of projects, and are not considered interchangeable with state highway user fees.

In studies prior to 2003, only the expenditures of state highway user fee revenues were allocated. This approach failed to account for the interchangeability of funds from other sources, and required local governments to estimate how state funds were spent because their accounting systems do not track expenditures by funding source.

In the 2003 study, all expenditures by local governments were allocated. The 2005 study refined the approach taken in the 2003 study by excluding certain categories of own-source revenue that generally are not interchangeable.

Expenditure Categories

The four major expenditure categories are:

- **Modernization (new construction or reconstruction).** Examples include adding lanes and straightening curves. Modernization generally adds to the capacity of a roadway either directly or by improving the throughput of a facility. A replacement bridge with more lanes than the bridge it replaces is considered modernization.
- **Preservation (rehabilitation).** Most preservation projects involve repaving existing roads. Preservation projects extend the useful life of a facility, but generally do not add to its capacity. A replacement bridge that does not add capacity is considered preservation.

- **Maintenance and Operations.** Examples of maintenance include pothole patching, pavement striping, snow and ice removal, and maintaining bridges. Examples of operations include traffic signals and signage.
- **Administration, Collection, Planning and Other Costs (everything else).**

Within each of these major categories, expenditures are further broken down into a number of individual work types. Maintenance and Operations, for example, includes 16 individual work types. A separate allocation is performed for the expenditures in each individual work type. Chapter 3 contains a full listing of these work categories and the allocators used for each.

Revenues Attributed

The revenues attributed to vehicles are based on forecast collections for the 2009-11 biennium by major state revenue source under the existing tax structure and current-law tax rates (i.e., current registration and title fees, 24 cent per gallon fuel tax rate, current weight-mile tax, flat fee, and road use assessment fee rates).

Because non-State funding sources are included among the expenditures allocated, the dollar amount of revenues allocated is considerably smaller than the dollar amount of expenditures allocated. This difference in absolute size does not, however, affect the calculation of equity ratios, which are ratios of ratios (each vehicle class's share of attributed revenues divided by its share of allocated expenditures).

Chapter 3

General Methodology and Study Approach

This chapter presents the general methodology and approach used in the 2009 Oregon Highway Cost Allocation Study.

Cost-Occasioned Approach

All Oregon highway cost allocation studies, as well as the studies conducted by the federal government and most other states, use what is called the "cost-occasioned approach". The basic premise of this approach is that each class of road user should pay for the system of roads in proportion to the costs associated with road use by that class. The equity of a road tax system may then be judged by how well shares of payments by different classes of road users match their shares of costs resulting from their use of the road system.

The principal alternative to the cost-occasioned approach is the benefits approach, in which an attempt is made to identify and measure the benefits received by both users and nonusers of the system. The benefits approach begins with the recognition that the purpose of a highway system is to provide benefits, both directly to highway users and indirectly to the rest of society. Basing user fees on the value of benefits received, rather than the costs imposed, would promote both fairness (people pay in proportion to the value they receive) and efficiency (agencies would have less incentive to build facilities where the costs exceed the benefits). The benefits approach has two major drawbacks: benefits are not directly measurable, and the benefits associated with traveling a mile on a given road can vary greatly between identical-appearing vehicles or individuals, and for the same vehicle or person at different times.

A long-running debate about the proper balance of cost responsibility and tax burden between highway users and non-users continues at both the state and federal levels, fueled over the years by numerous studies. Arguments that support charging nonusers for highways are based on the societal benefits attributable to the highway system, including increased mobility, safety, and economic development. There are, however, some serious conceptual problems in quantifying benefits and deciding which accrue to users and which accrue to nonusers. In many cases, highway improvements benefit individuals or businesses simultaneously as both users and nonusers. Additionally, the more readily-understood economic impacts of highway improvements often reflect a transfer of user benefits to nonusers—the clearest example being reduced shipping costs, which are passed to businesses and consumers in the form of lower product prices.

Because of these problems, and because of the inherent advantages of user fees in promoting an economically efficient allocation of scarce resources, the federal government and most states conducting cost allocation studies now rely on a cost-occasioned approach to determine responsibility for highways. The Oregon studies continue to use a cost-occasioned approach.

Incremental Method

Within the cost occasioned approach, different methods may be used to allocate costs or expenditures to the various vehicle classes. Virtually every recent study, including Oregon's, has used some version of what is referred to as the incremental method. This method divides selected aspects of highway costs into increments, allocating the costs of successive increments to only those vehicles needing the higher cost increment. The design considered adequate for light vehicles only is viewed as a common responsibility of all highway users and shared by all vehicle classes. Each group of successively larger and heavier vehicles also shares in the incremental costs they occasion.

In Oregon, the incremental method is used directly in the allocation of bridge costs. The first increment for a new bridge, for example, identifies the cost of building the bridge to support its own weight, withstand other non-load-related stresses (e.g., stream flow, high winds and potential seismic forces), and carry light vehicle traffic only.[1] This cost is a common responsibility of all vehicles and assigned to all classes on the basis of each class's share of total vehicle miles traveled (VMT). The second increment identifies the additional cost of building the bridge to accommodate trucks and other heavy vehicles weighing up to 50,000 pounds. This cost is assigned to all vehicles with gross weights exceeding 10,000 pounds on the basis of the relative VMT of each class over 10,000 pounds. Similarly, the additional cost of the third increment is assigned to all vehicles with gross weights over 50,000 pounds, and the cost of the fourth and final increment to vehicles having gross weights over 80,000 pounds.

National Pavement Cost Model (NAPCOM)

In the past, highway cost allocation studies typically used an incremental methodology to allocate pavement costs as well. Increased depth and strength of pavement surface and base is required to support increases in the number, and particularly weight, of the vehicles anticipated to use the pavement during its design life.

For the 1997 federal study, Roger Mingo adapted the National Pavement Cost Model (NAPCOM) for use in highway cost allocation. The model still has two increments: non-load-related costs and load-related costs, but the load-related costs are allocated using results from detailed engineering models of several different pavement degradation mechanisms that take into account the effects of climate, traffic levels, mix of vehicle types, and the interactions between different mechanisms. Mingo adapted the pavement model to use Oregon's special weighings data[2] and to use 2,000-pound increments of declared vehicle weight for data input and results reporting.

[1] The factors influencing the design requirements, and therefore costs of bridges, are sometimes expressed by the terms "dead load," "live load," and "total load." Bridges need to be designed to support their own weight and the other non-load-related forces such as stream flow, wind, and seismic forces (the dead load) plus the traffic loadings anticipated to be applied to the bridge (the live load). The total design load is the sum of the dead and live loads. Although the precise relationships differ by the type and location of bridge under consideration, as a general rule the longer the span length, the greater the relative importance of the non-load-related factors in determining the total cost of the bridge.

[2] Special weighings record the weight of every truck passing the scale, even if empty. Weights are reported for each axle grouping, along with the number of axles in the group. This data replaces the more-generalized assumed distributions of operating weight and vehicle configurations used in the national model.

The allocation of costs in the second increment uses the detailed results of the Oregon-specific pavement cost model, which provides allocation factors by weight class and number of axles for each combination of functional class and pavement type (flexible or rigid).

The Choice of Appropriate Cost Allocators

Some quantifiable measure, or allocator, must be used to distribute each category of cost, or each increment within a category where the incremental approach is used, to the individual vehicle classes. For many costs, there are logical relationships that suggest a particular allocator as most appropriate.

Wear-related costs are the easiest to allocate. Wear-related costs are a direct, empirically-established consequence of use by vehicles. The amount of wear a vehicle imposes per mile of travel generally relates closely to measurable attributes of the vehicle. Two approaches may be used for choosing allocators for wear-related costs.

Results from a detailed model that predicts costs imposed by individual vehicles may be used to develop allocation factors that produce the same attribution of costs as the model. That is how pavement costs are handled in this study.

If a detailed model for attributing wear-related costs does not exist, one may choose allocation factors that one expects to vary in proportion to the wear imposed per unit of use by the vehicles in each category. For example, striping costs are allocated according to axle-miles of travel because it is expected that stripes wear in proportion to the number of axles that pass over them.

Capital costs do not vary with the amount of actual use that occurs on a new facility once built. Conceptually, the decision to add capacity is an investment decision that the user benefits of the enhancement exceed its costs. This, in turn, is usually related to congestion levels on existing facilities, as relief of this congestion is the primary basis for additional user benefits. Hence, the share of efficient fees (which measure the contribution of a vehicle class to existing congestion), whether or not they are actually charged, is the appropriate allocator for capital costs expended to relieve that congestion; in this way, those vehicles responsible for the current congestion "problem" are appropriately charged for its "solution".

For structures, and, to a lesser extent, roadways, the cost of constructing a facility with a given capacity will vary with the maximum weight and size of vehicle expected to use it. Part of the difference in construction cost, however, may be offset by increased useful life of a sturdier facility. If one attributes capital costs based on differences in the size or strength of the structure required to accommodate different types of vehicle, then the incremental approach may be used. The incremental approach, by itself, does not account for the capacity demand that drove the decision to build the facility. The incremental approach may be modified to take into account the expected effects of structure design on useful life, as was done in the allocation of bridge costs in recent Oregon studies.

All other approaches to capital-cost allocation are theoretically arbitrary and thus inherently second best. However, other approaches may be selected because of their convenience, despite the lack of a compelling underlying logic. One such second-best approach to allocating capacity-enhancing capital costs was used in the two most recent Oregon studies. The non-wear-related portion of capital costs were allocated in proportion to passenger-car-equivalent vehicle-miles traveled during the peak hour (peak PCE-VMT), which varies in proportion to each vehicle's contribution to congestion on existing facilities, but does not take into account the relationship between volume and capacity on existing facilities. The approach also assumes that the value of time is equal across all vehicle types, trip types, and vehicle occupancies.

If the benefits resulting from a given expenditure vary with vehicle use, the cost may be allocated in proportion to the level of benefit. For example, if the occupants of every vehicle passing a safety improvement benefit from reduced risk of death or injury, the cost could be attributed on the basis of occupant-miles traveled or, if occupancy is assumed to be the same across all vehicles, vehicle-miles traveled. Other costs may not vary at all with vehicle use, but must still be allocated to vehicles. If one attributes costs that do not vary with use, any allocator that seems "fair" may be chosen. In these cases, there is no single right allocator to use.

In general, an allocator that varies more closely with costs imposed should be selected over one that varies less closely. The degree of correlation may be measurable given sufficient data, but the necessary data usually do not exist, so one must calculate the expected relationship based on engineering and economic theory. A strong statistical correlation does not necessarily indicate a good allocator, as there is no reason to believe that an accidental correlation will persist. An allocator must also vary with measurable (and measured) attributes of vehicles, such as miles traveled, weight, length, number of axles, or some combination of those.

Allocators Used in This Study

As noted above, there are a number of cost allocators available for use in a cost allocation study. Allocators may be applied on either a per-vehicle or a per-vehicle-mile-traveled basis. Because it is generally vehicle use, rather than the existence of vehicles, that imposes costs on the highway system, all costs in the current Oregon study are allocated using some type of weighted vehicle-miles traveled (VMT).

Unweighted VMT are the most general measure of system use and are considered a fair way to assign many types of common costs, i.e., costs considered to be the joint responsibility of all highway users. VMT represent a reasonable and accepted measure to assign costs among the members of a subgroup (e.g., the individual vehicle classes within a cost increment), especially when members of the subgroup have similar characteristics or when an investment is made to provide a safer highway facility. Unweighted VMT are used for many traffic-oriented services, such as the provision of lighting, signs and traffic signals, since these services are generally related to traffic volumes.

Weighting VMT with an appropriate vector of zeros and ones will produce an allocator that restricts the allocation to a corresponding subset of weight classes. Such allocators are used to implement the incremental approach for bridge costs and for other costs allocated on VMT for a subset of all vehicles. One example is the allocation of Motor Carrier Transportation Division administrative costs only to vehicles over 26,000 pounds.

Other VMT weighting factors may also be used to allocate certain costs more appropriately. VMT can be weighted to account for the effective roadway space occupied by various types of vehicles relative to a standard passenger car. This is accomplished by using passenger-car equivalence (PCE) factors to weight VMT, producing PCE-VMT. Because trucks are larger and heavier than cars and require greater acceleration and braking distances, they occupy more effective roadway space and therefore have higher PCE factors. A variety of PCE factors were developed for the 1997 federal study, including different factors for different functional classes and different levels of traffic congestion, as well as uphill factors for steep grades. The uphill factors are used in this study to allocate the costs of climbing lanes.

Congested (or peak period) PCE-VMT is peak-period VMT weighted by the PCE factors for congested traffic conditions. It is used in this study for the common cost portion of projects undertaken to add capacity to the highway system.

Exhibit 3-1 shows the allocators applied to each expenditure category in this study.

Work Type	Work Type Description	Allocator 1	Share 1	Allocator 2	Share 2
1	Preliminary and Construction Engineering (and etc.)	Congested PCE	37.5%	Other Construction	62.5%
2	Right of Way (and Utilities)	Congested PCE	35.3%	Other Construction	64.7%
3	Grading and Drainage	Congested PCE	100.0%		0.0%
4	New Pavements-Rigid	Congested PCE	6.9%	Rigid Pave	93.1%
5	New Pavements-Flexible	Congested PCE	4.5%	Flex Pave	95.5%
6	New Shoulders-Rigid	Congested PCE	100.0%		0.0%
7	New Shoulders-Flexible	Congested PCE	100.0%		0.0%
8	Pavement and Shoulder Reconstruction-Rigid	Congested PCE	26.9%	Rigid Pave	73.1%
9	Pavement and Shoulder Reconstruction-Flexible	Congested PCE	24.5%	Flex Pave	75.5%
10	Pavement and Shoulder Rehab-Rigid	All VMT	26.9%	Rigid Pave	73.1%
11	Pavement and Shoulder Rehab-Flexible	All VMT	24.5%	Flex Pave	75.5%
12	Pavement and Shoulder Rehab-Other	All VMT	100.0%		0.0%
13	New Structures	None-Bridge Split	100.0%		0.0%
14	Replacement Structures	None-Bridge Split	100.0%		0.0%
15	Structures Rehabilitation	None-Bridge Split	100.0%		0.0%
16	Climbing Lanes	Uphill PCE	100.0%		0.0%
17	Truck Weight/Inspection Facilities	Over 26 VMT	100.0%		0.0%
18	Truck Escape Ramps	Over 26 VMT	100.0%		0.0%
19	Interchanges	None-Bridge Split	100.0%		0.0%
20	Roadside Improvements	All VMT	100.0%		0.0%
21	Safety Improvements	Congested PCE	100.0%		0.0%
22	Traffic Service Improvements	Congested PCE	100.0%		0.0%
23	Other Construction (modernization)	Other Construction	100.0%		0.0%
24	Other Construction (preservation)	All VMT	100.0%		0.0%
25	Surface and Shoulder Maintenance-Rigid	All VMT	26.9%	Rigid Pave	73.1%
26	Surface and Shoulder Maintenance-Flexible	All VMT	24.5%	Flex Pave	75.5%
27	Surface and Shoulder Maintenance-Other	All AMT	100.0%		0.0%
28	Drainage Facilities Maintenance	All VMT	100.0%		0.0%
29	Structures Maintenance	All VMT	100.0%		0.0%
30	Roadside Items Maintenance	All VMT	100.0%		0.0%
31	Safety Items Maintenance	All VMT	100.0%		0.0%
32	Traffic Service Items Maintenance	Congested PCE	100.0%		0.0%
33	Pavement Striping and Marking (maintenance)	All AMT	100.0%		0.0%
34	Sanding and Snow and Ice Removal (maintenance)	All VMT	100.0%		0.0%
35	Extraordinary Maintenance	All VMT	100.0%		0.0%
36	Truck Scale Maintenance-Flexible	Over 26 VMT	100.0%		0.0%
37	Truck Scale Maintenance-Rigid	Over 26 VMT	100.0%		0.0%
38	Truck Scale Maintenance-Buildings and Grounds	Over 26 VMT	100.0%		0.0%
39	Studded Tire Damage	Basic VMT	100.0%		0.0%
40	Miscellaneous Maintenance	All VMT	100.0%		0.0%
41	Bike/Pedestrian Projects	All VMT	100.0%		0.0%
42	Railroad Safety Projects	All VMT	100.0%		0.0%
43	Transit and Rail Support Projects	Congested PCE	100.0%		0.0%
44	Fish and Wildlife Enabling Projects	All VMT	100.0%		0.0%

Exhibit 3-1, continued

Work Type	Work Type Description	Allocator 1	Share 1	Allocator 2	Share 2
45	Highway Planning	All VMT	100.0%		0.0%
46	Transportation Demand & Transportation System Management	Congested PCE	100.0%		0.0%
47	Multimodal	Congested PCE	100.0%		0.0%
48	Reserve Money, Fund Exchange, Immediate Opportunity Fund	All VMT	100.0%		0.0%
49	Seismic Retrofits on Structures	All VMT	100.0%		0.0%
50	Other Common Costs	All VMT	100.0%		0.0%
55	Other--Over 26,000 Only	Over 26 VMT	100.0%		0.0%
56	Other--Basic Only	Basic VMT	100.0%		0.0%
57	Other--Over 8,000 Only	Over 10 VMT	100.0%		0.0%
58	Other--Under 26,000 Only	Under 26 VMT	100.0%		0.0%
59	Other Administration	All VMT	100.0%		0.0%
60	Bridge --All Vehicles Share (no added capacity)	All VMT	100.0%		0.0%
61	Bridge --Over 8,000 Vehicles Share	Over 10 VMT	100.0%		0.0%
62	Bridge --Over 50,000 Vehicles Share	Over 50 VMT	100.0%		0.0%
63	Bridge --Over 80,000 Vehicles Share	Over 80 VMT	100.0%		0.0%
64	Bridge --Over 106,000 Vehicle Share	Over 106 VMT	100.0%		0.0%
65	Bridge --All Vehicles Share (added capacity)	Congested PCE	100.0%		0.0%
66	Other Bridge	Other Bridge	100.0%		0.0%
67	Interchange Modernization	None-Bridge Split	100.0%		0.0%
68	Bridge Replacement with Capacity	None-Bridge Split	100.0%		0.0%
101	Local Gov: Preliminary and Construction Engineering (and etc.)	Congested PCE	55.9%	Other Construction	44.1%
102	Local Gov: Right of Way (and Utilities)	Congested PCE	55.9%	Other Construction	44.1%
103	Local Gov: Grading and Drainage	Congested PCE	100.0%		0.0%
104	Local Gov: New Pavements-Rigid	Congested PCE	8.1%	Rigid Pave	91.9%
105	Local Gov: New Pavements-Flexible	Congested PCE	7.6%	Flex Pave	92.4%
106	Local Gov: New Shoulders-Rigid	Congested PCE	100.0%		0.0%
107	Local Gov: New Shoulders-Flexible	Congested PCE	100.0%		0.0%
108	Local Gov: Pavement and Shoulder Reconstruction-Rigid	Congested PCE	28.1%	Rigid Pave	71.9%
109	Local Gov: Pavement and Shoulder Reconstruction-Flexible	Congested PCE	27.6%	Flex Pave	72.4%
110	Local Gov: Pavement and Shoulder Rehab-Rigid	All VMT	28.1%	Rigid Pave	71.9%
111	Local Gov: Pavement and Shoulder Rehab-Flexible	All VMT	27.6%	Flex Pave	72.4%
112	Local Gov: Pavement and Shoulder Rehab-Other	All VMT	100.0%		0.0%
113	Local Gov: New Structures	None-Bridge Split	100.0%		0.0%
114	Local Gov: Replacement Structures	None-Bridge Split	100.0%		0.0%
115	Local Gov: Structures Rehabilitation	None-Bridge Split	100.0%		0.0%
116	Local Gov: Climbing Lanes	Uphill PCE	100.0%		0.0%
117	Local Gov: Truck Weight/Inspection Facilities	Over 26 VMT	100.0%		0.0%
118	Local Gov: Truck Escape Ramps	Over 26 VMT	100.0%		0.0%
119	Local Gov: Interchanges	None-Bridge Split	100.0%		0.0%
120	Local Gov: Roadside Improvements	All VMT	100.0%		0.0%

Exhibit 3-1, continued

Work Type	Work Type Description	Allocator 1	Share 1	Allocator 2	Share 2
121	Local Gov: Safety Improvements	All VMT	100.0%		0.0%
122	Local Gov: Traffic Service Improvements	Congested PCE	100.0%		0.0%
123	Local Gov: Other Construction	Other Construction	100.0%		0.0%
124	Local Gov: Other Rehabilitation	All VMT	100.0%		0.0%
125	Local Gov: Surface and Shoulder-Rigid	All VMT	28.1%	Rigid Pave	71.9%
126	Local Gov: Surface and Shoulder-Flexible	All VMT	27.6%	Flex Pave	72.4%
127	Local Gov: Surface and Shoulder-Other	All AMT	100.0%		0.0%
128	Local Gov: Drainage Facilities	All VMT	100.0%		0.0%
129	Local Gov: Structures	All VMT	100.0%		0.0%
130	Local Gov: Roadside Items	All VMT	100.0%		0.0%
131	Local Gov: Safety Items	All VMT	100.0%		0.0%
132	Local Gov: Traffic Service Items	Congested PCE	100.0%		0.0%
133	Local Gov: Pavement Striping and Marking	All AMT	100.0%		0.0%
134	Local Gov: Sanding and Snow/Ice Removal	All VMT	100.0%		0.0%
135	Local Gov: Extraordinary Maintenance	All VMT	100.0%		0.0%
136	Local Gov: Truck Scale-Flexible	Over 26 VMT	100.0%		0.0%
137	Local Gov: Truck Scale-Rigid	Over 26 VMT	100.0%		0.0%
138	Local Gov: Truck Scale-Buildings and Grounds	Over 26 VMT	100.0%		0.0%
139	Local Gov: Studded Tire Damage	Basic VMT	100.0%		0.0%
140	Local Gov: Miscellaneous / Unspecified	All VMT	100.0%		0.0%
141	Local Gov: Bike/Pedestrian Projects	All VMT	100.0%		0.0%
142	Local Gov: Railroad Safety Projects	All VMT	100.0%		0.0%
143	Local Gov: Transit and Rail Support Projects	Congested PCE	100.0%		0.0%
144	Local Gov: Fish, Wildlife Enabling Projects	All VMT	100.0%		0.0%
145	Local Gov: Planning	All VMT	100.0%		0.0%
146	Local Gov: Transportation Demand & Transportation System Management	Congested PCE	100.0%		0.0%
147	Local Gov: Multimodal	Congested PCE	100.0%		0.0%
148	Local Gov: Reserve Money, Fund Exchange, Immediate Opportunity Fund	All VMT	100.0%		0.0%
149	Local Gov: Seismic Retrofits	All VMT	100.0%		0.0%
150	Local Gov: Other Admin	All VMT	100.0%		0.0%
160	Local Gov: Bridge --All Vehicles Share	All VMT	100.0%		0.0%
161	Local Gov: Bridge --Over 8,000 Vehicles Share	Over 10 VMT	100.0%		0.0%
162	Local Gov: Bridge --Over 50,000 Vehicles Share	Over 50 VMT	100.0%		0.0%
163	Local Gov: Bridge --Over 80,000 Vehicles Share	Over 80 VMT	100.0%		0.0%
164	Local Gov: Bridge --Over 106,000 Vehicle Share	Over 106 VMT	100.0%		0.0%
165	Local Gov: Bridge Modernization	None-Bridge Split	100.0%		0.0%
166	Local Gov: Other Bridge	Other Bridge	100.0%		0.0%
167	Local Gov: Interchange Modernization	None-Bridge Split	100.0%		0.0%
168	Local Gov: Bridge Replacement with Capacity	None-Bridge Split	100.0%		0.0%

VMT can also be weighted to reflect the amount of pavement wear imposed by vehicles of various weights and axle configurations. The factors used for this weighting are produced from the results of the pavement model described above.

Costs not accounted for as a part of specific construction projects, but that are expected to vary with the overall level of construction are allocated with special factors developed during the allocation process. These factors allocate costs in proportion to the construction costs that were allocated from specific projects. Separate "other construction" factors are calculated and applied for work performed by the state and by local governments.

Prospective View

The costs or expenditures allocated in a cost allocation study can be those for a past period, those anticipated for a future period, or a combination of past and future costs. Some studies conducted by the federal government and other states have allocated both historical and planned expenditures.

The Oregon studies have traditionally used a prospective approach in which the expenditures allocated are those planned for a future period, specifically, the next fiscal biennium. Similarly, the traffic data used in the studies is that projected for a future year. This is done to allow for changes in expenditure level and traffic volumes, and so that the study results will be applicable for the period in which legislation enacted to implement the study recommendations will become effective.

There are some disadvantages associated with allocating only projected future expenditures. Specifically, it requires relying on forecasts, which are subject to greater error than historical data, and it does not address issues related to facilities with useful lives far in excess of the two-year study period.

The 1996 Cost Responsibility Blue Ribbon Committee recommended the Oregon studies continue allocating only projected future expenditures. The current Oregon study again follows that recommendation, with the exception of incorporating study-period expenditures on the repayment of bonds issued in the prior study periods, allocated in the same proportions as in the prior studies.

Exclusion of External (Social) Costs

The Oregon studies, as well as the studies conducted by most other states, have chosen to allocate direct governmental expenditures and exclude external costs associated with highway use. The proponents of a cost-based approach argue that, to be consistent, a HCAS should include all costs that result from use of the highway system. They further argue economically-efficient pricing of highways requires the inclusion of all costs, and that failure to do so encourages an over-utilization of highways. Including external costs would add to the breadth and completeness of the analysis, and could help determine appropriate user charges necessary to reflect these costs.

However, there are several disadvantages associated with including external costs. Although these costs represent real costs to society, they are decidedly more difficult to quantify and incorporate in the analysis than are direct highway costs. Inclusion of external costs therefore would increase the data requirements and complexity of the studies, and could reduce their overall accuracy.

The 1996 Blue Ribbon Committee recommended the Oregon studies continue to exclude social costs until such time as the state implements explicit user charges to capture these costs. Both the 1982 and 1997 Federal HCASs included some social costs in supplementary analyses. The 1999 Oregon Study recommended future studies include "a separate assessment of the impacts of proposed changes in highway user taxes on the total costs of highway use including all major external costs." The 2001 and 2003 studies made this same recommendation. That recommendation has not been implemented to date.

Expenditure Allocation

The Oregon studies allocate expenditures rather than costs. Over the long run, expenditures must cover the full direct costs being imposed on the system or the system will deteriorate. Over any shorter period, however, expenditures will exceed or fall short of the costs imposed.

Some past Oregon studies, including a special analysis in the 2001 study, attempted to estimate and allocate a full-cost budget in addition to a base (actual expenditure) level budget. The intent was to approximate costs by estimating the level of expenditures required to preserve service levels and pavement conditions at existing levels. In these studies heavy vehicles were found to be responsible for a greater share of the preservation level budget than of the base level budget. This was because the majority of unmet needs at that time involved pavement rehabilitation and maintenance, items for which heavy vehicles have the predominant responsibility.

There exist strong arguments for moving toward a full cost-based approach in highway cost allocation studies. The problem is that "true" costs are more difficult to quantify and incorporate in the analysis than are direct highway expenditures. As a practical matter, therefore, most studies, including this study, continue to focus on the allocation of expenditures rather than costs.

Treatment of Debt-Financed Expenditures and Debt Service

Oregon traditionally has relied much less on debt financing of its highway program than many other states. This has changed since the enactment of the Oregon Transportation Investment Act (OTIA) by the 2001 Legislature. The first OTIA authorized the issuance of $400 million in new debt for projects to be completed across Oregon. It provided $200 million for projects that add lane capacity or improve interchanges and $200 million for bridge and pavement rehabilitation projects. Automobile and truck title fees were increased to finance the repayment of construction bonds for the OTIA projects.

Favorable bond-rate conditions allowed the 2002 Special Legislative Session to authorize an additional $100 million in debt without needing to further increase revenues. The original OTIA projects became known as OTIA I, and the additional projects as OTIA II.

The 2003 Legislature authorized an additional $2.46 billion in new debt and increased title, registration, and other DMV fees to produce the additional revenue necessary to repay the bonds. The OTIA III money will be spent as follows:

- $1.3 billion to repair or replace 365 state bridges
- $300 million to repair or replace 141 locally-owned bridges
- $361 million for local-government maintenance and preservation
- $500 million for modernization

The issue of how to treat OTIA project expenditures and the associated debt service was discussed at some length by the study review teams for both the 2003 and 2005 studies. Debt finance introduces a disconnect between study-period revenues and expenditures in that the time period in which the revenues are received differs from the period in which the funds are expended. Care needs to be taken to avoid double counting, which would occur if both the debt-financed project expenditures and full debt service expenditures (including interest and repayment of principal) were included.

While not all of the funds expended on OTIA projects come from bonds, the bonded amounts are easily identifiable, as are the associated debt service expenses. The dollar amount allocated in the model is the study-period debt service expenditure, given the bond rate and amortization period, in this case 20 years. The expenditures associated with each bond-financed project are scaled down by a bond factor to one study period's worth of debt service expenditure before allocation. This method retains the necessary project detail to assign expenditure shares by vehicle class. The dollar amounts allocated to each vehicle class for bonded projects are recorded and carried forward to each of the next nine studies.

This approach has two disadvantages: the choice of which projects get bond financing can affect the results of the study, as well as the next nine studies, and the allocation of those expenditures in future studies remains based on traffic conditions expected for the first two years of the 20-year repayment period. The Study Review Team considered a number of alternative approaches and decided that the advantages of simplicity and limited data requirements for the chosen approach outweighed its disadvantages. They also noted that the failure to update the allocation in future studies was consistent with the treatment of cash-financed projects, which are completely ignored in all future studies.

Treatment of Alternative-Fee-Paying Vehicles

Under Oregon's existing highway taxation structure, some types of vehicles are exempt from certain fees or qualify to pay according to alternative-fee schedules. These types of vehicles are collectively referred to in this report as "alternative-fee-paying" vehicles. The two main types of such vehicles are publicly owned vehicles and farm trucks. Publicly owned vehicles pay a nominal registration fee, and are not subject to the weight-mile tax. Most types of publicly owned vehicles are now subject to the state fuel tax, but many diesel-powered publicly-owned vehicles are not. Operators of farm trucks pay lower annual registration fees than operators of regular commercial trucks, and most pay fuel taxes, rather than weight-mile taxes when operated on public roads.

The reduced rates paid by certain types of vehicles mean they are paying less per-mile than comparable vehicles subject to full fees. The difference between what alternative-fee-paying vehicles are projected to pay and what they would pay if subject to full fees is termed the "alternative-fee difference." The approach used in past Oregon studies is to calculate this difference for each weight class and sum these amounts. The total alternative-fee difference (subsidy amount) is then reassigned to all other, full-fee-paying vehicles on a per-VMT basis, i.e., this amount is treated as a common cost to be shared proportionately by all full-fee-paying vehicles.

The rationale for this approach is that the granting of these reduced fees represents a public policy decision, and most vehicles paying reduced fees are providing some public service that arguably should be paid for by all taxpayers in relation to their use of the system. Because the heavy vehicle share of the total alternative-fee difference is greater than their share of total statewide travel, reassigning this amount on the basis of relative vehicle miles has the effect of increasing the light vehicle responsibility share and reducing the heavy vehicle share.

Treatment of Tax Avoidance and Evasion

When vehicles subject to Oregon's fuel tax purchase fuel in another state and then drive in Oregon, they avoid the Oregon fuel tax. The reverse is also true, so if the number of miles driven in Oregon on out-of-state fuel equaled the number of miles driven outside Oregon on in-state fuel, net avoidance would be zero. Net avoidance in Oregon is significant because of the large number of people who live in Washington and work in Oregon. These people tend to buy a smaller proportion of their fuel in Oregon than the proportion of their total miles that are driven in Oregon. This net avoidance is specifically accounted for in the highway cost allocation study by assuming that 3.5 percent of VMT by fuel-tax paying vehicles do not result in fuel-tax collections for Oregon.

The International Fuel Tax Agreement sorts out the payments of state fuel taxes and the use of fuel in other states for interstate truckers. If truckers pay fuel tax in California, for example, and then use that fuel in Oregon while paying the weight-mile tax, IFTA provides a mechanism for California to reimburse them. If truckers then buy fuel in Oregon, paying no fuel tax, and drive in Washington, IFTA provides a mechanism for them to pay what they owe to Washington.

The avoidance of the weight-mile tax by vehicles that are not legally required to pay it is treated as described above, under alternative-fee paying vehicles, rather than as avoidance.

Virtually any tax is subject to some evasion. While it is generally agreed evasion of the state gasoline tax and vehicle registration fees is quite low, there is more debate concerning evasion of the weight-mile and use fuel (primarily diesel) taxes. For the purpose of this study, it was assumed that evasion of the weight-mile tax is equal to five percent of what would be collected if all that is due were paid. This is the midpoint of the 3 to 7 percent evasion rate estimated by the Oregon Weight-Mile Tax Study conducted by consultants for the Legislative Revenue Office in 1996. It also assumes that an additional 1.0 percent of the use-fuel tax on diesel (beyond the 3.5 percent avoidance) is successfully evaded.

Study Data and Forecasts

FIVE MAJOR TYPES OF DATA are required to conduct a highway cost allocation study. These are:

- **Traffic data.** The miles of travel by vehicle weight and type on each of the road systems used in the study.
- **Expenditure data.** Projected expenditures on construction projects by work type category, road system, and funding source, and projected expenditures in other categories by funding source.
- **Revenue data.** Projected revenues by revenue source or tax instrument.
- **Allocation factors.** Factors used to allocate costs to individual vehicle classes, including passenger-car equivalence (PCE) factors, pavement factors, and bridge increment shares.
- **Conversion factors and distributions.** Examples include distributions used to convert VMT by declared weight class to VMT by operating weight class or to VMT by registered weight class.

The allocation factors used in this study are described in Chapter 3 and the development and use of conversion factors is described in Appendix E, Technical Documentation.

The remainder of this chapter presents the traffic, expenditure, and revenue data used in the 2009 Study, and compares them with the data used in the prior two Oregon studies.

Traffic Data and Forecasts

VMT by road system, by vehicle weight class and number of axles, and by vehicle tax class are important throughout the cost allocation and revenue attribution processes. VMT estimates and projections are used both in the allocation of expenditures and attribution of revenues to detailed vehicle classes. Additionally, as explained in Chapter 3, VMT weighted by factors such as PCEs or pavement factors is used to assign several of the individual expenditure categories allocated in the study.

For this study, the required traffic data was first collected for the 2007 base year, the latest year for which complete historical data was available. This data then was projected forward to calendar year 2010, the middle 12 months of the 2009-11 fiscal biennium, which is the study period.

The base year traffic data were obtained from a number of sources. These include ODOT Motor Carrier Transportation Division (MCTD) weight-mile tax information, ODOT traffic counts and traffic classification statistics, HPMS submittals, MCTD and Driver & Motor

Vehicle Services vehicle registrations data, and the Special Truck Weighings previously discussed. For each road system used in the study, travel estimates are developed for light vehicles and each 2,000-pound truck weight class.

Information from state economic forecasts and from ODOT's revenue forecasting model is used to forecast projected study year traffic from the base year data. Data from the Special Truck Weighings are used to convert truck miles of travel by declared weight class to miles of travel by operating weight class and to obtain detailed information on vehicle configurations and axle counts for each weight class. HPMS data are used to spread VMT to functional classifications.

Exhibit 4-1 shows total vehicle travel in Oregon is projected to increase from 37.4 billion miles in 2007 to 38.5 billion miles in 2010. This represents an average annual growth of about 1.0 percent. Light vehicle travel is projected to increase from 34.6 billion miles in 2007 to 35.7 billion miles in 2010, which represents an average annual growth of 1.1 percent. Total heavy vehicle travel is forecast to decline slightly from 2.79 billion miles in 2007 to 2.76 billion miles in 2010, an average annual growth of about -0.4 percent. These projections are based on, and consistent with, the projections from ODOT's revenue forecast model.

The traffic growth projections for the current study are lower than the 1999, 2001, 2005, and 2007 studies, and roughly equal to the growth projections in the 2003 study. The 1999 study projected total state VMT would grow at an average annual rate of 1.7 percent between 1997 and 2000. The 2001 study projected 1.3 percent annual growth between 1999 and 2002. The 2003 study projected 1.1 percent annual growth between 2001 and 2004. The 2005 study growth projection of 1.6 percent reflected recovery from the economic downturn in Oregon and the nation that limited growth in the early part of the decade. The 2007 study projected 1.9 percent annual growth rate between 2005 and 2008, reflecting the upward trend in the economy during that period. The current study projects a growth rate of 1.1 percent from 2007 to 2010, reflecting the economic downturn, particularly the negative growth rate for heavy vehicles during these years.

While projected travel by heavy vehicles grew faster than projected travel by light vehicles in recent studies, forecasted heavy vehicle travel is expected to decline between 2007 and 2010 and forecasted light vehicle travel is expected to experience modest growth. Because of this, the share of travel accounted for by light vehicles is expected to increase from 92.5 percent to 92.8 percent between

Exhibit 4-1: Current and Forecasted VMT by Weight Group (Millions of Miles)

Declared Weight in Pounds			2007 VMT (estimate)	2010 VMT (forecast)	Average Annual Growth Rate
1	to	10,000	34,580	35,743	1.1%
10,001	to	26,000	646	654	0.4%
26,001	to	78,000	434	403	-2.5%
78,001	to	80,000	1,205	1,187	-0.5%
80,001	to	104,000	256	258	0.2%
104,001	to	105,500	246	255	1.2%
105,501	and	up	3	3	0.3%
Total for All Vehicles			37,371	38,503	1.0%
Total for Vehicles Under 10,001 pounds			34,580	35,743	1.1%
% for Vehicles Under 10,001 pounds			92.5%	92.8%	
Total for Vehicles Over 10,000 pounds			2,791	2,760	-0.4%
% for Vehicles Over 10,000 pounds			7.5%	7.2%	
Total for Vehicles Under 26,001 pounds			35,226	36,397	1.1%
% for Vehicles Under 26,001 pounds			94.3%	94.5%	
Total for Vehicles Over 26,000 pounds			2,145	2,106	-0.6%
% for Vehicles Over 26,000 pounds			5.7%	5.5%	

2007 and 2010. This is one reason for the slightly higher cost responsibility share for light vehicles reported in this study compared to the previous study.

Exhibit 4-1 also shows the growth projected for heavy vehicle travel varies by weight group. The lowest growth is expected to be in the 26,001 to 78,000 weight class group.

Exhibit 4-2: Projected 2010 VMT by Road System (Millions of Miles)

Road System	Light Vehicles		Heavy Vehicles		Total VMT
	Miles of Travel	Percent of Total	Miles of Travel	Percent of Total	
Interstate Urban	4,654	91.9%	409	8.1%	5,063
Interstate Rural	3,952	81.9%	876	18.1%	4,828
Other State Urban	5,882	96.2%	235	3.8%	6,117
Other State Rural	6,957	90.9%	695	9.1%	7,652
Subtotal-State Roads	21,445	90.6%	2,215	9.4%	23,660
County Roads	7,097	95.6%	325	4.4%	7,422
City Streets	7,089	97.1%	213	2.9%	7,302
Subtotal-Local Roads	14,185	96.3%	539	3.7%	14,724
Subtotal-State and Local Roads	35,630	92.8%	2,754	7.2%	38,385
Federal Roads	113	94.6%	6	5.4%	119
Total-All Roads	35,743	92.8%	2,760	7.2%	38,503

Exhibit 4-2 shows the distribution of projected 2010 travel between light and heavy vehicles for different combinations of functional classification and ownership. Although light vehicles are projected to account for 92.8 percent and heavy vehicles 7.2 percent of total statewide VMT, the mix of traffic varies significantly among the different road systems. Heavy vehicles are projected to account for 18.1 percent of the travel on rural interstate highways, but only 2.9 percent of the travel on city streets. Heavy vehicles are expected to account for 9.4 percent of the overall travel on state highways and 3.7 percent of the travel on local roads.

Exhibit 4-3 illustrates, in a slightly different manner, how the relative mix of traffic varies by road system. It presents the separate distributions of projected VMT by road system for light vehicles, heavy vehicles, and all vehicles. As shown, 61.5 percent of total travel in the state is expected to be on state highways and 38.2 percent on local roads and streets. These shares, however, differ significantly for light versus heavy vehicles. Rural interstate highways, for example, are projected to handle 12.5 percent of the total travel in 2010, but 31.7 percent of the heavy vehicle travel. At the other extreme, 19.8 percent of light vehicle travel, but only 7.7 percent of heavy vehicle travel, is forecast to be on city streets. State highways are expected to handle about 60.0 percent of the total travel by light vehicles and 80.3 percent of the travel by heavy vehicles.

Exhibit 4-4 compares the VMT projections

Exhibit 4-3: Distribution of Projected 2010 VMT by Road System

Road System	Percent of Light Vehicle Total	Percent of Heavy Vehicle Total	Percent of All Vehicle Total
Interstate Urban	13.0%	14.8%	13.2%
Interstate Rural	11.1%	31.7%	12.5%
Other State Urban	16.5%	8.5%	15.9%
Other State Rural	19.5%	25.2%	19.9%
Subtotal State Systems	60.0%	80.3%	61.5%
County Roads	19.9%	11.8%	19.3%
City Streets	19.8%	7.7%	19.0%
Subtotal Local Systems	39.7%	19.5%	38.2%
Federal Roads	0.3%	0.2%	0.3%
Total All Systems	100.0%	100.0%	100.0%

Exhibit 4-4: Comparison of Forecast VMT Used in OR HCASs: 1999, 2001, 2003, 2005, 2007 and 2009 (billions of miles)

	1999 Study		2001 Study		2003 Study		2005 Study		2007 Study		2009 Study	
Road System	2000 VMT	Percent of Total	2002 VMT	Percent of Total	2004 VMT	Percent of Total	2006 VMT	Percent of Total	2008 VMT	Percent of Total	2010 VMT	Percent of Total
Interstate Urban	4.0	11.8%	3.9	11.4%	3.9	11.2%	4.1	11.3%	5.0	12.9%	5.1	13.2%
Interstate Rural	4.4	12.9%	4.4	12.7%	4.4	12.6%	4.7	13.0%	4.8	12.4%	4.8	12.6%
Other State Urban	4.5	13.2%	5.5	15.7%	5.2	15.1%	5.3	14.7%	6.1	15.7%	6.1	15.9%
Other State Rural	7.5	22.1%	7.8	22.5%	7.5	21.6%	8.0	22.1%	7.7	19.8%	7.7	19.9%
Subtotal-State Systems	20.4	60.0%	21.7	62.3%	21	60.5%	22.1	61.1%	23.6	60.8%	23.7	61.6%
County Roads	8.6	25.3%	8	22.9%	8.9	25.6%	7.9	22.0%	8.3	21.3%	7.4	19.3%
City Streets	5.0	14.7%	5.1	14.8%	4.8	13.9%	6.1	17.0%	6.9	17.9%	7.3	19.0%
Subtotal-Local Systems	13.6	40.0%	13.1	37.7%	13.7	39.5%	14.1	38.9%	15.2	39.2%	14.7	38.4%
Total	34.0	100.0%	34.8	100.0%	34.7	100.0%	36.2	100.0%	38.8	100.0%	38.4	100.0%

note: VMT on federally-owned roads not included in totals

by road system used in the 1999, 2001, 2003, 2005, 2007, and 2009 studies. It shows the VMT shares on the six road systems have not changed substantially from the comparable projections made in the 2001 Study. The systems projected to account for the largest shares of total statewide travel are Other State Rural highways, County Roads, and City Streets. The current study projects a higher share of travel on city streets than did prior studies.

Expenditure Data

Until the 2001 study, Oregon highway cost allocation studies allocated only expenditures of Oregon highway user fees by state and local-government agencies. Because federal funds are in many cases interchangeable with state funds, and because the proportion of federal funds used for any particular project is arbitrary and subject to change between the time of the study and the time the money is spent, excluding federal funds can introduce arbitrary bias and inaccuracy into the study results. The 2001 study included the expenditure of federal funds by the state and reported their allocation both separately and in combination with state funds.

The 2003 study, for the first time ever, included all expenditures on roads and streets in the state. In addition to state-funded expenditures, expenditures (both state and local) funded from federal highway revenues and locally-generated revenues were also included. This change substantially increased the level and breadth of expenditures allocated in the 2003 study as compared to previous studies.

Following the 2005 study, the 2007 study and the current study include expenditures of state, federal, and local revenues, but exclude certain categories of local revenues determined not to be interchangeable with state user fees. Those sources are locally-issued bonds, property taxes (including local improvement districts), systems development charges, and traffic impact fees.

The expenditure data for this study were obtained from a number of sources. Data from ODOT's monthly Budget and Cash Flow Forecast were used to develop projected construction expenditures by project for the 2009-11 biennium. Projected expenditures on maintenance and other programs were obtained from ODOT Financial Services, and based on ODOT's Agency Request Budget.

Identifying those expenditures projected to be federally funded was relatively straightforward, and based on detailed information from the ODOT Cash Flow

Forecast model and Project Control System. Local expenditures were projected from data obtained from the 2007 Local Roads and Streets Survey combined with information from ODOT's Agency Request Budget.

Care was taken to accurately identify the bonded (OTIA) projects and treat them as a separate, independent funding source. It was assumed that any bridge projects that still remained in "option packages" and had not been assigned real project numbers by September of 2008 would not start construction until after the end of the 2009-11 biennium. Those projects were not included in the analysis.

Exhibit 4-5 presents the average annual expenditures projected for the 2009-11 biennium by major category (modernization, preservation, maintenance, bridge, and other) and funding source (state, federal, bond, and local). As shown, projected expenditures total $1.836 billion. This compares to annual expenditures allocated in the 1999, 2001, 2003, 2005 and 2007 studies of $691 million, $649 million, $1.491 billion, $1.499 billion, and $1.723 billion respectively.

Of the $1.836 billion total annual expenditures, $911 million (49.6 percent) are projected to be state-funded, $657 million (35.8 percent) federally-funded, and $232 million (12.7 percent) locally-funded. The remaining $35.1 million (1.9 percent) of allocated expenditures are the allocated portion of the $218.8 million per year of expended bond revenue. An additional $117.8 million per year of pre-allocated bond expenditure from the prior study is included in the allocated costs in this study.

The Local Funds column of Exhibit 4-5 includes only local expenditures from the own-source revenues that were included in this study. Local expenditures from state and federal revenues are included in the State and Federal Funds columns, respectively.

Bridge and interchange expenditures are shown separately from other modernization, preservation and maintenance expenditures.

The Other category in the exhibit encompasses expenditures for a large number of different activities. In addition to general administrative and tax collection costs for the State, counties, and cities, it includes expenditures for:

- Preliminary engineering
- Right of way acquisition and property management
- Safety-related projects, safety inspections, and rehabilitation and maintenance of existing safety improvements
- Pedestrian/bike projects
- Railroad safety projects
- Fish and wildlife enabling projects (e.g., salmon culverts)
- Transportation demand management and transportation system management projects (*e.g.*,

Exhibit 4-5: Average Annual Expenditures by Category and Funding Source (thousands of dollars)

Major Expenditure Category	State Funds	Percent of All Sources	Federal Funds	Percent of All Sources	Local Funds	Percent of All Sources	Bond Funds	Percent of All Sources	All Funding Sources
Modernization	88,374	30.6%	140,297	48.5%	57,712	20.0%	2,834	1.0%	289,217
Preservation	62,964	27.1%	134,635	58.0%	33,275	14.3%	1,282	0.6%	232,156
Maintenance	284,768	67.0%	65,678	15.5%	73,996	17.4%	330	0.1%	424,772
Bridge	24,320	14.1%	119,340	69.0%	4,254	2.5%	25,069	14.5%	172,983
Other	450,483	62.9%	197,232	27.5%	63,187	8.8%	5,596	0.8%	716,498
All Expenditures	910,909	49.6%	657,183	35.8%	232,424	12.7%	35,111	1.9%	1,835,626

Traffic Operations Centers)

- Multi-modal projects
- Transportation project development and delivery
- Transportation planning, research and analysis

The exhibit shows significant differences in the funding of different expenditure categories. Preservation and bridge expenditures, in particular, have a large federal funds component. About 58 percent of preservation expenditures and 69 percent of bridge expenditures will be federally funded. Maintenance expenditures, on the other hand, are largely state-, and to a lesser extent, locally-funded, with a very small federal funds component. About 71 percent of the OTIA expenditures in the study period will be on State- and locally-owned bridges. An additional 15.9 percent of OTIA expenditures fall into the “other” category. Most of those are for engineering and right of way expenditures associated with State- and locally- owned bridges.

Revenue Data and Forecasts

The revenues projected for this study include receipts from taxes and fees collected by the state from highway users, i.e., revenues flowing into Oregon’s dedicated State Highway Fund. Revenues from federal taxes and user fees are not estimated. Similarly, revenues generated by local governments from their own funding sources (e.g., property taxes, street assessments, system development charges, local fuel taxes, etc.) are not included. Because the expenditure of federal and local revenues are included among the expenditures to be allocated, and because a portion of the expenditure of bond revenue in the prior biennium is included, average annual allocated expenditures exceed average annual attributed revenues by $1.083 billion.

Exhibit 4-6: Revenue Forecasts by Tax/Fee Type (thousands of dollars) Average Annual Amounts for 2009-2011 Biennium

Tax/Fee	Forecast Revenue	Percent of Total
Fuel Tax	437,231	50.3%
Weight-Mile Tax	227,663	26.2%
Registration Fees	139,896	16.1%
Title Fees	58,158	6.7%
Other Motor Carrier Revenue	4,903	0.6%
Road Use Assessment Fees	1,858	0.2%
Total	869,710	100.0%

The revenue data required for the study are obtained directly from ODOT’s revenue forecasting model. The revenue forecast used for the present study was the June 2008 forecast; the latest available at the time the study was being conducted. The forecasts include the approximately 40 percent of State Highway Fund revenues transferred to local governments for use on local roads and streets, and all state funds used for highways including matching requirements for federal-aid highway projects.

Average annual state revenues for the 2009-11 biennium are expected to total $869.7 million. As shown in Exhibit 4-6, fuel taxes and the weight-mile tax are the two largest sources of state user-fee revenue. Revenue from the state fuel tax is projected to average $437.2 million per year (50.3 percent of total revenues) and weight-mile tax revenue is forecast to average $227.7 million (26.2 percent of total revenues). These two sources account for 76.5 percent of highway user revenues, illustrating that Oregon’s system of highway finance is based heavily on taxes and fees directly related to use of the system.

Revenue from registration and title fees is anticipated to average $198.1 million annually (22.8 percent of total revenues), consistent with the 2005 and 2007 studies, but up sharply from prior studies as a result of the fee increases enacted to repay OTIA bonds. Other revenue sources bring in smaller amounts of revenue.

Exhibit 4-7 compares the forecasts of average annual total revenues used in the 1999, 2001, 2003, 2005, 2007, and 2009 studies. The total revenues of forecast for the current study are $869.7 million, or 1.0 percent lower than in the prior study.

Caution should be used in comparing these forecasts, however, since they were made at different times for different biennia, and used somewhat different assumptions regarding the treatment of ODOT beginning and ending balances. Additionally, title fees were not identified as a revenue source in studies prior to 2003 because they did not produce net revenue.

Exhibit 4-7: Comparison of Forecast Revenue (Millions of Dollars) Used in OR HCASs: 1999, 2001, 2003, 2005, 2007, and 2009

Year of Study	Average Annual Forecast Revenue
1999	691.1
2001	690.0
2003	712.8
2005	825.5
2007	878.8
2009	869.7

Chapter 5

Expenditure Allocation and Revenue Attribution Results

This chapter presents the expenditure allocation and revenue attribution results of the 2009 Study and compares them to the results of previous Oregon studies. The following chapter reports equity ratios for each vehicle group and weight class based on the expenditure allocation and revenue attribution results.

Expenditure Allocation Results

The 2003 Study was the first to base expenditure allocation results on all highway expenditures, or those financed by federal, local, and state revenues; the 2005 Study did the same, but excluded some expenditure of local own-source revenues. This approach was considered necessary to address the impacts of the federal advance construction program on the expenditure. This change in approach means the expenditure allocation results for the 2003 study are not directly comparable to those of the earlier Oregon studies.

For the 2005 and 2007 studies, the approach used in the 2003 study was modified to exclude the expenditure of certain local-government own-source revenues that were not considered to be interchangeable with State Highway Fund monies. The excluded categories were property taxes (including local improvement districts), bond revenues, systems development charges, and traffic impact fees. The 2009 study uses the same methodology as the 2005 and 2007 studies. As a result, the expenditure allocations in this study are comparable to the 2005 and 2007 studies, but not directly comparable to those in the 2003 study or any prior study.

The results presented in this chapter are for all—full fee and alternative fee—vehicles, but do not include the allocated expenditure of bond revenues that are carried forward from the 2003, 2005 and 2007 studies. For this reason, most of the results presented in this chapter will show slightly lower allocated expenditures than are shown in the exhibits in Chapter 6.

Exhibit 5-1 presents the expenditure allocation results by major expenditure category and vehicle weight group. Light (up to 10,000 pound) and heavy (over 10,000 pound) vehicles are projected to be responsible for 64.5 percent and 35.5 percent (respectively) of average annual total expenditures for the 2009-11 biennium.

As shown in the exhibit, the responsibility shares vary significantly among the major expenditure categories. Heavy vehicles, as a group, are projected to be responsible for the majority of preservation and bridge expenditures (61.8 percent and 54.4 percent, respectively). The group is responsible for significantly smaller shares of maintenance, modernization, and other expenditures (38.1 percent, 37.1 percent, and 17.9 percent, respectively); this illustrates the point made previously that the mix of expenditures allocated can have a significant impact on the overall results.

Exhibit 5-1: Average Annual Cost Responbility by Expenditure Category and Weight Class (thousands of dollars)

	All Funding Sources						
Declared Weight in Pounds	Moderni-zation	Preser-vation	Mainte-nance	Bridge	Other	Prior Bonds	Total
1 to 10,000	181,812	89,581	261,956	78,852	587,645	60,922	1,260,769
10,001 to 26,000	12,758	13,783	20,730	12,175	15,819	5,680	80,945
26,001 to 78,000	14,251	17,031	24,013	8,405	19,067	6,002	88,769
78,001 to 80,000	55,019	79,652	77,996	27,526	62,779	22,564	325,538
80,001 to 104,000	12,655	17,948	18,622	22,889	15,327	10,531	97,973
104,001 to 105,500	11,242	14,571	16,774	22,847	14,825	11,830	92,090
105,501 and up	1,478	2,039	2,792	288	475	262	7,334
Total	289,217	234,605	422,884	172,983	715,938	117,791	1,953,417
Total for Vehicles Under 10,001 Pounds	181,812	89,581	261,956	78,852	587,645	60,922	1,260,769
% for Vehicles Under 10,001 Pounds	62.9%	38.2%	61.9%	45.6%	82.1%	51.7%	64.5%
Total for Vehicles Over 10,000 Pounds	107,404	145,023	160,928	94,131	128,292	56,869	692,648
% for Vehicles Over 10,000 Pounds	37.1%	61.8%	38.1%	54.4%	17.9%	48.3%	35.5%
Total for Vehicles Under 26,001 Pounds	194,571	103,365	282,686	91,026	603,464	66,602	1,341,714
% for Vehicles Under 26,001 Pounds	67.3%	44.1%	66.8%	52.6%	84.3%	56.5%	68.7%
Total for Vehicles Over 26,000 Pounds	94,646	131,240	140,198	81,956	112,473	51,189	611,703
% for Vehicles Over 26,000 Pounds	32.7%	55.9%	33.2%	47.4%	15.7%	43.5%	31.3%

Both the State and local governments spend funds from state user fees and from the federal government. Exhibit 5-2 shows the funds received from each revenue source and by whom they are expended. The difference between the funds received and the expenditures allocated is due to the allocation of bond expenditures. The upper part of the table shows the full expenditure of bond revenues and the lower part shows the portions of current and prior expenditures of bond revenues that are allocated to vehicles in this study. In the exhibits that follow, where allocated expenditures are broken down into state, federal, local, and bond, the categories correspond to rows in the lower part of Exhibit 5-2.

The responsibility amounts for state, federal, local, and bond expenditures are broken out separately in Exhibit 5-3. In this exhibit, the expenditure of state and federal monies by local governments are counted under the state and federal categories. The

Exhibit 5-2: Sources and Expenditures of Funds (thousands of annual dollars)

	Source of Funds				
Expenditures of Funds	State Revenues	Bond Revenues	Federal Revenues	Local Revenues	All Sources
State Government	641,462	0	558,925	0	1,200,387
Local Governments	269,447	0	98,258	232,424	600,128
Expenditure of Bond Revenue	0	218,780	0	0	218,780
All Expenditures	910,909	218,780	657,183	232,424	2,019,295
Allocated State Expenditures	641,462	0	558,925	0	1,200,387
Allocated Local Expenditures	269,447	0	98,258	232,424	600,128
Allocated Current Bond	0	35,111	0	0	35,111
Allocated Prior Bond	0	117,791	0	0	117,791
Allocated Expenditures	910,909	152,902	657,183	232,424	1,953,417

Exhibit 5-3: Expenditure Allocation Results for Weight Groups by Funding Source (thousands of dollars)

		Allocation to Vehicles			
Funding Source	Average Annual Total Expenditures Allocated	Under 10,001 Pounds	Over 10,000 Pounds	Under 26,001 Pounds	Over 26,000 Pounds
State (Highway Fund)	641,462	498,745	142,717	513,685	127,777
		77.8%	22.2%	80.1%	19.9%
Federal	558,925	311,635	247,290	336,291	222,634
		55.8%	44.2%	60.2%	39.8%
Local	600,128	373,450	226,678	407,237	192,891
		62.2%	37.8%	67.9%	32.1%
Bond	35,111	16,017	19,094	17,899	17,212
		45.6%	54.4%	51.0%	49.0%
Current	1,835,626	1,199,847	635,779	1,275,112	560,514
		65.4%	34.6%	69.5%	30.5%
Prior Bond	117,791	60,922	56,869	66,602	51,189
		51.7%	48.3%	56.5%	43.5%
Total	1,953,417	1,260,769	692,648	1,341,714	611,703
		64.5%	35.5%	68.7%	31.3%

local category contains only the expenditure by local governments of their own revenues.

Light vehicles are projected to be responsible for 77.8 percent of state, 55.8 percent of federal, 62.2 percent of local, and 45.6 percent of bond expenditures. Heavy vehicles are projected to be responsible for 22.2 percent of state, 44.2 percent of federal, 37.8 percent of local, and 54.4 percent of bond expenditures. Overall, state-funded expenditures are expected to average $641.5 million annually over the 2007-2009 biennium. Comparable annual amounts for federal, local, and bond-funded expenditures are $558.9 million, $600.1 million, and $35.1 million respectively.

Exhibit 5-4: Average Annual Cost Responsibility, State Highway Fund Detail (thousands of dollars)

Declared Weight in Pounds			Modernization	Preservation	Maintenance	Bridge	Other	Total
1	to	10,000	10,039	16,057	157,549	9,212	305,888	498,745
10,001	to	26,000	972	770	4,965	1,260	6,972	14,940
26,001	to	78,000	1,070	971	4,047	834	10,748	17,670
78,001	to	80,000	6,630	6,456	21,743	3,188	36,740	74,756
80,001	to	104,000	1,471	1,349	4,726	2,442	8,261	18,250
104,001	to	105,500	1,190	1,036	3,910	2,423	7,945	16,503
105,501	and	up	98	96	237	29	139	599
Total			21,469	26,734	197,177	19,389	376,693	641,462
Total for Vehicles Under 10,001 Pounds			10,039	16,057	157,549	9,212	305,888	498,745
% for Vehicles Under 10,001 Pounds			46.8%	60.1%	79.9%	47.5%	81.2%	77.8%
Total for Vehicles Over 10,000 Pounds			11,430	10,677	39,628	10,177	70,805	142,717
% for Vehicles Over 10,000 Pounds			53.2%	39.9%	20.1%	52.5%	18.8%	22.2%
Total for Vehicles Under 26,001 Pounds			11,011	16,827	162,514	10,472	312,860	513,685
% for Vehicles Under 26,001 Pounds			51.3%	62.9%	82.4%	54.0%	83.1%	80.1%
Total for Vehicles Over 26,000 Pounds			10,458	9,907	34,663	8,916	63,833	127,777
% for Vehicles Over 26,000 Pounds			48.7%	37.1%	17.6%	46.0%	16.9%	19.9%

Exhibit 5-5: Average Annual Cost Responsibility, Federal Detail (thousands of dollars)

Declared Weight in Pounds			Modernization	Preservation	Maintenance	Bridge	Other	Total
1	to	10,000	66,105	38,026	21,061	54,157	132,286	311,635
10,001	to	26,000	4,905	6,099	1,163	7,880	4,609	24,656
26,001	to	78,000	5,008	7,148	1,230	5,278	4,236	22,898
78,001	to	80,000	28,148	49,740	7,700	18,579	19,212	123,379
80,001	to	104,000	6,105	10,739	1,727	15,723	5,177	39,471
104,001	to	105,500	5,196	8,043	1,413	15,730	4,831	35,214
105,501	and	up	432	772	102	196	169	1,671
Total			115,899	120,568	34,397	117,542	170,520	558,925
Total for Vehicles Under 10,001 Pounds			66,105	38,026	21,061	54,157	132,286	311,635
% for Vehicles Under 10,001 Pounds			57.0%	31.5%	61.2%	46.1%	77.6%	55.8%
Total for Vehicles Over 10,000 Pounds			49,794	82,542	13,336	63,386	38,234	247,290
% for Vehicles Over 10,000 Pounds			43.0%	68.5%	38.8%	53.9%	22.4%	44.2%
Total for Vehicles Under 26,001 Pounds			71,010	44,125	22,224	62,036	136,895	336,291
% for Vehicles Under 26,001 Pounds			61.3%	36.6%	64.6%	52.8%	80.3%	60.2%
Total for Vehicles Over 26,000 Pounds			44,889	76,443	12,172	55,506	33,624	222,634
% for Vehicles Over 26,000 Pounds			38.7%	63.4%	35.4%	47.2%	19.7%	39.8%

Exhibit 5-6: Average Annual Cost Responsibility, Local Government Detail (thousands of dollars)

Declared Weight in Pounds			Modernization	Preservation	Maintenance	Bridge	Other	Total
1	to	10,000	104,410	35,102	83,243	4,745	145,951	373,450
10,001	to	26,000	6,746	6,851	14,584	1,585	4,020	33,787
26,001	to	78,000	8,027	8,834	18,717	1,328	3,882	40,787
78,001	to	80,000	19,328	22,922	48,418	1,552	5,777	97,996
80,001	to	104,000	4,883	5,745	12,139	781	1,579	25,126
104,001	to	105,500	4,686	5,405	11,429	972	1,765	24,257
105,501	and	up	935	1,162	2,451	20	155	4,723
Total			149,015	86,021	190,980	10,983	163,129	600,128
Total for Vehicles Under 10,001 Pounds			104,410	35,102	83,243	4,745	145,951	373,450
% for Vehicles Under 10,001 Pounds			70.1%	40.8%	43.6%	43.2%	89.5%	62.2%
Total for Vehicles Over 10,000 Pounds			44,605	50,919	107,737	6,238	17,178	226,678
% for Vehicles Over 10,000 Pounds			29.9%	59.2%	56.4%	56.8%	10.5%	37.8%
Total for Vehicles Under 26,001 Pounds			111,156	41,953	97,827	6,330	149,971	407,237
% for Vehicles Under 26,001 Pounds			74.6%	48.8%	51.2%	57.6%	91.9%	67.9%
Total for Vehicles Over 26,000 Pounds			36,924	44,068	93,153	4,653	13,158	191,956
% for Vehicles Over 26,000 Pounds			24.8%	51.2%	48.8%	42.4%	8.1%	32.0%

The allocation results for state, federal, local and bond expenditures are further broken out by major category in Exhibits 5-4 through 5-7. For most funding sources, heavy vehicles are projected to be responsible for the majority of modernization and preservation expenditures while light vehicles are projected to bear larger shares of maintenance, bridge, and other expenditures.

Because of restrictions on the types of expenditures for which federal-aid highway funds can be used, federal funds tend to be concentrated on construction (i.e., modernization and preservation) projects and other types of work for which heavy vehicles have the predominant responsibility. Additionally, federal funds are focused on projects on interstate and

Exhibit 5-7: Average Annual Cost Responsibility, Bond Detail (thousands of dollars)

Declared Weight in Pounds			Moderni-zation	Preser-vation	Mainte-nance	Bridge	Other	Current	Prior	Total
1	to	10,000	1,259	396	103	10,738	3,520	16,017	60,922	76,939
10,001	to	26,000	135	64	17	1,450	217	1,883	5,680	7,563
26,001	to	78,000	147	78	20	966	201	1,412	6,002	7,413
78,001	to	80,000	913	534	136	4,207	1,051	6,842	22,564	29,406
80,001	to	104,000	196	115	30	3,943	310	4,594	10,531	15,125
104,001	to	105,500	171	86	22	3,721	285	4,285	11,830	16,115
105,501	and	up	14	8	2	43	12	79	262	341
Total			2,834	1,282	330	25,069	5,596	35,111	117,791	152,902
Total for Vehicles Under 10,001 Pounds			1,259	396	103	10,738	3,520	16,017	60,922	76,939
% for Vehicles Under 10,001 Pounds			44.4%	30.9%	31.3%	42.8%	62.9%	45.6%	51.7%	50.3%
Total for Vehicles Over 10,000 Pounds			1,575	886	227	14,331	2,076	19,094	56,869	75,963
% for Vehicles Over 10,000 Pounds			55.6%	69.1%	68.7%	57.2%	37.1%	54.4%	48.3%	49.7%
Total for Vehicles Under 26,001 Pounds			1,394	460	120	12,188	3,737	17,899	66,602	84,501
% for Vehicles Under 26,001 Pounds			49.2%	35.9%	36.4%	48.6%	66.8%	51.0%	56.5%	55.3%
Total for Vehicles Over 26,000 Pounds			1,440	822	210	12,881	1,858	17,212	51,189	68,400
% for Vehicles Over 26,000 Pounds			50.8%	64.1%	63.6%	51.4%	33.2%	49.0%	43.5%	44.7%

other higher-order highways where the heavy vehicle share of travel is highest. Hence, the inclusion of federally-funded expenditures in a state HCAS will almost always have the effect of reducing the light vehicle responsibility share and increasing the heavy vehicle share.

Conversely, state funds are generally more concentrated on maintenance, operations, administration and other activities for which light vehicles have the largest responsibility share. This is particularly the case at the present time with ODOT's use of the federal advance construction programming technique and aggressive strategy to "federalize" a large portion of the construction program.

The inclusion of local expenditures in a state HCAS will, by itself, typically increase the relative responsibility of light vehicles and reduce that of heavy vehicles. This is because many types of expenditures are allocated on a relative travel basis and heavy vehicles account for a comparatively small share of the total travel on local roads and streets. This factor, however, is more than offset by the fact local governments spend more of their road and street funds on activities having a comparatively high heavy vehicle responsibility component; specifically rehabilitation, repair and maintenance of pavements and bridges.

Because pavements and bridges represent two of the largest and most important expenditure areas in a highway cost allocation study, the responsibility results for these expenditures are broken out separately in Exhibits 5-8 and 5-9.

Exhibit 5-8 shows that pavement expenditures allocated in the 2009 Study total $586.4 million, 103 percent of the pavement expenditure allocated in the 2007 Study.

The responsibility shares for particular types of pavement work are roughly the same between the two studies. Both studies found heavy vehicles responsible for relatively larger shares of new pavement, pavement reconstruction, and pavement rehabilitation expenditures and slightly smaller shares of maintenance expenditures. For this exhibit, other pavement expenditures include those for climbing lanes, pavement striping and marking, maintenance of truck scale pavements, and studded tire damage repair.

Exhibit 5-9 compares the bridge plus interchange expenditure amounts

Exhibit 5-8: Comparison of Pavement Responsibility Results From 2007 and 2009 OR HCASs (thousands of annual dollars)

	2007 Study			2009 Study		
Expenditure Work Type	Expenditures Allocated	Light Vehicle Responsibility	Heavy Vehicle Responsibility	Expenditures Allocated	Light Vehicle Responsibility	Heavy Vehicle Responsibility
New Pavements	90,849	20,616	70,233	76,099	15,674	60,425
	5.3%	22.7%	77.3%	4.1%	20.6%	79.4%
Pavement and Shoulder Reconstruction	38,162	14,131	24,031	40,358	13,395	26,963
	2.2%	37.0%	63.0%	2.2%	33.2%	66.8%
Pavement and Shoulder Rehabilitation	125,484	46,902	78,582	222,813	77,790	145,023
	7.3%	37.4%	62.6%	12.1%	34.9%	65.1%
Pavement Maintenance	304,009	118,980	185,029	228,214	87,945	140,269
	17.6%	39.1%	60.9%	12.4%	38.5%	61.5%
Other Pavement Expenditures	11,698	11,411	286	18,920	17,414	1,506
	0.7%	97.6%	2.4%	1.0%	92.0%	8.0%
Total Pavement Expenditures	570,202	212,041	358,161	586,403	212,218	374,186
	33.1%	37.2%	62.8%	31.9%	36.2%	63.8%

and responsibility results in the 2007 and present studies. Bridge-related expenditures were lower as a share of total expenditures in the current study (10.1 percent) than in the 2007 Study (15.0 percent) and the 2005 Study (26.4 percent), which were both considerably higher than in the 2001 study.

The heavy vehicle responsibility share for total bridge plus interchange expenditures in the present study is 51.3 percent, as compared to 42.7 percent in the 2007 Study. This reflects differences in the mix of bridge types, as well as a different treatment of bridge projects that are funded, but for which the bridges to be worked on have not yet been selected. Following the approach introduced in the 2007 study, "other bridge" work type expenditures were allocated in proportion to the allocation results for work on known bridges.

Exhibit 5-10 shows the amounts of allocated expenditures of bond revenues that were carried forward from the 2007 study. These represent amounts that were spent in the 2007-09 biennium and that

Exhibit 5-9: Comparison of Bridge and Interchange Responsibility Results from 2007 and 2009 OR HCASs (thousands of dollars)

	2007 Study			2009 Study		
Expenditure Work Type	Expenditures Allocated	Light Vehicle Responsibility	Heavy Vehicle Responsibility	Expenditures Allocated	Light Vehicle Responsibility	Heavy Vehicle Responsibility
Bridge and Interchange	235,244	127,341	107,903	172,972	78,842	94,130
	13.7%	54.1%	45.9%	9.4%	45.6%	54.4%
Bridge Maintenance	22,934	20,705	2,229	13,045	11,829	1,216
	1.3%	90.3%	9.7%	0.7%	90.7%	9.3%
Total Bridge and Interchange Expenditures	258,178	148,046	110,132	186,017	90,671	95,346
	15.0%	57.3%	42.7%	10.1%	48.7%	51.3%

will be repaid during the 2009-11 biennium. The 2011 study will include the same allocated expenditures from the 2003, 2005, and 2007 studies as well as allocated bond expenditures from the current study.

Exhibit 5-10: Average Annual Cost Responsibility by Weight Group with Prior Allocated Expenditures (thousands of dollars)

Declared Weight in Pounds			Total Without Prior Allocated Expenditures	Prior Allocated Expenditures	Total With Prior Allocated Expenditures
1	to	10,000	1,199,847	60,922	1,260,769
10,001	to	26,000	75,265	5,680	80,945
26,001	to	78,000	82,767	6,002	88,769
78,001	to	80,000	302,973	22,564	325,538
80,001	to	104,000	87,442	10,531	97,973
104,001	to	105,500	80,260	11,830	92,090
105,501	and	up	7,073	262	7,334
Total			1,835,626	117,791	1,953,417

For illustrative purposes, Exhibit 5-11 compares the expenditure allocation results (with prior allocated costs) for the present study with those of the previous study. As shown, the shares are nearly identical: the all-vehicle responsibility shares in the 2007 Study shares are 63.0 percent for light vehicles and 37.0 percent for heavy vehicles; the 2009 Study shares are 64.5 percent for light vehicles and 35.5 percent for heavy vehicles.

Revenue Attribution Results

The attribution of revenues to the various vehicle types and weight classes is an important element of a highway cost allocation study. Once accomplished, the shares of projected payments are compared to the shares of cost responsibility for each class to determine whether each class is paying more or less than its fair share under the existing tax structure and rates.

Exhibit 5-11: Cost Responsibility Distributions by Weight Group-Comparison Between 2007 and 2009 OR HCASs

Declared Weight in Pounds			2007 Study	2009 Study	Change in Percentage
1	to	10,000	63.0%	64.5%	1.5%
10,001	and	up	37.0%	35.5%	-1.5%
10,001	to	26,000	2.7%	4.1%	1.5%
26,001	to	78,000	5.6%	4.5%	-1.1%
78,001	to	80,000	18.3%	16.7%	-1.7%
80,001	to	104,000	4.8%	5.0%	0.2%
104,001	to	105,500	5.4%	4.7%	-0.7%
105,501	and	up	0.2%	0.4%	0.2%
			100.0%	100.0%	

Where significant imbalances are detected, recommendations for changes in tax rates are made to bring payments back into balance with cost responsibilities.

As noted in Chapter 4, most of the required revenue data for the study, including control totals for forecasted revenues by tax instrument (i.e., fuel, registration, weight-mile, etc.), are obtained from ODOT's revenue forecasting model. Every effort is made to ensure the data used in the HCAS are consistent with the most recent revenue forecast available at the time the study is being conducted. Some information required for the HCAS, however, is not available from the revenue forecasting model and so must be estimated from other sources. The revenue model, for example, does not project fuel tax payments by detailed, 2,000-pound weight class. Therefore, estimated fuel efficiencies by vehicle type and weight group must be used together with control totals from the revenue model to attribute projected fuel tax payments to the detailed vehicle classes.

The revenue attribution results are summarized in Exhibit 5-12. For the next biennium, under existing tax rates, it is forecasted that light vehicles will contribute 65.3 percent of State Highway Fund revenues and heavy vehicles will contribute 34.7 percent. The 34.7 percent projected payment share for heavy vehicles is less than the overall

Exhibit 5-12: Average Annual User-Fee Revenue by Tax Instrument and Weight Class (thousands of dollars)

Declared Weight in Pounds			Fuel Tax	Registration and Title Fees	Weight-Mile Tax	Other Motor Carrier	Flat Fee	RUAF	Total
1	to	10,000	413,501	154,769	0	0	0	0	568,270
10,001	to	26,000	21,003	15,858	0	0	0	0	36,861
26,001	to	78,000	2,183	4,063	18,217	747	87	0	25,297
78,001	to	80,000	281	15,674	140,799	2,953	4,458	0	164,165
80,001	to	104,000	94	3,491	27,520	560	3,908	26	35,599
104,001	to	105,500	171	4,051	31,863	635	811	22	37,552
105,501	and	up	0	149	0	9	0	1,810	1,968
Total			437,231	198,054	218,399	4,903	9,264	1,858	869,710
Total for Vehicles Under 10,001 Pounds			413,501	154,769	0	0	0	0	568,270
% for Vehicles Under 10,0001 Pounds			94.6%	78.1%	0.0%	0.0%	0.0%	0.0%	65.3%
Total for Vehicles Over 10,000 Pounds			23,731	43,285	218,399	4,903	9,264	1,858	301,441
% for Vehicles Over 10,000 Pounds			5.4%	21.9%	100.0%	100.0%	100.0%	100.0%	34.7%
Total for Vehicles Under 26,001 Pounds			434,504	170,627	0	0	0	0	605,131
% for Vehicles Under 26,001 Pounds			99.4%	86.2%	0.0%	0.0%	0.0%	0.0%	69.6%
Total for Vehicles Over 26,000 Pounds			2,728	27,427	218,399	4,903	9,264	1,858	264,580
% for Vehicles Over 26,000 Pounds			0.6%	13.8%	100.0%	100.0%	100.0%	100.0%	30.4%

responsibility share of 35.5 percent for these vehicles reported in Section 5.1. However, these results need to be adjusted to reflect the impacts of tax exemptions and reduced rates granted to certain types of vehicles. As explained in the following chapter, these adjustments have a significant effect on the relative shares of attributed revenues and allocated expenditures for the various vehicle classes.

Exhibit 5-12 also illustrates how the relative payments of different vehicle weight groups vary by tax instrument. Light vehicles are projected to contribute approximately 94.6 percent of fuel tax revenues and 78.1 percent of registration and title fee revenues. Heavy vehicles, on the other hand, contribute 100 percent of weight-mile tax, flat fee, and road use assessment fee revenues. Heavy vehicles also contribute 100 percent of the "Other Motor Carrier" revenue identified in the exhibit. This category includes revenues from truck overweight/overlength permit fees, late payment penalties and interest, etc.

Exhibit 5-13: Revenue Attribution Distributions by Weight Group-Comparison Between 2007 and 2009 OR HCASs

Declared Weight in Pounds			2007 Study	2009 Study	Change in Percentage
1	to	10,000	64.5%	65.3%	0.9%
10,001	and	up	35.5%	34.7%	-0.9%
10,001	to	26,000	2.7%	4.2%	1.5%
26,001	to	78,000	3.0%	2.9%	-0.1%
78,001	to	80,000	21.1%	18.9%	-2.2%
80,001	to	104,000	4.2%	4.1%	-0.1%
104,001	to	105,500	4.5%	4.3%	-0.2%
105,501	and	up	0.0%	0.2%	0.2%
Total			100.0%	100.0%	

Exhibit 5-13 compares the revenue attribution results of the present study with those of the 2007 Study. The projected share of revenues contributed by light vehicles has increased from 64.5 percent in the 2007 Study to 65.3 percent in the present study. Conversely, the overall heavy vehicle share of projected payments has decreased from 35.5 percent in the previous study to 34.7 percent in the present study.

Comparison of Expenditures Allocated to Revenues Paid

This chapter brings together the expenditure allocation and revenue attribution results reported in Chapter 5 to compare projected responsibilities and tax payments for each vehicle class and for broader groupings of vehicles (e.g., all heavy vehicles combined). This comparison is facilitated by the calculation of equity ratios, or the ratio of the share of revenues contributed by the vehicles in a class to the share of cost responsibility for vehicles in that class. An equity ratio greater than one indicates the vehicles in that class are projected to pay more than their cost-responsible share of user fees. Conversely, an equity ratio less than one indicates the vehicles in that class are projected to pay less than their cost-responsible share.

The comparison of revenue shares to cost responsibility shares in the Oregon studies traditionally is done for full-fee-paying vehicles only. This study takes the same approach, which requires some further adjustments to the numbers presented in Chapter 5. The model separately estimates the revenue contributions from full-fee-paying and alternative-fee-paying vehicles for each tax instrument. For alternative-fee-paying vehicles, the model also estimates the fees they would pay if they were full-fee-paying vehicles. The expenditures allocated to each vehicle class are apportioned among full-fee-paying and alternative-fee-paying vehicles on the basis of the relative miles of travel of each in that class.[1]

6.1 Presentation of Equity Ratios

Exhibit 6-1 includes calculated equity ratios for the summary-level weight groups shown in earlier exhibits. Exhibit 6-3, at the end of this chapter, shows the equity ratios for each 2,000-pound weight class. It needs to be emphasized that these results are for full-fee-paying vehicles only, and exclude vehicles that pay on an alternative-fee basis.

As shown in the first table within Exhibit 6-1, projected 2010 VMT for full-fee-paying vehicles are 37.270 billion, 93.6 percent of these miles being by light vehicles and 6.4 percent by heavy vehicles. This compares to projected 2010 miles of travel by all vehicles of 38.503 billion, 92.8 percent by light vehicles and 7.2 percent by heavy vehicles. As explained in the previous chapter, alternative-fee-paying vehicles are disproportionately concentrated in the heavy vehicle classes, so excluding them will reduce the heavy vehicle share of VMT. The heavy vehicle percentage share of VMT, in other words, will always be lower if only full-fee-paying vehicles are considered than if all vehicles are considered.

The projected total responsibility of full-fee-paying vehicles is $1,841.1 million, with responsibility shares of

[1] If, for example, 80 percent of the VMT in a weight class is by full-fee-paying vehicles and 20 percent by alternative-fee-paying vehicles, then 80 percent of the total responsibility of that class is assigned to full-fee-paying vehicles and 20 percent to alternative-fee-paying vehicles. This division is based on the reasonable assumption that two vehicles that are identical, except one is subject to full fees and the other alternative fees, have exactly the same per-mile cost responsibility.

66.8 percent for light vehicles and 33.2 percent for heavy vehicles. This compares to the projected total responsibility for all vehicles of $1,953.4 million. The difference between these two amounts is the projected responsibility of alternative-fee-paying vehicles.

Forecasted average annual user fees paid by full-fee-paying vehicles total $840.7 million, 66.5 percent from light vehicles and 33.5 percent from heavy vehicles. The difference between this total and the $869.7 million total for all vehicles represents projected revenues from alternative-fee-paying vehicles.

The total of the Allocated Alternative-Fee Difference column represents the average annual difference between what alternative-fee-paying vehicles are projected to pay and what they would pay if subject to full fees. This total is $17.2 million annually for the next biennium under existing tax rates.[2] Following the approach of previous studies, this amount is reassigned to the full-fee-paying vehicle classes based on the relative VMT of each of these classes.

Because the current study includes expenditures of funds from federal and local revenue sources, the allocated expenditures for full-fee-paying vehicles are over twice the attributed State revenues for these vehicles. This does not present a problem in calculating the equity ratios themselves, but does raise an issue as to how and at what stage the alternative-fee difference adjustment should be made.[3] In this study, the allocated alternative-fee difference is added to allocated costs for full-fee-paying vehicles before calculating the share of costs in the denominator of the equity ratio.

The equity ratios are calculated four different ways to illustrate the effects of considering only full-fee-paying vehicle costs and revenues and of adding the allocated alternative-fee difference. The bottom table in Exhibit 6-1 presents the unadjusted and alternative-fee difference-adjusted equity ratios for full-fee-paying vehicles. The adjusted ratios in the final column are the more important, however, since it is these results that form the basis for the determination of whether rates should be adjusted.

This study finds overall equity ratios of 0.9915 for light vehicles and 1.0173 for heavy vehicles as a group. This means that, for the 2009-11 biennium, under the existing tax structure and rates, light and heavy vehicles are each expected to pay very close to their fair shares.

Exhibit 6-1 also shows the overall equity ratios for vehicles under and over 26,000 pounds, as well as for the summary-level weight groups shown in earlier exhibits. Vehicles with weights between 10,001 pounds and 26,000 pounds are projected to overpay their responsibility by 15.8 percent. This is almost entirely a result of the adjustments for full-fee-paying vehicles in the equity-ratio calculation, as all vehicles in this group pay close to their fair share.

Vehicles with declared weights between 26,001 and 78,000 pounds as a group underpay their fair share and those between 78,001 and 80,000 pounds overpay by 12.3 percent. Vehicles in the 78,001-

[2] These amounts represent the underpayment by alternative-fee-paying vehicles relative to what they would pay on a full-fee basis – the difference, for example, between revenues from publicly owned vehicles under the existing tax structure versus revenues from these vehicles if they were all subject to the state fuel tax or weight-mile tax and full registration fees. The amounts, however, do not necessarily represent an underpayment relative to the cost responsibility of these vehicles. Some flat-fee vehicles, for instance, pay more under the alternative fee structure than they would under the weight-mile tax, while others pay less.

[3] The calculation of equity ratios in the model is accomplished by comparing ratios of revenues attributed to ratios of expenditures allocated. For each vehicle class, the ratio of the revenues attributed to this class to the total revenues attributed to all classes is first calculated. This ratio is then divided by the ratio of the expenditures allocated to this class to the total expenditures allocated to all classes. Thus, the calculation of the equity ratios does not require scaling of either the attributed revenues or allocated expenditures when the two are not equal.

Exhibit 6-1: Comparison of Average Annual Cost Responsibility and User Fees Paid by Full-Fee-Paying Vehicles by Declared Weight Class (Thousands)

Declared Weight			Annual VMT All	Annual VMT Full-Fee	Annual VMT Alternative Fee	Percent of Annual VMT All	Percent of Annual VMT Full-Fee	Percent of Annual VMT Alternative Fee
1	to	10,000	35,742,954,783	34,872,969,761	869,985,022	92.8%	93.6%	70.5%
10,001	to	26,000	654,219,821	526,838,253	127,381,569	1.7%	1.4%	10.3%
26,001	to	78,000	402,730,644	284,832,561	117,898,083	1.0%	0.8%	9.6%
78,001	to	80,000	1,187,035,125	1,126,209,846	60,825,280	3.1%	3.0%	4.9%
80,001	to	104,000	258,262,622	213,501,631	44,760,991	0.7%	0.6%	3.6%
104,001	to	105,500	254,934,019	242,264,604	12,669,415	0.7%	0.7%	1.0%
105,501	and	up	3,313,358	3,313,358	0	0.0%	0.0%	0.0%
	Total		38,503,450,372	37,269,930,012	1,233,520,360	100.0%	100.0%	100.0%
10,001	and	up	2,760,495,589	2,396,960,251	363,535,338	7.2%	6.4%	29.5%
26,001	to	80,000	1,589,765,769	1,411,042,406	178,723,363	4.1%	3.8%	14.5%
80,001	to	105,500	513,196,641	455,766,234	57,430,406	1.3%	1.2%	4.7%
26,001	to	105,500	2,102,962,410	1,866,808,641	236,153,770	5.5%	5.0%	19.1%
26,001	and	up	2,106,275,768	1,870,121,998	236,153,770	5.5%	5.0%	19.1%

Declared Weight			Annual Cost Responsibility State	Federal	Local	Total	Full-Fee	Percent of Cost Responsibility State	Federal	Local	Total	Full-Fee
1	to	10,000	575,684,126	311,634,502	373,450,201	1,260,768,829	1,230,081,662	72.5%	55.8%	62.2%	64.5%	66.8%
10,001	to	26,000	22,502,070	24,656,150	33,786,848	80,945,067	62,363,830	2.8%	4.4%	5.6%	4.1%	3.4%
26,001	to	78,000	25,082,827	22,898,283	40,787,416	88,768,525	64,470,472	3.2%	4.1%	6.8%	4.5%	3.5%
78,001	to	80,000	104,162,139	123,379,112	97,996,416	325,537,667	308,856,678	13.1%	22.1%	16.3%	16.7%	16.8%
80,001	to	104,000	33,374,796	39,471,426	25,126,472	97,972,694	80,467,032	4.2%	7.1%	4.2%	5.0%	4.4%
104,001	to	105,500	32,618,576	35,213,778	24,257,447	92,089,801	87,513,229	4.1%	6.3%	4.0%	4.7%	4.8%
105,501	and	up	939,307	1,671,499	4,723,264	7,334,069	7,332,018	0.1%	0.3%	0.8%	0.4%	0.4%
	Total		794,363,840	558,924,748	600,128,063	1,953,416,652	1,841,084,921	100.0%	100.0%	100.0%	100.0%	100.0%
10,001	and	up	218,679,715	247,290,246	226,677,862	692,647,823	611,003,259	27.5%	44.2%	37.8%	35.5%	33.2%
26,001	to	80,000	129,244,966	146,277,395	138,783,832	414,306,192	373,327,150	16.3%	26.2%	23.1%	21.2%	20.3%
80,001	to	105,500	65,993,373	74,685,203	49,383,919	190,062,495	167,980,261	8.3%	13.4%	8.2%	9.7%	9.1%
26,001	to	105,500	195,238,338	220,962,598	188,167,751	604,368,687	541,307,411	24.6%	39.5%	31.4%	30.9%	29.4%
26,001	and	up	196,177,645	222,634,097	192,891,014	611,702,756	548,639,429	24.7%	39.8%	32.1%	31.3%	29.8%

Exhibit 6-1 continues next page

Exhibit 6-1 (continued)

Declared Weight			Annual User Fees: All	Annual User Fees: Full-Fee	Annual User Fees: Alternative-Fee Difference	Annual User Fees: Allocated Alternative-Fee Difference	Percent of User Fees: All	Percent of User Fees: Full-Fee	Percent of User Fees: Alternative-Fee Difference	Percent of User Fees: Allocated Alternative-Fee Difference
1	to	10,000	568,269,775	558,960,722	4,635,485	16,064,008	65.3%	66.5%	27.0%	93.6%
10,001	to	26,000	36,860,773	32,786,677	4,323,044	242,685	4.2%	3.9%	25.2%	1.4%
26,001	to	78,000	25,296,606	23,032,453	5,188,458	131,206	2.9%	2.7%	30.2%	0.8%
78,001	to	80,000	164,164,558	157,225,607	1,552,621	518,781	18.9%	18.7%	9.0%	3.0%
80,001	to	104,000	35,598,778	30,170,736	604,228	98,348	4.1%	3.6%	3.5%	0.6%
104,001	to	105,500	37,552,055	36,507,199	864,316	111,598	4.3%	4.3%	5.0%	0.7%
105,501	and	up	1,967,866	1,967,866	0	1,526	0.2%	0.2%	0.0%	0.0%
Total			869,710,410	840,651,261	17,168,153	17,168,153	100.0%	100.0%	100.0%	100.0%
10,001	and	up	301,440,635	281,690,539	12,532,667	1,104,144	34.7%	33.5%	73.0%	6.4%
26,001	to	80,000	189,461,163	180,258,061	6,741,079	649,988	21.8%	21.4%	39.3%	3.8%
80,001	to	105,500	73,150,833	66,677,935	1,468,544	209,946	8.4%	7.9%	8.6%	1.2%
26,001	to	105,500	262,611,996	246,935,996	8,209,623	859,933	30.2%	29.4%	47.8%	5.0%
26,001	and	up	264,579,862	248,903,862	8,209,623	861,460	30.4%	29.6%	47.8%	5.0%

Declared Weight			Share of Full-Fee Revenues	Share of Full-Fee Costs	Share of Full-Fee Costs + Allocated Difference	Full-Fee Equity Ratio	Difference-Adjusted Full-Fee Equity Ratio
1	to	10,000	66.5%	66.8%	67.1%	0.9952	0.9915
10,001	to	26,000	3.9%	3.4%	3.4%	1.1514	1.1576
26,001	to	78,000	2.7%	3.5%	3.5%	0.7824	0.7881
78,001	to	80,000	18.7%	16.8%	16.6%	1.1149	1.1234
80,001	to	104,000	3.6%	4.4%	4.3%	0.8212	0.8278
104,001	to	105,500	4.3%	4.8%	4.7%	0.9136	0.9210
105,501	and	up	0.2%	0.4%	0.4%	0.5878	0.5932
Total			100.0%	100.0%	100.0%	1.0000	1.0000
10,001	and	up	33.5%	33.2%	32.9%	1.0097	1.0173
26,001	to	80,000	21.4%	20.3%	20.1%	1.0575	1.0655
80,001	to	105,500	7.9%	9.1%	9.1%	0.8693	0.8763
26,001	to	105,500	29.4%	29.4%	29.2%	0.9991	1.0068
26,001	and	up	29.6%	29.8%	29.6%	0.9936	1.0013

80,000 pound class alone account for 47.0 percent of the VMT by full-fee-paying heavy vehicles, and 60.2 percent of the VMT by over 26,000-pound vehicles. These vehicles also account for 50.5 percent of the cost responsibility (after allocation of the alternative-fee difference) and 55.8 percent of the user fees paid by full-fee-paying heavy vehicles. The reason for the large difference in the equity ratio between this group and the groups above and below it is that most truckers who are capable of operating at 80,000 pounds and do not know in advance how much their loads will weigh, declare at 80,000 pounds. As a result, the average operating weights of vehicles declared at 80,000 pounds are a substantially lower fraction of their declared weight than for other declared weight classes, and the wear-related costs they impose per mile are correspondingly lower.

As a group, vehicles between 80,001 and 105,500 pounds (Schedule B vehicles) pay 12.4 percent less than their fair share. Those in the 104,001 to 105,500 range pay 7.9 percent less than their fair share.

Vehicles over 105,500 pounds all pay the Road Use Assessment Fee, as do some vehicles between 98,001 and 105,500 pounds. Those over 105,500 pounds underpay their fair share by 40.7 percent. This study and the 2005 and 2007 studies report smaller underpayments for these vehicles than did the 2001 and 2003 studies primarily because the model was changed for the 2005 study to attribute portions of vehicle registration fees to these vehicles. Since no vehicle can register above 105,500 pounds, no registration fees were attributed to these vehicles in earlier studies.

6.2 Comparison with 1999, 2001, 2003, 2005 and 2007 Oregon Studies

The overall light and heavy vehicle equity ratios found by this study are slightly different from those determined by the prior five Oregon studies. The alternative-fee difference adjusted equity ratios found by the 1999 Study were 0.97 for light vehicles and 1.05 for heavy vehicles as a group, indicating a projected underpayment of 3 percent by light vehicles and overpayment of 5 percent by heavy vehicles. The analysis period for the 1999 Study was the 1999-01

Exhibit 6-2: Comparison of Equity Ratios from the 1999, 2001, 2003, 2005, 2007 and 2009 Oregon Highway Cost Allocation Studies

			Alternative-Fee Difference Adjusted Equity Ratios for Full-Fee-Paying Vehicles					
Declared Weight			1999	2001	2003	2005	2007	2009
1	to	10,000	0.9700	1.0027	0.9921	1.0032	0.9933	0.9915
10,001	to	26,000	1.0000	0.9440	1.3803	1.1846	1.2557	1.1576
26,001	to	78,000		0.9596	1.0091	0.7401	0.7485	0.7881
78,001	to	80,000		1.0603	1.0931	1.0610	1.1274	1.1234
80,001	to	104,000		0.9479	0.7430	0.9034	0.8427	0.8278
104,001	to	105,500		0.8712	0.7576	0.8759	0.8299	0.9210
105,501	and	up	1.3500	0.4727	0.2678	0.6395	0.6127	0.5932
Total			1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10,001	and	up	1.0500	0.9952	1.0158	0.9936	1.0129	1.0173
26,001	to	80,000				1.0189	1.0742	1.0655
80,001	to	105,500				0.8880	0.8357	0.8763
26,001	to	105,500				0.9812	1.0007	1.0068
26,001	and	up		0.9996	0.9870	0.9789	0.9984	1.0013

Exhibit 6-3: Detailed Comparison of Average Annual Cost Responsibility and User Fees Paid by Full-Fee-Paying Vehicles by Declared Weight Class (Thousands)

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
1	0	35,742,954,783	34,872,969,761	1,260,768,829	1,230,081,662	568,269,775	558,960,722	4,635,485	16,064,008	1.0124	0.9915
10001	0	116,100,179	102,673,051	8,007,561	7,081,477	5,550,356	5,128,669	249,017	47,296	1.5568	1.5903
12001	0	73,839,144	51,042,261	5,604,261	3,874,017	3,115,792	2,516,377	524,468	23,512	1.2487	1.4272
14001	0	133,037,924	117,077,783	11,122,514	9,788,181	7,328,042	6,727,966	317,086	53,931	1.4798	1.5111
16001	0	70,286,652	64,006,024	6,625,582	6,033,538	4,217,160	3,988,705	162,939	29,484	1.4296	1.4542
18001	0	68,860,756	59,394,428	7,450,263	6,426,071	4,349,763	4,017,604	308,170	27,360	1.3113	1.3761
20001	0	13,855,578	7,671,951	2,039,237	1,129,143	729,207	567,076	294,934	3,534	0.8032	1.1067
22001	0	38,560,782	28,291,557	6,707,181	4,920,974	2,486,832	2,198,269	509,362	13,032	0.8328	0.9849
24001	0	139,678,805	96,681,198	33,388,469	23,110,429	9,083,621	7,642,012	1,957,069	44,536	0.6111	0.7295
26001	0	15,912,528	2,265,344	2,822,883	401,872	486,686	121,345	365,679	1,044	0.3872	0.6657
28001	0	19,541,067	4,963,276	3,942,560	1,001,379	655,156	275,594	429,895	2,286	0.3732	0.6070
30001	0	47,910,914	13,018,153	11,932,284	3,242,190	1,693,352	692,593	855,609	5,997	0.3187	0.4713
32001	0	32,488,810	27,325,665	8,558,732	7,198,572	1,634,982	1,585,688	250,319	12,587	0.4291	0.4861
34001	0	10,909,076	4,895,701	2,417,767	1,085,029	369,935	321,481	346,421	2,255	0.3437	0.6536
36001	0	4,640,798	2,231,675	1,290,982	620,810	157,216	144,528	143,333	1,028	0.2735	0.5138
38001	0	31,901,022	4,585,014	4,377,995	629,233	370,234	349,246	2,059,705	2,112	0.1899	1.2228
40001	0	4,633,289	4,184,553	725,663	655,383	298,250	287,433	20,006	1,928	0.9231	0.9666
42001	0	3,323,823	2,527,688	885,442	673,358	220,562	196,054	37,242	1,164	0.5595	0.6425
44001	0	28,858,260	26,325,684	5,621,324	5,128,001	2,045,379	1,978,263	123,196	12,127	0.8173	0.8507
46001	0	21,952,020	19,483,713	5,490,133	4,872,817	1,554,291	1,487,729	121,912	8,975	0.6359	0.6736
48001	0	26,086,661	23,869,756	6,087,784	5,570,429	1,908,539	1,832,350	93,991	10,995	0.7041	0.7257
50001	0	16,224,906	15,351,016	3,006,916	2,844,960	1,211,411	1,191,968	48,412	7,071	0.9049	0.9238
52001	0	28,065,293	26,850,765	5,540,507	5,300,741	2,178,045	2,149,714	68,906	12,369	0.8830	0.8944
54001	0	37,799,929	36,385,083	11,238,806	10,818,139	3,087,268	3,026,638	57,061	16,761	0.6170	0.6175
56001	0	10,173,096	9,928,813	2,755,364	2,689,200	845,297	840,379	15,759	4,574	0.6890	0.6896
58001	0	9,293,242	8,887,925	1,713,024	1,638,312	799,600	787,718	24,041	4,094	1.0484	1.0602
60001	0	2,707,874	2,680,221	582,607	576,657	243,500	243,105	2,113	1,235	0.9387	0.9299

Exhibit 6-3 continued

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
62001	0	3,324,258	3,236,025	862,165	839,281	311,884	309,327	5,877	1,491	0.8125	0.8133
64001	0	15,514,400	15,221,911	3,443,233	3,378,318	1,522,579	1,524,751	31,469	7,012	0.9932	0.9956
66001	0	3,045,082	2,975,598	570,273	557,260	317,836	318,547	8,149	1,371	1.2518	1.2605
68001	0	8,679,475	8,267,777	1,541,628	1,468,504	935,039	930,502	41,798	3,808	1.3623	1.3970
70001	0	8,823,669	8,770,687	1,370,242	1,362,014	1,041,264	1,040,725	5,747	4,040	1.7068	1.6841
72001	0	2,189,586	2,120,072	357,024	345,690	270,404	269,558	7,993	977	1.7011	1.7188
74001	0	7,539,981	7,445,098	1,293,077	1,276,805	981,956	981,469	12,022	3,430	1.7056	1.6946
76001	0	1,191,586	1,035,349	340,112	295,518	155,941	145,749	11,802	477	1.0298	1.0885
78001	0	1,187,035,125	1,126,209,846	325,537,667	308,856,678	164,164,558	157,225,607	1,552,621	518,781	1.1327	1.1234
80001	5	7,568,266	3,823,542	3,130,434	1,581,518	927,093	502,722	67,988	1,761	0.6652	0.7019
80001	6	688,886	348,030	138,532	69,988	52,727	26,854	426	160	0.8549	0.8462
80001	7	307,416	155,309	49,313	24,913	24,549	12,322	-158	72	1.1181	1.0902
80001	8	338,893	171,211	59,085	29,850	21,710	11,065	192	79	0.8253	0.8172
80001	9	24,466	12,361	4,441	2,244	1,493	761	13	6	0.7553	0.7479
82001	5	11,802,180	11,210,422	4,901,154	4,655,411	1,741,472	1,675,593	22,570	5,164	0.7981	0.7947
82001	6	1,828,300	1,736,630	545,035	517,707	247,193	235,233	458	800	1.0187	1.0028
82001	7	217,789	206,869	39,640	37,652	26,928	25,782	215	95	1.5258	1.5098
82001	8	213,808	203,088	36,327	34,505	25,220	24,146	200	94	1.5594	1.5427
82001	9	28,860	27,413	4,620	4,388	3,240	3,102	26	13	1.5754	1.5582
84001	5	14,796,590	11,294,818	7,152,583	5,459,848	2,033,078	1,605,953	70,774	5,203	0.6384	0.6496
84001	6	6,451,669	4,924,812	2,530,501	1,931,631	893,944	690,903	11,162	2,269	0.7935	0.7897
84001	7	429,048	327,509	115,746	88,353	63,891	48,230	-709	151	1.2398	1.2046
84001	8	252,206	192,519	46,111	35,198	24,687	19,226	499	89	1.2025	1.2044
84001	9	52,163	39,818	8,291	6,329	4,871	3,793	98	18	1.3196	1.3210
86001	5	3,692,829	2,068,297	1,700,959	952,681	520,604	297,033	9,732	953	0.6874	0.6885
86001	6	21,745,875	12,179,533	8,923,119	4,997,703	2,654,371	1,551,325	115,432	5,610	0.6681	0.6854
86001	7	1,613,374	903,626	447,700	250,750	133,166	73,466	-1,996	416	0.6681	0.6466
86001	8	708,636	396,896	187,858	105,216	55,334	31,441	802	183	0.6616	0.6594
86001	9	21,971	12,305	9,183	5,143	2,470	914	-837	6	0.6041	0.3926

Exhibit 6-3 continued

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
88001	5	1,922,339	1,473,431	864,178	662,374	288,849	238,882	22,813	679	0.7507	0.7964
88001	6	39,235,032	30,072,803	15,676,129	12,015,414	5,233,342	4,144,545	173,914	13,853	0.7498	0.7616
88001	7	2,366,341	1,813,749	701,536	537,712	259,247	199,509	1,045	835	0.8300	0.8189
88001	8	382,721	293,348	106,623	81,724	39,901	30,828	319	135	0.8405	0.8325
88001	9	37,080	28,421	6,562	5,030	3,541	2,738	31	13	1.2119	1.2000
90001	5	486,682	440,285	169,101	152,980	76,160	69,642	821	203	1.0116	1.0050
90001	6	9,779,775	8,847,450	4,389,839	3,971,347	1,404,809	1,286,506	17,265	4,076	0.7188	0.7153
90001	7	2,346,977	2,123,235	797,923	721,856	329,371	308,818	11,989	978	0.9271	0.9444
90001	8	222,781	201,543	40,558	36,691	26,648	24,361	280	93	1.4758	1.4639
90001	9	16,237	14,689	2,973	2,689	1,849	1,690	19	7	1.3968	1.3855
92001	5	812,465	639,808	283,453	223,216	122,014	99,218	3,979	295	0.9668	0.9813
92001	6	1,576,556	1,241,521	730,255	575,068	258,142	203,308	31	572	0.7940	0.7807
92001	7	1,207,991	951,280	399,406	314,528	144,207	118,358	6,092	438	0.8109	0.8307
92001	8	149,135	117,442	24,479	19,277	16,097	13,035	456	54	1.4770	1.4905
92001	9	17,358	13,669	3,175	2,500	1,781	1,442	50	6	1.2600	1.2717
94001	5	785,953	699,070	249,470	221,893	132,254	119,926	2,577	322	1.1907	1.1930
94001	6	2,657,239	2,363,496	1,052,928	936,533	576,431	526,281	15,259	1,089	1.2296	1.2407
94001	7	22,837,213	20,312,686	8,165,993	7,263,288	3,050,184	2,721,708	9,787	9,357	0.8390	0.8273
94001	8	1,586,831	1,411,415	399,545	355,378	194,132	175,593	3,284	650	1.0913	1.0902
94001	9	141,804	126,129	27,625	24,571	16,431	14,869	287	58	1.3359	1.3345
96001	5	2,476,137	2,338,153	984,489	929,628	458,440	433,075	192	1,077	1.0459	1.0286
96001	6	3,141,941	2,966,854	1,036,023	978,290	570,172	531,478	-7,329	1,367	1.2361	1.1992
96001	7	33,200,029	31,349,932	11,873,404	11,211,750	4,665,947	4,415,971	10,630	14,441	0.8826	0.8695
96001	8	1,590,289	1,501,669	473,455	447,071	197,099	186,543	453	692	0.9350	0.9209
96001	9	217,297	205,188	48,542	45,837	9,210	8,802	112	95	0.4261	0.4236
98001	5	126,545	100,086	20,021	15,835	6,553	2,713	-3,123	46	0.7352	0.3776
98001	6	1,076,311	851,268	332,767	263,190	201,189	166,181	8,924	392	1.3580	1.3937
98001	7	13,921,637	11,010,799	4,520,711	3,575,487	1,890,233	1,519,854	31,412	5,072	0.9391	0.9383
98001	8	998,270	789,544	334,913	264,887	116,751	92,757	528	364	0.7830	0.7730
98001	9	27,504	21,753	4,629	3,661	2,913	2,330	33	10	1.4134	1.4029

Exhibit 6-3 continued

Weight Class	Axles	Annual VMT: All	Annual VMT: Full-Fee	Annual Cost Responsibility: All	Annual Cost Responsibility: Full-Fee Cost	Annual User Fees: All	Annual User Fees: Full-Fee	Alternative-Fee Difference: Alternative Fee Difference	Alternative-Fee Difference: Allocated Alternative-Fee Difference	Equity Ratio: Plain	Equity Ratio: Alternative-Fee Adjusted
100001	5	18,534	17,226	3,296	3,063	5,345	486	-4,823	8	3.6428	0.3495
100001	6	13,711	12,743	5,658	5,259	14,569	2,917	-11,430	6	5.7835	1.2250
100001	7	7,260,764	6,748,132	2,435,256	2,263,320	1,080,257	1,015,563	12,454	3,108	0.9963	0.9905
100001	8	4,921,751	4,574,261	1,611,404	1,497,635	664,498	619,085	1,616	2,107	0.9262	0.9125
100001	9	18,314	17,021	3,214	2,987	2,296	2,155	22	8	1.6043	1.5901
102001	5	10,524	10,401	1,715	1,695	3,510	971	-2,527	5	4.5970	1.2632
102001	6	44,641	44,120	8,303	8,206	4,697	1,726	-2,950	20	1.2706	0.4639
102001	7	7,309,738	7,224,507	2,852,581	2,819,320	1,132,457	1,116,401	-2,886	3,328	0.8917	0.8743
102001	8	20,532,762	20,293,351	7,298,238	7,213,141	2,938,648	2,910,050	5,734	9,348	0.9044	0.8906
102001	9	4,192	4,143	1,692	1,673	564	558	1	2	0.7483	0.7371
104001	5	731,617	695,258	133,058	126,446	18,927	14,463	-3,708	320	0.3195	0.2522
104001	6	558,090	530,354	115,587	109,843	8,195	4,027	-3,958	244	0.1592	0.0809
104001	7	91,537,432	86,988,310	31,897,276	30,312,082	14,056,759	13,706,355	366,380	40,071	0.9898	0.9982
104001	8	158,607,147	150,724,873	58,741,269	55,822,014	23,031,204	22,359,730	497,845	69,430	0.8806	0.8843
104001	9	3,499,734	3,325,808	1,202,611	1,142,845	436,969	422,624	7,757	1,532	0.8161	0.8163
106001	5	0	0	181	0	0	0	0	0		
106001	6	36,552	36,552	78,151	78,151	14,168	14,168	0	17	0.4072	0.4007
106001	7	32,166	32,166	25,635	25,635	7,643	7,643	0	15	0.6697	0.6587
106001	8	2,229	2,229	3,917	3,917	374	374	0	1	0.2143	0.2109
106001	9	2,944	2,944	1,299	1,299	435	435	0	1	0.7513	0.7387
108001	6	52,488	52,488	79,039	79,039	21,395	21,395	0	24	0.6080	0.5982
108001	7	68,215	68,215	55,032	55,032	17,574	17,574	0	31	0.7172	0.7055
108001	8	4,345	4,345	6,581	6,581	772	772	0	2	0.2634	0.2592
108001	9	12,159	12,159	5,529	5,529	1,795	1,795	0	6	0.7292	0.7169
110001	6	49,770	49,770	81,279	81,279	23,273	23,273	0	23	0.6431	0.6328
110001	7	25,154	25,154	21,998	21,998	6,732	6,732	0	12	0.6873	0.6761
110001	8	1,869	1,869	3,175	3,175	351	351	0	1	0.2481	0.2441
110001	9	8,054	8,054	3,841	3,841	1,269	1,269	0	4	0.7423	0.7299
112001	6	51,566	51,566	92,660	92,660	24,629	24,629	0	24	0.5970	0.5874

Exhibit 6-3 continued

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
112001	7	29,136	29,136	26,815	26,815	8,089	8,089	0	13	0.6775	0.6665
112001	8	4,898	4,898	4,698	4,698	968	968	0	2	0.4628	0.4552
112001	9	3,401	3,401	2,040	2,040	570	570	0	2	0.6276	0.6172
114001	6	34,685	34,685	124,151	124,151	17,260	17,260	0	16	0.3123	0.3073
114001	7	93,826	93,826	60,796	60,796	26,987	26,987	0	43	0.9970	0.9805
114001	8	7,846	7,846	8,469	8,469	1,786	1,786	0	4	0.4736	0.4659
114001	9	53,989	53,989	26,751	26,751	9,050	9,050	0	25	0.7598	0.7471
116001	6	24,960	24,960	97,482	97,482	13,419	13,419	0	11	0.3092	0.3043
116001	7	39,648	39,648	28,901	28,901	12,197	12,197	0	18	0.9479	0.9323
116001	8	3,018	3,018	3,813	3,813	717	717	0	1	0.4225	0.4156
116001	9	1,765	1,765	1,683	1,683	314	314	0	1	0.4184	0.4116
118001	5	0	0	1,869	0	0	0	0	0		
118001	6	40,022	40,022	91,993	91,993	23,118	23,118	0	18	0.5644	0.5554
118001	7	116,845	116,845	147,783	147,783	39,450	39,450	0	54	0.5996	0.5899
118001	8	10,992	10,992	9,482	9,482	2,832	2,832	0	5	0.6708	0.6598
118001	9	5,338	5,338	5,233	5,233	1,001	1,001	0	2	0.4298	0.4228
120001	6	13,933	13,933	63,744	63,744	8,466	8,466	0	6	0.2983	0.2936
120001	7	49,998	49,998	44,090	44,090	17,880	17,880	0	23	0.9109	0.8960
120001	8	4,958	4,958	6,135	6,135	1,327	1,327	0	2	0.4858	0.4779
120001	9	1,368	1,368	1,889	1,889	270	270	0	1	0.3215	0.3163
122001	6	14,060	14,060	69,145	69,145	9,105	9,105	0	6	0.2958	0.2911
122001	7	49,011	49,011	46,354	46,354	18,508	18,508	0	23	0.8968	0.8822
122001	8	5,872	5,872	7,198	7,198	1,689	1,689	0	3	0.5270	0.5185
122001	9	510	510	1,290	1,290	116	116	0	0	0.2023	0.1990
124001	6	3,025	3,025	15,932	15,932	2,141	2,141	0	1	0.3018	0.2970
124001	7	97,140	97,140	108,451	108,451	38,625	38,625	0	45	0.7999	0.7869
124001	8	17,250	17,250	21,987	21,987	5,134	5,134	0	8	0.5245	0.5160
124001	9	14,202	14,202	10,403	10,403	3,375	3,375	0	7	0.7286	0.7166
126001	6	3,009	3,009	16,915	16,915	2,220	2,220	0	1	0.2947	0.2901

Exhibit 6-3 continued

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
126001	7	73,010	73,010	87,231	87,231	30,491	30,491	0	34	0.7851	0.7723
126001	8	7,035	7,035	10,578	10,578	2,164	2,164	0	3	0.4596	0.4521
126001	9	1,048	1,048	2,547	2,547	259	259	0	0	0.2288	0.2252
128001	6	1,461	1,461	8,739	8,739	1,180	1,180	0	1	0.3033	0.2985
128001	7	112,690	112,690	261,441	261,441	51,569	51,569	0	52	0.4430	0.4359
128001	8	26,601	26,601	38,060	38,060	8,981	8,981	0	12	0.5300	0.5214
128001	9	11,272	11,272	10,901	10,901	2,904	2,904	0	5	0.5983	0.5885
130001	7	56,701	56,701	86,109	86,109	27,648	27,648	0	26	0.7212	0.7095
130001	8	12,018	12,018	18,092	18,092	4,298	4,298	0	6	0.5336	0.5250
130001	9	4,174	4,174	4,085	4,085	1,117	1,117	0	2	0.6142	0.6042
132001	7	80,917	80,917	237,261	237,261	41,885	41,885	0	37	0.3965	0.3902
132001	8	23,024	23,024	22,515	22,515	8,464	8,464	0	11	0.8444	0.8306
132001	9	3,319	3,319	4,194	4,194	888	888	0	2	0.4758	0.4681
134001	6	28	28	1,050	1,050	28	28	0	0	0.0598	0.0588
134001	7	65,816	65,816	214,808	214,808	35,384	35,384	0	30	0.3700	0.3641
134001	8	26,702	26,702	27,126	27,126	10,350	10,350	0	12	0.8570	0.8431
134001	9	18,545	18,545	16,156	16,156	5,334	5,334	0	9	0.7415	0.7294
136001	6	19	19	144	144	21	21	0	0	0.3267	0.3216
136001	7	25,062	25,062	90,230	90,230	14,727	14,727	0	12	0.3666	0.3607
136001	8	11,440	11,440	20,176	20,176	4,663	4,663	0	5	0.5191	0.5108
136001	9	4,465	4,465	4,886	4,886	1,329	1,329	0	2	0.6109	0.6009
138001	6	2	2	15	15	2	2	0	0	0.3335	0.3282
138001	7	40,762	40,762	160,676	160,676	25,176	25,176	0	19	0.3519	0.3463
138001	8	38,642	38,642	40,449	40,449	16,524	16,524	0	18	0.9176	0.9026
138001	9	12,331	12,331	13,982	13,982	3,793	3,793	0	6	0.6093	0.5994
140001	7	27,245	27,245	66,557	66,557	17,917	17,917	0	13	0.6046	0.5949
140001	8	9,674	9,674	17,091	17,091	4,524	4,524	0	4	0.5945	0.5849
140001	9	7,198	7,198	7,726	7,726	2,286	2,286	0	3	0.6647	0.6539
142001	7	9,635	9,635	44,707	44,707	6,818	6,818	0	4	0.3425	0.3371

Exhibit 6-3 continued

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
142001	8	11,377	11,377	22,297	22,297	5,662	5,662	0	5	0.5703	0.5612
142001	9	5,772	5,772	6,528	6,528	2,007	2,007	0	3	0.6904	0.6792
144001	7	32,978	32,978	164,761	164,761	24,325	24,325	0	15	0.3316	0.3263
144001	8	38,353	38,353	45,637	45,637	19,852	19,852	0	18	0.9771	0.9612
144001	9	18,468	18,468	14,847	14,847	6,605	6,605	0	9	0.9991	0.9827
146001	7	12,183	12,183	65,266	65,266	9,717	9,717	0	6	0.3344	0.3291
146001	8	36,158	36,158	78,681	78,681	19,078	19,078	0	17	0.5446	0.5359
146001	9	11,310	11,310	9,774	9,774	4,158	4,158	0	5	0.9554	0.9398
148001	7	4,617	4,617	26,424	26,424	3,867	3,867	0	2	0.3287	0.3235
148001	8	35,643	35,643	87,081	87,081	20,588	20,588	0	16	0.5310	0.5225
148001	9	28,508	28,508	34,839	34,839	10,765	10,765	0	13	0.6940	0.6828
150001	7	422	422	2,574	2,574	371	371	0	0	0.3234	0.3183
150001	8	16,321	16,321	24,232	24,232	9,754	9,754	0	8	0.9041	0.8895
150001	9	15,789	15,789	13,159	13,159	6,278	6,278	0	7	1.0716	1.0541
152001	7	71	71	458	458	66	66	0	0	0.3220	0.3169
152001	8	24,135	24,135	65,255	65,255	15,147	15,147	0	11	0.5214	0.5130
152001	9	11,474	11,474	15,610	15,610	4,677	4,677	0	5	0.6730	0.6621
154001	7	127	127	872	872	123	123	0	0	0.3172	0.3121
154001	8	32,198	32,198	53,746	53,746	20,852	20,852	0	15	0.8714	0.8574
154001	9	35,058	35,058	50,709	50,709	14,992	14,992	0	16	0.6640	0.6533
156001	7	17	17	124	124	18	18	0	0	0.3189	0.3138
156001	8	12,621	12,621	38,219	38,219	8,805	8,805	0	6	0.5174	0.5092
156001	9	14,081	14,081	20,634	20,634	6,725	6,725	0	6	0.7321	0.7203
158001	7	32	32	247	247	35	35	0	0	0.3173	0.3122
158001	8	36,262	36,262	113,810	113,810	26,023	26,023	0	17	0.5136	0.5054
158001	9	47,648	47,648	49,979	49,979	23,711	23,711	0	22	1.0656	1.0482
160001	8	9,581	9,581	18,382	18,382	7,163	7,163	0	4	0.8753	0.8612
160001	9	10,187	10,187	11,123	11,123	5,273	5,273	0	5	1.0648	1.0475
162001	8	29,301	29,301	58,741	58,741	23,664	23,664	0	13	0.9048	0.8903

Exhibit 6-3 continued

		Annual VMT		Annual Cost Responsibility		Annual User Fees		Alternative-Fee Difference		Equity Ratio	
Weight Class	Axles	All	Full-Fee	All	Full-Fee Cost	All	Full-Fee	Alternative Fee Difference	Allocated Alternative-Fee Difference	Plain	Alternative-Fee Adjusted
162001	9	16,823	16,823	30,035	30,035	9,045	9,045	0	8	0.6764	0.6655
164001	7	16	16	143	143	20	20	0	0	0.3097	0.3047
164001	8	11,317	11,317	41,081	41,081	9,479	9,479	0	5	0.5183	0.5100
164001	9	40,981	40,981	80,196	80,196	23,672	23,672	0	19	0.6630	0.6523
166001	8	2,001	2,001	7,599	7,599	1,736	1,736	0	1	0.5131	0.5049
166001	9	21,347	21,347	41,127	41,127	12,971	12,971	0	10	0.7084	0.6970
168001	8	5,572	5,572	22,107	22,107	5,113	5,113	0	3	0.5194	0.5112
168001	9	48,752	48,752	103,524	103,524	31,085	31,085	0	22	0.6744	0.6636
170001	8	841	841	3,481	3,481	797	797	0	0	0.5141	0.5059
170001	9	21,393	21,393	47,989	47,989	14,069	14,069	0	10	0.6585	0.6479
172001	9	29,525	29,525	69,937	69,937	20,893	20,893	0	14	0.6710	0.6602
174001	8	47	47	213	213	50	50	0	0	0.5291	0.5207
174001	9	80,650	80,650	117,329	117,329	58,683	58,683	0	37	1.1234	1.1052
176001	9	20,810	20,810	54,773	54,773	15,766	15,766	0	10	0.6465	0.6362
178001	8	20	20	98	98	23	23	0	0	0.5271	0.5187
178001	9	49,514	49,514	79,524	79,524	39,988	39,988	0	23	1.1294	1.1112
180001	9	10,077	10,077	30,877	30,877	8,441	8,441	0	5	0.6140	0.6042
182001	9	34,492	34,492	64,333	64,333	29,926	29,926	0	16	1.0448	1.0280
184001	9	59,317	59,317	194,824	194,824	54,431	54,431	0	27	0.6275	0.6175
186001	9	16,779	16,779	56,469	56,469	15,732	15,732	0	8	0.6257	0.6158
188001	9	37,943	37,943	76,343	76,343	37,094	37,094	0	17	1.0913	1.0738
190001	9	23,208	23,208	88,874	88,874	23,849	23,849	0	11	0.6027	0.5931
192001	9	19,236	19,236	79,621	79,621	20,537	20,537	0	9	0.5793	0.5701
194001	8	71	71	450	450	114	114	0	0	0.5677	0.5587
194001	9	29,095	29,095	69,034	69,034	31,935	31,935	0	13	1.0390	1.0224
196001	9	14,261	14,261	62,793	62,793	16,367	16,367	0	7	0.5854	0.5761
198001	9	35,348	35,348	159,410	159,410	41,626	41,626	0	16	0.5865	0.5772
200001	9	350,174	350,174	1,626,539	1,626,539	426,380	426,380	0	161	0.5888	0.5794
		38,503,450,372	37,269,930,012	1,953,416,652	1,841,084,921	869,710,410	840,651,261	17,168,153	17,168,153		

biennium. On the basis of these results, the 1999 Legislature enacted an across-the-board 12.3 percent reduction in the weight-mile tax rates.[4] This reduction became effective September 1, 2000.

The 2001 Study found adjusted equity ratios of 1.003 for light vehicles and 0.995 for heavy vehicles as a group. This indicated a situation of near-perfect equity for the 2001-03 biennium analysis period, *i.e.*, a 0.3 percent projected overpayment by full-fee-paying light vehicles and 0.5 percent projected underpayment by heavy vehicles. As a consequence, no adjustment in tax rates was deemed necessary by the Legislature to satisfy the constitutional requirement of "fairness and proportionality" between light and heavy vehicles.

The 2003 study found adjusted equity ratios of 0.9921 for light vehicles and 1.0158 for heavy vehicles. The 2003 legislature did not change rates as a direct result of the 2003 study, but did increase registration and other fees to meet the debt-service requirements of the OTIA III bond program. Those fee increases were designed to preserve light/heavy equity given the nature of the projects they would fund and the results of this study indicate they succeeded.

The 2005 study found adjusted equity ratios of 1.0032 for light vehicles and .9936 for heavy vehicles. This indicated near-perfect equity for the 2005-2007 biennium analysis period: a 0.32 percent projected over payment by full-fee paying light vehicles and a 0.64 percent underpayment by full-fee paying heavy vehicles.

The 2007 study found adjusted equity ratios of 0.9933 for light vehicles and 1.0129 for heavy vehicles. As in the 2005 study, these equity ratios indicated near-perfect equity for the 2007-2009 biennium analysis period.

All five prior studies, as well as this study, have projected an overpayment by vehicles in the 78,001-80,000 pound class, and underpayment by vehicles weighing more than 80,000 pounds.

[4] The overall results of the 1999 Study were implemented by a proportionate reduction in all the weight-mile tax rates. The Legislature, however, did not implement the detailed recommendations of the 1999 or 2001 study.

Chapter 7

Recommendations for Changes in Tax Rates

Because light and heavy vehicles pay equitable shares of highway costs in Oregon, there is no constitutional requirement to change user-fee rates for the 2009-2011 biennium. This report does not recommend any change that would affect the distribution of revenue burdens between light and heavy vehicles. Should rates be adjusted for other reasons, such as to fund additional highway projects, the proportional burdens on light and heavy vehicles should be maintained.

Within the various classes of heavy vehicles, there are inequities that the Legislature could choose to address through changes to the rate structure. In this chapter, we offer alternative rate schedules that, if implemented, would bring about substantially greater equity within heavy vehicle classes without noticeably changing the total amount of revenue collected from heavy vehicles.

The inequities within heavy vehicle classes may be generalized as follows:

- vehicles weighing over 80,000 pounds are paying less than their fair share,
- vehicles with a declared weight of 78,000 to 80,000 pounds (which account for 56 percent of all vehicle miles by vehicles over 26,000 pounds and 43 percent of all heavy vehicle miles) are paying more than their fair share,
- vehicles weighing more than 26,000 pounds, but less than 78,000 pounds, are paying less than their fair share, and
- vehicles between 10,000 and 26,000 pounds are paying more than their fair share.

To achieve equity within heavy vehicle classes, several rate schedules would need to be changed. These include the Table A and Table B weight-mile tax rates; the optional flat fee rates for haulers of logs, sand and gravel, and wood chips; and the Road Use Assessment Fee applicable to vehicles operated under single-trip, non-divisible load permits at gross weights over 98,000 pounds.

Weight-Mile Tax Table A and Table B Rates

Commercial vehicles operated at declared weights of 26,001 to 105,500 pounds are subject to the weight-mile tax for their Oregon miles of travel. Operators of vehicles with declared weights of 26,001-80,000 pounds pay the statutory Table A rates. Vehicles operated under special annual permits at declared weights of 80,001-105,500 pounds are subject to the statutory Table B rates.[1]

Table A rates are specified for each 2,000-pound declared gross weight increment. The existing rates range from

[1] Under the Oregon weight-mile tax system, a power unit (tractor) can have multiple declared weights, depending on the configuration in which it is being operated (i.e., the number of trailers/semi-trailers the truck or tractor is pulling). Hence, during any given reporting period, a portion of a vehicle's miles may be reported under Table A and a portion under Table B.

4.00 cents per mile for vehicles declared at 26,001-28,000 pounds to 13.16 cents per mile for vehicles declared at 78,001-80,000 pounds.

To achieve better equity within heavy vehicle classes, Table A rates could be changed to range from 7.34 cents per mile to 11.09 cents per mile as shown in Exhibit 7-1. These rates are higher than existing rates for lower weights and lower than existing rates for the highest weights and would result in a 10 percent reduction in revenue collected from vehicles paying Table A rates.

Table B rates are specified for combinations of 2,000-pound increment and number of axles. The rates are structured so that, at any given declared weight, carriers can qualify for a lower rate by utilizing additional axles. At a declared weight of 98,000 pounds, for example, the per-mile rate for a five-axle vehicle is 18.51 cents and the rate for a six-axle vehicle is 15.28 cents. Thus, by adding an axle, a carrier can reduce his or her tax liability by over three cents per mile. Current Table B rates range from 10.41 cents per mile for a nine-axle vehicle declared at 82,000 pounds to 18.51 cents per mile for a five-axle vehicle declared at 98,000 pounds. Vehicles declared at over 98,000 pounds must have six or more axles, and vehicles declared at over 100,000 pounds must have seven or more axles.

To achieve better equity within the heavy vehicle classes, Table B rates could be adjusted as shown in Exhibit 7-2.

Exhibit 7-1: Weight-Mile Tax Table A

Declared Weight			Current WMT Rate	Alternative Rate	Difference	Percent Difference
26,001	to	28,000	$0.0400	$0.0734	$0.0334	83.39%
28,001	to	30,000	$0.0424	$0.0748	$0.0324	76.47%
30,001	to	32,000	$0.0443	$0.0763	$0.0320	72.22%
32,001	to	34,000	$0.0463	$0.0778	$0.0315	67.95%
34,001	to	36,000	$0.0481	$0.0792	$0.0311	64.72%
36,001	to	38,000	$0.0506	$0.0807	$0.0301	59.48%
38,001	to	40,000	$0.0525	$0.0822	$0.0297	56.51%
40,001	to	42,000	$0.0544	$0.0836	$0.0292	53.74%
42,001	to	44,000	$0.0564	$0.0851	$0.0287	50.89%
44,001	to	46,000	$0.0583	$0.0866	$0.0283	48.49%
46,001	to	48,000	$0.0602	$0.0880	$0.0278	46.25%
48,001	to	50,000	$0.0622	$0.0895	$0.0273	43.91%
50,001	to	52,000	$0.0645	$0.0910	$0.0265	41.05%
52,001	to	54,000	$0.0669	$0.0924	$0.0255	38.19%
54,001	to	56,000	$0.0694	$0.0939	$0.0245	35.32%
56,001	to	58,000	$0.0723	$0.0954	$0.0231	31.93%
58,001	to	60,000	$0.0756	$0.0969	$0.0213	28.11%
60,001	to	62,000	$0.0795	$0.0983	$0.0188	23.67%
62,001	to	64,000	$0.0839	$0.0998	$0.0159	18.94%
64,001	to	66,000	$0.0887	$0.1013	$0.0126	14.16%
66,001	to	68,000	$0.0950	$0.1027	$0.0077	8.13%
68,001	to	70,000	$0.1017	$0.1042	$0.0025	2.45%
70,001	to	72,000	$0.1084	$0.1057	-$0.0027	-2.52%
72,001	to	74,000	$0.1146	$0.1071	-$0.0075	-6.52%
74,001	to	76,000	$0.1205	$0.1086	-$0.0119	-9.87%
76,001	to	78,000	$0.1263	$0.1101	-$0.0162	-12.85%
78,001	to	80,000	$0.1316	$0.1109	-$0.0207	-15.76%

Exhibit 7-2: Weight-Mile Tax Table B

Declared Weight			Axles	Current Rate	Alternative Rate	Difference	Percent Difference
80,001	to	82,000	5	$0.1359	$0.1786	$0.0427	31.42%
80,001	to	82,000	6	$0.1243	$0.1355	$0.0112	9.02%
80,001	to	82,000	7	$0.1162	$0.0939	-$0.0223	-19.17%
80,001	to	82,000	8	$0.1104	$0.0896	-$0.0208	-18.88%
80,001	to	82,000	9	$0.1041	$0.0807	-$0.0234	-22.52%
82,001	to	84,000	5	$0.1403	$0.1876	$0.0473	33.72%
82,001	to	84,000	6	$0.1263	$0.1438	$0.0175	13.83%
82,001	to	84,000	7	$0.1181	$0.0988	-$0.0193	-16.35%
82,001	to	84,000	8	$0.1118	$0.0946	-$0.0172	-15.35%
82,001	to	84,000	9	$0.1055	$0.0863	-$0.0192	-18.24%
84,001	to	86,000	5	$0.1445	$0.1966	$0.0521	36.07%
84,001	to	86,000	6	$0.1292	$0.1520	$0.0228	17.66%

Exhibit 7-2: Weight-Mile Tax Table B, continued

84,001	to	86,000	7	$0.1200	$0.1037	-$0.0163	-13.62%
84,001	to	86,000	8	$0.1132	$0.0997	-$0.0135	-11.89%
84,001	to	86,000	9	$0.1070	$0.0919	-$0.0151	-14.15%
86,001	to	88,000	5	$0.1494	$0.2056	$0.0562	37.64%
86,001	to	88,000	6	$0.1320	$0.1603	$0.0283	21.42%
86,001	to	88,000	7	$0.1219	$0.1085	-$0.0134	-10.98%
86,001	to	88,000	8	$0.1152	$0.1048	-$0.0104	-9.00%
86,001	to	88,000	9	$0.1084	$0.0975	-$0.0109	-10.09%
88,001	to	90,000	5	$0.1552	$0.2146	$0.0594	38.30%
88,001	to	90,000	6	$0.1354	$0.1685	$0.0331	24.46%
88,001	to	90,000	7	$0.1239	$0.1134	-$0.0105	-8.50%
88,001	to	90,000	8	$0.1171	$0.1099	-$0.0072	-6.13%
88,001	to	90,000	9	$0.1104	$0.1031	-$0.0073	-6.64%
90,001	to	92,000	5	$0.1619	$0.2237	$0.0618	38.15%
90,001	to	92,000	6	$0.1393	$0.1768	$0.0375	26.90%
90,001	to	92,000	7	$0.1257	$0.1182	-$0.0075	-5.94%
90,001	to	92,000	8	$0.1190	$0.1150	-$0.0040	-3.35%
90,001	to	92,000	9	$0.1123	$0.1087	-$0.0036	-3.24%
92,001	to	94,000	5	$0.1692	$0.2327	$0.0635	37.51%
92,001	to	94,000	6	$0.1431	$0.1850	$0.0419	29.30%
92,001	to	94,000	7	$0.1277	$0.1231	-$0.0046	-3.61%
92,001	to	94,000	8	$0.1209	$0.1201	-$0.0008	-0.66%
92,001	to	94,000	9	$0.1138	$0.1143	$0.0005	0.41%
94,001	to	96,000	5	$0.1769	$0.2417	$0.0648	36.62%
94,001	to	96,000	6	$0.1475	$0.1933	$0.0458	31.03%
94,001	to	96,000	7	$0.1301	$0.1280	-$0.0021	-1.65%
94,001	to	96,000	8	$0.1229	$0.1252	$0.0023	1.87%
94,001	to	96,000	9	$0.1156	$0.1199	$0.0043	3.69%
96,001	to	98,000	5	$0.1851	$0.2507	$0.0656	35.44%
96,001	to	98,000	6	$0.1528	$0.2015	$0.0487	31.89%
96,001	to	98,000	7	$0.1330	$0.1328	-$0.0002	-0.14%
96,001	to	98,000	8	$0.1249	$0.1303	$0.0054	4.31%
96,001	to	98,000	9	$0.1176	$0.1255	$0.0079	6.69%
98,001	to	100,000	6	$0.1585	$0.2098	$0.0513	32.35%
98,001	to	100,000	7	$0.1359	$0.1377	$0.0018	1.31%
98,001	to	100,000	8	$0.1272	$0.1354	$0.0082	6.43%
98,001	to	100,000	9	$0.1195	$0.1311	$0.0116	9.68%
100,001	to	102,000	7	$0.1388	$0.1425	$0.0037	2.69%
100,001	to	102,000	8	$0.1301	$0.1405	$0.0104	7.97%
100,001	to	102,000	9	$0.1215	$0.1367	$0.0152	12.49%
102,001	to	104,000	7	$0.1417	$0.1474	$0.0057	4.02%
102,001	to	104,000	8	$0.1330	$0.1456	$0.0126	9.44%
102,001	to	104,000	9	$0.1239	$0.1423	$0.0184	14.83%
104,001	to	106,000	7	$0.1455	$0.1523	$0.0068	4.65%
104,001	to	106,000	8	$0.1359	$0.1507	$0.0148	10.85%
104,001	to	106,000	9	$0.1263	$0.1479	$0.0216	17.08%

Optional Flat Fee Rates

Under existing law, carriers hauling qualifying commodities—logs, sand and gravel, and wood chips—have the option of paying monthly flat fees in lieu of the weight-mile tax. There are separate flat fee rates applicable to each of the three different commodity groups. Each rate is set so that carriers paying it should, on average, pay the same amount as they would on a mileage basis.

The existing statutory flat fee rate for carriers transporting logs is $6.10 per 100 pounds of declared combined weight. The comparable rates for carriers transporting wood chips and sand and gravel are $24.62 and $6.05, respectively. These are annual rates that typically are paid in monthly installments. The monthly flat fee applicable to a log truck declared at 80,000 pounds, for example, is $407 (*i.e.*, $6.10 x 800 = $4,880/12 months = $407). This amount must be paid each month the vehicle remains on a flat fee basis, regardless of the number of miles traveled during the month.

The flat fee rates are required to be reviewed biennially and appropriate adjustments in these rates presented to each regular legislative session. This review is accomplished through the biennial flat fee studies, the latest of which was completed in September 2008. That study compared flat fee revenues in 2007 to what those vehicles would have paid in weight-mile tax in 2007. On January

1, 2004, both flat-fee rates and weight-mile rates were increased as a result of the OTIA III legislation. The study found that wood chip haulers reporting on a flat fee basis paid more than they would have on a mileage basis in 2007, while flat fee log and sand and gravel haulers paid less than they would have on a mileage basis.

We applied 2007 flat-fee rates and weight-mile rates to the 2007 data and found that current flat-fee rates for woodchip haulers result in overpayment and current flat-fee rates for log haulers and for sand and gravel haulers result in underpayment relative to the weight-mile taxes those haulers would otherwise pay.

When paying the weight-mile tax, log haulers are allowed to use a lower declared weight when their trailer is empty and stowed above the tractor unit. We assumed that 50 percent of log-truck miles are with an empty, decked trailer, with a declared weight of 44,000 pounds. We also tested the assumption that 55 percent of log-truck miles are with an empty, decked trailer. Weight-mile taxes apply only to miles on public roads in Oregon, but log trucks incur some of their miles on logging roads. The Flat Fee Report includes an analysis of the extent to which operators correctly reported taxable miles and concluded that total reported miles should be reduced by a factor of 0.9622. We incorporated that recommendation in our development of recommended flat-fee rates.

Exhibit 7-3 shows the flat fee rates necessary to achieve revenue neutrality with both existing weight-mile rates and with the weight-mile rates recommended in this chapter. These rates represent an increase in the statutory rate for sand and gravel trucks and a reduction in the statutory rates for wood chip trucks. For log trucks, the recommended rate to match the current weight-mile tax rates is higher than the current flat-fee rate, but the rate to match our recommended weight-mile tax rates is lower. The flat-fee rates presented here were recalculated to match the alternative weight-mile tax rates presented above, using 2007 flat-fee mileage data.

Exhibit 7-3: Flat Fee

Rate per 100 pounds per year	Logs (50% empty)	Logs (55% empty)	Sand & Gravel	Wood Chips
Current flat-fee rate	$6.10	$6.10	$6.05	$24.62
Rate to match current WMT	$6.58	$6.31	$7.90	$13.53
Rate to match recommended WMT	$5.98	$6.06	$8.23	$14.37

Road Use Assessment Fee Rates

Since 1990, carriers operating vehicles under single-trip, non-divisible load permits at gross weights above 98,000 pounds pay the Road Use Assessment Fee. The Road Use Assessment Fee takes the place of the weight-mile tax for the loaded portion of non-divisible load hauls. With rare exceptions, the empty back haul portion of these trips is subject to the weight-mile tax and taxed at the vehicle's regular declared weight.

The existing statutory Road Use Assessment Fee rate is 5.7 cents per equivalent single-axle load (ESAL) mile of travel. The fees carriers actually pay are contained in a table of per-mile rates expressed in terms of permit gross weight and number of axles. Because of its size, that table is not reproduced in this report. Per-mile rates for loads over 200,000 pounds are calculated from the actual weight on each axle. As with the Table B rates, carriers are charged a lower per-mile fee for the use of additional axles at any given gross weight. This reflects the fact that spreading any given total load over additional axles reduces the amount of pavement damage imposed by that load.

The equity ratio results presented in Chapter 6 suggest the weight classes above 105,500 pounds are significantly underpaying their responsibility. To increase equity within heavy vehicles, the Road Use Assessment Fee rates could be increased to 9.4 cents per ESAL-mile. Doing so would increase revenues from the Road Use Assessment Fee by 65 percent.

Appendix A

Glossary of Highway Cost Allocation Terms

List Of Acronyms

AAA	**American Automobile Association**
AMT	**Axle Miles of Travel**
DAS	**Department of Administrative Services**
DL	**Dead Load**
DMV	**Department of Motor Vehicles**
ESAL	**Equivalent Single Axle Load**
FHWA	**Federal Highway Administration**
HCAS	**Highway Cost Allocation Study**
HPMS	**Highway Performance Monitoring System**
LL	**Live Load**
MCTD	**Motor Carrier Transportation Division**
NAPCOM	**National Pavement Cost Model**
NAPHCAS	**National Pavement Model for Highway Cost Allocation**
ODOT	**Oregon Department of Transportation**
OHCAS	**Oregon Highway Cost Allocation Study**
OTIA	**Oregon Transportation Investment Act**
PCE	**Passenger Car Equivalent**
SRT	**Study Review Team**
VMT	**Vehicle Miles Of Travel**

Definitions

Alternative fee A fee charged to some vehicles in place of the usual fee (e.g., a lower registration fee for publicly-owned vehicles)

Arterial A road or highway used primarily for through traffic.

Attributable Costs Costs that are a function of vehicle size, weight, or other operating characteristics and therefore can be attributed to vehicle classes based on those characteristics.

Axle Miles of Travel (AMT) Vehicle miles of travel multiplied by number of axles. Since trucks, on average, have roughly twice as many axles as cars (i.e., four versus two), their share of the total axle miles of travel on any given highway system will be about double their share of the vehicle miles of travel on that system.

Axle Weight or Axle Load The gross load carried by an axle. In Oregon, 20,000 pounds is the legal maximum for a single axle and 34,000 pounds is the legal maximum for a tandem (double) axle.

Benefits Things that make people better off, or the value of such things.

Collector A road that connects local roads with arterial roads.

Common Costs Expenditures that are independent of vehicle size, weight, or other operating characteristics and so cannot be attributed to any specific class of vehicles. These expenditures must therefore be treated as a common responsibility of all vehicle classes and are most typically assigned to all classes on the basis of a relative measure of use such as vehicle miles of travel.

Cost Allocation The analytical process of determining the cost responsibility of highway system users.

Cost Occasioned Approach An approach that determines responsibility for highway expenditures/costs based on the costs occasioned or caused by each vehicle class. Such an approach is not based solely on relative use, nor does it attempt to quantify the benefits received by different classes of road users.

Cost Responsibility The principle that those who use the public roads should pay for them and, more specifically, that payments from road users should be in proportion to the road costs for which they are responsible. The proportionate share of highway costs legitimately assignable to a given vehicle type user group.

Cost-Based Approach An approach in which the dollars allocated to the vehicle classes are measures of the costs imposed during the study period, rather than expenditures made during the study period. The difference between the cost-based and expenditure-based approaches is most evident when considering large investments in long-lived structures and when deferred maintenance moves the expenditures associated with one period's use into another period.

Cross-Subsidization A condition where some vehicles are overpaying and others are underpaying relative to their respective responsibilities.

Dead Load The load on a bridge when it is empty

Debt Financing Funding current activities by issuing debt to be repaid in the future

Debt Service Funds used for the repayment of previously incurred debt (both principal and interest.)

Deck The roadway or surface of a bridge.

Declared Weight In Oregon, vehicles choose a declared weight and pay the weight-mile tax based on that weight. They may not exceed that weight while operating without obtaining a special trip permit. For tractor-trailer combinations, a single tractor may have multiple declared weights; one for each configuration it expects to be a part of.

Depreciation The amount of decrease in value of a physical asset due to ageing in a time period

Efficiency The degree to which potential benefits are realized for a given expenditure

Efficient Pricing Setting prices for the use of highway facilities so that each vehicle pays the costs it imposes at the time and place it is traveling. Efficient pricing promotes the most efficient use of existing facilities and generates the right amount of revenue to build the most efficient system and perform the optimal amount of maintenance

Equity Generally interpreted as the state of being just, impartial, or fair. Horizontal equity refers to the fair treatment of individuals with similar circumstances. Vertical equity refers to the fair treatment of individual in different circumstances.

Equity Ratio The ratio of the share of revenues paid by a highway user group to the share of costs imposed by that group.

Equivalent Single Axle Load (ESAL) The pavement stress imposed by a single axle with an 18,000-pound axle load. ESAL-Miles are equivalent single-axle loads times miles traveled. Research has concluded that the relationship between axle weight and ESALs is an approximate third or fourth-power exponential relationship; ESALs therefore rise rapidly with increases in axle weight.

Excise Tax A tax levied on the production or sale of a specific item such as gasoline, diesel fuel, or vehicles.

Expenditure The amount of money spent in a time period.

External Cost A cost imposed on individuals who do not use the facility

Federal Highway Funds Funds collected from federal highway user fees and distributed to states by the Federal Highway Administration for spending on transportation projects by state and local governments.

Functional Classification The classification of roads according to their general use, character, or relative importance. Definitions are provided by the Federal Highway Administration for Rural Interstate, Rural Other Principal Arterial, Rural Minor Arterial, Rural Major Collector, Rural Minor Collector, Rural Local, Urban Interstate, Urban Other Expressway, Urban Other Principal Arterial, Urban Minor Arterial, Urban Collector, and Urban Local.

Fungibility The relative ability to use funds from different sources for the same purposes. Funds from some sources carry restrictions on how they may be spent; to the extent that those funds free up unrestricted funds that would otherwise be spent that way, they may be considered fungible with the unrestricted funds.

Gross Vehicle Weight The maximum loaded weight for a vehicle.

Heavy Vehicle Vehicles All vehicles weighing more than the upper limit in the definition of a light (basic) vehicle (see light vehicle). Includes trucks, buses, and other vehicles weighing 10,001 pounds or more.

Highway Cost Allocation Study (HCAS) A study that estimates and compares the costs imposed and the revenues paid by different classes of vehicles over some time period.

Highway Performance Monitoring System (HPMS) The Federal Highway Administration collects and reports data about a sample of road segments in every state in a common format.

Highway User A person responsible for the operation of a motor vehicle in use on highways, roads, and streets. In the case of passenger vehicles, the users are the people in the vehicles. In the case of goods-transporting trucks, the user is the entity transporting the goods.

Incremental Cost The additional costs associated with building a facility to handle an additional, heavier (or larger) class of vehicle.

Incremental Method A method of assigning responsibility for highway costs by comparing the costs of constructing and maintaining facilities for the lightest class of vehicles only and for each increment of larger and heavier vehicles. Under this method, vehicles share the incremental cost of a facility designed to accommodate that class as well as the cost of each lower increment.

Light (or Basic) Vehicles The lightest vehicle class, usually including passenger cars. In Oregon, the current definition of Light Vehicles includes vehicles up to 10,000 pounds, which account for over 90 percent of the total vehicle miles of travel on Oregon roads.

Live Load The additional load on a structure by traffic (beyond the load imposed by holding itself up).

Load-Related Costs Costs that vary with the load imposed by traffic on a facility.

Marginal Cost The increase in total cost that results from producing one additional unit of output. With respect to highway use, the marginal cost is the increase in total highway costs that results from one additional vehicle trip. Economic efficiency is achieved when the price charged to the user is equal to the marginal cost.

National Highway System (NHS) A set of highways throughout the United States that have been designated as National Highways by the federal government. The Federal Highway Administration sets design and maintenance standards and provides funding for national highways, but the highways are owned by the states.

National Pavement Cost Model (NAPCOM) A model of pavement costs that incorporates the wear-and-tear costs imposed by vehicle traffic of different weights and configurations as well as deterioration from age and environmental factors, taking into account the soil type, road base depth, pavement material, pavement thickness, and climate zone.

Non-Divisible Load Non-divisible loads are large pieces of equipment or materials that cannot be feasibly divided into smaller individual shipments. All states issue special permits for non-divisible loads that would otherwise violate state and federal gross vehicle weight, axle weight, and bridge formula limits.

Operating Weight The actual weight of a vehicle on at a particular time

Overhead Costs Costs that vary in proportion to the overall level of construction and maintenance activities but are not directly associated with specific projects.

Passenger Car Equivalent (PCE) A measure of road space effectively occupied by a vehicle of a given type under given terrain, vehicle mix, road type, and congestion conditions. The reference unit is the standard passenger car operating under the conditions on the road category in question.

Registered Weight The weight that determines the registration fee paid by a single-unit truck or a tractor. For a tractor, it is typically the highest of that vehicle's declared weights.

Revenue Attribution The process of associating revenue amounts with the classes of vehicles that produce the revenues.

Right of Way The strip of land, property, or interest therein, over which a highway or roadway is built.

Road Use Assessment Fee In Oregon, vehicles carrying non-divisible loads over 96,000 pounds on special permit pay a fee based on the number of ESAL-miles for the trip (see Equivalent Single-Axle Load).

Social (or Indirect) Costs Costs that highway users impose on other users or on non-users. Costs typically included in this category are those associated with noise, air and water pollution, traffic congestion, and injury and property damage due to traffic accidents.

Span A section of a bridge

State Highway System Roads under the jurisdiction of the Oregon Department of Transportation

Studded Tire A tire with metal studs imbedded in its tread for better traction on icy roads.

Tax Avoidance The legal avoidance of a tax or fee

Tax Evasion The illegal failure to pay a tax or fee

Truck A general term denoting a motor vehicle designed for transportation of goods. The term includes single-unit trucks and truck combinations.

User Charge A fee, tax, or charge that is imposed on facility users as a condition of usage..

User Revenues Highway revenues raised through the imposition of user charges or fees.

Value Pricing Prices set in proportion to the benefits received, rather than the cost of production.

Vehicle Class Any grouping of vehicles having similar characteristics for cost allocation, taxation, or other purposes. The number of vehicle classes used in a cost responsibility (allocation) study will depend on the needs, purpose, and resources of the study. Since the Oregon weight-mile tax rates are graduated in 2,000-pound increments, the Oregon studies have traditionally divided heavy vehicles into 2,000-pound gross weight classes. Light (basic) vehicles are considered as one class in the Oregon studies. Potential distinguishing characteristics include weight, size, number of axles, type of fuel, time of operation, and place of operation.

Vehicle Miles of Travel (VMT) The sum over vehicles of the number of miles each vehicle travels within a time period.

Vehicle Registration Fees Fees charged for being allowed to operate a vehicle on public roads.

Weight-mile Tax In Oregon, commercial vehicles over 26,000 pounds pay a user fee based on the number of miles traveled on public roads within Oregon. The per-mile rate is based on the declared weight of the vehicle, and for vehicles weighing over 80,000 pounds, the number of axles. Vehicles paying the weight-mile tax are exempt from the use-fuel (diesel) tax.

Appendix B

Oregon Highway Cost Allocation Study 2009/2011 Biennium

Issue Papers

Issue Paper 1:

Bridge Cost Allocation Methodology Issues

Brian Leshko, HDR Engineering, Inc.

Introduction

Allocating the cost of Oregon's bridges continues to be one of the more important and complex tasks confronting the 2009 Oregon Highway Cost Allocation Study (HCAS). Approximately 500 conventionally reinforced concrete deck-girder bridges in the Oregon Department of Transportation (ODOT) inventory exhibit diagonal-tension cracks. Most of these cracked bridges were constructed in the late 1940s to early 1960s, and have exceeded their expected design life of 50 years. Since the cracks effectively decrease the structural capacity of the bridges, ODOT has posted these structures at lower loads, thus limiting heavy truck traffic. This has had a direct impact on the trucking industry and a corresponding effect on Oregon's economy. This also affects consumers since the cost of transporting goods and materials increases when trucks are either detoured or limited to carry lighter loads. The ongoing increasing fuel costs have a compounding affect on consumers. To remedy the current situation, 279 of these state highway bridges are being repaired or replaced at an estimated cost of $1.29 billion. The allocation of bridge costs will therefore be paramount in the 2009 Oregon HCAS.

Background

As a point of reference, the National Bridge Inspection Standards (NBIS) defines a bridge as any structure greater than 20 feet in length spanning a roadway, railway, body of water, or depression along the ground surface. A bridge is typically constructed from one or more of the following materials: steel, concrete or timber. A conventionally reinforced concrete member is comprised of a cast-in-place concrete component with embedded reinforcing steel bars. Concrete (a mixture of cement, water, aggregates and air) resists compressive forces, whereas steel provides tensile strength. Compression can be likened to pushing together or crushing, while tension is pulling apart or stretching. By design, the steel is placed close to the tension face of the member. By combining the two materials, the resulting reinforced concrete member can resist both compression (concrete) and tension (steel).

Diagonal cracks indicate shear stress in excess of the shear capacity provided by U-shaped steel stirrups embedded in the girders. They are categorized as tension cracks since the shear forces are causing the member to pull apart in a manner similar to shearing a piece of paper with scissors. The concrete member is not being cut; however, the resulting internal forces align along the horizontal and vertical planes with a resultant external crack forming at 45-degees to both reference planes. Once the crack has developed, the reinforced concrete member is in a "weakened" condition, such that passage of heavy truck traffic will cause the crack to propagate in length and open in width, thus exacerbating the resulting condition.

For the current study, the same five cost categories for bridges that were identified in the three previous Oregon HCAS will be used: New Bridge Construction, Bridge Replacement, Seismic Retrofitting, Bridge Rehabilitation (other than seismic retrofitting), and Bridge Maintenance. These categories, along with recommendations on how the costs in each category should be allocated, are discussed in this issue paper.

New Bridge Construction

New bridges are typically constructed to provide new capacity. This capacity could refer to Average Daily Traffic (ADT) or related Average Daily Truck Traffic (ADTT). The ADT and ADTT are determined from either observed traffic counts or prediction models. When the ADT and ADTT reach a threshold value, the capacity of a given bridge may be exceeded, resulting in the need for a new bridge with increased capacity. This higher capacity could be attained by constructing a new bridge with a wider deck to provide additional travel lanes, or by constructing a parallel bridge adjacent to the existing bridge (the original bi-directional bridge would convert to uni-directional traffic and the new parallel bridge would provide opposing uni-directional traffic).

The new capacity requirement could result from a traffic study which recommends a new crossing to provide access to a new development (residential, commercial or industrial). This new bridge would be constructed based upon a new capacity requirement. The width of the structure would be determined by the projected ADT and ADTT.

A new capacity requirement, in the form of ADT and ADTT, is derived from user demand. Congestion can result in a need for new capacity and thus new bridge construction. Beltway expansion projects are an example of new bridges constructed to provide new capacity.

When a new bridge is required, design engineers must use the current AASHTO design specifications and ODOT practice manuals. The new design must support the self-weight of the superstructure (deck, railing and beams), referred to as Dead Load (DL); the weight of the design vehicle traffic loadings, or the Live Load (LL); plus various environmental loads (wind, earthquake, thermal, stream flow and ice pressure).

Load-related factors influence the design of bridges such that increased structural strength (thicker deck, deeper beams/girders, increased area of steel reinforcement, etc.) is required to support increased gross vehicle weight. As vehicle weight increases, vehicle width also typically increases. Wider traffic lanes and shoulders are therefore required to safely accommodate the larger vehicles. The subsequent wider deck necessarily leads to an overall wider structure. Practically all highway cost allocation studies for new bridges have been based on an incremental analysis of the costs of constructing bridges for different design loadings (heavier/wider vehicle weight classes).

OBEC Consulting Engineers conducted the ODOT Bridge Cost Allocation Study to determine costs apportioned to five (5) different design vehicles (truck loads) for three (3) different span arrangements. For simplicity, the designs were based upon the AASHTO Group IA load combination of dead load and live load only. The vehicle types, gross vehicle weights, as well as lane and shoulder widths for design are as follows:

Vehicle Type (Load)	Gross Vehicle Weight	Lane Width	Shoulder Width
Basic (4 tons)	8,000 lbs	11’	8’
Type 3 (25 tons)	50,000 lbs	12’	10’
Type 3S2 (40 tons)	80,000 lbs	12’	10’
Permit 2 (49 tons)	98,000 lbs	12’	10’
Permit 4 (114 tons)	228,000 lbs	12’	10’

The three span arrangements are as follows:

- 100’ simple span (single span from abutment to abutment)
- 150’ simple span (single span from abutment to abutment)
- 60’-90’-60’ continuous spans (multiple spans over intermediate piers)

The results of the study indicate an increase in structure costs/unit area as the vehicles get heavier up to the 98,000 lbs vehicle. For single span structures, the plotted curves flatten out after the 98,000 lbs vehicle to the 228,000 lbs vehicle, suggesting not much increase in structure cost to design a single span bridge for a 228,000 lbs vehicle compared to a 98,000 lbs vehicle. For the three-span continuous bridge, there is an increase in cost per square foot as the vehicles get heavier from the 98,000 lbs vehicle to the 228,000 lbs vehicle.

The study compared the Live Load + Impact Factor (LL+I) to the Dead Load (DL) for each vehicle type and span arrangement. The impact factor accounts for the increased live loading effect of vehicle speed, vibration and momentum. $I = 50/(L+125)$, where L is the span length, in feet. The impact factor is a function of the span length, decreasing as the span length increases. The maximum value of the impact factor (I) is 30%. The trend showed higher (LL+I)/DL ratios as vehicle weight increases, suggesting structures become more efficient as design Live Load becomes heavier.

The superstructure/substructure cost ratio for single span bridges show a slight increase as the vehicles get heavier up to the 98,000 lbs vehicle, then show a slight decrease from the 98,000 lbs vehicle to the 228,000 lbs vehicle. For the three-span bridge, there is a steady decrease in superstructure/substructure cost ratio as vehicles weights increase.

Bridge-Related Issue/Question 1: “Have there been changes in design standards, designs, materials, construction techniques, or relative prices of materials since the 2002 OBEC study that would indicate that that study should be redone soon?”

Material costs for structural steel, concrete (cast-in-place, precast, prestressed, post-tensioned) and reinforcing steel have increased significantly since the 2002 ODOT Bridge Cost Allocation Study by OBEC, which used ODOT 2001 Cost Data (1999, 2000 and 2001 years as basis). Due to ongoing credit problems attributable to the sub-prime market issue, right-of-way (real estate) acquisition may have decreased. The labor market may reflect the pulse of the economy, such that contractor costs for labor-intensive activities such as mobilization, pile driving, concrete finishing, iron workers, etc. may have decreased since the OBEC study. In addition, the time and effort associated with permitting, archeology, natural resources, environmental issues, etc. may have relaxed. Since the 2002 ODOT Bridge Cost Allocation Study incorporated principle assumptions and cost data tied to the early 2000s, it may be prudent to revisit and perhaps redo the OBEC study with updated information, costs and assumptions.

In the 1997 Federal HCAS Summary Report, an incremental approach was used to allocate new bridge construction costs to vehicles: “…costs for constructing the base facility of a new bridge are allocated to all vehicle classes in proportion to their passenger car equivalent vehicle miles traveled (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 due to their weight and axle spacing."

As published in the Federal Motor Carrier Safety Administration, 49 CFR Part 658: Truck Size and Weight, Route Designations – Length, Width and Weight Limitations, Appendix C, Trucks over 80,000 Pounds on the Interstate System and Trucks Over STAA Lengths on the National Network, the current truck loads and configurations allowed on Oregon state highways are similar to many western states but differ from 30 other states in that many trucks above the national legal gross vehicle weight limit (80,000 lbs) are allowed on Oregon highways as permit vehicles up to a maximum allowable gross weight of 105,500 lbs. This presents a problem since bridge design and rating are based upon national truck models, which are derived from data collected in other states that may not reflect actual Oregon loads. Using national truck models to design bridges in Oregon may introduce error in the structural analysis

For the present study, it is recommended that new bridge expenditures continue to be allocated incrementally based on the Oregon bridge cost model.

Bridge Replacement

Bridges are typically replaced when functional and/or structural problems are found during a routine NBIS in-service inspection that is performed biennially for all structures in excess of 20 feet in length. In the early 2000s, ODOT bridge inspectors discovered an alarming increase in the numbers of conventionally reinforced concrete deck-girder bridges in the ODOT inventory exhibiting diagonal-tension cracks and/or in the propagation of these cracks in bridges that were previously reported.

Over 500 conventionally reinforced concrete deck-girder bridges in the ODOT inventory exhibit diagonal-tension cracks with nearly half of these structures located along the major north-south and east-west transportation corridors, Interstate 5 (I-5) and Interstate 84 (I-84), respectively. ODOT contracted with OSU to investigate the remaining capacity and life of conventionally reinforced concrete deck-girder bridges with diagonal-tension cracks. The initial findings of this research were published in the April 2004 report entitled, "Remaining Life of Reinforced Concrete Beams with Diagonal-Tension Cracks" by the Structural Engineering Group of the Department of Civil Engineering at OSU.

The report is divided into two parts: Part I – A database of Oregon's conventionally reinforced concrete deck-girder bridges most prone to diagonal-tension cracks, and Part II – An analysis of a bridge with diagonal-tension cracks. The database developed in Part I focused on 442 cracked bridges constructed between 1947 and 1962. Bridges in Crack Stage 1 have low density cracks, randomly dispersed; Crack Stage 2 indicates medium density cracks, mostly near supports; Crack Stage 3 indicates high density cracks, widely dispersed. Bridges in Crack Stages 2 and 3 are typically candidates for repair or replacement. A general trend observed from the database research showed that, "bridges at a higher crack stage tended to have larger girders and longer span lengths. This is likely due to the design practice at the time. When more capacity was needed and the addition of reinforcing steel was not possible due to constructability…a designer would increase the girder size to obtain more contribution from the concrete. As a result, girders of larger dimensions would have proportionally less steel reinforcement than corresponding girders of smaller dimensions. This is further compounded by a higher concrete stress for design than would be permissible today." This explains why there are bridges with larger girders and longer spans in Crack Stage 3. Except for this isolated finding, "there were no strong or predominant trends within parameters or inter-relationships found within the database." The overall conclusion is that, "…assessment of shear-cracked conventionally reinforced concrete deck-girder bridges in Oregon may not permit a uniform or standard approach, but will likely require assessment of individual bridges and member proportion details."

Based upon the field studies and finite element analysis results of an in-service 1950s era conventionally reinforced concrete slab-girder bridge with diagonal-tension cracks, the following conclusions were reported:

- The bridge girders do not meet modern design requirements for shear. [Due to overestimation of the concrete shear strength that was allowed in the design specification in effect at the time of the design.]
- Stirrup strains were well below the fatigue limit for long life of reinforcing steel. [Metal fatigue leading to fracture of the stirrups is unlikely.]
- Cracks were observed to open in the simple span, and open and close in the continuous spans. [May have implications for epoxy injection of cracks and bond fatigue of stirrups.]
- Stirrup strains and crack displacements in the continuous spans were higher than those in the simple span. [Fewer girders and structural indeterminacy.]
- Peak strain measurements in stirrups tended to increase with increasing vehicle speed. [20% increase in strain for vehicle near posted speed compared to slow speed (5 mph).]
- Maximum calculated stress range in the steel stirrups (11.1 ksi) is less than the safe stress range (23.6 ksi) based upon the AASHTO Standard Specification. [Below the maximum allowed; therefore, not a problem.]
- Stirrup stresses under combined Live Load + Impact and Dead Load were estimated to be above the allowable stress (20 ksi). Dead Load contributed significantly to the stress magnitude. [A problem, since above the maximum allowed. Consider milling before overlaying the wearing surface to limit the increase in stirrup stress due to Dead Load.]
- The finite element model subjected to Live Load + Impact, Dead Load, and loads due to drying shrinkage and non-uniform temperature change predicted diagonal-tension cracking of the girders. [Analysis results estimated that an HS truck configuration corresponding to HS12 caused the initial diagonal-tension cracking near the center support. A heavier truck, HS33, generated a subsequent diagonal-tension crack next to the first crack located a distance of approximately the girder's effective depth away. Note: The HS truck classification/designation indicates the weight, in thousands of pounds, that a structure is rated to safely carry.]
- It is anticipated that the bridge would exhibit diagonal-tension cracks from actual truck loads operating on the bridge from combined effects of Live Load + Impact with Dead Load as well as temperature and drying shrinkage effects.

Bridge-Related Issue/Question 2: "If a bridge is adequate to carry part of the traffic, but is replaced anyway so that heavier vehicles may cross, should those heavier vehicles pay a higher proportion of the costs than for a new bridge? Does it make a difference if the existing bridge was not intended to carry the heaviest vehicles?"

In order to efficiently manage the repair and replacement of the identified conventionally reinforced concrete deck-girder bridges with diagonal-tension cracks, ODOT changed policy from a “worst-first” approach to a “corridor-based strategy”. The impetus for this fundamental change is to keep freight moving through Oregon along I-5 and I-84. Bridges were replaced along the corridor and built to carry the heaviest vehicles.

From the OTIA III State Bridge Delivery Program Monthly Progress Report, No. 43, April 2008, Program Data through March 30, 2006, the Design & Construction Stages 1-5 are as follows:

Stage	# of Bridges	No Work	Repair	Replace	BOR Amount	Current Budget
1	23	1	2	20	$60,729,600	$66,415,969
2	119	35	48	36	$500,207,600	$520,753,235
3	104	16	33	55	$481,884,800	$420,687,783
4	77	24	34	19	$193,948,400	$166,056,662
5	42	10	10	22	$106,800,600	$117,136,345
Total	365	86	127	152	$1,343,571,000	$1,291,049,994

The Bridge Options Report (BOR) of March 2003 identified 365 bridges at a cost of $1.34 billion. As the scopes of work have been refined, 86 bridges were identified with no work recommendations, resulting in a total of 279 bridges to be repaired or replaced. The revised program cost estimate is $1,291,049,994, down from the original BOR amount of $1,343,571,000.

Structural deficiency does not necessarily imply that a bridge is unsafe. It does, however, mean that a structure is unable to carry the vehicle loads or tolerate the speeds that would normally be expected for that particular bridge in its designated system. Functional obsolescence means that the bridge has inadequate width or vertical clearance for its associated highway system.

A functionally obsolete bridge has inadequate width or vertical clearance for its associated highway system. Structurally deficient bridges are unable to carry the vehicle loads or tolerate the speeds that would normally be expected for that particular bridge in its designated system. The National Bridge Inspection Standards classifies bridges as functionally obsolete or structurally deficient on the basis of condition ratings for bridge structural elements and on the basis of appraisal ratings for the services provided by a bridge. Both scales range from zero (worst) to nine (best). The condition rating scale is 9 (Excellent), 8 (Very Good), 7 (Good), 6 (Satisfactory), 5 (Fair), 4 (Poor), 3 (Serious), 2 (Critical), 1 (“Imminent” Failure), 0 (Failed). The appraisal rating scale is 9 (Superior to present desirable criteria), 8 (Equal to present desirable criteria), 7 (Better than present minimum criteria), 6 (Equal to present minimum criteria), 5 (Somewhat better than minimum adequacy to tolerate being left in place as is), 4 (Meets minimum tolerable limits to be left in place as is), 3 (Basically intolerable requiring high priority of corrective action), 2 (Basically intolerable requiring high priority of replacement), 1 (Not used), 0 (Bridge closed).

As described in Non-Regulatory Supplement OPI: HNG-33, from the U.S. Department of Transportation, Federal Highway Administration, a bridge is structurally deficient if it has a condition rating of 4 or less for Item 58 – Deck, or Item 59 – Superstructures, or Item 60 – Substructures, or Item 62 – Culvert and Retaining Walls, or has an appraisal rating of 2 or less for Item 67 – Structural Condition or Item 71 – Waterway Adequacy. A bridge with an appraisal rating of 3 or less for Item 68 – Deck Geometry, or Item 69 – Underclearances, or Item 72 – Approach Roadway Alignment; or an appraisal rating of 3 for Item

67 – Structural Condition or Item 71 – Waterway Adequacy, is functionally obsolete.

Oregon's inventory of structurally deficient and functionally obsolete bridges, both on and off the National Highway System (NHS), as of December 2007 follows:

Highway System	Structurally Deficient	Functionally Obsolete	Structurally Deficient + Functionally Obsolete	Count	%
NHS	90	326	416	1,562	26.6
Non-NHS	424	829	1,253	5,756	21.8
All Systems	514	1,155	1,669	7,238	23.1

The condition and appraisal ratings are determined by a qualified bridge inspector based upon the findings from a field inspection of the bridge. The Structure Inventory and Appraisal data is required to be reported to the Federal Highway Administration (FHWA) through the state's Bridge Management System (BMS). Any bridge classified as structurally deficient is excluded from the functionally obsolete category, thus such a structure will not be classified under both categories.

From the 1997 Federal HCAS Summary Report, costs are assigned according to the types of improvements that are made. For structurally deficient bridges, costs to provide additional structural capacity should be allocated to those vehicles that require the greater strength. Functionally obsolete bridge improvement costs should be allocated on the basis of capacity used as indicated by passenger equivalent-vehicle miles traveled (PCE-VMT).

For the present study, it is recommended that replacement bridge expenditures be allocated incrementally based on the Oregon bridge cost model.

Seismic Retrofitting of Existing Bridges

Oregon is located adjacent to the Cascadia Subduction Zone, where the Juan de Fuca Plate is moving under the North American Plate. Plate tectonics theory indicates the probability of Magnitude 8 or 9 earthquakes (Richter scale) along the plate boundary. The relatively new information regarding seismic loading has prompted ODOT to address failure mechanisms determined from vulnerable detailing. Although Oregon's inventory of bridges has always met the basic AASHTO criteria in effect at the time of the design, current seismic requirements dictate either superstructure or substructure retrofits to address the vulnerability to a moderately severe earthquake.

From ODOT's "Assessing Oregon's Seismic Risk": "The first failure mechanism would engage when the motion from the earthquake causes the bridge's superstructure to separate from the substructure. A typical bridge designed prior to extensive seismic detailing would not have an available beam seat greater than 12 inches for seismic movement in the longitudinal direction. Additionally, the beam seat would not have shear lugs designed to resist much, if any, transverse direction seismic force." Typical Phase 1 seismic retrofit to the superstructure includes installing longitudinal cable restraints and transverse shear lugs. "… The second failure mechanism would engage when the motion from the earthquake causes the bridge's substructure to collapse from the seismic force. Similar to the superstructure design shortcomings of earlier typical bridge design, substructures (columns in particular) were not designed to resist the intense forces experienced in a seismic event." A typical Phase 2 seismic retrofit to the substructure includes installing steel casing around substandard concrete columns.

For the present study, it is recommended that seismic retrofitting expenditures be allocated separately from other bridge rehabilitation expenditures.

Bridge Rehabilitation (Other Than Seismic Retrofitting)

Bridge rehabilitation focuses on three major components: Deck, Superstructure and Substructure. The deck provides a smooth riding surface for vehicles, is the component of the bridge to which the live load is directly applied, and transfers the live load and dead load of the deck to the superstructure through the floor system. Work activities involving the bridge deck include deck restoration/overlays, deck joint repair/replacement, and deck replacement. Deck patching and waterproofing overlays (latex concrete, bituminous with membrane, etc.) extend the life of the deck and improve rideability. Deck joints typically leak, enabling water mixed with road salt or cinders to seep through the joint onto the superstructure below. Any steel superstructure, or concrete superstructure with cracks opened to the embedded reinforcing steel, would have an increased rate of corrosion with the presence of the electrolyte (water and deck runoff) to maintain the corrosion cell. Repairing, replacing or installing new expansion dams to ensure leakproof joints will break the corrosion cell and result in longer life for the superstructure. To remedy a structurally deficient deck, the existing deck can be replaced with a stronger deck.

The superstructure carries loads from the deck across the span and transmits the loads of the deck and superstructure to the bridge supports. Rehabilitating a superstructure typically consists of strengthening a deficient component of the floor system (stringer, floor beam, girder, diaphragm, truss member, lateral bracing, sway bracing, etc.). A structural analysis can determine the governing member for load rating the structure. By strengthening the governing member, the structure can be rated at a higher level. Typical strengthening details include restoring deteriorated reinforced concrete or prestressed concrete beam-ends, or adding steel plates/rolled sections to increase the section properties (moment of inertia). Additional methods include post-tensioning with tendons or bars. For conventionally reinforced concrete deck-girder bridges with diagonal cracks, repair techniques and materials include: pressure injecting the cracks through multiple ports along the length of the crack with epoxy (epoxy injection), external supplemental steel stirrups, internal supplemental steel stirrups, and carbon fiber-reinforced polymers (CFRP) bonded supplemental external shear reinforcement on the girder faces.

The substructure transfers the loads from the superstructure to the foundation soil or rock. Substructure units typically include abutments and piers. Abutments provide support for the ends of the superstructure, whereas piers provide support for the superstructure at intermediate points along the length of the bridge. A majority of these components have been constructed of reinforced concrete. Common concrete deficiencies are cracks, delaminations and spalls. Rehabilitation schemes include epoxy injection, saw cutting/jack hammering, and grouted patches, respectively. For concrete bent caps, post-tensioning techniques have been successful. Other types of substructure units are steel bents and towers. These units are typically rehabilitated using similar methods as for steel superstructure strengthening.

Bridge rehabilitation projects for system preservation may consist of any of the items discussed above, either alone or in combination. The extent of the deterioration or deficiency will dictate the overall scope of work to be performed. For steel structures, bridge protective coatings, such as painting (system replacement, overcoats, or spot/zone painting), galvanizing, or metalizing, may be warranted.

For the present study, it is recommended that bridge rehabilitation expenditures be allocated based on the cost occasioned approach.

Bridge Maintenance

Deferring maintenance on a minor problem in the base year (lower cost) may become a major problem in subsequent years (higher cost). Investing a small amount of time and money today can pay dividends tomorrow due to the higher costs in both time and money that must be expended at a later date to fix a more substantial problem. Maintenance activities include bridge component repairs due to damage (i.e. repairing a fascia girder struck by an overheight vehicle).

Bridge maintenance does not substantially improve the condition or function of the overall structure and generally is not related to vehicle characteristics. Environmental costs, related to weather, drainage, etc. should be assigned on a VMT or passenger car equivalent-VMT basis, as reported in the 2001 Oregon HCAS, Issue Paper 1. The 1997 Federal HCAS recommended that all costs associated with bridge maintenance be assigned to the base increment using VMT allocation.

It is imperative that costs be allocated for bridge maintenance, in addition to the other categories discussed above. Oregon should not concentrate on repairing and replacing the 279 cracked bridges exclusively, without due regard for maintaining the remaining inventory of bridges. New bridge construction and seismic retrofitting of existing bridges also need to be addressed, but not at the expense of bridge maintenance. Bridge maintenance costs should be assigned to the base increment using VMT allocation.

Research Initiatives

From the October 2004 report, “Assessment Methodology for Diagonally Cracked Reinforced Concrete Deck Girders” by the Structural Engineering Group of the Department of Civil Engineering at OSU, Section 5, “Reliability Based Assessment Methodology”, details the development of a reliability assessment methodology to enable ODOT staff, “to rationally establish load restrictions, prioritize bridges for replacement or repair, and identify specific segments of bridges requiring repair.” Oregon-specific truck loading, determined from weigh-in-motion data, was integrated with the analysis from field and laboratory testing. A reliability index was calculated for each critical section along the girder, “by comparing the maximum operating forces in the section with the estimated capacity of the section and incorporating the inherent variability of the capacity estimate.” The overall capacity of the bridge is controlled by the girder location with the smallest reliability index.

Following the calibration of the reliability index from a set of bridges, “a minimum reliability index can be selected for Oregon’s conventionally reinforced concrete (CRC) deck-girder bridges that represents an acceptable level of risk.” This reliability assessment methodology provides a rational method for prioritizing the repair or replacement of Oregon’s conventionally reinforced concrete deck-girder bridges.

Bridge-Related Issue/Question 3: “Has any new research revealed whether heavier loads on a given bridge affect its useful life? If so, by how much?”

No quantitative research to date has addressed this issue. However, the Federal Highway Administration (FHWA) Long-Term Bridge Performance (LTBP) Program and the Transportation Research Board, second Strategic Highway Research Program, TRB SHRP 2 Project R19-A were both awarded in 2008. “The objective of the LTBP program is to collect, document, and make available high-quality quantitative performance data on a representative sample of bridges nationwide. Data will be collected through detailed inspections and evaluations, supplemented by a limited number of continuously monitored structures and forensic autopsies on decommissioned bridges. In the latter years of the program, the collected data will be analyzed to develop improved knowledge about bridge performance and degradation, better design methods and performance predictive models, and advanced management decision-making tools.

Specifically, the anticipation is that the LTBP program will provide a better understanding of bridge deterioration due to corrosion, fatigue, weather and exposure, and loads. The program also will provide information about the effectiveness of current maintenance and improvement strategies, and should lead to improving the operational performance of bridges with the potential to reduce congestion, delay, and crashes."

The objective of the TRB SHRP 2 Project R19-A, "Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems and Components", "is to improve existing systems, subsystems, and components that historically limit the service life of bridges, and to identify and prove promising concepts for alternative systems, subsystems, and components. As a result of this project, methodologies, concepts and ideas will be developed to extend the service life of existing bridges and promising concepts will be developed to result in 100 plus years of service life in quantifiable ways. The focus of this project will be on bridges with span lengths of less than 300 ft."

These two independent bridge research projects may provide results that could answer the question whether heavier loads on a given bridge change its useful life. The downside is that the data will be mined over a period of 20 years.

Respectfully submitted on May 16, 2008; revised and resubmitted on July 16, 2008 by:

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Issue Paper 2

Data Issues

THIS ISSUE PAPER ADDRESSES ISSUES RELATED to the availability of data for the Oregon Highway Cost Allocation Study. For each major category of data, it describes what data would be available in an ideal world, what currently is available, and potential opportunities to improve from the current situation.

Project Expenditure Data

The Ideal

Ideally, we would like data that showed expenditures for the study period only, by funding source, by work type category, by functional class, by ownership, with separate rows for each project. We would want it by project because, for certain types of projects, additional information is necessary to choose the most appropriate allocation factor(s). For example, for bridge projects, we need bridge matched to the closest of the bridge types for which we have allocation factors. For many replacement or reconstruction projects, it makes a difference whether the rebuilt facility adds capacity.

The Current Situation

Project Expenditures from Cash Flow Projection

Through the 2001 study, the STIP formed the basis for project-expenditure projections. There were several problems with using the STIP, which is intended to be a planning tool, rather than an accounting tool.

The dollar amounts in the STIP represent entire projects, and are not broken down into biennial spending amounts. New projects start each year and most take more than one year to complete. The projects with the largest dollar amounts take more than two years. The best we could do was to pro-rate project expenditures based on the number of within-study-period months compared to total project months. We knew this was inaccurate because project expenditures typically are much higher in a few months near the end of the project, when the actual construction takes place.

Significant expenditures in the upcoming biennium were for projects that were no longer in the STIP because they were already underway. Looking to old STIPs for these projects proved inadequate because old STIPs are not updated as project specifications and budgets change.

We solved the problem of identifying planned expenditure amounts for the study period by abandoning the STIP-based approach and relying instead on ODOT's cash-flow projections, which are already broken down by project and funding source and are continuously updated with the best available information.

The shortcoming of the cash-flow-projection approach is that we have not developed a good way to divide expenditures on a given project into work-type categories. Each project has a primary work type and that is what we use for the entire project's expenditures. As a result, dollars have shifted into the "primary" work-type categories, such as Pavement Reconstruction, from ancillary work-type categories, such as Grading and Drainage. The allocation factors have not been adjusted to account for the shift, and it would be better if they weren't.

We request the cash-flow projections at the time budget data become available so that they are consistent with the budget, around the end of August.

We then identify all projects in bridge and interchange work-type categories and try to find which bridges are involved from the Project Control System (PCS) data. We then look up those bridges in the bridge inventory to try to determine which of the prototypical bridge designs from the 2002 OBEC Bridge Study most closely matches them. This requires interpretation and judgment, as the "spans" represented in the inventory data do not always match the concept of "spans" in the OBEC study and sometimes include approaches. We also try to determine whether a replacement bridge will have additional capacity by comparing the information in the PCS to the information in the bridge inventory.

The most recent study of studded tire damage is too old to use in current HCAS work, so we now use somewhat subjective estimates from ODOT's pavement engineers. These are available whenever we have the conversation.

Opportunities to Improve

As far as we know, the data we receive is the best and most relevant that ODOT has to offer. Where we could improve would be to move at least the more judgment-intensive parts of the manual matching exercise from the consultant to ODOT staff who are much more familiar with the facilities and projects. The people at ODOT who have this knowledge are extremely busy working on tasks that have (and should have) higher priority. There is no one person at ODOT who has all the knowledge and the person most knowledgeable about any particular project likely is an a regional office.

There certainly exist ways to accomplish the spreading of expenditures on a project among the multiple work-type categories associated with that project. As a part of this project, we will work with ODOT staff to determine whether data exist to support that effort. If not, we will ask ODOT staff to develop factors for spreading expenditures between categories and over months for prototypical projects in the primary work-type categories.

For this study we will try to find studies from other states that address the costs imposed by studded tires. Even if we find such a study, it is not clear that its conclusions will be useful. We don't need any information about which class of vehicles imposes studded tire damage. Only basic vehicles are allowed to have studded tires. What we need to know is what part of budgeted preservation expenditures in Oregon are attributable to studded tire damage. It is not clear that evidence from other states will answer that unless the study calculated studded tire damage repair as a proportion of preservation costs.

Non-Project Expenditure Data

The Ideal

Ideally, we would like data that showed expenditures for the study period only, by funding source, by work type category. For collection costs, we also would like to know how much collection cost is associated with each revenue instrument. It also has been suggested that it would be useful to subdivide the "other" expenditure categories so that it is no longer the case that they contain the largest dollar amounts. Even if they all end up being allocated in the same way, it would look better and would enable someone reading the study to determine for themselves whether they should, in fact, have all been allocated that way.

The Current Situation

Budgeted non-project expenditures come from spreadsheets used to develop the Agency Request Budget and became available at the end of August for the 2007 study. A breakdown of DMV collection costs comes from a subsidiary spreadsheet within that set of budgeting spreadsheets.

Opportunities to Improve

As a part of this study we will work with ODOT Finance staff to identify opportunities for further subdividing some of the larger non-project expenditure categories and will then revisit with the SRT the proper allocation of expenditures in those subcategories.

Local Government Expenditure Data

The Ideal

Ideally, local government would be provided in exactly the same way as the ideal state-level expenditure data described above, with the same levels and categories of cross-tabulation.

The Current Situation

Prior-fiscal-year revenues and expenditures by local governments come from the LRSS reports compiled by ODOT. We obtained those for the 2007 study in mid-July.

We add up the reported expenditures across local governments and also add up revenues from certain revenue sources that the AOC told us are not fungible with State revenues and are not collected directly from users (e.g., bonds, TIFs, and SDCs). We then subtract the amount of the revenues from these non-fungible sources from the categories in which they are likely to be spent (modernization). The remaining expenditures are then matched to HCAS work-type categories as best we can and scaled to match expected revenues in the upcoming biennium.

The cash-flow and PCS data from ODOT contain information about the projects in which ODOT is involved, generally the largest of the local-government projects. We use that information for expenditures associated with those projects, subtracting an equal number of dollars from the more-general categories in the local government data.

To estimate expenditures by local governments on studded tire damage, we use a method developed for the 2005 study. That method scales estimated State expenditures on studded tire damage taking into account VMT and average speeds by functional class. The damage a studded tire imposes increases with speed squared.

Opportunities to Improve

Available local-government data are far from ideal and numerous opportunities exist to improve them. It is not clear, however, if any of those opportunities are feasible, given the number, diversity, and limited resources of cities and counties in Oregon.

Until the 2005 study, local governments were surveyed by ODOT as part of the HCAS data-collection effort. The survey took up a large part of one ODOT employee's time for a couple of months and the results were not very satisfactory. Some local governments completed the survey quickly and accurately. Many did not. The local governments with the largest expenditures had the most difficulty. It often took numerous phone calls to identify an employee who would accept the survey, and in many cases, that employee would say that they did not have sufficient information and did not have the time or resources to assemble it. For at least one large city, questions about transportation expenditures apparently are so politicized that staff are unwilling to provide any information that has not already been approved for public consumption.

Even though the survey was providing good information for many local governments, it imposed a significant burden on both ODOT and local government staff and those local governments about which good information was obtained accounted for a relatively small proportion of the total expenditure dollars.

For this study, we will make use of the County Road Needs Report and the data used to prepare it, which were made available by the Association of Oregon Counties.

Vehicle-Miles Traveled

The Ideal

Ideally, we would like a forecast of vehicle miles traveled by vehicle tax class, by vehicle weight class, by functional class, by ownership.

The Current Situation

ODOT Finance produces VMT estimates for use in its estimation of revenues for budgeting. These become available at the same time as the Agency Request Budget, which has been at the end of August. For heavy vehicles, these estimates include only miles by vehicles that pay weight-mile tax.

The Motor Carrier Transportation Division of ODOT produces data on truck registrations weigh-mile tax collections, and flat-fee collections. The collections data include reported miles for the historical year. These data are cleaned and consolidated into a set of reports called Highway Use Statistics. We have used the cleaned, unconsolidated data, which became available for the 2007 study at the end of August.

We use the collections data, adjusted for assumed evasion, along with estimates of miles by weight class for a number of other tax classes to estimate base-year VMT by tax class by weight class. For many of the other tax classes, the estimates are based on numbers of registrations times an assumed annual miles traveled per registered vehicle.

Once we have base-year estimates by tax class by weight class, we apply assumed growth rates by weight class to get estimates for the model year, which is the calendar year in the middle of the fiscal biennium. The growth rates are calibrated so that growth rates for light, medium and heavy vehicles, as groups, match those from the ODOT forecast.

To forecast VMT by weight class by functional class by ownership, we develop control totals by functional class and ownership from FHWA's *Highway Statistics* publication and form Oregon HPMS data and scale those so they add up to the total forecast for the model year. Those become the column totals in a large matrix and the totals by weight class become the row totals. The matrix is filled with the result of the same effort from the prior study and iterative proportional fitting is used to make the rows add up to their control totals at the same time that columns add up to their control totals. The iterative proportional fitting method achieves this with the smallest possible changes from the prior study's data.

Opportunities to Improve

The main difficulty with VMT data is that nobody counts VMT except for heavy, commercial vehicles. Estimates for other vehicles are derived from a combination of fuel taxes paid (requiring assumptions about miles per gallon) and traffic counts on selected road segments (requiring assumed expansion factors for extrapolation).

Another confounding factor is that it is believed that more gallons of fuel are burned in Oregon than are sold in Oregon. The reason is that more people commute from Vancouver, Washington to Portland than the other way around, and commuters typically purchase more fuel near their homes than near their workplace. ODOT has developed assumptions about the proportion of net total miles that consume out-of-state fuel, but those estimates are based on a chain of assumptions, some of which have been changing over the years. In recent years, commuter traffic between Portland and Vancouver has become more balanced and Washington has raised its fuel tax significantly, while Oregon has not. Both these changes would be expected to reduce the proportion of net out-of-state miles.

While traffic counts are extremely useful, Oregon (like other states) has experienced difficulty keeping loop detectors functioning properly. On any given day, a significant proportion of automatic data recorders will not be recording data. As they are fixed, others break. The result is that traffic counts require a lot more adjustment and extrapolation than they should and the reported traffic counts incorporate significant uncertainty.

Without either changing the law and imposing additional reporting burden on motorists or installing many more traffic recorders and keeping them functioning, it will not be possible to know with reasonable accuracy how many miles are driven by vehicles that pay the fuel tax. One side effect of a VMT tax would be much better data about VMT.

Some small, but still important, categories of vehicles could, and probably should, be required to report their miles in exchange for their special tax treatment. For example, publicly-owned vehicles that burn diesel fuel do not have to pay any fuel tax, so it is important to the HCAS to know how many miles they drive, but they do not report. All publicly-owned vehicles could be required to report miles. At one time they were supposed to report miles driven and gallons consumed to the Oregon Department of Energy (which no longer exists). Many did not file their reports or left parts blank, so that data was not very useful, even when it existed.

Other special categories of vehicles, such as farm and non-profit vehicles, presumably could be required to report on-road miles in exchange for their special tax treatment.

Other Cost Allocation Factors

The Ideal

Other distributional data required for cost allocation include declared-to-registered weight distributions and declared-to-operating weight distributions for the model and more-detailed distributions by weight and configuration by functional class for the pavement model. The pavement model also requires data about the roadway and base for HPMS segments, some of which is no longer included in the HPMS data set.

The Current Situation

Special Weighings studies are data collected at weigh stations on days special days when every truck is weighed. Normally, empty trucks do not need to be weighed. Each study uses Special Weighings data accumulated over prior studies plus additional studies completed since the last study. For the 2007 study, data from the the last batch of special weighings became available in early August. These data are provided by ODOT. From these data, we develop both the declared-to-operating distribution and the detailed data for the pavement model. One weakness of the Special Weighings data are that Special Weighings are rarely done on interstate freeways and never at the busiest weigh stations. There is just too much traffic to process all the trucks and the empties must be allowed to bypass or trucks would back up onto the busy freeway. If the distributions of weight and configuration are different on the interstates (and we believe they are), the Special Weighings data do not accurately reflect the true distributions, especially given the truck volumes on interstates.

The Motor Carrier Transportation Division of ODOT produces data on truck registrations weigh-mile tax collections, and flat-fee collections. The collections data include reported miles for the historical year. These data are cleaned and consolidated into a set of reports called Highway Use Statistics. We have used the cleaned, unconsolidated data, which became available for the 2007 study at the end of August. These data allow the development of accurate declared-to-registered distributions.

HPMS Data

The Highway Performance Monitoring System is a federal program that collects data from each state each year. Over the years, the number of data elements that must be reported has been reduced, but the data still are extremely useful in highway cost allocation and in developing pavement factors. For the 2007 study, the HPMS data were provided in early July.

Opportunities to Improve

Weigh-in-motion (WIM) data may prove to be a very useful supplement to the Special Weighings data, especially for interstate freeways. We will be working with Portland State University to explore how WIM data may be incorporated into the HCAS. There are issues with accuracy (while generally accurate, the equipment generates some observations that clearly aren't) and not all vehicles that are weighed can be matched to registration records (only those with transponders, which may differ, on average, from those without transponders is several important ways other than weight).

ODOT maintains a Pavement Management System that tracks the data about roadway and base characteristics that are no longer included in the HPMS database. We investigated the feasibility of using this data and obtained a copy. We also learned that it is incomplete and is known to contain errors. ODOT's pavement engineers are working to improve the data for their own purposes and it is expected that it will become complete and accurate over time.

Revenue Attribution Factors

The Ideal

Ideally, we would have data that tell us how much each category of vehicle pays of each revenue instrument for each mile driven. For some instruments, the tax rates tell us exactly that, by definition. Others require data to describe the relationship between miles and whatever units are taxed.

The Current Situation

Fuel taxes are the largest single revenue source for the highway fund and the vast majority of fuel taxes are paid by basic vehicles. The relationship between miles traveled and fuel taxes paid depends on the miles per gallon for vehicles in each category. Estimates of fleet average MPG for basic vehicles are available from several sources. MPG for non-basic vehicles varies greatly with vehicle weight and with where and how they are driven. Estimates of fleet-average MPG for 10,000- to 26,000-pound vehicles are not available and not easily constructed, because we do not know much about the composition of the fleet or how much different types of vehicles within the fleet are driven.

We know how many gallons of fuel were taxed in the base year and we have an estimate of miles traveled by basic vehicles. Dividing miles by gallons yields a close approximation of miles per gallon for basic vehicles. Small changes in the assumed miles per gallon for basic vehicles make little difference in the share of revenue attributed to basic vehicles, but make large differences in the shares of revenue attributed to 10,000- to 26,000-pound vehicles because the basic vehicles account for so many more miles. Lacking any better information, and because it makes no noticeable difference in the light/heavy equity results, we have since the 2005 study adjusted the assumed miles per gallon by weight class so that 10,000- to 26,000-pound vehicles consume whatever amount of fuel causes them to be at 100 percent equity (before subsidy adjustment) and assumed that basic vehicles consume whatever is not accounted for by heavier vehicles.

DMV vehicle registration data are no longer required for the attribution of registrations revenue, but are still used to estimate VMT by weight class by tax class for the base year. For the past three studies, we have been unable to obtain these data from DMV, but have been able to obtain them from elsewhere within ODOT. If that does not work this time, we may have to rely on published summary reports to get registrations by registration type and assume that the distribution among weight classes remained constant.

Opportunities to Improve

ODOT management could find a way to improve the availability of DMV data. We do not need any identifying information about vehicles or their owners. If DMV staff cannot cross-tabulate the data in the way we need, they could deliver the raw data with identifying information removed, and we can cross-tabulate it ourselves. That is what we have done with the data we received second-hand.

The State could require the reporting of miles for vehicles in alternative-fee-paying classes. The most important of these would be publicly-owned vehicles, other school buses, and farm vehicles.

Sensitivity Tests

For this study, we will conduct sensitivity tests in which certain key data elements are scaled to determine the potential effects on equity ratios of inaccuracies in the data.

Issue Paper 3

Current Issues in Pavement Cost Allocation

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Introduction

The 1982 Federal Highway Cost Allocation Study (HCAS) significantly advanced the process of allocating pavement cost responsibility. Prior to that time, the results of the AASHO Road Test in the 1950's had been used to determine the relative responsibility of vehicle classes for pavement costs. The Road Test had subjected thin pavement sections to repeated applications of axles of various weights and had originated the concept of "Equivalent Single Axle Loads (ESALs)"—measures of the relative impacts of axles of various weights that varied roughly with the fourth power of axle weight.

By the time of the 1979 to 1982 Federal study, advances in pavement engineering had increased the awareness that pavement deterioration was much more complex than could be expressed by a single measure. Pavement deterioration could be measured by various "distresses" (such as rutting, transverse cracking, or roughness). Some of these distressed might vary with the fourth power of axle weight while others might vary with only the first or second power.

Further, the trucking industry was well aware that a fourth power assumption might severely overcharge them if used to allocate pavement cost responsibility. As a result of the high visibility and potential high stakes in making assumptions about pavement deterioration, Federal Highway Administration (FHWA) devoted considerable effort to incorporating the best then-available knowledge in more precisely quantifying pavement cost responsibility, and developed a set of empirically-based pavement performance models for estimating cost responsibilities.

The 1982 models were updated later in the 1980s with the initial development of the National Pavement Cost Model (NAPCOM). For their 1995 HCAS, FHWA updated NAPCOM using several mechanistic-empirical pavement damage equations that describe the relationship of axle loads and repetitions to pavement distresses. See Appendix A for a more thorough description of the current version of NAPCOM and how it estimates pavement cost responsibility by the various vehicle classes.

Current Work to Improve NAPCOM

FHWA decided in 2003 to update both NAPCOM and the somewhat related pavement deterioration models used in their Highway Economic Requirements System (HERS), using the new Mechanistic-Empirical Pavement Design Guide (MEPDG) models. To that end, they contracted with Applied Research Associates (ARA), developers of the MEPDG, and with Battelle. Over a three year period, the study team completed the first phase of the work-- developing a proposed model for evaluating pavement rehabilitation projects in HERS. The proposed model is currently being evaluated in the second stage of the research, and has not yet been incorporated into HERS.

Concurrently, the work used to develop the proposed HERS models is being extended to refine the individual distress models in NAPCOM by my firm with the assistance of Auburn University and ARA. The HERS models made the assumption that ESALs can adequately characterize traffic for the purpose of national pavement cost analysis. Unfortunately, this assumption is a non-starter for NAPCOM since it would mean a return to the fourth power rule for allocating pavement cost responsibility.

Neither the HERS model nor the anticipated refined NAPCOM models use the MEPDG models directly. The MEPDG requires far more information about a pavement structure, its environment, and its traffic loadings than we could feasibly supply for the large number of pavement sections we need to adequately typify the highway system in a state or in the nation. Further, the processing time for a single section is far greater than would be tolerable for a system-wide analysis.

Instead, the MEPDG will be used to essentially recreate a large number of electronic Road Tests if you will. On selected example pavement sections, we will vary traffic loads systematically to track the relative effect of various axle weights and types. We will start with a moderately low set of mixed traffic, then add very large numbers of, for example, 1500 pound axles to see how many create a certain increment of damage. We will repeat for 2000 pound axles, 4000-pound axles, and so on, then will consider tandem and tridem axles at the full range of feasible weights. The absolute rates of deterioration for each axle load and each distress type will be adjusted as necessary so that the predicted deterioration of the base level of traffic matches. In the adjustment process, the relative rates will remain intact.

It is important to note that the overall structure of NAPCOM will most likely change little from its current form. We may add or subtract a distress type or two for each type of pavement, and we may identify other important data items that we might need, but the overall structure will follow the current structure, as described in Appendix A.

The refinement of the NAPCOM distress models is scheduled for completion in April 2009, and realistically might be later than that date, so cannot feed directly into the 2009 Oregon HCRS.

Improving the Application of NAPCOM

As a national model, NAPCOM includes highway section data from each state but does not tailor all specific parameters of the model to best match the conditions in each state. The Highway Performance Monitoring System (HPMS) provides the section data, but NAPCOM has to make assumptions about some pavement parameters not included in the HPMS section data. We could improve the application of the model in Oregon by working with ODOT pavement engineers to make sure the assumptions implicit in NAPCOM for national application are accurate assumptions for Oregon

(**Recommended**).

Further, NAPCOM emulates typical state pavement rehabilitation strategies by using a point-rating system that rates the overall condition of a pavement as a function of the progression of a series of distresses. We could try to more closely emulate ODOT's rehabilitation policies by working with ODOT pavement management engineers to adjust the distress weighting factors (**Recommended**).

Varying Allocation Factors as a Function of VMT Levels

NAPCOM is a complex Fortran model that does not easily allow integration into another custom software program. That being said, however, there are ways to account for variations in assumptions about future VMT levels.

We could apply NAPCOM to the full set of Oregon pavement sections using variable VMT assumptions. It is not clear that wide variations in VMT would significantly affect the relative contribution of various vehicle classes, but it might. A reasonable approach might be to run the model at the recommended VMT assumptions, then again with a 20% decrease in VMT, and a third time with a 20% increase in VMT. If the load equivalency factors varied significantly, we might decide to make additional runs at intermediate points. We could then integrate the findings of this exercise into the overall model so that equivalency factors would vary as a function of VMT levels (**Recommended**).

Incorporating Studded Tire Damage into NAPCOM

NAPCOM currently includes national-average studded tire damage as an implicit part of its skid resistance distress model. No recent work on studded tire damage, however, has been incorporated into the model. Further, skid resistance is not included in the MEPDG distresses, so the skid resistance distress model in NAPCOM will probably not be revised in the new NAPCOM.

The best way to make NAPCOM more responsive to Oregon's experience with studded tire damage would be to work with ODOT's pavement management staff to see if sufficient empirical data are available to adjust NAPCOM's distress models for application in Oregon. If we have sufficient historic data on enough sections, we could develop an empirical model that we could incorporate in the skid resistance and/or rutting distress models in NAPCOM (**Not Recommended**). We could also search for publications from other states that quantify the effects of studded tire damage (**Recommended**).

[Issue Paper 3] Appendix A: Allocation of Pavement Rehabilitation Costs Using NAPCOM

Overview:

The National Pavement Cost Model (NAPCOM) attributes pavement rehabilitation costs to specific groups of vehicles. This Appendix summarizes NAPCOM and its supporting data.

For each of a large number of specific highway sections, NAPCOM applies a set of pavement deterioration models to determine the expected pavement condition at the end of each year of analysis. When a pavement section reaches a condition that would trigger a need for major rehabilitation or reconstruction, NAPCOM takes note of the specific distresses and their contribution to the need to rehabilitate, the contribution of specific groups of vehicles to each of these distresses, and the year of failure. It accumulates these factors by pavement type, highway type, and state.

After all pavement section have been analyzed, NAPCOM converts the tabulated arrays of failure data into vehicle cost responsibilities and relative responsibilities per mile. It produces output files not only in the form needed for the cost allocation analysis spreadsheet, but also for such analyses as effective load equivalence factors.

NAPCOM does not use standard Equivalent Single Axle Loads (ESALs) in its distress models. Instead, the relative effect effect of each axle weight varies widely depending upon distress, pavement thickness, and various environmental and design variables. The resulting allocation factors, at least for the national sample of pavements used in the cost allocation study, charge heavy axle loads somewhat less than if ESALs had been used.

The following sections describe in somewhat more detail various aspects of NAPCOM's application for highway cost allocation.

Highway Section Data Used in NAPCOM:

NAPCOM uses information about specific, representative highway sections supplied by the states to FHWA's Highway Performance Monitoring System (HPMS). The full national HPMS sample consists of over 100,000 pavement sections. Some states collect data on more sections than are included in the national sample in oreder to meet state needs. States can apply NAPCOM to their augmented section data, since NAPCOM works at either a national level or a subset of the the national level.

This highway section data provides information about number of lanes, type of pavement, pavement thickness, current pavement condition, average daily traffic, percentage of trucks in the traffic stream, predicted 20-year traffic levels, climatic zone, and some rudimentary information about pavement base.

Since the deterioration models used in NAPCOM (described below) require more information than the HPMS section file contains, we need to supplement the HPMS section data with such data items as freeze-thaw cycles, freezing index, Thornthwaite moisture index, modulus of subgrade reaction, average annual rainfall, and thickness of base.

In some cases, we need to use information btied to climatic zones. Examples of data that vary by climatic zone include: average maximum temperature, aggregate reactivity, and concentration of summer thermal efficiency.

We considerably enhanced the section traffic data, as described below, adjusting truck and overall traffic levels by factors necessary to ensure that the total traffic on all analyzed sections corresponded to the HCAS travel estimates described in the body of this report.

Vehicle Fleet Data Used in NAPCOM:

NAPCOM uses the following fleet data: (a) estimates of annual vehicle miles travelled (VMT) by vehicle class, highway functional class, and state, (b) operating weight distributions for each vehicle class on groups of highway types in groups of states, and (c) axle weights for the midpoint of each weight group for each vehicle class.

As mentioned above, we calculated the annual VMT for all vehicles, for single unit trucks, and for combination trucks implied by expanding the average daily traffic in the HPMS data file for all sections on a given functional class in a given state. We compared this implied VMT with the actual estimated VMT for the same grouping of vehicle classes, and derived a calibration factor for each state, functional class, and year of analysis. We needed this step to ensure that allocated costs corresponded exactly to estimated travel levels used throughout the cost allocation study.

Further, because we derived national attributed shares by aggregating state shares for each highway functional class, we needed to account for the missing five states. We did this by accumulating VMT by vehicle class on each type of highway, then multiplying vehicle shares for each vehicle class and weight group by a ratio of total estimated VMT to total VMT accumulated on the analyzed sections.

We derived estimated allocated shares for the three functional classes not included in HPMS (Rural Minor Collector, Rural Local, and Urban Local) by a similar procedure: multiplying shares for the closest corresponding functional class by a ratio of total VMT estimates by vehicle class and weight group.

Since we did not use ESALs, we applied the deterioration model for each distress on each pavement section to each axle in each weight group of each vehicle class. We calculated the proportional deterioration caused that year by all the travel by this axle, then accumulated the total deterioration by all axles of a distress type.

Pavement Deterioration and Rehabilitation Triggering Logic:

The HPMS section data contains each pavement section's pavement serviceability rating (PSR) and/or its international roughness index (IRI). We used this information to calculate a pavement's age by applying our model for PSR to the pavement section. We then estimated the current levels for each other pavement distress based on the accumulated years and traffic loadings.

We calculated the current overall pavement condition score (OPCS) based on weighting the distress levels by corresponding "deduction point" maxima, and subtracting from 100. We added one year's worth of traffic at a time and repeated our calculation of PSR and OPCS. When a pavement deteriorated to a PSR level of 2.5 or less or an OPCS of 10 or less, we deemed the pavement ready for major rehabilitation and stopped analyzing it.

At this point, NAPCOM tabulates the specific distresses and their contribution to the need to rehabilitate and the contribution of specific groups of vehicles to each of these distresses. It accumulates the expanded lane miles and vehicle shares by pavement type, highway type, and state.

We used the following deduction point maxima:

Flexible Pavements:

PSR Loss	50
Cracking	25
Rutting	30
Skid Resistance Loss	20

Rigid Pavements:

PSR Loss	50
Faulting	30
Skid Resistance Loss	20
Cracking	30
Spalling	10
Swelling and Depression	20

In each case, we converted the physical distress measurement to an index that varied from zero (for a newly-installed, distress-free pavement) to a value of one at the critical distress level. We then multiplied this normalized deterioration value to the maximum deduction points for that particular distress.

When a pavement deteriorated to the point of needing major rehabilitation, we first divided each distress into load-related and non-load-related portions (as described below), then distributed the load related share to each vehicle group based on its accumulated equivalent loadings. We weighted each distress share by its contribution to the loss in the OPCS at the time of failure.

Pavement Deterioration Models in NAPCOM:

NAPCOM includes some models newly derived from mechanistic-empirical analysis, as well as some developed earlier as part of the 1982 Highway Cost Allocation Study. NAPCOM includes the flexible pavement distresses (1) traffic-related PSR loss, (2) expansive-clay-related PSR loss, (3) fatigue cracking, (4) thermal cracking, (5) rutting, and (6) loss of skid resistance. Distresses for rigid pavements consist of (1) traffic-related PSR loss, (2) faulting, (3) loss of skid resistance, (4) fatigue cracking, (5) spalling, and (6) soil-induced swelling and depression.

The newly-developed and most of the older models use environmental descriptors directly in their model form and equations. Only the older model for flexible pavement traffic-related PSR loss has separate equations for each of four climatic zones.

Flexible Pavement Traffic-Related PSR Loss

NAPCOM's flexible pavement PSR loss model uses the general form:

Damage = (LEFS / RHZ) ^ (BEZ / (LEFS / RHZ)

where: LEFS = summation of accumulated load equivalents, RHZ / RH(ax)
RHZ = number of applications to failure of standard axle
RH(ax) = applications to failure of axle load "ax"
BEZ = coefficient of exponent (beta)
^ = an operator that raises the first quantity to the power of the second

Each of the factors RHZ, RH(ax), and BEZ derive from various environmental and design factors, as described below. RHZ follows from the equation for RH(ax), using a single axle of 18 kips (18,000 pounds). The equations for RH(ax) and BEZ vary by climatic zone: (1) wet freeze, (2) dry freeze, (3) wet no-freeze, (4) dry no-freeze.

RH(ax) and BEZ derive from the following equations:

RH(ax)

zone 1 = 0.000780 * (Lx + L2) ^ (-5.2007 -0.179700 * thk) * L2 ^ 4.5084 * subm ^ 2.7631 * strn ^ 3.6271 * thk ^ 7.1145

zone 2 = 0.005665 * (Lx + L2) ^ (-4.5847 -0.239900 * thk) * L2 ^ 4.3140 * subm ^ 2.3364 * strn ^ 3.8468 * thk ^ 8.1663

zone 3 = 0.000536 * (Lx + L2) ^ (-6.4275 -0.004884 * thk) * L2 ^ 4.7937 * subm ^ 3.8685 * strn ^ 5.1466 * thk ^ 0.4485

zone 4 = 0.148400 * (Lx + L2) ^ (-6.4900 +0.015640 * thk) * L2 ^ 4.9571 * subm ^ 3.5203 * strn ^ 5.9548 * thk ^ (-0.96679)

BEZ

zone 1 = 0.0865 + 0.06180 * 19.0 ^ (0.497 - 0.159 * thk +.0135 * thk2) * subm ^ 0.295 * strn ^ (-2.805) * thk ^ 0.541

zone 2 = 0.0820 + 0.15500 * 19.0 ^ (0.700 - 0.223 * thk + 0.0184 * thk2) * subm ^ 0.107 * strn ^ (-2.072) * thk ^ 0.631

zone 3 = 0.0703 + 0.00963 * 19.0 ^ (0.645 - 0.219 * thk + 0.0160 * thk2) * subm ^ 0.333 * strn ^ (-2.872) * thk ^ 1.646

zone 4 = 0.0760 + 0.01830 * 19.0 ^ (0.739 - 0.197 * thk + 0.0139 * thk2) * subm ^ 0.229 * strn ^ (-2.909) * thk ^ 1.685

where: Lx = axle load in thousands of pounds (kips)
L2 = indicator of axle type (1 for single axle, 2 for tandem)
thk = thickness of asphalt surface layer (inches)
thk2 = thk * thk
subm = subgrade modulus (psi)
strn = structural number of pavement and base (as in AASHTO ***Pavement Design Guide***)

In the application of these models, we assumed that PSR moved from 4.5 for new pavements to 2.5 for ready-for-rehabilitation pavements. The damage equations represent proportional PSR loss, so that a damage value of zero represents a PSR value of 4.5 and a damage value of 1.0 represents a PSR value of 2.5. Further, tridem axles were given no special treatment and were assumed to have an RH(ax) value equal to 1.5 times a tandem having the same weight per tire.

As the title implies, NAPCPM treats this portion of PSR loss as entirely traffic related. Also, the form of the equations shows that design and soil parameters influence the rate of deterioration, but only through their interaction with traffic loads.

Expansive-Clay-Related PSR Loss

NAPCOM's expansive-clay PSR loss model has the following equation:

Damage = 0.087 * exsp ^ 0.13 * clay ^ .05 / (dpth ^ 0.20 * cexc ^ 1.22 * acpi ^ 1.31 * rnge ^ 1.32) * age ^ 0.53

where: exsp = exchange sodium capacity
clay = percent clay (grain size less than 0.002 mm) in subgrade
dpth = effective depth of asphalt layer (equivalent to 2.3 times its thickness)
cexc = cation exchange capacity of subgrade
acpi = activity (plasticity index / percent clay)
rnge = range of values of Thornthwaite moisture index for a 20-year period
age = number of years since pavement construction or reconstruction

Because expansive clays occur in specific geographic bands, we assigned a probability of occurrence to each state, then randomly assumed expansive clay conditions for highway sections in each state according to that probability. We combined the traffic-related and the expansive-clay PSR losses and prorated the responsibility for the loss in pavement rating between the two component contributors to PSR loss.

NAPCOM treats this portion of PSR loss as entirely non-load-related.

Fatigue Cracking

NAPCOM's fatigue cracking model starts by calculating the number of repetitions to failure (20 percent fatigue cracking) of each axle load. Rather than using a standard axle reference as a basis for load equivalence, we simply used the reciprocal of the number of cycles to failure as the load equivalence factor. A sum of the LEFS directly states the progression toward failure, from zero to one.

NAPCOM used the Asphalt Institute's equation for predicting the number of stress cycles to failure:

N(ax) = 18.4 * 10 ^ M * 0.004325 * ep(ax) ^ (-3.291) * easc ^ (-0.854)

where: N(ax) = number of applications to failure for an axle load of a given weight and type
M = 4.84 * (Vb / (Vb + Vv) - 0.6875)
Vb = percent volume of asphalt in mix
Vv = percent volume of air voids in mix
ep(ax) = tensile strain at bottom of asphalt layer (see below)
easc = asphalt modulus of elasticity (psi)

NAPCOM calculates the tensile strain at the bottom of the asphalt layer by calculating the strains for 3, 12, and 30-kip single axle weights and for 6, 24, and 60-kip tandem axle weights, then interpolating between the applicable values. Tridems are treated as 1.5 tandems, effectively, as for PSR loss. To calculate the strains at the representative axle loads, NAPCOM used the following equations:

ES3 = 0.00029 - 1.032e-10 * easc - 0.00004681 * thk - 7.87e-10 * ebse + 8.39e-11 * ebse * thk + 1.03e-11 * thk * easc + 0.000002057 * thk2

ES12 = 0.000753 - 2.87e-07 * easc - 0.00008643 * thk - 4.415e-6 * ebse - 3.405e-6 * tbse - 1.350e-6 * esub + 1.485e-8 * easc * thk + 1.535e-9 * easc * ebse + 2.6e-7 * thk * ebse + 3.140e-6 * thk * thk + 7.7728e-9 * ebse * ebse

ES30 = 0.001126 - 3.263e-7 * easc - 0.00007256 * thk - 6.6103e-6 * ebse - 2.441e-5 * tbse - 8.461e-6 * esub + 2.9e-9 * easc * ebse + 4.866e-7 * thk * ebse +1.6221e-6 * thk * tbse + 6.444e-7 * esub * tbse

ET6 = 0.000267 - 7.15e-8 * easc - 0.00004146 * thk - 1.065e-6 * ebse - 7.48e-7 * tbse - 2.114e-6 * thk * thk + 4.8317e-10 * ebse * easc + 8.392e-8 * thk * ebse

ET24 = 0.00066 - 1.95e-7 * easc - 8.80995e-5 * thk - 3.375e-6 * ebse -2.935e-6 * tbse - 3.376e-6 * thk * thk + 1.4894e-9 * ebse * easc + 2.610e-7 * thck * ebse

ET60 = 0.001084 - 3.19e-7 * easc -1.01e-4 * thk - 6.443e-6 * ebse - 1.6634e-5 * tbse + 2.2229e-6 * thk * thk + 2.758e-9 * ebse * easc + 4.880e-7 * thk * ebse + 1.599e-6 * tbse * thk

where: ES3 = strain at bottom of asphalt layer for 3-kip single axle
ES12 = " for 12-kip "
ES30 = " for 30-kip "
ET6 = " for 6-kip tandem axle
ET24 = " for 24-kip "
ET60 = " for 60-kip "
easc = asphalt modulus of elasticity (psi)
thk = thickness of asphalt surface layer (inches)
ebse = elastic modulus of base layer (psi)
tbse = thickness of base layer (inches)
esub = elastic modulus of subgrade (psi)

NAPCOM uses the following equations to interpolate between the characteristic axle loads:

EP(ax) = (Lx/3.) * ES3
[L2 = 1, Lx < 3.0]
EP(ax) = ES3 + ((ES12 - ES3) / 1.732) * (Lx ^ 0.5 - 1.7321)
[L2 = 1, 3.0 < Lx < 12.0]
EP(ax) = ES12 + ((ES30 -ES12) / 2.0131) * (Lx ^ 0.5 - 3.4641)
[L2 = 1, 12.0 < Lx < 30.0]
EP(ax) = (Lx/30.) * ES30
[L2 = 1, Lx > 30.0]
EP(ax) = (Lx/6.) * ET6
[L2 = 2, Lx < 6.0]
EP(ax) = ET6 + ((ET24 - ET6) / 2.4495) * (Lx ^ 0.5 - 2.4496)
[L2 = 2, 6.0 < Lx < 24.0]
EP(ax) = ET60 + ((ET60-ET24) / 2.84698) * (Lx ^ 0.5 - 4.8990)
[L2 = 2, 24.0 < Lx < 60.0]
EP(ax) = (Lx/60.) * ET60
[L2 = 2, Lx > 60.0]

where: EP(ax) = strain at bottom of asphalt layer for a given axle load and type
Lx = axle load (kips)
L2 = axle type (1 = single, 2 = tandem)

NAPCOM treats all fatigue cracking as load related.

Thermal Cracking

NAPCOM uses the following equation to predict thermal cracking:

STHR = -2.66 + 3.06 * (0.25 * peni + 0.5) ^ 0.257 * (rbsp / 125.6) ^ 0.122 * 0.519 * vcoa ^ 24.5 * (aasr / 240.) ^ 1.97 /
rutd = 0.286 * age ^ 0.13 * (thk * (n * CSac(ax) ^ (1/(1-a1))) ^ (1-a1) + tbse * (n * CSbase(ax) ^ (1/(1-a2))) ^ (1-a2) + 12.0 * (n * CSsubg(ax) ^ (1/(1-a3))) ^ (1-a3))

(thk / 8.) ^ 0.410 * ((tpmm + 20.) / 55.7) ^ 7.43 * (age / 10.) ^ 1.16

where: sthr = percentage of thermal cracking
peni = penetration index of asphalt
rbsp = ring and ball softening point (def F)
vcoa = volumetric concentration of the aggregate
aasr = average annual solar radiation (Langleys per day)
thk = thickness of asphalt layer (inches)
tpmm = minimum monthly temperature
age = number of years since construction or reconstruction

NAPCOM treats thermal cracking as entirely non-load related.

Rutting

NAPCOM's rutting model first calculates the number of repetitions to failure (1.5 inch rut depth) of each axle load. As with fatigue cracking, rather than using a standard axle reference as a basis for load equivalence, we simply used the reciprocal of the number of cycles to failure as the load equivalence factor. A sum of the LEFS directly states the progression toward failure, from zero to one.

Unlike for fatigue cracking, however, we had to use an iterative procedure to solve for the number of passages to a given rut depth, based on the following equation:

rutd = 0.286 * age ^ 0.13 * (thk * (n * CSac(ax) ^ (1/(1 a1))) ^ (1 a1) + tbse * (n * CSbase(ax) ^ (1/(1 a2))) ^ (1 a2) + 12.0 * (n * CSsubg(ax) ^ (1/(1 a3))) ^ (1 a3))

where: rutd = rut depth (inches) for a given number of load applications of a given axle

age = number of years since pavement construction or reconstruction

thk = thickness of asphalt layer

n = number of applications of axle load of interest

tbse = thickness of base layer (inches)

a1 = 0.6

a2 = 0.7

a3 = 0.7

CSac = compressive strain at top of asphalt layer

= abs[(Lx / (18 * L2)) * (-0.000182 + 4.56e-7 * easc – 2.217e-5 * thk + 4.26e-8 * ebse - 4.64 e-7 * tbse - 2.123e-6 * esub - 2.56e-10 * easc * easc + 1.778e-6 * thk * thk + 6.009522e-8 * esub * esub)]

CSbase = compressive strain at top of base layer

= (Lx/18) * exp(-4.6588 - 0.00186 * easc - 0.38 * thk - 0.0157 *ebse - 0.124 * tbse - 0.0123 * esub + 0.00217 * Tmb * Tmb + 1.02e-5 * easc * ebse + 0.0172 * easc / ebse + 3.10e-5 * easc * tbse + 0.680e-4 * thk * ebse + 0.006924 * Tmb * Tmb * thk) [L2 = 1]

= (Lx/36.) * exp(-4.6386 - 0.001853 * easc - 0.396 * thk - 0.015684 * ebse - 0.12622 * tbse - 0.01492 * esub + 0.002198 * Tmb * Tmb + 1.0241e-5 * easc * ebse + 0.017392 * easc / ebse + 3.288e-5 * easc * tbse + 0.683e-4 * thk * ebse + 0.008305 * Tmb * Tmb * thk) [L2 = 2]

CSsubg = compressive strain at top of subgrade

= (Lx/18.) * exp(-3.98533 - 8.7e-4 * easc - 0.331 * thk - 0.0078 * ebse - 0.13671 * tbse - 0.0958 * esub + 2.87e-5 * easc * tbse + 3.81e-4 * ebse * thk + 6.76e-3 * thk * tbse + 1.58e-4 * ebse * esub + 0.006149 * thk * thk + 0.001814 * esub * esub) [L2 = 1]

= (Lx/36.) * exp(-3.83746 - 8.3e-4 * easc - 0.37066 * thk - 0.00789 * ebse - 0.14805 * tbse - 0.10899 * esub + 3.97e-5 * easc * ebse + 4.78e-4 * ebse * thk + 8.956e-3 * thk * tbse + 1.46e-4 * ebse * esub + 0.008688 * thk * thk + 0.002188 * esub [L2 = 2]

Lx = axle load (in kips)

L2 = axle type (1 for single, 2 for tandem)

exp = exponential operator

easc = elastic modulus of asphalt layer

ebse = elastic modulus of base

esub = elastic modulus of subgrade

Tmb = thk + 0.5 * tbase

Because of the form of the equation for rut depth, unlike for other distresses, NAPCOM cannot calculate rut depth for a combination of axle loads by simply summing the LEFs. Instead, it sums the product of number of applications of each axle load times the individual compressive strains for each layer raised to the corresponding exponents in the equations above, then calculates rut depth from the following equation:

rdpth = 0.286 * age ^ 0.13 * (thk * sum1 ^ (1-a1) + tbse * sum2 ^ (1-a2) + 12. * sum3 ^ (1-a3)) ^ 0.765

where: rdpth = rut depth for mixed traffic

sum1 = summation of (n * CSac(ax) ^ (1/(1-a1))) across all axles

sum2 = summation of (n * CSbase(ax) ^ (1/(1-a2))) across all axles

sum3 = summation of (n * CSsubg(ax) ^ (1/(1-a3))) across all axles

NAPCOM treats rutting as entirely load related.

Loss of Skid Resistance

NAPCOM's loss-of-skid-resistance model predicts loss of skid resistance based on the total weight of all axles passing over the pavement's most heavily-travelled lane. Thus the equivalence factor for each axle is proportional to its load.

skid = -1.781 - 1.199 * plsh + (0.290 + 0.152 * plsh) * log10(0.11 * sum)

where:
- skid = skid resistance damage (zero at new pavement to 1.0 at full loss of skid resistance)
- plsh = dummy variable (1 = polish-susceptible aggregate, 0 = not)
- sum = total weight of all axles

NAPCOM treats skid resistance loss as entirely load related.

Rigid Pavement PSR Loss

NAPCOM's rigid pavement PSR loss model uses the general form:

Damage = LEFS / RHZ

where:
- LEFS = summation of accumulated load equivalents, RH(ax)
- RHZ = number of applications to failure of standard axle
- RH(ax) = applications to failure of axle load "ax"
- BEZ = coefficient of exponent (beta)

RHZ, BEZ, and RH(ax) derive from the following equations:

RHZ = 1.e6 * exp(1.333 * styp - 0.009024 * frzi + btyp * (1.156 * slbt - 6.966) + jlts * (0.6556 * slbt + 1.763) + 0.803)
[JPCP]

= 1.e6 * exp(0.4593 * slbt - 0.01167 * thmi + 0.6758 * btyp - 1.709)
[JRCP]

BEZ = max(0.0006076 * frzi + btyp * (-0.01435 * slbt - 0.0683) + jlts * (-0.09997 * slbt + 0.7107),0) + 0.544
[JPCP]

= 7.656 / jtsp + 0.04152 * tobl + 0.43516
[JRCP]

RH(ax) = esal(Lx,L2) ^ BEZ

where:
- exp = the exponential operator
- styp = type of subbase soil (0 = granular, 1 = coarse)
- frzi = freezing index (32 deg F-- CE method)
- btyp = type of base (0 = nonstabilized, 1 = stabilized)
- slbt = slab thickness (inches)
- jlts = joint load transfer system (0 = undowelled, 1 = dowelled)
- thmi = Thornthwaite moisture index
- max = a function that selects the listed expression with the highest value
- jtsp = average joint spacing (feet)
- tobl = thickness of base layer (inches)
- esal(ax) = standard AASHTO ESALs for specified axle load and type

NAPCOM treats all rigid pavement PSR loss as load related.

Faulting

As with flexible pavement fatigue cracking, NAPCOM's rigid pavement faulting model starts by calculating the number of repetitions to failure (defined as 0.1 inches) of each axle load. As before, we used the reciprocal of the number of cycles to failure as the load equivalence factor. A sum of the LEFS directly states the progression toward failure, from zero to one.

NAPCOM used the following equation for predicting the number of stress cycles to failure:

N(ax) = 10 ^ (6.27 - 1.6 * log10(DE - 0.002)   [DE > 0.002]
    = 10 ^ 25.47   [DE = < 0.002]

where:

N(ax)	= number of applications to failure for an axle load of a given weight and type
DE	= differential energy of subgrade deformation
	= 0.5 * ksub * (wl + wul) * (wl - wul)
ksub	= modulus of subgrade reaction
wl	= loaded corner deflection
	= wl0 + (wl36 - wl0) / 3.
wul	= unloaded corner deflection
	= wul0 + (wul36 - wul0) / 3.
wl0	= wul0 / LTE0
wl36	= wul36 / LTE36
wul0	= wfe0 * LTE0 / (1 + LTE0)
wul36	= wfe36 * LTE36 / (1 + LTE36)
lte0	= 0.01 / (0.01 + 0.012 * aggkl ^ (-0.849))
lte36	= 0.01 / (0.01 + 0.003483 * aggkl ^ (-1.13677))
aggkl	= 2. * exp(1 + 0.2 * dodb ^ 2 - 0.17 * jtsp / l)
dodb	= diameter of dowel bars (inches)
jtsp	= average joint spacing (feet)
l	= (Ecnc * 1000. * (thk ^ 3) / (12 * (1-mu) * ksub)) ^ 0.25
Ecnc	= concrete modulus of elasticity
thk	= thickness of slab
mu	= Poisson's ratio
wfe0	= (0.000086= (1.0023 - 0.0337002 * axsp + 0.000308639 * axsp * axsp - 0.043436 * l + 0.00178717 * axsp * l - 0.0000168611 * axsp * axsp * l + 0.000796801 * lsq - 0.0000265334 * axsp * lsq + 2.41667e-07 * axsp * axsp * lsq) * 1000. * Lx/ (ksub * lsq) [tandem axle]
	= (0.43246 - 0.0138288 * axsp + 0.000135903 * axsp * axsp - 0.01548 1.70800e-07 * axsp * axsp * lsq) * 1000. * Lx/ (ksub * lsq) [tridem axle]
wfe36	= (0.0000648 * lsq + 0.003934 * l - 0.02548) * 1000. * Lx / (ksub * lsq) [single axle]
	= (-0.142828 + 0.00360675 * axsp - 0.0000174028 * axsp * axsp + 0.00909779 * l - 0.000251908 * axsp * l + 0.000001473 * axsp * axsp * l - 0.0001004 * lsq + 0.000006225 * axsp * lsq - 5.13889e-08 * axsp * axsp * lsq) * 1000. * Lx/ (ksub * lsq) [tandem axle]
	= (-0.572713 + 0.0215153 * axsp -0.000187292 * axsp *axsp + 0.0313199 * l - 0.00122083 * axsp * l + 0.0000109722 * axsp * axsp * l - 0.000423601 * lsq + 0.0000190917 * axsp * lsq - 1.79167e-07 * axsp * axsp * lsq) * 1000. * Lx/ (ksub * lsq) [tridem axle]
lsq	= l * l
axsp	= axle spacing for tridems and tandems (inches)
Lx	= axle load (kips)

NAPCOM treats all faulting damage as load-related.

Loss of Skid Resistance

NAPCOM's rigid loss-of-skid-resistance model predicts loss of skid resistance based on the total weight of all axles passing over the pavement's most heavily-travelled lane. Thus the equivalence factor for each axle is proportional to its load.

skid = sum / 1.11e9

where: skid = skid resistance damage (zero at new pavement to 1.0 at full loss of skid resistance)
sum = total weight of all axles in lane (kips)

NAPCOM treats skid resistance loss on rigid pavements as entirely load related.

Fatigue Cracking

NAPCOM's rigid pavement fatigue cracking model uses the general form:

Damage = LEFS / RHZ

where: LEFS = summation of accumulated load equivalents, RH(ax)
RHZ = number of applications to failure of standard axle
RH(ax) = applications to failure of axle load "ax"
BEZ = coefficient of exponent (beta)

RHZ, BEZ, and RH(ax) derive from the following equations:

RHZ = 1.e6 * exp(jlts * (4.872 + 0.0435 * (slbt - 7) ^ 3) + btyp * (0.0535 * slbt * slbt - 0.2745 * slbt) + 1.698 * styp - 0.105 * tdif + 2.386) [JPCP]

= 1.e6 * exp(79.51 / aarf - 0.5949 * slbt + 0.7 * drnt -0.0011546 * frzi + 0.550745 * btyp + 2.805 + 0.053188 * slbt * slbt) [JRCP]

BEZ = 1.510 + 0.16 * btyp [JPCP]

= -0.003513 * thmi + 1.324 [JRCP]

RH(ax) = esal(Lx,L2) ^ BEZ

where: exp = the exponential operator
jlts = joint load transfer system (0 = undowelled, 1 = dowelled)
slbt = slab thickness (inches)
btyp = type of base (0 = nonstabilized, 1 = stabilized)
styp = type of subbase soil (0 = granular, 1 = coarse)
tdif = difference between average maximum and monthly temperatures
aarf = average annual rainfall (cm)
drnt = drainage type (0 = no underdrains, 1 = yes)
frzi = freezing index (32 deg F-- CE method)
thmi = Thornthwaite moisture index
esal(ax) = standard AASHTO ESALs for specified axle load and type

NAPCOM treats all rigid pavement fatigue cracking as load related.

Spalling

NAPCOM's spalling model for jointed plain concrete pavement (JPCP) has the form:

spall = (0.00257 * age ^ 0.6 * (ftcy * thk) ^ 1.2) / 40

where:
- spall = spalling damage (zero at new pavement to 1.0 at existence of 40 percent spalling)
- age = number of years since slab placement
- ftcy = average number of annual freeze-thaw cycles
- thk = slab thickness (inches)

NAPCOM treats all JPCP spalling as non-load related. On the other hand, NAPCOM's model for JRCP spalling has a load-related component and a non-load-related component, each of which it adds to a constant term to predict total spalling. NAPCOM prorates spalling damage between the load-related and the non-load-related components in assessing cost responsibility, and uses ESALs to distribute the load-related portion, following the model form.

spall = (79.66426 + nlsp - lrsp) / 40

where:
- spall = spalling damage (zero at new pavement to 1.0 at existence of 40 percent spalling)
- nlsp = non-load-related spalling
  = jtsp * (1.565966 * pref - 0.004343 * ftcy) + aari * (0.035802 * age - 1.311778) - thkb * (10.422486 * pref + 0.029727 * thkb) - 0.00119 * ksub * frzi
- lrsp = 2.439e-9 * lefs * frzi
- jtsp = average joint spacing (feet)
- pref = presence of preformed joint sealant = 1, other types = 0
- ftcy = average number of annual freeze-thaw cycles
- aari = average annual rainfall (inches)
- age = number of years since slab placement
- thkb = thickness of base layer (inches)
- ksub = modulus of subgrade reaction
- frzi = freezing index (32 deg F-- CE method)
- lefs = summation of standard ESALs for all traffic

Soil-Induced Swelling and Depression

NAPCOM uses the following equations to predict damage from swells and depressions:

sdas = age * (0.000159 * thmi - 0.00004515 * cbrs - 0.0155 * btyp + 0.027746) [JPCP]
= age * (0.000350 * aarf - 0.007427 * btyp - 0.01785) [JRCP]

where:
- sdas = swell/depression damage (zero at new pavement to 1.0 at maximum swelling)
- age = number of years since slab placement
- thmi = Thornthwaite moisture index
- cbrs = California bearing ratio of foundation soil
- btyp = base type (0 = nonstabilized, 1 = stabilized)
- aarf = average annual rainfall (cm)

NAPCOM treats swelling and depression as entirely non-load related.

Issue Paper 4:

Finance-Related Issues

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The purpose of this paper is to examine recent trends in highway finance and their implications for cost responsibility and for the Oregon cost allocation methodology. Many of these topics were discussed in the 2007 Cost Allocation Study, including public-private partnerships, toll financing, road pricing and other types of innovative finance. Since that time there have been new developments in all these areas. Oregon has increased its experience as a result of the Newberg-Dundee toll road proposal and the Mileage Fee Pilot.

The paper begins with recent developments in toll financing, public-private partnerships and road pricing. These are interrelated topics with overlapping issues. That discussion is followed by a discussion of debt financing which also considers the implications of amortizing construction costs over the life of projects.

A third section includes a discussion of carbon taxes. Global warming and concern over CO_2 emissions has led to discussion of carbon taxes, which could have important implications for cost responsibility, depending on how such a tax is implemented. The discussion carbon tax helps to clarify the relationship between cost responsibility and other theories of taxation and road pricing.

A fourth section considers what changes to the cost responsibility approach in Oregon might accommodate new approaches to road finance and build in element of economic efficiency and equity. One of the key findings of this paper is that proposed new financing mechanisms including congestion pricing and a carbon tax are moving in the direction of marginal cost pricing. As these new financing mechanisms become commonplace they will have important implications for traditional highway cost allocation.

The paper has two appendices. Appendix A provides a quantitative illustration of how toll financing and public-private partnerships might affect cost responsibility calculations. Appendix B is Article IX Section 3a of the Oregon Constitution which is referenced several times in the paper.

1.0 Toll Financing, Public-Private Partnerships and Congestion Pricing

1.1 Background and Recent Developments

Toll financing, public-private partnerships and congestion pricing are interrelated in that they often appear in the same projects. Throughout the United States, state departments of transportation as well as local and regional road authorities continue to experiment with high-occupancy toll (HOT) lanes, express lanes and other route-specific tolls. These may incorporate congestion pricing which increase charges during peak periods of congestion in order to manage demand and preserve capacity. There has also been increasing discussion of the potential for truck only toll lanes.

Recently New York City attempted to impose a toll in the form of a cordon fee. This follows highly publicized cordon tolls in a number of Asian and European Cities including London, Stockholm and Singapore. These also seek to manage demand by variable tolls and charges that increase during times of peak congestion.

Closer to home, the Newberg-Dundee project attempted to introduce a toll road in Oregon through a public-private partnership. The Oregon Mileage Fee Pilot experimented with mileage fees which could vary by time of day and area in order to charge higher fees during congested time periods. The Puget Sound area demonstrated an electronic tolling system in which all freeways and arterials were tolled using different tolls by facility and time of day to incorporate congestion externalities into the pricing structure.

Appendix A of this paper contains a quantitative example of cost responsibility impacts discussed in the remainder of this section.

1.2 Toll Roads

1.2.1 History in Oregon

The early history of the Oregon road system included several toll roads and bridges. Since creation of the State Highway System in the early 1900s, however, tolls have been used only to finance bridges. Tolls on these bridges were limited to repayment of bonds used to finance the bridges and for maintenance and operation until the bonds were retired. Only two bridges are tolled today: Cascade Locks and Hood River. Both are operated by port authorities. Oregon laws were revised in 1991, 1995, 1997 and 2001 to permit development of new toll facilities. In 2003 the law was revised again to explicitly allow tolls as part of public-private partnerships for road development. To date, no new toll facilities have been created in Oregon.

1.2.2 New Approaches to Toll Facilities

Recent research for ODOT identified a number of different types of tolls or toll facilities that are currently being discussed or experimented with.[1] These include:

- New toll roads
- New toll bridges and tunnels
- High occupancy toll lanes (HOT lanes)
- Express lanes
- Truck-only toll lanes (TOT lanes)
- Cordon tolls

None of these new mechanisms in and of themselves present serious problems for calculating cost responsibility. Revenue attribution becomes very easy with tolling. In most cases, since revenues are expended on the specific facility from which they are collected, costs can be allocated directly. Truck only toll lanes which are limited to a specific class of user, and cordon tolls which are not facility-specific can both be easily handled easily within existing frameworks of revenue attribution and cost allocation. It is noted that truck only lanes could create internal cross subsidy issues among heavy vehicles and that is discussed below.

Setting Tolls to Meet New Tolling Objectives

Although the toll mechanisms themselves do not present theoretical or practical problems for calculation of cost responsibility, the methods of computing

[1] Cambridge Systematics, for ODOT, The Future of Tolling in Oregon, August 2007.

tolls and the uses of toll revenue could present issues with cost responsibility. Recent ODOT research pointed out that the recent discussions of tolling have become more complex and introduced multiple objectives. In addition to, or in place of, raising revenue for a specific facility, implementation tolls now consider four additional objectives:

- Revenue generation (beyond the facility being tolled)
- Environmental objectives
- Congestion management, and
- Economic growth.

Some of these objectives may be a part of highway projects even without tolls. Two things create special problems for cost responsibility. First, to the extent that tolls generate revenue that is used for facilities other than those being tolled, they explicitly introduce cross subsidies. While cross subsidies within user classes are not a violation of Oregon's cost responsibility requirements, they raise equity issues that will have to be addressed.

More importantly, use of tolls to achieve environmental and congestion management objectives moves the financing structure in the direction of marginal cost pricing and the inclusion of costs not normally a part of highway cost allocation. For instance, to achieve environmental objectives the toll may introduce the cost of vehicle emissions. But since the cost responsibility formula includes only road expenditures there is no mechanism for allocating these costs.

Variable tolls may be set to manage congestion or to charge for congestion costs. These raise another set of issues which are discussed in Section 1.4.

Attribution of Revenue and Allocation of Costs

Revenue Attribution – As noted, toll revenue collected on state highways must be considered as road user revenue and attributed to vehicle classes.

Cost Allocation – To the extent that most toll revenue is expended on highways, there is no inherent difference why it should be allocated differently than other road expenditures. A consideration may be whether to segment revenue raised on a toll facility and cost expended on that facility in order to separate it from general road revenues and expenditures. This may be desirable to avoid distorting the relation between general road user revenue and expenditures. However, in the final analysis, constitutional cost responsibility requirements would seem to indicate that all costs and expenditures be considered together.

It should be noted that public-private partnerships and congestion pricing may generate additional considerations for allocation of expenditures related to toll facilities. Those issues are discussed in the following section.

New Approaches to Tolling and Potential for Cross Subsidies

While Oregon's cost responsibility concept does not require any correspondence of revenue and equity between facilities and facility types or any matching for revenue and costs for a specific vehicle, the use of tolls would make it possible to explicitly compare costs and revenues by vehicle type for a specific facility. This could raise interesting equity questions about toll financed facilities, particularly if evaluation of tolls and other revenue attributed to those paying the tolls revealed increased cross subsidies within user classes.

Cross subsidies could be a significant issue with truck only lanes. If tolls paid the full cost of truck only lanes, then the costs and revenues associated with these projects could be isolated and calculation of cost and revenue allocations would be very straightforward. In addition, if the intent of the truck lanes were to reduce general congestion, for which light vehicles also had responsibility, then it might be expected that general road construction funding would augment funding obtained through truck tolls. Under this scenario would light vehicles bear some responsibility for these costs, even though they do not use the facility?

Finally, since modern toll facilities are more likely to be developed in urban areas would the fact that urban road users were paying both the tolls and the basic user fees result in cross subsidies from urban to rural users, or would it result in more urban toll projects which are subsidized by non-toll revenue as well? While regional equity and cross subsidies within user classes do not violate Oregon cost responsibility requirements they do introduce issues that may have to be addressed as toll facilities are developed.

1.3 Public-Private Partnerships

1.3.1 Definition and Recent Developments

The essence of a public-private partnership is the sharing of costs between private investors and the public. This has been a common practice in the past when developers share the cost of developing interchanges or other road features to improve land access. In that case cost responsibility calculations are very straightforward. There is no road user revenue associated with the private contribution and those costs are simply left out of cost allocation calculations. However, when public-private partnerships develop toll facilities several significant issues are introduced.

A typical practice in developing toll facilities is for the public agency to make an agreement with a private consortium that builds and operates the facility. The public contributes to the construction costs, probably through a sale of bonds. Ongoing payments may occur either from the private consortium to the public or from the public to the private consortium.

1.3.2 Cost Responsibility Issues

Revenue Attribution

Tolls collected from a toll facility built as a public-private partnership would have to be attributed to users as road user revenue. If the facility is part of the public road system then toll revenue or other fees collected from road users for the use of the road must be treated as road user revenue according to the Oregon constitution.[2] The tolls would be subject to constitutional restrictions on use and would become part of the cost allocation process that ensures equity between vehicle classes. It would make no difference whether the fees were collected by a private party or the state. The attribution of these fees to user groups should not present problems and can even be built into revenue reporting requirements. The allocation of corresponding expenditures is discussed below.

Cost Allocation

Public Costs – The public contribution to a public-private partnership involves two special considerations. First, what part of the project is the public financing? In most cases, the initial public investment is in the construction of the project and could be allocated as such. To the extent that these public costs are financed by bonds, they may be amortized as described in Section 2 of this paper.

An important question with regard to the allocation of public costs is whether these costs should be considered as financing for only certain features of the project or should they be allocated based on overall project cost distribution? The most obvious conclusion would be that the public funds should be allocated according to the costs of the elements for which they are contributing. It is likely, however, that any distribution of costs by feature between public and private participants would be solely on the basis of convenience in financing. For instance, in building a bridge the public partner may finance the approaches strictly because it is convenient for timing and cash flow, while the private

[2] If the road were not on a public road system, then road use funds could not be spent on it and the entire facility would be outside the cost responsibility framework.

partner pays for the main span. In that example, the reality is that both are participating in the entire project and public costs could be allocated across the entire project.

After construction the new facility would either be turned over to the government for operation, in which case maintenance and operation become a normal part of the highway cost allocation formula; or the private party would operate the facility, in which case maintenance and operation are part of private costs, discussed below.

A special case may arise if the public pays the private contractor ongoing fees as a condition of the agreement. If these are for operation they should be allocated according to the maintenance and operations allocation formulas. If the ongoing payments are for repayment of the private investment they should be allocated as other debt service, according to the amortized construction costs.

Private Costs – If the facility is generating revenue from tolls or other user charges it would be appropriate to allocate the costs to which those revenues were applied. For instance, if revenues were used to pay for operation and maintenance, then operating and maintenance costs of the facility would be allocated to vehicle classes up the amount of the tolls used in that way.

Other private costs, not recovered from users, do not need to be included in cost allocation. Since a private developer may benefit from land development or other returns not directly associated with user charges, it is quite conceivable that there may be “unrecovered” private contributions.

A special case may arise if the private partner makes regular payments to the public partner as part of the agreement. To the extent that these payments came from toll revenue they can be allocated as user revenue to whatever purpose the public wants to use them. A likely use would be retirement of construction bonds, but there could be other purposes to be determined by the specifics of the agreements. If the payments were from non-user sources, they could be treated as reductions in costs for whatever categories the public agency applied them.

Federal Road Use Taxes and Federal Aid Expenditures

This analysis of public-private partnerships raises an interesting comparison with federal road use taxes and federal-aid highway expenditures. If tolls charged by a private partner are considered road use “imposts”, should federal fuel taxes and other taxes on vehicles be considered road use taxes? They are, after all, levied against users of the public road system and paid as a condition of using that system. If federal road use taxes were considered in the same light as state and local taxes, then those revenues would be attributed to the user groups and the highway expenditures resulting from those revenues would be allocated as costs.

Arguing against this point of view is the fact that the Oregon constitutional requirements which restrict uses of road use taxes and require equity among user groups based on cost responsibility have never been held to apply to federal taxes and expenditures. Also, it has to be recognized that federal taxation and revenue distribution may be based on entirely different policies and that any attempt to fold them into Oregon HCAS would in effect be using state policy to compensate for federal policy.

1.4 Variable Tolls and Congestion Pricing

1.4.1 Definition and Recent Developments

Variable tolls are set by time of day with increased charges during peak periods. In true congestion pricing tolls are set to reflect the marginal costs that each vehicle imposes on other users of the system. Tolls may also be set to optimize revenue or to manage traffic to a pre-determined volume. All strategies have the effect of reducing traffic during congested times and thus “rationing” the use of the facility. The concept of congestion pricing is closely related to marginal cost pricing in which prices for a public facility or service are set at rates reflecting full social costs. Full social costs include the public costs of providing the facility, the environmental costs associated with its use and the cost imposed on other users by the inefficiencies associated with over use of the facility. Those users who value the facility at less than the full social cost are priced off the facility. For highways, this would require changing prices by time of day, since during uncongested periods each user is imposing little or no cost on other users.

In practical terms there are a number of choices to be made in setting congestion prices. First, are the prices set for individual facilities, as in toll bridges or HOT lanes; or they could be set for areas as with cordon prices? Second, would the prices be set at predetermined levels that vary by time of day, as with the London cordons and California SR-91, or would they by dynamic, as with the I-15 HOT lanes in San Diego where tolls adjust constantly based on traffic levels?

1.4.2 Cost Responsibility Issues

Cost Responsibility and Marginal Cost Pricing

There is an inherent conflict between cost responsibility, as currently defined, and marginal cost pricing of social and environmental costs. The current cost responsibility concept relates user fees to expenditures on road construction, maintenance and operation. Equity is achieved when each user class pays its proportional share of these road costs. Congestion pricing, on the other hand, may consider the marginal cost that each user imposes on others and uses elasticity of demand to set fees to ration the use of the facility.

If congestion charges are only a small part of road user fees then they can be attributed to the contributing classes of road users and the resulting revenue allocated based on overall road expenditures which they help to finance. However, if congestion fees become commonplace and generate a sizable portion of state highway revenue, conflicts would arise and the philosophy behind cost responsibility would have to be revisited.

There are two issues in particular that would be likely to arise if congestion pricing became common practice. First, the highest priced facilities and those that generate the most revenue would likely not be the facilities receiving the highest level of investment. Given the elasticity of demand for urban freeways, tolls could generate considerable revenue while expenditures on these facilities would be limited by land use or environmental considerations. The imbalance between revenue and expenditure on specific facilities could become large enough that the contribution of an entire class of user might exceed the expenditures being made on their behalf according to cost allocation formulas. In that case congestion pricing would have to be cut back, funds redistributed by some other means such as a rebate, or the fundamental cost responsibility concept would have to be modified.

The second conflict with cost responsibility that could result from extensive congestion pricing has to do with regional equity. Presumably most congestion fees would be collected in urban areas. If expenditure patters did not change, funding would flow from urban to rural areas. In addition, as cost responsibility studies showed light vehicles contributing more and more congestion fees, gas taxes would have to be lowered proportionately to keep cost responsibility in line. Since most congestion fees would be collected in urban areas, overall fees paid in rural areas would go down.

While these types of results are a long way in the future, they are worth considering as the state moves in that direction. In Section 4.0 an alternative marginal cost approach to cost responsibility is presented.

Accounting for Congestion Pricing within the Cost-Responsibility Framework

Until the revenue imbalance from congestion pricing becomes large enough to significantly distort equity within user groups or among regions as described above, these fees can be handled easily within the existing cost responsibility framework.

Revenue Attribution – As noted in the tolling discussion, regardless of the basis for setting tolls, they are easily attributed to the user classes who paid them.

However, forecasting tolls in order to calculate cost responsibility relationships for future time periods will become more of a problem with these types of tolls. If they are successful they will divert or reduce traffic. If dynamic tolling is used forecasts become even more difficult. In dynamic tolling, tolls are allowed to vary throughout the day based on traffic volumes. This is different from time of day pricing in which the toll changes according to set schedules throughout the day. The consequences of missing revenue forecasts will depend on the structure of the agreements under which the tolls are being applied, so a solution to the forecasting problem may become apparent when specific proposals are developed.

Cost Allocation – Variable tolls and congestion pricing deals with the revenue side of the cost responsibility equation. The cost side will be determined by how the revenue is used. There are at least four alternative uses of revenue from congestion pricing that could be considered, notwithstanding constitutional restrictions:

1. Invest in additional highway facilities that would reduce congestion costs and social and environmental externalities. Current highway funding levels leave many significant projects unfunded. To the extent that they would reduce congestion or improve traffic flow they would reduce congestion costs imposed on society improve the efficiency of the transportation network.
2. Mitigation of environmental or land use consequences of highways. To the extent that prices are set to reflect full social costs, not just highway expenditures, this may be a logical use of revenue. In that case, assuming charges are set correctly, revenue and expenditures are a wash and have no impact on other cost responsibility calculations.
3. Investment in alternative infrastructure and services such as public transit. In this case, there may have to be some consideration of the purpose and beneficiaries of the expenditures, similar to current considerations for other modes such as bicycles.
4. Reducing other road use taxes or returning revenue to users in some neutral manner. In this case, there would be no road costs to allocate. Such an allocation could be considered a reduction in road user taxes and taken account of in the attribution calculation.

Allocation of expenditures will depend on which of these or other options for the use of congestion fees is implemented.

1.6 Oregon Examples and Experiments

During the past two years Oregon has gained experience in new road use finance approaches by working toward a public-private partnership for a toll road project and by conducting a mileage fee experiment. While the toll project ultimately did not go forward, a better understanding of the cost responsibility consequences can be gained by reviewing major features of the project. Likewise, while the mileage fee pilot was only an experiment, it can be reviewed for cost responsibility implications regarding mileage fees and congestion pricing.

1.6.1 Newberg-Dundee Project

While the Newberg-Dundee bypass ultimately did not proceed to construction, the project development process addressed many of the elements that must be considered in evaluating the impact of toll roads and public-private partnerships on cost responsibility.

The project was to be an eleven-mile bypass with an estimated price between $325 and $425 million. The project was being considered by the Oregon Transportation Investment Group (OTIG), a partnership with Macquarie as the principal partner. The project was to be a toll road, with additional funding from state and federal highway funds. It was recognized that tolls could not cover the full cost of the road.

Two features of the project were particularly significant in terms of highway cost allocation.

First, the road was to be a state highway, even though it would be constructed by OTIG and OTIG would collect the tolls. This is a common feature of most public-private road building partnerships in which the roads are actually leased to the private partner and revert to the state after an agreed time period. The result of the road remaining in public ownership is that by current definitions of road user taxes and cost responsibility contained in the Oregon constitution, the tolls would be road user taxes and subject to cost responsibility requirements. The toll revenue would have to be attributed to user groups and the road costs would be subject to cost allocation.

The other interesting characteristic of the Newberg-Dundee project was the method by which the state would have contributed to the project. The project was to be financed initially by the private consortium using some federal funding. ODOT was to make annual payments to the consortium for its share of project construction costs. The private consortium was to maintain and operate the road using tolls.

Revenue Attribution

As noted, tolls on this project would meet the constitutional definition of road user charges and would, therefore, be attributed to appropriate user classes.

Cost Allocation

Allocation of Costs Financed From Toll Revenue -- Cost allocation would have had to consider both the costs paid for by the tolls and the costs of annual payments by the state. Toll revenues would have been allocated to maintenance and operation as well as construction costs. Operations would have included the toll collection system as well as other operational features of the road. Among the important questions to be considered in allocating these costs:

- Would the private partner provide a budget showing how revenue would be used in order to facilitate cost allocation?
- Would maintenance and construction costs be considered to have the same cost distribution characteristics as other roads on the state system or would there by unique features of this road that would have to be allocated separately?
- How would toll collection be allocated?
- How would private consortium profits be allocated? Would they be treated as financing costs from the state perspective?

Allocation of Future State Payments – Future payments could be either for ongoing operations and maintenance, for debt retirement or for a combination of the two. In any case, future state payments to the private partner could easily be treated the same way as other highway cost allocation as though the private partner were a contractor carrying out the state highway program.

1.6.2 Oregon Mileage Fee Pilot

ODOT launched a 12-month pilot program in April 2006 designed to test the technological and administrative feasibility of this mileage fees for passenger vehicles.. The program included 285 volunteer vehicles, 299 motorists and two service stations in Portland. Vehicles were equipped with mileage recording devices that could record mileage accumulated by zone and by time period. Users paid a per mile fee when they purchased fuel at one of the participating service stations. Some of the participants paid variable fees for operating at congested time periods in an urban zone, but a lower fee at other times and places.

The study showed that a mileage fee was feasible and that variable pricing features would work. An important finding for cost responsibility was that the potential for evasion is minimal with this type of system. Because the mileage recorder cannot be tampered with undetected and because payments cannot be avoided when fuel is purchased, the potential for evasion is very small. The inability to avoid the fee and the ability to determine directly, without a fuel economy calculation, the payments by light vehicles, both mean that mileage fees would improve the attribution of fees for light vehicles.

The variable pricing element of the mileage fee pilot demonstrated the need to better define the relation between marginal cost pricing and cost responsibility. Some mileage pilot vehicles were subject to a flat rate of 1.2-cents per mile. Other participants were subject to congestion charges and paid either 10-cents per mile at peak periods or 0.43-cents off peak. Both of these rate structures were revenue neutral compared to current state gas taxes. For those vehicles which were subject to variable charges, those charges were more than 20 times higher than the "off-peak" rate. That differential is far in excess of any potential difference in highway construction, maintenance and operation expenses that might occur between peak and off-peak periods. The higher fee for peak travel may reflect the differential in marginal costs between the peak and off peak travel, but it cannot be justified using the existing cost responsibility formula.

The flat mileage fee appears to be very compatible with cost responsibility across weight classes. In fact, it is be better than the fuel tax in this regard because fuel taxes per mile among different vehicles in the same weight class vary more than cost responsibility. However, when congestion pricing elements are introduced equity between weight classes, as determined by traditional cost responsibility will be disrupted. Once again this illustrates the need to rethink cost responsibility in relation to marginal cost pricing if congestion pricing is to be introduced effectively.

2.0 Debt Financing and Road Depreciation

Recent cost allocation studies have used a method of allocating debt service that projects the cost of debt-financed projects forward and allocates those costs in proportion to the amount of debt service that will be paid as a result of those expenditures. This is consistent with the forward-looking perspective of the cost allocation methodology. The 2007 Cost Allocation Study examined a number of alternatives for handling debt. Among these were:

1. Recompute responsibility for debt service in each new study by looking backward at the expenditures financed by the debt. As an alternative to the present methodology, debt financed projects could be reallocated in each new study based on traffic patterns existing at that time. This would actually be a better refection of marginal costs, since increases or decreases in traffic levels would result in changes in allocations and better reflect actual costs over time than does an allocation as a project is being built, which is never revisited even if assumptions about usage turn out to be inaccurate.

2. Calculate depreciation on the facilities which were financed by the current debt. This depreciation would be attributed to user groups based on rates of deterioration and rates at which capacity are used up on these facilities. The calculation of depreciation could be done either for the individual projects that were part of the debt package or for the highway system as a whole. In either case, a value would be placed on key components of the system, such as road surfaces, drainage structures, bridge structures, bridge decks, etc. Elements would be subdivided into those that depreciate strictly with time, such as drainage structures, those that deteriorate with use, such as road surfaces and those for which capacity is used up by traffic over the life of the facility. By this method depreciation could be assigned to user groups and weight classes. Debt service would then be allocated by the depreciation on the debt-financed facilities.

Both of these alternatives to the present system have the effect of moving the cost allocation closer to marginal cost pricing by considering the degree to which traffic results in greater depreciation of the asset. Both would, however, be much more complex to calculate.

The 2007 Study also suggested that it would be possible to move in the direction of allocating costs rather than just expenditures by calculating the depreciation of all asset that takes place as a result of time and as a result of traffic. The current approach to cost allocation actually allocates expenditures rather than costs. While cost impacts form the basis of allocations, it is actually the projected budget of expenditures that is allocated. By allocating depreciation costs the study would move in the direction of marginal cost pricing.

The distinction between costs and expenditures is easy to understand in relation to surface preservation expenditures. Surfaces deteriorate and costs accumulate with use and time. But the expenditures are only allocated in the year a preservation project is undertaken. This will often be years after the actual wear and tear costs were incurred. On the other hand, construction costs which are financed by current revenues are allocated as costs in the year of construction, even though costs of use and depreciation will actually take place over many years following construction. Businesses account for their capital costs by use of depreciation expenses which assign the costs of facilities to the time periods in which they took place. No such system within the present cost allocation formula currently exists.

Current road users, whose road use taxes paid for the facility, may not be the ones to benefit from it or to contribute to its deterioration over the life of the facility. Instead future users both benefit from the facility and "use it up." Those who are using up the facility are not paying for it unless it was financed by debt or unless there is some mechanism for recovering depreciation from current users. As discussed above, it would be possible to calculate depreciation and allocate these costs to the current users. Just as the depreciation allocation for debt service would be used to allocate that budget, the system depreciation allocation would be used to allocate capital construction costs.

3.0 Carbon Tax

3.1 Definition and Recent Developments

Current discussion of a carbon tax is important to cost responsibility because it is an explicit example of folding an environmental cost into the product which produces the cost – in this case the burning of carbon fuel. Discussions of road pricing, congestion charges and marginal cost pricing have already raised the issue of whether social and environmental costs should be considered in road pricing and cost responsibility. Consideration of carbon taxes makes that discussion explicit by folding the cost of CO_2 emissions into the cost of motor fuel.

Several European countries have imposed carbon taxes as a way to combat global warming. These taxes are levied on carbon fuels based on tons of carbon content. British Columbia will introduce its carbon tax in July 2008. The tax will be at $10 per metric ton of carbon content, which translates into approximately 2.41 cents per liter, or 9.13 cents per gallon. The rate will climb to $30 per metric ton by 2012.

The primary purpose of carbon taxes is to internalize the environmental cost of CO_2 emissions to the cost of fuel. Because their primary purpose is not to raise revenue, some governments, notably British Columbia, have made their taxes revenue neutral by redistributing the proceeds. Revenue neutrality is also a feature of proposed carbon taxes in the US. Other potential uses of carbon taxes would be:

- Use as general fund revenue within the government's budget;
- Reduce other taxes;
- Dedicate to purchase of carbon offsets;
- Dedicate to other carbon reduction programs including highway and other transportation investments that have positive environmental impacts.

Carbon taxes have been discussed for Oregon[3] and have interesting implications for cost responsibility. Even though a carbon tax would likely be levied on all carbon fuel based on carbon content, that portion falling on motor fuels would appear quite similar to the existing motor fuel tax.

There are a number of questions surrounding the potential introduction of a carbon tax in Oregon. First, could a carbon tax be structured in such a way as to avoid conflict with Oregon's constitutional dedication of motor fuel taxes to highways? Oregon's constitution currently requires that any tax levied on the sale or consumption of motor fuel be used only for roads and streets. There is currently no provision for use of these revenues for redistribution (the revenue neutral option), for mitigating carbon impacts or for funding alternative energy sources.

3.2 Constitutional Questions

The Oregon Constitution restricts the use of gasoline taxes to public roads and streets.[4] Oregon courts have interpreted this article very strictly and it is difficult to see how a state carbon tax could be levied on motor fuel and used for anything except roads. For a variety of reasons it is difficult to see how a carbon tax could be effective if its use were restricted to road infrastructure. That being the case, it is assumed that such a tax would have to be accompanied by a new constitutional interpretation[5] or amendment. The remainder of this section assumes that any required constitutional changes would accompany a carbon tax on motor fuel.

3.3 Economic Theory

According to economic theory a carbon tax could improve the economic efficiency of driving a road use decision. If all the costs associated with an activity or product are included in its price, the decision of consumers to purchase the product or engage in the activity will send the correct price signals through the economy resulting

[3] Remarks by Governor Ted Kulongoski to Forum for Business and the Environment, Friday, April 11, 2008.

[4] For the exact wording, see Appendix A

[5] One such interpretation could be built off the same logic as the construction of sound walls. These walls do not directly aid drivers and are not part of the roadway used by vehicles. They are instead used to reduce an environmental impact of roads on adjoining property. In a similar way the carbon tax might be used to offset the impact of carbon emissions on the general population. This would have to be argued in court or voted on by the public.

in optimal production and consumption of products and services. With regard to any good, but especially in the case of quazi-public goods[6] like roads, it is possible that some costs are not included in the price consumers pay. These are referred to by economists as "external costs" or "externalities." Because they are not included in the price users pay for the service, they will tend to over use the service. By folding these "externalities" into the cost of the service more efficient consumption expenditures are made.

The concept of a carbon tax is based on internalizing the cost of CO_2 emissions. By raising the cost of carbon based motor fuel the consumer will use less of it, either by driving less, finding substitutes or using more efficient vehicles.

A carbon tax would have two important links to the cost responsibility concept. First, cost responsibility is a method of pricing roads that encourages economically efficient decisions by charging vehicles for the cost of providing roads. To the extent that a carbon tax improves the price signal to road users by including the cost of CO_2 emissions, this would result in more economically efficient decisions by road users.

A more compelling link would exist if the carbon taxes were used to purchase carbon offsets. A carbon offset is a financial instrument representing the reduction of carbon released into the atmosphere.[7] An offset may be generated by reducing emissions or by reforestation or other means of reducing CO2 in the atmosphere. If offsets were purchased to keep CO2 emissions at a targeted area the cost of this environmental measure would automatically be internalized in the cost of fuel. This environmental measure would in some sense be similar to the use of road user taxes to build sound walls which have no direct benefit to road users, but shield non-users from noise, which is another negative by-product of road use.

Following this logic, a carbon tax would be consistent with cost responsibility and would require no adjustments to existing methodology. Since the carbon tax is levied on tons of carbon content in fuel and tons of carbon content correspond directly to environmental impacts and costs of offsets vehicles would automatically pay the correct "carbon cost responsibility." Users could avoid the tax by shifting to more efficient or non-carbon burning vehicles and this would have no impact on other aspects of the cost responsibility calculations.[8]

There is an alternative train of logic that would make a carbon tax clearly unconstitutional and counter to the Oregon cost responsibility concept. If the tax were levied strictly on motor fuel and the proceeds used to finance highway alternatives, including public transit, which related to road use but not necessarily to use of carbon fuels the link to economic efficiency and cost responsibility would be lost. Likewise the link would be lost if the tax proceeds were not based on any cost considerations, such as the cost of purchasing offsets, and funds were redistributed in a revenue neutral scheme. However, in either of these cases, as in the cost responsibility consistent cases,

[6] A public good is one for which the use by one consumer does not prevent another from also using it. "Quazi-public" refers to the fact that use by one additional consumer may have impacts on others, but it does not exclude the other consumer. In the case of roads this characteristic may allow a road to accommodated more and more users who generate additional costs to others which are not recovered by road use charges.

[7] There is considerable debate at the present time about whether currently proposed systems of offsets and cap-and-trade businesses are yielding effective results. This paper takes no position on the effectiveness of current structures, but recognizes that the intent of purchasing and generating offsets is a logical approach to linking a carbon tax with actual reductions in CO_2 levels in the atmosphere. .

[8] There is, of course, an issue with how to collect appropriately allocated costs from vehicles not powered by traditional motor fuels, but that problem exists apart from the question of carbon content and will have to be addressed whether or not there is a carbon tax.

no adjustments would be needed in cost allocation formulas. The tax could be treated as completely outside the normal cost allocation formula and therefore ignored in the calculations.

3.3 Cost Responsibility Calculations for a Carbon Tax

3.3.1 Revenue Attribution

This proposal on revenue attribution for a carbon tax is based on two assumptions:

1. That the tax is levied on a volumetric basis on all carbon fuels, and
2. That the revenue is used for highway purposes and not simply to purchase offsets or provide taxpayer rebates. If the tax were used to purchase offsets or provide rebates, the cost allocation to non-highway purposes would exactly equal the revenue attribution and the discussion would be moot.

With these two provisos, a carbon tax would be attributed exactly proportional to fuel consumption. However, because the carbon content of gasoline, diesel and other carbon based fuels is different, each fuel type would have to be attributed separately.

3.3.2 Cost Allocation of Carbon Taxes

Without further definition of how carbon taxes are to be used the following methodology for allocation of costs is speculative. Recognizing this, expenditures of carbon taxes would likely be divided into three groups:

1. Expenditures for non-highway purposes that are exactly proportional to tax collections themselves. This would be the case with purchase of carbon offsets or funds used for tax rebates to make the tax revenue neutral. As noted previously if all carbon taxes were treated this way the entire cost allocation exercise would be moot as revenue and costs would balance by definition.
2. Expenditures on roads. These expenditures would be allocated as other road expenditures.
3. Expenditures on non-highway activities which would not necessarily be proportional to tax collections. For instance if the constitution were amended to allow expenditures on transit in order to reduce auto trips those costs would logically be allocated to light vehicles.

4.0 Alternative Approaches to Cost Allocation

Recent trends in transportation finance suggest the consideration of alternative approaches to cost allocation. Among these:

- The potential use of tolling to raise revenue that is used outside the specific project being tolled;
- The potential for congestion pricing which introduces value pricing and marginal social costs;
- The increased use of debt financing which requires amortization of construction expenditures; and
- The consideration of carbon taxes which reflect marginal environmental costs of road use.

None of these innovations are likely to be implemented so rapidly that existing cost allocation techniques could not be used to assure equity in the existing road user tax structure while alternative approaches are sorted out.

Two aspects of Oregon's cost responsibility philosophy that should be considered in attempting to sort out future approaches to highway cost allocation and road user taxes are economic efficiency and equity.

4.1 Economic Efficiency

Economic efficiency requires that each user pay for the costs they create by using the road system. This is sometimes referred to as the exclusion principle of pricing because it eliminates trips for which the cost is greater than the benefit to the user, resulting in a more efficient allocation of resources.

There are a number of alternative theories and practices regarding which costs should be considered in determining an economically efficient price for using the road system. The current cost responsibility structure includes only road costs which are financed from state and local road user taxes. Alternative theories suggest that all road user costs should be included, including those that are not recouped by taxes and fees. Economic theory would suggest that social and environmental costs should also be included in the calculation. As discussed previously, the consideration of carbon taxes is a move in that direction.

A second question with regard to economic efficiency is whether pricing of public goods should consider average or marginal costs and whether short term or long term. Economists generally agree that marginal rather than average costs should be use because marginal costs reflect cost imposed by the last user making a choice about whether or not to use the system and because economic theory demonstrates marginal costs to be the most economically efficient method of pricing. A short term marginal cost structure would likely consider three elements:

- Operation, maintenance and preservation costs of the road system;
- Congestion costs which each new user imposes on other users; and
- Environmental costs.

Such a system would provide sufficient funding for construction because funds raised from congestion fees would be available to expand the road system. However, consideration of congestion pricing and carbon taxes move in the direction of marginal cost pricing.

Oregon's structure is more of a long term average cost structure because it considers the cost of adding capacity as well as the cost of operation and maintenance and because costs cannot be differentiated between the average and the marginal user. In considering long term costs the Oregon structure does in fact have an element of marginal cost pricing in the treatment of incremental construction costs created by larger vehicles. These vehicles are seen as incurring more costs because the facilities to accommodate them must be wider, higher and stronger.

Finally, economic efficiency requires the consideration of costs rather than expenditures. A cost occurs when a user has an impact on the system, such as by contributing to surface deterioration. However, the expenditure only occurs when the cost is actually addressed, such as when a preservation project is carried out to correct surface deterioration. One of the long-recognized deficiencies of the Oregon structure in regard to economic efficiency has been that allocated costs are actually based on budgeted expenditures rather than true costs. A call for basing road use fees on actual maintenance and preservation needs is a move in the direction of considering costs rather than expenditures.

4.2 Equity in Road User Taxes and Fees

The Oregon system of cost allocation is characterized by two equity considerations. First that each class of user should pay a fee that is proportionate to the costs it creates. Further, it has been accepted that the best method of determining these fair costs is incremental cost allocation. A second equity principle that often goes along with cost responsibility is the idea that funds raised from road user fees should be reinvested in roads.

In addition, while not strictly equity considerations, two aspects of tax accountability need to be addressed in any modification of the cost responsibility approach. First, in Oregon the legislature has consistently retained authority to set fees and taxes. Second, Oregon's constitution requires that those taxes and fees be based on cost responsibility and dedicated to road uses.

These approaches to equity would require modification if Oregon's cost responsibility and road use taxation approach were to move to a marginal cost pricing approach.

4.3 An Alternative Cost-Responsibility Approach

Recognizing trends toward congestion pricing and consideration of incremental environmental and social costs, is there a cost responsibility structure toward which the state could move, consistent with legislative prerogatives and constitutional limitations? Such an approach could be developed based on the following principles:

4.3.1 A Basic Maintenance Fee

Individual vehicles and vehicle classes should, at a minimum pay for the maintenance, operation and preservation costs they impose on the road system. These costs are the most basic short term cost that each vehicle imposes on the system. Maintenance, operation and preservation costs should include full costs, not just current expenditures. Thus, preservation maintenance and preservation costs would be based on cost of actually preventing deterioration rather than on funds budgeted. They are generally proportional to weight and are incurred on roughly a mileage basis so that they could easily be collected as mileage fees. For the immediate future, fuel taxes will have to continue to be a substitute for mileage fees on light vehicles.

4.3.2 Tolls and Congestion Pricing

Toll and peak period pricing fees should be based primarily on marginal costs – that is, the costs imposed on other vehicles by the introduction of additional user and the additional social and environmental costs created.

4.3.3 Funding of Construction and New Capacity

If mileage fees and congestion tolls calculated as described above were used throughout the system then new construction would be funded from congestion tolls. During an interim period when congestion tolls are not universal new construction would be financed from two sources: (1) tolls, where tolling is feasible and (2) mileage fees in excess of maintenance, operation and preservation and registration fees in excess of administrative costs.

4.3.4 Environmental, Social and Non-Road Costs

In addition to funding of highways, a future cost responsibility approach would consider social and environmental costs. Contributions to social and environmental costs could be considered as those fees specifically levied to reflect those costs and any other tolls, congestion charges or other road user charges in excess of construction and maintenance costs. A carbon tax levied to reflect CO_2 output would fit this definition even if funding were ultimately used to finance highway projects.

4.3.5 Administration and Oversight of Road-Use Fees

Such a revised structure would be very difficult to manage if fees were only adjusted by the legislature every two years. Such an approach would require a more flexible approach to setting tolls. It might also require the use of sinking funds or other accounting mechanisms to match fees and costs with appropriate timing of expenditures.

One way to accomplish the more flexible structure required would be to treat roads as public utilities and allow the Public Utility Commission (PUC) to set fees based on legislative guidelines. As an interim step the PUC might be required to approve tolls and fees proposals for new capacity, whether publicly or privately funded, based on costs, demand and reasonable return on investment. Eventually, the entire registration fee, mileage fee and tolling structure might be considered as utility fees and also set based on cost, demand and reasonable return.

4.4 Future Cost Allocation Studies

Within this context, future cost allocation studies would answer a series of questions:

1. How well does the financing system reflect the marginal social and environmental costs imposed by individual users and user groups?
2. What is the overall allocation of highway expenditures and revenue between user groups based on the current definition of cost responsibility and how does this compare to the marginal costs attributable to each group?
3. Is the contribution to maintenance, operation and preservation of the road system made by each user group adequate to reflect the costs they are imposing on the system and is the variation between costs and revenues large enough to justify a different collection mechanism to reflect actual cost?
4. Is the contribution to construction costs of each user group proportional to the capacity needs they are creating on the system based on incremental cost allocation and how closely do they correspond to marginal congestion costs by each user group?

[Issue Paper 4] Appendix A: A Hypothetical Tolling Example of Toll Impacts

The following example is not based on specific facility, but could be typical of a major urban freeway project in the Portland area. It is presented as an illustration of how tolled facilities and public private partnerships might affect cost responsibility calculations.

Consider a 10 mile, 6-lane urban freeway that is projected to carry an average of 160,000 vehicles per day over the next 20 years. An additional lane in each direction is proposed at a cost of $300 million. The project is intended to be built using 20 year bonds with debt service of $25 million per year. For the sake of discussion traffic on the facility breaks down as follows:

- 88% light vehicles
- 5% medium weight trucks 12,000-78,999lbs
- 6% heavy trucks 80,000 lbs and over
- 1% other vehicles including buses and motor cycles.

The jurisdiction might consider four options:

1. Fund the facility from existing road user revenues;
2. Toll the entire facility at a relatively small charge of $1.00 per passenger vehicle net of collection costs;
3. Create an express lane for light vehicles using variable tolls that average $2.00 per vehicle net of collection costs;
4. Create a high-occupancy toll HOT lane where multi-occupant vehicles travel free and others pay a variable rate that averages $3.00 per vehicle net of collection costs.

Funding through Existing Revenue without Tolls -- In funding the facility from existing user revenue it would be noted that the facility itself does not generate enough revenue from variable taxes on existing users to pay for it. Motor fuel and weight-mile taxes would generate on the facility would equal roughly $13 million per year at existing tax rates. It would to the $25 million per year needed to retire the bonds, plus maintenance and operation. Thus, the facility would be subsidized by other road users or federal assistance if built with existing funding.

Funding by Tolling the Entire Facility -- If tolls were applied to all users at the rate described, they would generate $65 million per year. This would be enough to retire the debt, pay for maintenance and operation and cross subsidize other road projects. However, it has not yet proven politically feasible in North America to convert a free facility to a toll facility.

Creation of and Express Lane with Variable Tolls -- The facility could be constructed as an express lane for light vehicles which might pay a variable charge averaging $2.00 per trip. If 20% of the light vehicles on the system used the express lane this would generate approximately $23 million per year. This is close to the amount needed to repay the bonds. Combined with existing revenue already collected from the facility users through motor fuel and weight-mile taxes it pays for construction of the new facility along with maintenance and operation of the entire facility.

Funding as a High-Occupancy Toll (HOT) Lane -- If the facility were constructed as a HOT lane with users paying a variable charge averaging $3.00 per trip, the number of paying users might be half the number who would use the new lanes under the express lane scenario. This would generate approximately $15 million per year Again, not enough to pay for the facility, but enough, combined with motor fuel and weight distance taxes, to make the project financially feasible.

Impacts on Cost Allocation and Revenue Attribution

The cost allocation resulting from

constructing the facility by traditional means or as a fully tolled facility would be similar since the facility would function the same way with regard to both light and heavy vehicles. The cost of toll collection and related capital costs would be allocated to the users in proportion to collection costs – probably at the same per vehicle rate for all vehicles. Revenue attribution for a fully tolled facility would be straightforward with tolls attributed to the specific vehicle class paying them. Because the fully tolled option would generate revenue in excess of costs it would be significantly different from traditional option in its impact on cost responsibility calculations across the entire road system. Allocation of costs funded by excess tolls but not associated with the specific facility would have no relation to the facility that generated the revenue, but would be a cross subsidy to other users.

Under the tolling option less contribution would be required from general road user taxes, resulting in a net subsidy of all user classes for their use of other facilities.

Cost allocation resulting from dedicated express lane or HOT lane options would be significantly different if heavy vehicles were considered to bear no responsibility for their construction costs because they could not use the new lanes. On the other hand, since all vehicles would benefit from the new lanes even if they did not use them there could be a case for allocating some of the costs to all vehicle classes anyway. Revenue attribution would be straightforward with toll revenues being attributed to the light vehicles paying the tolls. In terms of impacts on cost responsibility calculations across the system, these options would not have large impacts because the cost of the facility is fairly close the toll revenue generated by the facility. If more aggressive tolls were used the net impacts would be unclear. Toll revenue would increase per vehicle using the new lanes but more vehicles would be priced out of the lanes potentially resulting in less net revenue.

In summary, the major cost responsibility issues with regard to tolling are: (1) the degree to which tolls raise from a specific facility exceed the cost of that facility and thereby subsidize other highway activities; and (2) the degree to which specialized facilities available only to specific vehicle classes actually benefit other classes of vehicles and what responsibility those other classes of vehicles then have for the facility.

Impacts of Public Private Partnership (PPP)

The illustration also demonstrates that the introduction of a PPP in funding toll roads does not affect the cost responsibility calculation unless the private partner makes substantive changes in costs. In the example, suppose the private partners built the additional lanes and fully tolled the facility. The private partner would retain tolls required for construction and maintenance and, because tolls are road use charges, the remainder would be paid back to the state. Attribution of revenue would be the same regardless of who collected it. In allocating costs the state would have to allocate the part of the tolls retained by the private partner as though they were construction and maintenance costs. For the portion of tolls returned to the state, the related costs would be allocated based on how they were used. This would yield the same result as if the state built the project.

In the express and HOT lane options the state might have to compensate the private partner for construction and operations costs since the tolls alone would not be sufficient to cover them. In this case the toll revenue would still be attributed as before. The costs contributed by the state would have to be allocated to whatever activities they funded, either construction or operation and maintenance. The costs paid for by the tolls would also have to be allocated based on which costs they covered. In the end, the total cost allocation would be the same.

There are two ways in which a PPP might affect cost allocation. First, financing mechanisms could be different.

For instance, in the fully tolled facility example, the private partner might choose to fully finance construction and retain all tolls until it was repaid. This could result in a different amortization of costs from what would result if the state paid for construction with bonds. However, with the same amortization schedules and treating private return as a cost of capital the presence of a PPP should not significantly affect the calculation of cost responsibility.

The other way in which a PPP might affect cost responsibility is if the private partner paid for some of the costs as compensation for benefit it received other than road tolls. For instance, in the express lane example the private partner might agree to build and operate the facility in exchange for the tolls collected in exchange for the right to develop land that has improved access from the new facility. In this case revenue attribution would be the same, but total costs to be allocated would be reduced.

Appendix B: Oregon Constitutional Requirements for Road Use Taxes

Article IX, Section 3a. Use of revenue from taxes on motor vehicle use and fuel; legislative review of allocation of taxes between vehicle classes. (1) Except as provided in subsection (2) of this section, revenue from the following shall be used exclusively for the construction, reconstruction, improvement, repair, maintenance, operation and use of public highways, roads, streets and roadside rest areas in this state:

(a) Any tax levied on, with respect to, or measured by the storage, withdrawal, use, sale, distribution, importation or receipt of motor vehicle fuel or any other product used for the propulsion of motor vehicles; and

(b) Any tax or excise levied on the ownership, operation or use of motor vehicles.

(2) Revenues described in subsection (1) of this section:

(a) May also be used for the cost of administration and any refunds or credits authorized by law.

(b) May also be used for the retirement of bonds for which such revenues have been pledged.

(c) If from levies under paragraph (b) of subsection (1) of this section on campers, motor homes, travel trailers, snowmobiles, or like vehicles, may also be used for the acquisition, development, maintenance or care of parks or recreation areas.

(d) If from levies under paragraph (b) of subsection (1) of this section on vehicles used or held out for use for commercial purposes, may also be used for enforcement of commercial vehicle weight, size, load, conformation and equipment regulation.

(3) Revenues described in subsection (1) of this section that are generated by taxes or excises imposed by the state shall be generated in a manner that ensures that the share of revenues paid for the use of light vehicles, including cars, and the share of revenues paid for the use of heavy vehicles, including trucks, is fair and proportionate to the costs incurred for the highway system because of each class of vehicle. The Legislative Assembly shall provide for a biennial review and, if necessary, adjustment, of revenue sources to ensure fairness and proportionality. [Created through S.J.R. 7, 1979, and adopted by the people May 20, 1980 (this section and section 3 adopted in lieu of former section 3 of this Article); Amendment proposed by S.J.R. 44, 1999, and adopted by the people Nov. 2, 1999; Amendment proposed by S.J.R. 14, 2003, and adopted by the people Nov. 2, 2004]

Issue Paper 5:

Choice and Application of Allocation Methods

Allocation and allocation methods

THE PURPOSE OF A HIGHWAY COST ALLOCATION STUDY is to attribute the costs of a highway system to the vehicles that impose the costs on that system. To achieve that, several steps are taken:

1. The costs are identified, measured, and assigned to categories.
2. Vehicles are divided into categories (classes) based on their potential to impose different amounts of cost per unit of vehicle
3. A vector of allocation factors (allocator) is developed for each cost category, where each factor relates a unit of vehicle activity to the costs imposed for a particular category of vehicle.
4. For each cost category, each vehicle category's share of costs is the product of that vehicle category's vehicle activity level times its factor divided by the sum all such products over all vehicle categories.
5. For each cost category, each vehicle category's attributed cost is its share of costs times total costs in that category.

The choice of an appropriate allocator depends on the nature of the cost and the relationship between the attributes of the vehicles and the amount of cost imposed. Costs may be divided into three broad categories:

1. Wear-related costs are the easiest to allocate. Wear-related costs are an empirically-established, direct consequence of use by vehicles and the amount of wear a vehicle imposes in a mile of travel generally relates closely to measurable attributes of the vehicle. Two approaches may be used for choosing allocators for wear-related costs.
   - If a detailed model exists to predict costs imposed by individual vehicles, the results of that model may be used to develop allocation factors that produce the same attribution of costs as the model. That is how pavement costs are handled in the Oregon Highway Cost Allocation Study.
   - If one is attributing wear-related costs and a detailed model does not exist, one may choose allocation factors that one expects to vary in proportion to the wear imposed per unit of use by the vehicles in each category. For example, striping costs were allocated according to axle-miles of travel in the most recent Oregon Highway

Cost Allocation Study because it was expected that stripes wear in proportion to the number of axles that pass over them.

2. Capital costs do not vary with the amount of actual use that occurs on new facilities once they are built, although design decisions may take into account expected future use. The decision to add capacity is an investment decision that is driven by the determination that the user benefits of the enhancement exceed its costs. This, in turn, usually is related to congestion levels on existing facilities, since it is relief of this congestion that forms the primary basis for user benefits. The share of efficient fees (which measure the contribution of a vehicle class to existing congestion), whether or not they are actually charged, is the appropriate allocator for capital costs expended to relieve that congestion; in this way, those vehicles responsible for the current congestion “problem” are appropriately charged for its “solution”.

For structures, and, to a lesser extent, roadways, the cost of constructing a facility with a given capacity will vary with the maximum weight and size of vehicles that are expected to use it. Part of the difference in construction cost, however, may be offset by increased useful life for a sturdier structure or roadway. If one is attributing capital costs and the basis for attribution is differences in the size or strength of the structure (and, hence, differences in the cost of the project) imposed by different categories of vehicles, then the incremental approach may be used.

The incremental approach, used by itself, does not take into account the demand that led to the decision to make the capital expenditure, only differences in cost once the decision was made. The incremental approach may be modified to take into account the expected effects on the useful life of a structure, as was done in the allocation of bridge costs in the most recent Oregon Highway Cost Allocation Study.

This perspective leads to the following general observations about choosing allocators:

- If one is attributing capital costs and the basis for attribution is the demand for the capital project imposed by different categories of vehicles, the efficient-fee approach will produce the desired results. The 2001 Oregon Highway Cost Allocation Study demonstrated the effects of using the efficient-fee approach, but the results of that allocation were not relied upon in setting recommended rates.

- If a the cost of building a new facility is higher than it would otherwise be because it is built to accommodate heavier vehicles, the incremental costs should be allocated to the heavier vehicles. Multiple increments may be used. The efficient-fee approach may be combined with the incremental approach by allocating the base increment using the efficient-fee approach.

- All other approaches to capital-cost allocation are theoretically arbitrary and thus inherently second-best. However, other approaches may be selected because of their convenience, despite the lack of a compelling underlying logic.

- One such second-best approach to allocating capacity-enhancing capital costs was used in the three most recent Oregon Highway Cost Allocation studies. Capital costs were allocated in proportion to passenger-car-equivalent vehicle-miles traveled during the peak hour (peak PCE-VMT), which varies in proportion to each vehicle’s contribution to congestion on existing facilities, but does not take into account the relationship between volume and capacity on existing facilities, and assumes that the value of time is equal across all vehicle types, trip types, and vehicle occupancies.

3. If the benefits resulting from an expenditure relate to vehicle use, the cost may be allocated in proportion to the level of benefit. For example, if the occupants of every vehicle passing a safety improvement benefit from reduced risk of death or injury, the cost could be attributed on the basis of occupant-miles traveled, or if occupancy is assumed to be the same across all vehicles, vehicle-miles traveled.
4. Other costs may not vary at all with vehicle use, but still must be allocated to vehicles. If one is attributing costs that do not vary with use, any allocator that seems “fair” may be chosen. In these cases, there is no right allocator to use.

In general, an allocator that varies more closely with costs imposed should be preferred to one that varies less closely. If sufficient data are available, the degree of correlation may be measured. Usually, though, data permitting such a measurement are not available, so one must rely on the expected relationship, based on engineering and economic theory.

In any case, the expected relationship must be strong, i.e., there must be a story behind it that an engineer would believe. A strong statistical correlation is not sufficient as there is no reason to believe that an accidental correlation will persist.

An allocator also must vary with measurable (and measured) attributes of vehicles, such as miles traveled, weight, length, number of axles, or some combination of those.

Implementation of allocation methods—allocation factors

Allocation of pavement expenditures

Pavement costs comprise several work type categories and the costs within those categories are split further for the purpose of allocation. Those work type categories are:

- New Pavements. These are new roads or additional lanes on existing roads. There are separate categories for rigid (concrete) and flexible (asphalt) pavements.
- New Shoulders. These categories (rigid and flexible) have not had any dollars in them recently. The costs of projects that build new roads (including shoulders) have not been separated into the cost of road and the cost of shoulders.
- Pavement and Shoulder Reconstruction. These are existing roads that are torn out and rebuilt, including realignments. There are separate categories for rigid and flexible.
- Pavement and Shoulder Rehabilitation. These are preservation projects, and consist mostly of overlays of more than two inches. Overlays thinner than two inches are considered to be maintenance, rather than preservation. There are separate categories for rigid, flexible, and other, though there have not been dollars in the rigid or other categories recently. When concrete roads are overlaid, they generally are overlaid with asphalt. Other pavements would be gravel or chip seal, and those generally receive only maintenance.
- Studded Tire Damage. This is a special category for cost allocation. Dollars are moved from Pavement and Shoulder Rehabilitation and from Engineering into this category during the cost allocation process.

Most of the deterioration of pavement in travel lanes is due to wear and tear from vehicles. But even if no vehicle used the road, the pavement would eventually need replacement because of deterioration from environmental factors. Pavement outside the travel lanes (e.g., shoulders) deteriorates almost entirely because of environmental factors.

In some past studies, an incremental width-based approach was used in combination with other factors. The theory was that both travel lanes and shoulders needed to be built wider to accommodate trucks. Recent studies have dropped consideration of width because basic vehicles enjoy safety and other benefits from wider lanes and the public likely would not accept narrow lanes on roads intended for high-speed travel. For highways, it is not really the case that but for trucks, lanes would be narrow.

In the 1992 study, new pavements were allocated in two increments. The cost of building a road for basic vehicles only was allocated to all vehicles on VMT (vehicle miles traveled) if rural or PCE-miles (passenger-car equivalent miles) if urban. The difference between what the road actually cost and the cost of a road for basic vehicles only was divided based on width. One foot's worth of cost was allocated to heavy vehicles only on ESAL-miles (equivalent single axle load miles) and the rest was allocated to all vehicles on ESAL-miles. For pavement rehabilitation, costs were divided into increments using percentages that depended on ownership: 30 percent for state-owned roads, 35 percent for county-owned, and 40 percent for city-owned roads were allocated to all vehicles on VMT if rural or PCE-miles if urban. The remainder was allocated to all vehicles on ESAL-miles.

In the 1999 study, the approach used in the 1997 Federal HCAS was applied to Oregon. Pavement costs were allocated using the NAPHCAS (National Pavement Model for Highway Cost Allocation) model developed for the 1997 Federal HCAS by Roger Mingo. Costs were divided into load-related and non-load-related portions based on factors obtained from NAPHCAS. The non-load-related portion of each project was allocated to all vehicles on either VMT or PCE-miles depending on whether the project was determined to be VMT-related or PCE-related. The load-related portion was allocated to all vehicles using cost shares from the NAPHCAS model.

The approach to pavement cost allocation first employed in the 1999 study has been used ever since, with changes to the factors obtained from re-running the NAPHCAS model on new data. In 2002, Roger Mingo updated the NAPHCAS model for Oregon, modifying it to use 2,000-pound weight increments and to use truck configuration definitions that could be directly matched to Oregon special truck weighings data. In recent studies, the portion of costs for preservation projects treated as non-load-related was reduced to account for the fact that only the travel-lane portions of the roadway typically are overlaid.

In the 2007 study, the following dollar amounts were allocated as pavement expenditures:

- New pavement: $181,697,143
- Pavement reconstruction: $76,324,019
- Pavement rehabilitation: $250,968,068
- Studded tire damage: $22,079,291

Allocation of bridge expenditures

Expenditures on bridges have been allocated incrementally in every study since 1992. The details have changed, but the basic approach has remained the same. Various studies have been commissioned to estimate the costs of building sets prototypical bridges that, within each set, are the same as each other except for the heaviest vehicles they can safely carry. The strongest bridge in each set is as strong as bridges that are actually built. Different sets represent different lengths and types of bridges. The ratio of the cost of the weakest bridge, which can carry only basic vehicles, to the cost of the strongest is the basic increment, and that portion of the cost of each actual bridge of that type that is built during the study period is allocated to all vehicles. The ratio of the difference between the second-weakest bridge and the weakest bridge to the cost of the strongest bridge is the second increment and that portion of the cost of actual bridges is allocated to all vehicles that are heavier than basic vehicles, and so on.

Interchanges consist of a bridge and ramps, which usually are built on earth. Their costs have been allocated incrementally, but using different incremental factors that reflect the combination of bridge and ramp costs.

In the 1992 study, expenditures on new bridges were allocated by VMT using the five increments defined in a 1986 study that was updated for 1992. For replacement bridges, the results of that study were altered. Each of the third through fifth increments was increased by 50 percent, and the first two increments were reduced proportionately. Fifty five percent of bridge rehabilitation expenditures were allocated to all vehicles on VMT, 35 percent to heavy vehicles on ESAL-miles, and ten percent to heavy vehicles on VMT. Expenditures on interchanges were allocated incrementally by VMT using the results of a special study of interchange costs.

In the 1999 study, expenditures on new and replacement bridges and on bridge rehabilitation were treated the same as each other and allocated using the increments from the 1992 update of the 1986 study. But expenditures on some bridges were allocated were allocated by VMT and some by PCE-miles. Expenditures on interchanges were allocated in proportion to the allocation of grading, pavement, and general construction expenditures on all other, non-interchange projects.

In the 2001 study, expenditures on new and replacement bridges and on bridge rehabilitation were treated the same as each other and allocated on VMT using the increments from the 1992 update of the 1986 study. Expenditures on interchanges were allocated incrementally by VMT using the results of a special study of interchange costs.

In the 2003 study, bridge-related expenditures were allocated in the same way as in the 2001 study, but a 2002 study of bridge costs was used to define the increments. ODOT engineers updated the interchange increments as well using the results of the new bridge study. A new work category for seismic retrofits was added and expenditures in that category were allocated to all vehicles on VMT.

In the 2005 study, a method was developed to adjust the incremental factors to account for differences in the expected life of a structure resulting from differences in the mixture of weights of vehicles using the bridge. No data were found to parameterize that method, so it was assumed that there would be no difference in expected life and the increments were the same as in the 2003 study.

In the 2007 study, the same increments as in the 2003 and 2005 studies were used, but the allocation of the first increment was based on peak-period, congested PCE miles for those replacement bridges that represented added capacity over the bridge they replaced. Otherwise, allocation was on VMT.

In the 2007 study, the following dollar amounts were allocated as pavement expenditures:

- Basic increment (no new capacity): $199,095,731
- Basic increment (new capacity): $10,240,512
- Over 10,000 increment: $75,482,820
- Over 50,000 increment: $18,444,079
- Over 80,000 increment: $44,995,388

Allocation of other construction expenditures

Other construction expenditures comprise a variety of work type categories:

Preliminary and Construction Engineering. This is the engineering and planning work done on construction projects before they become projects. It also includes planning and preliminary engineering for potential projects that never become actual projects.

In the 1992 study, these expenditures were separated into modernization and preservation. Those classified as modernization were allocated in proportion to the allocation of all other expenditures modernization projects and likewise for preservation. In the 1999 study, all expenditures in this category were allocated to all vehicles in proportion to the allocation of all construction costs. In the 2001 and later studies, expenditures in this category were divided into modernization and preservation based on the ratio of expenditures in categories that can be identified as modernization or preservation. Those assigned to preservation were allocated to all vehicles in proportion to the allocation of construction costs. In 2001, those assigned to modernization were allocated to all vehicles on PCE miles. In the 2003 and subsequent studies, those assigned to modernization were allocated to all vehicles on peak-hour congested-PCE miles.

Right of Way and Utilities. This is the cost of land and access as well as the cost of moving utilities (underground and overhead) out of the way.

In the 1992 study, these expenditures were allocated incrementally by VMT based on roadway width requirements. In the 1999 study, they were allocated to all vehicles based on VMT. In the 2001 and later studies, expenditures in this category were divided into modernization and preservation based on the ratio of expenditures in categories that can be identified as modernization or preservation. Those assigned to preservation were allocated to all vehicles in proportion to the allocation of construction costs and those assigned to modernization were allocated to all vehicles on peak-hour congested-PCE miles.

Grading and Drainage. This is the cost of preparing the land for the project. In most cases, these costs are included among the costs assigned to the overall purpose of the project, rather than accounted for separately.

In the 1992 study, these expenditures were allocated incrementally by VMT based on roadway width requirements. In the 1999 study, 42.2 percent of these expenditures were allocated to all vehicles based on PCE miles and 57.8 percent were allocated to all vehicles on VMT. In the 2001 and subsequent studies, all expenditures in this category were allocated to all vehicles on peak-hour congested-PCE miles.

Roadside Improvements. This is the cost of improvements off to the side of the road, such as signs, light fixtures, or sound walls.

In the 1992 study, and in the 2003 and all subsequent studies, these expenditures were allocated to all vehicles on VMT. In the 1999 study, all expenditures in this category were allocated to all vehicles in proportion to the allocation of all construction costs. In the 2001 study, all expenditures in this category were allocated to all vehicles on peak-hour congested-PCE miles.

Safety Improvements. This is the cost of improvements built for the purpose of enhancing safety.

In the 1992 study, these expenditures were allocated to all vehicles on VMT. In the 1999 study, all expenditures in this category were allocated to all vehicles in proportion to the allocation of all construction costs. In the 2001 and subsequent studies, all expenditures in this category were allocated to all vehicles on peak-hour congested-PCE miles.

Traffic Service Improvements. This is the cost of improvements intended to improve traffic flow. It may include signals, signal synchronization, turn lanes, or ramp meters.

In the 1992 study, these expenditures were allocated to all vehicles on VMT. In the 1999 study, all expenditures in this category were allocated to all vehicles on PCE miles. In the 2001 and subsequent studies, all expenditures in this category were allocated to all vehicles on peak-hour congested-PCE miles.

Other Construction (modernization). This includes any expenditure on construction of new facilities that does not fit into another category.

In the 1992 study, these expenditures were allocated to all vehicles on VMT. In the 1999 study, all expenditures in this category were allocated to all vehicles on PCE miles. In the 2001 study, all expenditures in this category were allocated to all vehicles on peak-hour congested-PCE miles. In the 2003 and subsequent studies, all expenditures in this category were allocated to all vehicles in proportion to the allocation of construction costs.

Other Construction (preservation). This includes any expenditure (beyond maintenance) on extending the useful life of existing facilities that does not fit into another category.

In the 1992 and subsequent studies, these expenditures were allocated to all vehicles on VMT.

Bike/Pedestrian Projects. These are expenditures on projects that serve non-motorized traffic, such as pedestrian overpasses.

In the 1992 and subsequent studies except for 1999, these expenditures were allocated to all vehicles on VMT. Expenditures in this category were not allocated in the 1999 study.

Railroad Safety Projects. These are expenditures on facilities that improve the safety of rail crossings.

In the 1992 and subsequent studies except for 1999, these expenditures were allocated to all vehicles on VMT. Expenditures in this category were not allocated in the 1999 study.

Transit and Rail Support Projects. These are expenditures on highway improvements in support of transit or rail. There were no dollars in this category for the 2007 study.

In the 1992 and 2001 studies, these expenditures were allocated to all vehicles on VMT. Expenditures in this category were not allocated in the 1999 study. In the 2003 and subsequent studies, all expenditures in this category were allocated to all vehicles on peak-hour congested-PCE miles.

Fish and Wildlife Enabling Projects. These are expenditures on projects whose primary purpose is protecting fish or wildlife. Many other projects include costs related to fish, but those costs are not separated out because doing so would require costing the project with and without fish protection and there is no possibility of building it without fish protection, so that costing is not done. This category did not exist before the 2001 study. In the 2001 and subsequent studies, these expenditures were allocated to all vehicles on VMT.

In the 2007 study, the following dollar amounts were allocated as other construction expenditures:

- Preliminary and construction engineering: $214,393,955
- Right of way and utilities: $189,055,241
- Grading and Drainage: $909,919
- Roadside improvements: $7,746,467
- Safety improvements: $6,879,966
- Traffic service improvements: $26,157,299
- Other construction (modernization): $8,503,538
- Other construction (preservation): $1,146,216
- Bike/pedestrian projects: $55,559,735
- Railroad safety: $5,973,524
- Fish and wildlife enabling projects: $4,166,049

Allocation of maintenance expenditures

Surface and shoulder maintenance (rigid, flexible,and other). In the 1992 study, 75 percent of the expenditures on maintaining rigid and flexible pavements were allocated to all vehicles on ESAL miles and 25 percent were allocated to all vehicles on VMT. 37.5 percent of expenditures on maintaining other pavement types were allocated on ESAL miles and 25 percent on VMT. In the 1999 study, all expenditures on maintaining flexible and rigid pavements were allocated to all vehicles on pavement factors. In the 1999 and subsequent studies, all expenditures on maintaining other pavements were allocated to all vehicles on VMT. In the 2001 and subsequent studies, approximately 75 percent (the percentage varies from study to study) of expenditures on maintaining rigid and flexible pavements have been allocated to all vehicles on pavement factors and the remainder has been allocated to all vehicles on VMT.

Drainage facilities maintenance. In the 1992 study, these expenditures were allocated incrementally based on width requirements. In all subsequent studies, they have been allocated to all vehicles on VMT.

Structures maintenance. In the 1992 study, 80 percent of these expenditures were allocated to all vehicles on VMT, 15 percent were allocated to vehicles over 26,000 pounds only on VMT, and five percent were allocated to all vehicles on ESAL miles. In the 1999 study, 46.7 percent were allocated to all vehicles on VMT, 48.3 percent were allocated to all vehicles on PCE miles, and five percent were allocated to all vehicles on pavement factors. In the 2001 and subsequent studies, these expenditures were allocated to all vehicles on VMT.

Roadside items maintenance has been allocated to all vehicles based on VMT since 1992.

Safety items maintenance has been allocated to all vehicles based on VMT since 1992.

Traffic service items maintenance. In the 1992 study, these expenditures were allocated to all vehicles on VMT. In the 1999 study, they were allocated to all vehicles on PCE miles. In the 2001 and subsequent studies, they were allocated to all vehicles on peak-period, congested-PCE miles.

Pavement striping and marking. In the 1992 study, these expenditures were allocated to all vehicles on VMT. In the 1999 study, they were allocated to all vehicles on PCE miles. In the 2001 study, they were allocated to all vehicles on peak-period, congested-PCE miles. In the 2003 and subsequent studies, they were allocated to al vehicles on axle miles. There were no dollars in this maintenance category category in the 2007 study.

Sanding and snow and ice removal. In the 1992 study, these expenditures were allocated incrementally based on width requirements. In the 1999 study, they were allocated to all vehicles on PCE miles. In the 2001 study, they were allocated to all vehicles on peak-period, congested-PCE miles. In the 2003 study, they were allocated to all vehicles using a special “snow” allocation factor that took vehicle width into account. In the 2005 and 2007 studies, they were allocated to all vehicles on VMT.

Extraordinary maintenance has been allocated to all vehicles based on VMT since 1992, except for the 199 study, in which it was allocated in proportion to the allocation of all other maintenance expenditures.

Miscellaneous maintenance has been allocated to all vehicles based on VMT since 1992, except for the 199 study, in which it was allocated in proportion to the allocation of all other maintenance expenditures.

In the 2007 study, the following dollar amounts were allocated as maintenance expenditures:

- Surface and shoulder maintenance: $608,018,770
- Drainage facilities maintenance: $14,523,980
- Structures maintenance: $43,295,339
- Roadside items maintenance: $50,928,963
- Safety items maintenance: $88,278,195

- Traffic service items maintenance: $67,311,313
- Sanding and snow removal: $61,223,470
- Extraordinary maintenance: $18,254,293
- Miscellaneous maintenance: $68,245,547

Allocation of other expenditures

Motor Carrier collection costs. These are expenditures by the Motor Carrier Transportation Division on collecting registration fees, weight-mile taxes, flat-fee taxes, and road use assessment fees. In the 1992 study, these were allocated to all vehicles over 26,000 pounds in proportion to fees paid. In the 1999 and subsequent studies they were allocated to all vehicles over 26,000 pounds on VMT.

Fuel tax collection costs. These are expenditures on collecting fuel taxes. In the 1992 study, these were allocated to all vehicles in proportion to fees paid. In the 1999 and subsequent studies they were allocated to all vehicles under 26,000 pounds on VMT. (A few vehicles that weigh more than 26,000 pounds pay fuel taxes.)

DMV registration fee collection costs (other than trailers). These are expenditures by DMV and Central Services on collecting registration fees. The Motor Carrier Division collects registration fees from the trucks that it regulates and collects apportioned fees from trucks registered in multiple states. Other heavy vehicles register through DMV. These expenditures are allocated to vehicles under 26,000 pounds on VMT.

DMV registration fee collection costs (trailers). These are expenditures by DMV and Central Services on collecting registration fees for trailers. These are divided into fees associated with light trailers, which are allocated to vehicles under 26,000 pounds on VMT, and fees associated with heavy trailers, which are allocated to vehicles over 26,000 pounds on VMT.

DMV title fee collection costs. These are expenditures by DMV and Central Services on collecting title fees. They are estimated for basic and non-basic vehicles separately. Those associated with basic vehicles are allocated entirely to basic vehicles. Those associated with non-basic vehicles are allocated to non-basic vehicles only on VMT.

Other Highway Division. These are expenditures by the Highway Division that do not fall into the categories under construction, engineering, grading and drainage, right of way and utilities, or maintenance. In the 1992 and subsequent studies, they have been allocated to all vehicles on VMT.

Other ODOT. These are expenditures of Highway Fund monies by ODOT that do not fall into any category listed above. In the 1992 and subsequent studies, they have been allocated to all vehicles on VMT. (It may be the case that not all Highway Fund expenditures were allocated in the 1999 study).

In the 2007 study, the following dollar amounts were allocated as other expenditures:

- Motor Carrier collection costs: $63,712,602
- Fuel tax collection costs: $2,833,552
- DMV registration fee collection costs (except trailers): $19,137,884
- DMV registration fee collection costs (light trailers): $3,864,028
- DMV registration fee collection costs (heavy trailers): $146,941
- DMV title fee collection costs (basic vehicles): $50,498,759
- DMV title fee collection costs (non-basic vehicles): $2,519,215
- Other Highway Division: $185,767,359
- Other ODOT: $276,564,757

Issue Paper 6:

HCAS and Climate Change

Issues related to climate change have attracted the attention of policy makers in Oregon and elsewhere. According to the Governor's Climate Change Integration Group, the burning of transportation fuels produces 34 percent of the greenhouse-gas emissions in Oregon, more than any other source. All uses of electricity combined account for 32 percent.

Policies can affect the consumption of transportation fuels through several means. Policies that affect the locations of households, businesses, or transportation facilities can change the distances people and goods travel to get to where they want to go. Policies that affect the mode of transportation that is used, the occupancy of the vehicle, the fuel-efficiency of the vehicle, or the amount of congestion along the way can change the amount of fuel it takes to get a person or thing to where it is going. Policies that affect the choice of fuel can change the net amount of carbon that is emitted per unit of fuel burned. Burning fossil fuels increases the amount of carbon in the atmosphere, whereas burning "renewable" fuels has less effect because as carbon from the fuel produced yesterday is burned today, plants growing today to produce fuel tomorrow are removing carbon from the air at the same rate. Burning hydrogen emits no carbon, but energy is required to produce the hydrogen. Nuclear, hydroelectric, wind, tidal, and solar electricity are produced without carbon emissions, but building and maintaining the generating facilities does involve carbon emissions.

The most economically-efficient policy tool for reducing carbon emissions is pricing. When the prices faced by consumers do not reflect the marginal cost to society, inefficient consumption results. When the costs imposed on others through the consumption of a good or service are included in the price, people will consume the amount that is best for them, at that price, and taken together, everyone's consumption will add up to what is best for everyone. Optimal pricing not only can achieve optimal consumption, but the revenue produced from charging people for the costs they impose on others could be invested in mitigating those costs through carbon sequestration or could be used to compensate those who are harmed.

The problem of congestion can be efficiently addressed by charging road users for the delay costs they impose on others when they use a congested facility. Similarly, the costs imposed on others by emitting carbon into the atmosphere can be efficiently addressed by charging users of carbon-based fuels for those costs. One major difference between congestion and

[1] January 2008. Governor's Climate Change Integration Group. A Framework for Addressing Rapid Climate Change. State of Oregon.

carbon is that it is relatively easy to infer the cost of delay from people's behavior. The cost to society of additional carbon in the air may be estimated only very indirectly through the application of long-run climate models and long chains of assumptions about how changes in climate would affect people, how people would adapt, what the value of any net change would be, and the rate at which the value of future changes are discounted.

Carbon Taxes

Pricing of carbon-related costs is achieved through a carbon tax, which is a tax on the carbon content of fuels. A carbon tax also may tax other industrial and agricultural processes that release carbon into the atmosphere (e.g., cement kilns, bakeries, lumber kilns, or manure lagoons). When costs associated with climate change are included in the price users pay for burning carbon-based fuels, users will adjust their consumption to reflect those costs. If the value to the user of burning an additional gallon of fuel does not exceed the cost, including the cost of climate change, they will refrain from consuming the additional gallon.

A carbon tax can address climate change in at least one of three ways. It will always lead to a direct reduction the amount of greenhouse gasses emitted because, by increasing the price of carbon-based fuels to consumers, less carbon-based fuel will be consumed. How much less depends on sensitivity of demand for fuel to changes in price, which in turn depends on several factors, including the availability of substitutes for the fuel itself and for whatever the fuel is being used to produce (e.g., travel). If revenues from the tax are spent on sequestering carbon, it can further reduce atmospheric carbon levels. Revenues also may be spent on coping with the effects of climate change, to the extent that it occurs.

If the carbon tax is implemented in a revenue-neutral way, as British Columbia's is intended to be (through reductions in personal and business taxes), revenues from the carbon tax would not be available for sequestration or mitigation unless other spending were reduced. If it is not revenue-neutral, there could be additional, indirect and induced effects that would further reduce carbon emissions by reducing the overall level of economic activity. These effects would be the net effect of the reduced private activity and increased government activity. The indirect and induced effects also would result in lower-than-expected revenues from the carbon tax as well as from other taxes on economic activity such as income, excise, and sales taxes. Highway user fees that are imposed on fuels, such as the gas tax and the use-fuel tax, would produce less revenue both from the direct effect of the carbon tax on demand for motor fuels and from the indirect and induced effects on demand for travel.

A gallon of gasoline contains about 2.42 kilograms of carbon (or about 5.34 pounds) and a gallon of diesel contains about 2.78 kilograms. When burned, a gallon of gasoline produces about 8.88 kilograms (19.57 pounds) of carbon dioxide, a greenhouse gas. A carbon tax is applied per unit of carbon (e..g., so many cents per kilogram) and would apply to all carbon-based fuels whether they were burned on highways or elsewhere. For example, a carbon tax of one cent per kilogram would add 2.42 cents to the cost of a gallon of gas and 2.78 cents to the cost of a gallon of diesel and would produce about $55.5 million per year in revenue from highway users alone, at 2008 consumption levels. A tax of ten cents per kilogram would add 24.2 cents to the cost of a gallon of gasoline and would be expected to produce less than ten times as much revenue, because it would be expected to lead to some reduction in consumption.

British Columbia currently intends to implement a carbon tax at a rate of once cent per kilogram of carbon, which will increase to three cents by 2012. Sweden currently imposes a carbon tax of approximately four cents per kilogram of carbon.

The HCAS model could be used to estimate the revenue from a carbon tax, making use of the procedures already built into the model to estimate revenues from fuel taxes. It also could be used to estimate the incidence of the carbon tax on users of highway fuels by weight class. With enhancements, it could estimate the incidence on highway users categorized in other ways as well. Policy analysts in Oregon should be made aware of the relevant data and accounting framework from the model.

Whether a carbon tax would have any additional implications on the revenue side of the model would depend on how the revenues will be spent. If the purpose of a carbon tax is to limit the effects of climate change, revenues from the carbon tax might be spent on some combination of further reducing carbon emissions, sequestering carbon that has already been emitted, or dealing with the effects of climate change resulting from the remaining carbon emissions, up to the point where the benefits of an additional dollar of expenditure equal one dollar. Additional revenues could be used to reduce other taxes or fees, or could be spent in ways that benefit those who paid them. Investments that provide benefits to highway users could be in the category of further reducing carbon emissions. Projects that reduce congestion can result in less fuel used to get people to where they are going and so could be justifiable as appropriate uses of carbon tax revenue. Investments in alternative modes also could reduce both fuel consumption (by those using the alternative mode) and congestion (for those remaining on the highways). Highway users also would enjoy the benefits of reduced travel times if congestion were reduced.

The portion of carbon tax revenues that is spent on congestion relief arguably should be treated as a highway user fee. The expenditures would enter the cost side like any other highway expenditure and the portion of the tax that pays for those expenditures would be attributed as revenue to those vehicles that pay it. Expenditures on mitigation or sequestration that become a part of highway projects (and therefore passed through the highway fund), and the revenues to pay for them, probably also would be included in the HCAS, just as noise abatement is when it is a part of a construction project.

The imposition of a carbon tax could affect the costs of building and maintaining highways as well. The cost of concrete probably would be most affected as large amounts of carbon-based fuels are burned in the manufacture of portland cement, an essential ingredient in concrete, and the process of converting limestone to cement releases large quantities of carbon dioxide from the limestone. A cubic foot of concrete corresponds to the release of 2.23 kilograms into the atmosphere from the manufacture of the portland cement it contains, plus whatever carbon is emitted transporting the materials to the construction site. A carbon tax of one cent per kilogram would add over $2,500 per lane-mile to the cost of a concrete roadway that is 16 inches thick and has 16-foot wide lanes. The effects of carbon taxation of construction costs would depend on the geographic extent to which they would be applied (could the tax on portland cement be avoided if the cement were made somewhere else?), on the scope of carbon-emitting activities to which they would be applied, and on the rate per kilogram of carbon emitted.

Any additional per-unit construction costs resulting from a carbon tax would need to be reflected in the engineering estimates provided to the HCAS by ODOT. Changes in cost could affect the results of the HCAS if they disproportionately affect work type categories that are allocated significantly differently than other work type categories and the dollar amounts involved are large. It is unlikely that effects on the cost allocation side of the HCAS would noticeably affect equity ratios.

Cap and Trade

Cap and trade refers to a permitting process whereby the government sets a cap on consumption of a good, in this case carbon emissions. Each permit is effectively a right to emit a certain amount of carbon into the atmosphere. Once the permits are issued, companies may buy and sell their permits. While one ton of carbon emitted from a paper mill has the same effect on the atmosphere as one ton of carbon emitted from a power plant, the costs of filtering or otherwise reducing carbon emissions may not be the same for the different plants. The marginal abatement cost, or cost of eliminating an additional unit of pollution, will vary for different industries and different companies; it is therefore more efficient to allow companies to trade these rights rather than to set a cap individually on each company. While the government decides the acceptable level of total emissions, a cap and trade system allows the prices set by a free market to determine how the pollution right will be distributed.

Although the theoretical idea behind cap and trade is simple, its administration would be quite complex. Monitoring and enforcement are critical to the success of the system and present an administrative challenge. Additionally, the initial permit allocation methods (permits may be auctioned, allotted, or sold) and cap levels can become a political issue and are often the subject of lobbying efforts that can push the cap above or below its optimal level. There may also be lack of consensus regarding what the optimal level is and therefore where the cap should be set. Theoretically, the optimal level of pollution is that in which the cost to society of an additional unit of pollution is equal to the benefit to society of its production (such as the value of the energy produced from burning fossil fuels). Determining the optimal amount of a carbon tax presents similar challenges.

There is currently no consensus among economists regarding whether cap and trade is more or less efficient than a carbon tax. Both programs address the same objective, but approach the problem from different angles. A carbon tax sets the price of pollution and allows the market to determine the quantity produced at this price. A cap and trade system sets the quantity of pollution and allows the market to determine the price at this quantity. Cap and trade systems may also be made to mimic price instruments through the implementation of a safety valve. In a safety valve system, the maximum (or minimum) permit price is capped. Emitters can purchase permits through either the free market or directly from the government. While difficult to implement, this hybrid system has many advantages, including addressing the possibility of unstable permit prices.

While cap and trade may lower the cost to society of reducing pollution compared to an indiscriminate tax imposed equally on all producers, the implementation, monitoring, and enforcement of a carbon tax is much simpler. The administration and legal costs of cap and trade systems are higher than with a tax, and cap and trade may lead to greater opportunities for corruption and evasion.

The Western Climate Initiative, which includes Oregon, six other western states and three Canadian provinces, is currently developing a cap and trade program to limit green house gas emissions. A final draft of this proposal is due in August 2008. As currently written, the cap and trade system would pertain to Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, all of which are green house gases. The program will cover emissions from electricity generation; combustion at industrial and commercial facilities; residential, commercial and industrial fuel combustion at facilities below the WCI thresholds; industrial process emission sources, including oil and gas process emissions; and transportation fuel combustion from gasoline and diesel.

The precise point of regulation for

transportation fuel combustion is still to be determined. The proposal currently specifies that emissions would be regulated at the terminal rack, final blender, or distributor. By placing the cap at a wholesale or refinery level, emissions from vehicles are guaranteed to remain within the cap but individual consumers do not bear the transaction costs associated with purchasing and trading permits. Rather, the cap and trade regulation results in increased operating costs for fuel producers, and these costs are passed on, at least in part, to the consumer, causing a decrease in fuel consumption.

WCI member jurisdictions have not yet determined how permits will initially be distributed. There has been discussion of allotting seventy-five percent of allowances and auctioning the remaining twenty-five percent. The WIC is currently considering establishing a minimum percentage of allowances that will be subject to auction and then allowing member jurisdictions to make individual decisions regarding the distribution of the remaining permits. WIC expects that a decision on this matter will be made in the fall of 2008.

Effects of Cap and Trade on the OHCAS Process

Each jurisdiction is given a certain number of permits, called a permit allowance. If permits are distributed at auction, member jurisdictions will receive revenue from the auction. The current WCI proposal specifies that a minimum percentage of the value of each jurisdiction's allowance budget be dedicated to purposes such as energy efficiency and renewable energy incentives and achievement; research, development, and deployment of carbon capture and carbon sequestration technology; and promoting emissions reductions and sequestration in agriculture, forestry, and other uncapped sources. The remainder may be distributed as the jurisdiction sees fit, although WIC suggests considering objectives such as reducing the financial impact to low income consumers. Oregon may choose to allocate part of this revenue to the Department of Transportation for use on any number of projects including road maintenance, new road construction, or smart growth efforts.

There is likely to be some decline in gas tax revenue as a result of cap and trade. Cap and trade increases the operating costs of firms, and a large percentage of this cost will be passed on to the consumer. Gasoline and diesel fuel will become more expensive and as a result, consumers will drive less and purchase fewer gallons of gasoline. While there may be a change in the proportion of vehicle classes using the road, resulting from shifting prices of gasoline and diesel, there is no other effect on Oregon's cost allocation process. Cap and trade is a regulatory instrument designed to control the amount of pollution emitted; it is not a tax on motor vehicle fuel. The change in consumer behavior would be similar to any other event causing increased gas prices such as a reduction in oil production due to OPEC supply constraints, adverse weather, refinery/pipeline availability, etc.

Meeting Minutes

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of November 16, 2007 1:00 p.m. to 3:00 p.m.

DAS Executive Building
Conference Room A, 2nd Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members
Dae Baek, Lorna Youngs, Doug Anderson, Tim Morgan, Jon Oshel, Bob Russell, Doug Benzon, Don Negri
Support Staff and Interested Parties
Holly Edwards, Brian Hedman, Ron Chastain, John Merriss, Ellen Crecelius

Welcome, Introductions & Opening Remarks

Holly Edwards opened the meeting at 1:00 p.m. and welcomed the Study Review Team (SRT) members and support staff.

Introductions were made and Dae Baek thanked the SRT members for their participation. Dae indicated that Tom Potiowsky was assuming the position of State Economist in January of 2008 and would be chairing the SRT at that time.

2009 HCAS Progress

Holly indicated that the deadline for responding to the RFP for the study contractor has been extended until November 30, 2007. The SRT will review the responses to the RFP. An orientation on the selection process will be conducted on December 5 for the SRT members. Selection of the contractor will be made by December 14. An SRT meeting will be held December 14 to finalize the decision if more than one response is received.

Review of 2007 Study

John distributed a summary of the results of the 2007 Study, which indicated that the light vehicle/heavy vehicle equity ratios were in relative parity. John gave a brief overview of the input data and modeling underlying the analysis. He also described the purpose of the study: to inform the legislature whether the revenues collected from the various vehicle classes match the costs imposed by each class.

John reviewed the assumptions used in the 2007 Study. He indicated that the current study is not bound by the assumptions and methodology of prior studies.

Tim noted that the numerical precision shown in the results is not indicative of the accuracy of the analysis; i.e., the results are not accurate to two decimal points. John concurred with this assessment.

Potential 2009 Study Issues

John presented a list of potential issues that may be addressed by the SRT in the development of the 2009 HCAS. He indicated the list was for discussion purposes and suggestive only, recognizing that the SRT members may have other issues not on the list that they would like to see addressed. The list included:

- Allocation of basic increment portion of new and replacement bridge expenditures
- Allocation of replacement bridge expenditures
- Assignment of alternative-fee subsidy amount
- Treatment of evasion
- Historical versus prospective analysis period
- Treatment of local government expenditures
- Revenue attribution (to attribute all revenues or just State Highway Fund revenues)
- Use of traditional incremental approach versus an economics-based cost approach
- Treatment of social costs

The contractor and the SRT will determine the final set of issues to be researched no later than the March 2008 SRT meeting.

There was general discussion regarding what information is "required" by the HCAS constitutional and statutory mandates and what additional information may be useful to the legislature if time and budget allow. John noted that several of the items on his list of potential issues fall into the latter category, but said he included them anyway for the sake of discussion.

Ron Chastain described the need to develop a transparent, auditable model that uses commonly available tools and methodologies. The contractor will be directed to develop an Excel version of whatever model is used for the study.

Holly described the contents of the study contractor RFP and distributed a summary of the key RFP requirements.

The work plan for the 2009 Study was distributed. A fully executed contract with the study contractor is expected in early January 2008. SRT meetings will resume in March and occur approximately every six weeks thereafter. The meetings will address HCAS issue resolution, model development, data acquisition, and model results. The draft report is scheduled for December 2008, and a final report is to be produced by January 2009.

The SRT members determined that future meetings will be held from 1:00 p.m. to3:00 p.m. unless there is a reason to deviate from this schedule.

Next Meeting and Meeting Location

The next meeting will be held on December 5 from 1:30 p.m. to 2:00 p.m. in Conference Room B of the DAS Executive Building. The purpose of this meeting will be to receive copies of the study contractor proposals to the RFP and evaluation instructions.

Holly adjourned the meeting at 3:00 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of March 3, 2008 1:30 p.m. to 3:30 p.m.

DAS Executive Building
Conference Room A, 2nd Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Lorna Youngs, Doug Anderson, Tim Morgan, Bob Russell, Doug Benzon, Don Negri, Chris Monsere

Support Staff and Interested Parties

Holly Edwards, Brian Hedman, Ron Chastain, John Merriss, Ellen Crecelius

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:30 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

Tom indicated that this was the kick-off meeting of the actual project now that the contractor had been selected. He emphasized the value that the SRT provides to DAS and the consultant in the development of the Highway Cost Allocation Study. He noted that the group's role is advisory, and that the contractor will determine how to incorporate suggestions. He thanked the SRT members for donating their time to this effort.

The November 16, 2007 meeting minutes were approved.

2009 HCAS Schedule

Carl Batten presented his proposed schedule for the 2009 project:

- Issue papers will be prepared and presented at SRT meetings during April through June
- All papers will be finalized by the end of July
- Data collection occurs through September and is mostly centered toward the end of summer
- Model development and refinement will occur during August and September
- Preliminary results produced by the end of October and draft report by the end of November
- Final results by mid-December with final report by January 9th
- Ongoing support and presentations to the legislature as required

Tom noted that a sub-group had been formed to study the documentation needs for the model. The documentation is intended to allow DAS, ODOT or others to input data and run the model independently.

Allocation Factors

Carl noted that the allocation factors did not change in the 2007 study, although there were some minor changes between the 2003 and 2005 factors.

Carl explained that passenger car equivalence (PCE) referred to the amount of space on a road that a vehicle requires due to size, acceleration and stopping distance. He noted that the PCE values were determined in a 1997 federal study.

Carl noted that the pavement allocation factors were also developed for the 1997 Federal HCAS and that Roger Mingo modified those for use in Oregon. Roger is updating those factors under a current federal contract. Carl intends to have Roger modify his modeling approach to allow integration of the pavement factor calculations with the Oregon HCAS model. It was suggested that Roger test his new model using the old data to determine if the results are consistent. It was also suggested that Roger provide documentation of the model.

Safety issues associated with weighing all trucks on the freeways means that truck weight data is skewed toward non-interstate, rural highways. There is some concern that truck configurations on rural, non-interstate highways are not representative of configurations on the interstates.

Data Collection

Carl indicated that additional special truck weighings will be scheduled for May and June of this year. There was discussion about the possibility of using weigh-in-motion data together with the special weighings data to obtain better information about trucking characteristics.

Carl also noted that more detailed pavement specifications may be available from ODOT's new pavement management system and he will request this data.

Carl distributed a hand-out that describes the various data categories, their source and their use.

It was suggested that Dave Kavanaugh be invited to discuss the transportation revenue forecasts.

There was a discussion about what may be contained in policy option packages and how to incorporate those.

It was noted that the studded tire data was fairly old; however, there probably is insufficient time to conduct a study to incorporate the information in this HCAS.

Carl noted that his approach is to try to use data that is already produced for other purposes rather than create special requests just for the HCAS to minimize cost.

Carl described the model refinements that will be completed as part of the study.

Potential Issue Papers

Carl handed out a suggested list of issue papers. A general discussion on these and other potential issues was held.

It was decided that it would be useful to review the issue of bridge replacement, even though it has been reviewed in prior studies. It would be helpful to have input from ODOT's bridge engineers such as Bert Hartman.

The potential for a carbon tax and its impacts on highway cost allocation was identified as a potential new issue.

It was decided that equity issues were well explored during the 2007 HCAS process and an additional issue paper on the topic was not needed.

It was also decided that funding from local governments was covered in an issue paper during the 2007 HCAS and will not be further researched.

Issues regarding bond-related expenditures were explored and resolved during the 2005 HCAS. Holly will send out an email with the website that contains the prior studies and their associated issue papers for review.

Carl will send out a revised list of issue papers and solicit comments from the SRT via email. The list will be finalized once comments are received. Comments are due April 1.

Discussion of Potential Additions to the SRT

It was noted that Chris Monsere has agreed to participate on the SRT. No further additions are contemplated at this time.

Next Meeting and Meeting Location

Brian will draft a schedule of the remaining meetings for the 2009 HCAS and distribute it for comments.

The next meeting will be held on April 28 from 1:30 p.m. to 3:30 p.m. in Conference Room B of the DAS Executive Building.

Tom adjourned the meeting at 3:47 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of April 28, 2008 1:30 p.m. to 3:30 p.m.

DAS Executive Building
Conference Room B, 2nd Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Doug Anderson, Tim Morgan, Bob Russell, Doug Benzon, Don Negri, Mazen Malik, Jon Oshel, Mike McArthur

Support Staff and Interested Parties

Brian Hedman, Ron Chastain, Ellen Crecelius, Carl Batten, Craig Campbell

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:35 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The March 3, 2008 meeting minutes were approved.

Model Documentation Committee Report

Brian summarized the documentation requirements that the documentation sub-group has established with the assistance of the DAS Information Resources Management Division. The documentation will consist of:

- User documentation that will allow a non-expert to run the model
- Technical documentation that will document the workings of the model such that a modeling expert/programmer can modify the model as necessary
- Assumptions documentation that will document the specific data and assumptions that are used in the final 2009 HCAS

Carbon Impacts Issue Paper

Carl indicated the purpose of the paper was to determine what impacts the state's efforts to address climate change might have on highway cost allocation and whether the highway cost allocation system has information that would be useful to policy makers for climate change mitigation efforts.

British Columbia increased fuel taxes to discourage consumption and offset the increase with a decrease in income taxes. It was noted that Oregon law requires fuel taxes be used for highway purposes, consequently a B.C. approach would not work in Oregon.

It was noted that a carbon tax would tax more than just vehicle fuels.

The addition of a carbon tax without a commensurate reduction in other taxes would provide additional funds that could be used to reduce congestion or otherwise address transportation issues.

There was discussion regarding whether a cap and trade system would have different implications than a carbon tax system. It is believed a cap and trade system would drive the market to the same total fuel cost as a tax that is set at the economically efficient level.

The HCAS model does estimate fuel usage by vehicle class. This information may be useful to Oregon policy makers.

The SRT directed Carl to add some discussion of cap and trade implications and to clarify the distributional versus efficiency issues.

Allocators

Carl noted that the Allocation Methods issue paper is a description of the current allocation methodology. Individual issues, such as the choice of allocators for bridges, will be dealt with in separate issue papers. Issues that are not addressed separately may be identified and added to this paper.

Joe Stowers, who participated in writing the federal HCAS model, was retained in the 1999 Oregon Study to refine the HCAS model.

A question was raised about whether the changes in allocators and their assignment have impacted the HCAS results. Carl noted that only 20 out of the roughly 50 cost categories have significant dollars. Shifts in expenditure amounts between the categories generally have more impact than changes in the allocators.

Data categorization often has a larger impact than changes in the allocators. Currently, the other and maintenance categories are relatively large. Part of the other category is overhead cost that is appropriately allocated on the basis of the underlying work. The SRT directed Carl to explore whether finer detail is available that would allow better categorization of this data.

Next Meeting and Meeting Location

The next meeting will be held on May 23 from 1:30 p.m. to 3:30 p.m. in Conference Room A of the DAS Executive Building.

Tom adjourned the meeting at 2:56 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of May 23, 2008 1:30 p.m. to 3:30 p.m.

DAS Executive Building
Conference Room A, 2nd Floor
155 Cottage Street N.E.

Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Doug Anderson, Bob Russell, Doug Benzon (via phone), Don Negri, Mazen Malik, Jon Oshel, Lorna Youngs

Support Staff and Interested Parties

Brian Hedman, Ron Chastain, Ellen Crecelius, Carl Batten, Craig Campbell, Bert Hartman, John Merriss

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:37 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The April 28, 2008 meeting minutes were approved.

Bridge Issue Paper

Carl presented the draft bridge issue paper. The paper concludes that a “cost occasioned approach” be used to allocate bridge expenditures. The paper does not define “cost occasioned”. Carl is working with the author to provide a definition. Carl believes that the author intends the cost occasioned approach to mirror the federal study methodology that treats replacement bridges on a different basis than new bridges. This would be a change from the current methodology employed in Oregon.

Carl will provide the federal study to the SRT.

Doug Benzon offered to report on what other states have done recently.

The SRT discussed the distinction between structural deficiency and functional obsolescence. Structural deficiency refers to the bridge’s ability to meet its design criteria and carry the vehicle loads or tolerate the speeds for which it was designed. A bridge that is structurally deficient may have to be repaired or replaced immediately or may have to be load-limited to prohibit its use by vehicles over a certain gross weight. Functional obsolescence refers to bridges that still meet their load-related design criteria, but have geometric features (i.e., height, width, alignment, etc.) that are inadequate to handle the volume and/or mix of traffic presently using the bridge. A good example is the I-5 Columbia River bridges.

Currently, the Oregon HCAS treats all replacement bridges, regardless of the reason for the replacement, in the same manner as new bridges. It was noted that many of the bridges being replaced have already exceeded their design life. After further discussion, the SRT recommended no change from the current methodology.

It was also noted that the statement on page 4 of the paper indicating that truck loads and configurations in Oregon differ from most other states and exceed the national weight limit is incorrect. The SRT recommended this statement be clarified.

Data Issue Paper

Carl presented the issue paper regarding data requirements and limitations. The paper details the ideal and current situation by data type and discusses opportunities to improve the data. The SRT discussed several areas.

Local government expenditure data remains difficult to obtain. In the past, a survey has been conducted, but it was found to be expensive and time consuming. John Oshel offered to provide the detail data from the Oregon County Needs Report.

There was a question raised regarding whether forcing the results for the 10,000 to 26,000 pound vehicle group to equity impacted the overall study results. This weight range does not have sufficient data to analyze. Carl indicated that the magnitude of the revenues and expenditures associated with the group were insignificant when compared with the total, so that the assumption of equity for this vehicle group has little impact on the total study results.

The SRT requested that a section on studded tire impacts be added to the paper.

The SRT also suggested that a list of data requirements be prepared and that ODOT and other sources be notified so that the data collection can be incorporated into biennial work plans. It is particularly important the data needs and sources be well documented so that institutional knowledge is not lost when employees change positions. Data requests and fulfillment will be coordinated through John Merriss.

Project Status and Timeline

Carl reported that the project is generally on schedule or ahead of schedule. The next meeting will be to review the last two issue papers (pavement and finance). Final papers will be completed by August 1. Some data is becoming available. Model enhancements are underway. Documentation is being developed as the model is enhanced.

Next Meeting and Meeting Location

The next meeting will be held on June 30 from 1:30 p.m. to 3:30 p.m. in Conference RoomA of the DAS Executive Building.

Tom adjourned the meeting at 3:14 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of June 30, 2008 1:30 p.m. to 3:30 p.m.

DAS Executive Building
Conference Room A, 2nd Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Doug Anderson, Bob Russell, Doug Benzon, Don Negri, Chris Monsere, Art Schlack (for Jon Oshel), Craig Campbell

Support Staff and Interested Parties

Brian Hedman, Ron Chastain, Ellen Crecelius, Carl Batten, John Merriss, Mark Ford

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:35 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The May 23, 2008 meeting minutes were approved.

Pavement Cost Allocation Issue Paper

Carl presented the pavement cost allocation issue paper that was written by Roger Mingo. There was a general consensus that the paper should be expanded to include a fuller discussion of the new pavement cost allocation model and that there should be more specific recommendations about how to use the information from the model in the Oregon process.

The paper indicates that the new model will not be available in time for the 2009 Oregon HCAS.

It was noted Roger Mingo is the sole source for the pavement cost information and that the process for developing and using the NAPCOM pavement cost model is not well documented. Carl noted that NAPCOM is owned by the Federal Highway Administration and as such the model is in the public domain. Roger has freely shared the source code and data inputs. However, the model consists of multiple equations that describe the pavement impacts that are based on engineering estimates and are generally beyond a lay person's ability to review.

NAPCOM has been modified to assist the Oregon process. In particular, the vehicle class weight increments were changed from 5,000 pounds to 2,000 pounds and the model was changed to use truck configurations based on scale data rather than the federally defined configurations.

Finance Issues Paper

Mark Ford presented his finance issues paper. Mark noted that there are no new finance options that will need to be dealt with in the current HCAS, consequently the issues presented are theoretical.

Public/private partnership financing may create issues if projects are undertaken. Revenues are easily attributed, however the private entity costs could be more difficult to assign.

Carbon taxes will also create issues. If the tax is on the fuel itself, it is likely the Oregon Constitution would require that the revenues be used for highway expenditures. For example, the revenues would not be available to purchase carbon offsets. It was noted that a carbon tax would likely be treated as other fuel taxes.

Mark also indicated that moving towards a marginal cost approach would impact cost and revenue attribution. Carl noted that in 2001, the HCAS had a parallel study that added a wear and tear charge and a congestion charge to approximate a marginal cost approach. The results of the parallel study were consistent with the traditional study. Bob noted that other externalities such as air and water pollution were not included in the 2001 parallel study, but are now growing in importance.

There was a discussion on how tolls are established. It was noted that tolls are generally set to optimize revenue, not to relieve congestion or to match marginal costs.

It was also noted that congestion pricing would penalize employees that are not able to shift their work schedules. Some states are beginning to encourage flexible hours to help alleviate congestion. Mark indicated that the Texas Transportation Institute has valuable information on the topic of congestion.

Tom suggested that the paper illustrate the constitutional issues that inhibit alternate funding mechanisms that might address congestion, carbon or other non-traditional highway cost issues.

Project Status and Timeline

Carl reported that the project remains on schedule. The next meeting will be to present the revised drafts of the issue papers.

The following data has been collected:

- Weight-mile tax records
- Flat fee records
- Road use assessment fee records
- Motor carrier registration records
- Highway statistic tables

- Federal fleet report
- Backup data on county needs study
- Pavement management data
- Oregon special weighings data (received 2007 data, 2008 will be in September)
- Weigh-in-motion data is underway, Carl is working with Chris

Data not yet available:

- DMV records, permission has been granted. Data will be available by the end of July
- Local road and street survey is being reviewed by John
- HPMS data is now available, but not yet down loaded
- Budget data is anticipated in late August or early September
- Forecast of VMT and MPG assumptions will be delivered with the budget data

Next Meeting and Meeting Location

The next meeting will be held on August 5 from 1:30 p.m. to 3:30 p.m. in the SFMS Conference Room of the DAS Executive Building.

Tom adjourned the meeting at 3:03 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of August 5, 2008 1:30 p.m. to 3:30 p.m.

DAS Executive Building
SMFS Conference Room
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members
Dae Baek (for Tom Potiowsky), Bob Russell, Doug Benzon, Don Negri, Jon Oshel, Craig Campbell, Lorna Youngs
Support Staff and Interested Parties
Brian Hedman, Ellen Crecelius, Carl Batten, John Merriss, Dave Kavanaugh

Welcome, Introductions & Opening Remarks

Dae Baek opened the meeting at 1:37 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The June 30, 2008 meeting minutes were approved.

Revenue and VMT Forecasting

Dave Kavanaugh distributed a presentation on the revenue forecast modeling methodology.

The model consists of:

- Motor Vehicle Fuels Module
- Weight-Mile and Heavy Vehicles Registration Module
- DMV Module
- Aviation Module (not used for HCAS)

Dr. Kavanaugh discussed each of the modules and the revenue shares of each of the categories. Revenues were forecast to be approximately $1.9 billion at December 2007. DMV represents 23%, large vehicles approximately 30% and motor fuels approximately 46%. On a net basis, after administration costs and transfers to the state highway fund DMV represents about 15%, large vehicles approximately 32% and motor fuels approximately 53%.

Points discussed include:

- Global Insights is the source for fuel price increases and fuel efficiency estimates.

- Revenue growth mirrors growth in overall population.
- Economic activity dominates price effects.
- The 12 month moving average of growth in fuel consumption has been negative since January of 2006.
- The HCAS will be based on the July forecast. Dave will provide forecast once it is public.
- Dave provided an illustration of the model's accuracy. In general the historical accuracy of the model is 1% to 1.5%.

Final Drafts of Issue Papers

Pavement Issue Paper

Roger Mingo is planning to talk with the state pavement engineer to determine whether the pavement wear equations that he has in the model correctly represent the highway construction practices in Oregon. Carl indicated that Roger will be running the model and preparing the inputs for the HCAS analysis in early October.

It was suggested that the model equation specifications be moved to an appendix to the final report to improve readability for the lay audience.

Data Issue Paper

Accepted as final without comment.

Allocation Issue Paper

Accepted as final without comment.

Finance Issue Paper

John Merriss provided Carl with minor edits.

Carbon/Climate Change Issue Paper

A discussion of a cap and trade approach was added to the paper. An impact on highway cost might occur if the approach resulted in modified driver behavior.

Bridges Issue Paper

The SRT recommended adding language that describes why seismic retrofitting is treated separately from other bridge expenditures.

In general, the rest of the paper suffers the same limitation. The paper describes the issue, such as replacement bridges, and the jumps to the recommended cost allocation treatment without addressing why that treatment is recommended. Carl indicated that he would draft language for the paper and submit it to the author for review.

Efficient Pricing Model

Efficient pricing requires additional data not currently available. It was noted that automatic traffic recorders are not currently reliable.

Federal highway planning is considering efficient pricing methodologies.

Carl indicated that he would prepare a summary of the congestion pricing work that he is undertaking in the Seattle area.

There was a recommendation to provide both methodologies during the next HCAS cycle.

Project Status and Timeline

Carl reported that the project remains on schedule with the exception of the DMV data that has not yet been received and remains a concern.

Next Meeting and Meeting Location

The next meeting will be held on September 24 from 1:30 p.m. to 3:30 p.m. in Conference Room B of the DAS Executive Building.

Dae adjourned the meeting at 3:47 p.m.

- Draft -
Oregon Highway Cost Allocation Study Review Team Meeting Minutes of September 24, 2008
1:30 p.m. to 3:30 p.m.

DAS Executive Building
Conference Room B, Second Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members
Tom Potiowsky, Bob Russell, Don Negri, Lorna Youngs, Tim Morgan, Chris Monsere, Mazen Malik
Support Staff and Interested Parties
Brian Hedman, Carl Batten, John Merriss, Sarah Dammen

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:35 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The August 5, 2008 meeting minutes were approved.

Data Gathering

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- Carl indicated that the following data had been received to date:
- Weight-mile tax
- Flat fee
- Road use assessment fee
- Motor Carrier registrations
- Federal highway statistics
- U.S. General Services Agency
- Local Roads and Streets Survey
- Backup to county needs study
- DMV registrations
- HPMS submission
- Oregon Dept of Education school bus mileage report

- Oregon special truck weighings data
- Budgeted project expenditures
- Partially received transit district mileage reports
- Carl noted he was still waiting for:
- Budgeted revenues
- Budgeted non-project expenditures by category

John Merriss arranged a meeting with Dan Porter, Tessa Jantzi, Richard Brock and Stefan Hamlin to discuss whether they can provide a breakdown of the "other" highway division and "other" ODOT expenditures in more detail than available in the past. Additionally, project expenditures may be able to be split into multiple work categories. In the past, the data has only allowed for the assignment of one work category per project.

Carl has also requested the implied number of vehicle miles traveled by light, medium and heavy vehicles and the implied miles per gallon from Dave Kavanaugh's transportation revenue forecast model.

Modeling

Sarah Dammen and Alex Reed have been working to update the model, enter the data, and revamp the input tabs to make them easier to use and meet the requirements the documentation committee outlined. Sarah is also reviewing the internal workings of the model. The 8,000-10,000 pound weight class is being eliminated since the dividing line between light and heavy vehicles is now 10,000 pounds gross weight.

There are no substantive changes to the model. Carl will be working with Mazen to set up the model to more effectively model policy analysis during the legislative session. One example may be variable registration fees based on vehicle mileage.

Carl indicated that the modeling and data gathering are on approximately the same pace as the last iteration.

Efficient Pricing Study

Carl presented an overview of the "Traffic Choices Study" prepared by ECONorthwest and others for the Puget Sound Regional Council. The study investigated the way people respond to price signals for travel on certain roads at certain times. People respond by:

- Changing their mode of transportation
- Chaining trips together
- Changing the time of day of their trips
- Changing their destination
- Changing their route

The study tracked participant behavior via a GPS unit installed in the vehicle. The unit registered tolls for roads that were designated as being toll roads. The unit downloads the data to a remote location for summarization. The summary of the participant trips and tolls incurred were available via the Web. Approximately 270 households and 400 vehicles participated. Participants were randomly selected with adjustments made to assure representation from various areas and people with and without good transit access.

A three-month base period was observed with no tolls. Participants were then endowed with a toll account balance that would allow them to maintain their current driving habits. Tolls were programmed into the GPS units. The participants were able to keep any savings they accrued by changing their traffic patterns.

Results were:

- 18% reduction in VMT on tolled roads
- 12% reduction in overall VMT
- 8% reduction in travel time
- 7% reduction in tours (number of trips)
- ½ of all tolls were generated on 5% of the roads

Results indicated that actual tolls could have a significant impact on congestion and would raise funds approximately six times larger than the current gas tax. GPS-based tolling appears to be a cost-effective method of implementing tolling.

The study suggests that people are three times as likely to change their behavior where transit is available. Targeted expansion of transit service has a larger impact than broader general expansion.

The study also indicated that the value of time does not increase linearly with income.

The benefit/cost ratio of ubiquitous tolling was 6 to 1. The figure for freeway-only tolling was approximately 75% of that for ubiquitous tolling. Area pricing and cordon pricing did not demonstrate significant benefits. HOT lane tolling provided significant benefits, but was substantially more expensive to implement.

Policy Option Packages

Carl indicated that several large policy option packages have been sent to the Governor. Historically, policy option packages have not been included in the study. The question before the review team is how, if at all, to include the policy option packages.

It was noted that several are revenue neutral, i.e. they would not be implemented unless there were associated fee increases to fund the package. Others are shifts from capital to O&M and infrastructure upgrades.

There was a general consensus to exclude the policy option packages from the study due to the uncertainty with their implementation.

Next Meeting and Meeting Location

The next meeting will be held on November 13 from 1:30 p.m. to 3:30 p.m. in Conference Room A of the DAS Executive Building.

Tom adjourned the meeting at 2:49 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of November 13, 2008 1:30 p.m. to 3:30 p.m.

DAS Executive Building
Conference Room A, Second Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Bob Russell, Don Negri, Lorna Youngs, Tim Morgan, Chris Monsere, Mazen Malik, Doug Benzon, Doug Anderson, John Oshel

Support Staff and Interested Parties

Kerstin Rock, Carl Batten, John Merriss, Sarah Dammen, Craig Campbell

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:30 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The September 24, 2008 meeting minutes were approved.

Preliminary results

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Carl presented the preliminary study results. Items of particular note include:

- Overall subsidy-adjusted equity ratios for full-fee paying vehicles are 98% for light vehicles and 103% for heavy vehicles.
- Expenditures by category are consistent between the 2007 study and the 2009 study, with the exception of construction which is up by over $200 million.
- Expenditures by source of funds are also consistent between the 2007 study and the 2009 study, with the exception of local funds which are up $235 million. These may be OTIA funds included as local funds. Carl will get together with Jon Oshel to take another look at these numbers.
- The current economic climate may significantly affect the actual expenditures in the next biennium.
    - Unless there is a new budget prepared, however, it is not possible to quantify and reflect the potential decreases.
    - The state revenue office runs sensitivities.
- The total flat-fee subsidy is one half that of the 2007 study, likely caused by the higher flat fee miles used in the 2009 study.
- It was noted that basic vehicle VMT is estimated based on fuel sales. The majority of non-basic VMT is directly reported via the weight-mile tax.

- The forecasted VMT increase between 2009 and 2010 is dramatic, significantly larger than any of the (actual or forecasted) annual changes between 2003 and 2009.
    - The SRT suggested that the assumptions behind the increase be investigated. In particular, some members noted that heavy vehicle VMT typically recovers at a faster percentage rate than light vehicle VMT as we come out of a recession, which is projected to happen in 2010. The forecast, however, shows just the opposite, with 2010/2009 increases of 4.3% for light vehicle VMT versus only 0.9% for heavy vehicle VMT.
    - The SRT also asked how these VMT increases might affect the equity ratio calculations.
- Carl is checking some of the model inputs:
    - Project expenditure details
    - Bridge package projects
    - Work type assignments
    - New pavement factors from Roger Mingo
    - VMT may change based on Global Insight forecasts

Carl also noted the model is being upgraded to treat the basic increment separately for bridges that are built wider for future traffic.

The next step is the updated results and draft report in December, and then the final results in January. Changes are usually minor between the draft and final results, mostly consisting of error checking and minor input changes.

Model Documentation

Carl discussed the updated model documentation.

- Several input tabs have been revised to accept raw input data in order to reduce pre-processing.
    - The local government expenditures can be copied and pasted directly.
    - The base year VMT are imported directly from ODOT spreadsheets by weight class, tax class and fuel type.
    - Carl distributed a summary of all the raw data sources.
- The goal is to make it easier for an inexperienced user to work from the raw data to the final product.
- There will be three sets of documentation:
    - User guide
    - Technical documentation
    - Structural detail including model code
- Final documentation will be prepared after January when the model and final report are completed.

Report Finalization

A transmittal letter is due to the legislature by the end of January 2009. The final report will be available in February.

Next Meeting and Meeting Location

The next meeting will be held on December 19 from 1:30 p.m. to 3:30 p.m. in the SFMS Conference Room of the DAS Executive Building.

Tom adjourned the meeting at 3:02 p.m.

Oregon Highway Cost Allocation Study Review Team
Meeting Minutes of December 19, 2008
1:30 p.m. to 3:30 p.m.

DAS Executive Building
SFMS Conference Room, First Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Bob Russell, Tim Morgan, Mazen Malik, Doug Anderson, John Oshel

Support Staff and Interested Parties

Brian Hedman, Carl Batten, John Merriss, Sarah Dammen, Dave Kavanaugh

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 1:30 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

The meeting was conducted via conference phone between EcoNorthwest's offices in Portland and the SFMS conference room in Salem due to inclement weather.

The November 13, 2008 meeting minutes were approved as written, however it was noted that the observation in the minutes that heavy vehicle VMT typically recovers at a faster percentage rate than light vehicle VMT as we come out of a recession may be historically true, but may not hold true for the current recession due to its depth and breadth.

Update on data and model

-

Carl updated the SRT regarding the current state of the model and inputs:

- The model is completed.
- All inputs have been entered except for pavement factors which are not yet available.
- The report is being drafted.
- The SRT discussed a contingency plan in the event the pavement factors are not available in time to incorporate in this study.
  - The pavement factors from the last study are an option to use, however there is an expectation that the legislature will address various transportation revenue sources during this session. Consequently, there is

a strong desire to have the most current pavement factors incorporated in the analysis.

Model Documentation

Carl discussed the model updates and documentation.

- Inputs are now designed to be cut-and-paste where possible; SQL code has been developed for voluminous data items.
- Additional documentation has been added to the user interface.
- Automated auditing has been added to the model, e.g. control totals.
- Base year VMT is now directly linked into the model.
- Additional detailed outputs have been developed.
- Costs by allocation factors have been added.
- Detail of distribution of bridge costs to allocation work type has been added.
- Dollar amounts moved from preservation to studded tire repair have been added.
- Details of subsidy calculation showing actual and as-if revenue for each of the alternative fee vehicles will be output.
- Empty log truck adjustment has been moved into the model.
- Model will output what the flat fees would need to be for the base year.
- Carbon accounting tab will be added.

The SRT discussed whether carbon should be included in the report. It was noted that EcoNorthwest was also working on a separate carbon study and it would be important to assure that results and methodologies are consistent between the two studies. For the purpose of this report, the SRT recommended that carbon impacts not be reported, pending completion of the separate carbon study. The HCAS report should include language that indicates carbon impacts are currently being examined and will be included in future studies.

Carl will discuss the issue with Dr. Grover at EcoNorthwest and present the carbon calculations to the SRT at the next meeting.

Discussion of VMT Modeling

Dave Kavanaugh further explained the VMT and revenue forecasting methods used for the study:

- Current forecast based on June 2008 data, which may not be representative of the current conditions.
- Forecast is being updated, but will not be available in time to incorporate in this study.
- The observation that forecasted light vehicle VMT increases substantially between 2009 and 2010 whereas heavy vehicle VMT does not is due to the lag in the timing of shipping as we grow out of the recession. VMT for heavy vehicles shows a

substantial increase in 2011, however the table presented earlier reports VMT only through 2010, the study or forecast year for the present study.

- Dave also noted the model had been consistently over predicting fuel usage into 2008, so an adjustment was made to calibrate the model to current observations for several quarters after which the model is allowed to make the predictions based on the underlying assumptions. Consequently, by 2010 the calibration adjustment is no longer impacting the prediction.
- Dave noted that the model relies on historical data back to 1981 and so encompasses several business cycles.
- The modeling also demonstrates fairly constant light and heavy vehicle VMT shares over time.

Model Documentation

Sarah described the model documentation that is being prepared:

- User guide
    - How to copy from distribution CD.
    - Description of files needed to run and update the model.
    - How to install Python software.
    - Overview of the model, how it works.
    - Structure of Excel workbook and how the tabs relate to one another.
    - Tab by tab explanation of the Excel workbook.
    - Graphical picture of the worksheet with instructions on how to update or create the input data.
    - Data may require processing or transformation within the workbook.
    - Data sources and units will be described.
    - Description of assumptions and calculations used in the model, including valid ranges for assumptions.
    - Instructions on how to update the text based data files, including data source, assumptions and format.
    - Instructions for running the model and debugging any errors.
    - Tab by tab explanation of model outputs.
    - How to audit the model.

- Alternative fee user guide
    - Illustration of alternative rate input worksheet.
    - Summary of current and alternative revenue instruments.
    - Explanation of how the alternative rate instruments work in model.
    - Expected changes due to decrease or increase of alternative rates.
    - Description of the alternative rate output worksheets.
    - Case studies illustrating typical policy alternatives.

It was noted that Python was public domain software that is readily available and currently in use by the State of Oregon.

- Technical Documentation
  - Theoretical Documentation
    - Narrative of model including purpose and methodology, analysis period, prospective view of expenditures, vehicle classes, historical issue papers.
    - Description of VMT calculations.
    - Distribution of VMT by vehicle tax classes and weight classes and VMT growth rates.
    - Discussion of expenditure allocation including funding sources and fungibility of funds and debt financing.
    - Description and choice of allocation factors.
    - Discussion of revenue attribution, including tax avoidance, evasion and alternate fee paying vehicles.
    - Discussion of equity ratios and determining rate recommendations

  - Technical Documentation of Model Structure and Code
    - High-level diagram
    - Visual representation of major model processes (flow charts, etc).
    - Tables of model class objects, methods and functions.
    - Description of programming code.
    - Assumptions/algorithms.
    - Data dictionaries.
    - Glossary.

Carl noted that a new NAPCOM (NAPHCAS) model is being developed by Roger Mingo and will be incorporated in the next HCAS study.

The SRT expressed its appreciation for the thorough nature of the proposed documentation.

Final model documentation will be delivered after the report is finalized and presented to the legislature.

Legislative memo

The legislative memo is due January 31th in accordance with ORS 366.506(4).

Next Meeting and Meeting Location

The next meeting will be held on January 14 from 3:30 p.m. to 5:00 p.m. in the SFMS Conference Room of the DAS Executive Building.

Tom adjourned the meeting at 2:50 p.m.

Oregon Highway Cost Allocation Study Review Team Meeting Minutes of January 14, 2009 3:30 p.m. to 5:00 p.m.

DAS Executive Building
SFMS Conference Room, First Floor
155 Cottage Street N.E.
Salem, Oregon 97301-3966

Attendees: Study Review Team Members

Tom Potiowsky, Bob Russell, Tim Morgan, Mazen Malik, Doug Anderson, John Oshel, Lorna Youngs, Don Negri

Support Staff and Interested Parties

Brian Hedman, Carl Batten, John Merriss, Sarah Dammen, Craig Campbell, Damon Bell

Welcome, Introductions & Opening Remarks

Tom Potiowsky opened the meeting at 3:30 p.m. and welcomed the Study Review Team (SRT) members and support staff. Participants introduced themselves.

It was noted that a memo to the legislature was due on January 31 indicating that the study was complete.

Tom excused himself and introduced Damon Bell to participate in the remainder of the meeting on behalf of DAS.

The minutes from the December 19th meeting were approved.

The SRT discussed including the efficient allocation methodology in the next study. Carl will work with ODOT to determine the availability of data needed for that methodology. The 2011 study will include both the current methodology and the efficient allocation methodology.

Study Results

- Carl presented the study findings and indicated that based on the relative equity between classes the study did not indicate that a change in tax rates was warranted:
- The final results indicate the light vehicle ratio of revenues to costs is 0.9915 and the heavy vehicle ratio is 1.0173, which represents an approximately $4.8 million underpayment by light vehicles and a similar overpayment by heavy vehicles. Carl noted that these amounts are within the error margin of the analysis.
- One factor is the increase in VMT for light vehicles relative to heavy vehicles. Tim Morgan is working with Dave Kavanaugh to better understand the VMT forecast.

Carl noted, however, that both revenues and costs vary positively with VMT, so the relative proportions of VMT don't have a significant impact on the final equity ratios.

- Carl also noted that bridge expenditures were lower in this study and that heavy vehicles are typically allocated a higher share of bridge expenditures.
- The SRT indicated the existing tax rates should be adjusted towards equity only if the rates are being changed for other purposes (e.g., in connection with a transportation funding package).
- It was noted that the revenue office uses the model to analyze potential new revenue packages and that consideration of the impact on equity ratios is considered in that analysis.
- A revised revenue and VMT forecast is anticipated in early 2009. Carl will send out an informational update with the results of the new forecast.
- It was suggested that the number of weight groups included in the results tables be reduced for clarity.

Next Steps

The report will be distributed via email for comments and finalized over the next few weeks.

Mazen will schedule presentations before the House and Senate revenue and transportation committees. These will most likely be joint meetings of the two House committees and of the two Senate committees.

Next Meeting and Meeting Location

There are no additional SRT meetings scheduled for the 2009 HCAS. Carl will present the findings to the House and Senate revenue and transportation committees. SRT members are encouraged to attend the presentations and comment on the SRT process as appropriate.

The meeting was adjourned at 4:40 p.m.

Appendix D

Oregon Highway Cost Allocation Study Model User Guide

Introduction

The 2009 Oregon Highway Cost Allocation Study User Guide describes the steps required to update and run the 2009 version of the Oregon Highway Cost Allocation Study (HCAS) Model. A user should be able to modify the model assumptions and update the input data and then "recalculate" the model with the information in this User Guide, along with instructions in the model tabs. The HCAS Model User Guide is organized as follows:

Section 1 provides a general overview of the HCAS model and describes the model workbook structure.

Section 2 lists the computer system requirements and software necessary to run the model. This section also describes how to copy the HCAS Model folder from the distribution CD to the local computer and lists the contents of the HCAS Model folder.

Section 3 describes the data sets and any data pre-processing required to update the HCAS model.

Section 4 describes the input text files, model workbook tabs and the output text files. Each input file is described in terms of the file contents and the data required to update the input text file. The tab-by-tab explanation of the model displays a screen shot of the model tab, and then describes the contents of the worksheet, how the data on the tab are used in the model, and the process for updating the data and other user-specified assumptions.

In Section 5, the user is guided through the steps to "recalculate" the model and audit the model calculations using the *Audit* tab. This section also contains tips for troubleshooting errors from recalculating the model.

Section 6 is a User Guide for an Alternative Rate Analysis using the HCAS Model. In this section the various revenue instruments of the model are described, along with how alternative rates for each instrument will affect the HCAS model results. The *Alt Rates* tab and Alt Rate output tabs are explained in the same tab-by-tab fashion as the other workbook tabs in Section 4. Three case studies provide step-by-step examples of how to conduct an alternative rates analysis for three different revenue instruments.

Section 1: HCAS Model Overview

The purpose of the Highway Cost Allocation study is to determine whether each class of highway users is paying their fair share. Paying one's fair share is defined as contributing the same share of total revenues as the share of costs that one imposes.

The HCAS model calculates each user class share of costs and then calculates the user class share of revenues to calculate equity ratios for each user class. Equity ratios close to 1.0 indicate that the vehicle class is paying their share of costs. An equity ratio less than one indicates the vehicle class is paying more than their share of costs, and an equity ratio greater than one indicates the vehicle class is paying less than their share of costs.

The HCAS Model, an Excel workbook, is the model user interface for updating data and assumptions used in the model calculations and viewing the output from recalculating the model. The HCAS Model folder contains the HCAS Model workbook and a series of other input text files, supplementary workbooks and the HCAS Module code file. The majority of the model assumptions and data inputs are located in the main HCAS Model user interface. Some data processing and calculations must be performed in either the supplemental workbooks or using database software on the raw data files to produce summarized data tables, which are then pasted into the HCAS Model workbook.

The HCAS Model workbook tabs are oriented from left to right, with the main control tab at the far left, followed by the tabs for the input for the VMT calculations, input for the costs to allocate, revenue input, intermediate output, the auditing tab, summary results, and lastly the report tables. The model tabs are colored to indicate whether the tab contains data or assumptions that can be changed by the user (yellow); alternative rate analysis user input (lavender); intermediate output or tables (light blue); final results (dark blue); or alternative rate analysis results (dark purple).

To update and run the model the user edits the model data and parameters as needed and clicks a "recalculate" button to run the model program. "Recalculating" the model will call up the HCAS Module program code which will read in the data from the HCAS Model workbook and the input text files. Using this data, the HCAS program will perform the VMT calculations, the cost allocation, the revenue attribution and the alternative rates revenue attribution calculations. Once the calculations have been performed the HCAS module will generate a set of output text files in the HCAS Model folder and will populate the output in the model output tabs with the new results.

The instructions and content provided in this user guide are best followed in the order given; steps where no modifications are needed can be skipped.

Section 2: Initial Set-Up

Section 2 describes the computer system and software requirements to update and run the HCAS Model; how to copy the HCAS Model folder from the HCAS distribution CD; and the contents of the HCAS Model folder.

System Requirements and Software, Settings

The HCAS Model can be updated and run using standard computer software and available open-source programming software.

System Requirements To run the HCAS Model, the user must open the HCAS Model in Excel 2003 on a computer with Windows Operating System.

Excel The HCAS Model is an Excel workbook, which can be run using Microsoft Office Excel 2003. The Excel security options must be set to enable macros.

Python Python is an open-source, object-oriented programming language. The user must download and install the (free) Python software maintained by the Python Software Foundation.[1]

Text Editor A text editor or Excel can be used to view the input and output files.

Database Software Pre-processing of some of the original data files must be done outside of the HCAS model due to the size of the data sets or the type of data tabulations. The pre-processing may be done using desktop database software such as PostgreSQL or Microsoft Access. PostgreSQL is an open-source object-relational database management system (DBMS), which supports SQL programming language.

Table 1: Files in the HCAS Model Folder

File Name	File Type	File Use
HCAS Model	Excel	Model User Interface
Flat Fee Axle	Excel	Supplemental Excel workbook
Base VMT	Excel	Supplemental Excel workbook
PE and ROW	Excel	Supplemental Excel workbook
HCASModule	Python	Python model code
AxleShares	Text	Input text file
BasicSharePeak	Text	Input text file
Bonds2003-2005	Text	Input text file
Bonds2005-2007	Text	Input text file
Bonds2007-2009	Text	Input text file
declared_pave_factors	Text	Input text file
DeclaredOperating	Text	Input text file
DeclaredRegistered	Text	Input text file
paveFactors	Text	Input text file
PCEFactors	Text	Input text file
SeedData	Text	Input text file
SimpleFactors	Text	Input text file
allocatedCosts_bond	Text	Output text file
allocatedCosts_federal	Text	Output text file
allocatedCosts_local-federal	Text	Output text file
allocatedCosts_local-other	Text	Output text file
allocatedCosts_local-state	Text	Output text file
allocatedCosts_other	Text	Output text file
allocatedCosts_state	Text	Output text file
Bonds2009-2011	Text	Output text file
flat_fee_report	Text	Output text file
missing_pavement_factors	Text	Output text file
VMTMaster	Text	Output text file

Copy the HCAS Model folder from the distribution CD

Insert the HCAS distribution CD into the computer CD disk drive. Open the *My Computer* window to view the HCAS distribution CD contents. Click and copy the HCAS Model folder (and all of the folder contents) to the local computer.

Contents of Model Folder

There are three types of files in the HCAS Model folder: Excel files, text files and a Python file. The HCAS Model user interface is an Excel workbook. The HCASModule.py is a Python file, containing the model code that performs the model calculations. In addition to the input and model output data in the HCAS Model Excel workbook, the HCAS Module reads in a set of input data files in ".txt" (text) format and will produce output text files. Also included in the HCAS Model folder are supplemental Excel workbooks containing data and calculations performed outside of the Excel model workbook. Table 1 lists the files in the HCAS Model folder on the HCAS Model distribution CD.

Section 3: HCAS Model Data and Pre-processing of Data for Model

This section describes the original data files and the data sources required to update the HCAS model. Many of these data files are obtained from sources within the Oregon Department of Transportation and are produced or adapted specifically for the Oregon Highway Cost Allocation Study. For each data set, the data files, source for the data and any pre-processing of the data outside of the model is described. The SQL code corresponding to the pre-processing of the data for the 2009 HCAS can be found in Appendix F.

[1] Python can be downloaded from: http://www.python.org/download. The Python Software Foundation website also contains documentation and other related material. The user should consult the Python documentation for additional information on how to install the program and open the Python editor.

Special Weighings Data

Source: ODOT

Special Weighings studies are data collected at weigh stations on special days when every truck is weighed. Normally, empty trucks do not need to be weighed. The Special Weighings data has accumulated from prior studies plus additional studies are completed each year.

The special weighings data are used to create the table of the declared weight to operating weight for the *DecalredOperating* input text file.

Pre-processing of Special Weighings Data

New special weighings data get some additional columns added, which are calculated from the columns in the original data, and are appended to data from prior special weighings. From the special weighings, we calculate distributions of operating weight for each declared weight and distributions of vehicle configurations for each operating weight.

HPMS Data

Source: ODOT

The Highway Performance Monitoring System (HPMS) is a federal program that collects data from each state each year. Over the years, the number of data elements that must be reported has been reduced, but the data still are extremely useful in highway cost allocation and in developing pavement factors.

Processing of HPMS Data

The entire HPMS data set is an input file for the NAPCAS model. It uses fields that describe the pavement characteristics, base, soil type, and climate zone. The HPMS data also are used in the process of estimating distributions of VMT by functional class and ownership in the *VMT by FC* tab (VMT by FC is the vehicle miles traveled (VMT) by the facility class (FC) where each facility class is defined by a functional class and ownership).

To perform the data tabulation of the HPMS data for the *VMT by FC* tab, divide the HPMS section AADT by the section length (after converting the section length from kilometers to miles) to calculate the section VMT. Since HPMS is a sample, each section VMT is expanded by the section weight to estimate the VMT by functional class and ownership statewide. A summary table of VMT by functional system and ownership is tabulated and then pasted into the *VMT by FC* tab such that the rows are the functional system and the column headings are ownership and the cell entries are the sum of VMT.

FHWA *Highway Statistics Data*

Source: Office of Highway Policy Information, Federal Highway Administration http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.cfm

The Federal Highway Administration (FHWA) publishes an annual report called *Highway Statistics*. Data from tables VM-1 and MV-2 from the *Highway Statistics* are used in the HCAS model for the base year VMT and *VMT by FC*. The Oregon row from table VM-2 'Functional Travel System Travel-2007 (Year) 1/Annual Vehicle-Miles' is pasted into the *VMT by FC* tab. The Oregon row from Table MV-7 'Publicly Owned Vehicles-2007' is used in the Federal tab in the Base VMT workbook. FHWA usually begins to release tables and chapters from the *Highway Statistics* in late Fall or Winter of the following year. The *2007 Highway Statistics* became available in December 2008. Use the *Highway Statistics* report corresponding to the study base year.

The appropriate rows from these tables should be pasted into the yellow-shaded cells in HCAS Model and Base VMT workbook tabs where indicated. No pre-processing of this data is required.

Federal Fleet Report, General Services Administration (GSA)

Source: U.S. General Services Administration, www.gsa.gov/vehiclepolicy

The *Federal Fleet Report* is an annual publication produced by the U.S. General Services Administration. The *Federal Fleet Report* provides data on the number of federal vehicles and vehicle miles traveled by vehicle type and department or agency. These data are used in the Base VMT workbook as part of the federal vehicle class VMT calculations. The tables from the Federal Fleet Report used in the study are: 'Table 2-5 Passenger Vehicles', 'Table 2-6 Trucks* and Other Vehicles', and 'Table 4-2: Average Miles Per Vehicle'.

The *Federal* tab in the Base VMT workbook lists the tables and rows from the *Federal Fleet Report* that should be pasted into the yellow-shaded cells on the tab. No pre-processing of this data is required.

Transit VMT Data

Source: Tri-Met, Lane Transit District, Salem-Keizer Charriots Transit District.

Update the transit bus VMT on the *Transit* tab in the Base VMT workbook with VMT information from the three largest transit agencies in Oregon: Tri-Met, Lane Transit District, and Salem Keizer Charriots. Call each transit district to request information on the total calendar year VMT for buses by bus weight class for the base year. Enter this data directly into the yellow-shaded *Transit* tab.

VMT Estimates and Forecast

Source: Financial and Economics Analysis Unit, ODOT Financial Service Branch.

The Financial and Economic Analysis Unit of ODOT's Financial Services Branch produces VMT estimates for use in its estimation of revenues for budgeting. These become available at the same time as the Agency Request Budget, which has been at the end of August.

The ODOT VMT estimates and forecast are used to determine the base year to model year VMT growth rate for light, medium-heavy and heavy vehicle groups. The data do not require pre-processing and should be pasted into the yellow-shaded cells on the *VMT Growth* tab so that the new base year and forecast year match the base year and forecast year labels to the left of the yellow-shaded 'Year' cells.

The base year VMT from the ODOT forecast are also pasted into the *Intermediate Base VMT* tab in the Base VMT workbook for the control total VMT for the basic and medium-heavy vehicle classes.

VMT Growth rates for heavy vehicle classes: In past studies an ODOT expert familiar with heavy vehicles in Oregon has made adjustments to the VMT Growth rates for the heavy vehicles (26,001 and up) such that the total heavy vehicle VMT growth rate matches the group VMT growth rate from the ODOT forecast, however allows for variation across weight classes within the heavy vehicles. Small modifications in the VMT growth rates for the 78,001 and the 104,001 vehicle groups will have the greatest impact on the total heavy vehicle group VMT growth rate since a majority of the heavy vehicle VMT are in these two weight classes. The heavy vehicle class growth rates should not be requested/adjusted until the Base VMT workbook has been completely updated and the HCAS Model workbook link to the Base VMT workbook data has been updated since the group growth rate will depend on the VMT at each individual weight class.

Motor Carrier Data

The Motor Carrier Transportation Division (MCTD) of ODOT produces data on truck registrations, weigh-mile tax collections, and flat-fee collections. These data are cleaned and consolidated into a set of reports called Highway Use Statistics. We have used the cleaned, unconsolidated data.[2]

[2] Weight class and axle class are two important variables used in the HCAS model for defining vehicle classes. HCAS weight classes are shown in the *Codes* tab in the model. Basic vehicles are those vehicles weighing under 10,001 pounds. For vehicles from 10,001 up to 200,001 pounds, weight classes are defined in 2,000 pound increments, (e.g. 10,001, 12,001, 14,001…80,001, 82,001…200,001). The vehicle weight recorded in the original data source is used to assign the record to a HCAS weight class. For a weight recorded in pounds, subtract one

Motor Carrier Registrations Data

Source: Motor Carrier Transportation Division, ODOT

The Motor Carrier Registrations data are used to develop distributions of registered weights by declared weights for the *declaredRegistered* input text file. For each declared weight category, the *declaredRegistered* input file contains the share of vehicle registrations at a registered weight.

Pre-processing of the Motor Carrier Registrations Data

The Motor Carrier Registrations data are pre-processed using SQL in PostgreSQL. The share of vehicle registrations for the distribution of registered weights for each declared weight is calculated from the count of registrations. The final processed table for the *declaredRegistered* input file contains the declared weight, the registered weight and the share of registrations at that declared weight.

Flat Fee Collections Reports

Source: Motor Carrier Transportation Division, ODOT

The Flat Fee Report data are used in the Flat Fee VMT Axle supplemental workbook to calculate the Flat Fee VMT for the Base VMT workbook and to estimate VMT per Month and Axle Shares for the *Revenue* tab in the HCAS Model.

Pre-processing of the Flat Fee Collections Reports

The Flat Fee Collections Reports are processed in the Flat Fee VMT Axle workbook. The Flat Fee data are pasted into the Flat Fee Reports tab into the yellow-shaded cells. Additional variables are created from the Flat Fee Collection reports and a series of tables are created from this data. See the instructions for the Flat Fee VMT Axle supplemental workbook for the full description of the processing.

WMT Collections

Source: Motor Carrier Transportation Division, ODOT

The WMT Collections (or WMT payments) reports are pre-processed and then used in the Base VMT workbook to determine the VMT for the various WMT vehicle classes.

Processing of the WMT Collections Reports

The size of the weight mile tax (WMT) collections report data set requires that the data pre-processing take place outside of the HCAS Model. The SQL code for the pre-processing of the WMT data for the 2009 HCAS is provided in Appendix F. The SQL code assigns the records to a weight class and axle class using the HCAS weight class and axle classes, and the sums the miles traveled from the WMT Collections report for each weight and axle class. This summary table is then pasted into the *WMT* tab in the Base VMT workbook.

Road Use Assessment Fee (RUAF) Data

Source: Motor Carrier Transportation Division, ODOT

The Road Use Assessment Fee data are the records from the vehicles paying the RUAF at weight class 96,001 and above. Each RUAF record contains an id number, Issue Date, Axles, Weight, Miles, and Tax. The RUAF data are used to determine the VMT by RUAF vehicles by weight and axle class in the *Base VMT* workbook.

The RUAF data do not require any pre-processing. Paste the RUAF data directly

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from the entered weight, divide by 2000, truncate or round to the decimal point, then multiply by 2000 and add one. Or Trun((Weight-1)/2000)*2000 + 1 in SQL or Round((Weight-1)/2000,0)*2000+1 in Excel.

Axle class is assigned for weight classes 80,001 pounds and up. The HCAS axle class is either a zero, five, six, seven, eight or nine (plus). If the weight class is under 80,001 then axle class is zero. For 80,001 and above, a record with five or fewer reported axles is assigned to axle class five, nine or more axles are assigned to axle class nine. If the reported axle count is six, seven, or eight then the axle class is set equal to the reported number of axles.

into the yellow-shaded cells on the *RUAF* tab in the Base VMT workbook. Make sure the Weight Class and Axle Class formulas assign a valid weight class and axle class to all of the RUAF records (columns G and H in the *RUAF* tab).

Local Government Revenues and Expenditures

Source: ODOT conducted Local Roads and Streets Survey (LRSS)

Prior-fiscal-year revenues and expenditures by local governments come from the Local Roads and Streets Survey compiled by ODOT.

The processing of local government data has evolved significantly in each of the last three studies. For the 2009 study, the local cost approach and calculations have been formalized and incorporated into the model in the *Local Costs* tab. Paste the LRSS data into the *Local Costs* tab and the raw data on base year expenditures to the estimates of future expenditures by work type and funding source.

Budgeted Non-Project Expenditures

Source: ODOT Agency Request Budget

Budgeted non-project expenditures come from spreadsheets used to develop the Agency Request Budget are required to update the *Non-Project Costs* tab. These data are available around the end of August and are completed by ODOT Finance Section. The Highway Programs Office provides the breakdown of non-project maintenance costs by maintenance work type. The Non-Project Expenditure data are pasted into the *Non-Project Costs* tab, no pre-processing is required.

Project Expenditures

Source: Various analysts, ODOT Financial Services

Project cost information is collected from several sources. The ODOT Cash Flow Projection system tracks expenditures by work category for each project for each month. Upon request, project expenditure files are produced containing data for all projects with expected expenditures in the upcoming biennium. ODOT Finance then matches these projects to the Project Control System (PCS) to obtain additional data about the nature of the projects, particularly the project funding sources and project work types. For bridge projects additional research is conducted using information in the PCS files, the Oregon Bridge Log, or correspondences with ODOT bridge section staff to determine relevant characteristics of the bridges involved so that the expenditures may be assigned to bridge types. Expenditures on different bridge types are allocated using different factors. The project expenditures data are requested when the Agency Request Budget data become available so that the project data are consistent with the budget, around the end of August, or early September.

Processing of Project Expenditure Data

Given the number of different sources, some in non-standardized formats, used to create the project expenditures input data, no formalized method for processing and developing the project costs table exists. The general steps for processing and creating the project expenditures table are the following:

1. Identify projects with expenditures during the study period from Cash Flow Projections
2. Assign a functional class to the project using information in the Project Control System
3. Determine the share of project funding from each funding source
4. Determine the project HCAS work type(s) using the project information and/or the ODOT specified work types
5. If the project has more than one work type, determine the share of project expenditures by work type
6. For each bridge project work type, assign bridge type

Using the list of projects in the Cash Flow Projection and Project Control

System (PCS), create a list of projects with expenditures in the study period.

Assign a functional class to each project. If a functional class is included in the project location information, validate that the functional system is a valid FHWA functional system or HCAS facility class. Projects are assigned a functional class based on the project funding sources if functional class is not provided. Functional system of zero is the default for unknown functional system.

For each project, determine the share of project expenditures by funding source. The project expenditure shares by funding source reflect the total project funding, not necessarily the expenditures during the stud period. The shares or dollar amounts by funding source are provided in the Project Control System data. Funding source should be entered as: federal, state, bond, or other. Make sure the funding source is spelled correctly and is not capitalized.

Use the PCS project work type(s) and project description (SXYR Work Description) to assign HCAS work type(s) to the project. The project may have up to three work types. ODOT may already have listed three project work types and the work type funding shares in PCS. The analyst should review the ODOT assigned work types and then assign the appropriate HCAS work type. The share of total project costs associated with each work type must be entered when multiple work types are assigned. Only assign multiple work types when the share of total project cost can be identified for each work type.

Bridge types are assigned to all projects. If the project is not a bridge project, then the bridge type can be entered as zero; zero is also used when the bridge type is unknown. The bridge length and number of spans determine the bride type. When multiple bridge types are being built or replaced in a single project, the bridge types may be entered separately, as if they were different work types, but using the same work type code. For example, if a project is a bridge bundle project replacing a single span bridge and a multi-span bridge the bridge replacement work type would be assigned twice to the project, once for the single span bridge type and once for the multi-span bridge type. Again, the project can only have up to three work type/ bridge type combos and the share of total project funding must be identified for each work type/bridge type when broken out separately. The list of work types and the list of bridge types are located in the *Codes* tab.

The bridge length and spans may be reported in the PCS files, or the Bridge number can be used to look up the bridge characteristics in the Oregon Bridge Log. The Oregon Bridge Log[3] will likely display the former bridge type in the case of bridge replacements. If the project is a bridge replacement, it may be necessary to contact the ODOT Bridge Section to find out information on the new bridge type.

For the 2009 HCAS, the project expenditure file was first created by working in a file where each project was a single record with columns for each of the funding sources, funding source project cost share, functional class, work types, work type project cost share, bridge types and total project amount. Once all of the funding source, work type and bridge type data are entered make sure that all of the entered data are valid and that the funding source and work type shares sum to 100 percent. Also make sure that the project expenditure is positive. The project expenditure data are then used to create the table of project expenditures by funding source and work type for the *Project Costs* tab. Since a project may have up to four funding sources and up to three

[3] The Oregon Bridge Log is an annual ODOT publication. The Oregon Bridge Log does not contain information on covered bridges. Most covered bridge projects are maintenance projects (on the covered structure); most covered bridges are single spans less than 125 ft.

work types each single project can potentially be turned into twelve separate entries in the *Project Costs* table. Paste in the final project costs table into the *Project Costs* tab using the format shown in Table 2.

Table 2 Example of a Project With Multiple Work Types and Funding Sources Entered in the Project Costs tab

Funding	Work Type	Functional Class	Bridge Type	Dollars	Key Number
state	11	0	0	1,194,517	15740
state	22	0	0	95,018	15740
state	21	0	0	67,870	15740
federal	11	0	0	10,597,355	15740
federal	22	0	0	842,971	15740
federal	21	0	0	602,122	15740

Table 2 displays an example of the *Project Costs* tab entries for a project that has two funding sources (state and federal) and three work types (11, 21, and 22). 'Dollars' is produced by multiplying the total project expenditures in the biennium by the fund source share and work source share. Key number is included for project identification; the key number is not read into the model.

Budgeted Revenue Control Totals

Source: Financial and Economics Analysis Unit, ODOT Financial Services Branch

Budgeted revenue control totals come from spreadsheets used to develop the Agency Request Budget by the Financial and Economics Analysis Unit of the ODOT Financial Services Branch. These data are usually available at the end of August before the upcoming biennium.

The data in the Revenue Forecast worksheet are pasted into the yellow-shaded cells on the *Rev Forecast* tab in the HCAS workbook; no pre-processing of the data is required. Gross revenue amount by revenue source is linked to the appropriate revenue control on the *Revenues* tab.

Current-Law Tax Rates and Fee Schedules

Source: Oregon Revised Statues, or the ODOT DMV and MCTD websites.

Current-law fuel tax rates, WMT rates, registration and title fees and other vehicle and road use related fees may be obtained from Oregon Revised Statutes and Oregon Administrative Rules. The rates and fee schedules can also be found at the ODOT Department of Motor Vehicles (DMV) and Motor Carrier Transportation Division (MCTD) websites.

Rates must be converted to the proper unit for each revenue instrument, otherwise no calculations or processing is required. Update the current tax rates if changes have been made in the Oregon Revised Statues.

Estimated Average Basic-Vehicle Miles per Gallon

Source: Financial and Economics Analysis Unit, Financial Service Branch, ODOT

The ODOT revenue forecast and budget-development process incorporates assumptions about fuel consumption per mile that are developed from data from Global Insight and other sources. These fuel consumption assumptions are used to inform the user choice of parameters on the *Gas and Diesel* tab in the model. While the fuel consumption per mile assumptions provided by ODOT are not direct inputs into the model, the user specified assumptions regarding the implied MPG on the *Gas and Diesel* tab should be generally consistent with the assumptions made by the ODOT Chief Economist.

DMV Vehicle Registrations

Source: Department of Motor Vehicles, Request made by ODOT Financial Services

The DMV Registrations data are used to build the estimates of VMT by weight class by tax class for the base year for certain vehicle tax classes. For the 2009 HCAS, ODOT Financial Services was granted permission to obtain de-identified registration records from DMV.

Processing of the DMV Registrations Data

Due to the size of the DMV Registrations data, pre-processing of the registrations takes place outside of the HCAS Model. The SQL code used to process the DMV data for the 2009 HCAS can be found in Appendix F.

Two summary tables created from the DMV Registrations are used to update the model: a summary table of motor home registrations by vehicle length; and a summary table of vehicle registrations by fuel type and weight class for the following vehicle tax classes: Commercial Trucks (10,001 to 26,000 pounds), Tow Trucks, Farm Vehicles, Charitable Non-profit, E-Plate, and School Buses.

Motor home registrations data do not necessarily include vehicle weight, so motor home registrations are tabulated by vehicle length and then assigned a HCAS weight class using vehicle length. The motor home registrations summary table is pasted into the *MotorHomes* tab in the Base VMT workbook. The motor home registration summary table has the following columns: motor home plate indicator ('HC'), vehicle length and sum of registrations (by vehicle length).

For the main DVM summary table, weight class is assigned to each registration record by converting the registered vehicle weight to the standard HCAS weight class. A fuel type variable is also created from the DMV fuel variable to identify whether the vehicle is gasoline-powered or non-gasoline powered (gasoline-powered vehicles corresponded with fuel code 1 or 5 in the 2007 DMV Registrations data, fuel type 6 was excluded for the registrations data).

The license plate string is used to identify the vehicle tax classes using the plate vehicle class designations. Table 3 lists the plate identifiers for the vehicle tax classes included in summary DMV table created for the *DMV* tab in the Base VMT workbook.

Table 3 HCAS Vehicle Classes by DMV Plate Identifier

Plate Identifier	Vehicle Class
B	Bus
CH	Charitable/non-profit
E	Exempt (E-Plate)
F	Farm
HF	Heavy fixed-load (e.g. backhoes)
HS	Heavy trailer (over 8,000 lbs)
PF	Permanent fleet
SC	School bus
TW	Tow truck
T	Truck

Pavement Factors

Source: RD Mingo & Associates

RD Mingo and Associates produce the Oregon specific pavement factors using the Oregon HPMS submittal data in the National Pavement Costs Model (NAPCOM). The pavement factors are used to update the *PavementFactors* text file and to update the pavement allocators on the *Policy* tab. Minimal processing of the pavement factors data may be necessary to get the pavement factors into the correct format for the *PavementFactors* input text file.

Section 4: HCAS Model, Input Files and Output Files

Input Text Files

This section describes the input text files used to recalculate the model. The user may update some of the input text files, however some files are carried forward to future studies without modification. Each input text file is listed below, followed by a description of how the file is used, the file contents, and how to update the file. See Appendix E for more information on the input and output text files.

Bonds2003-2005.txt

This file contains the prior allocated bonds from the 2003 HCAS. The prior allocated bonds are read into the model and used in the class method that performs the bond cost allocation calculations. The file contents are the prior allocated bond expenditures (dollars), by weight class and axles. This file is not updated.

Bonds2005-2007.txt

This file contains the prior allocated bonds from the 2005 HCAS. The prior allocated bonds are read into the model and used in the class method that performs the bond cost allocation calculations. The file contents are the prior allocated bond expenditures (dollars) by weight class and axles. This file is not updated.

Bonds2007-2009.txt

This file contains the prior allocated bonds from the 2005 HCAS. The prior allocated bonds are read into the model and used in the class method that performs the bond cost allocation calculations. The file contents are the prior allocated bond expenditures (dollars) by weight class and axles. This file is not updated.

DeclaredOperating.txt

This file contains a distribution of operating weights for each declared weight and the share of vehicles within each operating weight created from the Special Weighings data. The DeclaredOperating data are used to build the pavement factors for each row of the VMT data in the VMT calculations of the Model.

DeclaredRegistered.txt

This file contains a distribution of registered weights for each declared weight and the share of vehicles within each registered weight created from the Motor Carrier Registrations data. The DeclaredRegistered data are used to attribute registration and title fee revenues.

paveFactors.txt

This file contains the responsibility shares for flexible and rigid pavement costs by weight class and number of axles. This file is produced by Roger Mingo using the HPMS submission data in the National Pavement Cost Model (NAPCOM) model.

PCEFactors.txt

The *PCEFactors* file contains the passenger-car equivalents (by weight class and number of axles) on regular, uphill, and congested roadways. This file is not updated.

SeedData.txt

The *SeedData* file contains VMT by weight class, functional class, ownership, and number of axles. (This file essentially contains proportions that guide the model as it fits data for the VMT master table.) This file is not updated.

SimpleFactors.txt

This text file contains vectors of ones and zeros that help the model select the appropriate VMT for cost allocation. For example, for a cost allocated on Over 106,000 lb. VMT the model will isolate the proper VMT records by applying a simple factor. In this case, a vector containing zeros for all weight classes except those above 106,000 lbs is applied to the VMT master. This file does not need to be updated for new studies unless the allocators are changed.

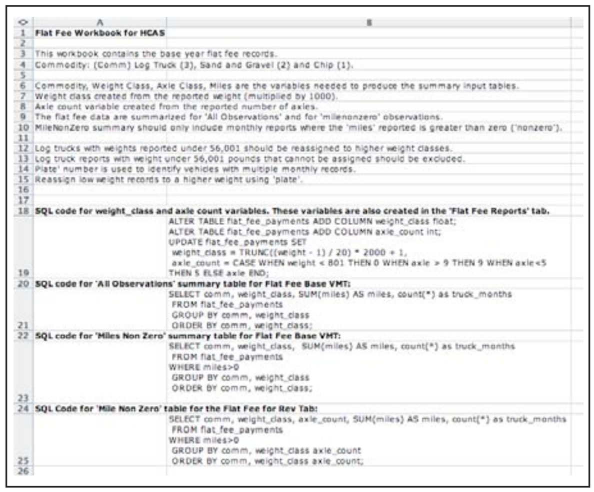
Supplemental Excel Workbooks

Three ‘supplemental’ Excel workbooks for the processing of the input data are included in the HCAS Model folder. Each of these workbooks should be updated and then the specified output from these workbooks is either pasted into the HCAS Model workbook or, in the case of the Base VMT workbook, the supplemental workbook is linked to the HCAS Model. Like the HCAS Model workbook, the majority of the required calculations and data tables are automatically updated when the yellow-shaded input cells are modified.

The three supplemental workbooks are the Base VMT workbook, which is linked to the *Base VMT* tab in the Model; the Flat Fee VMT Axle workbook, which provides input for the Base VMT workbook and the *Revenues* tab in the Model workbook; and the Split PE and ROW workbook, which calculates the shares for the Preliminary Engineering and Right-of-Way work type allocators which should be pasted into the *Policy* tab in the Model workbook.

Flat Fee VMT Axle

The *Flat Fee VMT Axle* workbook tabulates the flat fee reports for use in the Base VMT workbook and the Flat Fee VMT per Month and Flat Fee Axle Shares for the *Revenue* tab in the HCAS Model workbook.



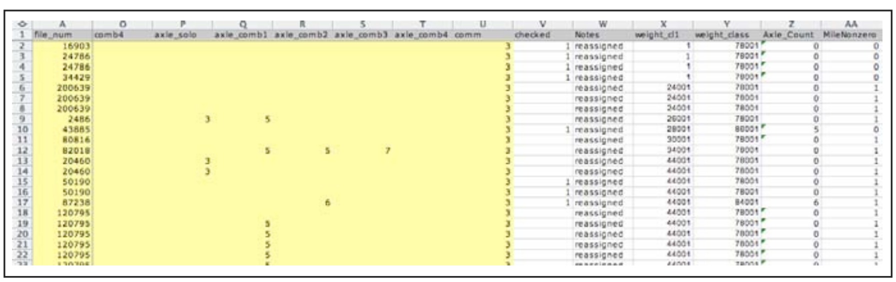
	A	B
1	**Flat Fee Workbook for HCAS**	
2		
3	This workbook contains the base year flat fee records.	
4	Commodity: (Comm) Log Truck (3), Sand and Gravel (2) and Chip (1).	
5		
6	Commodity, Weight Class, Axle Class, Miles are the variables needed to produce the summary input tables.	
7	Weight class created from the reported weight (multiplied by 1000).	
8	Axle count variable created from the reported number of axles.	
9	The flat fee data are summarized for 'All Observations' and for 'milenonzero' observations.	
10	MileNonZero summary should only include monthly reports where the 'miles' reported is greater than zero ('nonzero').	
11		
12	Log trucks with weights reported under 56,001 should be reassigned to higher weight classes.	
13	Log truck reports with weight under 56,001 pounds that cannot be assigned should be excluded.	
14	Plate' number is used to identify vehicles with multiple monthly records.	
15	Reassign low weight records to a higher weight using 'plate'.	
16		
17		
18	**SQL code for weight_class and axle count variables. These variables are also created in the 'Flat Fee Reports' tab.**	
19		ALTER TABLE flat_fee_payments ADD COLUMN weight_class float; ALTER TABLE flat_fee_payments ADD COLUMN axle_count int; UPDATE flat_fee_payments SET weight_class = TRUNC((weight - 1) / 20) * 2000 + 1, axle_count = CASE WHEN weight < 801 THEN 0 WHEN axle > 9 THEN 9 WHEN axle<5 THEN 5 ELSE axle END;
20	**SQL code for 'All Observations' summary table for Flat Fee Base VMT:**	
21		SELECT comm, weight_class, SUM(miles) AS miles, count(*) as truck_months FROM flat_fee_payments GROUP BY comm, weight_class ORDER BY comm, weight_class;
22	**SQL code for 'Miles Non Zero' summary table for Flat Fee Base VMT:**	
23		SELECT comm, weight_class, SUM(miles) AS miles, count(*) as truck_months FROM flat_fee_payments WHERE miles>0 GROUP BY comm, weight_class ORDER BY comm, weight_class;
24	**SQL Code for 'Mile Non Zero' table for the Flat Fee for Rev Tab:**	
25		SELECT comm, weight_class, axle_count, SUM(miles) AS miles, count(*) as truck_months FROM flat_fee_payments WHERE miles>0 GROUP BY comm, weight_class axle_count ORDER BY comm, weight_class axle_count;
26		

Cover

The *Cover* tab provides information on the contents and calculations in the Flat Fee VMT Axle workbook. This tab is an additional resource the user can reference when updating the Flat Fee VMT Axle workbook. The *Cover* tab contains the SQL code for creating the summary tables from the Flat Fee Collection Reports.

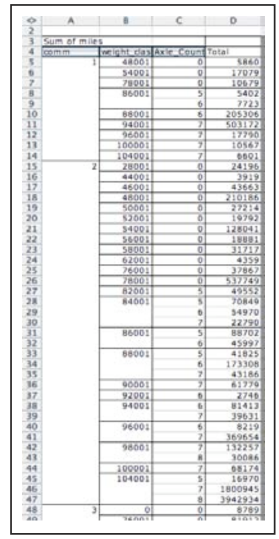
Flat Fee Reports

The raw Flat Fee collections report data for the base year are pasted into the yellow-shaded cells on the *Flat Fee Reports* tab. Formulas are used to create the weight class, axle class and ‘milenonzero’ (miles non-zero indicator) variables in the columns to the right of the yellow-shaded cells.



	A	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	file_num	comb4	axle_solo	axle_comb1	axle_comb2	axle_comb3	axle_comb4	comm	checked	Notes	weight_cl1	weight_class	Axle_Count	MileNonzero
2	16903							3	1	reassigned	1	78001	0	0
3	24786							3	1	reassigned	1	78001	0	0
4	24786							3	1	reassigned	1	78001	0	0
5	34429							3	1	reassigned	1	78001	0	0
6	200639							3		reassigned	24001	78001	0	1
7	200639							3		reassigned	24001	78001	0	1
8	200639							3		reassigned	24001	78001	0	1
9	2486		3	5				3		reassigned	26001	78001	0	1
10	43885							3	1	reassigned	28001	80001	5	0
11	80816							3		reassigned	30001	78001	0	1
12	82018			5	5	7		3		reassigned	34001	78001	0	1
13	20460		3					3		reassigned	44001	78001	0	1
14	20460		3					3		reassigned	44001	78001	0	1
15	50190							3	1	reassigned	44001	78001	0	1
16	50190							3	1	reassigned	44001	78001	0	1
17	87238				6			3	1	reassigned	44001	84001	6	1
18	120795							3		reassigned	44001	78001	0	1
19	120795			5				3		reassigned	44001	78001	0	1
20	120795			5				3		reassigned	44001	78001	0	1
21	120795			5				3		reassigned	44001	78001	0	1
22	120795			5				3		reassigned	44001	78001	0	1

In the model calculation, the log truck flat fee analysis includes an adjustment for log truck empty miles to account for the log hauler option of declaring a lower weight when their trailer is empty and stowed above the tractor unit. Since the analysis will account for the empty log truck VMT, the input log truck VMT must be correctly entered at their fully loaded weights. Log trucks reported at weights under 56,000 pounds are assumed to be a data entry or report error, (*i.e.* reported as the empty or average operating weight when the weight reported should be the loaded weight). Thus, log trucks with a reported weight



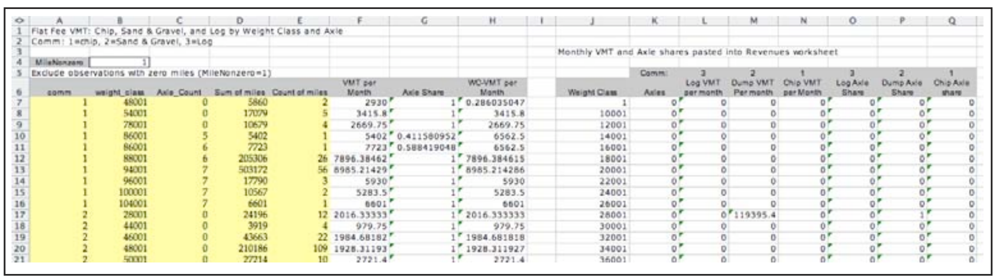
	A	B	C	D
3	Sum of miles			
4	comm	weight_clas	Axle_Count	Total
5	1	48001	0	5860
6		54001	0	17079
7		78001	0	10679
8		86001	5	5402
9			6	7723
10		88001	6	205306
11		94001	7	503172
12		96001	7	17790
13		100001	7	10567
14		104001	7	6601
15	2	28001	0	24196
16		44001	0	3919
17		46001	0	43663
18		48001	0	210186
19		50001	0	27214
20		52001	0	19792
21		54001	0	128041
22		56001	0	18881
23		58001	0	31717
24		62001	0	4359
25		76001	0	37867
26		78001	0	537749
27		82001	5	49552
28		84001	5	70849
29			6	54970
30			7	22790
31		86001	5	88702
32			6	45997
33		88001	5	41825
34			6	173308
35			7	43186
36		90001	7	61779
37		92001	6	2748
38		94001	6	81413
39			7	39631
40		96001	6	8219
41			7	369654
42		98001	7	132257
43			8	30086
44		100001	7	68174
45		104001	5	16970
46			7	1800945
47			8	3942934
48	3	0	0	8789

under 56,000 pounds should be reassigned to a higher weight class. If the plate number for the under 56,000 pounds record is also reported at a higher weight, the lower weight record is entered at the higher weight class. Log truck records entered at weights under 56,000 pounds that are not reassigned to a higher weight class are excluded.

Pivot Table

A summary table of the monthly miles and count of the monthly reports from the *Flat Fee Reports* tab is created using a series of pivot tables or the user may choose to export the Flat Fee Reports data and create the summary tables using an alternative software program. The pivot table rows are commodity (comm), weight class, and axle count. The 'milenonzero' indicator is used in the 'Page Fields' so that the pivot table can produce results for 'All Observations' and for 'Milenonzero' (only) records. The results from the pivot tables are pasted into the yellow-shaded cells on the *Flat Fee for Rev Tab* tab and the *Flat Fee VMT* tab.

Flat Fee for Rev



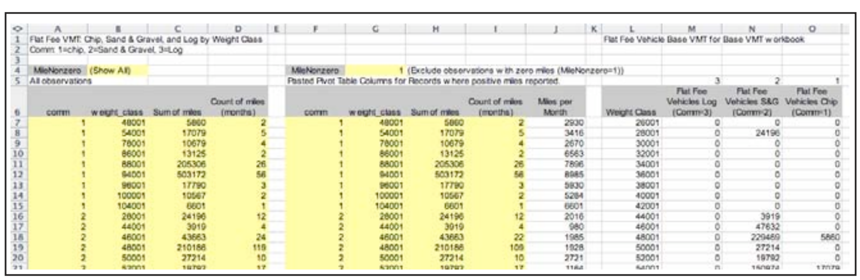
Flat Fee VMT: Chip, Sand & Gravel, and Log by Weight Class and Axle
Comm: 1=chip, 2=Sand & Gravel, 3=Log
MileNonzero 1
Exclude observations with zero miles (MileNonzero=1)
Monthly VMT and Axle shares pasted into Revenues worksheet

Row	comm	weight_class	Axle_Count	Sum of miles	Count of miles	VMT per Month	Axle Share	WC-VMT per Month
7	1	48001	0	5860	2	2930	1	0.286035047
8	1	54001	0	17079	5	3415.8	1	3415.8
9	1	78001	0	10679	4	2669.75	1	2669.75
10	1	86001	5	5402	1	5402	0.411580952	6562.5
11	1	86001	6	7723	1	7723	0.588419048	6562.5
12	1	88001	6	205306	26	7896.38462	1	7896.384615
13	1	94001	7	503172	56	8985.21429	1	8985.214286
14	1	96001	7	17790	3	5930	1	5930
15	1	100001	7	10567	2	5283.5	1	5283.5
16	1	104001	7	6601	1	6601	1	6601
17	2	28001	0	24196	12	2016.33333	1	2016.333333
18	2	44001	0	3919	4	979.75	1	979.75
19	2	46001	0	43663	22	1984.68182	1	1984.681818
20	2	48001	0	210186	109	1928.31193	1	1928.311927
21	2	50001	0	27214	10	2721.4	1	2721.4

Row	Weight Class	Comm: Axles	3 Log VMT per month	2 Dump VMT Per month	1 Chip VMT per Month	3 Log Axle Share	2 Dump Axle Share	1 Chip Axle share
7	1	0	0	0	0	0	0	0
8	10001	0	0	0	0	0	0	0
9	12001	0	0	0	0	0	0	0
10	14001	0	0	0	0	0	0	0
11	16001	0	0	0	0	0	0	0
12	18001	0	0	0	0	0	0	0
13	20001	0	0	0	0	0	0	0
14	22001	0	0	0	0	0	0	0
15	24001	0	0	0	0	0	0	0
16	26001	0	0	0	0	0	0	0
17	28001	0	0	119395.4	0	0	1	0
18	30001	0	0	0	0	0	0	0
19	32001	0	0	0	0	0	0	0
20	34001	0	0	0	0	0	0	0
21	36001	0	0	0	0	0	0	0

The *Flat Fee for Rev Tab* tab calculates the monthly VMT and the axle shares for the *Revenues* tab in the HCAS Model workbook. Pivot table or summary table results using the records from the *Flat Fee Reports* tab are used to create the yellow-shaded input for the *Flat Fee for Rev Tab*. The records where miles is not zero ('milesnonzero') are used to calculate the average VMT per month and the axle share of VMT for each weight class. The axle shares and WC-VMT per month and the summary table of the monthly variables are all calculated using array formulas. The formula ranges should be correctly entered to cover the range of input data and the formulas should be bracketed (to produce curly brackets, press CTRL+SHIFT+ENTER in cell). Copy and paste the VMT per month and axle shares into the *Revenues* tab in the HCAS Model workbook.

Flat Fee Base VMT



Flat Fee VMT: Chip, Sand & Gravel, and Log by Weight Class
Comm: 1=chip, 2=Sand & Gravel, 3=Log
MileNonzero (Show All)
All observations
MileNonzero 1 (Exclude observations with zero miles (MileNonzero=1))
Pasted Pivot Table Columns for Records where positive miles reported
Flat Fee Vehicle Base VMT for Base VMT workbook

Row	comm	weight_class	Sum of miles	Count of miles (months)
7	1	48001	5860	2
8	1	54001	17079	5
9	1	78001	10679	4
10	1	86001	13125	2
11	1	88001	205306	26
12	1	94001	503172	56
13	1	96001	17790	3
14	1	100001	10567	2
15	1	104001	6601	1
16	2	28001	24196	12
17	2	44001	3919	4
18	2	46001	43663	24
19	2	48001	210186	118
20	2	50001	27214	10

Row	comm	weight_class	Sum of miles	Count of miles (months)	Miles per Month
7	1	48001	5860	2	2930
8	1	54001	17079	5	3416
9	1	78001	10679	4	2670
10	1	86001	13125	2	6563
11	1	88001	205306	26	7896
12	1	94001	503172	56	8985
13	1	96001	17790	3	5930
14	1	100001	10567	2	5284
15	1	104001	6601	1	6601
16	2	28001	24196	12	2016
17	2	44001	3919	4	980
18	2	46001	43663	22	1985
19	2	48001	210186	109	1928
20	2	50001	27214	10	2721

Row	Weight Class	3 Flat Fee Vehicles Log (Comm=3)	2 Flat Fee Vehicles S&G (Comm=2)	1 Flat Fee Vehicles Chip (Comm=1)
7	26001	0	0	0
8	28001	0	24196	0
9	30001	0	0	0
10	32001	0	0	0
11	34001	0	0	0
12	36001	0	0	0
13	38001	0	0	0
14	40001	0	0	0
15	42001	0	0	0
16	44001	0	3919	0
17	46001	0	47632	0
18	48001	0	229469	5860
19	50001	0	27214	0
20	52001	0	19792	0

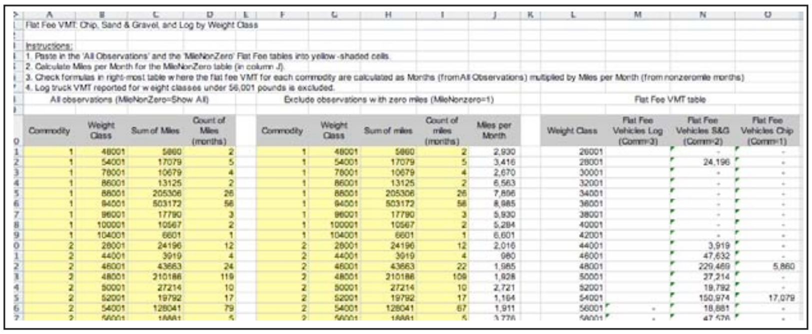
The *Flat Fee Base VMT* tab is the original source for the input for the *Flat Fee* tab in the Base VMT workbook. The Flat Fee Reports data should be used to create the yellow-shaded input tables for the *Flat Fee Base VMT* tab. The 'All observations' and 'milenonzero' tables can then be pasted into the *Flat Fee* tab in the Base VMT workbook. The Flat Fee VMT summary table in the *Flat Fee Base VMT* tab should be the same as the one reproduced in the *Flat Fee* tab in the Base VMT workbook.

Base VMT Workbook

Base year VMT is calculated in a separate supplemental workbook due to the number and variety of different data sources and the size of some of the input data tables used to calculate the base VMT. For the 2009 HCAS model the approach for calculating the base VMT was formalized with the intermediate calculations performed in a supplemental workbook and linked to the model. To the extent possible, this allows the user to see the steps from the raw, original data to the detailed base year VMT table.

The following is a tab-by-tab explanation of the data and calculations in the *Base VMT* workbook.

Flat Fee


Flat Fee VMT: Chip, Sand & Gravel, and Log by Weight Class

Instructions:
1. Paste in the 'All Observations' and the 'MileNonZero' Flat Fee tables into yellow-shaded cells.
2. Calculate Miles per Month for the MileNonZero table (in column J).
3. Check formulas in right-most table where the flat fee VMT for each commodity are calculated as Months (fromAll Observations) multiplied by Miles per Month (from nonzeromile months)
4. Log truck VMT reported for weight classes under 56,001 pounds is excluded.

All observations (MileNonZero=Show All)				Exclude observations with zero miles (MileNonzero=1)					Flat Fee VMT table			
Commodity	Weight Class	Sum of Miles	Count of Miles (months)	Commodity	Weight Class	Sum of miles	Count of miles (months)	Miles per Month	Weight Class	Flat Fee Vehicles Log (Comm=3)	Flat Fee Vehicles S&G (Comm=2)	Flat Fee Vehicles Chip (Comm=1)
1	48001	5860	2	1	48001	5860	2	2,930	26001		-	-
1	54001	17079	5	1	54001	17079	5	3,416	28001		24,196	-
1	78001	10679	4	1	78001	10679	4	2,670	30001		-	-
1	86001	13125	2	1	86001	13125	2	6,563	32001		-	-
1	88001	205306	26	1	88001	205306	26	7,896	34001		-	-
1	94001	503172	56	1	94001	503172	56	8,985	36001		-	-
1	96001	17790	3	1	96001	17790	3	5,930	38001		-	-
1	100001	10567	2	1	100001	10567	2	5,284	40001		-	-
1	104001	6601	1	1	104001	6601	1	6,601	42001		-	-
2	28001	24196	12	2	28001	24196	12	2,016	44001		3,919	-
2	44001	3919	4	2	44001	3919	4	980	46001		47,632	-
2	46001	43663	24	2	46001	43663	22	1,985	48001		229,469	5,860
2	48001	210186	119	2	48001	210186	109	1,928	50001		27,214	-
2	50001	27214	10	2	50001	27214	10	2,721	52001		19,792	-
2	52001	19792	17	2	52001	19792	17	1,164	54001		150,974	17,079
2	54001	128041	79	2	54001	128041	67	1,911	56001	-	18,881	-
2	56001	18881	5	2	56001	18881	5	3,776	58001	-	47,576	-

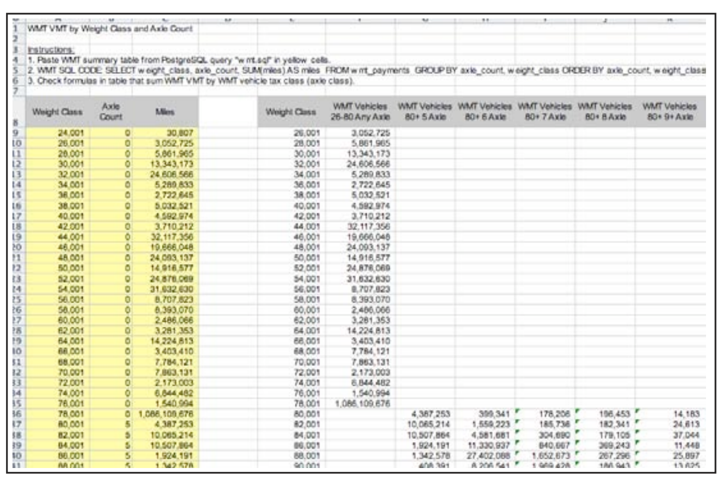
The *Flat Fee* tab contains the calculation of the Flat Fee VMT. Certain commodity carriers (log trucks, sand and gravel and chip) can opt to pay a flat monthly fee. These carriers submit monthly reports of their mileage at their loaded operating weights. Flat fee VMT are tabulated from these Flat Fee Collections Reports in the Flat Fee VMT Axle workbook and then pasted into the yellow-shaded cells on the *Flat Fee* tab in the Base VMT workbook. Since some of the monthly Flat Fee Collections data do not report VMT, we tabulate the VMT per month from reports where miles were non-zero and then multiply by the total number of months reported in the Flat Fee Data (all observations).

The miles per month for the non-zero mile observations is calculated in column J as the sum of miles divided by count of miles (*i.e.*, months). The Flat Fee VMT for each commodity by weight class is calculated by multiplying the miles per month from the non-zero mile observations by the number of months for all observations. Log truck VMT for weight class 56,001 pounds and under should be zero. Check to see that all of the miles per month formula is filled in for all of the Flat Fee records. Flat fee reports for vehicles with weights over 105,500 are data entry errors and are excluded from the Flat Fee VMT table.

Pasting in the 'Flat Fee-All Observations' and 'Flat Fee-Miles NonZero' tables into the yellow-shaded cells will automatically update the Flat Fee VMT summary table.

WMT

The WMT VMT are tabulated from the base year WMT Collection reports. The WMT data are too large for a workbook, so the pre-processing the WMT reports requires using SQL code to produce the summary table of WMT VMT by weight and axle class, which is pasted into the yellow-shaded cells on the *WMT* tab in the Base VMT workbook. The HCAS weight class and axle class variables are created from the reported weight and axles in the WMT reports. A


WMT VMT by Weight Class and Axle Count

Instructions:
1. Paste WMT summary table from PostgreSQL query "wmt.sql" in yellow cells.
2. WMT SQL CODE: SELECT weight_class, axle_count, SUM(miles) AS miles FROM wmt_payments GROUP BY axle_count, weight_class ORDER BY axle_count, weight_class
3. Check formulas in table that sum WMT VMT by WMT vehicle tax class (axle class).

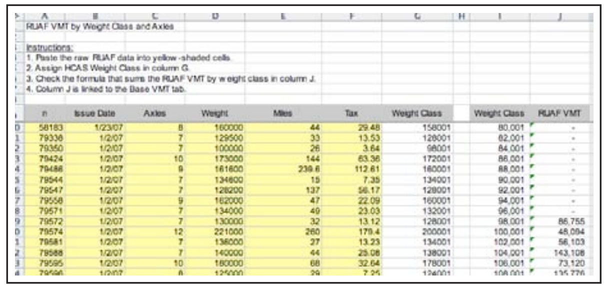
Weight Class	Axle Count	Miles	Weight Class	WMT Vehicles 26-80 Any Axle	WMT Vehicles 80+ 5 Axle	WMT Vehicles 80+ 6 Axle	WMT Vehicles 80+ 7 Axle	WMT Vehicles 80+ 8 Axle	WMT Vehicles 80+ 9+ Axle
24,001	0	30,807	26,001	3,052,725					
26,001	0	3,052,725	28,001	5,861,965					
28,001	0	5,861,965	30,001	13,343,173					
30,001	0	13,343,173	32,001	24,606,566					
32,001	0	24,606,566	34,001	5,289,833					
34,001	0	5,289,833	36,001	2,722,645					
36,001	0	2,722,645	38,001	5,032,521					
38,001	0	5,032,521	40,001	4,592,974					
40,001	0	4,592,974	42,001	3,710,212					
42,001	0	3,710,212	44,001	32,117,356					
44,001	0	32,117,356	46,001	19,666,048					
46,001	0	19,666,048	48,001	24,093,137					
48,001	0	24,093,137	50,001	14,916,577					
50,001	0	14,916,577	52,001	24,876,069					
52,001	0	24,876,069	54,001	31,632,630					
54,001	0	31,632,630	56,001	8,707,823					
56,001	0	8,707,823	58,001	8,393,070					
58,001	0	8,393,070	60,001	2,486,066					
60,001	0	2,486,066	62,001	3,281,353					
62,001	0	3,281,353	64,001	14,224,813					
64,001	0	14,224,813	66,001	3,403,410					
66,001	0	3,403,410	68,001	7,784,121					
68,001	0	7,784,121	70,001	7,863,131					
70,001	0	7,863,131	72,001	2,173,003					
72,001	0	2,173,003	74,001	6,844,482					
74,001	0	6,844,482	76,001	1,540,994					
76,001	0	1,540,994	78,001	1,086,109,676					
78,001	0	1,086,109,676	80,001		4,387,253	399,341	178,206	196,453	14,183
80,001	5	4,387,253	82,001		10,065,214	1,559,223	185,736	182,341	24,613
82,001	5	10,065,214	84,001		10,507,864	4,581,681	304,690	179,105	37,044
84,001	5	10,507,864	86,001		1,924,191	11,330,937	840,667	369,243	11,448
86,001	5	1,924,191	88,001		1,342,578	27,402,088	1,652,673	267,296	25,897
88,001	5	1,342,578	90,001		406,391	8,206,541	1,969,428	186,943	13,625

WMT VMT summary table is then created for each weight class and axle class.

The WMT VMT table to the right of the yellow-shaded input table is automatically updated with the new WMT VMT when the yellow-shaded input cells are updated.

RUAF

The Road Use Assessment Fee (RUAF) records from the base year are pasted directly into the yellow-shaded cells in the *RUAF* tab. The HCAS weight class variable is calculated from the RUAF reported vehicle weight. The RUAF collection records do not require any pre-processing. The summary RUAF table (to the right of the yellow-shaded cells) sums the VMT from the RUAF data by weight and axle class. Make sure the formulas that sum the VMT include the entire range of the RUAF data. The Road User Assessed Fees provide the exact VMT by weight class for vehicles in this tax class. The model assumes there is no evasion or avoidance of the RUAF.

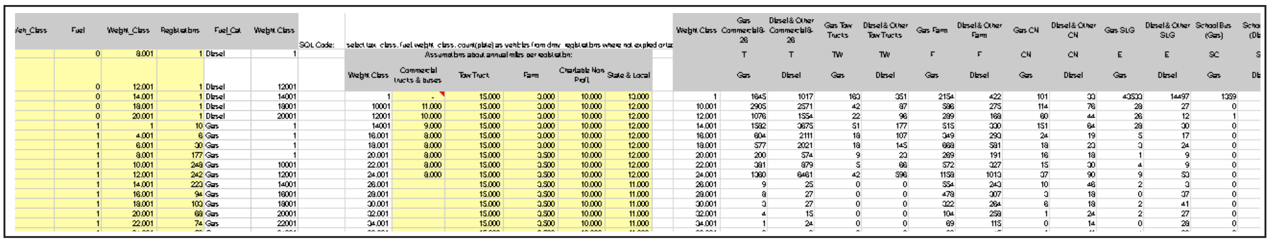


RUAF VMT by Weight Class and Axles

Instructions:
1. Paste the raw RUAF data into yellow-shaded cells.
2. Assign HCAS Weight Class in column G.
3. Check the formula that sums the RUAF VMT by weight class in column J.
4. Column J is linked to the Base VMT tab.

n	Issue Date	Axles	Weight	Miles	Tax	Weight Class		Weight Class	RUAF VMT
58183	1/23/07	8	160000	44	29.48	158001		80,001	-
79336	1/2/07	7	129500	33	13.53	128001		82,001	-
79350	1/2/07	7	100000	26	3.64	98001		84,001	-
79424	1/2/07	10	173000	144	63.36	172001		86,001	-
79486	1/2/07	9	161600	239.6	112.61	160001		88,001	-
79544	1/2/07	7	134600	15	7.35	134001		90,001	-
79547	1/2/07	7	128200	137	56.17	128001		92,001	-
79558	1/2/07	9	162000	47	22.09	160001		94,001	-
79571	1/2/07	7	134000	49	23.03	132001		96,001	-
79572	1/2/07	7	130000	32	13.12	128001		98,001	86,755
79574	1/2/07	12	221000	260	179.4	200001		100,001	48,094
79581	1/2/07	7	136000	27	13.23	134001		102,001	56,103
79588	1/2/07	7	140000	44	25.08	138001		104,001	143,108
79595	1/2/07	10	180000	68	32.64	178001		106,001	73,120
79596	1/2/07	8	125000	29	7.25	124001		108,001	135,776

DMV-Other



Veh_Class	Fuel	Weight_Class	Registrations	Fuel_Cat	Weight Class
	0	8,001	1	Diesel	1
	0	12,001	1	Diesel	12001
	0	14,001	1	Diesel	14001
	0	18,001	1	Diesel	18001
	0	20,001	1	Diesel	20001
	1	1	10	Gas	1
	1	4,001	6	Gas	1
	1	6,001	30	Gas	1
	1	8,001	177	Gas	1
	1	10,001	248	Gas	10001
	1	12,001	242	Gas	12001
	1	14,001	223	Gas	14001
	1	16,001	94	Gas	16001
	1	18,001	103	Gas	18001
	1	20,001	68	Gas	20001
	1	22,001	74	Gas	22001

SQL Code: select tax_class, fuel, weight_class, count(plate) as vehicles from dmv_registrations where not expired or tax

Assumptions about annual miles per registration:

Weight Class	Commercial trucks & buses	Tow Truck	Farm	Charitable Non Profit	State & Local
1	-	15,000	3,000	10,000	13,000
10001	11,000	15,000	3,000	10,000	12,000
12001	10,000	15,000	3,000	10,000	12,000
14001	9,000	15,000	3,000	10,000	12,000
16,001	8,000	15,000	3,000	10,000	12,000
18,001	8,000	15,000	3,000	10,000	12,000
20,001	8,000	15,000	3,500	10,000	12,000
22,001	8,000	15,000	3,500	10,000	12,000
24,001	8,000	15,000	3,500	10,000	12,000
26,001		15,000	3,500	10,000	11,000
28,001		15,000	3,500	10,000	11,000
30,001		15,000	3,500	10,000	11,000
32,001		15,000	3,500	10,000	11,000
34,001		15,000	3,500	10,000	11,000

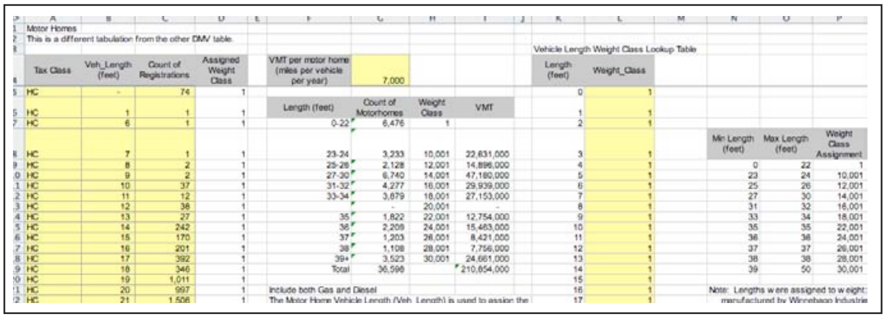
Weight Class	Gas Commercial <26	Diesel & Other Commercial <26	Gas Tow Trucks	Diesel & Other Tow Trucks	Gas Farm	Diesel & Other Farm	Gas CN	Diesel & Other CN	Gas SLG	Diesel & Other SLG	School Bus (Gas)
	T	T	TW	TW	F	F	CN	CN	E	E	SC
	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas
1	1645	1017	163	351	2154	422	101	33	43533	14497	1359
10,001	2905	2571	42	87	596	275	114	76	28	27	0
12,001	1076	1554	22	96	289	168	60	44	26	12	1
14,001	1582	3675	51	177	515	330	151	64	28	30	0
16,001	604	2111	18	107	349	293	24	19	5	17	0
18,001	577	2021	18	145	668	581	18	23	3	24	0
20,001	200	574	9	23	289	191	16	18	1	9	0
22,001	381	879	5	66	572	327	15	30	4	9	0
24,001	1360	6461	42	596	1158	1013	37	90	9	53	0
26,001	9	25	0	0	554	243	10	46	2	3	0
28,001	8	27	0	0	478	307	3	18	0	37	0
30,001	3	27	0	0	322	264	6	18	2	41	0
32,001	4	15	0	0	104	258	1	24	2	27	0
34,001	1	24	0	0	69	115	0	14	0	28	0

The *DMV-Other* tab contains the DMV registration counts and assumed annual mileage used to calculate VMT for 'Other' vehicle tax classes: Commercial Trucks and Buses (commercial vehicles that do not pay WMT), Tow Trucks, Farm Vehicles, Charitable Non-Profit, and State and Local Government (E-Plate). DMV Registrations data are processed to produce a summary table of registrations by vehicle class, weight class and fuel type for each of the 'Other' vehicles tax classes listed above. The vehicle registrations are multiplied by assumed annual miles per vehicle to estimate the total VMT by weight class for each tax class in the *Intermediate Base VMT* tab. The summary table of DMV Registrations data from the DMV SQL query should be pasted into the left-most table of yellow-shaded cells on the *DMV-Other* tab. Fuel type ('gas' or 'diesel') and weight class variables are calculated in the columns to the right of the pasted DMV registrations data.

The annual miles per vehicle assumptions for each vehicle class are in the yellow-shaded cells in the center table on the tab. The annual miles per vehicle for basic commercial trucks is set to zero since these VMT should be captured in the basic VMT calculated from the basic vehicle VMT control total. Commercial basic vehicles include hearses, ambulances, and other commercial vehicles, which register as commercial vehicles. Since these vehicles also pay fuel use tax their VMT is included in the basic vehicle VMT estimate from the revenue forecast.

Vehicle registrations at vehicle weights greater than 200,001 pounds are data entry errors and are excluded from the VMT calculations. Commercial trucks and buses should only be registered at weights under 26,001 pounds. Assumed annual mileage for commercial trucks and buses over 26,000 pounds is left empty so that any vehicles incorrectly registered at 26,001 or higher are not assigned VMT.

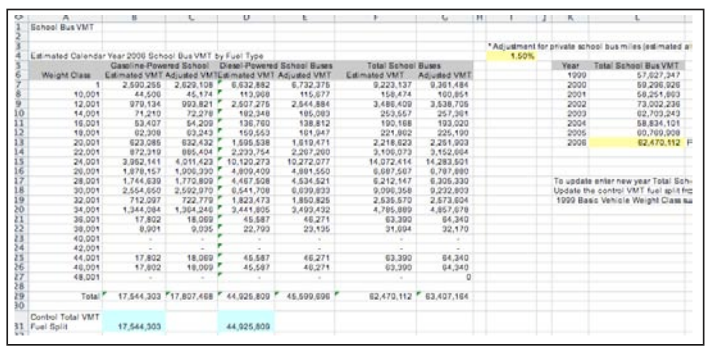
MotorHomes



Motor home VMT is estimated using motor home vehicle counts from the DMV registrations data and an assumed annual VMT of 7,000 per vehicle. The summary table of DMV Registrations for motor homes (plate designated as 'HC') is pasted into the yellow-shaded cells on the left side of the *MotorHomes* tab. The annual VMT per vehicle assumption is the yellow-shaded single cell at the top center of the *MotorHomes* tab.

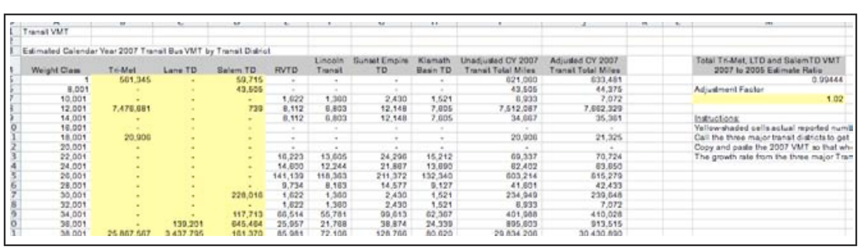
Since motor home vehicle weight information is not available from the DMV registrations data for motor homes, the vehicle length (feet) field is used to assign the motor home weight classes. Information on manufacturer motor home vehicle specifications was used to develop a table of motor home weight classes by vehicle lengths. The assumed weight class and vehicle length categories are assumptions in the yellow-shaded cells in a table on the right-hand side of the *MotorHomes* tab.

SchoolBus



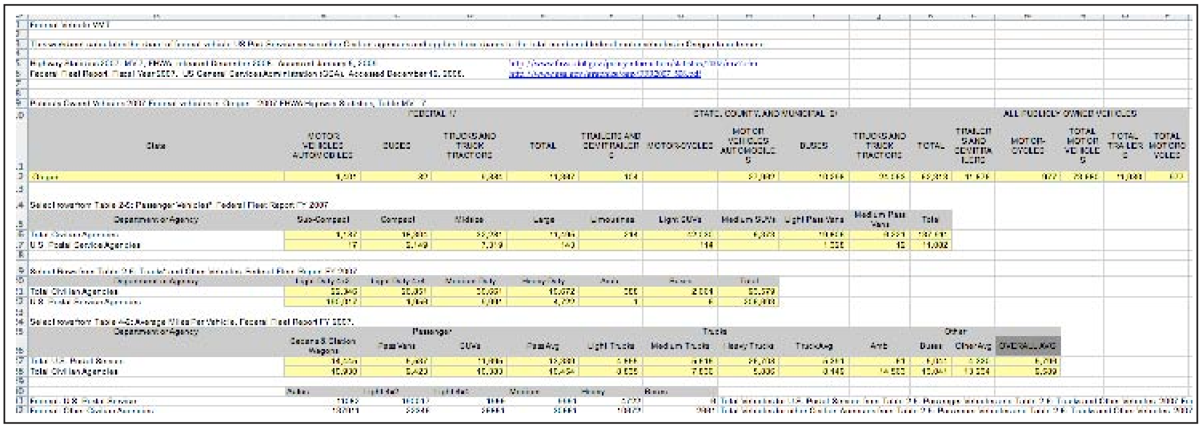
The *SchoolBus* tab contains the estimates of school bus VMT in Oregon. School bus VMT by weight class and fuel type from 1999 is the base VMT distribution for the school bus VMT estimates. The Department of Education (DOE) estimate of total school bus VMT for 2006 is used as the control total for updating the VMT. The 2006 school bus VMT is distributed across weight classes using the school bus VMT distribution from 1999. The school bus registrations by fuel type (gasoline or diesel) from the *DMV-Other* tab is applied to the 2006 school bus VMT to determine the fuel-type split for the school bus VMT. The control total VMT by weight class are also adjusted by an assumed percent to account for private school bus miles not included in the DOE estimated school bus VMT.

Transit



The *Transit* tab estimates transit bus VMT in Oregon. Transit VMT estimates developed in 2005 are updated by scaling the transit district VMT by the change in the VMT for the three largest transit districts in Oregon. To update this tab, the transit bus VMT by weight class for Tri-Met, Lane Transit District, and Salem Transit District are collected for the base year (yellow-shaded input cells). The change in VMT for these three transit districts is used to adjust the 2005 transit VMT estimates. A final adjustment factor is used to adjust the transit VMT reported by the seven transit districts. The adjustment factor is in a yellow-shaded cell to the right of the base year table. The adjustment factor is an artifact from the original 2005 transit VMT calculations provided by ODOT.

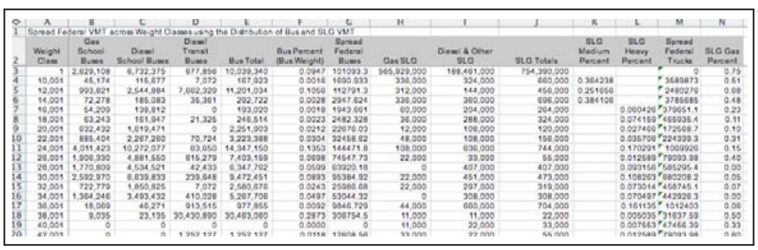
Federal



Paste the indicated table rows from the FHWA *Highway Statistics* (Table MV-7) and from the *Federal Fleet Report* (U.S. General Services Administration) into the yellow-shaded cells on the *Federal* tab. The input data on the *Federal* tab are used with the Federal Spread Weights to calculate the federal VMT in the *Federal Summary* tab. It is important that the input data are pasted into the exact cells as indicated by the row and column headings since the cells are referenced in the VMT calculations at the bottom of the *Federal* tab. The calculations at the bottom of the tab aggregate the various reported vehicle types and classes to calculate total federal VMT for buses, medium heavy trucks, and heavy trucks.

Fed Weight Class Spread

The *Federal* tab contains federal VMT and number of federal vehicles. The *Fed Weight Class Spread* tab uses the share of VMT for school buses (*SchoolBus* tab) and transit buses (*Transit* tab) by weight classes to spread the federal bus VMT across vehicle weight classes. Similarly, the State and Local Government (SLG) VMT (final estimates calculated in the *Intermediate Base VMT* tab) are used to spread the federal heavy vehicle VMT across weight classes. This tab essentially creates the shares or weights for each weight class which are then applied to the federal VMT input from the *Federal* tab.



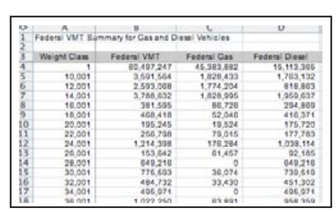
Spread Federal VMT across Weight Classes using the Distribution of Bus and SLG VMT

Weight Class	Gas School Buses	Diesel School Buses	Diesel Transit Buses	Bus Total	Bus Percent (Bus Weight)	Spread Federal Buses	Gas SLG	Diesel & Other SLG	SLG Totals	SLG Medium Percent	SLG Heavy Percent	Spread Federal Trucks	SLG Gas Percent
1	2,629,108	6,732,375	677,856	10,039,340	0.0947	101093.3	565,929,000	188,461,000	754,390,000			0	0.75
10,001	45,174	115,677	7,072	167,923	0.0016	1690.933	336,000	324,000	660,000	0.364238		3580873	0.51
12,001	993,821	2,544,884	7,662,329	11,201,034	0.1056	112791.3	312,000	144,000	456,000	0.251656		2480276	0.68
14,001	72,278	185,083	35,361	292,722	0.0028	2947.624	336,000	360,000	696,000	0.384106		3785685	0.48
16,001	54,209	138,812	0	193,020	0.0018	1943.661	60,000	204,000	264,000		0.060420	379651.1	0.23
18,001	63,243	161,947	21,325	246,514	0.0023	2482.328	36,000	288,000	324,000		0.074159	466935.4	0.11
20,001	632,432	1,619,471	0	2,251,903	0.0212	22676.03	12,000	108,000	120,000		0.027460	172608.7	0.10
22,001	885,404	2,267,280	70,724	3,223,388	0.0304	32458.62	48,000	108,000	156,000		0.035706	224339.3	0.31
24,001	4,011,423	10,272,077	63,650	14,347,150	0.1353	144471.8	108,000	636,000	744,000		0.170291	1069926	0.15
26,001	1,906,330	4,881,550	615,279	7,403,159	0.0698	74547.73	22,000	33,000	55,000		0.012589	79093.98	0.40
28,001	1,770,809	4,534,521	42,433	6,347,762	0.0599	63920.18	0	407,000	407,000		0.093156	585295.4	0.00
30,001	2,582,970	6,639,833	239,648	9,472,451	0.0893	95384.92	22,000	451,000	473,000		0.108263	680208.2	0.05
32,001	722,779	1,850,825	7,072	2,580,676	0.0243	25986.68	22,000	297,000	319,000		0.073014	458745.1	0.07
34,001	1,364,246	3,493,432	410,028	5,267,706	0.0497	53044.32	0	308,000	308,000		0.070497	442926.3	0.00
36,001	18,069	46,271	913,515	977,855	0.0092	9846.729	44,000	660,000	704,000		0.161136	1012403	0.06
38,001	9,035	23,135	30,430,890	30,463,060	0.2873	306754.5	11,000	11,000	22,000		0.005035	31637.59	0.50
40,001	0	0	0	0	0.0000	0	11,000	22,000	33,000		0.007553	47466.30	0.33

All of the calculations on this tab are linked to other tabs in the Base VMT workbook. The analyst may check that the shares are properly calculated and applied to the federal VMT such that the total federal VMT is still equal to the VMT on the *Federal* tab.

Federal Summary

The *Federal Summary* tab adds up the federal VMT by weight class from the *Federal* tab and the *Fed Weight Class Spread* tab. Federal VMT for basic vehicles is the sum of the basic VMT from the *Federal* tab and the federal bus VMT from the *Fed Weight Class Spread* tab. Federal VMT for vehicles 10,001 pounds and above are the federal bus and truck VMT from the *Fed Weight*

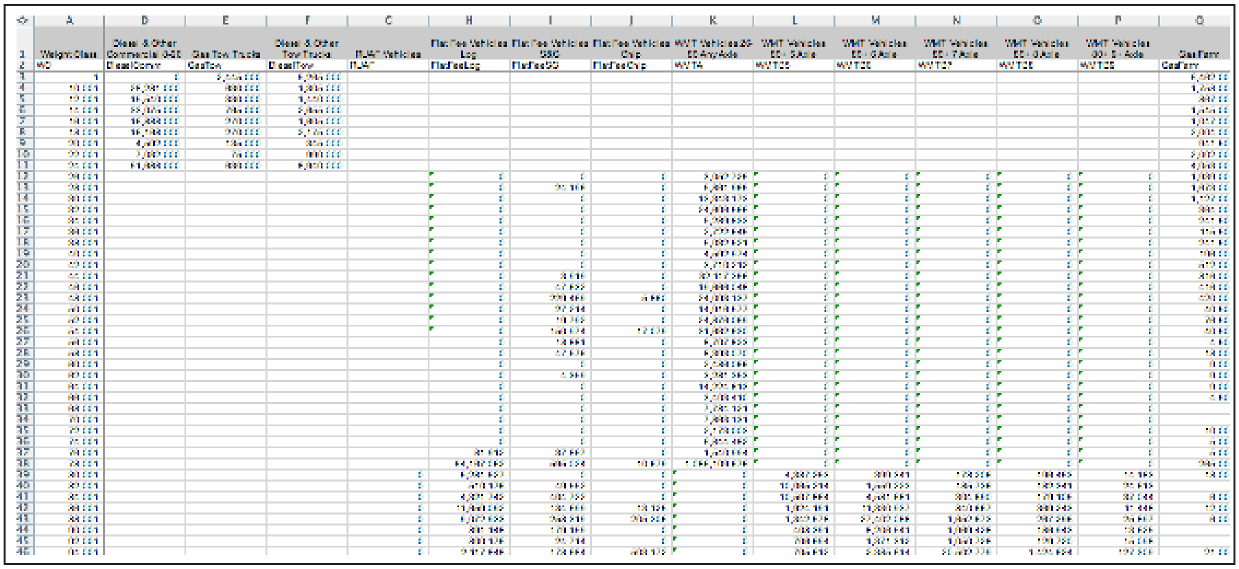


Federal VMT Summary for Gas and Diesel Vehicles

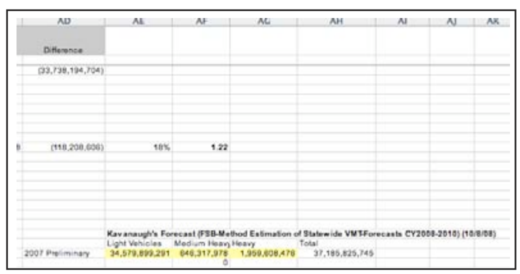
Weight Class	Federal VMT	Federal Gas	Federal Diesel
1	60,497,247	45,383,882	15,113,365
10,001	3,591,564	1,828,433	1,763,132
12,001	2,593,068	1,774,204	818,863
14,001	3,786,632	1,826,995	1,959,637
16,001	381,595	86,726	294,869
18,001	468,418	52,046	416,371
20,001	195,245	19,524	175,720
22,001	256,798	79,015	177,783
24,001	1,214,398	176,284	1,038,114
26,001	153,642	61,457	92,185
28,001	649,216	0	649,216
30,001	776,603	36,074	730,510
32,001	484,732	33,430	451,302
34,001	406,071	0	406,071

Class Spread tab. Federal Gas VMT is derived by applying the percent gasoline from the SLG vehicles to the Federal VMT; Federal Diesel VMT is total Federal VMT less Federal Gas VMT.

Intermediate Base VMT



The *Intermediate Base VMT* tab consolidates all of the vehicle tax class VMT from the individual vehicle class tabs. The *Intermediate Base VMT* tab is so named because this tab contains the raw VMT numbers prior to the control total adjustment for the basic and medium-heavy vehicle weight classes. The *Intermediate Base VMT* tab references each tab in the workbook. For most of the vehicle classes, this tab links the vehicle VMT by weight class into the correct column for the final format of the *Base VMT (no WMTEvasion)* tab. The VMT per year and the annual vehicle registrations are multiplied in this worksheet for the 'Other' vehicle classes from the *DMV-Other* tab.

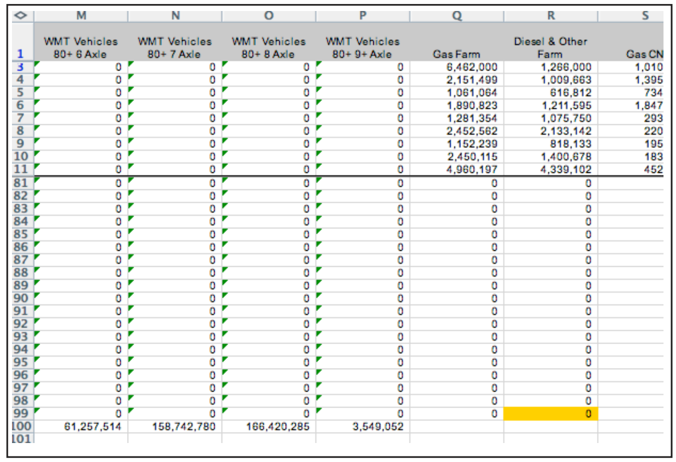


The VMT estimates for the base year from the ODOT Transportation and Revenue forecast are pasted into the yellow-shaded cells to the right of the VMT table on the *Intermediate Base VMT* tab. The VMT estimates for the base year are the control totals for the basic vehicle and medium-heavy vehicle classes. The VMT for the tax classes calculated separately (transit, school bus, etc.) are subtracted from the light-vehicle control total to determine the Private Passenger basic VMT. The medium-heavy vehicle VMT are scaled such that the total medium-heavy vehicle VMT equals the control total. The *Intermediate Base VMT* tab and the *Base VMT (no WMTEvasion)* tab both reference these control totals and use the medium vehicle control total to calculate the scaling factor used to adjust the medium-heavy VMT for each vehicle tax class.

Base VMT (no WMTEvasion)

The *Base VMT (no WMTEvasion)* tab is the final worksheet in the Base VMT workbook and is linked to *Base VMT* worksheet in the HCAS model. The *Base VMT (no WMTEvasion)* tab contains the calculated base year VMT for each vehicle tax class by weight class and adjusts the basic and medium heavy VMT so that the total for these two weight groupings equal their corresponding VMT forecast from the ODOT Economic and Revenue

Forecast (for the base year). The "No WMTEvasion" in the tab name is to indicate that the WMT VMT reflect the WMT VMT reported in the WMT collection reports. WMT VMT are adjusted to include the assumed WMT evasion rate in the *Base VMT* tab in the HCAS Model workbook.



	M	N	O	P	Q	R	S
1	WMT Vehicles 80+ 6 Axle	WMT Vehicles 80+ 7 Axle	WMT Vehicles 80+ 8 Axle	WMT Vehicles 80+ 9+ Axle	Gas Farm	Diesel & Other Farm	Gas CN
3	0	0	0	0	6,462,000	1,266,000	1,010
4	0	0	0	0	2,151,499	1,009,663	1,395
5	0	0	0	0	1,061,064	616,812	734
6	0	0	0	0	1,890,823	1,211,595	1,847
7	0	0	0	0	1,281,354	1,075,750	293
8	0	0	0	0	2,452,562	2,133,142	220
9	0	0	0	0	1,152,239	818,133	195
10	0	0	0	0	2,450,115	1,400,678	183
11	0	0	0	0	4,960,197	4,339,102	452
81	0	0	0	0	0	0	
82	0	0	0	0	0	0	
83	0	0	0	0	0	0	
84	0	0	0	0	0	0	
85	0	0	0	0	0	0	
86	0	0	0	0	0	0	
87	0	0	0	0	0	0	
88	0	0	0	0	0	0	
89	0	0	0	0	0	0	
90	0	0	0	0	0	0	
91	0	0	0	0	0	0	
92	0	0	0	0	0	0	
93	0	0	0	0	0	0	
94	0	0	0	0	0	0	
95	0	0	0	0	0	0	
96	0	0	0	0	0	0	
97	0	0	0	0	0	0	
98	0	0	0	0	0	0	
99	0	0	0	0	0	0	
100	61,257,514	158,742,780	166,420,285	3,549,052			
101							

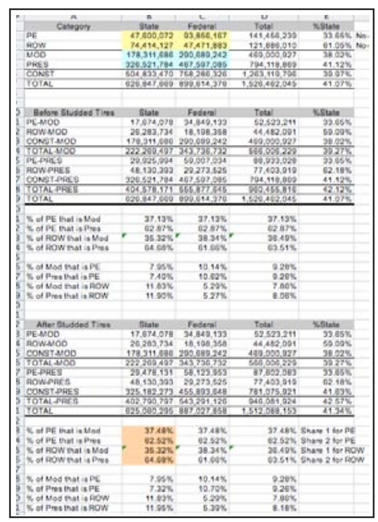
The basic vehicle VMT for cars is equal to the basic vehicle control total minus the VMT reported for the other vehicle tax classes on the *Intermediate Base VMT* tab.

The medium-heavy control total adjustment factor is applied to the VMT for medium heavy vehicle classes (vehicles between 10,001 and 26,000 pounds) from the *Intermediate Base* VMT tab. VMT for vehicles in the 26,001 weight class and above are equal to the VMT in the Intermediate Base VMT tab. The references and calculations on this tab are automatically updated or calculated when the rest of the tabs in the workbook are changed.

Once the Base VMT workbook has been completely updated and reviewed, the user should update the linked *Base VMT* tab in the HCAS model workbook by opening the model workbook and 'updating' links.

Split PE and ROW Workbook

The Split PE and ROW workbook calculates the split of the Preliminary Engineering (PE) and Right-of-Way (ROW) Costs between modernization and preservation projects in order to determine the cost allocator shares for the Preliminary Engineering and Right-of-Way work types on the *Policy* tab in the HCAS Model.

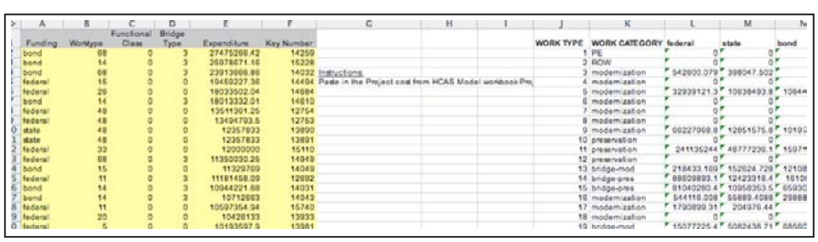


Category	State	Federal	Total	%State	
PE	47,600,072	93,856,167	141,456,239	33.65%	No-
ROW	74,414,127	47,471,883	121,886,010	61.05%	No-
MOD	178,311,686	290,689,242	469,000,927	38.02%	
PRES	326,521,784	467,597,085	794,118,869	41.12%	
CONST	504,833,470	758,286,326	1,263,119,796	39.97%	
TOTAL	626,847,669	899,614,376	1,526,462,045	41.07%	
Before Studded Tires	State	Federal	Total	%State	
PE-MOD	17,674,078	34,849,133	52,523,211	33.65%	
ROW-MOD	26,283,734	18,198,358	44,482,091	59.09%	
CONST-MOD	178,311,686	290,689,242	469,000,927	38.02%	
TOTAL-MOD	222,269,497	343,736,732	566,006,229	39.27%	
PE-PRES	29,925,994	59,007,034	88,933,028	33.65%	
ROW-PRES	48,130,393	29,273,525	77,403,919	62.18%	
CONST-PRES	326,521,784	467,597,085	794,118,869	41.12%	
TOTAL-PRES	404,578,171	555,877,645	960,455,816	42.12%	
TOTAL	626,847,669	899,614,376	1,526,462,045	41.07%	
% of PE that is Mod	37.13%	37.13%	37.13%		
% of PE that is Pres	62.87%	62.87%	62.87%		
% of ROW that is Mod	35.32%	38.34%	36.49%		
% of ROW that is Pres	64.68%	61.66%	63.51%		
% of Mod that is PE	7.95%	10.14%	9.28%		
% of Pres that is PE	7.40%	10.62%	9.26%		
% of Mod that is ROW	11.83%	5.29%	7.86%		
% of Pres that is ROW	11.90%	5.27%	8.06%		
After Studded Tires	State	Federal	Total	%State	
PE-MOD	17,674,078	34,849,133	52,523,211	33.65%	
ROW-MOD	26,283,734	18,198,358	44,482,091	59.09%	
CONST-MOD	178,311,686	290,689,242	469,000,927	38.02%	
TOTAL-MOD	222,269,497	343,736,732	566,006,229	39.27%	
PE-PRES	29,478,131	58,123,953	87,602,083	33.65%	
ROW-PRES	48,130,393	29,273,525	77,403,919	62.18%	
CONST-PRES	325,182,273	455,893,648	781,075,921	41.63%	
TOTAL-PRES	402,790,797	543,291,126	946,081,924	42.57%	
TOTAL	625,060,295	887,027,858	1,512,088,153	41.34%	
% of PE that is Mod	37.48%	37.48%	37.48%	Share 1 for PE	
% of PE that is Pres	62.52%	62.52%	62.52%	Share 2 for PE	
% of ROW that is Mod	35.32%	38.34%	36.49%	Share 1 for ROW	
% of ROW that is Pres	64.68%	61.66%	63.51%	Share 2 for ROW	
% of Mod that is PE	7.95%	10.14%	9.28%		
% of Pres that is PE	7.32%	10.70%	9.26%		
% of Mod that is ROW	11.83%	5.29%	7.86%		
% of Pres that is ROW	11.96%	5.39%	8.18%		

Split Non-Construction

The *Split Non-Construction* tab determines the shares to assign for the allocation of PE and ROW costs. The updated state and federal funded PE and ROW non-project costs from the *Non-Project Costs* tab in the HCAS Model should be pasted into the yellow-shaded cells on this tab. The state funded PE (ROW) amount should be the sum of the state and bond funded PE (ROW) work type from the *Non-Project Costs* tab. The blue-shaded cells on this tab are automatically updated from the *Proj Costs Mod and Pres* tab.

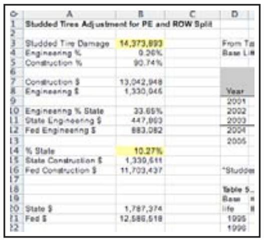
The orange-shaded cells at the bottom of the tab are the shares of PE and ROW costs that are allocated to modernization and preservation projects. The shares for PE (work type 1) and ROW (work type 2) should be pasted into the appropriate 'Shares' for work types 1 and 2 on the *Policy* tab in the HCAS Model workbook once all of the tabs in the Split PE and ROW workbook are updated.



Funding	Worktype	Functional Class	Bridge Type	Expenditure	Key Number		WORK TYPE	WORK CATEGORY	federal	state	bond
bond	88	0	3	27475288.42	14259		1	PE	0	0	
bond	14	0	3	26078671.16	15228		2	ROW	0	0	
bond	88	0	3	23913668.86	14032	Instructions	3	modernization	542600.079	398047.502	
federal	15	0	0	10459227.36	14404	Paste in the Project cost from HCAS Model workbook Pro	4	modernization	0	0	
federal	29	0	0	18033502.04	14684		5	modernization	32939121.3	10638493.8	1064
bond	14	0	3	18013332.01	14610		6	modernization	0	0	
federal	48	0	0	13511361.25	12754		7	modernization	0	0	
federal	48	0	0	13494793.5	12753		8	modernization	0	0	
state	48	0	0	12357833	13890		9	modernization	60227968.8	12851575.8	1019
state	48	0	0	12357833	13891		10	preservation	0	0	
federal	33	0	0	12000000	15110		11	preservation	241135244	48777236.1	1597
federal	88	0	3	11350030.26	14949		12	preservation	0	0	
bond	15	0	0	11329769	14049		13	bridge-mod	218433.169	152624.728	1210
federal	11	0	3	11181458.09	12692		14	bridge-pres	88809893.1	12423316.4	1610
bond	14	0	3	10944221.88	14031		15	bridge-pres	81040280.4	10958353.5	6593
bond	14	0	3	10712683	14043		16	modernization	544110.008	55889.4088	2988
federal	11	0	0	10597354.94	15740		17	modernization	1790899.31	204976.44	
federal	20	0	0	10428133	13933		18	modernization	0	0	
federal	5	0	0	10193597.9	13981		19	bridge-mod	15077225.4	5062438.71	6856

Proj Costs Mod and Pres

Paste the input from the *Project Costs* tab into the yellow-shaded cells on the *Proj Costs Mod and Pres* tab. The project costs data are used to determine the share of preservation and modernization project expenditures by funding source on the *Split Non-Construction* tab.



	A	B	C	D
1	Studded Tires Adjustment for PE and ROW Split			
2				
3	Studded Tire Damage	14,373,893		From Ta
4	Engineering %	9.26%		Base Li
5	Construction %	90.74%		
6				
7	Construction $	13,042,948		
8	Engineering $	1,330,945		Year
9				2001
10	Engineering % State	33.65%		2002
11	State Engineering $	447,863		2003
12	Fed Engineering $	883,082		2004
13				2005
14	% State	10.27%		
15	State Construction $	1,339,511		
16	Fed Construction $	11,703,437		"Studde
17				
18				Table 5...
19				Base
20	State $	1,787,374		life
21	Fed $	12,586,518		1995
22				1996

Studded Tires

The *Studded Tires* tab contains the studded tire related cost breakdown used to adjust the preservation and modernization project costs for the PE and ROW split. Data from the *Studded Tires in Oregon* Study are used to adjust the preservation and modernization costs for studded tire damage. No user input is necessarily required on this tab, however the funding shares and amount can be adjusted if new data or information is available (yellow-shaded cells).

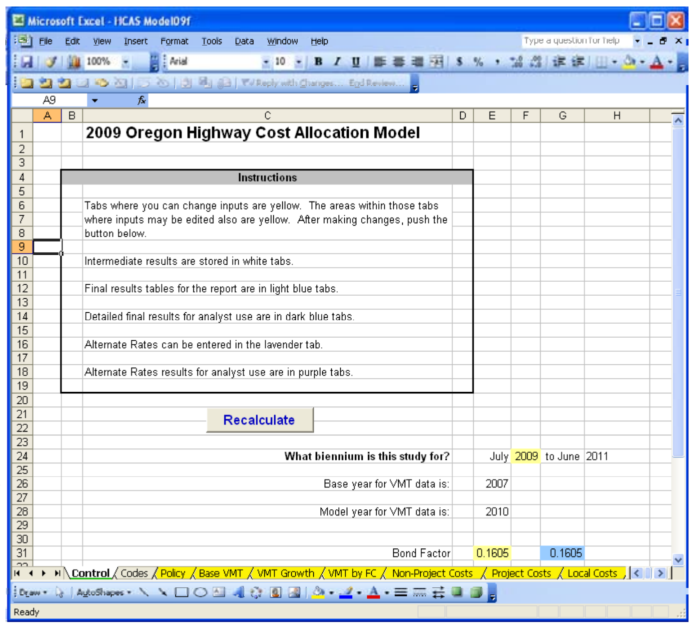
Tab-by-Tab Explanation of HCAS Model

This section provides a tab-by-tab explanation of the tabs in the HCAS Model. Following the tab-by-tab explanation of the input tabs is the description of how to “recalculate” the model, audit the model output, and then a tab-by-tab explanation of the intermediate output tabs and the result tabs.

After updating the data and assumptions in the input tabs, check that the named ranges in the HCAS model workbook are defined to include the full range of input data. To view and change a named range, go to the ‘Insert’ menu, ‘Name’, ‘Define’, select the named range and then review and change (if necessary) the “Refers to” cell references.

Excel Macros must be enabled to recalculate the model. To enable Excel Macros, a message should appear when opening the Excel workbook asking whether to open with macros enabled. If this message does not appear, or it is unclear whether macros are enabled, in the Excel workbook, go to ‘Tools,’ ‘Options’, click the ‘Security’ tab, and under ‘Macro Security’, select ‘Medium’ and click okay. Exit Excel and then open the HCAS Model. The next time the model workbook is opened the enable macro message should appear.

Control



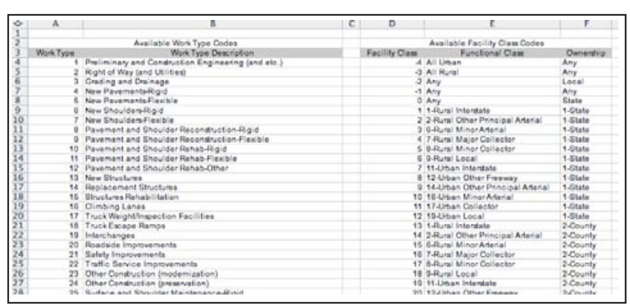
The *Control* tab contains the “Recalculate” button, which will run the HCAS model. The “Recalculate” button calls the Excel VBA Module (macro), which captures the input data from the HCAS Model workbook and then calls the HCASModule (Python) to perform the model calculations.

Enter the biennium study period and the bond factor in the *Control* tab.

To update the study biennium, enter the first year of the biennium in the yellow-shaded cell following the question *“What biennium is this study for?”* The biennium start year should be the calendar year for the first year of the biennium.

Enter the bond factor in the yellow-shaded cell next to the bond factor label. The bond factor can be calculated using Excel’s “PMT” function in the blue-shaded cell and then be pasted into the yellow-shaded bond factor cell. The bond factor should be the share of payments on bond expenditures in this biennium paid in this biennium.

The Excel PMT function calculates the bond loan payment based on the assumptions of constant repayment periods and a constant interest rate. In the 2009 HCAS and previous HCAS studies, the bond factor has been calculated using a repayment period of 20 years and an interest rate of 5%. The bond factor is used in the model to calculate the portion of bond expenditures allocated to the current study.



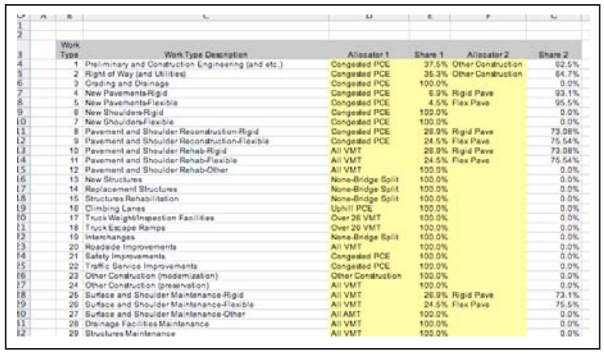
Codes

The *Codes* tab contains the lookup codes with their descriptive names for the project

Work Type, Facility Class and Available Bridge Types (top three tables) and the Summary Work types and Summary Weight Classes (below the Work Types and Facility Class tables). The Summary Work Types and the Summary Weight Class lookup tables are used by the model to aggregate the costs to allocate and allocated costs in the intermediate output tables.

The user should refer the to the tables in the *Codes* tab to lookup the description corresponding to a numeric code and also to determine the valid range of codes for the work types, facility classes or bridge types in the user input tabs.

Policy



Work Type	Work Type Description	Allocator 1	Share 1	Allocator 2	Share 2
1	Preliminary and Construction Engineering (and etc.)	Congested PCE	37.5%	Other Construction	62.5%
2	Right of Way (and Utilities)	Congested PCE	35.3%	Other Construction	64.7%
3	Grading and Drainage	Congested PCE	100.0%		0.0%
4	New Pavements-Rigid	Congested PCE	6.9%	Rigid Pave	93.1%
5	New Pavements-Flexible	Congested PCE	4.5%	Flex Pave	95.5%
6	New Shoulders-Rigid	Congested PCE	100.0%		0.0%
7	New Shoulders-Flexible	Congested PCE	100.0%		0.0%
8	Pavement and Shoulder Reconstruction-Rigid	Congested PCE	26.9%	Rigid Pave	73.08%
9	Pavement and Shoulder Reconstruction-Flexible	Congested PCE	24.5%	Flex Pave	75.54%
10	Pavement and Shoulder Rehab-Rigid	All VMT	26.9%	Rigid Pave	73.08%
11	Pavement and Shoulder Rehab-Flexible	All VMT	24.5%	Flex Pave	75.54%
12	Pavement and Shoulder Rehab-Other	All VMT	100.0%		0.0%
13	New Structures	None-Bridge Split	100.0%		0.0%
14	Replacement Structures	None-Bridge Split	100.0%		0.0%
15	Structures Rehabilitation	None-Bridge Split	100.0%		0.0%
16	Climbing Lanes	Uphill PCE	100.0%		0.0%
17	Truck Weight/Inspection Facilities	Over 26 VMT	100.0%		0.0%
18	Truck Escape Ramps	Over 26 VMT	100.0%		0.0%
19	Interchanges	None-Bridge Split	100.0%		0.0%
20	Roadside Improvements	All VMT	100.0%		0.0%
21	Safety Improvements	Congested PCE	100.0%		0.0%
22	Traffic Service Improvements	Congested PCE	100.0%		0.0%
23	Other Construction (modernization)	Other Construction	100.0%		0.0%
24	Other Construction (preservation)	All VMT	100.0%		0.0%
25	Surface and Shoulder Maintenance-Rigid	All VMT	26.9%	Rigid Pave	73.1%
26	Surface and Shoulder Maintenance-Flexible	All VMT	24.5%	Flex Pave	75.5%
27	Surface and Shoulder Maintenance-Other	All AMT	100.0%		0.0%
28	Drainage Facilities Maintenance	All VMT	100.0%		0.0%
29	Structures Maintenance	All VMT	100.0%		0.0%

The *Policy* tab contains the allocator or allocators applied to each work type. The user may change the yellow-shaded cells in the work type-allocator table for the allocator name and the allocator share for each work type. Available allocators are listed to the right of the main table. Note that all allocators must be entered exactly as shown (spaces, spelling, etc.) for the model to function properly; the user should copy and paste allocator names into the yellow-shaded allocator name columns to avoid errors.

The user can enter the allocator share (enter a value in percent between 0 percent and 100 percent) for the first allocator, the percentage for a second allocator is automatically calculated as 100 percent minus the percentage for the first allocator. Do not change this; the allocator percentages must add to exactly 100 percent.

The Preliminary and Construction Engineering and Right of Way allocators are updated using the calculations from the supplemental Split PE and ROW workbook. Pavement work type allocators are from the pavement factors developed by RD Mingo and Associates.

Base VMT

The *Base VMT* tab contains the base year VMT by weight class and vehicle tax class. The *Base VMT* tab is linked to the *Base VMT* supplemental workbook. Once the Base VMT workbook has been updated, update the linked data when prompted when opening the HCAS model workbook. The linked data can also be updated by going to the *Edit* menu, choosing *Links*, and then clicking *Update Values* for the Base VMT workbook link.

The WMT evasion factor,[4] adjusts the WMT VMT to account for the additional VMT not reported for WMT payments. The WMT VMT evasion factor is applied to the VMT for WMT vehicle classes in this tab. The WMT evasion rate is a user-specified assumption located on the *Revenue* tab.

The base VMT are used in the HCAS model to calculate the model year VMT. The VMT are used to allocate costs and attribute revenues by vehicle tax and weight class.

VMT Growth

The VMT growth rates are calculated from the change in VMT from the base year to the forecast year in the ODOT Economic and Revenue Forecast. The June Economic and Revenue Forecast has typically been used in the previous HCAS studies, however the ODOT Transportation Forecast is usually produced twice a year. To update the growth

[4] WMT Evasion factor is calculated as one divided by one minus the WMT evasion percent. (1/(1-WMT Evasion)

Oregon Transportation Economic and Revenue Forecast
Table 1. FSB-Method Estimation of Statewide VMT - Forecasts CY2008-2010
Dec-08

	Year	Light Vehicles /1	Annual % Change	Med Heavy /2	Annual % Change	Heavy /3	Annual % Change	Total	Annual % Change
	2003	33,675,350,270	-	578,634,515	-	1,833,137,935	-	36,087,122,720	-
	2004	33,828,433,833	0.45%	602,321,904	4.1%	1,885,148,472	2.84%	36,315,904,009	0.6%
	2005	34,288,770,342	1.36%	615,515,525	2.2%	1,983,676,146	5.23%	36,887,962,012	1.6%
	2006	34,717,242,807	1.25%	632,405,087	2.3%	2,006,490,550	1.15%	37,353,575,732	1.3%
Base Year:	**2007**	**34,579,899,291**	**-0.40%**	**646,317,978**	**2.2%**	**1,959,608,476**	**-2.34%**	**37,185,825,745**	**-0.4%**
	2008	34,470,159,593	-0.30%	643,086,388	-0.50%	1,957,648,867	-0.10%	37,070,894,849	-0.3%
	2009	33,372,922,486	-3.20%	675,240,707	5.00%	1,846,062,882	-5.70%	35,894,226,076	-3.2%
Forecast Year:	**2010**	**34,207,245,548**	**2.50%**	**692,121,725**	**2.5%**	**1,942,058,152**	**5.20%**	**36,841,425,425**	**2.6%**

1 Based on taxable motor fuels consumption
2 Based on a new prototype framework for medium heavy vehicle stock and fuel consumption
3 Based on HUS for 2007.

rates, paste the ODOT Economic and Revenue Forecast VMT into the yellow-shaded cells under the table titled 'Oregon Transportation Economic and Revenue Forecast' so that the base year and forecast year match the 'base year' and 'forecast year' row names to the left of the year column. The compound VMT growth rates are automatically calculated for light, medium-heavy and heavy vehicle classes below the VMT forecast table. In the middle of the tab, the 'Target Growth Rates' for the three vehicle class groups are automatically set to the new compound growth rates.

On the far left-hand side of the tab, the VMT growth rates by weight class for the basic and medium vehicle classes are set equal to their calculated compound vehicle class growth rates.

Weight Class	Growth Rate
1	-0.36%
10,001	2.31%
12,001	2.31%
14,001	2.31%
16,001	2.31%
18,001	2.31%
20,001	2.31%
22,001	2.31%
24,001	2.31%
26,001	-0.600%
28,001	-0.600%
30,001	-2.000%
32,001	2.100%
34,001	-3.800%
36,001	-7.800%
38,001	-4.350%
40,001	-4.350%
42,001	-13.000%
44,001	-7.650%
46,001	-1.650%
48,001	-1.650%
50,001	-0.400%
52,001	1.200%
54,001	3.300%
56,001	3.050%
58,001	0.500%
60,001	1.200%
62,001	-1.800%
64,001	0.900%
66,001	-6.650%
68,001	0.500%
70,001	2.300%
72,001	-2.100%

VMT Growth Rates by Weight Class

Target rate		Group average rate
-0.36%	basic	-0.36%
2.31%	medium	2.31%
-0.30%	heavy	-0.30%

Also on the far left-hand side of the tab, the heavy vehicle growth rates in the yellow-shaded cells should be adjusted such that the total heavy vehicle VMT growth rate matches the target VMT growth rate, however variation still exists across the weight classes within the heavy vehicles. In past studies an expert from ODOT familiar with heavy vehicles in Oregon has made adjustments to the VMT growth rates for the heavy vehicles (vehicles 26,001 pounds and up). Small modifications in the VMT growth rates for the 78,001 and the 104,001 weight classes will have the greatest impact on the total heavy vehicle group VMT growth rate since a majority of the heavy vehicle VMT are in these two weight classes.

Since the group adjusted growth rates are calculated using the base year VMT, the heavy vehicle class growth rates should not be adjusted until the Base VMT workbook has been completely updated and the HCAS Model workbook link to the Base VMT workbook data has been updated.

The VMT growth rates by weight class are applied to the base VMT data to calculate the model year VMT.

VMT by FC

The *VMT by FC* tab calculates VMT by functional system and ownership which is used in the model with the *Base VMT* and *VMT Growth* input to produce the output in the *Master VMT* tab.

VMT by Functional Class

Functional System	Ownership 1	2	4	5	6	7	8
1	4,381,281,515						
2	4,593,592,589	33,530,609					
6	1,685,112,881	374,449,038	6,587,654		0	1,176,165	
7	639,563,317	1,350,150,364	32,219,004	0		43,904,708	
8	0	0	0	0		0	
9	0	0	0	0	0	0	0
11	4,574,672,020						
12	1,307,547,822	21,703,128	15,197,704				
14	3,929,768,573	309,696,733	1,013,991,432	3,771,034	0		
16	273,701,081	1,241,299,791	2,215,391,234		0		
17	0	717,121,129	1,604,969,387	2,402,564	0		
19	0	0	0	0	0	0	

Paste table from HPMS submission data into the yellow-shade cells above.

	RURAL							URBAN			
STATE	INTERSTATE	OTHER PRINCIPAL ARTERIAL	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR	LOCAL	TOTAL	INTERSTATE	OTHER FREEWAYS AND EXPRESSWAYS	OTHER PRINCIPAL ARTERIAL	MINOR ARTERIAL
Oregon	4,381	4,710	2,068	2,067	611	1,410	15,247	4,576	1,344	5,140	3,[illegible]

Paste Oregon row from Table VM2 "Functional Travel System Travel 2007" from the Highway Statistics into the row above.
http://www.fhwa.dot.gov/policyinformation/statistics/2007/vm2.cfm

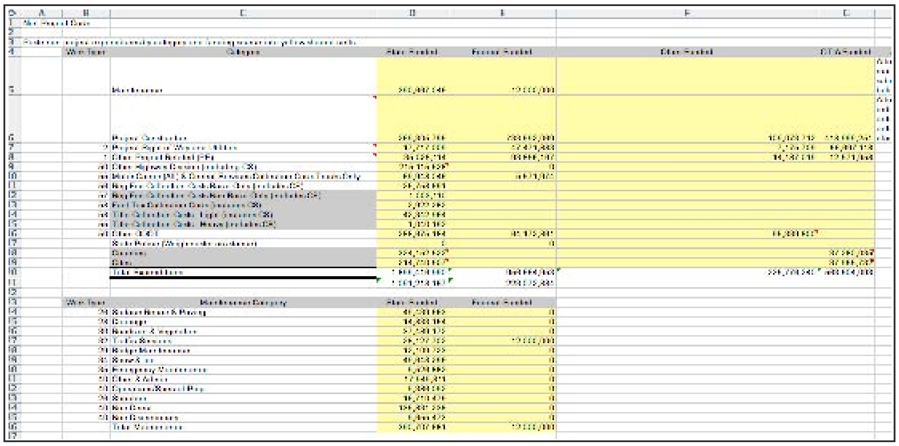
Two data sources are used to update the input on this tab: Oregon's Highway Performance Monitoring System (HPMS) submission data and data from the annual Federal Highway Administration (FHWA) *Highway Statistics* report.

The Oregon HPMS submission data corresponding to the base year are pre-processed outside of the HCAS Model. The summary table of VMT by functional system and ownership is pasted into the yellow-shaded cells in the table at the top of the *VMT by FC* tab.

The second data source needed to update the *VMT by FC* tab is the Oregon information from the FHWA *Highway Statistics* Report Table VM-2. Paste the Oregon row from Table VM-2 into the yellow-shaded cells in the middle row of the tab.

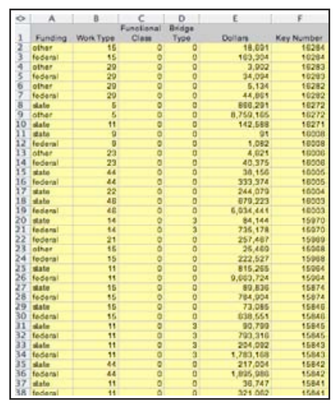
The input data are combined into a single table of VMT by functional system and ownership at the bottom right of the tab. This table is then used to create the column of VMT by facility class located at the bottom left of the tab.

Non-Project Costs



The *Non-Project Costs* tab contains the administrative and non-project related costs by funding source. The non-project costs are allocated to the vehicle weight classes in the model cost allocation calculations. *Non-Project Costs* tab include the DMV and Motor Carrier collection costs, right-of-way costs and preliminary engineering costs. Non-project maintenance costs are broken out by their specific maintenance work category. The data for the *Non-Project Costs* tab is based on ODOT's proposed budget. ODOT staff completes a worksheet with the same format as the yellow-shaded tables of the *Non-Project Costs* tab. When pasting the data into the yellow-shaded cells, it is important that the row and column headings match exactly since the non-project cost entries at the bottom of the tab are referenced by work type to the input data.

Project Costs

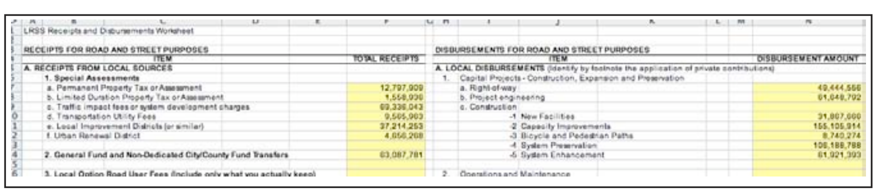


	A	B	C	D	E	F
1	Funding	Work Type	Functional Class	Bridge Type	Dollars	Key Number
2	other	15	0	0	18,091	16284
3	federal	15	0	0	163,304	16284
4	other	29	0	0	3,902	16283
5	federal	29	0	0	34,094	16283
6	other	29	0	0	5,134	16282
7	federal	29	0	0	44,861	16282
8	state	5	0	0	660,291	16272
9	other	5	0	0	8,759,165	16272
10	state	11	0	0	142,588	16271
11	state	9	0	0	91	16008
12	federal	9	0	0	1,082	16008
13	other	23	0	0	4,821	16006
14	federal	23	0	0	40,375	16006
15	state	44	0	0	38,156	16005
16	federal	44	0	0	333,374	16005
17	state	22	0	0	244,079	16004
18	state	46	0	0	679,223	16003
19	federal	46	0	0	6,034,441	16003
20	state	14	0	3	84,144	15970
21	federal	14	0	3	736,178	15970
22	federal	21	0	0	257,487	15969
23	other	15	0	0	26,460	15968
24	federal	15	0	0	222,527	15968
25	state	11	0	0	815,265	15964
26	federal	11	0	0	9,063,724	15964
27	state	15	0	0	89,836	15874
28	federal	15	0	0	784,904	15874
29	state	15	0	0	73,085	15846
30	federal	15	0	0	638,551	15846
31	state	11	0	3	90,799	15845
32	federal	11	0	3	793,316	15845
33	state	11	0	3	204,092	15843
34	federal	11	0	3	1,783,168	15843
35	state	44	0	0	217,004	15842
36	federal	44	0	0	1,895,986	15842
37	state	11	0	0	36,747	15841
38	federal	11	0	0	321,062	15841

The *Project Costs* tab contains the project costs for the biennium, which are allocated to vehicle classes in the cost allocation procedure in the model.

Project expenditures are broken out by their funding source, work type and bridge type (if applicable). Only one functional system is assigned to the project, however the project may have up to four (federal, state, local, bond) funding sources, three work types (see work type codes on the *Codes* tab) and three bridge types, which correspond to the work types (bridge types are also listed on the *Codes* tab). Thus, a single project may be listed multiple times in the *Project Costs* tab, once for each possible funding source, work type, and bridge type combination. The user can change the *Project Costs* input data by pasting project expenditures into the yellow-shaded cells. The model ignores entries in the memo column and stops reading data at the first empty row, so be sure eliminate spaces between entries.

Local Costs



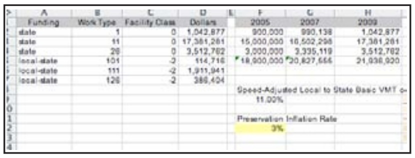
LRSS Receipts and Disbursements Worksheet

RECEIPTS FOR ROAD AND STREET PURPOSES ITEM	TOTAL RECEIPTS	DISBURSEMENTS FOR ROAD AND STREET PURPOSES ITEM	DISBURSEMENT AMOUNT
A. RECEIPTS FROM LOCAL SOURCES		A. LOCAL DISBURSEMENTS (identify by footnote the application of private contributions)	
1. Special Assessments		1. Capital Projects - Construction, Expansion and Preservation	
a. Permanent Property Tax or Assessment	12,797,909	a. Right-of-way	49,444,556
b. Limited Duration Property Tax or Assessment	1,558,930	b. Project engineering	61,049,792
c. Traffic impact fees or system development charges	69,336,043	c. Construction	
d. Transportation Utility Fees	9,505,903	-1 New Facilities	31,807,660
e. Local Improvement Districts (or similar)	37,214,253	-2 Capacity Improvements	155,105,914
f. Urban Renewal District	4,656,268	-3 Bicycle and Pedestrian Paths	8,740,274
		-4 System Preservation	106,188,788
2. General Fund and Non-Dedicated City/County Fund Transfers	63,087,781	-5 System Enhancement	61,921,393
3. Local Option Road User Fees (include only what you actually keep)		2. Operations and Maintenance	

The *Local Costs* tab contains the local agency expenditures by project work type, facility class, and bridge type. The Local Roads and Streets Survey (LRSS) Receipts and Disbursements data are used to update the *Local Costs* tab. The LRSS data should be pasted in the yellow-shaded cells on the *Local Costs* tab. Make sure that the LRSS data are pasted into the correct rows since the calculations refer to specific cells for the different expenditure types.

Once the LRSS data are pasted into the *Local Costs* tab, calculations are performed to remove the non-fungible local revenue sources from the expenditures and then sum the remaining expenditures by HCAS work type. The *Local Cost* tab calculations automatically update the local costs table at the bottom of the *Local Costs* tab.

Studded Tires



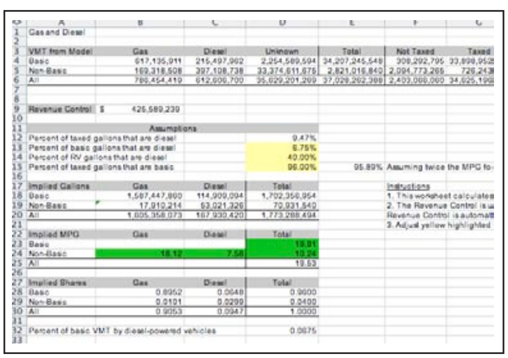
The *Studded Tire* tab contains the state and local studded tire related expenditures.

The top right table on the *Studded Tire* tab contains the state studded tire costs from the 2005, 2007, and 2009 studies. Issue paper 5 from the 2005 HCAS study explains the studded tire cost approach developed for the 2005 HCAS. The 2005 HCAS studded tire costs have been updated in subsequent studies by adjusting the studded tire costs for inflation (the general increase in the cost of the preservation work) and the increase in studded tire damage, which is approximated using the basic vehicle VMT growth rate.

The inflation rate is a user specified assumption in a yellow-shaded cell labeled “Preservation Inflation Rate.” Past studies have assumed a three percent inflation rate. The basic vehicle VMT growth rate from the *VMT Growth* tab is automatically applied to the previous study studded tire costs along with the inflation rate.

Local studded tire costs are estimated from the state studded tire costs using the share of basic VMT on local roads compared to basic VMT on state roads. The Speed-Adjusted Local to State Basic VMT on Urban Principal Arterials is applied to the state studded tire expenditures to calculate the local expenditures for each studded tire related work type. The speed-adjusted local to state basic VMT should not change much between studies. If the user chooses to update this assumption, the *VMT Master* tab containing the VMT by functional class and ownership by weight class can be used to update this assumption.

Gas and Diesel



The *Gas and Diesel* tab uses the VMT from the *Base VMT* tab and the *VMT Growth* tab rates to determine VMT in the model year for gas and diesel vehicles. The VMT and user-specified assumptions are used to determine the implied gallons and implied MPG for basic and non-basic vehicle classes. These estimates are then used to derive the percent of basic VMT by diesel-powered vehicles, an input in the *Revenues* tab.

Below the VMT table is the Revenue Control, which is the average annual gas and diesel tax revenues. Gas tax revenues and diesel tax revenues from the *Revenues* tab are added and divided by two to calculate the average annual revenue. Revenue Control is divided by the gas/diesel tax rate per gallon to calculate the total implied gallons.

Percent of taxed gallons that are diesel, the first entry in the Assumptions table, is calculated from the gas and diesel tax revenues from the *Revenues* tab. Diesel tax revenues are divided by total gas and diesel tax revenues to derive the percent of fuel tax revenues from diesel fuel.

Once the base VMT, VMT Growth rates and revenue totals have been updated, adjust the yellow-shaded assumptions until the green-highlighted implied MPG are reasonable for their corresponding vehicle class. Reasonable MPG is around twenty for basic vehicles and about ten for non-basic vehicles, with the gas MPG higher than the diesel MPG.

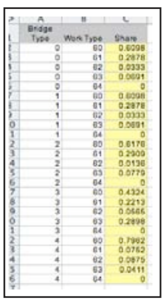
The yellow-shaded assumptions are: percent of basic gallons that are diesel, percent of RV gallons that are diesel, and percent of taxed gallons that are basic. The user should adjust these assumptions using the values specified in the previous study as starting points.

- The percent of basic gallons that are diesel should be entered as a percent; a reasonable value would be within the range of five to eight percent.
- The percent of RV gallons that are diesel should be entered as a percent. A reasonable range for this assumption would be between 30 and 60 percent.
- The percent of taxed gallons that are basic is entered as a percent, and should be roughly equal to the taxed basic VMT divided by total taxed VMT plus total taxed non-basic VMT (assume basic vehicles have roughly twice the fuel efficiency of non-basic vehicles).

The ranges for each of these user-specified rates are only guidelines; the objective should be reasonable MPG estimates.

The percent of basic VMT by diesel-powered vehicles, the bottom line on the tab, adjusts as the implied shares for gas and diesel-powered vehicles changes. The percent of basic VMT by diesel-powered vehicles is referenced by the *Revenues* tab and is used to attribute fuel tax revenues.

Bridge Splits

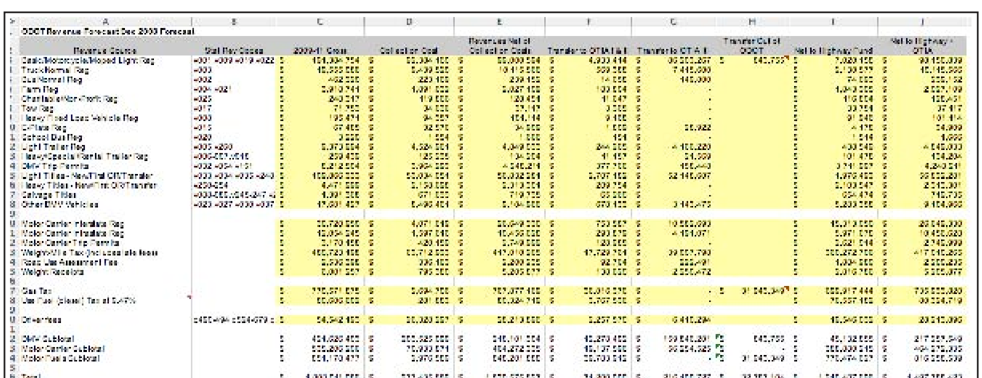


Bridge Type	Work Type	Share
0	60	0.6098
0	61	0.2878
0	62	0.0333
0	63	0.0691
0	64	0
1	60	0.6098
1	61	0.2878
1	62	0.0333
1	63	0.0691
1	64	0
2	60	0.6176
2	61	0.2909
2	62	0.0136
2	63	0.0779
2	64	0
3	60	0.4324
3	61	0.2213
3	62	0.0566
3	63	0.2898
3	64	0
4	60	0.7962
4	61	0.0752
4	62	0.0875
4	63	0.0411
4	64	0

The *Bridge Splits* tab contains the split of the bridge costs for the incremental allocation of bridge project expenditures. The available bridge types and the bridge reclassification work types are listed on the *Codes* tab.

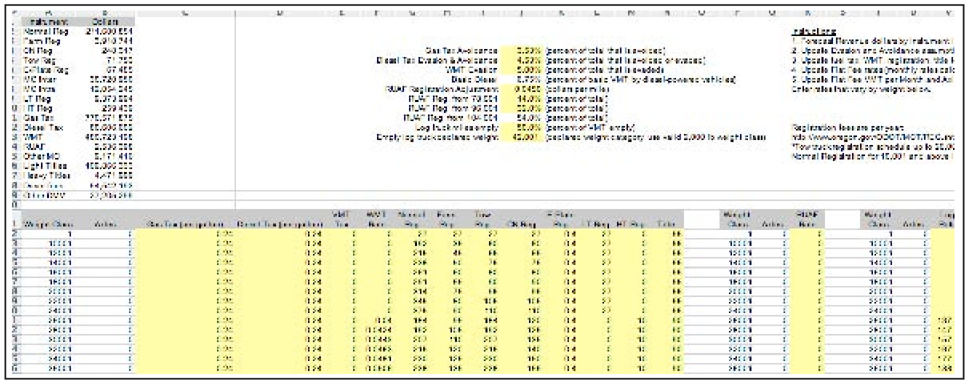
Work types 60 through 65 are designated bridge reclassification codes for splitting the bridge project expenditures. Expenditures entered for bridge projects work types (work types 13, 14, 15, 16, 19, or 68) in the *Project Costs* tab are reclassified using their bridge type and work type into work types 60 through 65. This bridge splits are used by the model for the incremental bridge cost allocation approach used in the study. The user can adjust the share for each bridge type and work type, such that the sum of the shares by bridge type total one.

Rev Forecast



The ODOT Revenue Forecast (total revenue dollars) by revenue source for the study period should be pasted into the yellow-shaded cells on the *Rev Forecast* tab. The ODOT Revenue Forecast is provided by the Financial and Economics Analysis Unit, of the ODOT Financial Services Branch. Make sure the row and column headings in the tab correspond to the new data when pasting the new revenue forecast into the yellow-shaded cells since the revenues by revenue sources will automatically calculate the revenue control totals in the top left of the *Revenues* tab.

Revenues



The *Revenues* tab contains three different sets of input used in the revenue attribution calculations: revenue control totals, evasion rates, and the revenue instrument rates (tax rates and fees).

	A	B
1	Instrument	Dollars
2	Normal Reg	211,600,851
3	Farm Reg	3,918,741
4	CN Reg	248,317
5	Tow Reg	71,753
6	E-Plate Reg	67,485
7	MC Inter	30,720,950
8	MC Intra	12,054,245
9	LT Reg	9,373,994
10	HT Reg	259,439
11	Gas Tax	770,571,875
12	Diesel Tax	80,606,602
13	WMT	480,723,198
14	RUAF	2,536,398
15	Other MC	9,171,416
16	Light Titles	109,866,333
17	Heavy Titles	4,471,999
18	Driver fees	54,542,193
19	Other DMV	27,205,299

The revenue control totals, at the top left of the *Revenues* tab, are updated by the data on the *Rev Forecast* tab. The revenue control totals are used to attribute revenues to the vehicle classes. The Registration Fee revenues and the Other MC revenue totals are set equal to the control totals in the revenue attribution calculations, while the other revenue instrument revenue totals are calculated using the revenue rates and VMT calculations. 'Driver Fees' and 'Other DMV' revenues are displayed on the *Revenues* tab, but are not included in the HCAS Model since revenue from these sources do not go into the State Highway Fund (i.e. the named range *RevenueTotals* should not include the last two cells of the revenue control input).

The evasion assumptions, located in the center of the top portion of the *Revenues* tab, are the user-specified assumptions for the gas, diesel and WMT avoidance or evasion rates; the percent of basic VMT by diesel-fueled vehicles (calculated in the *Gas and Diesel* tab); the RUAF registration revenue allocation; and empty log truck miles and weight.

Gas Tax Avoidance	3.53%	(percent of total that is avoided)
Diesel Tax Evasion & Avoidance	4.53%	(percent of total that is avoided or evaded)
WMT Evasion	5.00%	(percent of total that is evaded)
Basic Diesel	6.75%	(percent of basic VMT by diesel-powered vehicles)
RUAF Registration Adjustment	0.0450	(dollars per mile)
RUAF Reg. from 78,001	14.0%	(percent of total)
RUAF Reg. from 96,001	32.0%	(percent of total)
RUAF Reg. from 104,001	54.0%	(percent of total)
Log truck miles empty	50.0%	(percent of VMT empty)
Empty log truck declared weight	42,001	(declared weight category, use valid 2,000 lb weight class)

The gas tax avoidance rate and the diesel tax avoidance/evasion rate are both expressed as the percent of total taxable VMT that avoids the gas tax by purchasing fuel out-of-state. The avoidance/evasion rates are applied to their respective gas and diesel VMT to calculate gas and diesel tax revenues. Change this assumption by entering a percentage in the yellow-shaded evasion cells.

Similarly, the WMT tax evasion rate is expressed as the percent of total WMT VMT that evades the WMT tax. The WMT evasion rate is applied to WMT vehicle class VMT to calculate WMT tax revenues. The WMT evasion rate is also used to adjust the WMT Base VMT in the *Base VMT* tab since the Base VMT data are calculated from the WMT tax collection reports. Change the WMT evasion rate by entering a percentage in the yellow-shaded WMT evasion cell.

The Basic Diesel assumption is not a yellow-shaded assumption since this cell is linked to the calculated value in the *Gas and Diesel* tab. The percent of basic VMT by diesel-powered vehicles is used to split basic vehicle VMT into gasoline-powered VMT and diesel-powered VMT for the calculation of gasoline and diesel tax revenues.

Road Use Assessment Fee (RUAF) vehicles are credited with a portion of the heavy vehicle registration revenues using the RUAF Reg assumptions. The first RUAF Reg assumption is the RUAF Reg adjustment in dollars per mile. This assumption is the registration revenue dollars per RUAF mile credited to the RUAF vehicles class. The next three RUAF Reg assumptions allocate the RUAF registration revenue across three RUAF vehicle weight groups by specifying the portion of RUAF vehicles, which register at three different registration weight classes. Since the total of these three assumptions must equal 100 percent, the percent of total for ‘RUAF Reg. from 104,001’ is calculated as 100 minus the values specified in ‘RUAF Reg. from 78,001’ and ‘RUAF Reg. from 96,001’. ‘RUAF Reg. 78,001’ and ‘RUAF Reg. 104,001’ must be entered as percentages in the yellow-shaded cells.

Two assumptions are used to adjust the log truck VMT for the “as if” WMT revenue calculations. The ‘Log truck miles empty’ assumption specifies the percent of log truck VMT without a load (empty) and the ‘Empty log truck declared weight’ is the weight class the empty log truck VMT are assigned (enter a valid HCAS vehicle weight class). Log truck VMT in the flat fee reports should be reported using the loaded weight. Since log haulers are allowed to use a lower declared weight when their trailer is empty and stowed above the tractor unit, the log truck VMT must be adjusted to take into account the empty VMT at the lower weight class for calculation of the as-if WMT tax revenues.

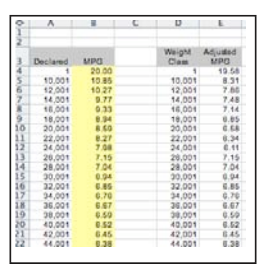
The tax and fee rates for the revenue instruments are located in the yellow-shaded cells at the bottom of the *Revenues* tab. Each of the revenue rates is used with its corresponding vehicle tax class VMT to calculate or attribute revenues to the vehicle classes. The current law rates can be found in the Revised Oregon Statutes or obtained from ODOT publications.

- The gas and diesel tax rates are entered as dollars per gallon.
- The VMT tax, WMT tax, and RUAF rates are entered as dollars per mile. Oregon does not currently have a VMT tax so rates are entered as zero for this instrument. The WMT tax and RUAF will vary by weight class and should be entered following the WMT tables or by calculating the weight class rate using the mid-point weight for the weight class.
- Registration fees are entered as dollars per year. Take the two-year registration fee and divide by two to “annualize” the registration fee. The Normal Reg is the passenger vehicle registration fee for basic vehicles and the heavy vehicle registration fee table for vehicles 10,001 pounds and greater.
- Public vehicles are required to pay a one-time registration fee of $2. The E-Plate Reg fee is set to 0.4 dollars per year, using the assumption that each public vehicle has a 5-year service life ($2 registration fee divided by 5 years equals $0.40 per year).
- The title fee is entered as dollars per transaction. The light vehicle title fee is used for weight classes 24,001 pounds and under, and the heavy vehicle title fee is used for weight classes 26,001 and greater.
- The annual Flat Fee rates per 100 pounds are converted to monthly rates for each weight class by dividing by 12 (months per year) and using the mid-point of the weight category to calculate the rate for the weight class. The Flat Fee monthly VMT and axle shares are tabulated in the Flat Fee VMT Axle workbook.

Alt Rates

The *Alt Rates* tab is described in the Alternative Rate Analysis User Guide in Section 6.

MPG



	A	B	C	D	E
1					
2					
3	Declared	MPG		Weight Class	Adjusted MPG
4	1	20.00		1	19.58
5	10,001	10.85		10,001	8.31
6	12,001	10.27		12,001	7.80
7	14,001	9.77		14,001	7.48
8	16,001	9.33		16,001	7.14
9	18,001	8.94		18,001	6.85
10	20,001	8.60		20,001	6.58
11	22,001	8.27		22,001	6.34
12	24,001	7.98		24,001	6.11
13	26,001	7.15		26,001	7.15
14	28,001	7.04		28,001	7.04
15	30,001	6.94		30,001	6.94
16	32,001	6.85		32,001	6.85
17	34,001	6.76		34,001	6.76
18	36,001	6.67		36,001	6.67
19	38,001	6.59		38,001	6.59
20	40,001	6.52		40,001	6.52
21	42,001	6.45		42,001	6.45
22	44,001	6.38		44,001	6.38

The *MPG* tab contains the MPG assumptions by declared weight class and the adjusted MPG by weight class.

The assumed MPG values in the yellow-shaded cells were derived from a regression analysis of the Vehicle Inventory and Use Statistics (VIUS) 2002 data (U.S. Census Bureau). VIUS data collection was discontinued after 2002. The MPG assumptions by weight class can be updated when better information or data on MPG by weight class becomes available; however no standardized method for updating this tab has been developed.

The assumed MPG are used in the initial allocation of fuel tax revenues by weight class in the model. Gasoline and diesel fuel tax revenues are attributed separately because the model allows for different tax rates and different evasion/ avoidance assumptions for the two fuel types. VMT by fuel type and weight class for fuel-tax paying vehicles are assembled and adjusted for evasion/avoidance. A preliminary attribution is made by dividing the adjusted VMT in each combination of weight class and fuel type by the assumed miles per gallon for that weight class from the *MPG* tab and multiplying the resulting number of gallons by the per-gallon rate for that fuel type. The attribution to vehicles between 10,001 and 26,000 lbs is then adjusted to bring those weight classes, as a group to equity (before considering subsidies). The revenue attributed to basic vehicles is adjusted so that the total revenue attributed equals the forecast revenues from the budget. The implied miles per gallon after adjustment for each weight class is calculated and sent back to Excel where it may be examined for reasonableness. Adjusted MPG is also a set of MPG values (by weight class) adjusted to account for the wide variation in VMT for 10,000-26,000 lb. vehicles. The reasons for using this approach are detailed in Issue Paper 6 of the 2007 HCAS.

Recalculating the Model

To recalculate the model, go to the *Control* tab and click the “Recalculate” button. Make sure that the Excel workbook macros are enabled and that the HCASModule.py has been registered. See the Technical Documentation in Appendix E for instructions on how to register the HCASModule file.

Auditing

Recalculating the model should take a few seconds. Once the model results have been recalculated there are several checks that can be performed to audit the model calculations.

After the model has successfully recalculated, first review the model results to check that the VMT, cost allocation, and revenue attribution in the intermediate and results tabs are reasonable.

The *Audit* tab has been added to the HCAS Model to facilitate the auditing of the input and model output data for the VMT, allocation vectors and costs. See the description of the *Audit* tab in the tab-by-tab explanation of the Model output tabs.

When auditing the model input and output the *Audit* tab allows for rounding errors. For example, the costs to allocate and allocated costs should be within a few dollars of each other. A discrepancy equal to the magnitude of biennial project expenditures would indicate that some of the costs to allocate (input) were not allocated in the model calculations. In this case, the user should review the project cost, non-project costs and local costs to see that funding, work types, functional system, and bridge types were correctly entered.

The following are the general checks that can be performed to audit the model output:

- Check that the Model VMT and Master VMT are consistent. Total Model VMT by weight class should equal the Master VMT for facility class zero (the facility class for any functional system, any owner).
- Check that the costs to allocate (the non-project costs, project costs and local costs data entered into the model by the user) are equal to the allocated costs from the model. If costs to allocate are different from the allocated costs go back to the non-project costs, project costs, and local costs tabs to check that all costs were entered with valid work types, funding sources, functional systems and bridge types.

- Check the reasonableness of the adjusted MPG rates compared to the initial assumed MPG by weight class on the *MPG* tab.
- Check to see if any pavement factors are listed as missing by reviewing the *missing_ pavement_factors* text file in the HCAS Model folder. If the *missing_pavement_factors* file does have missing pavement factors listed, check the pavement factors input file.
- *Attributed Revenues* for Registration fees and Other MC in the *Attributed Revenues* tab should equal their control totals from the *Revenues* tab.

Basic Troubleshooting

If nothing happens after clicking “Recalculate” button, or the Excel Visual Basic Editor opens after clicking “Recalculate,” check that Excel macros are enabled.

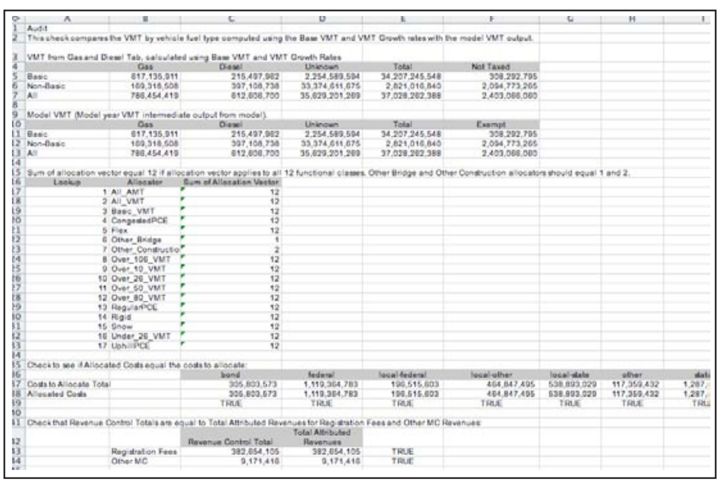
Invalid data or assumptions entered in input fields or a misspelled allocator can trigger an error, which will prevent the model from recalculating. Review all input data and make sure all named ranges in the HCAS Model workbook are properly defined and contain valid data.

Tab-by-Tab Explanation of Model Output

Recalculating the HCAS model will produce new output in the intermediate, results and report exhibit tabs.

Intermediate results can be found in the following tabs: *Audit*, *Model VMT, VMT Master, Allocated Costs by SWT, Costs to Allocate by SWT, Allocated Costs, Attributed Revenues, and Allocation Vectors*. Additional detailed output can be found in the model output text files in the HCAS Model folder.

Audit


Audit

This check compares the VMT by vehicle fuel type computed using the Base VMT and VMT Growth rates with the model VMT output.

VMT from Gas and Diesel Tab, calculated using Base VMT and VMT Growth Rates

	Gas	Diesel	Unknown	Total	Not Taxed
Basic	617,135,911	215,497,982	2,254,589,594	34,207,245,548	308,292,795
Non-Basic	169,318,508	397,108,738	33,374,611,675	2,821,016,840	2,094,773,265
All	786,454,419	612,606,700	35,629,201,269	37,028,262,388	2,403,066,060

Model VMT (Model year VMT intermediate output from model).

	Gas	Diesel	Unknown	Total	Exempt
Basic	617,135,911	215,497,982	2,254,589,594	34,207,245,548	308,292,795
Non-Basic	169,318,508	397,108,738	33,374,611,675	2,821,016,840	2,094,773,265
All	786,454,419	612,606,700	35,629,201,269	37,028,262,388	2,403,066,060

Sum of allocation vector equal 12 if allocation vector applies to all 12 functional classes. Other Bridge and Other Construction allocators should equal 1 and 2.

Lookup	Allocator	Sum of Allocation Vector
1	All_AMT	12
2	All_VMT	12
3	Basic_VMT	12
4	CongestedPCE	12
5	Flex	12
6	Other_Bridge	1
7	Other_Constructio	2
8	Over_105_VMT	12
9	Over_10_VMT	12
10	Over_26_VMT	12
11	Over_50_VMT	12
12	Over_80_VMT	12
13	RegularPCE	12
14	Rigid	12
15	Snow	12
16	Under_26_VMT	12
17	UphillPCE	12

Check to see if Allocated Costs equal the costs to allocate:

	bond	federal	local-federal	local-other	local-state	other	stat
Costs to Allocate Total	305,803,573	1,119,364,783	190,515,603	464,847,495	538,893,029	117,359,432	1,287,
Allocated Costs	305,803,573	1,119,364,783	190,515,603	464,847,495	538,893,029	117,359,432	1,287,
	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRU

Check that Revenue Control Totals are equal to Total Attributed Revenues for Registration Fees and Other MC Revenues:

	Revenue Control Total	Total Attributed Revenues	
Registration Fees	382,654,105	382,654,105	TRUE
Other MC	9,171,416	9,171,416	TRUE

The *Audit* tab compares the model input and output for the VMT, cost allocation, allocation vectors and revenue attribution for select revenue instruments. While the *Audit* tab is not a comprehensive validation of the model input and calculations, if the model data has been updated without any further code modifications, then the *Audit* tab will allow the user to check that the input data was processed and used in the model calculations correctly.

VMT Check The Gas and Diesel VMT calculated in the model workbook using the *Base VMT* and *VMT Growth* rates are compared to the same Gas and Diesel VMT table calculated from the output on the *Model VMT* tab.

VMT from the *VMT Master* tab and the *Model VMT* tab are compared in columns L through O to check that Model Year VMT totals by weight class are equal the VMT for all functional class/ownership in the *VMT Master* tab.

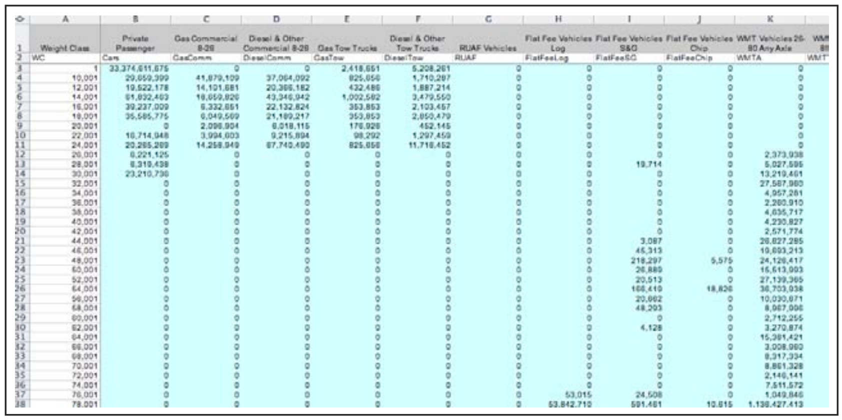
Allocation Vectors The allocation vectors should sum to 12 for allocators applied on all 12 functional systems and to another whole number if another type of allocator applied to limited number of functional systems. Check that the allocation vectors sum to a whole number and make sense given the type of allocator.

Costs to Allocate and Allocated Cost Check Check that the summarized costs to allocate are equal to the allocated costs by comparing the costs by summary work types. A discrepancy (of more than a few dollars) will likely indicate a data input error on the *Project Costs* tab.

Revenue Control Total Check Check that the registration fees and Other MC revenues are equal to their revenue control totals. These are the only two revenue instruments set to their control totals.

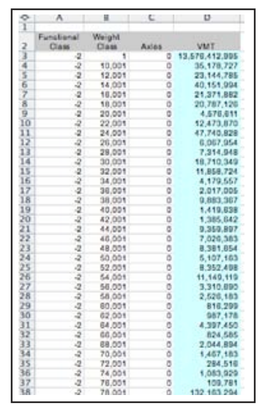
Model VMT

The *Model VMT* tab contains the intermediate output of projected VMT in the forecast year by vehicle weight class and vehicle tax class. This table is analogous to the Base VMT table but for the model year. The VMT growth rates are applied to the Base VMT to produce the Model VMT output.



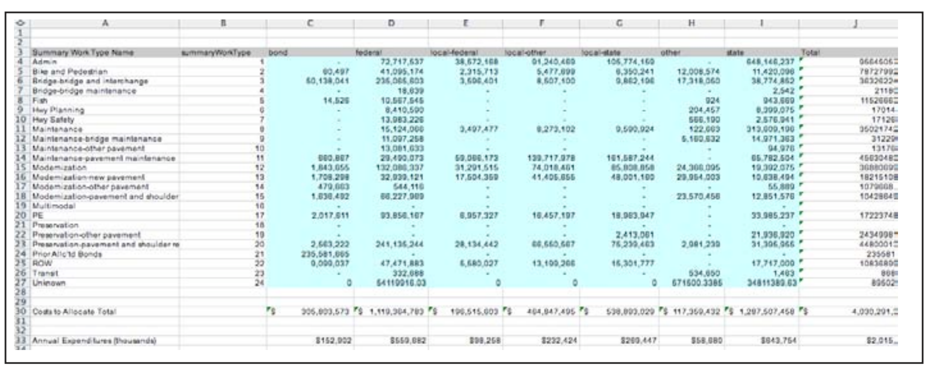
VMT Master

The V*MT Master* tab contains the output of the model year VMT by roadway system. The model VMT calculations use the Base VMT, VMT Growth Rates and VMT by FC input data to calculate VMT by roadway system and vehicle weight class. The *VMT Master* tab data are summarized in the *Equity* tab and *Alt Equity* tab and also used in the report exhibit tabs.

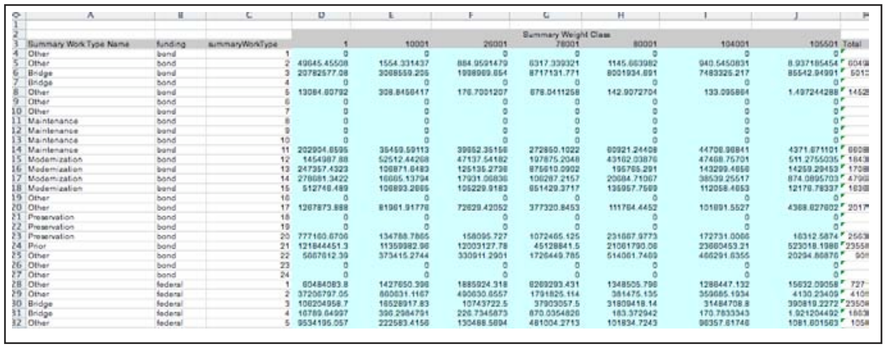


Costs to Allocate by SWT

The *Costs to Allocate by SWT* tab displays a summary table of the input data in the *Project Costs*, *Non-Project Costs* and *Local Costs* tabs by Summary Work Type. While the model combines the cost input data from the three tabs to produce this summary table, no other calculations are performed on the input data to produce the *Costs to Allocate by SWT*. The tabulated costs from all funding sources on the *Costs to Allocate by SWT* tab are compared with the output on the *Allocated Costs by SWT* tab to ensure that all input costs are allocated in the model calculations. The *Costs to Allocate by SWT* tab is also used to create the Final Report Chapter 4 exhibits.



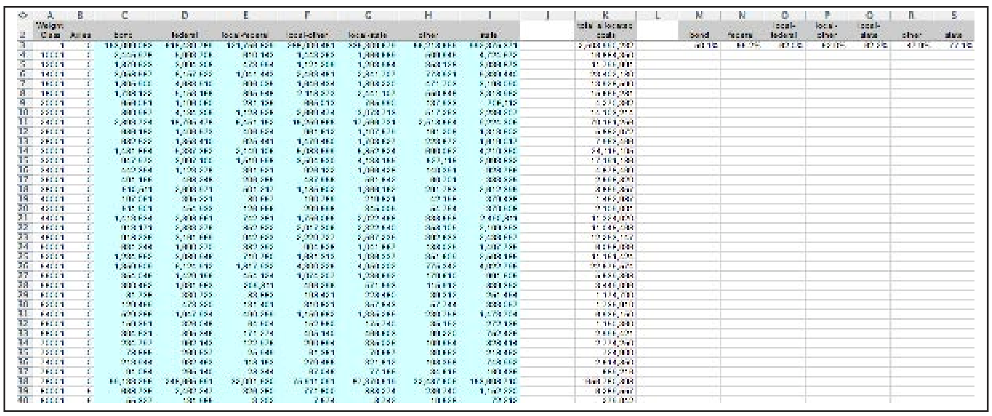
Allocated Costs by SWT



	A	B	C	D	E	F	G	H	I	J	K
1											
2				Summary Weight Class							
3	Summary Work Type Name	funding	summaryWorkType	1	10001	26001	78001	80001	104001	105501	Total
4	Other	bond	1	0	0	0	0	0	0	0	
5	Other	bond	2	49645.45508	1554.331437	884.9591479	6317.339321	1145.663982	940.5450831	8.937185454	6049
6	Bridge	bond	3	20782577.08	3098559.205	1998969.854	8717131.771	8001934.891	7483325.217	85542.94991	5013
7	Bridge	bond	4	0	0	0	0	0	0	0	
8	Other	bond	5	13084.80792	308.8458417	176.7001207	876.0411258	142.9072704	133.095884	1.497244288	1452
9	Other	bond	6	0	0	0	0	0	0	0	
10	Other	bond	7	0	0	0	0	0	0	0	
11	Maintenance	bond	8	0	0	0	0	0	0	0	
12	Maintenance	bond	9	0	0	0	0	0	0	0	
13	Maintenance	bond	10	0	0	0	0	0	0	0	
14	Maintenance	bond	11	202904.8595	39459.59113	39952.35156	272850.1022	80921.24408	44706.96841	4371.671101	6608
15	Modernization	bond	12	1454987.88	52512.44268	47137.54182	197875.2048	43162.03876	47468.75701	511.2755035	1843
16	Modernization	bond	13	247357.4323	106871.6483	125135.2738	875610.0902	195765.291	143299.4856	14259.29453	1708
17	Modernization	bond	14	278081.3422	16005.13794	17931.06836	106287.2157	20684.71067	38539.25517	874.0895703	4790
18	Modernization	bond	15	512746.489	106893.2865	105229.9183	851429.3717	135957.7569	112058.4853	12176.78337	1838
19	Other	bond	16	0	0	0	0	0	0	0	
20	Other	bond	17	1267873.888	81961.91776	72629.42052	377320.8453	111764.4452	101891.5527	4368.827602	2017
21	Preservation	bond	18	0	0	0	0	0	0	0	
22	Preservation	bond	19	0	0	0	0	0	0	0	
23	Preservation	bond	20	777160.0706	134788.7865	158095.727	1072465.125	231887.9773	172731.0066	18312.5874	2563
24	Prior	bond	21	121844451.3	11359982.96	12003127.78	45128841.5	21061790.06	23680453.21	523018.1986	23558
25	Other	bond	22	5887612.39	373415.2744	330911.2901	1726449.785	514061.7469	466291.6355	20294.86876	909
26	Other	bond	23	0	0	0	0	0	0	0	
27	Other	bond	24	0	0	0	0	0	0	0	
28	Other	federal	1	65484083.8	1427650.396	1885924.318	6269293.431	1348505.796	1286447.132	15632.09058	727
29	Other	federal	2	37206797.05	600031.1167	490630.6557	1791825.114	381475.135	359685.1934	4130.23409	410
30	Bridge	federal	3	108204958.7	16528917.83	10743722.5	37903057.5	31809418.14	31484708.8	390819.2272	23506
31	Bridge	federal	4	16789.64997	390.2984791	226.7345873	870.0354826	183.372942	170.7833343	1.921204492	1803
32	Other	federal	5	9534195.057	222583.4156	130488.5894	481004.2713	101834.7243	96357.61746	1081.601563	1058

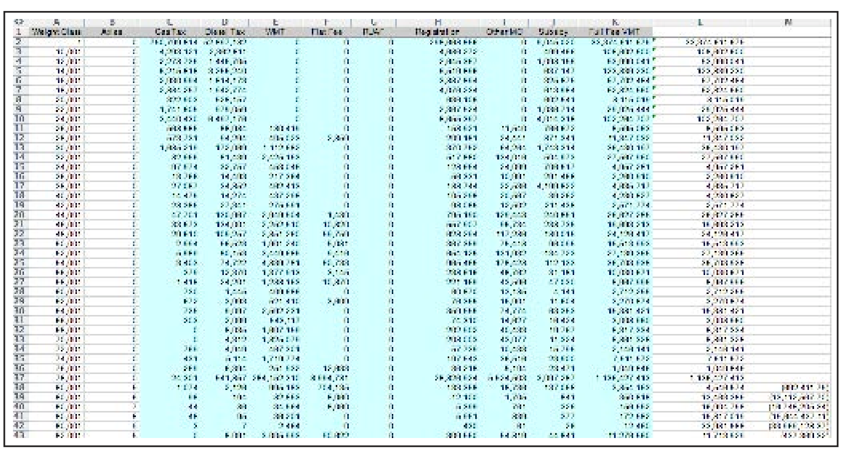
The *Allocated Costs by SWT* tab displays the model output of the allocated costs by summary work type, funding source and summary weight class. The allocated costs on this tab are the same allocated costs displayed in the *Allocated Costs* tab and in the *Allocated Cost* output text files. Whereas the *Allocated Costs* tab contains the allocated costs for every weight class, the *Allocated Costs by SWT* is a summary table for the purpose of creating the exhibits for Chapter 5 of the Final Report.

Allocated Costs



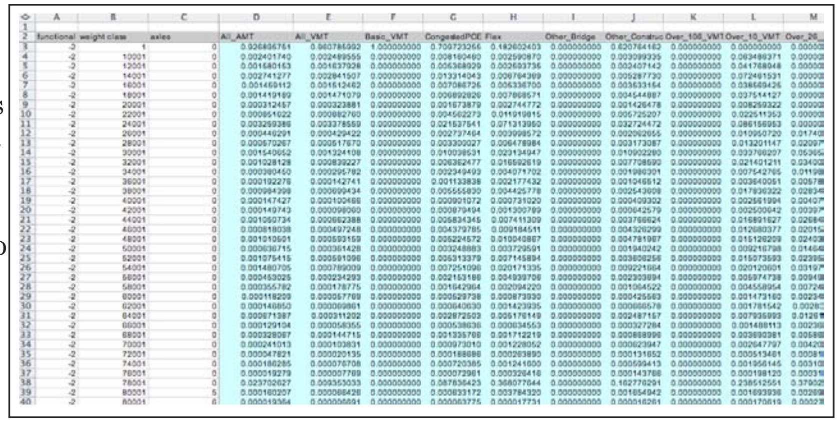
The *Allocated Costs* tab displays the costs allocated in the model for each funding source to each weight class and axle class. This tab does not contain any information on the work types of the allocated costs. The output on the *Allocated Costs* tab is used in the *Equity* tab and in the *Summary* tab to determine cost responsibility by weight class and user groups.

Attributed Revenues



The *Attributed Revenues* tab displays the attributed user fees by major revenue source for each weight and axle class. The revenue totals are calculated in the Attribute Revenues calculations in the model. The output on the *Attributed Revenues* tab is used in the *Equity* tab and *Summary* tab to determine each vehicle class annual user fees and share of revenues.

Allocation Vectors

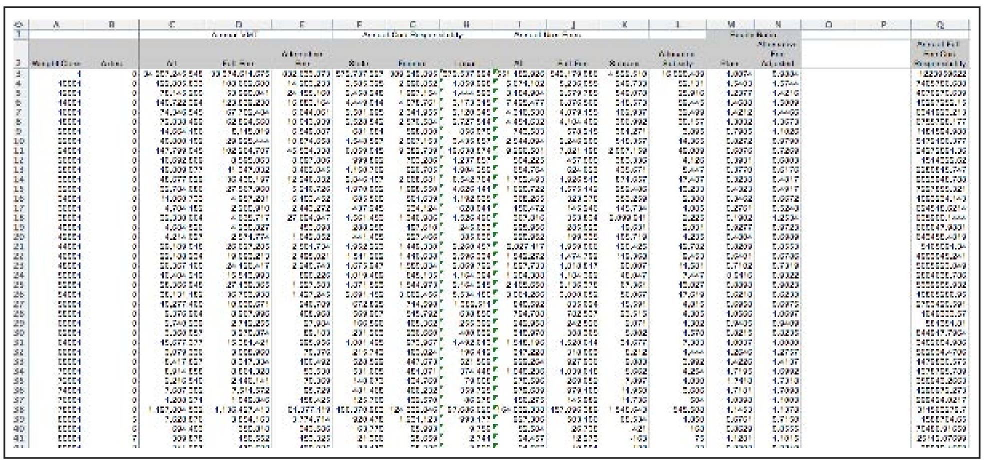


The *Allocation Vectors* tab displays the Allocation Vectors used in the model. This output tab was added to the model for auditing purposes. Each allocation vector should sum to twelve if the allocator applies to all twelve facility classes.

Results tabs

The *Equity* and *Summary* tabs summarize the intermediate output tabs, displaying the final results and equity ratios. These tabs reference the intermediate output tabs and do not require any user input.

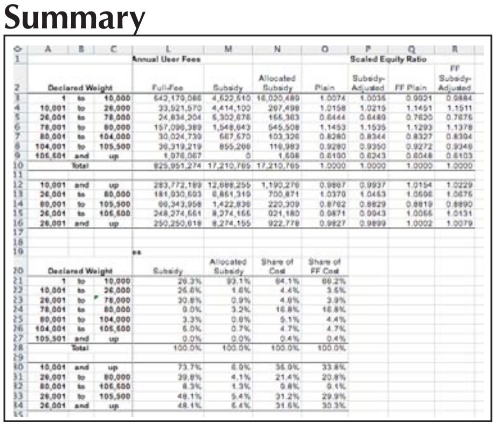
Equity



The *Equity* tab contains the Annual VMT, Annual Cost Responsibility, Annual User Fees, Subsidy and Equity Ratios for each 2,000 pound weight class. The VMT, Cost Responsibility and User Fee Revenues are shown for All Vehicles and for Full-Fee Vehicles.

Full-Fee Costs are calculated by scaling total Cost Responsibility by the ratio of full-fee VMT to total VMT. The Allocated Subsidy is the total from the Subsidy column distributed over the vehicle weight classes using the vehicle weight class share of full-fee VMT. The 'Plain' Equity Ratio is calculated as the ratio of the cost responsibility share to the user fee share for all vehicles, whereas the Adjusted-Equity Ratio is the ratio of the share of full-fee cost responsibility to the full-fee user fee share.

Summary



Declared Weight			Annual User Fees: Full-Fee	Subsidy	Allocated Subsidy	Scaled Equity Ratio: Plain	Subsidy-Adjusted	FF Plain	FF Subsidy-Adjusted
1	to	10,000	642,170,086	4,622,610	16,020,489	1.0074	1.0036	0.9021	0.9884
10,001	to	26,000	33,521,570	4,414,100	287,498	1.0158	1.0215	1.1451	1.1511
26,001	to	78,000	24,834,204	6,302,676	166,363	0.6444	0.6480	0.7620	0.7676
78,001	to	80,000	157,098,389	1,548,643	545,508	1.1453	1.1535	1.1293	1.1378
80,001	to	104,000	30,024,730	687,670	103,326	0.8280	0.8344	0.8327	0.8304
104,001	to	105,500	36,319,219	855,266	116,983	0.9280	0.9350	0.9272	0.9346
105,501	and	up	1,076,067	0	1,608	0.6100	0.6243	0.6048	0.6103
	Total		925,951,274	17,210,765	17,210,765	1.0000	1.0000	1.0000	1.0000
10,001	and	up	283,772,189	12,688,255	1,190,276	0.9867	0.9937	1.0154	1.0229
26,001	to	80,000	181,930,603	6,861,319	700,871	1.0370	1.0453	1.0606	1.0676
80,001	to	105,500	66,343,956	1,422,836	220,309	0.8762	0.8829	0.8819	0.8890
26,001	to	105,500	248,274,561	8,274,155	921,180	0.9871	0.9943	1.0065	1.0131
26,001	and	up	250,250,618	8,274,155	922,778	0.9827	0.9899	1.0002	1.0079

Declared Weight			Subsidy	Allocated Subsidy	Share of Cost	Share of FF Cost
1	to	10,000	26.3%	93.1%	64.1%	66.2%
10,001	to	26,000	26.6%	1.6%	4.4%	3.6%
26,001	to	78,000	30.8%	0.9%	4.6%	3.9%
78,001	to	80,000	0.0%	3.2%	16.8%	16.8%
80,001	to	104,000	3.3%	0.6%	5.1%	4.4%
104,001	to	105,500	6.0%	0.7%	4.7%	4.7%
105,501	and	up	0.0%	0.0%	0.4%	0.4%
	Total		100.0%	100.0%	100.0%	100.0%
10,001	and	up	73.7%	6.0%	36.0%	33.8%
26,001	to	80,000	39.8%	4.1%	21.4%	20.8%
80,001	to	105,500	8.3%	1.3%	9.8%	9.1%
26,001	to	105,500	48.1%	5.4%	31.2%	29.9%
26,001	and	up	48.1%	6.4%	31.6%	30.3%

The *Summary* tab summarizes the model results for the major vehicle weight classes. The Annual VMT, Annual Cost Responsibility, and Annual User Fees are linked to the *Equity* tab. The VMT, Cost Responsibility and User Fee shares and the equity ratios are also located on the *Summary* tab.

The summary worksheet calculates the different Scaled Equity Ratios as follows:

- Plain Scaled Equity Ratio: Ratio of the share of All User Fees to the share of All Cost Responsibility.

- Subsidy-Adjusted Scaled Equity Ratio: Ratio of the share of All User Fees to the share of All Cost Responsibility plus the Allocated Subsidy.
- Full-Fee Plain Scaled Equity Ratio (FF Plain): Ratio of the share of Full-Fee User Fees to the share of Full-Fee Cost Responsibility.
- Full-Fee Subsidy-Adjusted Equity Ratio (FF Subsidy-Adjusted): Ratio of the share of Full-Fee User Fees to the share of Full-Fee Cost Responsibility plus the Allocated Subsidy.

Report Exhibits

The exhibit tabs are the tables that are typically included in the HCAS Final Report. The report exhibit tabs in the model workbook reflect the exhibit number in the 2009 HCAS Report. In the tables, the 2009 values are linked to the current model tabs, while previous study numbers are hard pasted values in the tables.

To update the tables for a future biennial study, change the titles and column headings as appropriate to reflect the new study years. For exhibits displaying past study results, insert new columns for the 2009 HCAS results into the tables to the left of the cells with links to the current model tab results if the table shows previous study results. Make sure to preserve the formulas and links to the other tabs. Copy and paste the 2009 results in the newly inserted columns. Tables where only the current study results are displayed are automatically updated.

4-1 Exhibit 4-1 Current and Forecasted VMT by Weight Group

This table shows the VMT for the base year and the forecast year for each weight group (the major grouping of weight classes). The cell values for the top portion of this table are linked to the *Base VMT* tab, the bottom portion of the table are linked to the *Summary* results tab. This table is automatically updated.

4-2 Exhibit 4-2 Projected 2010 VMT by Road System (Millions of Miles)

This table shows the forecast year VMT by road system for light and heavy vehicles and the percent of total miles for light and heavy vehicles by road system. The top portion of the table is linked to the *VMT Master* tab and is automatically updated. VMT for city and county roads must be copied from the VMT Master output text file and pasted into the table (divide by 1,000,000 so that all table values are in million of miles).

4-3 Exhibit 4-3 Distribution of Projected 2010 VMT by Road System

This table shows the percent of projected VMT by roadway system. This table is automatically updated using the model results in Exhibit 4-2.

4-4 Exhibit 4-4 Comparison of Forecast VMT Used in OR HCASs: 1999, 2001, 2003, 2005, 2007, and 2009 (billions of miles)

This table compares the VMT forecast from previous studies to the current study. The VMT from the previous studies are pasted into the table. The current study VMT are linked to the *Model VMT* tab and are automatically updated when the model is recalculated.

4-5 Exhibit 4-5 Average Annual Expenditures by Category and Funding Source (thousands of dollars)

This table shows the annual expenditures over the biennium by summary work type and funding source. This table is linked to the *Costs to Allocate by SWT* tab.

4-6 Exhibit 4-6 Revenue Forecasts by Tax/Fee Type (thousands of dollars) Average Annual Amount for 2009-2011 Biennium

This table displays the total revenue attributed by major revenue instrument. This table is linked to data in the *Revenues* tab and *Attributed Revenues* tab.

4-7 Exhibit 4-7 Comparison of Forecast Revenue (Millions of Dollars) Used in OR HCASs: 1999, 2001, 2003, 2005, 2007, and 2009

The previous study revenue forecasts are entered into the table and the current study revenue is linked to Exhibit 4-6.

5-1 Exhibit 5-1 Average Annual Cost Responsibility by Expenditure Category and Weight Class (thousands of dollars)

This table shows the average annual cost responsibility by summary work type and vehicle weight class. This table is linked to Exhibit 5-4.

5-2 Exhibit 5-2: Sources and Expenditures of Funds (thousands of annual dollars)

This table compares the costs to allocate and allocated costs by their funding source. The top portion of the table is linked to the Costs to Allocate tab and the bottom portion of the table is linked to the Allocated Costs by SWT tab.

5-3 Exhibit 5-3: Expenditure Allocation Results for Weight Groups by Funding Source (thousands of dollars)

This table shows the cost allocation results using the data in Exhibits 5-4, 5-5, and 5-6.

5-4 Exhibit 5-4: Average Annual Cost Responsibility, State Highway Fund Detail (thousands of dollars)

This table displays the Allocated Costs by summary work type (SWT) for State funded projects.

5-5 Exhibit 5-5: Average Annual Cost Responsibility, Federal Detail (thousands of dollars)

This table displays the Allocated Costs by summary work type (SWT) for Federally funded projects.

5-6 Exhibit 5-6: Average Annual Cost Responsibility, Local Government Detail (thousands of dollars)

This table displays the Allocated Costs by summary work type (SWT) for Locally funded projects.

5-7 Exhibit 5-7: Average Annual Cost Responsibility, Bond Detail (thousands of dollars)

This table displays the Allocated Costs by summary work type (SWT) for bond funded projects and is automatically updated. This table displays both current bond expenditures total and the prior bond expenditures allocated in the current study.

5-8 Exhibit 5-8: Comparison of Pavement Responsibility Results From 2007 and 2009 OR HCASs (thousands of annual dollars)

This table compares the current and previous study pavement expenditures for basic and heavy vehicle classes using the Allocated Costs by SWT tab data and is automatically updated.

5-9 Exhibit 5-9: Comparison of Bridge and Interchange Responsibility Results from 2007 and 2009 OR HCASs (thousands of dollars)

Exhibit 5-9 displays the summarized bridge and interchange project costs. This table uses data from the Allocated Costs by SWT tab and is automatically updated.

6-1 Exhibit 6-1: Comparison of Average Annual Cost Responsibility and User Fees Paid by Full-Fee-Paying Vehicles by Declared Weight Cass (Thousands)

Exhibit 6-1 is the results summary table in the final HCAS report which displays the model VMT, cost responsibility and revenue attribution results by major weight class groups. Exhibit 6-1 has commonly been used as a handout for presenting the model results since the equity ratio results are summarized for the major vehicle classes. Exhibit 6-1 is linked to the *Summary* tab and is automatically updated.

6-2 Exhibit 6-2 Comparison of Equity Ratios from the 1999, 2001, 2003, 2005, 2007, and 2009 Oregon Highway Cost Allocation Studies

Exhibit 6-2 compares the equity ratios from the 1999-2009 HCAS studies. The previous year equity ratios are hard-pasted into the table and the right-most column is linked to tab *6-1*. This table updates the current model results automatically.

6-3 Exhibit 6-3 Detailed Comparison of Average Annual Cost Responsibility and User Fees Paid by Full-Fee-Paying Vehicles by Declared Weight Class (Thousands)

Exhibit 6-3 is similar to the *Equity* tab containing the summarized VMT, cost allocation, revenue attribution and equity ratios for each weight class. This table updates automatically.

Output Text files

Running the model generates several output text (.txt) files. It is important to keep the bond allocation output file in the HCAS Model folder since this file becomes an input file for future studies. Running the 2009 model generates the bond file for 2009-2011 that will be used in the 2011 HCAS study, along with the prior bond files from the previous three studies.

AllocatedCosts text files

The following allocated costs text files are generated with each model run: allocatedCosts_bond, allocatedCosts_federal, allocatedCosts_state, allocatedCosts_local-federal, allocatedCosts_local-state, allocatedCosts_local-other, and allocatedCosts_other

For each funding source, the text file contains allocated costs by work type for each vehicle weight and axle class. The size of these files requires that output text files be generated instead of including this disaggregate intermediate output as tabs in the model. Since there are just over 100 different weight and axle classes and over a hundred work types each of these seven text files could contain up to roughly 10,000 records.

The format of the allocatedCosts text files is the same for all funding sources. The columns in the files are: funding, work type, weight class (WC), axles, and dollars.

Since allocated costs by funding source are summarized in the model intermediate output tab *Allocated Costs by SWT*, the allocatedCosts text output files are only required when the user/analyst is interested in looking at allocated costs for a particular work type or specific weight and axle class.

Bonds2009-2011

Bond expenditures allocated during the 2009-2011 study.

DeclaredpaveFactors

The delcaredpaveFactors file contains the pavement factors by declared operating weight.

Flat_fee_report

Flat_fee_report contains a summary of the flat fee revenues and as-if revenues for each flat fee commodity by weight class and axle class.

missing_pavement_factors

Missing_pavement_factors is an output file that will list any missing pavement factors. This file should be checked during the auditing of the model run. If this file lists missing pavement factors the weight classes and pavement factor input file should be checked for completeness.

VMTMaster

The VMTMaster text file contains the most disaggregate output of the calculated VMT. VMT are reported for each facility class by ownership, weight class, and axle class. This text file is used to report the VMT by county and city ownership in Exhibit 4-2.

HCAS User Guide for Policy Analysis of Alternative Rates

The Highway Cost Allocation Study (HCAS) Model includes the option to analyze changes in revenue instrument taxes or fees. Alternative Rates is an optional analysis, if alternative rates have not been specified in the model the user should ignore the alternative rate analysis output tabs.

The Alternative Rate Analysis allows the user to estimate the effects of different road user tax rates and fees by entering the alternative rates in the *Alt Rates* tab and pressing the "recalculate" button. In the model calculations, the program calibrates the model to the rates and control totals in the *Revenues* tab, and then evaluates the effect of the modified rates specified by the user in the *Alt Rates* tab. The model reports the output from the current rates and alternative rate analyses separately.

The HCAS Model compares the share of costs for each vehicle class to their share of revenues to calculate the equity ratios. Altering the tax rates does not affect the allocation of costs to user groups.

The HCAS model does not contain any travel demand price elasticities, thus changing the use-related tax rates does not affect the underlying VMT used in the model. Nor does changing the fixed costs associated with owning a vehicle alter the assumed vehicle registrations or vehicle miles traveled.

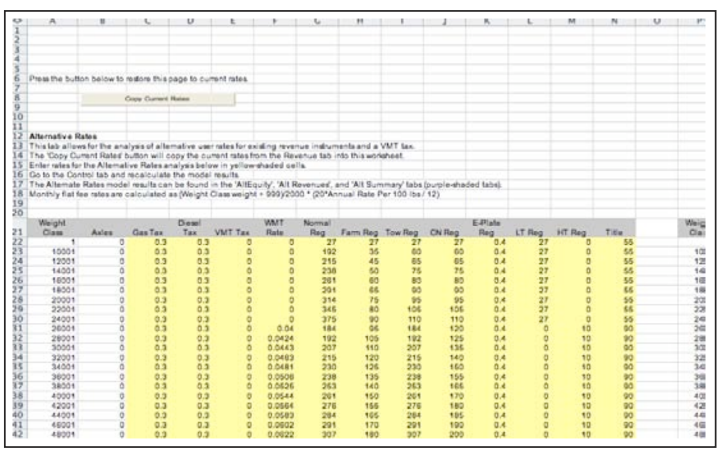
The process for conducting an alternative rate analysis is straightforward. The general procedure is to:

1. Update the current rates in the *Alt Rates* tab by pressing the "Copy Current Rates" button.
1. Enter the alternative rates in the *Alt Rates* tab.
2. Run the model using the newly specified alternative rates. Go to the *Control* tab and click the 'Recalculate' button.
3. View the alternative rate results on the *Alt Revenues, Alt Equity* and *Alt Summary* tabs.

The next section provides a tab-by-tab explanation of the alternative rate analysis tabs, followed by a detailed description of the revenue instruments and three alternative rate case studies to illustrate the alternative rate analysis.

Alt Rates Tab

The *Alt Rates* tab contains the revenue instrument tax rates for gas, diesel, VMT, WMT and registration fees, the RUAF rates and the flat fee monthly rates, VMT per month and axle shares. These rates are in the yellow-shaded tables below the 'Copy Current Rates' button. The 'Copy Current Rates' button runs an Excel macro, which will copy the revenue instrument tax rates from the *Revenues* tab into the *Alt Rates* tab.



Press the button below to restore this page to current rates.

Copy Current Rates

Alternative Rates
This tab allows for the analysis of alternative user rates for existing revenue instruments and a VMT tax.
The 'Copy Current Rated' button will copy the current rates from the Revenue tab into this worksheet.
Enter rates for the Alternative Rates analysis below in yellow-shaded cells.
Go to the Control tab and recalculate the model results.
The Alternate Rates model results can be found in the 'AltEquity', 'Alt Revenues', and 'Alt Summary' tabs (purple-shaded tabs).
Monthly flat fee rates are calculated as (Weight Class weight + 999)/2000 * (20*Annual Rate Per 100 lbs / 12)

Weight Class	Axles	Gas Tax	Diesel Tax	VMT Tax	WMT Rate	Normal Reg	Farm Reg	Tow Reg	CN Reg	E-Plate Reg	LT Reg	HT Reg	Title
1	0	0.3	0.3	0	0	27	27	27	27	0.4	27	0	55
10001	0	0.3	0.3	0	0	192	35	60	60	0.4	27	0	55
12001	0	0.3	0.3	0	0	215	45	65	65	0.4	27	0	55
14001	0	0.3	0.3	0	0	238	50	75	75	0.4	27	0	55
16001	0	0.3	0.3	0	0	261	60	80	80	0.4	27	0	55
18001	0	0.3	0.3	0	0	291	65	90	90	0.4	27	0	55
20001	0	0.3	0.3	0	0	314	75	95	95	0.4	27	0	55
22001	0	0.3	0.3	0	0	345	80	105	105	0.4	27	0	55
24001	0	0.3	0.3	0	0	375	90	110	110	0.4	27	0	55
26001	0	0.3	0.3	0	0.04	184	96	184	120	0.4	0	10	90
28001	0	0.3	0.3	0	0.0424	192	105	192	125	0.4	0	10	90
30001	0	0.3	0.3	0	0.0443	207	110	207	135	0.4	0	10	90
32001	0	0.3	0.3	0	0.0463	215	120	215	140	0.4	0	10	90
34001	0	0.3	0.3	0	0.0481	230	125	230	150	0.4	0	10	90
36001	0	0.3	0.3	0	0.0506	238	135	238	155	0.4	0	10	90
38001	0	0.3	0.3	0	0.0526	263	140	263	165	0.4	0	10	90
40001	0	0.3	0.3	0	0.0544	261	150	261	170	0.4	0	10	90
42001	0	0.3	0.3	0	0.0564	276	155	276	180	0.4	0	10	90
44001	0	0.3	0.3	0	0.0583	284	165	284	185	0.4	0	10	90
46001	0	0.3	0.3	0	0.0602	291	170	291	190	0.4	0	10	90
48001	0	0.3	0.3	0	0.0622	307	180	307	200	0.4	0	10	90

Revenue Instruments

In Oregon's current highway finance system, vehicles under 26,001 lbs pay registration fee, and the gas or diesel tax and vehicles over 26,000 lbs pay registration fee, and a weight mile tax.

Other special vehicles classes pay the following combination of use-related taxes and registration fees:

- Charitable non-profit vehicles: pay the charitable non-profit registration and gas or diesel tax.
- E-Plate (publicly owned vehicles (e-plate): pay the E-plate registration fee.
- Tow-trucks: Tow-Truck Registration Fee (excludes Tow Truck Certificate Cost), and gas or diesel tax. Tow-trucks under 26,000 pound have their own registration fee schedule. Tow-trucks over 26,000 pounds register with the Motor Carrier Transportation Division and follow the normal heavy vehicle registration fee schedule.
- Farm vehicles: Farm vehicles have their own Farm Registration Fee Schedule and pay the gas or diesel tax (farm vehicles do not pay the weight-mile tax).
- Flat fee vehicles: Carriers hauling logs, sand and gravel, or wood chips have the option of paying a flat monthly fee based on vehicle weight instead of the weight mile tax. Flat fee vehicles are registered using the Motor Carrier Division registration schedule for tractors, trucks and buses (normal registration fees).
- Road user assessment fee (RUAF) vehicles: Vehicles operating with single-trip permits at a gross weight above 98,000 pounds pay a road use assessment fee of 5.7 cents per equivalent single-axle load for the loaded portion of their trip and pay WMT tax for the unloaded portion. These vehicles pay regular registration fees according to their normally declared weight.
- Title fees are one-time fees for new vehicles and for title transfers.

Tax rates for each of the unique revenue instruments can be copied from the *Revenues* tab into the *Alt Rates* tab and then modified by the user. The tax rates and fees are:

Gas tax: dollars per gallon

The gas tax rate specified in the *Alt Rates* tab is applied to the imputed gallons of taxed gasoline, which is calculated in the model as the gas tax VMT divided the adjusted MPG.

The gas tax VMT is the sum of the VMT from the following vehicle classes: Gasoline fueled Basic cars (car VMT minus the portion of basic car minus the assumed diesel share of basic VMT), Gas Commercial (GasCOMM) VMT, Gas Tow Trucks (GasTow) VMT, GasFarm VMT, GasCN VMT, GasSLG, GasFed, and GasSchool.

The total gasoline VMT is then adjusted by the gas tax avoidance assumption to determine the total taxed gasoline VMT. The gas tax evasion factor is an assumption specified in the *Revenues* tab.

Key assumptions and data used in the calculation of the gas tax revenues are the percent of basic VMT by diesel-powered vehicles, the gas tax avoidance rate, MPG, VMT and the gasoline tax rates.

The adjusted MPG is calculated by fuel type for each weight class and used in the revenue attribution for the HCAS model is also used in the alternative rate revenue attribution. Thus the revenues from an increase (or decrease) in the gas tax rates is adjusted appropriately so that the gas tax revenues from each vehicle weight class reflect their adjusted MPG and the specified alternative gas tax rate.

A majority of gasoline-powered (and taxed) vehicle miles are basic vehicles (basic vehicles accounted for 80 percent of gasoline VMT in the 2009 HCAS). Since the majority of the gas tax vehicle miles are by basic vehicles, increasing the gas tax rate will increase the revenue share paid by basic vehicles and increase the basic vehicle equity share. Similarly, a decrease in the gasoline tax rate will have the opposite effect, decreasing the gasoline tax revenues, which will decrease the basic vehicle share of revenues and decrease the basic vehicle equity ratio.

Diesel tax: dollars per gallon

The diesel tax rate specified in the *Alt Rates* tab is applied to the imputed gallons of taxed diesel fuel to determine the diesel tax revenues. The imputed gallons of taxed diesel fuel is calculated as the diesel Tax VMT divided by the adjusted MPG.

Diesel Tax VMT is calculated as diesel tax evasion and avoidance-adjusted sum of the following vehicle class VMT: Car-Diesel (basic vehicle VMT multiplied by the percent of basic VMT by diesel-powered vehicles), Diesel Comm, DieselTow, DieselFarm, and DieselCN.

The diesel tax, paid by diesel-fueled vehicles, like the gasoline tax, affects both basic and non-basic vehicles; however the majority of diesel fuel taxed VMT are by heavy vehicles (non-basic vehicles accounted for just over 60 percent of diesel VMT in the 2009 HCAS). In addition to having a higher share of diesel VMT, heavy vehicles also have lower mile-per-gallon (mpg) fuel efficiency, which means that heavy vehicles use more fuel per mile. Both of these factors imply that an increase in the diesel tax rate will result in a higher share of revenues for heavy vehicles, all other rates and assumptions held constant.

VMT Tax: dollars per mile

As of January 2009, no VMT tax exists in Oregon, however the VMT tax is a potential future revenue instrument and the HCAS model has included the VMT tax instrument as a possible policy option for the alternative rate analysis.

The VMT tax is entered as dollars per mile, similar to the current WMT tax. The VMT tax is applied to all full-fee basic vehicles and non-basic vehicles that do not pay the WMT, Flat Fee or RUAF tax (e.g. VMT tax is applied to vehicles currently paying either the gasoline or diesel tax).

The VMT tax revenues are calculated by applying the VMT tax rates to the gas VMT and diesel VMT. A VMT tax can be entered instead of, or in addition to, gas and diesel tax rates. Flat Fee, RUAF, and WMT vehicle classes continue to be taxed using their respective tax instruments and rates.

The impact of a VMT tax on the basic and heavy revenue shares and equity ratio will depend on the VMT tax rates specified for the different weight classes.

Weight Mile Tax (WMT Tax): dollars per mile

The weight mile tax rate is measured in dollars per mile. The ODOT WMT Table A lists the weight mile tax rates for heavy vehicles between 26,000 and 80,000 pounds and the ODOT WMT Table B contains the per mile rates for heavy vehicles between 80,000 and

105,500 pounds. Vehicles weighing more than 105,500 pay the road use assessment fee (RUAF).

The WMT revenues and revenue attribution are calculated by multiplying the WMT tax rate by the WMT evasion-adjusted WMT VMT. Increasing the WMT tax rates will increase the share of revenue for heavy vehicles (vehicles over 26,000 pounds) and increase the heavy vehicle equity ratio. The WMT rate structure will affect the equity ratios for individual weight classes within the heavy vehicle group.

Vehicle Registration Fees: dollars per year

The Oregon Department of Motor Vehicles (DMV) registers most vehicles, with the exception of heavy vehicles (over 26,000 pounds) which must register with the Motor Carrier Transportation Division (MCTD). Vehicle registration fee schedules can be found at the DMV website and the Tractor, Truck and Buses Registration Fee Schedule can be found at the MCTD website. All registration fees are entered as dollars per year on the *Revenues* and *Alt Revenues* tab.

Normal Vehicle Registration (Normal Reg) Current normal registration for basic vehicles (under 8,000 lbs) is $54 for a two-year registration ($27 per year). The Motor Carrier Transportation Division Registration Fee Schedule is used for vehicles 10,000 lbs and up.

Farm Vehicle Registration (Farm Reg) Certified farm operation vehicles have their own registration schedule ('Fee Schedule: Trucks Registered as Farm Vehicles').

Tow Truck Registration (Tow Reg) The fee schedule for tow/recovery vehicles is used for tow trucks under 26,000 lbs; and the registration fee entered in the *Revenues* and *Alt Rates* tabs should exclude the tow truck certificate fee. Tow trucks weighing more than 26,000 lbs must register with the Motor Carrier Transportation Division and pay registration fees following the MCTD registration fee schedule

Charitable Non-Profit Registration (CN Reg) per year registration fee. Charitable Non-Profits pay registration fees following the DMV "Fee Schedule For Charitable, Non-Profit and Manufactured Structure Toter Vehicles." This fee schedule includes vehicles up to 105,500 pounds.

E-Plate Registration (E-Plate Reg) per year registration fee. Publicly owned vehicles pay a one-time registration fee of $2.00. It is assumed that the life of a publicly owned vehicle is five years, thus the annual amount for registration fees is set equal to $0.40 dollars per year in the 2009 HCAS.

Light Trailer Registration (LT Reg) The per year registration fee paid by light trailers weighing less than 26,001 lbs.

Heavy Trailer Registration (HT Reg) The per year registration fee paid by heavy trailers weighing more than 26,000 lbs.

Title Fee: dollars per title transaction

Title fee is paid when buying a vehicle and registering the vehicle for the first time in Oregon. As of January 2009 there were two different title fees depending on vehicle class. The title fee for vehicles weighing under 26,000 lbs was $55 and the fee for vehicles 26,000 pounds and over was $90. The title fee revenue control total amount is attributed to the vehicle classes based on VMT at each weight class and the Title Fee.

RUAF: dollars per mile

The Road Use Assessment Fee is a flat rate entered as dollars per equivalent single-axle load (ESAL) by weight class from the RUAF fee schedule. The RUAF rate is applied to the RUAF VMT by weight class, which are tabulated from the base year RUAF collection reports. For a given weight class, the RUAF rates decrease as the number of axles increases since the vehicle weight is being distributed over more axles causing less road damage.

Flat Fee: monthly flat fee paid by flat fee commodity hauler

Flat fee rates apply to carriers hauling chips, sand and gravel or logs. These carriers pay per month according to their loaded operating weight. The Flat Fee rates are entered as dollars per month. The VMT per month and axle share are based on the base year flat fee report data and are used to determine the WMT revenue from flat fee haulers in the "as-if" revenue calculation.

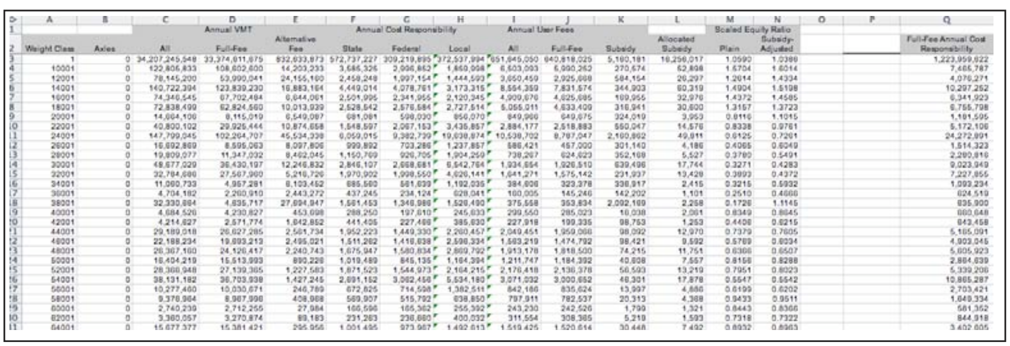
Under the current flat fee rates, log haulers may pay $6.10 per 100 pounds, sand and gravel haulers may pay $6.05 per 100 pounds, wood chip haulers may pay $24.62 per 100 pounds, and for-hire farm carriers in trucks under 46,000 pounds combined weight may pay $5.00 per 100 pounds. Flat fee rates apply to vehicles hauling log, sand and gravel or chips, over 26,000 pounds.

The monthly rate is calculated as the flat fee rate paid by a hauler operating at the mid-point for the weight category (weight class plus 999 lbs). For example, the log truck annual rate of $6.10 per 100 pounds is converted to monthly rate per 2000 lbs by dividing the annual rate by twelve and multiplying that value by twenty (20*(6.10 /12)=10.17). The monthly rate per 2,000 lbs applied to midpoint of the weight class divided by 2,000 lbs.

Alt Rate Output Tabs

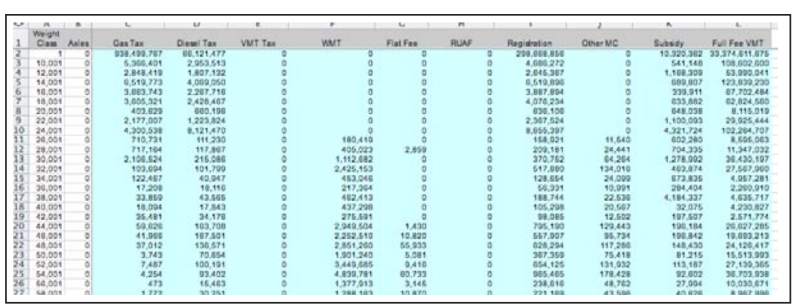
The alternative rate analysis results are displayed in three purple output tabs: *Alt Equity, Alt Revenues,* and *Alt Summary*.

Alt Equity



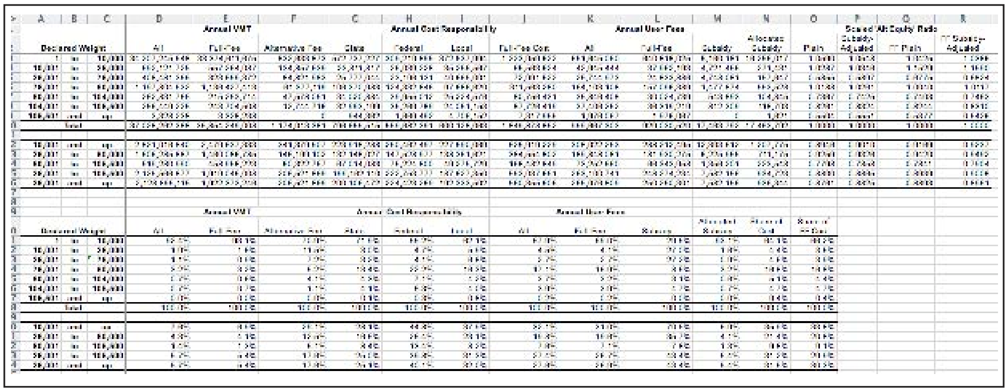
The *Alt Equity* tab displays the Annual VMT, Annual Cost Responsibility, Annual User Fees, and Scaled Equity Ratio by weight and axle class for the alternative rate analysis. The Alt Equity tab refers to the *Master VMT, Alt Revenues,* and *Allocated Costs* tabs.

Alt Revenues



The *Alt Revenues* tab contains model output of the attributed revenues by major revenue instrument for each weight and axle class. The *Alt Revenues* are summed to produce Annual User Fees in the *Alt Equity* and *Alt Summary* tabs to

Alt Summary



The *Alt Summary* tab displays the summary results of the annual model VMT, annual cost responsibility, annual user fees, the subsidy and allocated subsidy, and the equity ratios by aggregated major vehicle weight class for the alternative rate analysis.

Alternative Fee Analysis Case Studies

The following section illustrates three different alternative rate analyses. For each case study a step-by-step explanation of how to conduct the analysis is provided, followed by a description of the impact of the rate changes on the vehicle equity ratios.

The first case study increases the gas and diesel tax from $0.24 per gallon to $0.30 per gallon. The second case study doubles the basic vehicle registration fee. The third case study imposes a new VMT tax of 1.5 cents per mile, repealing the state fuel tax. The second case study illustrates the effect of a change in a single revenue instrument, while the first and third case studies involve changes to more than one revenue instrument. The net effect of an analysis of two or more revenue instrument rate changes will depend on the relative magnitude of the change to each revenue instrument rate and which vehicle class revenues are affected.

Case Study A: Change in Gas Tax

This case study considers an increase in the gas and diesel tax from the current rate of $0.24 per gallon to $0.30 per gallon—a six-cent increase. Only the gas and diesel tax rates are increased in this case study, all other revenue instrument rates are set to their current (2009 HCAS Study) rates.

Perform an alternative rate analysis of an increase in the gas and diesel tax rates following these steps:

1. In the *Alt Rates* tab, copy the current rates using the “Copy Current Rates” button.
2. In the Gas Tax column (column “C” beginning in row 21) enter 0.30 for each weight class. This step specifies the alternative gas tax rate of $0.30 per gallon.
3. In the Diesel Tax column (column “D” beginning in row 21) enter 0.30 for each weight class. This step specifies the alternative diesel tax rate of $0.30 per gallon.
4. Go to the *Control* tab (left most tab in the HCAS Model workbook). Click the “Recalculate” button to run the model using the new gas and diesel tax rates specified in the *Alt Rates* tab.
5. View the alternative rate analysis results in the *Alt Equity, Alt Revenues*, and *Alt Summary* tabs.

The revenue in the *Alt Revenues* tab will now reflect the increase in the gas and diesel tax rates.

Comparing the *Equity* tab output to the *Alt Equity* tab output one can see that the VMT and Cost Responsibility for each weight class have not changed. Only the Attributed

Revenues (Annual User Fees) have changed. Since the change in the attributed revenues has also changed the revenue shares, the equity ratios will reflect the shift in the share of revenues attributed to the vehicle classes.

Table 4 compares the gas tax revenue, diesel tax revenue, and other revenue for the 2009 HCAS Model and the Gas Tax/Diesel Tax Alternative Analysis. Both the gas tax and diesel tax revenues have increased by 25 percent (a six cent increase in the 24 fuel tax rate is a 25 percent increase) in the alternative rate analysis, and total revenues have increased by 12.6 percent as a result of the gas and diesel tax rate increases.

Table 4 Comparison Annual Revenues from an Alternative Rate Analysis of an Increase in the Gas and Diesel Tax Rates (thousands of dollars)

Revenue Source	HCAS 2009	Alternative Rate Analysis	Difference in Revenues	Percent Change in Revenues
Gas Tax Revenues	399,452	499,315	99,863	25%
Diesel Tax Revenues	37,780	47,225	9,445	25%
Other Revenues	432,479	432,479	0	0
Total Revenue	869,710	979,018	109,308	12.60%

In the 2009 HCAS study the basic vehicle equity share is 0.9915. The basic vehicle equity share in the alternative rate analysis (found in the *Alt Summary* tab after recalculating the model with the alternative rates) is 1.0404. The basic vehicle equity share has increased since the net effect of the gas and diesel tax increase was to increase the basic vehicle revenue share, which in turn increases the basic vehicle equity ratio.

Table 5 Comparison of Revenue Shares and Equity Ratios for Gas and Diesel Tax Case

Weight Class	Share of Annual User Fees		FF Subsidy-Adjusted Equity Ratio	
	HCAS 2009	Alternative	HCAS 2009	Alternative
1 to 10,000	66.50%	69.80%	0.9915	1.0404
10,001 and up	33.50%	30.20%	1.0173	0.9178

Case Study B: Change in Registration Fee

In the second case study, a change in the registration fees, we consider doubling the normal registration fee for basic vehicles from $27 to $54 dollars per year.

Perform an alternative rate analysis of a change in the Normal Registration Fee by following these steps:

1. In the *Alt Rates* tab, copy the current rates using the “Copy Current Rates” button.
2. In the ‘Normal Reg’ column (column G beginning in row 21) enter 54 for Weight Class 1. This step specifies the alternative registration fee of $54 per year for basic vehicles (vehicles under 10,000 pounds).
3. Go to the *Control* tab and click the “Recalculate” button to recalculate the model output using the new registration fee specified in the *Alt Rates* tab.
4. View the alternative rate analysis results in the *Alt Equity, Alt Revenues, and Alt Summary* tabs.

Table 6 Comparison of Revenue Shares and Equity Ratios for Basic Vehicle Registration Fee Case

Weight Class	Share of Annual User Fees		FF Subsidy-Adjusted Equity Ratio	
	HCAS 2009	Alternative	HCAS 2009	Alternative
1 to 10,000	66.50%	69.90%	0.9915	1.0417
10,001 and up	33.50%	30.10%	1.0173	0.9151

Since the registration fee paid by basic vehicles has increased while all other rates have been held constant, the basic vehicle share of revenues will increase, in turn increasing the basic vehicle equity ratio. Since the heavy vehicle class revenues remain unchanged, the heavy vehicle revenue share declines as the basic share increases.

Case Study C: VMT tax

The third case study evaluates the impact of the implementation of a vehicle-mile-traveled tax (VMT tax) and the repeal of the gas and diesel tax.

Perform an alternative rate analysis of a new VMT tax and repeal of the gas and diesel tax following these steps:

1. In the *Alt Rates* tab, copy the current rates using the “Copy Current Rates” button.
2. In the ‘Gas Tax’ and ‘Diesel Tax’ columns (columns C and D beginning in row 21) enter 0 for all weight classes. This step sets the gas and diesel tax rates to zero.
3. In the ‘VMT Tax’ column (column E, beginning in row 21) enter 0.015 for all weight classes. This step sets the VMT tax rate to 1.5 cents per mile (0.015 dollars per mile).
4. Go to the *Control* tab (left-most tab in the HCAS Model workbook). Click the “Recalculate” button to run the model using the new VMT tax specified in the *Alt Rates* tab.
5. View the alternative rate analysis results in the *Alt Equity, Alt Revenues, and Alt Summary* tabs.

A VMT tax rate of 1.5 cents per mile produces average annual revenues of approximately $527.8 million. Basic vehicle full-fee revenue share increases to 70.7 percent in the alternative rate analysis from 66.5 percent in the current model.

A VMT Tax rate of 1.5 cents per dollar is roughly equal to the effective fuel tax rate paid for vehicles with fuel efficiency of 16 miles per gallon. Since the majority of the vehicle miles traveled by vehicle tax classes paying the gas and diesel tax are by basic vehicles, in the model assumed to have closer to 20 MPG, the revenues from a VMT tax of 1.5 cents per mile are greater than the fuel taxes generated from a 24 cents per gallon fuel tax. Thus, the basic vehicle revenues and equity share increase as shown in Table 7-Case C table.

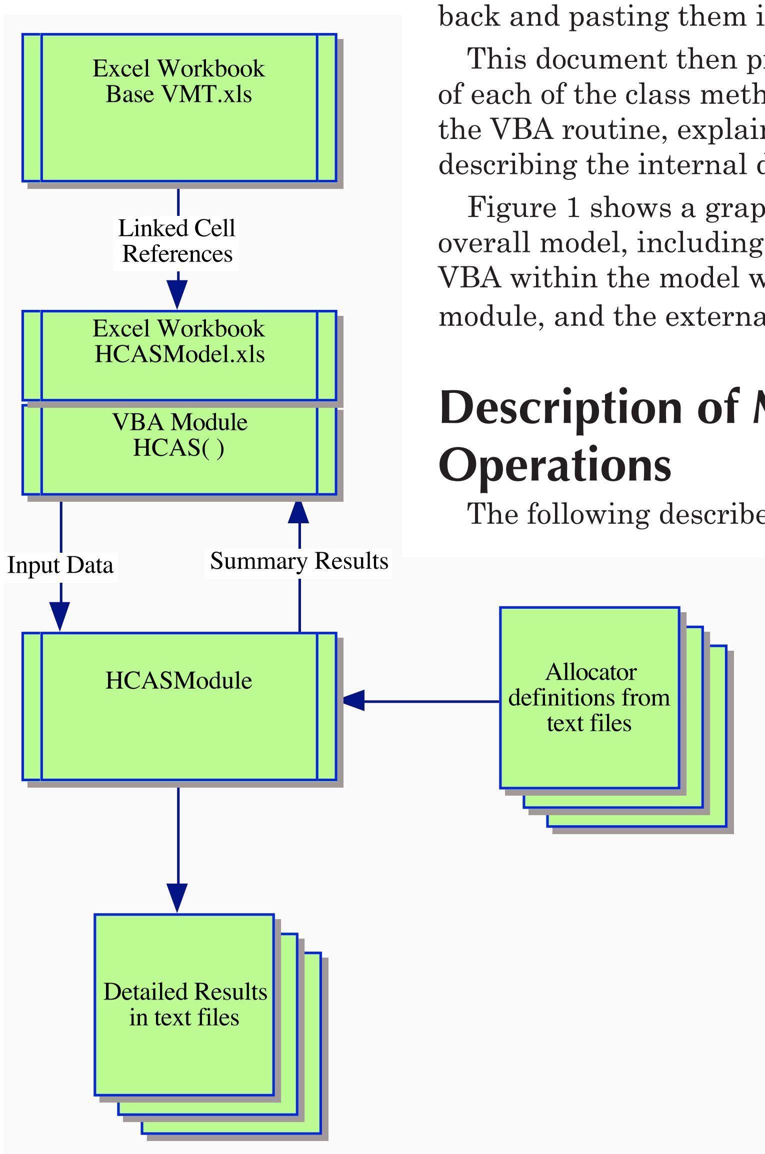
Table 7 Comparison of Revenue Shares and Equity Ratios for VMT Tax Case

Weight Class	Share of Annual User Fees		FF Subsidy-Adjusted Equity Ratio	
	HCAS 2009	Alternative	HCAS 2009	Alternative
1 to 10,000	66.50%	70.70%	0.9915	1.0549
10,001 and up	33.50%	29.30%	1.0173	0.8883

2009 HCAS Model Documentation

THE FULL SOURCE CODE FOR the 2009 Oregon Highway Cost Allocation Model is included with the model distribution. The model is contained within a class that can be run by Excel as an Active-X module and each of the class methods within it can be called from within Excel.

This document begins with a description of the Visual Basic for Applications (VBA) routine that runs when the "Recalculate" button on the "Control" tab of the HCASModel.xls workbook is pressed. That routine makes a series of calls to the Active-X module, sending data from Excel, and then retrieving calculated results back and pasting them into worksheets.



This document then provides a detailed description of each of the class methods that are called by the VBA routine, explaining the calculations and describing the internal data structures they use.

Figure 1 shows a graphical representation of the overall model, including the Excel workbooks, the VBA within the model workbook, the external code module, and the external data files.

Description of Model Calculation Operations

The following describes what happens when the "Recalculate" button is pressed. The "Recalculate" button is connected to the HCAS() subroutine in the workbook's VBA module. That subroutine is described line-by-line here. These lines are always executed in the order shown and every line is executed with every recalculation.

Initialization

```
Sub HCAS()
 ChDrive (ActiveWorkbook.Path)
  ChDir (ActiveWorkbook.Path)
  Set HCASModel = CreateObject("HCASModule")
```

The first two lines of the HCAS() routine allow the model to work if the workbook was opened by double-clicking the workbook file. They set Excel's path to the drive and directory where the workbook resides, assuming that HCASModule.py and the text files it needs will be located in the same directory.

The third line loads the HCASModule into memory. When the HCASModule loads, it runs its initialization methods. Those read in data from seven text files. These data are:

- **SeedData.** Used to populate a preliminary VMT Master table for iterative proportional fitting (described below).
- **AxleShares.** These data are developed from Special Weighings data and describe the share of each weight class with each possible number of axles (nine or more axles are coded as nine-plus).
- **SimpleFactors.** A vector of factors to be multiplied by VMT for simple allocators (different weight groupings of VMT.) These factors are mostly zeros and ones, reflecting the definition of the allocator. For example, the Under26 factor is one for all weight classes up to 26,000 pounds and zero for all weight classes over 26,000 pounds.
- **PaveFactors.** Cost responsibility factors (by weight class, functional class, and number of axles) for wear and tear of flexible and rigid pavement projects. These factors are produced by the NAPHCAS-OR model (the Oregon version of the National Pavement Cost Model for Highway Cost Allocation developed by Roger Mingo).
- **PCEFactors.** Passenger car equivalents (by weight class, functional class, and number of axles) for vehicles on regular, uphill, and congested roadways. These factors represent the amount of roadway capacity a single vehicle of a particular weight class takes up as a proportion of the capacity consumed by a basic vehicle. These factors were developed from the results of a special study conducted as a part of the 1997 Federal Highway Cost Allocation Study.
- **DeclaredOperating.** Shares of vehicles in each declared weight class operating at each operating weight class. These data were developed from the Special Weighings data.
- **DeclaredRegistered.** Shares of vehicles in each declared weight class that are registered in each registered weight class. These data were developed from Motor Carrier and DMV registration data.
- **BasicSharePeak.** The basic-vehicle share of peak-hour VMT for each functional class. These data were developed from automatic traffic recorder data.

Send Base-Year VMT Data and Retrieve Model-Year VMT Data

```
Call HCASModel.setGrowthRates([GrowthRates].Value)
Call HCASModel.setVMTByFC([VMTByFC].Value)
Call HCASModel.setBaseVMT([BaseVMT].Value)
Call HCASModel.setEvasion([Evasion].Value)
```

The next four lines send input data from the workbook to the HCASModule so that it can calculate model-year VMT.

Growth rates, from the VMT Growth tab, tell the model how fast VMT in each weight class is expected to grow between the base year (the most recent calendar year for which data are available) and the model year (the calendar year in the middle of the fiscal biennium being modeled).

VMT by functional class, from the VMT by FC tab, provides control totals for base-year VMT in each functional class.

Base VMT, from the BASE VMT tab provides base-year VMT by weight class and tax class.

Evasion rates, from the Revenues tab, tell the model what evasion and avoidance rates to assume. Evasion and avoidance are combined.

```
vmtMaster = HCASModel.makeVMTMaster()
Sheets("VMT Master").Activate
[A3:D5117].Value = vmtMaster
modelVMT = HCASModel.makeVMTByVehicles()
Sheets("Model VMT").Activate
[A3:AB99].Value = modelVMT
```

The call to makeVMTMaster() tells the model to do its VMT calculations and send back a portion of the Master VMT table, which is pasted into the "VMT Master" tab. The call to makeVMTByVehicles() tells the model to calculate model-year VMT by weight and tax class and send those back, where they are pasted into the "Model VMT" tab.

Send Costs to Allocate and Retrieve Allocated Costs

```
Call HCASModel.setPath([Path].Value)
```

The path, defined in the Policy tab, defines the set of allocators to be applied to each work type. Each work type may have up to two allocators. If there are two, the proportion of costs in that work type to which each will be applied also is defined in the path. The proportions must add up to one.

```
Call HCASModel.setProjectCosts([ProjectCosts].Value)
Call HCASModel.setNonProjectCosts([NonProjectCosts].Value)
Call HCASModel.setLocalCosts([LocalCosts].Value)
```

The next three lines send costs to allocate to the model from the "Project Costs", "Non-Project costs", and "Local Costs" tabs. Items (rows) in the lists of costs to allocate include information about the funding source, work type, functional class, and dollar amount. Project costs also include the bridge type, which is zero if not a bridge project.

```
Call HCASModel.setStuddedTire([StuddedTire].Value)
```

The next line sends studded-tire adjustments from the "Studded Tires" tab. These move costs from their original combination of funding source and work type into the studded tire work type with the same funding source.

```
Call HCASModel.setBridgeFactors([BridgeFactors].Value)
```

The next line sends bridge factors from the "Bridge Splits" tab. These factors are used to reassign bridge costs from their original work types to incremental cost work types so that incremental allocators may be applied. There will be a set of factors for each bridge type.

```
Call HCASModel.setBondFactor([BondFactor].Value)

Call HCASModel.setBiennium([Biennium].Value)
```

The next two lines send information necessary for the proper treatment of the expenditure of bond revenues. Both come from the "Control" tab.

```
Call HCASModel.setSummaryWorkTypes([SWT].Value)

Call HCASModel.setSummaryWeightClasses([SWC].Value)
```

The next two lines send information from the "Codes" tab that allows the model to tabulate allocated costs by summary work type and summary weight class for the report tables. These tabulations are done in the model, rather than the workbook, because it is faster, more reliable, and keeps the workbook size reasonable.

```
allocatedCosts = HCASModel.allocateCosts()

Sheets("Allocated Costs").Activate

[A3:I343].Value = allocatedCosts
```

The call to allocateCosts() tells the model to allocate costs and return the allocated costs by weight class and funding source, which are then pasted into the "Allocated Costs" tab.

Send Revenues and Rates and Retrieve Attributed Revenues

```
Call HCASModel.setRevenueTotals([RevenueTotals].Value)

Call HCASModel.setRates([Rates].Value)

Call HCASModel.setRUAFRates([RUAFRates].Value)

Call HCASModel.setFFRates([FFRates].Value)
```

The next four lines send information from the "Revenues" tab to the model. Revenue totals are the control totals by instrument from the budget. Rates are for instruments that vary by weight class (e.g., weight-mile tax rates) or not at all (e.g., fuel taxes). The two other types of rates have different dimensions, so are sent separately. RUAF rates extend to a much linger list of weight classes. Flat fee rates are by commodity and include information about the average miles per month for each weight class and the distribution of VMT in each weight class to numbers of axles for weights over 80,000 pounds.

```
Call HCASModel.setMPG([MPG].Value)
```

The next line sends estimated miles per gallon by operating weight class from the "MPG" tab.

```
attributedRevenues = HCASModel.attributeRevenues()

Sheets("Attributed Revenues").Activate

[A1:K342].Value = attributedRevenues
```

The call to attributeRevenues() tells the model to attribute revenues and return the attributed revenues by weight class and revenue instrument, which are then pasted into the "Attributed Revenues" tab.

```
adjustedMPG = HCASModel.getAdjustedMPG()
Sheets("MPG").Activate
[D3:E100].Value = adjustedMPG
```

The call to getAdjustedMPG() tells the model to return the adjusted miles per gallon (already calculated as part of the revenue attribution calculations), which are then pasted into the "MPG" tab to the right of the initial MPG estimates. The initial estimates are adjusted to allow fuel tax revenues to add up the the revenue control totals for fuel taxes.

Retrieve Summary Tabulations for Report Tables

```
AllocatedCostsbySWT = HCASModel.getAllocatedCostsByWorkType()
Sheets("Allocated Costs by SWT").Activate
[B3:J171].Value = AllocatedCostsbySWT
```

The call to getAllocatedCostsByWorkType() tells the model to send allocated costs by summary work type, funding source, and summary weight class, which are then are pasted into the "Allocated Costs by SWT" tab.

```
CostsToAllocatebySWT = HCASModel.getCoststoAllocate()
Sheets("Costs to Allocate by SWT").Activate
[B3:I27].Value = CostsToAllocatebySWT
```

The call to getCostsToAllocate() tells the model to return costs to allocate by summary work type and funding source, which are then pasted into the "Costs to Allocate by SWT" tab.

Retrieve Scaled Allocation Vectors

```
AllocationVectors = HCASModel.getAllocationVectors()
Sheets("Allocation Vectors").Activate
[A2:T5117].Value = AllocationVectors
```

The call to getAllocationVectors tells the model to return the scaled allocation vectors. These are the allocation vectors after they have been weighted by model-year VMT and then scaled so they add up to one. They are pasted into the "Allocation Vectors" tab.

Send Alternative Rates and Retrieve Attributed Alternative Revenues

```
Call HCASModel.setAltRates([AltRates].Value)
Call HCASModel.setAltRUAFRates([AltRUAFRates].Value)
Call HCASModel.setAltFFRates([AltFFRates].Value)
```

The next three lines send alternative rates from the "Alt Rates" tab to the model. These alternative rates are used for policy analysis to test the effect on equity of proposed changes to revenue instruments. They do not require changes to revenue control totals, because they use the calibrated miles per gallon and miles per registration from the original revenue attribution calculations, which were calculated from the control totals and rates provided there.

```
attributedRevenues = HCASModel.attributeAltRevenues()
Sheets("Alt Revenues").Activate
[A1:L342].Value = attributedRevenues
```

The call to attributeAltRevenues() tells the model to attribute revenues using the alternative rate schedules and return results by weight class and revenue instrument. Those are pasted into the "Alt Revenues" tab.

```
Sheets("Summary").Activate
```

The last line of the HCAS() routine leaves the workbook with the "Summary" tab open so the user can see the summary results of the model run.

Table 1 describes the input ranges in various tabs of the HCASModel.xls workbook, listing the input range name, the tab it is located in, the data it contains, the units those data are in, the class method that moves the data to the external model code, and the name of the data structure in the external model code that accepts the data.

Table 2 describes the tab-delimited text files that contain input data for the external model code, listing the file name, what data each contains, the units the data are in, and the data structure in the external model code that accepts the data.

Table 3 describes the outputs from the external model code that are sent back to the HCASModel.xls workbook, listing the data structure in the external model code from which the data are extracted, the method called to calculate and retrieve the data, the tab into which the data are pasted, the upper-left corner of the cell range into which the data are pasted, and the contents of the data.

Table 4 describes the tab-delimited text files that are written when the external model code runs, listing the data structure in the external model code from which the data are extracted, the method called to calculate and write the data, the file names, and the contents of the data.

Detailed Description of Class Methods in the Model

This part of the documentation serves two purposes: it describes in detail for anyone who is interested how the model does what it does and it provides a guide for someone seeking to follow the source code. The class methods are described in the order they appear in the source code, which is the order in which they are called by the VBA subroutine. Line numbers from the version of the code included with the 2009 model distribution are included to facilitate following the source code.

Class methods for getting data into the model

The class methods described in this section serve to get data into the HCAS Model. Data that are not expected to be changed by the user are read in from tab-delimited text files. Data and assumptions that an analyst is more likely to want to change between model runs are transferred from the Excel workbook that runs the model.

Other class methods, described in later sections, make use of the data and return results to Excel. Some also write additional, more-detailed data to tab-delimited text files.

Note that variables beginning with "self." belong to the class object and are available to any class method to which the self reference has been passed. Other variables are available only within the method that creates them.

The readData() method (line 16) is run during initialization and imports the following

Table 1 Input Ranges

Excel Range	Tab	Contains	Units	Method to Send to Model	Model Data Structure
GrowthRates	VMT Growth	VMT growth rates	annual growth rate (e.g., 0.05 means 5% per year)	setGrowthRates()	self.growthRates
VMTByFC	VMT by FC	VMT by functional class and ownership	Base-year vehicle-miles traveled	setVMTByFC()	self.VMTbyFC
BaseVMT	Base VMT	Base-year VMT by weight class and tax class	Base-year vehicle-miles traveled	setBaseVMT()	self.baseVMT
Evasion	Revenue	assumptions for gas-tax avoidnace, use-fuel tax evasion and avoidance, weight-mile tax evasion, share of basiv VMT that burn diesel, registration rate per mile for RUAF vehicles, share of RUAF vehicles registered at 78,001-80,000 lbs, share of RUAF vehicles registered at 96,001-98,000 lbs, shareof RUAF vehicles registered at 104,001-105,500 lbs, percent of flat-fee log truck miles that are empty, declared weight for empty log trucks	all are shares (e.g., 0.05 means 5%) except RUAF Registration Rate is in dollars per mile traveled and Empty Log Weight is in pounds	setEvasion()	self.gasEvasion, self.dieselEvasion, self.wmtEvasion, self.basicDiesel, self. ruafRegRate, self.ruafReg78, self. ruafReg96, self.ruafReg104, self. emptyLogPercent, self.emptyLogWeight
Path	Policy	Allocator(s) to use for each work type	names of allocators and shares	setPath()	self.path
ProjectCosts	Project Costs	Costs to allocate for construction projects	biennial dollars	setProjectCosts()	self.projectCosts
NonProjectCosts	Non-Project Costs	Other costs to allocate	biennial dollars	setNonProjectCosts()	self.nonProjectCosts
LocalCosts	Local Costs	Local-government costs to allocate	biennial dollars	setLocalCosts()	self.localCosts
StuddedTire	Studded Tires	Studded-tire adjustments	biennial dollars	setStuddedTire()	self.studdedTire
BridgeFactors	Bridge Splits	Incremental factors for bridge work types	shares	setBridgeFactors()	self.bridgeFactors
BondFactor	Control	Proportion of bonded expenditures to allocate in a biennium	share	setBondFactor()	self.bondFactor
Biennium	Control	First year of model biennium	four-digit year	setBiennium()	self.biennium
SWT	Codes	Definitions of summary work types	work type codes	setSummaryWorkTypes()	self.summaryWorkTypes
SWC	Codes	Definitions of summary weight classes	pounds	setSummaryWeightClasses()	self.summaryWeightClasses
RevenueTotals	Revenue	Control totals for revenues by instrument	biennial dollars	setRevenueTotals()	self.revenueTotals
Rates	Revenue	Current-law rates except RUAF and flat fee	dollars per whatever	setRates()	self.rates
RUAFRates	Revenue	Current-law RUAF rates	dollars per mile	setRUAFRates()	self.RUAFRates
FFRates	Revenue	Current-law flat fee rates	dollars per month, miles per month, and shares	setFFRates()	self.flatfee
MPG	MPG	Assumed miles per gallon	miles per gallon	setMPG()	self.MPG
AltRates	Alt Revenues	Alternative rates except RUAF and flat fee	dollars per whatever	setAltRates()	self.altRates
AltRUAFRates	Alt Revenues	Alternative RUAF rates	dollars per mile	setAltRUAFRates()	self.altRUAFRates
AltFFRates	Alt Revenues	Alternative flat fee rates	dollars per month, miles per month, and shares	setAltFFRates()	self.altFlatfee

Table 2 Input Text Files

Text File	Contains	Units	Model Data Structure
SeedData.txt	Used to populate a preliminary VMT Master table (VMTdata) for iterative proportional fitting (see below). Any seed values (except zeros) could be used to generate fitted results, but this particular set already contains data that reflect the relative proportions of different vehicle types on different functional classes, and so will produce a distribution that not only adds up to the correct totals for each weight class and each combination of functional class and ownership, but also reflects the fact that some functional classes carry higher proportions of heavy vehicles than others. There are five columns: facility class (combines functional class and ownership), functional class, ownership, weight class, axles, and VMT. The first four are keys.	unitless numbers	self.seedData
AxleShares.txt	Contains the shares of vehicles weighing more than 105,500 pounds with each number of axles (5 to 9+) by weight class. These data are developed from Special Weighings data. There are three columns: weight class, axles, and share. The first two are keys	shares (e.g., 0.5 means 50%)	self.shares
SimpleFactors.txt	Contains vectors of factors to be multiplied by VMT for simple allocators (different weight groupings of VMT.) These factors are mostly zeros and ones, reflecting the definition of the allocator. For example, the Under26 factor is one for all weight classes up to 26,000 pounds and zero for all weight classes over 26,000 pounds. There are ten columns: weight class, axles, AllVMT, BasicVMT, Over10VMT, Over26VMT, Over50VMT, Under26VMT, Over80VMT, Over106VMT, Snow, and AllAMT. The first two are keys; the rest are allocators.	shares	self.simpleFactors
PaveFactors.txt	Contains cost responsibility factors (by weight class, functional class, and number of axles) for wear and tear of flexible and rigid pavement projects. These factors are produced by the NAPHCAS-OR model (the Oregon version of the National Pavement Cost Model for Highway Cost Allocation developed by Roger Mingo). There are five columns: facility class (combines functional class and ownership), weight class, axles, flexible, and rigid. The first three are keys.	shares	self.paveFactors
PCEFactors.txt	Contains passenger car equivalents (PCEs) by weight class, functional class, and number of axles for vehicles on regular, uphill, and congested roadways. These factors represent the amount of roadway capacity a single vehicle of a particular weight class takes up as a proportion of the capacity consumed by a basic vehicle. These factors were developed from a study conducted as a part of the 1997 federal highway cost allocation study. There are six columns: facility class (combines functional class and ownership), weight class, axles, regularPCE, UphillPCE, and congestedPCE. The first three are keys.	shares	self.pceFactors
DeclaredRegistered.txt	Contains shares of vehicles in each declared weight class that are registered in each registered weight class. These data were developed from Motor Carrier registration data. There are three columns: declaredWeight, registeredWeight, and share. The first two are keys.	shares	self.declaredRegistered
DeclaredOperating.txt	Contains shares of vehicles in each declared weight class operating at each operating weight class. These data were developed from the Special Weighings data. There are five columns: declared, declaredAxles, operating, operatingAxles, and Share. The first four are keys.	shares	self.declaredOperating
BasicSharePeak.txt	Contains the basic-vehicle share of peak-hour VMT for each functional class. These data were developed from automatic traffic recorder data. There are two columns: functionalClass and share. The first is the key.	shares	self.peakShares
BondsYYYY-YYYY.txt	Contains allocated bonded expenditures from prior studies. Uses such files, if they exist, from the nine most recent prior biennia. Columns are declared weight class, declared number of axles, and dollars. The first two are keys. Actual files will have biennium beginning and ending years in place of “YYYY”.	biennial dollars	self.priorBondAmount

Table 3 Outputs

Model Data Structure	Method to Retrieve	Tab	Upper Left	Contains
self.VMTMaster	makeVMTMaster()	VMT Master	A3	Model-year VMT by declared weight class, declared axles, functional class, and ownership
self.vmtByVehicles	makeVMTByVehicles()	Model VMT	A3	Model year VMT by weight class and tax class
self.fullAllocatedCosts	allocateCosts()	Allocated Costs	A3	Allocated costs by declared weight class, declared number of axles, and funding source
attributedRevenues	attributeRevenues()	Attributed Revenues	A1	Attributed revenues by declared weight class, declared number of axles, and revenue instrument
self.adjustedMPG	getAdjustedMPG()	MPG	D3	Calibrated estimates of miles per gallon by weight class
self.fullAllocatedCosts	getAllocatedCostsByWorkType()	Allocated Costs by SWT	B3	Allocated costs by funding source, summary work type, and summary weight class
self.projectCosts, self.nonProjectCosts, self.bondCosts, self.priorBondAmount	getCoststoAllocate()	Costs to Allocate by SWT	B3	Costs to allocate by funding source and summary work type
self.allocators	getAllocationVectors()	Allocation Vectors	A2	Allocation factors used in cost allocation by declared weight class, declared number of axles, and allocator
attributedRevenues	attributeAltRevenues()	Alt Revenues	A1	Attributed alternative revenues by declared weight class, declared number of axles, and revenue instrument

Table 4 Output Text Files

Model Data Structure	Method to Create	Contains	Units	File Name
self.fullAllocatedCosts	allocateCosts()	Contains allocated costs from current and prior bonded expenditures. Columns are funding source, work type, declared weight class, declared number of axles, and dollars. The first four are keys.	biennial dollars	allocatedCosts_bond.txt
self.fullAllocatedCosts	allocateCosts()	Contains allocated costs from the expenditure of federal funds by state government. Columns are funding source, work type, declared weight class, declared number of axles, and dollars. The first four are keys.	biennial dollars	allocatedCosts_federal.txt
self.fullAllocatedCosts	allocateCosts()	Contains allocated costs from the expenditure of federal funds by local government. Columns are funding source, work type, declared weight class, declared number of axles, and dollars. The first four are keys.	biennial dollars	allocatedCosts_local-federal.txt
self.fullAllocatedCosts	allocateCosts()	Contains allocated costs from the expenditure of local funds by local government. Columns are funding source, work type, declared weight class, declared number of axles, and dollars. The first four are keys.	biennial dollars	allocatedCosts_local-other.txt
self.fullAllocatedCosts	allocateCosts()	Contains allocated costs from the expenditure of state funds by local government. Columns are funding source, work type, declared weight class, declared number of axles, and dollars. The first four are keys.	biennial dollars	allocatedCosts_local-state.txt
self.fullAllocatedCosts	allocateCosts()	Not used. This may be ignored.	biennial dollars	allocatedCosts_other.txt
self.fullAllocatedCosts	allocateCosts()	Contains allocated costs from the expenditure of state funds by state government. Columns are funding source, work type, declared weight class, declared number of axles, and dollars. The first four are keys.	biennial dollars	allocatedCosts_state.txt
allocatedBonds	allocateCosts()	Contains allocated bonded expenditures from this study. Will be used for the next nine biennia as an input file. Columns are declared weight class, declared number of axles, and dollars. The first two are keys. Actual file name will have beginning and ending years of the model biennium in place of "YYYY".	biennial dollars	BondsYYYY-YYYY.txt
self.pavement	makeVMTMaster()	Contains pavement factors by facility class, declared weight class, and declared number of axles that are constructed from the raw pavement factors, which are by functional class, operating weight class, and actual number of axles. Columns are facility class, functional class, ownership, declared weight class, declared number of axles, flexible factor, and rigid factor. The first five are keys.	unitless factors	declared_pave_factors.txt
ffRevenue, asifWMTRevenue	allocateCosts()	Reports fees paid by flat-fee vehicles and the fees they would pay if they paid weight-mile tax. Columns are declared weight class, declared number of axles, log revenue, as-if log revenue, dump revenue, as-if dump revenue, chip revenue, and as-if chip revenue. The first two are keys.	biennial dollars	flat_fee_report.txt
N/A	makeVMTMaster()	Lists any errors encountered while attempting to make pavement factors by facility clss, declared weight class, and declared number of axles from raw pavement factors, which are by functional class, operating weight class, and actual number of axles.	N/A	missing_pavement_factors.log
self.VMTMaster	makeVMTMaster()	Contains annual VMT. Columns are functional class, ownership, declared weight class, declared number of axles, and vehicle-miles traveled. The first four are keys.	annual vehicle-miles traveled	VMTMaster.txt

data sets from tab-delimited text files, which are expected to be in the same directory as the model:

SeedData.txt is read into self.seedData and used to populate a preliminary VMT Master table (VMTdata) for iterative proportional fitting (see below). Any seed values (except zeros) could be used to generate fitted results, but this particular set already contains data that reflect the relative proportions of different vehicle types on different functional classes, and so will produce a distribution that not only adds up to the correct totals for each weight class and each combination of functional class and ownership, but also reflects the fact that some functional classes carry higher proportions of heavy vehicles than others. There are five columns: facility class (combines functional class and ownership), functional class, ownership, weight class, axles, and VMT. The first four are keys.

AxleShares.txt. is read into self.shares and contains the shares of vehicles weighing more than 105,500 pounds with each number of axles (5 to 9+) by weight class. These data are developed from Special Weighings data. There are three columns: weight class, axles, and share. The first two are keys.

SimpleFactors.txt. is read into self.simpleFactors and contains vectors of factors to be multiplied by VMT for simple allocators (different weight groupings of VMT.) These factors are mostly zeros and ones, reflecting the definition of the allocator. For example, the Under26 factor is one for all weight classes up to 26,000 pounds and zero for all weight classes over 26,000 pounds.

There are ten columns: weight class, axles, AllVMT, BasicVMT, Over10VMT, Over26VMT, Over50VMT, Under26VMT, Over80VMT, Over106VMT, Snow, and AllAMT. The first two are keys; the rest are allocators.

PaveFactors.txt is read into self.paveFactors and contains cost responsibility factors (by weight class, functional class, and number of axles) for wear and tear of flexible and rigid pavement projects. These factors are produced by the NAPHCAS-OR model (the Oregon version of the National Pavement Cost Model for Highway Cost Allocation developed by Roger Mingo). There are five columns: facility class (combines functional class and ownership), weight class, axles, flexible, and rigid. The first three are keys.

PCEFactors.txt is read into self.pceFactors and contains passenger car equivalents (PCEs) by weight class, functional class, and number of axles for vehicles on regular, uphill, and congested roadways. These factors represent the amount of roadway capacity a single vehicle of a particular weight class takes up as a proportion of the capacity consumed by a basic vehicle. These factors were developed from a study conducted as a part of the 1997 federal highway cost allocation study. There are six columns: facility class (combines functional class and ownership), weight class, axles, regularPCE, UphillPCE, and congestedPCE. The first three are keys.

DeclaredOperating.txt is read into self.declaredOperating and contains shares of vehicles in each declared weight class operating at each operating weight class. These data were developed from the Special Weighings data. There are five columns: declared, declaredAxles, operating, operatingAxles, and Share. The first four are keys.

DeclaredRegistered.txt is read into self.declaredRegistered and contains shares of vehicles in each declared weight class that are registered in each registered weight class. These data were developed from Motor Carrier registration data. There are three columns: declaredWeight, registeredWeight, and share. The first two are keys.

BasicSharePeak.txt is read into self.peakShares and contains the basic-vehicle share of peak-hour VMT for each functional class. These data were developed from automatic traffic recorder data. There are two columns: functionalClass and share. The first is the key.

The following class methods capture data from Excel (user inputs) for the VMT calculations. Excel calls these methods to give data to the model before calls the makeVMTMaster method.

setGrowthRates() (line 70) captures VMT growth rates by weight class and puts them into self.growthRates. The key is weight class and values are annual growth rates for VMT.

setVMTByFC() (line 77) captures base-year VMT by functional class and ownership and puts them into self.VMTbyFC. The key is facility class (combination of functional class and ownership) and the values are base-year VMT. These data are developed from the State's HPMS submission and FWHA Highway Statistics reports.

setBaseVMT() (line 84) captures base-year VMT by weight class and tax class and puts them into self.baseVMT. self.baseVMT is a nested dictionary. The outer keys are weight classes (from the first column of the second and greater rows of the input data). The inner keys are vehicle tax classes from the contents of the second and greater columns of the first row. Values are base-year VMT in that combination of weight class and tax class. These data typically are developed from a variety of sources including the ODOT Revenue Forecast, DMV registrations data, Motor Carrier registrations data, weight-mile tax reports, flat-fee reports, and road-use assessment fee reports.

setEvasion() (line 94) captures evasion and avoidance rates, along with some other assumptions used in revenue attribution, and and puts them into:

- self.emptyLogWeight (the assumed declared weight of an empty log truck with its trailer decked)
- self.emptyLogPercent (the assumed share of log-truck VMT that are driven while empty and with the trailer decked)
- self.ruafReg104 (the assumed share of RUAF VMT by trucks with a registered weight of 104,001 to 105,500 pounds)
- self.ruafReg96 (the assumed share of RUAF VMT by trucks with a registered weight of 96,001 to 98,000 pounds)
- self.ruafReg78 (the assumed share of RUAF VMT by trucks with a registered weight of 78,001 to 80,000 pounds)
- self.ruafRegRate (the assumed per-mile registration fee paid by trucks that pay the RUAF)
- self.basicDiesel (the assumed proportion of basic VMT by diesel-powered cars and light trucks)
- self.wmtEvasion (the assumed percent of total miles traveled by WMT vehicles upon which taxes are not paid)
- self.dieselEvasion (the assumed percent of VMT by use-fuel-tax-paying vehicles for which the use-fuel tax was not paid; includes evasion and avoidance)
- self.gasEvasion (the assumed percent of VMT by gas-tax-paying vehicles for which the gas tax was not paid; probably is entirely avoidance)

These assumptions are specified by the analyst.

The following class methods capture data from Excel (user inputs) for the cost allocation calculations. Excel calls these methods to give data to the model before it calls the allocateCosts() method.

setPath() (line 114) captures allocation rules to be applied to each expenditure category (work type) and puts them into self.path. self.path is a nested dictionary. Outer keys are work-type codes and inner keys are allocator names. Values are shares of costs in that work type to which that allocator should be applied. These assumptions are specified by the analyst in conformance with the approach agreed upon by the Study Review Team.

setNonProjectCosts() (line 124) captures non-project costs to be allocated and puts them into self.nonProjectCosts. The key is a tuple consisting of funding source, work type, facility class (combination of functional class and ownership), and bridge type (always zero). The values are biennial dollars of costs to allocate. These typically are derived from the Agency Request Budget.

setProjectCosts() (line 134) captures project costs to be allocated and puts them into self.projectCosts. The key is a tuple consisting of funding source, work type, facility class (combination of functional class and ownership), and bridge type. The values are biennial dollars of costs to allocate. These typically are derived from the ODOT Cash Flow Model and Project Control System.

setLocalCosts() (line 144) captures local government costs to be allocated and puts them into self.localCosts. The key is a tuple consisting of funding source, work type, facility class (combination of functional class and ownership), and bridge type. The values are biennial dollars of costs to allocate. These typically are derived primarily from Local Roads and Streets Survey reports.

setStuddedTire() (line 154) captures studded tire costs to be allocated and puts them into self.studdedTire. The key is a tuple consisting of funding source, work type, facility class (combination of functional class and ownership), and bridge type (always zero). The values are biennial dollars of costs to allocate, which will later be moved from the work types specified here into the work type for studded tire damage. These assumptions are supplied by the analyst.

setBridgeFactors() (line 163) captures cost shares used to distribute bridge expenditures for incremental cost allocation and puts them into self.bridgeFactors. self.BridgeFactors is a nested dictionary. The outer key is the bridge type and the inner key is a bridge-reclassification work type. Values are shares of costs for that bridge type to be allocated according to that work type. Shares for each bridge type must add up to one. The default values for these assumptions were developed from the 2002 OBEC Bridge Cost Allocation Study.

setBondFactor() (line 172) captures the bond factor, which is the proportion of bond-funded expenditures that will be repaid in a single biennium, and puts it into self.bondFactor. This assumption is specified by the analyst. It represents the biennial repayment amount as a proportion of the principal amount.

setBiennium() (line 177) captures the starting year of the model biennium and puts it into self.biennium. Specified by the analyst.

The following class methods capture data from Excel (user inputs) for the revenue attribution calculations. Excel calls these methods to give data to the model before calling the attributeRevenues() method.

setRevenueTotals() (line 188) captures revenue control totals and puts them into self.revenueTotals. The keys is the name of the revenue instrument and the value is biennial dollars of revenue to attribute. These typically are derived from the Agency Request Budget and must be consistent with current-law rates and the VMT data and assumptions specified elsewhere.

setRates() (line 198) captures rates for each of gas tax, use-fuel tax, VMT tax, weight mile tax, normal registration, farm registration, tow registration, charitable/nonprofit registration, e-plate registration, light-trailer registration, heavy-trailer registration, and title fees and puts them into self.rates. self.rates is a nested dictionary. The outer keys are revenue instruments and the inner keys are tuples of weight class and number of axles. Values are rates in dollars per VMT, gallon, or year, as appropriate. These are specified by the analyst based on current law and must match the assumptions used to develop the revenue control totals.

setRUAFRates() (line 122) captures current-law road-use assessment fee rates and puts them into self.RUAFRates. The key is a tuple consisting of weight class and number of axles and values are dollars per mile. These are specified by the analyst based on current law.

setFFRates() (line 236) captures current-law monthly flat-fee rates, average monthly miles, and axle distribution and puts them into self.flatfee. The key is one of 'Log Rate', 'Dump Rate', 'Chip Rate', 'Log VMT', 'Dump VMT', 'Chip VMT', 'Log Axles', 'Dump Axles', or 'Chip Axles' and the values are rates in dollars per month, average miles per month, or shares of VMT in that weight class accounted for by trucks with that number of axles, as appropriate. Rates are specified by the analyst based on current law and the assumptions about average miles per month and distribution of miles among numbers of axles are derived from flat fee reports from MCTD.

setMPG() (line 260) captures initial MPG assumptions by weight class and puts them into self.MPG. The key is operating weight class and values are miles per gallon. The default values for these assumptions were derived from a regression analysis of Vehicle Inventory and Use Statistics (VIUS) data.

The following class methods capture data from Excel (user inputs) for the alternative revenue attribution calculations. Excel calls these methods to give data to the model before calling the attributeAltRevenues() method.

setAltRates() (line 210) captures alternative rates for each of gas tax, use-fuel tax, VMT tax, weight mile tax, normal registration, farm registration, tow registration, charitable/nonprofit registration, e-plate registration, light-trailer registration, heavy-trailer registration, and title fees and puts them into self.altRates. self.altRates is a nested dictionary. The outer keys are revenue instruments and the inner keys are tuples of weight class and number of axles. Values are rates in dollars per VMT, gallon, or year, as appropriate. These are specified by the analyst to test proposed changes to rates.

setAltRUAFRates() (line 229) captures alternative road-use assessment fee rates and puts them into self.altRUAFRates. The key is a tuple consisting of weight class and number of axles and values are dollars per mile. These are specified by the analyst to test proposed changes to rates.

setAltFFRates() (line 248) captures current-law monthly flat-fee rates, average monthly miles, and axle distribution and puts them into self.altFlatfee. The key is one of 'Log Rate', 'Dump Rate', 'Chip Rate', 'Log VMT', 'Dump VMT', 'Chip VMT', 'Log Axles', 'Dump Axles', or 'Chip Axles' and the values are rates in dollars per month, average miles per month, or shares of VMT in that weight class accounted for by trucks with that number of axles, as appropriate. These are specified by the analyst to test proposed changes to rates.

The following class methods capture data from Excel (user inputs) for use in tabulating summary tables of allocated costs and costs to allocate. Excel calls these methods to give data to the model before calling the getAllocatedCostsByWorkType() and getCostsToAllocate() methods.

setSummaryWorkTypes() (line 272) captures definitions of summary work types and puts them into self.summaryWorkTypes. The key is the work type and the value is the summary work type.

setSummaryWeightClasses() (line 279) captures definitions of summary weight classes and puts them into self.summaryWeightClasses. The key is the weight class and the value is the summary weight class.

VMT Analysis

The makeVMTMaster() method (line 292) returns VMT by functional class, ownership, weight class, and number of axles for the model year. It uses VMT by weight class and number of axles (VCTotals, obtained from self.baseVMT), VMT by functional class and ownership (FCTotals, obtained from self.VMTbyFC), and the seed data from self.seedDatato create a VMT Master table.

Using iterative proportional fitting, the program repeatedly scales the seed data until each row sums to its corresponding VC total and each column sums to its corresponding FC total. The program stops fitting data once the sum of squared errors for the fitted values falls below a specified threshold.

Methods within makeVMTMaster

The following methods are defined and used within the makeVMTMaster class method:

findFCSums() (line 307) sums VMTData by functional class and ownership across weight classes and numbers of axles.

findVCSums() (line 315) sums VMTData by weight class and number of axles across functional class and ownership.

scaleToFC() (line 323) multiplies each value in VMTData by the ratio of its FCTotal control total to its current FCSum.

scaleToVC() (line 330) multiplies each value in the VMTData by the ratio of its VCTotal control total to its current VCSum.

findSSE() (line 337) calculates the sum of squared errors for the FCSums. (The SSE for VCSums will equal zero because the scaling process for VCSums runs after scaling for FCSums.) The "errors" are differences between the sums of VMT by individual facility class and the control total for that facility class. They are squared (multiplied by themselves) before adding up over facility classes for two reasons: positive and negative differences can't cancel each other out and a large difference in an individual facility class will be given greater weight than several small differences that add up to the large difference. It is important that none be off by a lot, but it is acceptable for many to be off by a tiny amount each.

How makeVMTMaster() works

VMTMaster is a matrix of vehicle-miles traveled (VMT) by vehicle classes and by road classes. Vehicle classes are combinations of 2,000-pound weight increments and numbers of axles. Road classes are combinations of functional classes (defined by the Federal Highway Administration) and ownership.

We start with base-year VMT by declared weight class by tax class to develop the row totals. Vehicles weighing 80,000 pounds and under are not classified by axles (axles=0). Base-year VMT by weight-mile tax vehicles between 80,000 and 105,500 pounds are available by numbers of axles because the tax rate varies with the number of axles. Other vehicles in this range (e.g., farm, publicly-owned, or Road Use Assessment Fee) are assumed to have the same distribution of miles by number of axles within each weight class as weight-mile tax vehicles.

Base-year VMT by Road Use Assessment Fee Vehicles weighing more than 105,500 pounds are distributed among numbers of axles according to the proportions specified in self.axleShares. A dictionary named VCTotals, keyed by weight class and number of axles, is built to contain the row totals for the VMT Master matrix.

The column totals are copied from self.VMTbyFC and scaled to add up to exactly the same total as the row totals.

The individual cells of the VMT Master matrix are initialized with the proportions from self.seedData. The columns initially sum to one.

The iterative proportional fitting follows the following steps:

1. Scale each column so that it adds up to its column control total (scaleToFC())
2. Sum each row (findVCSums())
3. Scale each row so that it adds up to its row control total (scaleToVC())
4. Sum each column (findFCSums()
5. Find the sum of squared differences between column totals and column control totals and compare to the threshold value (findSSE()). The threshold value is arbitrarily set to 48, meaning that if each of the 48 facility classes was off by less than one vehicle-mile traveled (out of a total of over 30 billion), it would be satisfied.
6. If the sum of squared errors is less than the threshold, stop. Otherwise, go back to Step 1.

Once iterative proportional fitting is complete, the growth rates for each weight class from self.growthRates are applied to the fitted base-year VMT data to bring it to the model year (the middle 12 months of the study biennium).

Three additional, summary facility classes are then added to the matrix. FC 0 is all State-owned roads, FC -1 is all roads and FC -2 is all locally-owned roads.

VMTMaster is copied to self.VMTMaster for use by other methods, is written to disk, and selected portions (FC -2 to FC 0, and all combinations of State ownership and functional class) are returned to Excel.

The key in self.VMTMaster is a tuple consisting of facility class, declared weight class, and declared number of axles. Values are model-year VMT.

Once VMTMaster is built, it is used to convert self.paveFactors, which are by operating weight, actual number of axles, and functional class into factors by declared weight class, declared number of axles (zero if declared weight under 80,000 pounds and nine if nine or more), and facility class (combinations of functional class and ownership, including the aggregate facility classes for all roads, all state-owned roads,and alllocally-owned roads), which are stored in self.pavement and used in allocateCosts() to allocate pavement costs to declared weight classes. The factors in self.pavement are VMT-weighted averages of the factors in self.paveFactors. Factors are constructed for both flexible and rigid pavements.

self.pavement is a nested dictionary. The outer key is the pavement type (Flex or Rigid) and the inner key is a tuple consisting of facility class, declared weight class, and declared number of axles. The code for preparing the pavement factors is intermingled with the code for building VMTMaster to save repeated looping over the same data structures.

The makeVMTByVehicles() method (line 491) multiplies VMT values in self.baseVMT by the appropriate compounded growth rates to produce self.vmtByVehicles, which contains model-year VMT by weight class and tax class. These are returned to Excel. self.vmtByVehicles is a nested dictionary. The outer key is the tax class and the inner key is the weight class.

Cost Allocation

The allocateCosts() method (line 520) performs the following processes:

- Combine local costs data from self.localCosts with project costs data from self.projectCosts into self.projectCosts (line 524).
- Do bridge splits on project costs (line 528). For projects in work types 13, 14, 15, 19, 67, 68, 113, 114, 115, 119, 167, and 168 (bridge and interchange projects), the bridge type for each project is identified and the project's cost is split into multiple work types (60-65) using the bridge factors appropriate to the bridge type. Costs in the original work types are removed from self.projectCosts and the aggregated, split costs in work types 60-65 are inserted into self.projectCosts. Bridge projects that add capacity (work types 67, 68, 167, and 168) get their base increment allocated according to the allocator(s) specified in work type 65, so the portion of their costs that would go to work type 60 according to the bridge factors defined in the Bridge Splits tab of the workbook is instead assigned to work type 65.
- Separate bond projects and apply the bond factor (line 543). Projects where the funding source is "bond" are identified, their costs are multiplied by the bond factor, and they are removed from self.projectCosts and inserted into bondsToAllocate.
- Do studded tire adjustment (line 550). For each work type and corresponding dollar amount in self.studdedTire, the dollar amount is divided proportionally among all projects in that work type in self.projectCosts and moved out of those projects and into work type 39 or 139 (if the original work type was over 100, indicating work on locally-owned roads).
- Set up allocation vector data structure (allocators) and build allocation vectors (line 573). There are allocation vectors for each combination of allocator, functional class, and ownership. Within each allocation vector, there is an element for each combination of weight class and number of axles.
- Allocation vectors are built by starting with the vector of allocation factors appropriate to the allocator. The allocation factors are proportional to costs imposed per VMT and come from self.simpleFactors, self.pavement, and self.pceFactors. Each allocation factor is then multiplied by the VMT in that combination of weight class and number of axles for the combination of functional class and ownership for which the allocation vector is being prepared, which come from self.VMTMaster. The VMT multiplied by the allocation factors for Congested PCE are adjusted using the shares from self.peakShares so that they represent VMT during the peak hour for that functional class.
- The allocation vectors are then scaled so that the elements of each vector sum to one (line 627). The resulting allocation vectors then may be multiplied by a project cost and the result will be a vector of allocated costs with each element containing the dollar amount for that combination of weight class and number of axles. All the elements in the allocated costs vector sum to the original amount to be allocated. For this to work, it is necessary that there be non-zero VMT in the combination of functional class and ownership associated with the project. Incorrectly-recorded functional classes (e.g., locally-owned interstates) can cause costs to disappear during allocation.
- Apply allocation vectors to project costs to allocate (except for "other construction" and "other bridge" costs) as described above to generate allocated project costs (line 634).

- Make Other Bridge and Other Construction allocators (line 648). Once bridge project costs other than "other bridge" have been allocated, a special allocation vector is built to allocate "other bridge" costs in proportion to all previously-allocated bridge project costs. The same is done to create a special allocation vector is built to allocate "other construction" costs in proportion to all previously-allocated construction project costs.
- Apply Other Bridge and Other Construction allocators to "other bridge" and "other construction" costs (line 692).
- Apply allocators to non-project costs (line 706). Any bond-funded projects found in self.nonProjectCosts are removed, multiplied by self.bondFactor, and added to bondsToAllocate. Remaining non-project costs have the appropriate allocation factors applied to them and are added to allocatedCosts.
- Apply allocation vectors to bonded costs to allocate (line 728). Applies the allocators to bondstoAllocate and stores the result in allocatedBonds.
- Store allocated bonded costs (line 744). Creates a text file of allocated bond costs (allocatedBonds) for use in future studies. (Future model runs will use this file to obtain prior allocated bond costs.)
- Get prior allocated bonds from files (line 760). Captures allocated, current payments due on bonds issued for projects in previous biennia (priorBonds.)
- Add current and prior allocated bonded costs to allocatedCosts (line 782).
- Write out detailed allocation results to tab-delimited text files, one for each funding source (line 794). These are named allocatedCosts_federal.txt, allocatedCosts_state.txt, etc.
- Copy allocators to self.allocators and allocatedCosts to self.fullAllocatedCosts (line 809).
- Prepare a summary table of allocated costs and send it back to Excel (line 813). Columns are funding sources and rows are combinations of declared weight class and declared number of axles. Cells contain allocated biennial dollars.

The getAllocationVectors() method (line 834) gets the allocation vectors from self.allocators and returns them to Excel. Columns are allocators and rows are combinations of facility class, declared weight class, and declared number of axles.

The getAllocatedCostsByWorkType() method (line 865) gets allocated costs from self.fullAllocatedCosts and aggregates them by summary work type from self.summaryWorkTypes and by summary weight class from self.summaryWeightClasses and returns the aggregated allocated costs to Excel. columns are summary weight classes and rows are combinations of funding source and summary work type. Cells contain allocated biennial dollars.

The getCostsToAllocate() method (line 901) gets costs to allocate from self.projectCosts (which now includes local costs and excludes bonded costs), self.nonProjectCosts (which now excludes bonded costs), self.bondCosts, and seld.priorBondAmount and aggregates them by summary work type from self.summaryWorkTypes and returns the aggregated costs to allocate to Excel. Note that prior bond amounts do not contain information about their original work type and are put into their own summary work type (21). Columns are funding sources and columns are summary work types. Cells contain biennial dollars.

Revenue Attribution

The attributeRevenue() method (line 938) performs the following processes:

- Attribute Road Use Assessment Fee revenue (line 941). RUAF revenues are attributed to weight classes by multiplying their model-year VMT in each combination of weight class and number of axles by the appropriate RUAF rate from self.RUAFRates. RUAF VMT are the total VMT in that combination of weight class and number of axles from self.VMTMaster times the ratio of RUAF VMT in that weight class to all VMT in that weight class from self.vmtByVehicles. This assumes that axle shares for RUAF vehicles under 105,500 pounds will be the same as for weight-mile tax vehicles in the same weight class, which has been determined to be a reasonable assumption. The resulting revenues are doubled to make them biennial. It is assumed that there is no evasion of road use assessment fees. Attributed RUAF revenues are put into ruafRevenue, where the key is a tuple consisting of weight class and number of axles and the value is biennial dollars.
- Attribute Weight-Mile Tax revenue and as-if WMT revenue (line 953). WMT revenues are attributed to weight classes by multiplying their model-year VMT in each combination of weight class and number of axles form self.vmtByVehicles by the appropriate WMT rate from self.rates. The base-year VMT from which the model-year VMT were derived were adjusted upward from base-year WMT reports to account for assumed evasion, so the reverse adjustment must be applied to estimate WMT revenue. This is accomplished by multiplying revenues by (1.0 - self.wmtEvasion). The resulting revenues are doubled to make them biennial and stored in wmtRevenue. For all VMT by vehicles in weight classes to which WMT rates apply, but do not pay the WMT, flat fee, or RUAF, the weight-mile taxes they would pay if they did pay the WMT are calculated and stored in asifWmtRevenue. As-if WMT revenues for those paying flat fees are calculated later, along with flat-fee revenues. The key in both wmtRevenue and asifWmtRevenue is a tuple consisting of declared weight class and declared axles.
- Attribute flat-fee revenue (line 981). For each flat-fee commodity (log, dump, and chip), for each combination of weight class and number of axles, divide the model-year VMT by the average VMT per month for that commodity and weight, and multiply the resulting number of vehicle-months by the appropriate monthly flat-fee rate. As-if weight-mile taxes for flat-fee-paying vehicles are calculated at the same time. For flat-fee log trucks, the model VMT must be adjusted prior to estimating as-if WMT revenues. When paying the WMT, log trucks can declare a lower weight when empty and traveling with their trailer decked. When estimating as-if WMT revenues for flat-fee log trucks, VMT in each weight class are multiplied by (1.0 - self.emptyLogPercent) and then by the WMT rate appropriate to that weight class. The VMT then are multiplied by self.emptyLogPercent and the WMT rate appropriate to self.emptyLogWeight. The flat-fee and as-if WMT revenues are doubled to make them biennial and stored in ffRevenue and asifWmtRevenue, respectively. A tab-delimited text file, flat_fee_report.txt, containing flat-fee VMT, revenues, and as-if WMT revenues by commodity and weight class is written out to disk.
- Attribute registration and title revenues (line 1007). Budgeted total DMV registration, Motor Carrier Apportioned, Motor Carrier Non-Apportioned, and title fee revenues are attributed to vehicle classes using fee-weighted VMT. VMT for vehicles over 26,000 lbs are adjusted using the declared-to-registered factors. VMT

by tax class and weight class are multiplied by the registration fee that applies to that combination and the resulting amounts are scaled so that they add up to the total expected registration fee revenue. For vehicles over 26,000 lbs, registration fee revenues by registered weight are converted back to revenues by declared weight class using the same declared-to-registered factors. A further adjustment is made to give RUAF vehicles credit for the registration fees they pay.

- This method eliminates the need for forecasting vehicle counts and automatically accounts for the substantial registration revenues that are produced by fees other than the regular registration fee (e.g., temporary registrations, duplicates, etc.). It also eliminates the need for directly forecasting the number of titles that will be issued. There is an implicit assumption that vehicles in the different weight classes of heavy vehicles all travel the same number of miles per title issuance. "As-if" registration fees are estimated for alternative-fee-paying vehicles.
- The method loops over the rows (combinations of declared weight class and declared number of axles) in self.rates, which are the current-law rates entered in the "Revenues" tab of the workbook. It multiplies the fee per year by the VMT per year by the vehicles subject to that fee (as if the rate were per VMT). It then adds up those (large) numbers for each instrument and divides the biennial revenue control total for that instrument by the sum of annual miles times annual fee for that instrument. It applies that ratio to the annual miles times annual fee for each combination of declared weight class and declared number of axles to get biennial revenues for that combination and instrument.
- For vehicles over 26,000 pounds, an individual vehicle will have one registered weight, but may have multiple declared weights, depending on configuration. When getting the annual VMT to multiply by each rate, self.declaredRegistered, which contains the proportion of VMT for each declared weight class that is in each registered weight class, is used.
- For vehicles over 80,000 pounds, the revenues are attributed to vehicles classes defined by both declared weight and number of axles, so axle shares for each weight class are calculated and used to spread the registration revenues (which vary only with weight) among the numbers of axles for each weight class.
- At the same time that registration revenues are attributed for "alternative" registration fees (e.g., farm, charitable/non-profit, publicly-owned, etc.), "as-if" registration fees are calculated as if they paid the "normal" registration rate for their weight. Those are used later to calculate the "subsidy" amount.
- Make an adjustment to registration revenues to give RUAF vehicles some credit (line 1158). When a vehicle pays the Road Use Assessment Fee, it often is operating at a weight above the maximum allowed declared or registered weight of 105,500 pounds. These vehicles do pay registration fees, but at a weight that does not correspond to the weight recorded in the RUAF data. Assumptions are specified in the "Revenues" tab of the workbook that allow RUAF vehicles to be credited with registration fees by transferring attributed fees from lower weight classes.
- Attribute fuel tax and VMT tax revenues (line 1179). Gasoline and diesel fuel tax revenues are attributed separately because the model allows for different tax rates and different evasion/avoidance assumptions. VMT by fuel type and weight class for fuel-tax paying vehicles are assembled and adjusted for evasion/avoidance. A preliminary attribution is made by dividing the adjusted VMT in each combination

of weight class and fuel type by the assumed miles per gallon for that weight class from the mpg data set and multiplying the resulting number of gallons by the per-gallon rate for that fuel type. The attribution to vehicles between 10,001 and 26,000 lbs is then adjusted to bring those weight classes, as a group to equity (before considering subsidies). The attribution to basic vehicles (those 10,000 lbs and under) is adjusted to make the total revenues attributed add up to the forecast revenues from the budget. The implied miles per gallon after adjustment for each weight class is calculated and sent back to Excel where it may be examined for reasonableness. The reasons for using this approach are detailed in Issue Paper 6 from the 2005 study.

- The first step in attributing fuel tax revenues is finding the taxed VMT by weight class for the gas tax and for the use-fuel (diesel, etc.) tax, taking into account the portion of basic vehicles that do not burn gasoline, avoidance, evasion, and the fact that publicly-owned vehicles such as transit and school buses do not have to pay the use-fuel tax.
- The taxed VMT for each weight class are divided by the assumed miles per gallon from self.MPG and multiplied by the tax rate per gallon to get revenues by weight class. The assumed miles per gallon for vehicles between 10,001 and 26,000 pounds then are adjusted to force those weight classes into perfect equity (before the subsidy adjustment) and their attributed fuel-tax revenues are recalculated. The sum of attributed non-basic (over 10,001 pounds) fuel taxes are subtracted from their revenue control totals, leaving the amount from basic vehicles. The assumed average basic-vehicle is then recalculated so that basic vehicles will produce this amount of revenue and that amount is attributed to basic vehicles. The calibrated miles-per-gallon assumptions are stored in self.adjustedMPG.
- Attribute other motor carrier revenue (line 1262). Budgeted other motor carrier revenue is attributed to heavy vehicle weight classes on the basis of all RUAF and WMT VMT.
- Determine subsidy amount for each weight class (line 1295). These are calculated for each tax class by subtracting what they do pay in each revenue category from what they would pay if they paid the "regular" tax or fee. Subsidy amounts may be negative, especially for certain flat-fee vehicles.
- Prepare a table of attributed revenues and subsidy amounts and send it back to Excel (line 1314).

getAdjustedMPG() (line 1331) returns the calibrated miles-per-gallon assumptions from self.adjustedMPG to Excel.

Alternative Revenue Attribution

attributeAltRevenues() (line 1347) repeats the revenue attribution process using alternative rates specified by the analyst in the "Alt Rates" tab of the workbook.

The process for alternative revenue attribution is essentially the same as for the primary revenue attribution, but there are important differences. Those differences are:

When attributing registration and title fee revenues, assume that the revenues per VMT for each combination of instrument and weight class will change by the ratio of alternative rate to original rate. This allows estimating revenues from alternative registration and title fees without specifying the total revenue they will produce in advance.

When attributing fuel-tax revenues, use the calibrated miles per gallon from the original revenue attribution. This allows estimating revenues from alternative fuel-tax rates without specifying the total revenue they will produce in advance.

Running the HCASModule as a stand-alone program

When the HCASModule is run as a stand-alone program (by double-clicking HCASModule.py, from a command prompt, or through the "Run..." dialog), no class object is created and none of the methods described are run. Instead, the code on lines 1678 to 1681 runs and registers the module as an Active-X object in the Windows registry. This allows Excel to find and use the module and its methods. The module must be registered before the first use of the model and again any time the model and module code are moved to another directory in the user's hard drive (the entire directory must be kept together). The user who registers the module must have permission to write to the Windows registry. If registration doesn't work (you'll get a message saying you don't have permission), ask your IT staff to do it for you. Once the module is registered, any user can use it.

Documentation of Final 2009 HCAS Model Run

Appendix F documents the assumptions and data used in the final run of the HCAS model for the 2009 Highway Cost Allocation Study. Data used in the final model run were collected between roughly June 2008 and January 2009. The final model run was completed and verified January 2009.

Table 1 lists the assumptions used in the Base VMT workbook. These assumptions are yellow-shaded cells in their respective workbook tabs.

Table 1: Base VMT Workbook Assumptions

Tab	Assumption	Value
DMV-Other	Commercial Trucks and Buses Annual VMT (10,001 weight class)	11,000
DMV-Other	Commercial Trucks and Buses Annual VMT (12,001 weight class)	10,000
DMV-Other	Commercial Trucks and Buses Annual VMT (14,001 weight class)	9,000
DMV-Other	Commercial Trucks and Buses Annual VMT (16,001-24,001 weight class)	8,000
DMV-Other	Tow Truck Annual VMT	15,000
DMV-Other	Farm Vehicle Annual VMT	3,000
DMV-Other	Charitable and Non-Profit Annual VMT	10,000
DMV-Other	State and Local Annual VMT-Basic Vehicles	13,000
DMV-Other	State and Local Annual VMT-10,001-26,001 Weight Classes	12,000
DMV-Other	State and Local Annual VMT over 26,001 Weight Classes	11,000
Motorhomes	Motorhome Annual VMT	7,000
SchoolBus	Private School Bus adjustment factor	1.50%
Transit	Transt adjustment factor	1.02
Motorhomes	Motorhome length/weight class assumptions	various- see table 4

Table 2 lists the assumption used in the Studded Tire tab in the Split PE and ROW workbook.

Table 2: Split PE and ROW Workbook Assumptions

Tab	Assumption	Value
Studded Tires	% State (% of Construction State funded)	10.27%

Table 3 lists the assumptions in the HCAS Model workbook. The HCAS Model workbook tab is listed in the first column followed by the assumption name or brief description. All of the assumptions listed in Table 3 correspond to yellow-shaded cells in their respective workbook tab. Tables 4 through 6 display the assumptions for the motor home weight classes, bridge splits and initial mpg since these assumptions are tables or ranges, not single values.

Table 3: HCAS Model User-Specified Assumptions

Tab	Assumption	Justification/Source	Value
Bridge Splits	Split of bridge expenditures across bridge reclassification work types	2002 OBEC Bridge Allocation Study	various-see table
Control	Biennium	page 2-1	2009
Control	BondFactor	page 3-10	0.16
Gas and Diesel	Percent of basic gallons that are diesel	NA	6.75%
Gas and Diesel	Percent of RV gallons that are diesel	NA	40%
Gas and Diesel	Percent of taxed gallons that are basic	NA	96%
MPG	MPG (initial) by weight class	Regression on 2002 VIUS data	various-see table
Policy	Preliminary and Construction Engineering (and etc.) Share 1	page 3-4 through 3-8	37.50%
Policy	Right of Way (and Utilities) Share 1	page 3-4 through 3-8	35.30%
Policy	New Pavements-Rigid Allocator/Share 1	page 3-4 through 3-8	6.90%
Policy	New Pavements-Flexible Allocator/Share 1	page 3-4 through 3-8	4.50%
Policy	Pavement and Shoulder Reconstruction-Rigid Allocator/Share 1	page 3-4 through 3-8	26.90%
Policy	Pavement and Shoulder Reconstruction-Flexible Allocator/Share 1	page 3-4 through 3-9	24.50%
Policy	Pavement and Shoulder Rehab-Flexible Allocator/Share 1	page 3-4 through 3-10	26.90%
Policy	Pavement and Shoulder Rehab-Flexible Allocator/Share 1	page 3-4 through 3-11	24.50%
Policy	Surface and Shoulder Maintenance-Rigid Allocator/Share 1	page 3-4 through 3-12	26.90%
Policy	Surface and Shoulder Maintenance-Flexible Allocator/Share 1	page 3-4 through 3-13	24.50%
Policy	Local Gov :Preliminary and Construction Engineering (and etc.) Share 1	page 3-4 through 3-14	55.90%
Policy	Local Gov :Right of Way (and Utilities) Share 1	page 3-4 through 3-15	55.90%
Policy	Local Gov :New Pavements-Rigid Allocator/Share 1	page 3-4 through 3-16	8.10%
Policy	Local Gov :New Pavements-Flexible Allocator/Share 1	page 3-4 through 3-17	7.60%
Policy	Local Gov :Pavement and Shoulder Reconstruction-Rigid Allocator/Share 1	page 3-4 through 3-18	28.10%
Policy	Local Gov :Pavement and Shoulder Reconstruction-Flexible Allocator/Share 1	page 3-4 through 3-19	27.60%
Policy	Local Gov :Pavement and Shoulder Rehab-Flexible Allocator/Share 1	page 3-4 through 3-20	28.10%
Policy	Local Gov :Pavement and Shoulder Rehab-Flexible Allocator/Share 1	page 3-4 through 3-21	27.60%
Policy	Local Gov :Surface and Shoulder Maintenance-Rigid Allocator/Share 1	page 3-4 through 3-22	28.10%
Policy	Local Gov :Surface and Shoulder Maintenance-Flexible Allocator/Share 1	page 3-4 through 3-23	27.60%
Policy	All other Allocators Shares for work types not Prelim. Engineering, ROW, or Pavement	page 3-4 through 3-24	100%
Revenues	Gas Tax Avoidance	pages 3-10 and 3-11	3.50%
Revenues	Diesel Tax Evasion & Avoidance	pages 3-10 and 3-11	4.50%
Revenues	WMT Evasion	pages 3-10 and 3-11	5.00%
Revenues	RUAF Registration Adjustment	NA	0.05
Revenues	RUAF Reg. from 78001	NA	14.00%
Revenues	RUAF Reg. from 96001	NA	32.00%
Revenues	RUAF Reg. from 104001	NA	54.00%
Revenues	Log truck miles empty	page 7-4	50.00%
Revenues	Empty log truck declared weight	page 7-4	42,001
Revenues	E-Plate Reg	One-time registration fee of $2 divided by 5 years.	0.40
Studded Tires	State/Local-State split	NA	0.04
Studded Tires	Preservation costs inflation rate	NA	0.03

Table 4 displays the assumed weight classes by motor home length used to assign motor home VMT to weight classes in the Motor homes tab in the Base VMT workbook.

Table 4: Motor Home Vehicle Length to Weight Class Assumptions

Min Length (feet)	Max Length (feet)	Weight Class
0	22	1
23	24	10,001
25	26	12,001
27	30	14,001
31	32	16,001
33	34	18,001
35	35	22,001
36	36	24,001
37	37	26,001
38	38	28,001
39	50	30,001

Table 5 displays the assumed bridge splits used to split bridge project expenditures among the bridge reclassification work types. These assumed values are from the 2002 OBEC Bridge Allocation Report.

Table 5: Bridge Split Assumptions

Bridge Type	Work Type	Share
0	60	0.6098
0	61	0.2878
0	62	0.0333
0	63	0.0691
0	64	0
1	60	0.6098
1	61	0.2878
1	62	0.0333
1	63	0.0691
1	64	0
2	60	0.6176
2	61	0.2909
2	62	0.0136
2	63	0.0779
2	64	0
3	60	0.4324
3	61	0.2213
3	62	0.0565
3	63	0.2898
3	64	0
4	60	0.7962
4	61	0.0752
4	62	0.0875
4	63	0.0411
4	64	0

Table 6: MPG Assumptions (Initial MPG)

Declared	MPG
1	20
10,001	10.85
12,001	10.27
14,001	9.77
16,001	9.33
18,001	8.94
20,001	8.59
22,001	8.27
24,001	7.98
26,001	7.15
28,001	7.04
30,001	6.94
32,001	6.85
34,001	6.76
36,001	6.67
38,001	6.59
40,001	6.52
42,001	6.45
44,001	6.38
46,001	6.31
48,001	6.25
50,001	6.19
52,001	6.13
54,001	6.07
56,001	6.02
58,001	5.97
60,001	5.92
62,001	5.87
64,001	5.82
66,001	5.78
68,001	5.73
70,001	5.69
72,001	5.65
74,001	5.61
76,001	5.57
78,001	5.53
80,001	5.49
82,001	5.45
84,001	5.42
86,001	5.38
88,001	5.35
90,001	5.31
92,001	5.28
94,001	5.25
96,001	5.22
98,001	5.19
100,001	5.16
102,001	5.13
104,001	5.1

Declared	MPG
110,001	5.07
112,001	5.04
114,001	5.01
116,001	4.99
118,001	4.96
120,001	4.93
122,001	4.91
124,001	4.88
126,001	4.86
128,001	4.83
130,001	4.81
132,001	4.79
134,001	4.76
106,001	4.74
108,001	4.72
136,001	4.7
138,001	4.67
140,001	4.65
142,001	4.63
144,001	4.61
146,001	4.59
148,001	4.57
150,001	4.55
152,001	4.53
154,001	4.51
156,001	4.49
158,001	4.47
160,001	4.45
162,001	4.43
164,001	4.42
166,001	4.4
168,001	4.38
170,001	4.36
172,001	4.34
174,001	4.33
176,001	4.31
178,001	4.29
180,001	4.28
182,001	4.26
184,001	4.24
186,001	4.23
188,001	4.21
190,001	4.19
192,001	4.18
194,001	4.16
196,001	4.15
198,001	4.13
200,001	4.12

Table 6 (page F3) contains the assumed initial MPG, created from regression of the 2002 Vehicle Inventory and User Survey published by the U.S. Census Bureau. The Vehicle Inventory and Use Survey was discontinued after 2002.

Table 7 lists the files and sources of the data used in the 2009 Final HCAS model run. Following Table 7 is the SQL code used for pre-processing the DMV, WMT and Flat Fee data. All other transformations of the raw data are described in Appendix D-HCAS User Guide.

Table 7: 2009 HCAS Data Files and Sources

Data	Source	Date	File Name
Bridge Project Information	Teresa Yih, Bridge Section	Oct-08	UnknownBridges(Dammen-ECONorthwest)_1.xls
Bridge Project Information	Bruce Johnson, Bridge Section	Nov-08	Bridge Const 2009-2011_NI
Bridge Project Information	Lea Ann Hart-Chambers, OTIA III Statewide Bridge Delivery Program	Nov-08	Bridges with increased capacity data.10-31-2008.rev3.xls
Bridge Project Information	Teresa Yih, Bridge Section	Oct-08	Selected Budle Budget.xls
DMV Registrations	Ellen Crecelius	Jun-08	DMV Master File Data Dictionary, dmv_registrations.csv, dmv_registration_fields.xls
Federal Fleet Report FY 2007	http://www.gsa.gov/graphics/ogp/FFR2007_508.pdf	Sep-08	FederalFleetReport2007
FHWA Highway Statistics-Table MV7	http://www.fhwa.dot.gov/policyinformation/statistics/2007/mv7.cfm	Dec-08	FHWA Highway Statistics-Table MV7
FHWA Highway Statistics-Table VM2	http://www.fhwa.dot.gov/policyinformation/statistics/2007/vm2.cfm	Dec-08	FHWA Highway Statistics-Table VM2
Flat Fee Collections Reports	Ellen Crecelius	Jun-08	Flat fee data fields.xls, flat fee.csv
Heavy Vehicle VMT Growth Rates	John Merriss	Nov-08	VMT Growth tab in HCAS Model Workbook
HPMS Submittal Data	ftp://ftp.odot.state.or.us/tdb/trandata/HPMS_SUBMITTALS/ or Jennifer Campbell, HPMS Coordinator		2007HPMS.csv, 2007HPMS.mbd
Local Costs: Local Roads and Streets Survey	John Merriss	Jul-08	2007 City & County Combined Revised.xls
Motor Carrier Registrations	Ellen Crecelius	Jun-08	MCTD Regs Data Fields.xls, mctd_regs.out
Non-Project Costs	John Merriss	Nov-08	Costs to Allocate 2008.xls
Oregon Bridge Log 2008	http://www.oregon.gov/ODOT/HWY/BRIDGE/docs/brlog.pdf	Oct-08	brlog08.pdf
Pavement Factors	Roger Mingo	Jan-09	LRS_structure.doc, ODOT Pavement Structure Data.mdb, pavement type codes.xls, Surface Descriptions.csv, tpvmtbe.csv
Project Costs	Tessa Janzi	Sep-08	HCAS11 09-23-08.xls, HCAS2 09-23-08.xls, Work Types w-%.xls, UPD 09-10-08.xls, UPI 09-05-08.xls
Project Costs by funding source	Tessa Janzi	Nov-08	Darryls Summary 09-29-08 (09-11) Rev % (Values).xls
Revenue Forecast	Dave Kavannaugh	Oct-09	RICA 0806 subset for HCAS.xls
Revenue Forecast	Dave Kavannaugh	Oct-09	Table 1 FSB Estimation Methode HCAS Forecast.xls
Revenue Forecast	Dave Kavannaugh	Oct-09	Revenues 2009-11.xls
RUAF Collection reports	Ellen Crecelius	Jun-08	RUAF.xls

Data	Source	Date	File Name
Special Weighings	John Merriss	Sep-08	Special Truck weighings 1988-2002.csv, special weighings 03-07.xls, Truck Weight 2003 R.xls, Truck Weigh 2004.xls, Truck Weight 2005.xls, Truck Weight 2006.xls, Truck Weight 2007.xls, Truck Weight 2008.xls
Transit VMT-Lane Transit District	Andy Viborah – 541-682-6181	Sep-08	Transit tab in Base VMT Workbook
Transit VMT: Tri-Met	Nancy Jarigese-JarigesN@trimet.org	Oct-08	Transit tab in Base VMT Workbook
Transit VMT: Salem-Keizer Transportation District	Joe – joe@cherriots.org	Sep-08	Transit tab in Base VMT Workbook
WMT Collection Reports	Ellen Crecelius	Jun-08	WMT data fields.xls, HUS_Example.xls, weight mile.out

Processing of Original Data

The following section provides the SQL codes for the data sets requiring pre-processing outside of the HCAS model. Due to the complexity of the data tabulations and calculations or the sheer size of the data sets, these data transformation/summary tables were created in a database program which the output summary tables from these transformations pasted into the

DMV Registration Data

DMV registrations by weight class and tax class are used to estimate the BaseVMT (base year VMT) in the DMV-Other tab in the Base VMT workbook. The following SQL code was used to process the raw DMV Registration data. The plate numbers were used to determine the tax class and the veh_weight variable was used to assign the weight class. With the exception of exempt (E), buses (B), and school buses (SC) whose registrations do not necessarily expire, the data were filtered using the expiration date.

```
ALTER TABLE dmv_registrations ADD COLUMN expired boolean;
UPDATE dmv_registrations SET expired =    CASE
    WHEN substr(expire, 5, 4) > ‘2008’ THEN FALSE
    WHEN substr(expire, 5, 4) = ‘2008’ AND substr(expire, 1, 2) > ‘08’ THEN FALSE
    ELSE TRUE
  END;

ALTER TABLE dmv_registrations ADD COLUMN weight_class int4;
update dmv_registrations set weight_class =
int8((cast(veh_weight as int4)-1)/2000)*2000 + 1;

ALTER TABLE dmv_registrations ADD COLUMN tax_class varchar(255);
update dmv_registrations set tax_class=
CASE
when substr(plate,1,1)=’B’ and substr(plate,2,1)<’A’ then ‘B’
when substr(plate,1,1)=’E’ and substr(plate,2,1)<’A’ then ‘E’
when substr(plate,1,2)=’SC’ and substr(plate,3,1)<’A’ then ‘SC’
when substr(plate,1,2)=’CN’ and substr(plate,3,1)<’A’ then ‘CN’
when substr(plate,1,1)=’F’ and substr(plate,2,1)<’A’ then ‘F’
```

```
when substr(plate,1,2)='HC'and substr(plate,3,1)<'A' then 'HC'
when substr(plate,1,2)='HF' and substr(plate,3,1)<'A' then 'HF'
when substr(plate,1,2)='PF' and substr(plate,3,1)<'A' then 'PF'
when substr(plate,1,1)='T' and substr(plate,2,1)<'A' then 'T'
when substr(plate,1,2)='TW' and substr(plate,3,1)<'A' then 'TW'
else 'other'
End;

select tax_class, fuel, weight_class, count(plate) as vehicles
from dmv_registrations
where not expired or tax_class in ('E', 'SC', 'B') and fuel!='6'
group by tax_class, weight_class, fuel
order by tax_class, weight_class, fuel;
```

DMV Motor Home Registrations

Motor home VMT estimated using motor home vehicle counts from the DMV data with an assumed annual VMT. Weights are not included for motor homes in the DMV data so the vehicle length (in feet) is used with motor home manufacturer's data on vehicle lengths and weights to assign the motor home vehicle counts to weight classes. The SQL code processes the DMV data to create a table of motor home registration counts by vehicle length.

```
/* Motor Home data */
select tax_class, fuel, weight_class, veh_length, count(plate) as vehicles
from dmv_registrations
where not expired and tax_class in ('HC') and fuel!='6'
group by tax_class, fuel, weight_class, veh_length
order by tax_class, fuel, weight_class, veh_length;
```

WMT Collections

The SQL code for the WMT Collection reports data first create the weight_class and axle_count variables and then creates the WMT summary table which is pasted into the WMT tab in the Base VMT workbook.

```
ALTER TABLE wmt_payments ADD COLUMN weight_class float;
ALTER TABLE wmt_payments ADD COLUMN axle_count int;

UPDATE wmt_payments SET
      weight_class = TRUNC((weight - 1) / 20) * 2000 + 1,
      axle_count = CASE WHEN weight < 801 THEN 0 WHEN axle > 9 THEN 9 WHEN axle<5 THEN 5
         ELSE axle END;

SELECT weight_class, axle_count, SUM(miles) AS miles
FROM wmt_payments
GROUP BY axle_count, weight_class
ORDER BY axle_count, weight_class;
SELECT weight_class, axle_count, SUM(miles) AS miles  FROM wmt_payments  GROUP BY axle_count,
   weight_class ORDER BY axle_count, weight_class;
```

Open up the Base VMT workbook and paste the WMT summary table into the *WMT* tab.

Flat Fee Collection Reports

Since any log truck records with a reported weight under 56,001 are reassigned to higher weight class or excluded, the flat fee data transformations and reassignment can be done in Excel workbook (Flat Fee Axle VMT). The below code creates the Flat Fee summary table using all Flat Fee records, and 'Mile Non-Zero' records (records where a positive, non-zero number of miles were reported). If processing the Flat Fee report data using this SQL code, the log trucks with weights reported under 56,001 should first be reassigned.

```
ALTER TABLE flat_fee_payments ADD COLUMN weight_class float;
ALTER TABLE flat_fee_payments ADD COLUMN axle_count int;

UPDATE flat_fee_payments SET
weight_class = TRUNC((weight - 1) / 20) * 2000 + 1,
axle_count = CASE WHEN weight < 801 THEN 0 WHEN axle > 9 THEN 9 WHEN axle<5 THEN 5 ELSE
    axle END;

SELECT comm, weight_class, SUM(miles) AS miles, count(*) as truck_months
        FROM flat_fee_payments
GROUP BY comm, weight_class
ORDER BY comm, weight_class;
```

Make the table of 'All Observations' Miles and Months for the Flat Fee Base VMT:

```
SELECT comm, weight_class, SUM(miles) AS miles, count(*) as truck_months
        FROM flat_fee_payments
        GROUP BY comm, weight_class
        ORDER BY comm, weight_class;
```

Copy output and then paste into the 'All Observations' yellow-shade cells for Flat Fee Base VMT.

Make the table of "MileNonZero" for calculating the VMT per Month:

```
SELECT comm, weight_class,  SUM(miles) AS miles, count(*) as truck_months

FROM flat_fee_payments
WHERE miles>
GROUP BY comm, weight_class
ORDER BY comm, weight_class;
```

Make the table of "MileNonZero" for the monthly VMT and Axle Share for the *Flat Fee for Rev Tab:*

```
SELECT comm, weight_class,  axle_count, SUM(miles) AS miles, count(*) as truck_months

FROM flat_fee_payments
WHERE miles>0
GROUP BY comm, weight_class axle_count
ORDER BY comm, weight_class axle_count;
```

Copy the output and paste into the yellow-shaded cells in the *Flat Fee for Rev Tab* in the Flat Fee Axle VMT workbook.